Health impact from pesticide residues in a desert environment

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Countryside in Al-Ain

In olden days the desert was inhabited by the Nomads,
who moved from oasis to oasis in search of food
for their herds.

In these days greenery is brought to the oasis by man and
the inhabitants do not have to move anymore in search of food
for their herds nor for themselves.

Is there a price to pay!

Health impact from pesticide residues in a desert environment

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Abbreviations

1. AChE	Erythrocyte acetylcholinesterase activity
2. HAChE	Haemoglobin adjusted erythrocyte acetylcholinesterase activity
3. AT	Aiming Test
4. DST	Digit Symbol Test
5. ADI	Acceptable Daily Intake
6. NOEL	No observed effect level
7. MRL	Maximum Residue Levels
8. EDI	Estimated Daily Intake
9. EDI_{bw}	Estimated daily intake per unit body weight
10. FAO	Food and Agriculture Organization
11. WHO	World Health Organization
12. CAC	Codex Alimentarius Commission
13. CCPR	Codex Committee on Pesticide Residues
14. JMPR	Joint Meeting on Pesticide Residues
15. IPM	Integrated Pest Management
16. ICM	Integrated Crop Management
17. IFS	Integrated Farming System
18. IOFM	International Federation of Organization for Agricultural Movement
19. CA	Chromosomal aberrations
20. MN	Micronuclei
21. SCE	Sister Chromatid Exchanges

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Abstract

Health impact from pesticide residues in a desert environment

The amount and frequency of use of pesticides in vegetable farming have been shown to be high in the five farming areas in Al-Ain, UAE. The mean usage of all pesticides was high (6.81 g/m^2) while the usage of organophosphorus pesticides (2.11 g/m^2) was higher compared to the usage of all the other types of pesticides. A number of pesticides banned from use in the developed countries are still used in vegetable farming. The depletion of erythrocyte acetylcholinesterase (AChE) activity among farmworkers was positively correlated with the length ($p<0.01$), frequency($p<0.05$) and the use of pesticides ($p<0.0001$) and inversely correlated with the use of personal protective equipment ($p<0.05$) and personal hygiene practice ($p<0.05$). The morbidity profile among farmworkers was positively correlated with the use of pesticides on the farms ($p<0.0001$) and the non-use of personal protection ($p<0.05$).

The mean concentrations of all pesticide residues (1.19±0.09 mg/kg) and the organophosphorus pesticide residues (1.23±0.22 mg/kg) in the locally grown vegetables exceeded the respective MRLs by 4 and 6 times respectively. The mean concentrations for all pesticides and for organophosphorus pesticide residues in twelve of the thirteen vegetable commodities also exceeded the corresponding MRLs. The mean dietary intakes of all pesticide residues, as a percentage of ADI, were 14% and 17% respectively for the ethnic and farming populations, while corresponding values for organophosphorus pesticides were 37% and 45%

respectively. However, the dietary intakes of pesticide residues exceeded the ADI for mixtures for the ethnic (137%) and the farming populations (163%).

A review of congenital malformations among ethnic and immigrant non-farming populations has suggested an interplay of genetic, dietary and environmental factors. Methods are proposed to reduce the environmental exposure and the dietary intake of pesticide residues and these include the establishment of a pesticide register, the training of the farmworkers in the proper use of pesticides, the use of protective measures, alternate methods of farming, the proper processing of vegetables prior to consumption and a comprehensive risk assessment of reproductive and genetic toxicity of organophosphorus pesticides.

Chapter 1

Review of the study

1.1 Background

1.2 Aims and objectives of the study

1.3 Overview of the study plan

1.4 Peer reviewed publications

1.5 Conference presentations

1.6 Other presentations

1.7 Courses and workshops attended during the study period

1.1 Background

This study of the health impacts from pesticide residues in a desert environment was carried out in Al-Ain, Abu Dhabi, an emirate in the Federal Republic of the United Arab Emirates. The study was carried out in collaboration with the School of Health, Biological and Environmental Sciences, Middlesex University.

1.1.1 Selection of the study site

The Department of Community Medicine, Faculty of Medicine, UAE University initially planned a detailed study of the use of pesticides in the agricultural farms and their effect on the health of the farming community in Al-Ain under the leadership of the then Head of the Department , Prof. JAD Anderson. Prof. Anderson agreed to this study being carried out by James Gomes with a view to earning a doctorate degree. As a consequence the broad aims and objectives were developed and together with a core protocol for the study were submitted to the Faculty Research Committee for a grant. It was then necessary to look for an appropriate academic institution in the United Kingdom, which would accept the necessary candidature for a doctorate degree, as the Faculty of Medicine, UAE University was not able to offer doctorate degrees. In conjunction with an offer of funding for the study from the Faculty Research Committee, the Urban Pollution Research Centre (School of Health, Biological and Environmental Sciences), Middlesex University, under the leadership of Prof. Bryan Ellis, agreed to support the application of James Gomes for registration on an MPhil/PhD programme associated with the proposed project. The study was formally initiated in July 1993 under the guidance of Prof. JAD Anderson (Director of Studies), Prof. B Ellis and Prof. M. Revitt. Prof. O. Lloyd, Chairman, Dept. of Community Medicine, Faculty of Medicine joined the team when Prof. JAD Anderson retired in June 1995 and Prof. M. Revitt took over as Director of Studies.

1.1.2 *Pesticide usage in agriculture and its effect on human health*

The use of chemical compounds (pesticides) for protecting crops has been practised since biblical times when farmers used sulphur to control mildew. In the 1960's nicotine was used by French farmers to kill lace bugs and in the 1860's arsenic based compounds were used in the United States to control the potato beetle (Ebert *et al* 1988). Pesticides used in the early years were materials of natural origin such as salts of arsenic, copper, lead, mercury and zinc. However, with the discovery of dicholorodiphenyltrichloro-ethane (DDT) in 1939, an era of the use of synthetic organic pesticides began. In modern times and with the introduction of organic pesticides in the 1940's came a preponderance of thousands of synthetically developed compounds to help farmers to control the pests that destroy their crops.

Currently, approximately 90% of all pesticides are organic compounds with the remaining 10% being inorganic in nature. The American Chemical Society has listed more than 15,000 chemical compounds for use as pesticides. The Pesticide Index lists 1600 pesticides (active ingredients) which are mixed with a myriad of inert ingredients (without pesticidal properties, but not necessarily without adverse health effects) into more than 35,000 commercial brands of pesticides. The current world production of formulated pesticides is estimated to be more than 3 x 10^9 kg, of which 75% is consumed in the developing countries (McConnell 1994). Depending on the function and use, pesticides have been classified as:

- **Insecticides:** which are used to kill undesirable insects and other pests and are usually sprayed onto the crops; they include organochlorine, organophosphorus and carbamate type compounds.
- **Herbicides:** which are used to kill unwanted vegetation, to sterilize soil and are generally considered to have low systemic toxicity in humans; they include amides, arsenicals, carbamates, thiocarbamates and substituted urea type compounds
- **Fungicides:** which are used to control moulds and other fungi; they include thiocarbamates, phthalimides and organotin compounds
- **Fumigants:** which are used to kill insects by choking them with smoke produced by heating a fumigant type chemical compound; they include halogenated hydrocarbons and certain inorganic gases.
- **Rodenticides:** which are used to fumigate burrows and as baits, and include compounds of several metals including zinc, thallium and arsenic.
- **Nematocides:** which are used to kill nematodes and to sterilize soil, and include chemical compounds like dibromochloropropane, which is a testicular toxin.

Inorganic pesticides include calcium and sodium arsenite, lead, zinc, sodium and calcium arsenate, arsenic acid, borate sulphur, sodium chloride and cadmium, organotin and organomercuric compounds. Yellow phosphorus, zinc phosphide and thallium sulphate have been used as rodenticides. Inorganic copper compounds (cuprous and cupric oxide, copper hydroxide, copper carbonate, copper acetate and copper sulphate have been used as effective fungicides for a long time.

Pesticides are an extremely diverse group of substances with a wide potential for a variety of toxic effects. They can range in acute toxicity from being lethal at low doses, such as strychnine, to the relatively large quantities, such as sodium chloride, which is also edible in measured quantities. Pesticides have helped to increase crop production by controlling the pests that destroy the crops. However, some of the pesticides have adversely affected the non-target species by inducing carcinogenic, teratogenic, mutagenic, neuro-toxic effects as well as alterations of reproductive processes or functions in experimental animals and in man (Al-Saleh 1994). Certain pesticides (*o,p*-DDT) have been able to modulate the endocrine system by augmenting the sex steroid burden and have therefore been termed as endocrine disrupters (Gillesby and Zacharewski 1998). Pesticides have sustained the growth in food production and preservation, although, increased usage of pesticides, for good reasons, in both the developed and in the developing countries has resulted in contamination of food and the environment, through pesticide residues (Klotz *et al* 1996).

Contamination of food and the environment has caused concern over the potential adverse effects on animal and human well-being. The annual incidence rate for non-Hodgkin's lymphoma in the United States has risen from 5.9 per 100,00 population in 1950 to 13.7 per 100,000 population in 1989 in both males and females, blacks and whites and in all age groups except the very young (Weisenberger 1994). Similar findings have been reported from other developed countries, indicating that environmental factors could play an important role in the aetiology of non-Hodgkin's lymphoma. Rici *et al* (1985) have reported that an estimated 70% of human cancers would in principle be preventable if main risks and anti-risks factors were identified. The evaluation of the causal relationship of the adverse health effects is complex because of:

i) the use of vast numbers of toxic chemical compounds with diverse properties

ii) different catabolic and metabolic pathways *in vivo* and *vitro*, and

iii) the type of exposure among the different categories of people and the extent of exposure.

Environmental pollution by pesticides has been identified as one of the major environmental impacts from agriculture (Skinner *et al* 1997). Parent compounds as well as metabolites of pesticides have been identified in air (Rudel 1997), water (Boonyatumanond *et al* 1997) and soil (Redondo *et al* 1997). The list of pesticide related compounds which have been identified in the environment and proved to be carcinogenic is growing as new methods of detection have been developed and sensitivities and specificities of assays have been improved. In a comprehensive review, Miller & Miller (1979) reported on the many environmental chemicals which are carcinogenic and 90% of these chemicals were pesticide related. Some of the most commonly used insecticides like Toxophene, DDT, Aldrin and Dieldrin were found to be both carcinogenic and mutagenic, while carbaryl, ethylene dibromide and parathion were mutagenic. The herbicide, nitrofen, and the fungicide, captan, also possess similar properties.

Pesticides differ in their mode of action, uptake by the body, metabolism and elimination from the body and toxicity potential. Because of these differences some pesticides show acute short term effects, while others tend to accumulate in the body and with time demonstrate sub-lethal adverse health effects. Many of these compounds also persist in the environment and bioaccumulate in the animal and human tissues (El-Sebae 1986). The degradation and transformation of the non-persistent chemicals in the environment are dependent on their physico-chemical properties, the environment in which they reside and the threshold levels of these chemicals in the environment. Degradation and transformation processes do not always result in decreased activity or dilution of the parent compound, for the degraded or transformed products are at times more toxic, resulting in biomagnification of the toxicity of the parent compound.

Adverse reproductive health effects reported in animals from chronic exposure to pesticides and their metabolites include embryo mortality, reduced hatchability, teratogenic effects, skeletal abnormalities and impaired differentiation of the reproductive and nervous system through mechanisms of hormonal mimicking of oestrogens (Fry 1995). Similar effects among adult birds have been identified in reduced fertility, suppression of egg formation, eggshell thinning, impaired incubation and chick rearing behaviour (Fry 1995). Other adverse health effects in humans from chronic exposure include significant increases in non-Hodgkin's lymphoma, leukemia, multiple myeloma, soft tissue sarcoma and cancers of the breast, ovary, lung, bladder, cervix, sino-nasal cavities in women involved in agriculture (McDuffie 1994). A statistically significant increase in brain cancer has been reported among licensed pesticide users in Italy (Figga-Talamanca *et al* 1993). Farmworkers and farm owners/operators who are also occupationally exposed to pesticides were reported to be at an increased risk of developing multiple myeloma and cancers of stomach, prostrate and testes. However, farmworkers as a group were reported to have significantly higher incidence of cancers of the buccal cavity, pharynx, lung and liver (Zahm and Blair 1993). Recent studies on cancer incidence in France have shown an increase in bladder cancer in Southern France compared to Northern France. This increase correlated well with the large number of vineyards and increased usage of pesticides in Southern France (Viel and Challier 1995).

In recent years, pesticide related chemicals, which can disrupt endocrine development in wildlife and laboratory animals have been identified in rain water, lakes, oceans, freshwater and marine and terrestrial food products (Colborn *et al* 1993). The majority of the endocrine disrupting chemicals which are released into the environment are either pesticides or their metabolites, some of which being persistent are bioaccumulated and biomagnified. Exposure to endocrine disrupting pesticides and other chemicals in the environment has been associated with abnormal thyroid function in birds (Moccia *et al* 1986) and fish (Moccia *et al* 1981), decreased fertility in birds (Shugart 1980), fish (Leatherland 1992) and mammals (Reijnders 1986), decreased hatching successes in fish (Mac *et al* 1988), and birds (Kubiac *et al* 1989), demasculinization and feminization of male fish (Munkittrick *et al* 1991), birds (Fry and Toone 1981) and mammals

(Belan 1989), defeminization and masculinization of female fish (Davis and Bortone 1992), birds (Anthony *et al* 1993) and mammals (Martineua *et al* 1988). These deleterious health effects have been observed in many areas where the presence of multiple man-made chemicals and pesticides have been identified (Colborn *et al* 1990).

Studies on the endocrine mediated adverse health effects in wildlife have confirmed our fears of similar effects in humans. It is now suspected that increases in the incidence of numerous pathologies in men and women may be related to exposure to these pesticides and other endocrine disrupting chemicals that are oestrogen agonists. Laboratory experiments with small animals have confirmed the adverse effects on the reproductive system of both males and females from exposure to chlorinated pesticides (Gray *et al* 1989a). In the last two decades a substantial increase in breast cancer has occurred, the incidence of cyptorchidism has almost doubled, and the sperm count in adult males has decreased by approximately 50% (Colborn *et al* 1993). These trends could be the manifestation of the increased release of oestrogenic pesticides in the environment. Many endocrine disrupting chemicals have been reported in the reproductive tissues of men and women (Bush *et al* 1986).

Effects of environmentally persistent pesticides on the reproductive system have been reported since the late 1970s when DDT, dicofol, keltane and methoxychlor were linked to development of oviducts and gonads resembling ovaries in male birds (Fox 1992, Fry *et al* 1981). A number of laboratory studies suggest that fertility among human populations, like wildlife populations, when exposed to ubiquitous xenobiotics may be at risk (Fry *et al* 1981, Hess *et al* 1991, Couch 1984). A meta analysis that re-examined 61 sperm-count studies revealed that the worldwide sperm count has decreased by approximately 50% since 1938 (Carlsen *et al* 1992, Sharpe and Skakkebaek 1993). The number of male reproductive defects (cryptorchidism, hypospadia) have been reported to have doubled between 1970 and 1987 (Chilvers *et al* 1984, Jackson *et al* 1986). These and other effects have been related to maternal exposure to elevated levels of orgaochlorine pesticides during prenatal development of the offspring (Sharpe and Skakebaek 1993, Sharpe 1993).

Dietary intake has been shown to be one of the main sources of chlorinated pesticides to infants and general populations (Becher *et al* 1995). High intake of seafood from contaminated waters has been shown to result in an increased body burden of chlorinated pesticides (Schwartz *et al* 1983). The concentrations of PCDDs and PCDFs in milk from mothers living in rural and urban areas have been found to be similar to those for women in coastal areas, thereby implicating other components of the food chain (Becher *et al* 1995). Adults in the highly industrialised European countries such as Netherlands and Germany have been observed to have higher dioxins and furans in serum than those in less industrialised countries like Norway and Lithuania (Becher *et al* 1995). A concentration of approximately 500 ng/kg of 2,3,7,8-TCDD in human lipids could be attained by a daily dietary intake of 0.5 ng/kg body weight (Schlatter 1994). However, the dioxin body burden is 1-2 orders of magnitude below a toxic level and no acute adverse effects have been observed. Delayed sub-clinical health effects are yet to be studied and biomagnification of subtle adverse health effects across generations, together with genetic modifications, are yet to be researched and reported.

Agriculture is a relatively new industry in Al-Ain. Although it is a desert country, availability of water at certain locations has encouraged the government to set up small farms to grow vegetables. Among other difficulties in greening the desert are: non-fertile soil, easy infestation by pests and the limited time period available for cultivation (farming is possible only during the winter months). For the crops to be successful relatively high quantities of pesticides and fertilisers have to be used. This study was planned to determine the usage of pesticides in agriculture and further to identify the sources and levels of exposure in the farming and general populations. Farm water, soil, produce and dietary intake of locally grown produce were analysed for pesticide residues. Farmworkers were assessed for exposure to pesticides used on the farms and development of adverse health effects. The focus of this study being adverse health effects manifested in the farming and the general population from pesticide exposure the following aims and objectives were identified in the execution of the study.

1.2 *Aims and objectives of the study*

The project which studied the health impacts resulting from pesticide residues in a desert environment was designed to achieve the following aims and objectives.

1.2.1 *Aims*

The following aims were identified during the planning of the study and were used in its execution :

1. To investigate the occupational and non-occupational exposures to and the associated risks of pesticides used in agriculture in the United Arab Emirates (UAE).

2. To suggest risk control measures by establishing Allowable Daily Intake (ADI) of the pesticides in the locally grown produce and by proposing methods to reduce/limit the usage of pesticides in vegetable farming.

1.2.2 *Objectives*

To achieve the above mentioned aims the following broad objectives were established:

- Determination of the usage of pesticides in agriculture in Al-Ain, UAE, through a field survey.

- Assessment of the level of exposure from pesticides in farmworkers through a biomarker and examination of the usage of protective measures.

- Determination of the presence of pesticide residues in agricultural produce, farm water and farm soil in Al-Ain.

- Study of the dietary habits in the ethnic population, through an epidemiological survey, with a view to identifying their dietary exposure to pesticides.

- Determination of the adverse health effects from occupational and non-occupational exposure to pesticides among the ethnic and the farming populations.

- Establishment of Allowable Daily Intakes (ADI) for the general and the farming populations and development of Maximum Residue Levels (MRL) for the locally grown produce.

1.3 *Overview of the study plan*

Farming in a tropical desert country, like the United Arab Emirates (UAE), is difficult because of a host of factors. In the UAE, water is scarce and the climate is very hot for most of the year. Cultivation in sand is difficult due to its porosity, poor organic content and high salinity. However, in the past few years, where water sources are available, farms have been developed. At other locations where the water table is too deep, recycled sewage water is being provided by the government. Agriculture is restricted to the cooler months of the year (winter months) and the crops are selected carefully to concentrate on those which grow fast and mature quickly. The local produce, therefore, includes Tomatoes, Cucumbers, Cabbage, Cauliflower, Aubergines, Radish, Onion, Chillies, Capsicum, Potatoes, Carrots and Green leafy vegetables (Lettuce, Spinach, Molokia). Most of the farms are open farms, with only a few greenhouses where the cultivation of Cucumbers and Tomatoes is practised.

Healthy and abundant crops in a time based agricultural activity, can only be obtained with the efficient use of fertilisers, pesticides and water. Pesticides (insecticides, fungicides, herbicides, acaricides, algicides and nematocides), growth regulators, repellents and fumigants have, therefore, become integral parts of crop production in the UAE. Pesticides are used in increasing amounts during the winter months (November to April) when agricultural activity is at its peak. Fertilizers and other nutrients are also used optimally with drip irrigation to facilitate rapid growth and to ensure that the crops are ready before the change of the season. Faced with these requirements and other dilemmas, pesticides and fertilizers are often over-used for a variety of reasons.

A limited amount of pesticides are formulated in the UAE, however, all the required pesticides are either imported from neighbouring countries or imported from the Western countries. UAE does not have a pesticide registry for importing pesticides into the country but the Department of Agriculture keeps a list of those pesticides which it distributes at subsidized prices, however, there is no record available of pesticide imports made by private companies. When subsidized pesticides are in short supply, or are not effective for the prevalent pest, prescriptions are prepared by the Department of Agriculture, for the farmworkers, who then obtain the necessary pesticides from a private store. Since a comprehensive list of the pesticides used in agriculture was not available, it was necessary to initially conduct a survey of the farms in Al-Ain (Chapter III). This survey provided information on the identities and quantities of pesticides used and also the frequency of use of pesticides. In addition, information on the type of crops grown and the area used in cultivation for specific crops was also collected (Chapter IV).

To assess the impact of occupational exposure among farmworkers socio-demographic and dietary information was collected from farmworkers and their health profile was identified using a specifically designed questionnaire. A capillary blood sample was also collected to determine the level of erythrocyte acetylcholinesterase activity (AChE). Information was also obtained on their use of protective measures while handling pesticides and the practice of safety and hygiene while at work. Farmworkers, who had participated in the study during the farm visit were invited to the Occupational Health Clinic run by the Department of Preventive Medicine to be followed up for clinical assessment of their health status. At the clinic the farmworkers were medically checked by an occupational physician, and information was collected on their health profile and neuromuscular assessment tests were applied. A control (unexposed) group was selected from those other workers coming to the clinic, to get a fitness certificate to renew their work permit, and who had no exposure or contact with pesticides for the past five years. The control group was of similar socio-demographic profile and matched with the farmworkers by age and nationality. The exposure effect marker (AChE) was determined for both the farmworkers and the control group. Furthermore, another group of workers recently recruited from abroad to work on the farms was also included in the study as new farmworkers. These data have been reported and discussed in Chapter V.

During the farm visits, samples of farm water, farm soil and available ripe produce were collected for analysis of pesticide residues. The samples of vegetables were brought to the environmental laboratory of the Department of Community Medicine for further processing before storage until analysis at a later date. The individual samples were assayed and 1 kg was homogenized in a blender and 800 g of the homogenized paste was packed into freezer bags and frozen first at 0^{0}C for a day, then at -10^{0}C for another day and later at -80^{0}C until the time of analysis. At the time of analysis the vegetable samples stored at -80^{0}C were thawed at -10^{0}C for a day and then at 0^{0}C for another day. The sample was mixed well and the required amount was weighed and mixed with Celite. The sample mixture was then freeze dried and extracted using Supercritical Fluid Extraction (SFE) and analyzed using an established protocol using Gas Chromatography - Mass Spectrometry (GC-MS). Samples of farm water were extracted using liquid-liquid extraction (LLE) with dichloromethane and the soil samples were extracted using SFE. Extracts from water and soil were also analyzed using the GC-MS technique. Results of the analysis of the farm water, soil and vegetables for pesticide residues are reported in Chapter VI.

A population wide survey was carried out among the ethnic population to collect information on dietary habits, using a specifically designed questionnaire. The questionnaire was translated into the local language and self-administered to a sample of 529 adult males and females (Chapter III). The survey information was coded and analyzed to determine the intake of all vegetables and the intake of locally grown vegetables and the method of processing the vegetables prior to consumption. The survey details are provided in Chapter VII along with the estimated daily intake (EDI) of vegetables.

Information was collected on the incidence of congenital malformations among the local ethnic population in the Abu Dhabi Emirate through a local literature review. A meta analysis of the literature on the incidence of congenital malformation for consanguineous and non-consanguineous marriages was carried out (Chapter III). Consanguineous marriages are common among the local population and consanguinity has been implicated in higher incidence of congenital malformations (Abdulrazzaq *et al*, 1997). However, other studies on ethnic populations have reported that consanguinity did not increase the overall incidence of congenital malformations (Al-Gazali *et al*, 1995). Frequency and pattern of consanguineous and non-consanguineous induced congenital malformations were compared with data from mice experimentation. Chapter VIII reports on the incidence of congenital malformation in the ethnic population and shows the associations with the incidence of congenital malformations in organophosphorus pesticide exposed mice. The dietary intakes of pesticide residues from the locally grown vegetables have also been described in Chapter VIII.

The overall conclusions inferred in this study are collated in Chapter IX and suggestions have been made for future research. Methods to reduce the pesticide residues in the locally grown vegetables and also methods to reduce the dietary intakes of pesticide residues have been suggested. All the information from the field and epidemiological surveys, behavioural experiments and reproductive toxicology experiments was computed and statistically analyzed using the

Statistical Package for Social Sciences (SPSS). Student's t-test was used to test the significance of the difference in the categorical variables, and an analysis of variance (ANOVA) was used to test the significance of the difference between the means among the different groups. Multiple regression analysis was used to test the association between the dependent and independent variables. Bivariate correlation matrix was created to assess the nature of the association between two or more variables.

1.4 *Peer reviewed publications*

The following research papers have been prepared and published in peer reviewed journals, as a result of the work carried out in this study.

1.4.1 Gomes J, Lloyd OL, Revitt DM, Norman JN. Erythrocyte cholinesterase activity levels in desert farmworkers. J Occup Med 1997;47(2):90-94 (Appendix 1).

1.4.2 Gomes J, Lloyd OL, Revitt DM, Basha M. Long term exposure to pesticides: Morbidity in farmworkers in a desert country. Scand J Work Environ Health, 1998;24(3):213-219 (Appendix 2).

1.4.3 Gomes J, Lloyd OL, Revitt DM. The influence of personal protection, environmental hygiene and exposure to pesticides on the health of immigrant farmworkers in a desert country. Int Arch Occup Environ Health 1998; (494): (Appendix 3).

1.4.4 Gomes J, Dawodu AH, Lloyd O, Revitt DM, Anilal SV. Hepatic injury and disturbed amino acid metabolism following prolonged exposure to organophosphorus pesticides. Human Exp Toxicol 1998; (17): (Appendix 4).

1.5 *Conference presentations*

The following conference presentations were made during the tenure of the project. These presentations were based on the findings made as a result of this study.

1.5.1 Gomes J, Lloyd OL, Revitt DM. Pattern of erythrocyte cholinesterase (AChE) activity level among farmworkers. Fifth SETAC-Congress, June 25 - 28, 1995, Copenhagen, Denmark (Appendix 5).

1.5.2 Gomes J, Lloyd OL, Revitt DM. Organohalogen pesticide usage in a desert country. Sixth SETAC-Congress, May 19 - 22, 1996, Sicily, Italy (Appendix 6).

1.5.3 Gomes J, Lloyd OL, Pugh RNH, Revitt DM, Basha M. Morbidity in farm workers from chronic exposure to pesticides. Eight Annual Conference of the International Society for Environmental Epidemiology, August 17 - 21, 1996, Edmonton, Alberta, Canada (Appendix 7).

1.5.4 Gomes J, Revitt DM, Padmanaban R, Anilal SV, Lloyd O. Reproductive toxicity from organophosphorus pesticides I: low birth weight. Fourth International Symposium: Rural health and safety in a changing world, Oct. 18 - 22, 1998, Saskatoon, Saskatchewan, Canada (Appendix 8).

1.5.5 Gomes J, Lloyd O, Padmanaban R, Anilal SV, Revitt DM. Reproductive toxicity from organophosphorus pesticides II: congenital malformations. Fourth International Symposium: Rural health and safety in a changing world, Oct. 18 - 22, 1998, Saskatoon, Saskatchewan, Canada (Appendix 9).

1.5.6 Gomes J, Dawodu AH, Lloyd O, Revitt DM, Anilal SV. Hepatic injury and disturbed amino acid metabolism following prolonged exposure to pesticides. Fourth International Symposium: Rural health and safety in a

changing world, Oct. 18 - 22, 1998, Saskatoon, Saskatchewan, Canada (Appendix 10).

1.6 Other presentations

1.6.1 Gomes J. Impact of halogenated organocompounds on animal and human health. Department of Community Medicine, Faculty of Medicine, Faculty Seminar, The Bin Ham Main Conference Room, Mar 13, 1995, Al-Ain, UAE (Appendix 11).

1.7 Courses and workshops attended during the study period

During the period of the study, the following continuing education courses and workshops have been attended to facilitate knowledge and skills updates and to enable more efficient completion of the project.

1.7.1 Principles of Epidemiology, from Jan. '95 - Jun. '95, Center for Disease Control and Prevention (CDC), Distance Learning Programme (DLP), Atlanta, Georgia, USA.

1.7.2 Ecotoxicological modeling, Pre-conference workshop, June 25, '95, Society for Environmental Toxicology and Analytical Chemistry (SETAC), Copenhagen, Denmark.

1.7.3 Contaminated sediments, Pre-conference workshop, May 19, '96, Society for Environmental Toxicology and Analytical Chemistry (SETAC), Sicily, Italy.

1.7.4 Environmental Health Indicators, Post-conference workshop, August 21, '96, International Society for Environmental Epidemiology (ISEE), Edmonton, Alberata, Canada.

1.7.5 Capillary columns in Gas Chromatography, Oct. 21, '96, Hewlett Packard Middle East, Dubai, UAE.

1.7.6 Occupational and Environmental Epidemiology and Molecular Epidemiology and Use of Biomarkers, June 30, '97 - July 5, '97, New England Epidemiology Institute (NEEI), Boston, Massachusetts, USA.

1.7.7 Analytical Techniques in Marine Sciences, Nov. 23 - 27, '97, Faculty of Science, UAE University, UAE.

1.7.8 The biology and epidemiology of Cancer, June 22 - June 26, '98, New England Epidemiology Institute (NEEI), Boston, Massachusetts, USA.

Chapter 2

Introduction to the study

2.1 *Pesticides: types and mode of action*

2.2 *Exposure and toxicology of pesticides*

2.3 *Environmental and food chain contamination by pesticides*

2.4 *Adverse health effects from environmental exposure of pesticides*

2.5 *Adverse health effects from pesticide usage among farmworkers*

2.6 *Risk assessment of pesticide usage*

2.7 *Rationale for this study*

2.1 *Pesticides: types and mode of action*

A pesticide is a chemical or a biological agent used to prevent, destroy, repel or mitigate a pest (insect, rodent, nematode, fungus, weed, or other nuisance life) or a substance to be used as a plant regulator, defoliant or desiccant. The use of chemical compounds to protect crops and produce has been practised since ancient times. Early Greeks used sulphur and arsenic as fumigants and seed treatment for root vegetables. In these early years only materials of natural origin such as salts of arsenic, copper, lead, mercury and zinc were used.

The modern era of synthetic organic chemical control of pests began with the discovery of the insecticidal properties of 1,1-bis-(*p*-chlorophenyl)-2,2,2-

trichloroethane (DDT) in 1939. Following which many other synthetic new insecticides, herbicides and fungicides were synthesized. In the early 1970s as the environmental damage caused by and the persistence of DDT and other organochlorine pesticides were reported, the need to develop new and different types of compounds became ever more urgent. This urgency to develop new compounds was also increased by the environmental persistence of organochlorines used during the early seventies. As a result organophosphorus and carbamate insecticides (derivatives of nerve gases developed during the Second World War) were introduced into agriculture and public health. These pesticides were closely followed by synthetic pyrethroids, chlorphenoxy herbicides, bipyridyl herbicides, nitrophenolic herbicides, pentachlorophenol, paraquat, diquat and more recently other insecticides of biological origin.

2.1.1 Pesticide classification by chemical class

The basis for this type of classification is the type of the chemical compound (active ingredient) used in the preparation of the pesticide. The different categories under this classification are:

2.1.1.1 Organophosphorus pesticides which are esters, amides or thiol derivatives of phosphoric, phosphonic, phosphorothioic or phosphonothioic acids. These compounds can cause phosphorylation of acetylcholinesterase enzyme and are therefore also known as "Cholinesterase inhibitors". Organophosphorus pesticides are the most widely used pesticides.

2.1.1.2 Carbamate pesticides are commonly used as insecticides, fungicides, herbicides, nematocides or sprout inhibitors. Insecticide carbamates are ester derivatives of carbamate, herbicide carbamates have the general chemical structure $R^1NHC(O)OR^2$ in which R^1 and R^2 are aromatic and / or aliphatic groups. Fungicide carbamates contain the benzimidazole group. Carbamates can cause carbamylation of acetylcholinesterase enzyme and are therefore known as "Cholinesterase inhibitors".

2.1.1.3 Organochlorine pesticides are chlorinated derivatives of aromatic hydrocarbons and esters. These compounds are known for their lipid solublility, persistence in the environment and concentration in the food chain. Cyclodiene insecticides (Mirex, Aldrin, Endrin, Dieldrin, Heptachlor, Chlordane) are manufactured by chlorination of cyclopentadiene and therefore belong to the organochlorine group of compounds. These compounds are extremely useful in controlling a variety of insects, but are lipophilic and are environmentally persistent.

2.1.1.4 Chlorphenoxy herbicides are derivatised chlorphenoxyacetic acids and esters. Phenoxyacid herbicides do not show long term effects through storage and accumulation of residual complex molecules in biological tissues. However, the contaminants of chlorphenoxy herbicides, the polychlorinated dibenzodioxin (PCDD) family of compounds, are highly toxic and environmentally persistent.

2.1.1.5 Nitrophenolic herbicides are derivatives of nitrophenol. These agents have been used as herbicides, acaricides, nematocides, ovicides and fungicides.

2.1.1.6 Pentachlorophenol (PCP) is used as herbicide, algaecide, defoliant, germicide and fungicide. The use of PCP has been controlled in the industrialized countries because of it's toxicity. PCP is rapidly absorbed across the skin, mouth and gastrointestinal lining.

2.1.1.7 Dipyridyls are halogenated salts of pyridine. Paraquat and Diquat are classified as dipyridyls and are used as contact herbicides, desiccants and terrestrial herbicides.

2.1.1.8 Dithiocarbamates are used as insecticides, herbicides and fungicides. The general formula can be represented by R^1R^2-N-CS-S-R^3 and depending on the types of mono-amines used in the synthesis of these compounds mono or dialkylthiocarbamates are formed. Thiocarbamates are manufactured by reacting phosgene with an amine. Reaction with di-amines results in formation of two terminal dithiocarbamate groups. Thiocarbamates are relatively volatile and non-persistent in the environment.

2.1.1.9 Pyrethroids are synthetic pyrethrins and include chemical compounds like Alphametrin, Cyfluthrin, Cypermethrin, Deltamethrin and Esfenvalerate. Pyrethroids are usually used in combination with other pesticides. Pyrethroids are acutely neurotoxic in laboratory animals.

2.1.1.10 Inorganic pesticides have also been used in the control of unwanted pests. Sulfur is one of the most widely used fungicides. Other compounds of sulfur which are used as fungicides are calcium sulfide and lime-sulfur. Other inorganic compounds used as fungicides are salts of copper and Bordeaux mixture (copper sulfate and lime).

2.1.1.11 Insecticides of biological origin are those compounds derivatised from plant sources. Examples of this type of insecticide are Pyrethrum, Pyrethrin and Nicotine. Bacillus thuringiensis has been used as an insecticide because of it's pathogenicity to insects but relative non-toxicity to humans.

2.1.2 Pesticide formulations

Production of pesticides is a multi-stage process and involves complex chemical reactions which include chlorination, alkylation, nitration, phosphorylation, sulfonation and bromination. The first step in pesticide production is the manufacture of the active ingredient, which is the principal compound involved in delivering the desired effects of the pesticide. The second step is the formulation of pesticides, which involves mixing the active ingredient with inert substances. Formulated pesticides are ready for agriculture or public health use after the final constitution (preparation) by the end user with the delivery medium, prior to application at the site of use. The end user usually constitutes and applies the pesticides as suggested in the instructions for use or as per the directions from the regulatory agencies (Ebert *et al*, 1988).

Formulated pesticides are marketed as wettable powder (WP), water soluble powder for seed treatment (SS), water soluble powder (SP), soluble concentrate (SL), water soluble granules (SG), suspension (SC), oil miscible liquid (OL), emulsifiable concentrate (EC), emulsion (E), oil in water (EN), dustable powder (DP), granules (GR) or solutions. In the field, the delivery medium is mainly water, however, solvents or mixtures of solvents such as diesel oil, gasoline, kerosene or xylene have also been used.

2.1.3: *Inert ingredients*

Pesticidal active ingredients are only a small proportion of the pesticide formulations. The major portion of pesticide formulation are solvents, emulsifiers, spreaders, stickers, penetrants, anti-caking agents and other agents used as required. Volatile mixtures of aliphatic and aromatic hydrocarbons are the most common inert ingredients and are also sources of skin and eye irritation. Some of the inert ingredients have acute and chronic systemic toxicities (neurotoxic, reproductive) of their own while others are carcinogenic. Some inert ingredients enhance the acute and chronic systemic toxicity of the active ingredient. However, there are some inert ingredients which are the manufacturer's trade secrets and are not disclosed. Toxicity of these and other such compounds are therefore, not known. These esoteric ingredients give a commercial formulation a competitive edge over similar products from other manufacturers. Exposure to such solvents could partly explain some of the reported excesses of leukemia and non-Hodgkin's lymphoma among farmers (Petrelli *et al*, 1993). The net effect of a pesticide formulation is, therefore, different from the effect of the active ingredient alone.

2.1.4 *Acute and chronic effects of insecticides*

Insecticides are the most commonly and heavily used chemical compounds both in agriculture and public health. Insecticides are effective against insects and mites which destroy crops and bring disease to animals and humans. Organophosphates, carbamates, organochlorines, pyrethrum and pyrethroids have been used for their insecticidal properties.

2.1.4.1 Organophosphorus compounds poison insects and mammals primarily by phosphorylation of the acetycholinesterse (ACh) enzyme at the nerve endings. These compounds have, therefore, been called "cholinesterase inhibitors". The enzyme is critical to normal control of nerve impulse transmission from nerve fibre to muscle and gland cells and also to other nerve cells in autonomic ganglia and in the brain. The inhibition of ACh results in an increase in acetylcholine at the nerve endings and in over stimulation of the postsynaptic receptors in the cholinergic nervous system (muscarinic effects), at the skeletal nerve-muscle junctions and autonomic ganglia (nicotinic effects) and in the brain.

The nicotinic effects generally appear later and only in moderate to severe poisoning cases. Headache, anxiety and sleep disturbances often accompanied by excessive salivation and anorexia are common early symptoms of mild exposure to cholinesterase inhibitors. Chest tightness is a symptom of moderately severe poisoning after high dermal exposure, but occurs even at low inhalation exposure. Chronic low level exposure to organophosphates may result in weakness and malaise often accompanied by headache and light-headedness.

Organophosphate induced delayed neuropathy (OPIDP) is characterised clinically by muscle cramps in legs, paresthesias and motor weakness. Persistent visual disturbances, difficulty in concentrating, impaired memory, irritability and fatigue have also been reported among agricultural workers. Hypersecretion is often prominent and is manifested by excessive sweating, salivation, tearing, rhinorrhea and bronchorrhea (McConnell, 1994).

Organophosphates are efficiently absorbed by inhalation, ingestion and skin penetration. Breakdown of the absorbed organophosphorus compounds occurs mainly by hydrolysis in the liver. The rates of metabolism vary widely from one compound to another. The ACh enzyme depression is usually apparent within a few minutes or hours of significant exposure. Depression of plasma acetylcholinesterase enzyme activity generally persists several days to a few weeks, however, the erythrocyte acetylcholinesterase enzyme (AChE) activity takes longer to reach its minimum and usually remains depressed longer, sometimes between one to three months.

2.1.4.2 Carbamates act by reversible carbamylation of the ACh enzyme, thereby, allowing accumulation of acetylcholine at parasympathetic neuroeffector junctions (muscarinic effects), at skeletal muscle myoneural junctions and autonomic ganglia (nicotinic effects), and in the brain (CNS effects). At cholinergic nerve junctions with smooth muscle, high acetylcholine concentration causes muscle contraction and at gland cells causes excess secretion. At skeletal muscle junctions, excess acetylcholine causes muscle twitching. In the brain, elevated acetylcholine concentrations cause sensory and behavioural disturbances, lack of coordination and depressed motor function (Morgan, 1989).

The most commonly reported symptoms are malaise, muscle weakness, dizziness and sweating. However, headache, salivation, nausea, vomiting, abdominal pain and diarrhoea have also been reported. In severe exposure incidents, pulmonary oedema, miosis, lack of coordination and slurred speech have been reported (McConnell, 1994).

2.1.4.3 The primary toxic action of the organochlorines is on the nervous system, where they interfere with fluxes of cations across nerve cell membranes, increasing neuronal irritability. Early manifestations of exposure to organochlorine include headache, dizziness, nausea, vomiting, lack of coordination, tremor and neural confusion. Most of the organochlorines following exposure are stored in fat tissue as an unmetabolized compound. However, others are dechlorinated and oxidised prior to excretion through urine. Metabolic dispositions of DDT and DDE, the beta isomer of Hexachlorocylohexane, Dieldrin, Heptachlor epoxide, Mirex and Kepone tend to be slow, leading to storage in body fat.

2.1.4.4 Pyrethrum is a dermal and respiratory allergen and chronic exposure could result in contact dermatitis and allergic respiratory reactions (rhinitis and asthma). Pyrethrins are absorbed across the gut and pulmonary membrane, but poorly across intact skin. Once absorbed pyrethrins are effectively hydrolyzed to inert products by liver enzymes and excreted without any toxic effects.

2.2 *Exposure and toxicology of pesticides*

Occupational exposure mainly occurs among those people who come into direct contact with pesticides either during manufacture or application. The occupationally exposed population, therefore, includes manufacturers, formulators, handlers, applicators or farmworkers. Exposure among manufacturers and formulators occurs during the preparation of pesticides for commercial use and usually takes place at the factory or the production plant. Exposure in these people is usually high for they deal with concentrated products. The other groups of people at risk of occupational exposure along with applicators are farmworkers, farmers, public health workers and other ancillary staff involved in the field of use. The main routes of occupational exposure are inhalation, dermal absorption, ingestion and ocular absorption.

2.2.1: Inhalation exposure

Inhalation exposure occurs from the breathing in of pesticide dusts, vapours, mists and gases. Retention of pesticide particles within the lung depends on factors such as size, shape, hydroscopicity, density, reactivity and the inhalation process i.e. nasal or oral. Environmental concentrations of the pesticide at the site of use depend on the volatility of the pesticide preparation and other climatic conditions and these are therefore significant factors in the respiratory exposure (Ebert *et al,* 1988). The vapour pressure of pesticides varies from non-volatile materials such as Dieldrin to highly volatile materials such as Dichlorvos. High ambient temperatures in the tropical countries could increase the volatility and high humidity could enhance the toxicity of those chemical compounds which are relatively non-volatile at lower temperatures outside the tropics.

2.2.2 *Dermal exposure*

The rate at which a pesticide is absorbed through the skin is determined by the nature of the chemical compound, the condition of the skin and environmental factors such as temperature and humidity (Ebert *et al* 1988). Other factors which influence dermal exposure for a given pesticide are the total area of the exposed skin, duration of exposure and region of exposure (Mailbach *et al* 1971). Certain parts of the body have higher absorption rates than others. Higher rates of absorption have been reported for the head and neck region, scrotal skin and axilla. The physical state of the formulation significantly contributes to it's dermal absorption by the human body. Fine powders tend to be absorbed more readily than coarse powders for equivalent periods and for the same sites of contact. Pesticide handlers with minimal personal protective equipment in the third world countries could have significantly higher dermal exposure, compared to their counterparts in the industrialized countries were personal protective equipment is used (Wasilewski, 1987).

2.2.3 *Ingestion exposure*

Oral exposure could occur through accidental splashing of liquids into the mouth, by smoking or eating with contaminated hands or by swallowing inhaled material that has entered the upper respiratory tract or has been swept up by cilliary action into the trachea. Dry dustable powders are more likely to be ingested than liquids, because of the deposition of the dust on lips and mouth when unprotected (Ebert *et al,* 1988). Oral exposure could also occur by the consumption of the contaminated produce and if sufficient safety procedures have not been followed.

2.2.4 *Ocular exposure*

Ocular exposure usually occurs as a result of accidental splashes onto the face and eyes and the deposition of pesticide dust onto the eyes. Substantial doses of pesticides can be absorbed through the eye tissue and in acute exposures, damage to the lens and the cornea may result. However, in the case of chronic ocular exposure, ocular disease (Saku disease) has been reported (Ishikawa *et al* 1973).

2.2.5 *Non-occupational exposure*

Non-occupational environmental exposure occurs from drift of pesticide spray, contaminated water, residues in food products and from improperly disposed of pesticide waste. Although non-occupational exposure is often at a low level, there have been episodes of acute illness resulting from drift from nearby fields or from consumption of contaminated food (Goldman *et al* 1990). Non-occupational exposures to contaminated foods in the developing countries have not been adequately documented. There is a tendency in these countries to identify these episodes as food poisoning. In a survey of pesticide residues in those states in India reporting of food poisoning, 85% of the samples were found to contain pesticide residues, with 43% of the samples containing above the recommended doses (Dinham, 1997a). Dumped and unused pesticides can contaminate the environment and the food chain and can also provide an exposure route (Rwazo, 1997). The Food and Agriculture Organisation (FAO) has estimated that the amount of obsolete pesticide stocks in Africa is 15,000 to 20,000 tonnes. The comparable figures for Asia and Eastern Europe are not available but are estimated to be high (Wodageneh and van der Wulp, 1996).

2.2.6 *Pesticides and the developing countries*

Pesticide usage in the developing countries has been on the increase during the past decade. Although only 25% of the annual worldwide production of 3 million tons are used in these countries, 90% of the estimated 3 million yearly poisoning incidents and 99% of the 220,000 reported worldwide pesticide related deaths occurred in the developing countries (McConnell, 1994). Pesticide poisoning in these countries is under-diagnosed and under-reported and few agricultural workers have any information on the hazards they are exposed to, either from direct handling of chemicals at work or from exposure to contaminated environments (Santilo *et al,* 1997). For example, poisoning cases in Thailand are never reported and do not appear in published statistics, though estimates indicate that about 39,600 pesticide poisoning cases occur each year with total annual health costs of about 13 million Baht (Dinham, 1997b). A dramatic increase in the conditions which might be confused with organophosphate poisoning has been seen among men of working age in rural areas in the developing countries in recent years. A similar increase was not seen among those less likely to be exposed to pesticides, eg women. The increased mortality rate among men corresponded to the introduction of pesticides into common agricultural practice and was seen in a seasonal pattern that corresponded to the use of pesticides (Loevinsohn, 1987).

The farmworkers in developing countries mix, load and apply pesticides as part of their work and generally use no protective equipment, such as gloves, coveralls or shoes. Most of the agricultural workers in these countries are not trained and do not understand the information on the pesticide product labels (Alves de Oliveira and Toniato, 1995). In contrast pesticides in the developed countries are applied with advanced equipment and few people, with appropriate protection, are involved because of the level of mechanization. Because more individuals are involved in the application of pesticides in the developing countries and the job is done manually and without protective measures, exposure is high both in terms of the number of people and the degree of exposure. There is a need in the developing countries for improved occupational health policy, health education, use of personal protective equipment and mechanization in order to prevent exposure to pesticides (London, 1996).

Poor sanitation, hygiene and living conditions of the people in the rural farming areas together with unreported morbidity, mask all the possible pesticide related epidemics, in developing countries, such as the ones reported by Goldman *et al* (1990). Fruits and vegetables in Pakistan were found to be contaminated with organochlorine, organophosphorus and synthetic insecticides; 39% of the samples contained residues, 14% of which were in excess of Maximum Residue Limits (MRLs) set by FAO (Dinham, 1995). Similar reports on the contamination of the agricultural produce have appeared in India (Dinham, 1997a). Elevated risks were seen among children whose father or mother worked in agriculture and handled pesticides. The overuse of pesticides in the developing countries has lead to lasting damage to the environment; insecticides have seeped into drinking water wells and have contaminated the food chains (Coutts, 1995). Exposure to a multitude of pesticides, ill-defined conditions resulting from the exposure and curative rather than preventive approach to the management of the morbidity among rural farming communities make the situation complex, ill-understood and beyond solution.

2.3 *Environmental and food chain contamination by pesticides*

Pesticides protect seeds during germination, prevent deprivations during growth and eliminate or materially reduce losses during shipment and storage of harvested crops. The use of crop protection chemicals (pesticides) is a vital part of the crop production technology. Pesticides are intentionally released into the environment to control unwanted insects, plants and other pests. Pesticides, therefore, alter the ecology; undesirable species of insects are eliminated or restricted in favour of desired species i.e. those which are beneficial to man's existence. Harnessing the pesticides to deliver the desired effect creates little or no problem from the ecological point of view. However, problems arise when pesticides:

a) adversely affect the non-target population at the site of application,

b) leave pesticide residues in the environment (air, soil, water) at the site of application and at the other sites through drift and,

c) contaminate the food web.

The majority of pesticides are sprayed onto crops while the rest are channeled through water and manure into the soil. The ubiquitous nature of the biological and chemical processes which occur with pesticides once they are applied make it unlikely that even highly specific pesticides will not affect the non-target organisms. Some of the ecological changes brought about by the pesticides are transient, while others are more permanent and lead to the biomagnification of the contaminant in the food chain and amplification of the adverse effects.

Persistence, mobility, toxicity and ability to biomagnify are some of the important factors which need to be considered in assessing the environmental impact of pesticides. Persistent compounds that readily move from their application site and ultimately bioconcentrate into the fatty tissues of various aquatic and terrestrial food chains, offer the greatest environmental problems. Environmental parameters such as heat, humidity, light and the presence of other chemicals and organisms in the environment can all influence the degradation processes of pesticides. Each pesticide may yield one or more degradation products which may also conjugate with natural products in soils, plants and animals. Given the number of pesticides in current usage the total number of chemicals in the environment resulting from pesticide parent compound and its degradation products can reach alarming proportions.

However, not all degradation products are harmful or toxic or produce adverse effects when studied in isolation. Many of the established products though not harmful or toxic singly are highly toxic in combination with other compounds and produce additive and synergistic effects. Pesticides, which are lipophilic, sustain their toxic action for a long time by accumulating in human and animal body tissues. Recent advances in analytical techniques (gas chromatography, high pressure liquid chromatography, mass spectrometry) have enabled detection and identification of very small amounts of pesticide residues and metabolites in plants, soils, water and animal tissue and fluids. Improved methodologies and technologies have enhanced our understanding and capabilities in the establishment of causal relationships between adverse health effects and exposure to pesticides.

2.3.1 *Atmospheric contamination*

Air has been recognized as a major transport medium for the movement of pesticides globally. Atmospheric monitoring of pesticides has provided evidence for the ubiquity of pesticide residues and their airborne transport over considerable distances. Lindane residues identified in southern and western Denmark have been linked to it's use in Germany, where it is not banned

(Pesticide Brief, 1996). Global air currents have been known to transport pesticide residues from warmer to cooler areas, where environmental deposition occurs. This process has led to organochlorine residues having been identified in the food chain in the Arctic.

The effects of airborne pesticides have not been fully explored, however, aerial drifts of herbicides applied to fields have been identified to have damaged sensitive crops in the neighbourhood. Dislodgeable foliar residues can find their way into air and be transported depending on the climatic conditions (Iwata *et al,* 1981). Pesticides have not been used in the Arctic for a long time, however, the contamination of the food chain of the Inuit people has been caused by aerial transportation of the contaminants from the site of application (Ayotte *et al,* 1996, Kuhnlein *et al,* 1995). Reports on allergies and other forms of sickness caused by aerial movement of pesticides have not been well documented because of difficulties in proving the associations. However, urinary metabolites of organophosphorus pesticides have been found to have been well correlated with the air concentrations of the pesticides (Saito *et al,* 1986).

2.3.2 *Water contamination*

Pesticides can enter surface and ground waters through runoff from treated soils, leaching processes, aerial drift and inappropriate disposal methods. The developing countries, which still use organochlorine pesticides, have found that water bodies (lakes and rivers) have been contaminated with the environmentally persistent pesticide residues (Aguilar *et al,* 1997). Abouarab *et al* (1995) have shown that Lake Manzala and the River Nile has been contaminated with organochlorine pesticides (DDT, Heptachlor, Aldrin, Lindane, γ-chlordane, β-BHC). γ-HCH, Aldrin, Dieldrin, Endrin and *p,p*-DDT have also been found in the marine and estuarine sediments along the west coast of India. Among these organochlorine pesticides γ-HCH and *p,p*-DDT were the most commonly identified contaminants in both estuarine and offshore sediments (Sarkar *et al,* 1997). Chlorphenoxy herbicides have been frequently identified in surface water samples and metabolites of DDT (DDE and DDD) have been detected in sediment samples collected from South Florida canals (Dorfler *et al*, 1997; Miles *et al*, 1997). The presence of organochlorines in sediment samples suggests that these environmentally persistent compounds have been resident in the water bodies for a long time and may have contaminated the aquatic flora and fauna. Organochlorines, being lipophilic, are more likely to partition into the sediment and biota compared to chlorphenoxy herbicides, which being hydrophilic, are most likely to stay in the water. The most striking effect of some of the pesticides in water is their ability to concentrate in the fatty tissue of successively higher components of the aquatic food chain.

2.3.3 *Soil contamination*

Persistence of pesticides in soils is dependent upon a number of chemical, climatic and edaphic factors. Highly chlorinated compounds which have low water solubility are the most persistent. Water soluble pesticides, which are easily biodegradable such as methyl carbamate and organophosphate insecticides are not persistent in the soil. The edaphic factors that influence persistence include soil type, temperature, moisture, cultivation, application and microbial ecology. Loamy sands with low pH tend to have high pesticide dissipation rates (Adams *et al*, 1976). Warm moist soils containing high organic matter generally accelerate the decomposition process. The climatic factors which influence pesticide persistence in soil include air temperature, light intensity, rainfall and wind direction.

Pesticide residues in soils expose the crops grown in rotation to additional residues and inhibit beneficial microorganisms to critical levels. Excessive amounts of pesticide residues could alter the soil ecology, threaten the soil flora and fauna, and destroy the metabolic integrity of the soil. Pesticide residues in soils enter the food chain through the soil flora and fauna and bioaccumulate in the higher members of the food chain. Disposal of pesticide waste and used containers has been identified as one of the major causes of soil contamination other than for agricultural contamination. In the case of agricultural contamination, the top soils have been found to be the most contaminated. These pesticides could readily partition into the air, thereby increasing the risk of exposure in agricultural workers. Degradation of biodegradable pesticide residues in the soil takes place by first order kinetics. In contrast, non-biodegradable residues accumulate and enter the food chain (Ghardiri *et al,* 1995, Reiner *et al,* 1995).

2.3.4 Contamination of plants and agricultural produce

Plants obtain pesticide residues directly from application and indirectly by aerial drift, soil dust, volatilization and root uptake. Pesticides applied to the shoots of plants can migrate through the cuticular layer by two routes: a lipoid and an aqueous pathway. Compounds that penetrate the cuticle in the lipoid soluble form are non-polar, undissociated compounds, while those which enter through the aqueous route have a polar nature. Both types of compounds penetrate the cuticle better in conditions of increased humidity. The compounds absorbed by the plant may remain bound to the plant tissue, are stored in the vacuoles of the plant cells, form conjugates with the plant constituents or undergo degradative processes in the plant material. The unabsorbed materials on plant surface may be volatilized, washed down from the leaf surface by rainfall, or remain on the outer surface where it dries to crystalline form or concentrates to form a viscous liquid. Pesticides which are washed down are deposited in the soil and may be absorbed through the roots.

Plant root uptake of persistent residues is a common form of plant contamination. The quantity of pesticides sorbed by a given plant generally depends upon the water solubility of the pesticide, the quantity of pesticide within the soil and the organic matter content of the soil. The total amount absorbed by a single plant increases with time if the residue is persistent. For non-polar pesticides, soil organic matter is the most important soil factor influencing the sorption of residues. The hazard posed by the pesticide residues in the plant depends on the toxicity of the residue, the ability of the plant to metabolize or eliminate the residue before it is harvested and the translocation of the residue to the harvested portions of the plant. Non-phytotoxic residues in the plant pose a greater threat to the consumers than the phytotoxic one, because the latter type makes the plant sick and identifiable. Plants with non-phytotoxic residues cannot be identified and excluded from harvesting.

The level of contamination of plants and agricultural produce is associated with the intensity of usage of pesticides on farms. Government and private laboratories around the world monitor the levels of pesticide residues in imported and locally grown agricultural produce and varying levels of pesticide residues have been reported in the produce (Dogenheim *et al,* 1996a). The United States Food and Drug Administration has recently reported that 85% of domestic and 86% of imported agricultural produce was contaminated with pesticides (Roy *et al,* 1997). Significantly high quantities of pesticide residues have been reported in vegetables and fruits (Johnson & Stansbury, 1965), staple diets such as rice (Miyata *et al,* 1994, Meier *et al,* 1981), wheat (Chow *et al,* 1971), and grain (Anon, 1973). Insecticides have been identified in tomatoes (Hughes *et al,* 1969, Galera *et al,* 1997), onion (Wiersma *et al,* 1972), potatoes (Gorbach & Wagner, 1967), spinach (Menzer & Thomas, 1970), and green beans (Galera *et al,* 1997). Fruits (Gauer and Seiber, 1971) have also been reported to have been contaminated by both persistent and non-persistent pesticide residues. Pesticide residues have been identified in oranges (Cabras *et al,* 1995) and apples (Roy *et al,* 1997) in excessive amounts.

2.3.5 *Food chain contamination*

Lipid soluble and persistent pesticides accumulate in living organisms from bacteria to algae to higher plants and animals including man. Bioaccumulation of a contaminant occurs within each organism and within each food chain. In the grazing food chain, the lipophilic contaminants pass on from herbivores to carnivores and in the detritus food chain from dead organic matter into micro-organisms and then to detritus-feeding organisms and their predators. Each time a lower food chain organism is consumed by a higher food chain organism the pesticide residues will largely be retained by the consuming organism. Food chains are not isolated sequences but interlock with each other and form a food web. As the position of an organism in the food web increases, the pesticide residue concentration in that organism increases.

Agricultural and agricultural related sources of food (fish and animal meat and animal products) have been one of the main sources of transmission of contaminants to man. Eggs, milk and fat from animals have been found to be contaminated with pesticides and pesticide related compounds. Samples of local cow milk in Tunisia were found to have been contaminated with high levels of organochlorine pesticides (Sabbah *et al*, 1997); similar levels of contaminants were reported in Spanish milk samples (Garrido *et al,* 1994). Most of the local and imported butter samples in Mexico were identified to have residues of *p,p*-DDE, *p,p*-DDT, *o,p*-DDT, HCB, heptachlor and endosulfan (Waliszewski *et al,* 1996); butter samples from Argentina were also reported to have contained similar contaminants (Lenardon *et al,* 1994). Herrera *et al* (1994) reported that lamb and pork from the Spanish food list contained metabolites of DDT and Dieldrin in substantial quantities. Elevated levels of DDT and its metabolites, HCH isomers, Chlordane compounds, Aldrin, Dieldrin have been detected in most of the foodstuff of animal origin and fish from different locations in Australia, Papua New Guinea and the Solomon Islands (Kannan *et al,* 1994).

2.4 *Adverse health effects from environmental exposure of pesticides*

A number of agricultural chemicals are capable of binding to intracellular oestrogen receptors (Robinson *et al,* 1985, Bulger 1978). A meta-analysis that re-examined 61 sperm count studies revealed that worldwide human sperm counts had decreased by approximately 50% since 1938 (Carlsen *et al,* 1992). A doubling of cryptorchidism occurred in the United Kingdom between 1970 and 1987 (Chilvers *et al,* 1984, Jackson *et al,* 1986). Exposures to elevated levels of endocrine disrupting chemicals during prenatal development have been implicated in reproductive disorders in humans (Sharpe and Skakkabeck, 1993, Sharpe, 1993). Exposure of adult men to oestrogen has been implicated in the aetiology of prostate hyperplasia (vom Saal *et al,* 1993, Ghandian 1983). Many endocrine-disrupting chemicals have been identified in the reproductive tissues of men and women (Thomas and Colborn, 1992). These lipid soluble compounds appear to sequester in all fatty tissues in the body, so that organs and tissues with higher fat content hold some of these compounds on a net weight basis (Jensen and Slorach, 1991). Little is known about the concentrations of these contaminants in embryos and foetuses other than that they appear to be similar to those in mothers (Jensen and Slorach 1991, Saxena *et al*, 1983).

Autonomic nervous system disorders induced by organophosphorus pesticides have also caused cardiac and respiratory impairment in the general population (Cavaliere *et al*, 1996). Myopathy induced by chronic exposure is characterized by muscle cell degeneration, which involves the respiratory muscles. Chronic exposure to organophosphates have been reported to damage peripheral nervous system and the patient's behavioural abilities and/or personality, chronic fatigue syndrome and effects on the heart (Beaumont, 1997). Sheep dip farmers have been identified to report exhaustion, long term fatigue, memory loss and confusion (Buffin, 1995). Similar effects have been observed and reported in recent years among Gulf War veterans and included impaired cognition, confusion-ataxia and artho-myo-neuropathy (Kurt, 1998).

Oestrogenic pesticides such as Vinclozolin, 1,1,1-trichloro-2,2-bis(p-chlorophenyl) ethane, 1,1-dichloro-2,2-bis(p-chlorophenyl) ethylene, Dieldrin, Toxaphene and Alachlor mimic natural oestrogen and inhibit the action of the gonadal steroid hormones, oestradiol and testosterone (Sotto *et al*, 1994). The toxicity of environmental endocrine disruptors is insidious during sex differentiation and the development of sex organs, therefore endocrine disruptors adversely affects the male. Chemicals with anti-androgenic activity have been implicated in the increased incidence of male genital tract malformations, male infertility and female breast cancer and polycystic ovaries (Kelce *et al*, 1997, Dees *et al*, 1997, Safe *et al*, 1995). Declining semen quality has been reported in Belgium, Denmark, France and Great Britain (Toppari *et al*, 1996). The incidence of testicular cancer has also increased in recent years (Toppari *et al*, 1996).

The incidence of hypospadias and cryptorchidism has increased in recent years and the possible cause may be the exposure to endocrine disruptors in the foetal life or early childhood (Harrison *et al,* 1997). Substantial increases in the rates of hypospadias have occured in five European countries in the 1970s and 1980s (Paulozzi *et al,* 1997). Analysis of the Metropolitan Atlantic Congenital Defects Program (MACDP) and the Birth Defects Monitoring Program (BDMP) showed an approximate doubling of hypospadia rates in the 1970s and the 1980s in the United States. The MACDP data also showed that the rate of severe cases of hypospadias increased while the rate of mild cases decreased and the ratio of the mild to severe cases decreased. The BDMP data showed that hypospadia rates had increased markedly in certain regions of the United States (Paulozzi *et al,* 1997). These trends represent the largest number of cases and the first report on an increase in hypospadia rates outside of Europe.

Agricultural chemicals, including endocrine disruptors, used extensively in Hawaii over the past 40 years have leached into ground-water, and have caused widespread contamination. Breast cancer patterns in Hawaii have been associated with exposures to chlordane, heptachlor and 1,2-dibromo-3-chloropropane (DBCP) at levels that sometimes exceeded Federal standards by several orders of magnitude (Allen *et al,* 1997). Soto *et al,* (1997) have suggested that environmental oestrogens could play a role in increasing the incidence of breast cancer, testicular cancer and other problems of the reproductive system.

Birth defects affecting the eye, ear, palate, teeth, heart, feet, nipples, genitalia and the brain have been reported in children born to women exposed to chlorpyrifos during pregnancy (Sherman *et al,* 1995). Western Minnesota, a major wheat, sugar, beet and potato growing region, showed a high birth anomaly rate of 26.9/1000 births compared to a non-crop region where the corresponding figure was 18.3/1000 births (Garry *et al,* 1996). Elevated risk of limb anomalies, orofacial clefts and spontaneous abortion and stillbirth have been associated with maternal exposure to pesticides (Nurminen, 1995). Family pesticide usage has been linked to childhood brain cancers (Duffy *et al,* 1994; Davis *et al,* 1993). However, the incidence of birth defects from non-occupational exposures to pesticides is still debated with the pesticide manufacturer's questioning the association between exposure and birth defects. Exposure assessments from the food chain contamination has been difficult although the pesticide residue concentrations in most of the food items have been known (Ayotte *et al,* 1996). Parental occupational exposure to pesticides, however, have been positively associated with higher incidence of longer time to pregnancy, spontaneous abortions, stillbirths and other congenital malformations (Nurminen, 1995; Kristensen *et al,* 1997).

2.5 *Adverse health effects from pesticide usage among farmworkers*

The use of a vast number of chemical compounds in agriculture with diverse chemical properties and toxicities, produces a myriad of adverse health effects, which range from simple dermatological problems to cancer promotion and initiation. In the developing countries, farmworkers use minimal personal protection or none at all. In addition they handle the pesticides more closely than their counterparts in the developed world, because the latter can afford to use advanced methods of application (Subias Loren *et al,* 1995). Higher morbidity is expected in the developing countries because of the higher exposure in these countries. The developing countries also continue to use those pesticides which have been banned in the developed countries because of their adverse effects in the environment and to animals and humans. The adverse health effects in farmworkers could be primarily divided into acute effects and chronic effects. Acute effects are visible and possibly manifest in morbidity which requires immediate medical attention. However, chronic effects are not noticeable until at a late stage when they manifest into neuro-muscular degeneration, neurological, hepatic, gastric and renal dysfunction, degenerative diseases and cancer.

The most common symptoms reported by pesticide applicators in the developing countries were feeling faint, headache and dizzyness (Sivayoganathan *et al,* 1995). Pesticide illnesses reported by workers exposed to pesticides include symptoms like anxiety, vertigo, nausea, vomiting, tearing and weakness (Lessenger *et al,* 1995). Significant increases were observed in conjunctivitis, dermatitis and pigmentation disorders among farmworkers who do not use personal protection (Cole *et al,* 1997a). Common dermatological diseases which have been identified in greater numbers among farmworkers include vitiligo, psoriasis and suborrheic dermatitis, which were mainly linked with exposure to agricultural chemicals. Other dermatological problems included irritant plant dermatoses, onychopathies due to chronic trauma and contact dermatitis of the hands (Cellini & Offidani, 1994). Skin diseases in agricultural workers may be causally associated with crop-specific exposures and lack of protective equipment. Gamsky *et al,* (1992) reported the prevalence of 2% contact dermatitis and 13% lichenfied hand dermatitis among grape workers. These workers were more likely to have contact and lichenfied hand dermatitis than citrus or tomato workers reflecting the types of pesticides used on grape vines and secondly the closer contact of grapevine workers with the foliage.

Organophosphorus insecticides and carbamates inhibit acetylcholinesterase activity with the degree of inhibition depending on the type and the duration of exposure. Neurological and neuromuscular dysfunction have been observed in farmworkers from chronic exposure to pesticides. Memory disorders have also been reported from chronic exposure to pesticides (Sereda & Gromov, 1994). Exposure-related decreased conduction velocities were found in the motor fibres of the median and peroneal nerves and in the sensory fibres of the median and sural nerves (Ruijten *et al,* 1994). Neurologic dysfunction measured by postural sway was found to be significantly correlated with exposure to pesticides and plasma cholinesterase inhibition (Sack *et al,* 1993). Parkinson's disease has been positively associated with insecticide exposure, following residency in a fumigated house, herbicide exposure or rural residency at time of diagnosis (Butterfield *et al,* 1993). Semchuk *et al,* (1992) have reported on a dose response relationship between idiopathic Parkinson's disease risk and cumulative life time exposure to field crop farming, grain farming and occupational exposure to herbicides. Chronic exposure to pesticides is also identified with development of dementia of the Alzheimer type (Cannas *et al*, 1992).

Cytogenetic effects have been observed among agricultural workers. Male agricultural workers showed substantial clastogenic effects in their peripheral lymphocytes without indication of increases in the basal frequency of sister chromatid exchanges (SCE). These effects appear to be additive, increasing with the duration of exposure (Carbonell *et al*, 1993). A significant dose response increase in micronucleated (MN) lymphocytes was observed in floriculturists compared to unexposed subjects. Female floriculturists also showed a marked increase in MN frequency (Bolognesi *et al*, 1993). Agricultural workers showed a significant increase in the frequency of chromosomal aberrations (CA) mainly of the chromatid type when compared with the unexposed group. The frequency of CA was also related to the intensity of the pesticide exposure (Carbonell *et al*, 1995). An increase in chromatid breaks was observed at the end of the spraying season among farmworkers in Syria (Mohammad *et al*, 1995). Assessment of DNA adduct formation in peripheral white blood cells of floriculturists revealed that they were significantly more likely to form DNA adducts than non-exposed workers (Peluso *et al*, 1996).

Exposure to pesticides among pesticide handlers has resulted in the disruption of their reproductive health and adverse reproductive outcomes. Usage of older spraying techniques and tractors without cabins during the application of pesticides were observed to have resulted in low fecundability ratios among the exposed workers (Decock *et al*, 1994). Male infertility has been closely related to agricultural occupation, long term exposure to insecticides and contact with pesticides (Strohmer *et al*, 1993). Occupational exposure to pesticides during the first two months of gestation has been shown to significantly increase the risk of stillbirths due to congenital anomalies (Odds ratio; OR=2.4, 95%CI, 1.0-5.9) and stillbirths due to complications of the placenta, cord and membranes (Reletive risk; RR=1.7, 95%CI=1.1-2.3) (Pastore *et al*, 1997). Birth defects associated wtih circulatory, respiratory, urogenital, musculoskeletal and integumental showed significant increases in children born to private applicators (Garry *et al,* 1996). Maternal agricultural work was observed to have induced orofacial clefts in significantly higher numbers of children born to these women (Nurinen *et al,* 1995). High rates of occupational illnesses have been seen among women farmworkers exposed to biological, chemical and physical hazards on the farm (Engberg, 1993). Maternal exposure to pesticides has been associated with limb anomalies and orofacial clefts, elevated risk of spontaneous abortions and stillbirths have also been related to maternal agricultural occupation and pesticide exposure (Nurminen *et al,* 1995).

Wilm's tumour, non-Hogdkin's lymphoma, eye cancer and neuroblastoma in children between 0 to 4 years of age have been associated with parental occupation in horticulture or farming which resulted in pesticide exposure (Kristensen *et al,* 1996a). Excesses of non-Hogkin's lymphoma, leukemia, multiple myeloma, soft tissue sarcoma and cancers of the breast, ovary, lung, bladder, cervix and sino-nasal cavities have been observed in women in agriculture (McDuffie, 1994). Zahm *et al,* (1993b) have reported on the increased incidence of cervical cancer in female farmworkers.

A significant excess has been noted for brain cancer among a cohort of male workers licensed to handle pesticides (Figa-Talamanca *et al,* 1993). Farmworkers are reported to show an increased mortality for multiple myeloma, leukemia, gastric, renal and skin cancer (Viel & Richardson, 1993, Faustini *et al,* 1993). Frequent use of phenoxyacetic acid herbicides has been associated with 2 to 8 fold increases of non-Hodgkin's lymphoma (NHL) in Sweden, Canada and certain states in the United States (Zaham and Blair, 1972). Certain pesticides such as, Triazine herbicides, Organophosphate insecticides, fungicides and fumigants have been associated with the increased risk of NHL (Zahm & Blair 1992). Workers exposed to phenoxy herbicides and their contaminants are at a higher risk of soft tissue sarcoma (Kogevinas *et al,* 1995). Elevated risk of squamous cell carcinoma among farmworkers of both sexes has been reported by Luce *et al,* (1992). Farmers in central Italy were found to have a decreased risk of lung and bladder cancer and melanoma. However, farmers with greater than 10 years of exposure were at a significantly increased risk of stomach and kidney cancer while licensed pesticide users with more than 10 years of exposure were at a significantly increased risk of stomach, rectal and pancreatic cancer (Forastiere *et al*, 1993). Possible relationships have also been suggested between specific crops and cancer, viz., fruit crops with colon and bladder cancer; wheat crops with prostate cancer; olive and potato crops with kidney cancer (Forastieri *et al*, 1993).

2.6 *Risk assessment of pesticides in the environment*

A delicate balance exists in undisturbed natural ecosystems among the different biological components. Changes in the conditions of the elements of the biosphere causes imbalance in the functional pattern of the biological systems. Chemicals which are used in agriculture to bring about the desired effect do so by altering the biological systems and hence the ecosytem. Practically all of the crop protection chemicals are classified as pesticides and are to some degree poisonous to some biological systems. There has been concern in recent years regarding the use of pesticides and the resultant impact on the environment, food safety and animal and human well-being. In a survey conducted among agricultural produce consumers; 87% of the respondents disagreed with the statement "economic growth is more important than environmental protection" (Weber *et al*, 1995). Education, both formal and informal, could become the key to helping the public to make informed decisions about protecting the environment and the agricultural system.

A number of pesticides have been discontinued in recent years because, while some of these pesticides had become ineffective in controlling pests, others had contaminated the environment and the food chain, thereby creating the circle of poison. At least 520 species of insects and mites, 150 plant diseases and 113 weeds have been reported to have become resistant to pesticides (Pesticide Trust Rev, 1996). Excessive and indiscriminate use of pesticides has resulted in the decreasing effectiveness of pesticides and an increasing pesticide resistance. Since World War II there has been a ten fold increase in the use of synthetic pesticides.

However, the loss of food and fiber crops to insects has risen from 7% in the 1940s to 13% currently (Pesticide Trust Rev, 1996).

The potential toxic effect response from pesticides is mediated by intrinsic and extrinsic factors. Among the intrinsic factors are inherited predispositions which includes metabolic activation and detoxification, immunoantigens, DNA repair capacity, age and nutrition. The extrinsic factors are influenced by geographical and climatic variations, health sanitation and socio-environmental stress (Grandjean *et al,* 1995, Elsebae *et al,* 1996). Populations in developing countries have their own genetic trait characteristics, which interact synergistically with unfavourable ecological factors and health sanitation to elevate the risk to health hazards. Ethnic differences could increase the variability of the mean values of acceptable daily intake (ADI) or tolerable daily intake (TDI) within different population groups (Renwick *et al,* 1996).

2.6.1 Risk among farmworkers

The possibility for exposure to pesticides is the greatest among farmworkers in the developing countries. Farmworkers in these countries receive little or no training in handling pesticides and seldom use personal protective equipment. Farmworkers, both seasonal and migrant, along with pesticide applicators and women farmers have been identified as high risk populations and need to be monitored for long term adverse health effects such as cancers, neurobehavioural effects, neurological dysfunction and reproductive outcomes (Moses *et al,* 1993). Although the developing countries use only 25% of the world's pesticides, they account for 99% of deaths due to pesticide poisoning (Wasilewski, 1987). There is no waste pesticide disposal system and disposal of empty pesticide containers and unused pesticides is a major problem (Gomes *et al,* 1997; London 1994). Inappropriate disposal of these items increases the exposure among the farmworkers. Pesticide users in St. Lucia, West Indies were unaware that the skin and eyes were important potential routes of exposure. They rarely understood the labels on the pesticide containers and never followed the instructions (McDougall *et al,* 1993). Farmworkers in the developing countries also had less knowledge and information regarding the causes of cancer, it's prevention and it's early detection and treatment (Lantz *et al*, 1994). Male farmworkers who very often handled pesticides and never used protective equipment were observed to have an elevated risk for non-Hogdkin's lymphoma (Cantor *et al*, 1992), liver cancer (Dwivedi *et al*, 1994), leukemia and cancer of the lung (Dich *et al*, 1997), soft tissue sarcoma and malignant lymphoma (Dich *et al*, 1997), pancreatic cancer (Fryzek *et al*, 1997), testicular cancer (Soto *et al*, 1997), stomach and kidney cancer (Forastiere *et al*, 1993) and spina bifida in offspring born to farming parents (Blatter *et al*, 1997). Among women in agriculture excess of non-Hodgkin's lymphoma, leukemia, multiple myeloma, soft tissue sarcoma (McDuffie, 1994) and cancers of the breast (Dich *et al*, 1997), ovarian cancer (Dich *et al*, 1997), cervical cancers (Zaham and Blair, 1993) and cancers of the lung, bladder, sino-nasal cavities (McDuffie, 1994) were observed.

2.6.2 *Risk from food and environmental contamination*

Contamination of food and the environment is a cause for concern over the potential adverse effects of the contaminants on human health. All segments of the population are at risk of developing chronic effects such as cancer, adverse reproductive outcome and immunological effects (Al-Saleh, 1994) from exposure to pesticides in food and the environment. Adverse effects may be caused not only by the active ingredients but also by the solvents, carriers, emulsifiers and other constituents of the formulated pesticides. Assessment of the extent of exposure to pesticides from food and the environment in humans has been difficult and inconclusive in terms of adverse health effects. Exposure has been estimated by determining the concentration of pesticide residues in samples of serum (Martinez *et al*, 1993), fatty tissues (Djorjevic *et al*, 1994), urine, blood (Canossa *et al*, 1994) or breast milk (Ustumbas *et al*, 1994). Chromosomal aberration rates, sister chromatid exchange rates, micronucleai frequency in peripheral lyphocytes and adduct formation with haemoglobin and DNA have also been used in assessing susceptibility and the level of exposure (Anwar *et al*, 1997). Genetic susceptibility, climatic conditions and diversity of exposure in terms of types and concentrations of pesticides are some of the factors which need to be considered in the risk estimation.

Health risks from pesticide residues in food are expressed as a ratio of total intake/ADI (percentage ADI ingested) for each compound and by the sum of the percentages of ADI for each compound and by the sum of percentages of ADI for each compound within the same class of pesticides (Leoni *et al,* 1995). Dolara *et al,* (1993) reported that the average dietary exposure of Italian adults to carbamates, organophosphates and pyrethroids was high, but the levels were not sufficient to induce genotoxicity in laboratory animals. However, the differences between mean intakes and the ADI were smallest for children aged 1-4 years (Brussaard *et al,* 1996). Infants and growing children could be at a greater risk if the current ADI levels for adults are applied without an additional safety factor, and without specifying the type of compound and it's toxic action. Schilter *et al,* (1996) have reviewed the current safety limits for baby foods which is based on the ADI together with the use of an additional safety factor to account for the potential higher sensitivities of infants to toxicants. This assessment indicates that for a number of pesticides there is a need for adequate developmental studies to provide assurance that the current ADI levels are appropriate for infants. The intakes of organochlorines have been studied the most because of the environmental persistence of these compounds. However, very little information on the contamination of foods by organophosphates, carbamates and others, which are not environmentally persistent, is available.

The severity of the effects are related to the acute toxicity of the pesticide, the level of contamination and the rate of degradation or metabolism. The long term effects in animals may be of greater significance than the acute short term effects. The outcome of short-term acute exposure is either death or morbidity from which recovery may occur over time once the exposure has ceased. However, long term chronic exposures alter the biochemical and metabolic processes in biological systems, thereby inducing changes which are mostly adverse to these biological systems.

2.7 *Rationale for this study*

Agricultural morbidity and mortality is significantly under-reported and is a major public health problem, in the developing countries (London, 1992, Walisewski, 1987). Organophosphate compounds are most commonly and widely used insecticides with other less commonly used insecticides being carbamates, pyrethroids and organochlorines. Environmentally persistent organochlorine insecticides have been most studied and reported, however, only limited information is available on the adverse health effects of the relatively less persistent and cholinesterase activity inhibiting pesticides. The use of organochlorine insecticides has declined in recent years, however, the use of less environmentally persistent but equally toxic compounds such as organophosphates has increased. Concerted efforts are needed to identify morbidity and mortality among agricultural workers in the developing countries, where isolated reports of increased morbidity have been emerging.

Morbidity and mortality profiles among farmworkers in the developing countries are not regularly kept and reported (Wasilewski, 1987, London & Myers, 1995). Pesticide illness in the developing countries has not been recognized as a high priority by public health officials because of the lack of concrete data on the actual, as opposed to estimated, number of cases (Wasilewski, 1987). Protective equipment is mostly not accessible and therefore not used by the farmworkers in the developing countries (Sivayoganathan *et al*, 1995, Gomes *et al*, 1997). Lack of knowledge on pesticides and inability to afford protective clothing are the major factors that contribute to pesticide illness among agricultural workers in the developing countries. There is a tendency in these workers to ascribe any ill-health they suffer to something which is transient and which will soon pass off (Gomes *et al.* 1997). Clarke *et al*, 1997 reported that knowledge of the farmworkers on pesticide exposure routes and ability to follow instructions was poor. There is a need to develop programmes to train agriculture and public health workers responsible for vector control, in the use of personal protective equipment and safe methods of handling pesticides in the developing countries.

Quantification of exposure of agricultural workers to pesticides is difficult because of the heterogeneity of the pesticides used, the variability in methods of application and lack of adequate exposure data (Brouwer *et al,* 1994). Biological monitoring is the only appropriate method which can provide reliable information on the risk assessment (van der Oost *et al,* 1997). However, markers for many of the pesticides in current usage have yet to be developed and validated (Brewster *et al* 1993) and exposure to a number of pesticides at a time in different combinations and dosages needs to be investigated. Karr *et al,* (1992) identified acetylcholinesterase as a useful biological marker for sub-clinical organophosphate pesticide exposure, but the use of this biomarker in evaluating the exposure in farmworkers with diverse ethnic origins, under different climatic conditions and work habits needs to be explored.

High risk populations which need to be studied include pesticide applicators, seasonal and migrant farmworkers and women farmers (Moses *et al,* 1993). No comprehensive epidemiological study has assessed the magnitude of occupational health problems among migrant and seasonal farmworkers and their dependents (Mobed *et al.,* 1992). Although the migratory nature of this population makes long term studies difficult, the development of standardized data collection instruments for health consequences and scientific assessment of farm work exposures and working conditions are vital to characterize and reduce the occupational health risks among these workers.

A safety factor of 100-fold, which is the product of a 10-fold factor to allow for species differences between test animal and humans and a 10-fold factor to allow for inter-individual differences, is commonly applied to animal data to derive the ADI for humans (Renwick *et al,* 1995). However, the safety factors used in allocating the ADI's of several pesticides, seem to be inconsistent with the severity of the toxicity of the pesticide and thus may need further consideration (Lu, 1995). The advisory maximum residue limits (MRL) have to be re-evaluated taking into consideration the environmental factors, the intensity of pesticide usage and the method of consumption. Washing does not significantly reduce residues, whereas peeling does and cooking and steaming have varying results (Dejonckheere *et al,* 1996b).

Limited information on the dietary intake of organophosphorus and carbamate pesticide residues in non-farming populations was available, except for the total diet studies in Italy and Japan (Dolara *et al,* 1993; Nakagawa *et al,* 1995). The dietary intake of organophosphorus and carbamate pesticide residues from the consumption of locally grown vegetables is expected to be estimated for the first time for the local and the immigrant farming population having determined the level of pesticide residues in the locally grown agricultural produce. Adverse health effects from chronic exposure to pesticides among farmworkers will be determined and congenital malformations in the ethnic population will be identified and possibly associated with chronic exposure to pesticides. Acceptable daily intake and maximum residue levels for mixtures of pesticide residues needs to be established for the local agricultural produce.

This study was undertaken to determine the local usage of pesticides in agriculture, to assess the contamination of the agricultural produce and to identify adverse health effects among the immigrant farming and local non-farming populations from occupational, non-occupational and dietary exposure to pesticides. Though adverse health effects from occupational and non-occupational exposure to pesticides has been known the role of organophosphorus and carbamate pesticides in causing the reported chronic toxicity has not been described. Pesticides residues in the locally grown vegetables have not been reported, nor the usage of pesticides in local agriculture. Dietary intakes of organochlorines have been widely reported, however, the intake of organophosphorus and carbamate pesticides from locally grown vegetables are not known. ADI have been defined by JMPR for individual pesticides, however, ADI for mixtures of pesticides have not been described and have been explored for the first time in this study.

Chapter 3

Methods and materials

3.1 *Survey of agricultural farms and pesticide usage*

3.2 *Survey of immigrant farmworkers*

3.3 *Collection, extraction and analysis of farm water*

3.4 *Collection, extraction and analysis of farm soil*

3.5 *Collection, extraction and analysis of vegetables*

3.6 *Survey of dietary habits of the ethnic and farming populations*

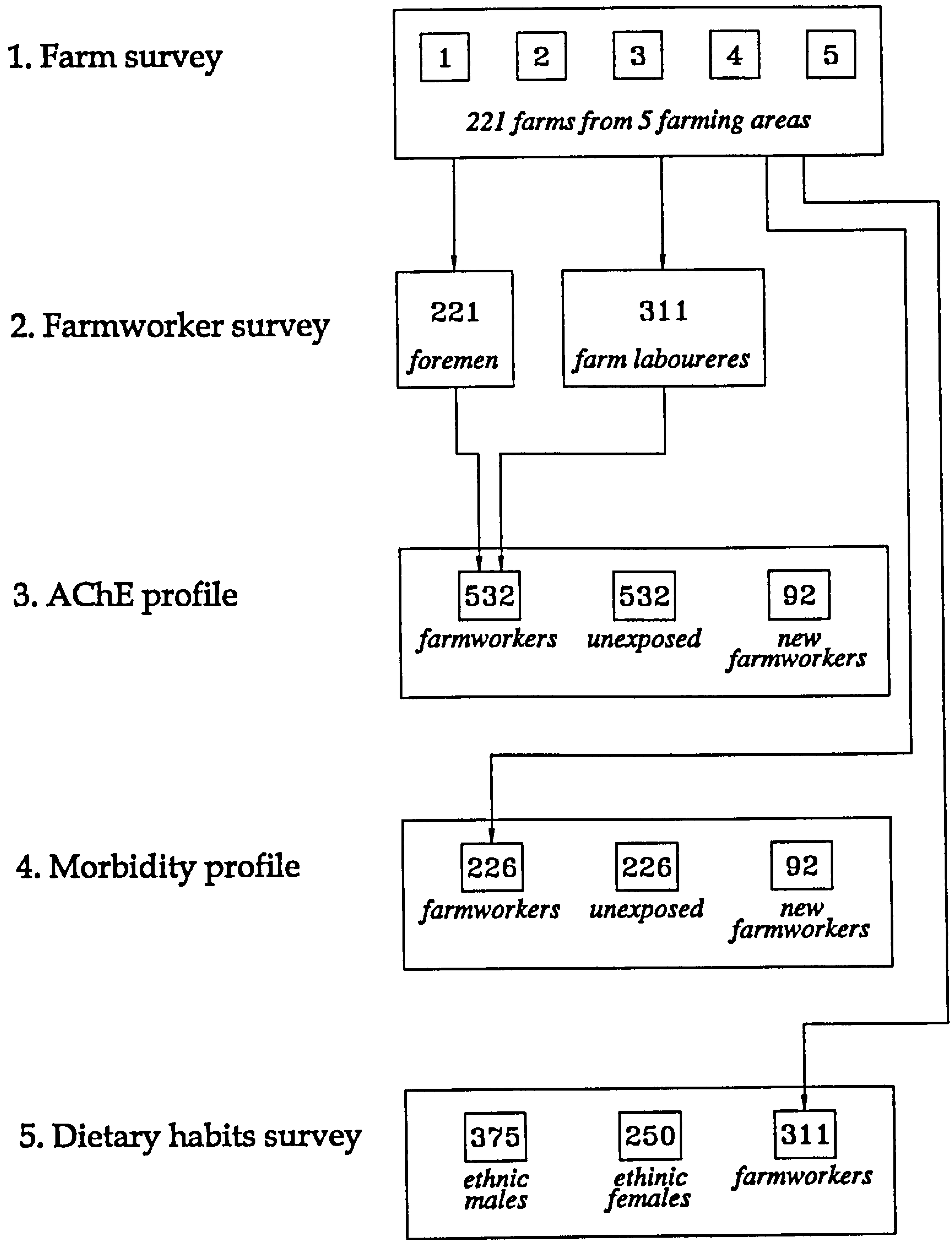
3.7 *Review of congenital malformations among the ethnic population*

3.8 *Statistical analysis*

3.1 *Survey of agricultural farms and pesticide usage*

The information on the number of farms and the type of vegetable crops grown in Al-Ain was collected from the Agriculture Department and the Ministry of Agriculture and the information on the number of farmworkers employed in the farming industry was collected from the Department of Preventive Medicine and the Ministry of Health. However, information on the use of pesticides, work habits of the farmworkers, management of vegetable crops and type of the irrigation systems used for vegetable crops was not available from any source. Therefore, an agricultural survey of vegetable crop farms was planned and

Fig 3.1: Flow diagram showing the sampling strategy for the different surveys



conducted to collect information on the farming practices in the cultivation of vegetable crops, the practice of pesticide usage and baseline information on the management of the farms. This survey was conducted with the help of the survey team and with the collaboration of the Department of Agriculture and the Faculty of Agriculture, UAE University. The scheme shown in Fig. 3-1 was used in the sample selection for the different surveys described in this chapter.

Information on the location of vegetable crop farms in the four different regions in Al-Ain was collected from the Agriculture Department and using a multistage sampling strategy two farming areas in the northern region, two in the western region and one in the southern region were selected. Al-Ain city has very few farms and because of the minimal agricultural activity was not selected in the survey. The criteria in selecting the five areas was that the vegetable farming activity of each region was represented by the selected sample. The five farming areas selected to be included in the study were Hayer and Gumadh in the northern region, Sleimat and Ramah in the western region and Waggan in the southern region. One out of every five farms in each of these areas was included in the survey. If the chosen farm was not under cultivation, then the neighbouring farm was used. The total number of farms surveyed in all the five farming areas were 221 farms, of which 34 (15%) were greenhouses and 187 (85%) were open farms. The total number of farms surveyed in Hayer were 34 out of 173 farms used in vegetable crop production, in Ramah 36 out of 182, in Gumadh 43 out of 217, in Sleimat 50 out of 248 and in Waggan 59 out of 298. Selection bias in choosing greenhouses was avoided by including a greenhouse if it happened to be the fifth farm.

3.1.1 *Survey of pesticides used in vegetable production*

A detailed layout of each of the area showing the individual farms and the name of the owner was provided by the agriculture department to assist the field team in the implementation of the survey. The layout shown in Fig. 3-1 was used to select one farm in every five farms to be included in the survey. Details of the farm sizes available on the layout were used in calculating the cultivated areas for each of the farms. Information on the use of all pesticides, supplied by the Agriculture Department and purchased from the private suppliers was collected during the farm survey of the five selected farming areas. A specifically designed questionnaire (Questionnaire for foremen, Appendix 12) was used to collect information on the type of pesticide used, frequency of use, method of application and the type of crops for which the pesticides were used. An inventory of all the pesticides used on the farm was made by inspecting the farm store and the disposal site on the farm for all the empty, half used and unused pesticide containers. Information on the frequency of use of pesticides and method of use was collected by interviewing the foreman and the farm labourers.

3.2 *Survey of immigrant farmworkers*

The survey of immigrant farmworkers was carried out in the five farming areas of Hayer, Ramah, Gumadh, Waggan and Sleimat selected in consultation with the Agriculture Department in Al-Ain to represent the agricultural activity in Al-Ain. The farm owners of the selected farms were contacted by a member of the survey team to fix an appointment to visit the farm and to collect information for the survey. If the selected farm was not under cultivation during the current year, then adjacent farm was selected in it's place. The survey team visited the farm on the appointed day and collected information using specifically designed questionnaires; Questionnaire for the foremen (Appendix 12) to be applied only to the foremen and Questionnaire for the farmworkers (Appendix 13) to be applied only to the farm labourers. Because of the wide diversities in the nationalities of the foremen and farm labourers the questionnaires were translated into Arabic and Urdu and interviewer applied by a member of the field team.

On the day of the visit the foreman was contacted first and having agreed to participate in the study and having signed the consent form was interviewed. With the approval of the foreman, one or two farm labourers (farmworkers) who were available on the farm were contacted and their approval and consent was

Fig. 3-1: The layout of a typical farming area which was used in selecting the farms to be included in the farming survey.

obtained for their participation in the survey. Among the 221 foremen from the 221 farms which were surveyed, only one declined to participate in the study. That farm was excluded and an adjacent farm was included in it's place. Among the farm labourers only five refused to participate for various reasons. A replacement farmworker from the same farm was then chosen if available. If none was available then no farm labourer was included from that farm in the study. A total number of 221 foremen one for each farm and 311 farm labourers were included in the study from the five farming areas in Al-Ain.

3.2.1 Foreman

The relevant questionnaire was used to collect personal information on the foremen and information pertaining to his work habits on the farm. Information was also collected from the foreman on the crops cultivated on the farm and the use of pesticides in the vegetable production. Details on the purchase of pesticides, safety procedures used on the farm when handling pesticides, personal protection equipment used on the farm, and storage and method of use of pesticides were also collected during this interview with the foremen. Height, weight and blood pressure were measured and a capillary blood sample was collected to estimate the erythrocyte acetylcholinesterase (AChE) activity. The results of the AChE activity are discussed in Chapter V.

3.2.2 Farm labourers

In the five farming areas a total of 311 farm labourers were interviewed, having obtained their consent to participate in the study following approval for their participation from the foreman. A specifically designed questionnaire *"Questionnaire for the farmworkers"* which is included in Appendix 13 was used to collect information from the farm labourers. Following two back translations the questionnaire was translated into Arabic and Urdu and administered by the same interviewer who administered the questionnaire to the foremen. Information on handling of pesticides on the farm, practice of hygiene and use of safety procedures on the farm including personal protection and disposal of unused pesticide formulations and empty pesticide containers was collected during this interview.

3.2.3 *Study population and tools of assessment of morbidity profile*

During the visit to the farms an appointment was made with one of the farmworkers, who would represent the farm, to visit the Occupational Clinic of the Department of Preventive Medicine, Ministry of Health for an assessment of their health status. At the Occupational Health Clinic the screening team applied to the farmworkers *"The Questionnaire for Health Status"* (Appendix 16) and then the farmworkers had their health status assessed by an occupational health physician. Blood pressure (systolic and diastolic) and pulse were also measured. Chronic cholinesterase-inhibiting pesticide exposure assessments were made by measuring the AChE activity and the neuromuscular co-ordination and memory assessments were made through the application of the Digit Symbol Test (DST) and the Aiming Test (AT). AChE activity measurements were made for these workers on a capillary blood sample and the depletion of acetylcholinesterase activity was measured as a function of exposure. The questionnaire for the assessment of the health status and the measurements of the AChE, AT and DST were also applied to a group of workers, just brought into the country to work in the farms (*new farmworkers*) and to those workers who had been in the country for at least two years and had never been occupationally exposed to pesticides (*unexposed*). The selection criteria for controls (unexposed) were that they had never handled pesticides for domestic use and that they were employed as domestic workers, in retail shops, offices or industries, and matched with the socio-economic status of the farmworkers. The new farmworkers were selected from those who had previously worked for at least two years in the farming industry in their home country.

The morbidity pattern was compiled using the thirty-day-recall information provided by the study population. The checklist for the past thirty-day health effects included watery eyes, blurred vision, running nose, itchy skin, dizziness, headache, restlessness, sleeplessness, muscle pain, abdominal pain, weakness, wheeze and chest tightness. The subjects were also asked to report on any health parameter which they might have experienced while at work or soon after work. Responses to each parameter were classified as experienced often, sometimes or never. This checklist was part of *"the questionnaire for health status"* and is included in Appendix 16. The current health status was assessed by the occupational physician at the Occupational Health Clinic and observations were made on conjunctiva (normal or irritated), vision test, wheezy chest and skin condition of the hands.

3.2.4 Measurement of erythrocyte acetylcholinesterase activity

The study population consisted of 221 foremen and 311 farm labourers and was compared with 532 controls (unexposed) population matched for age, nationality and socio-economic status (salary and living conditions). The unexposed population was selected from those workers attending the Preventive Medicine Clinic to obtain a Preventive Medicine health certificate to renew their work permit. Chronic exposure to cholinesterase-inhibiting organophosphorus and carbamate pesticides was assessed among the farmworkers and the unexposed population by measuring the AChE activity levels. Having obtained the consent from the study subjects, their blood pressure was measured and a 10μl capillary blood sample was collected to measure AChE activity. A Testmate Cholinesterase kit (EQM Research, Cincinnati, OH, USA) was used to analyze the capillary blood for haemoglobin and the erythrocyte acetylcholine enzyme activity level (McConnell *et al,* 1992, Meuling *et al,* 1992, EQM Research, 1991). AChE measurements were also made on a group (n=92) of new farmworkers newly recruited to work on the farms.

3.2.5 Neurological and muscular dysfunction measurements

The Aiming Test (AT) and the Digit Symbol Test (DST) have been usually employed in the assessment of the neurological and muscular dysfunction from chronic exposure to the neuro-toxic chemicals. The use of the AT and the DST has not been reported in the assessment of low dose chronic exposures to pesticides in farmworkers. This study used these tests for the first time in assessing chronic low dose exposure in farmworkers. The tests were adapted to local conditions and were given in the native language of the subject. After the test instructions had been explained to the subjects a practice session was held, following which the test was applied. Score sheets used in applying these tests have been included in the "*Questionnaire for health status*" in Appendix 16.

The AT and DST were applied to the study population consisting of 226 established farmworkers, (five farms were represented by two farmworkers) who had been given appointment to visit the Occupational Health Clinic at the Department of Preventive Medicine during the field visit, 92 new farmworkers and 226 unexposed were also invited at the clinic. The response rate was 99%; six people (one unexposed, one farmworker and 4 new farmworkers) did not participate in the study through lack of communication skills. The study population, which was mainly ethnic Asians, comprised Pakistanis (30%), Indians (29%), Bangladeshis (28%), Egyptians (9%) and Others (4%: Iranians, Jordanians, Sudanese, Syrians and Yemenis).

The AT and DST test papers were manually scored, and one point was given for each correct answer and no points were deducted for the wrong answers. The points were summed for each of the subjects and taken as their score for the test. Low scores for AT and DST indicated adverse effects on the neurological dysfunction, memory disorder and the neuromuscular co-ordination dysfunction. Higher test scores indicated good neurological and muscular function and memory.

3.3 *Collection, extraction and analysis of farm water for pesticide residues*

During the survey of the farms, a sample of 1.5 l of agricultural-use water was collected from each farm. A total of 217 water samples were collected from 221 farms in the five farming areas; four farms had no water on the day of the visit and therefore no water sample was collected from these farms. The water sample was collected from the main tap of the farm tank. The tap was opened and the water was allowed to run for one minute, after which the sample bottle was filled with water. The water sample was collected in a plastic bottle filled to the top with no air space left in the bottle. The bottle was marked with the farm number before leaving the farm. The bottle was tightly closed and transferred to the laboratory the same day and stored in the cold room at 5^0C until the time of analysis.

3.3.1 Extraction of the pesticide residues from the water sample

One day prior to the analysis, four samples of water were removed from the cold room and kept on the laboratory bench overnight to attain the ambient temperature of the laboratory. The facilities in the laboratory had been adapted to manually extract four samples a day. A liquid-liquid-extraction (LLE) method using dichloromethane was used to extract the pesticide residues from the farm water. The extraction procedure was a modified and optimised version of previously published methods (Hernandez *et al,* 1993; van der Hoff *et al,* 1991; Lopez-Avila *et al,* 1985).

The modified extraction procedure consisted of the following experimental steps:

1. A sample of 500 ml of water was taken in a separating funnel from the 1.5 l water sample collected in the field and the pH was adjusted to 7.0 with either 0.25M hydrochloric acid or 0.15M sodium hydroxide.

2. Approximately 15 g of sodium chloride was dissolved in the neutral water sample, followed by the addition of approximately 15 ml of 2M hydrochloric acid.

3. The above solution was thoroughly shaken with 100 ml of dichloromethane in a separating funnel for 2 minutes. The mixture was then allowed to stand for 15 to 30 minutes to allow the two layers to separate completely.

4. The lower organic layer was collected in a bottle containing 15 g of anhydrous sodium sulphate. The aqueous layer in the separating funnel was again extracted with 50 ml of dichloromethane in the same manner as described in Step 3. After separation the organic layer was combined with that obtained previously.

5. The aqueous layer in the separating funnel was extracted a third and final time with 50 ml of dichloromethane as in Step 3 above. The organic layer was combined with the previous two extracts.

6. The combined organic extracts were filtered through Whatman No.1 filter paper into a 500 ml rotary evaporator round bottom flask. The separating funnel and the solid residue on the filter paper were washed twice with 30 ml dichloromethane and the washes added to the round bottom flask.

7. The organic extract in the round bottom flask was evaporated to dryness in a rotary evaporator at 45^{0}C and 35 mm Hg vacuum.

8. The dry residue in the round bottom flask was then dissolved in 2 x 5 ml aliquots of dichloromethane and transferred to a graduated test tube.

9. The 10ml extract in the graduated test tube was evaporated under a stream of nitrogen at 40^{0}C to produce 1 ml of final extract.

10. The final extract was filtered through Whatman No. 1 filter paper and collected in a 2 ml vial for chromatographic analysis.

The above procedure involved the pesticides in a 500 ml water sample being extracted into 1ml of dichloromethane which represented a concentration factor of 500 for the final extract. This extract without any further dilution was used in the chromatographic analyses.

The final extract was found to be suitable for chromatographic analysis and did not require further clean-up. The first few extracts were further cleaned with Florosil columns followed by extraction with acetonitrile and hexane, but no significant changes were noted in the chromatogram for background or interference effects. Therefore, the clean-up procedure was abandoned. Similar procedures for chromatographic analysis without clean-up have been reported by Borburgh and Hammers (1992). The above extraction method worked well and extraction efficiencies between 95 to 150% were obtained for different pesticides.

3.3.2 Chromatographic analysis of farm water extracts

Benfenati *et al,* (1990), Lopez-Avila *et al,* (1985) and Alford-Stevens *et al,* (1988) have reported analytical methods for pesticide residue analysis using chromatographic techniques with a variety of specific detectors, including a mass spectrometer in one case. However, Nwankwoala and Osibanjo (1992), Miladis (1994), Dua *et al,* (1994), Pico *et al,* (1994), Burgeois *et al,* (1993) and Hernandez *et al,* (1993) have reported analysis of pesticide residues in natural, surface or river water using similar chromatographic techniques, but different detection and peak identification techniques. A gas chromatographic-mass spectrometry technique was used in this study to analyse the extracts from agricultural water.

A Hewlett Packard Gas Chromatograph 5890 Series II attached to a Hewlett Packard Mass Selective Detector 5972 Series was used to analyse the extracts. A Hewlett Packard Auto-sampler and Auto-injector HP 7673 were used to analyse the samples in batches. A Hewlett Packard Chem-station (HP G1034C) was used to integrate the chromatogram peaks and the Mass Spectral Library of Pesticides (G1038A) from Hewlett Packard was used to aid identification of the peaks to named pesticides. Wiley's Chemical Library was used to identify other chemical compounds in the chromatogram. For those active ingredients for which the mass spectra were not available in the Mass Spectral Library of Pesticides and the Wiley's Chemical Library a custom made library (James.L) was created by the author. All these libraries were used to identify the peaks to named pesticides. The dichloromethane extracts were stored at 8^0C until analysis. On the day of analysis, the extracts were kept at room temperature for about one hour and then analyzed using gas chromatography-mass spectrometry. Having experimented with different instrumental operating conditions for the gas chromatograph and mass spectrometer the following optimum conditions were used in the analysis of all the extracted samples.

Oven temperature:	Held at 80^{0}C for 2 min, followed by heating to 130^{0}C at a rate of 8^{0}C/min, heating to 220^{0}C at 6^{0}C/min and finally heating to 280^{0}C at 8^{0}C/min.
Injector temperature:	210^{0}C
Carrier gas:	Helium
Total and Septum purge flow:	50 ml/min and 5 ml/min.
Mass detector temperature:	180^{0}C
Volume of injected sample:	1µl.
Full scan mode:	50-550 amu.

3.3.3 Extraction efficiencies for liquid-liquid-extraction

Quantitation was performed by injecting 1 µl of a standard solution diluted by a factor of 1:500 and adjusting the instrumental operating conditions to give peak heights of 60-80% of full scale. Injections were repeated until ratios of Isoxathion, Profenofos and Phosphamidon were within ±1% of the previous injection. Without changing conditions, 1 µl aliquots of working standards and triplicate 1 µl aliquots of sample water extracts were injected. In each case retention times of peaks for residues and standards were measured from the solvent front and the peak areas were calculated for each of the peaks. The peaks for the pesticide residues and the breakdown products were quantified using an external standard calibration procedure as suggested by the HP-Chem station software. The limits of detection were set at a signal to noise ratio of 3:1 and based on measured peak heights these were identified at 0.1 ng/l for the selected standards.

The 500 ml water samples, used for the extraction of pesticides, were spiked with different amounts of Profenofos dissolved in dichloromethane. The spiked peak obtained from direct injection of the Profenofos standard and the one obtained from the extract were used in calculating the extraction efficiencies for Profenofos. Similar peaks were obtained for Isoxathion and Phosphamidon and their extraction efficiencies were calculated using these peaks. The extraction efficiencies for the different standards used in the analysis of water for pesticide residues are shown in Table 3-1. The percentage recovery for Isoxathion varied from 98% to 104%, for Profenofos from 88% to 96% and for Phosphamidon 86% to 95% liquid-liquid-extraction using dichloromethane.

Table 3-1: Percent recovery of the spiked standard

Pesticide	Spike µg/l	Recovered µg/l	Percent Recovery
Isoxathion	6.4	6.3	98.4±3.2
	21	21.9	104.5±9.5
Profenofos	6.4	5.6	88.0±4.1
	21	20.1	96.2±3.8
Phosphamidon	6.4	5.5	86.3±2.6
	21	20.0	95.4±4.0

3.4 Collection, extraction and analysis of farm soil for pesticide residues

Samples of the farm soil about 1 kg from 10 cm below the surface were collected from the farm in a plastic bag and the bag was sealed. The soil samples were transported to the laboratory and stored in a cold room at 5^0 C until the time of analysis. A day prior to the analysis the soil samples were removed from the cold room and kept at the ambient temperatures of the laboratory until the time of extraction. A total number of 221 soil samples were collected from the five farming areas. Five samples of farm soil were lost in handling, so a total of 216 samples were extracted and analyzed in the laboratory for pesticide residues and other pesticide associated chemical compounds.

3.4.1 Extraction of the pesticide residues from the soil samples

The pesticides were extracted from the farm soils by the supercritical fluid extraction (SFE) method. A Supercritical Fluid Extractor, SFE400 (Supelco, Bellafont, PA, USA) was used in the extraction of sand samples. The sand sample was assayed and 15 g was placed in a weighing boat. The sand sample in the weighing boat was mixed with 1.5 ml (10% of 15 g) of methanol (modifier for SFE extraction) and allowed to stand on the laboratory bench for about an hour. If any spike was to be added, it was introduced along with the methanol and mixed well. The sand sample was then placed in a pre-weighed 25ml extraction vessel with small tufts of pesticide grade glass wool at either end. The extraction vessel was closed and weighed to find the net weight of sand used in the extraction. The vessel was then loaded into the SFE chamber and extracted according to the procedure described below.

The extraction method was developed from the guidelines provided by Supelco and other methods reported by Ramsey and Wachob (1994). SFE has evolved as an extraction technique because of its efficiency in solventless extraction and its ease in handling small amounts of samples. The technique is also quick and can be used for extracting a variety of matrices (Myer *et al,* 1992; Knipe *et al,* 1992; Hawthorne, 1990). The use of SFE in extracting environmental samples has been reported by Lopez-Avila and Beckert (1992) and Camel *et al,* (1993). Lee and Peart (1993) have utilized the SFE extraction technique in extracting aromatic hydrocarbons from sediments. The method used in this study has been adopted from the method reported by Lee and Peart (1993) after having made modifications to suit the local laboratory and instrumental conditions.

The pesticide residues from the sand were extracted with carbon dioxide under the following SFE operating conditions:

Oven temperature:	60^0C
Restrictor temperature:	80^0C
Flow rate:	2ml/min
Column pressure:	4000 psi
Static extraction time:	10 min
Dynamic extraction time:	20 min

The extraction chamber containing the soil sample to be extracted was placed in the SFE oven and once the operating parameters had been achieved the soil sample was extracted statically for 10 min and dynamically for 20 min. The extracted organic compounds were collected in 2ml dichloromethane kept in a tank of crushed ice. The extracted solution was allowed to warm to room temperature and then stored at 8^0C until chromatographic analysis. The sand samples in this study were very dry and contained hardly any organic matter and moisture and therefore a clean extract was obtained. It was not necessary to dry or to subject the extract to further clean-up and direct injection into the chromatograph was possible.

Table 3-2: Recovery of pesticides from sand using Supercritical Fluid Extraction

Pesticide	Spike ng/g	Recovered ng/g	Percent recovered
Isoxathion	6.4	5	78.13±2.3
	21	18	85.71±3.4
Methidathion	6.4	3.4	53.13±2.6
	21	10	47.62±2.7
Phosphamidon	6.4	4.5	70.31±1.9
	21	14	66.67±3.5
Heptenophos	6.4	5	78.13±2.6
	21	16	76.19±4.0

3.4.2 Recovery of spiked standards

To quantitatively estimate the amount of pesticide residue in the sand sample a 50 μl spike of a standard active ingredient at 1 ng/μl in Toluene was mixed with the modifier and added to the sand sample. The SFE extract was collected in 2 ml dichloromethane. Some of the solvent evaporated during the extraction process so the final volume of the extract was adjusted to 1 ml by further evaporation at 40°C under a stream of nitrogen. The weight of sand used in the 25 ml extraction chamber was 14 g, with the final volume of the extracted solution being 1 ml, the concentration factor for the extraction was 14.

The chromatographic conditions for peak identification and quantification of the SFE extract were the same as described in Section 3.3. The concentration of the pesticides in the extracted solution was determined by comparing the peak areas for the known and the unknown. External standard calibration procedure described by HP Chem-station software was used to quantify the chromatogram peaks. Diluted solutions of the standards (Methidathion, Heptenophos, Formothion and Isoxathion) were prepared by diluting a 1000 ng/μl stock solution to produce standards with 250 ng/μl, 100 ng/μl, 50 ng/μl, 10 ng/μl and 1 ng/μl. The concentration of the extracted pesticide in the extracted solution was measured by using the standard curve developed with the help of above standards. The mean SFE extraction efficiencies shown in Table 3-2 were 82% for Isoxathion, 50% for Methidathion, 68% for Phosphamidon and 77% for Heptenophos, with an overall extraction efficiency of 69% for the SFE procedure used in this study.

3.4.3 Chromatographic analysis of farm soil extracts

The extracts were kept at room temperature for about one hour and then analyzed using the gas chromatography-mass spectrometry technique. The operational conditions for the chromatograph were the same as described in Section 3.3 for the analysis of water extracts.

3.5 Collection, extraction and analysis of vegetables for pesticide residues

During the farm survey, samples of vegetables were collected for future analysis of pesticide residues. A sample of any vegetable crop that was ready for harvesting at the time of visit to the farm was collected and transported to the laboratory. If the vegetable was large in size (cabbage, cauliflower) just one piece was taken otherwise, about 1 kg of the vegetable crop was sampled. The sample was taken either from growing plants or from the vegetable crates, which were being readied for dispatch to the government collection centre. All the samples were sealed in self locking plastic bags and transported to the laboratory where they were stored in a refrigerator for one to two days prior to processing.

In the first stage of the processing of the vegetable samples, the samples were removed from the bags and wiped to remove any sand which may be attached to them. Approximately 1 kg of the sample was cut into small pieces and then homogenised to a paste in a blender. A sample of about 800 g of this paste was then placed in a well sealed freezer bag, stored at -5^{0}C for about two days and then stored at -20^{0}C until analysis.

A total of 244 samples of 14 different commodities of vegetables were collected from the five different farming areas in Al-Ain during the farming survey. The number of individual vegetable samples collected from each of the five farming areas are shown in Table 3-3. The distribution of the vegetable samples according to the farming areas was: Hayer (13%), Ramah (24%), Gumadh (18%), Waggan (23%) and Sleimat (22%). Aubergines (19%), Onion (24%) and Tomatoes (24%) constituted the bulk of the samples collected for analysis. None of the samples were lost during the collection or handling process. All the collected samples were processed and analysed in the laboratory for pesticide residues. The types of crops grown by individual farms in the five farming areas are described in Chapter 4. The types and numbers of different vegetable samples collected for analysis were representative of the agricultural activity in the sampled farming areas.

Table 3-3: Vegetable samples collected from the different farming areas for analysis of pesticide residues.

Crops	Hayer n(%)	Ramah n(%)	Gumadh n(%)	Waggan n(%)	Sleimat n(%)	Total n (%)
Aubergines	3	8	13	14	10	46 (19)
Cabbage	1	3		1		5 (2)
Capsicum	1		2			3 (1)
Carrots		4				4 (2)
Cauliflower	2	2				4 (2)
Chillies		2	9	1		12 (5)
Corn	1	2	1		4	8 (3)
Cucumber	1		6	2		9 (4)
Green leafy vegs		2	1	8	4	15 (6)
Marrow	3	3	3	3	4	16 (7)
Onion		10	1	20	28	59 (24)
Potato	3	1				4 (2)
Radish	1					1 (0.4)
Tomato	16	24	7	8	3	58 (24)
Total	32 (13)	59 (24)	43 (18)	57 (23)	53 (22)	244

Green leafy vegs (15) Spinach (n=5) and Lettuce (n=10)

3.5.1 Processing of vegetable samples for extraction

The vegetable samples were thawed initially at -5^{0}C for two days and then at 8^{0}C for a further two days. On the day of analysis the thawed samples were assayed and 30 g of the homogeneous paste was weighed and mixed with 6 g of analytical grade Celite. Celite was used to dry the paste and to increase the porosity of the matrix during SFE extraction. The semi dry mixture of vegetable and Celite was then freeze dried overnight at -54^{0}C and 20x10^{-3} mBar vacuum. The dry mixture was collected in a clean, dry plastic container and stored at room temperature until the time of extraction of the pesticide residues. Spikes of pesticidal active ingredients were added before freeze drying to determine the possibility of loss of pesticide residues during drying.

To prepare the sample for extraction a 3 g portion of the dried vegetable mixture was weighed and mixed well with 0.3 ml of methanol to act as a modifier. If a pre-extraction-spike was to be added, it was mixed with methanol and added after freeze drying to the dried vegetable mixture. This mixture was allowed to stand on the laboratory bench for twenty minutes to dry prior to loading into the extraction vessel. The vegetable sample was then placed in a pre-weighed 5ml extraction vessel with small tufts of glass wool at either end. The extraction vessel was closed and weighed again to find the net weight of the vegetable used in the extraction. The vessel was then loaded into the SFE chamber and extracted according to the procedure described in section 3.4.1.

The extraction procedure was developed from the guidelines provided by Supelco (Ramsey and Wachob, 1994. Suggestions made by Janda (1993) and Hawthorne *et al,* (1993) were considered in controlling the operational parameters of SFE and in choosing the modifier. The use of SFE to extract pesticides from agricultural produce has been reported by Wheeler and McNally (1989) and Rankin *et al,* (1992), but in these studies the analytical techniques subsequently used in separating and analysing the extracts did not involve mass spectrometry. Reports by Hopper and King (1991) and Thomson and Chesney (1992) were useful in identifying the various SFE parameters including the dynamic and static extraction times.

3.5.2 Supercritical fluid extraction of the vegetable samples

A Supercritical fluid extractor, SFE400 (Supelco, Bellafont, PA, USA) was used in the extraction of the vegetable samples with liquid carbon dioxide as the extraction fluid. The dried vegetable powder obtained from the vegetables, post freeze drying, was loaded into the extraction vessel and placed in the SFE oven chamber and extracted as described in Section 3.4. The extract was collected in 2 ml of iso-octane over a tank of crushed ice. The extract was allowed to warm to room temperature and then stored at $8^{0}C$ until analysis by the chromatographic technique described below.

3.5.3 *Chromatographic analysis of vegetable extracts*

The extracts were kept at room temperature for about one hour and then analysed using the gas chromatography-mass spectrometry technique. A Hewlett Packard Gas Chromatograph 5890 series II attached to a Hewlett Packard mass selective detector 5972 series was used to analyse the extract. The conditions for the chromatographic analysis were the same as described in Section 3.3.

3.5.4 *Recoveries of pesticide standards through extraction and analysis*

The chromatographic and mass spectrometric operating conditions were optimised for individual pesticide standards as described previously in Sections 3.3 and 3.4. A mixture of ten pesticide standards was made in dichloromethane and diluted 1:500 to give a working pesticide solution concentration of 2000 ng/ml. One microlitre of this solution was injected and instrumental operating conditions were adjusted to give peak heights of 60% to 80% of the full scale. The retention times of peaks for the pesticides and the peak areas were calculated using the HP-Chem Station software, with shoulder off, threshold 0.02 and peak width 16. With the signal to noise ratio of 3:1 the minimum detection was set at 0.1 ng.

Spikes were added prior to freeze drying to determine the loss of pesticides through freeze drying; prior to extraction to determine the extraction efficiency and post extraction to determine the chromatographic separation and peak identification. Table 3-4 shows the percent recoveries of the different spikes added at different stages during the sample preparation, extraction and analysis. Formothion, Profenofos and Phosphamidon were added prior to freeze drying and Isoxathion and Acephate were added prior to extraction (Table 3-4). The recoveries of standard pesticides were assessed for Aubergines, Tomatoes and Onion and extrapolated to the other agricultural produce. Diluted solutions of pesticide standards were prepared by diluting 1000 ng/μl stock solution to produce standard curves with 250 ng/μl, 100 ng/μl, 50 ng/μl, 10 ng/μl and 1 ng/µl. The concentration of the extracted pesticide in the extract was measured using the standard curve.

Table 3-4: Recoveries of spiked standard pesticides at 10 µg/g by SFE and GC-MS method[a]

Matrix	Pesticide	Spike µg/g	Recovered µg/g	Percent Recovered
Aubergines	Formothion	10	8.0	80±5.1
	Profenofos	10	8.2	82±4.0
	Phosphamidon	10	8.8	88±4.5
	Isoxathion	10	9.0	90±3.2
	Acephate	10	7.3	73±2.5
Onion	Formothion	10	7.5	75±3.3
	Profenofos	10	7.2	72±5.0
	Phosphamidon	10	8.0	80±4.2
	Isoxathion	10	8.4	84±3.0
	Acephate	10	6.8	68±3.5
Tomatoes	Formothion	10	8.6	86±4.1
	Profenofos	10	8.2	82±5.5
	Phosphamidon	10	7.8	78±3.3
	Isoxathion	10	9.0	90±2.2
	Acephate	10	6.0	60±5.1

[a] *Data are means±standard deviations for three replicate extractions*

3.6 Survey of dietary habits of the ethnic and farming populations

A dietary survey was conducted among the male and female university students so that a fairly current trend in the dietary habits of the ethnic population could be obtained. Secondly, because of financial constraints it was necessary to collect the data with minimal expense whilst maintaining its reliability in terms of quality and ethnicity. The university population was available on campus and it was economical to contact and invite this population to participate in the study. A specifically designed questionnaire *"Questionnaire for the dietary survey"* (Appendix 22) was used to collect the required information from the ethnic population. Application of self administered questionnaires required a fairly high degree of accuracy and reliability which was possible with the university students.

This survey was conducted through a self administered questionnaire, which was designed on similar lines to the questionnaire used in the National Nutrition Survey (1992) and the surveys by Musaiger (1992) and Musbah and Musaiger (1992). The questionnaire was first written in English, but applied to the subject population in Arabic after having been back translated, at least twice, by two independent translators. The responses from the pilot survey were translated into English by an ethnic male and an ethnic female with knowledge of food. For the farmworkers, the English version of the questionnaire was applied through an interpreter because of their inability to respond to the questionnaire on their own.

A total of 625 questionnaires were distributed among 375 females and 250 males (female/male ratio = 3:2) at the different university hostels between September 1995 and December 1995. The inclusion criteria for the participants were that they were ethnic in origin and were between 16 and 30 years of age. Those invited to participate in the study were provided with a copy of a questionnaire and were asked to complete it at home over a weekend. The reason for asking the participants to take home the questionnaire was that dietary information of a typical day in the life of an ethnic family could be obtained. A total of 311 farmworkers between the ages of 24 and 40 years were interviewed for their dietary habits and for their consumption of the locally grown vegetables. The response rate was 100%, for all the contacted farmworkers consented to participate in the study and provided the required information. Apart from age, the only other selection factor was a minimum period of two years working on the farms in the UAE.

The questionnaires were coded with the help of male and female medical students who had backgrounds in nutrition. The questionnaires were also checked by these students for the accuracy of the information. The medical students also personally interviewed some of the respondents and quantified the food intake portion sizes for different foods. The completed questionnaires were computerised for statistical analysis using the Statistical Package for Social

Sciences (SPSS). The vegetable contents of different foods were estimated (Appendix 23) and from this information the dietary intake of vegetables and the pesticide residues was estimated (Chapter VII).

3.7 Review of congenital malformations among the ethnic population

All the published and the unpublished literature on congenital malformations among the ethnic population was reviewed to assess the nature and degree of malformations in this population. Al-Marzouqi (1997), Al-Neaimi (1994) and Al-Jawadi *et al* (1988) have reported on the congenital malformations among three tribal groups in the UAE. However, Topley and Dawodu (1995) have reported on the pattern of congenital malformation in the total ethnic population in the UAE. Al-Gazali *et al,* (1995) provided congenital malformation rates for the first 48 hours of life and Abdulrazzaq *et al,* (1997) identified the pattern of congenital malformations in consanguineous parents. All these scientific reports were reviewed and the results are described in Chapter VIII.

3.8 Statistical analysis of the data

Statistical Package for Social Sciences (SPSS) (Norisus, 1983) was used in the statistical analysis of the data. Measures of central tendency were used to identify a representative value for a group. The data for AT, DST and the concentrations of pesticide residue were identified for their log-normal distribution and were analysed accordingly. Student's t-test was used to assess the difference between two independent groups and chi-square was used in proportions of categorical variables. Analysis of variance (ANOVA) was used to test the significance between means among different groups and Kruskall-Wallis test for the distribution of categorical variables. Multiple regression models were computed where appropriate to determine the associations between different variables.

Chapter 4

Agricultural activity in Al-Ain, UAE

4.1 *The Al-Ain environment*

4.2 *Agricultural activity in the region*

4.3 *Pesticides used in the production of vegetable crops*

4.4 *Expatriate farmworkers involved in the agricultural activity*

4.1 *The Al-Ain environment*

The United Arab Emirates (UAE), is a federation of six governorates formed in 1971, these governorates are now known as Emirates and comprise Abu Dhabi, Dubai, Sharjah, Fujairah, Ras-al-Khaimah and Umm-al-Quwain. Abu Dhabi is the biggest Emirate and occupies 80% of the total land mass of the UAE. The city of Abu Dhabi is also the capital of the UAE. The Abu Dhabi Emirate is divided into four administrative regions; the northern region, the southern region, the western region and the eastern region. The Abu Dhabi Emirate has a desert landscape and the southern and the western region are barren except for the oil-fields. This Emirate on the North has the Arabian Gulf and borders Saudi Arabia on the South and The Sultanate of Oman on the East.

4.1.1 Al-Ain - the oasis

Al-Ain is the fourth largest city in the United Arab Emirates (UAE) and the second largest city in the Emirate of Abu Dhabi is located at latitude 24^0 13′ and longitude 55^0 47′ and at an altitude of 302m. Al-Ain is an oasis in the middle of a desert with a lot of natural greenery and plenty of natural water sources, although these are not potable. The natural greenery has existed in Al-Ain for a long time. However, most of the present greenery has been as a result of the "greening of Al-Ain" project funded by the Federal Government. As a result of this project natural greenery has been preserved and new plants, trees, shrubs and date palms have been planted. Today the city wears a green look with at least one park in every square kilometer of the city. There are also two natural fountains, one has been tapped commercially for mineral water source and the second has been a tourist spot because of the claims of healing properties of the water from this fountain. Because of the availability of the water source agriculture has been promoted in Al-Ain and therefore, Al-Ain has also been dubbed as the agricultural capital of the UAE. Al-Ain alone contributes over 80% of all the agricultural produce grown locally in the UAE.

4.1.2 The population of Al-Ain

Al-Ain also has been divided into four administrative regions for the purpose of governance and its four administrative regions are the northern region, the western region, the southern region and the city of Al-Ain. The current estimated population of Al-Ain is around 300,000, of which almost 75% is expatriate. The many industries in Al-Ain such as the education, agriculture, health, tourism and trade require a lot of man-power. The ethnic population is small and mainly unskilled and it is for this reason that a lot of expatriates pour into the country bringing with them skills, technology and expertise. The majority (75%) of the expatriate population is from the Indian sub-continent and the Phillipines, sub-Saharan Africa and other countries in Asia. The remainder (25%) of the expatriate population is from the other Gulf countries, Europe and North America. Many expatriates are lured to Al-Ain and the UAE with their technical and scientific expertise by the benefit of tax-free money. However, unskilled workers from the Indian sub-continent and the Phillipines and sub-Saharan African countries are brought into the UAE to provide a workforce for menial tasks. These workers are considerably less well paid but compared to their home country, the salary and lifestyle in the UAE is much better and superior. These unskilled workers stay in the UAE in labour camps and are not allowed to have their families in the country. It is for this reason that the population pyramid for the UAE is not normal and has a excess of males between 25 and 50 years of age.

4.1.3 The climate in Al-Ain

Al-Ain being in the interior of a desert with a lot of green areas enjoys a mixture of semi-desert and tropical climates. Summers are hot and dry, with temperatures at around 40^{0}C, while winter temperatures stay around 26^{0}C with rare and scattered rain showers. These readings were recorded in shade, therefore the mean actual temperature in the sun would be at least 10^{0}C higher. The mean relative humidity in the summer months is 38% and during the winter months rises to 60%. Wind speed remains fairly constant throughout the whole year at 3.5 m/sec. However, the wind direction changes with season such that cool winds from the Gulf and Indian Ocean are prevalent in summer months and warm winds from the Saudi desert occur in winter months.

The mean evaporation rates in the summer months are 17 mm/day and during the winter months 5 mm/day. The cooler winter months, between December and March, usually bring the rain showers, however, rainfall is scanty and isolated. The mean annual rainfall in the Al-Ain agricultural regions during the past six have been about 100 mm/year. However, since 1996 there has been a gradual decrease in the annual rainfall, with a record low of about 20 mm for 1998.

4.2 *Agricultural activity in the region*

Exploratory farming in this semi-desert region was initiated in the early eighties on an experimental basis because of the availability of water and the existence of natural greenery. Success in the initial agricultural experiments led to organised agricultural activities in the late nineteen eighties with the establishment of agricultural farms by the Agriculture Department. Agricultural farms and experimental stations were set up in all the four regions of Al-Ain, where water was available reasonably close to the surface, to promote the agricultural activities. Four types of agricultural activities were commenced: vegetable crops, field crops, fruit trees and forest and ornamental trees. Currently there are over twenty five farming areas in the four administrative regions of Al-Ain which employ over twenty five thousand agricultural and garden workers.

The areas which had natural trees, have been preserved and additional trees have been added in these areas. With the exception of these areas all the other areas marked for agricultural use have been prepared for this purpose by the Department of Agriculture. Ordinary desert sand is used in these agricultural areas for cultivation and Fig. 4-1 shows how the desert landscape has been changing in recent years with the emergence of agricultural farms.

4.2.1 Agricultural farms and crops in Al-Ain

The information on the agricultural activity in the region was collected from the annual reports of the department of Agriculture and through the agricultural survey. Forest and ornamental trees are used to green the desert and include ornamental shrubs, desert shrubs, flowering plants, ornamental hedges and traze plants. A portion of the forest trees are natural and have existed for some time because of the availability of the underground water. The colonies of naturally existing trees have been expanded by planting more ornamental and desert trees. Field crops have emerged more recently and include wheat and fodder crops. Fruit trees are usually grown in farms and include lime, orange, guava, fig, mango and banana. Vegetable crops which are grown on vegetable farms include a wide variety of agriculture produce such as Aubergines, Beetroot, Broad beans, Cabbage, Capsicum, Carrots, Cauliflower, Chillies, Corn, Cow peas, Cucumber, Dill, Garlic, Lettuce, Marrow, Parsley, Peas, Potatoes, Pumpkin, Radish, Spinach, Sweetcorn, Tomato, Turnip, Okra and Onion. Some of these commodities are grown in most of the vegetable farms for commerce while the other commodities are grown on an experimental basis only at the governmental research stations. With the exception of vegetable crops, which are under private ownership, field crops, fruit trees and forest and ornamental trees are all owned by the

Agriculture Department or by the state. The vegetable crops locally grown have been discussed in Section 3.1 of Chapter III and Section 4.2 of this chapter.

The total area under vegetable cultivation in 90-91 was $8.5x10^3$ dunum and in 95-96 was $14.0x10^3$ dunum. The annual rate of increase in the total area under cultivation was 917 dunum/year, from 90-91 to 95-96, for the five farming areas which were selected for the survey. The total number of farms under cultivation in 90-91 was 1047 and in 95-96 it was 1513, the annual rate of increase in the number of farms in the five farming areas, therefore, was 78 farms per year. The annual rate of increase in the number of greenhouses in these areas has been 83 greenhouses per year and the rate of increase in the area under greenhouse cultivation has been 43 dunum/year.

4.2.2 Irrigation systems used in farming

The irrigation systems used in all the four agricultural activities have been selected according to the type of activity and keeping in mind the scarcity of water. A pupler type of irrigation system is used for the forest and ornamental trees while the sprinkler type is used for field crops. Vegetable crops are mainly irrigated using drip irrigation and very rarely using flood irrigation. The water supply for farming comes from boreholes (tube wells), which are funded by the Agriculture Department. A number of tube wells, depending on the output from each well and the quantity of water required for irrigation, are bored by the department and the water from these wells is collected in a common overhead tank from where it is supplied to the farms. Depending on the size of the farm about 10 to 20 farms share the overhead tank. The conductivity, a measure for the salinity, of the tube well water ranges from 125 mmhos/cm in some areas to 30,000 mmhos/cm in other areas. The type of vegetable crops grown by the farms is partially dependent upon the salinity of the irrigation water. The farm soil also has high salinity in certain areas being sandy has very little organic content. The soil being sand has high porosity and only drip irrigation is able to provide sufficient water to the plant for its proper growth. Another reason for using drip irrigation is the high ambient temperature and high evaporation rates.

4.2.3 *Production of vegetable crops*

A large number of vegetable crops have been grown in Al-Ain, firstly because of the demand for these crops in the local market and secondly the government has encouraged the farm owners to cultivate vegetable crops by providing incentives. However, in many places the desired crops cannot be grown either because of high salinity in the soil and/or irrigation water or shortage of water. The ordinary desert soil has been used in the farms for agriculture, this soil being poor in organic content and nutrients, the production of the vegetable and other crops largely depends on the efficient supply of water and nutrients through drip irrigation. The grain quality of the soil varies from place to place and with it the soil porosity and the water retention capacity of the soil. It is for this reason that the production of vegetable crops varies from area to area and within the area from farm to farm. Natural compost prepared on the farm from agricultural waste has been used in those farms which have the capability to prepare the compost. Natural compost has been mainly used to increase the organic content of the farm soil. Fig. 4-2 shows a typical farm in Hayer with a compost pit in the background. In this picture the survey team members are also seen talking to a farmworker in his usual attire for work on the farm.

During the past six years the local demand for the produce has declined (Table 4-1), while there is no international market for the local produce. The local consumption of the locally grown agricultural produce has declined from almost 34% in 90-91 to 14% in 95-96 (Table 4-1). The surplus agricultural produce is sent to the vegetable canning factory to be canned, and the surplus from the canning factory is sent to agricultural waste. The individual farm owners do not lose because of the lack of demand for their produce, as it is bought at source by the government, through the Department of Agriculture and then marketed in its retail outlets or sent to the canning factory. With the produce sent to waste by the government after having purchased it, does not sound as an economically viable policy, but the objective of the government in pursuing this agricultural policy is

Fig. 4-1: Vegetable farms in Al-Ain exist side by side with the desert landscape

Fig. 4-3: A typical farm in Al-Hayer currently under cultivation; staff conducting the agricultural survey is also seen in the foreground.

Table 4-1: Production and supply of vegetables from the Al-Ain region.

Year	Total agricultural produce (tons)	Local value of the produce (x1000 Dhs)*	Surplus produce (tons)	Consumed produce (tons)	Percent produce consumed (%)
90-91	186,692	262,563	123,320	63,372	33.9
91-92	267,514	382,484	197,520	69,994	26.2
92-93	277,737	404,178	215,194	62,543	22.5
93-94	312,711	511,087	244,199	68,592	21.9
94-95	405,907	745,503	338,578	67,329	16.6
95-96	441,747	858,865	379,025	62,722	14.2

** Dhirams (local currency), (1Dhs = 3.69 $US)*
Information obtained from the Annual report of the Agriculture Department

to green the desert and to give a source of income to the ethnic population with the hope of finding self sufficiency in vegetable crops. The country as a whole currently imports about 80% of its agricultural produce for local consumption from the neighbouring countries.

4.2.4 Vegetable crops in Al-Ain as identified through the survey

Vegetable crops in Al-Ain are mainly planted during the winter season (agricultural season), however, some farms also planted during the pre-summer period. The crops grown during the winter season for human consumption as identified during the farm survey of the five farming areas were Aubergines, Cabbage, Carrots, Cauliflower, Coriander, Cucumber, Lettuce, Marrow, Onion, Pepper, Potato, Radish, Spinach and Tomato. The summer vegetable and fruit crops grown for human consumption were Aubergines, Beans, Cabbage, Coriander, Peas, Pepper, Marrow, Molokia, Okra, Onion, Peas, Pepper, Yellow melon and Water melon (Table 4-2). The Alfa-alfa and Jath crops were grown for

Table 4-2: Vegetable crops grown in winter and summer seasons as identified in the survey in Al-Ain, 1994-95.

Crops	Hayer	Ramah	Gumadh	Sleimat	Waggan	Total (%)
Winter crops	n=34	n=36	n=42	n=59	n=50	n=221
Aubergines	27	29	32	52	32	172 (78)
Cabbage	31	31	37	56	30	185 (84)
Carrot	1	21	3	1	3	29 (13)
Cauliflower	11	23	21	28	7	90 (41)
Coriander	0	3	14	6	6	29 (13)
Cucumber	8	10	14	18	9	59 (27)
Lettuce	20	0	17	20	7	64 (29)
Marrow	4	14	21	26	11	76 (34)
Onion	8	32	11	50	41	142 (64)
Pepper	26	18	31	6	8	89 (40)
Potato	15	0	15	6	0	36 (16)
Radish	0	0	0	0	5	5 (2)
Spinach	3	2	1	2	1	9 (4)
Tomato	33	36	41	59	30	199 (90)
Summer crops						
Alfa-alfa*	0	0	0	0	8	8 (4)
Aubergines	0	0	0	2	2	4 (2)
Beans	4	0	0	0	0	4 (2)
Cabbage	0	0	4	0	0	4 (2)
Coriander	4	15	28	9	6	62 (28)
Jath*	0	0	1	0	5	6 (3)
Marrow	7	10	23	7	2	49 (22)
Okra	4	0	0	1	2	7 (3)
Onion	0	12	0	11	11	34 (15)
Peas	8	0	0	1	0	9 (4)
Pepper	0	0	2	2	0	4 (2)
Water melon	25	16	11	9	9	70 (32)
Yellow melon	22	19	29	24	6	100 (45)

* *These crops have been grown only for the camels and sheep.*

the camels and sheep. The vegetable crops cultivated by most number of farms in winter were Tomato (199/221, 90%), Cabbage (185/221, 84%), Aubergines (172/221, 78%) and Onion (142/221, 64%) the rest of the crops were grown by less than 50% of all the farms in the five farming areas. During the summer season fewer farms cultivated a few crops and among these crops the common ones were Yellow melon (100/221, 45%), Water melon (70/221, 30%), Coriander (62/221, 28%), Marrow (49/221, 22%) and Onion (34/221, 15%). The farming areas of Gumadh, Sleimat and Waggan cultivated 13 commodities of vegetables each and Hayer and Ramah cultivated 12 commodities each during the winter season.

4.3 Pesticides used in the production of vegetable crops

The farm owner is not directly involved in the activities of the farm. The farm foreman manages the farm, in consultation with the Agriculture Department. Information and advice on the care of crops and the use of pesticides is provided by the department. The Agriculture Department also provides subsidized supplies of fertilizers and pesticides, although this is not sufficient to meet demand primarily because of over-use of these materials by the farmworkers. To meet the demand for excess pesticides the Agriculture Department writes prescriptions for the pesticides which can be purchased from private importers and suppliers in the area. The terms "fertilizers" and "pesticides" are used synonymously by the Agriculture Department, farm owners and the farmworkers, for in the local language both the terms are referred to as "chemicals". The logic in using fertilizers and pesticides by the farmworkers is that a little excess of fertilizers and pesticides is not harmful to the plant but beneficial, this is also because in the minds of the farmworkers there has been an unclear understanding of the reason of use of pesticides or fertilizers and of the difference between the two. The farmworkers believe that insufficient usage of pesticides or fertilizers could be dangerous to the crops.

The annual report compiled by the Department of Agriculture provides details of the pesticides used in the region. However, these details are only for those pesticides supplied by the department, moreover, the quality of the information in the annual report being poor, a complete pattern of the usage of pesticides on the vegetable farms could not be obtained. However, the amounts of pesticides used by type and the trends in the pattern of the usage of pesticides during the past six years, from the information supplied by the Agriculture Department are shown in Figs. 4-3 and 4-4 respectively. The information on the use of pesticides purchased by farmers from private suppliers was not available and therefore, has not been included in the total quantities shown in Figs. 4-3 and 4-4. There has been little variability in the use of Insecticides, Acaricides and Herbicides from year to year during the six-year period from 1990 to 1996 (Fig. 4-4). However, the usage of Fungicides and Nematocides was higher during 1994-95 compared to the other years. Overall the trend in the total quantities of all pesticides used in the production of vegetables during the six-year period showed a very small decrease (Fig. 4-4). The trends were similar for the use of Insecticides, Fungicides, Acaricides, Nematocides and Herbicides. The seasonal use of all pesticides (insecticides, fungicides, acaricides, nematocides and herbicides) during the six-year period is shown in Fig. 4-5. The small decrease in the use of all pesticides during June and July was because of low agricultural activity during these months. The peak during August indicates the pre-planting usage of pesticides to prepare the soil and the peak during December indicates the pre-harvest usage of pesticides.

The information on the number of farms and the farming areas is more reliable than the information on pesticide usage, because construction work on farm extensions is organized through the Agriculture Department and efficient records are kept. The information on the total quantities of pesticides used is compiled by the Agriculture Department from the requests it issued for the purchase of pesticides by the Ministry of Agriculture. There is no register for pesticides in the Agriculture Department nor in the Ministry of Agriculture. The private importers and suppliers import pesticides through the Ministry of Industry and Commerce, which does not identify pesticides by name but as agricultural goods. There is a need, as identified in Fig. 9-1, for the establishment of a national pesticide register so that the usage of pesticides in agriculture is efficiently controlled.

4.3.1 Pesticides used in vegetable production

Results of the survey of the farms for usage of pesticides showed that on an average each farm used about eighteen different pesticides at any given time with the minimum number of pesticides used being eight and the maximum being

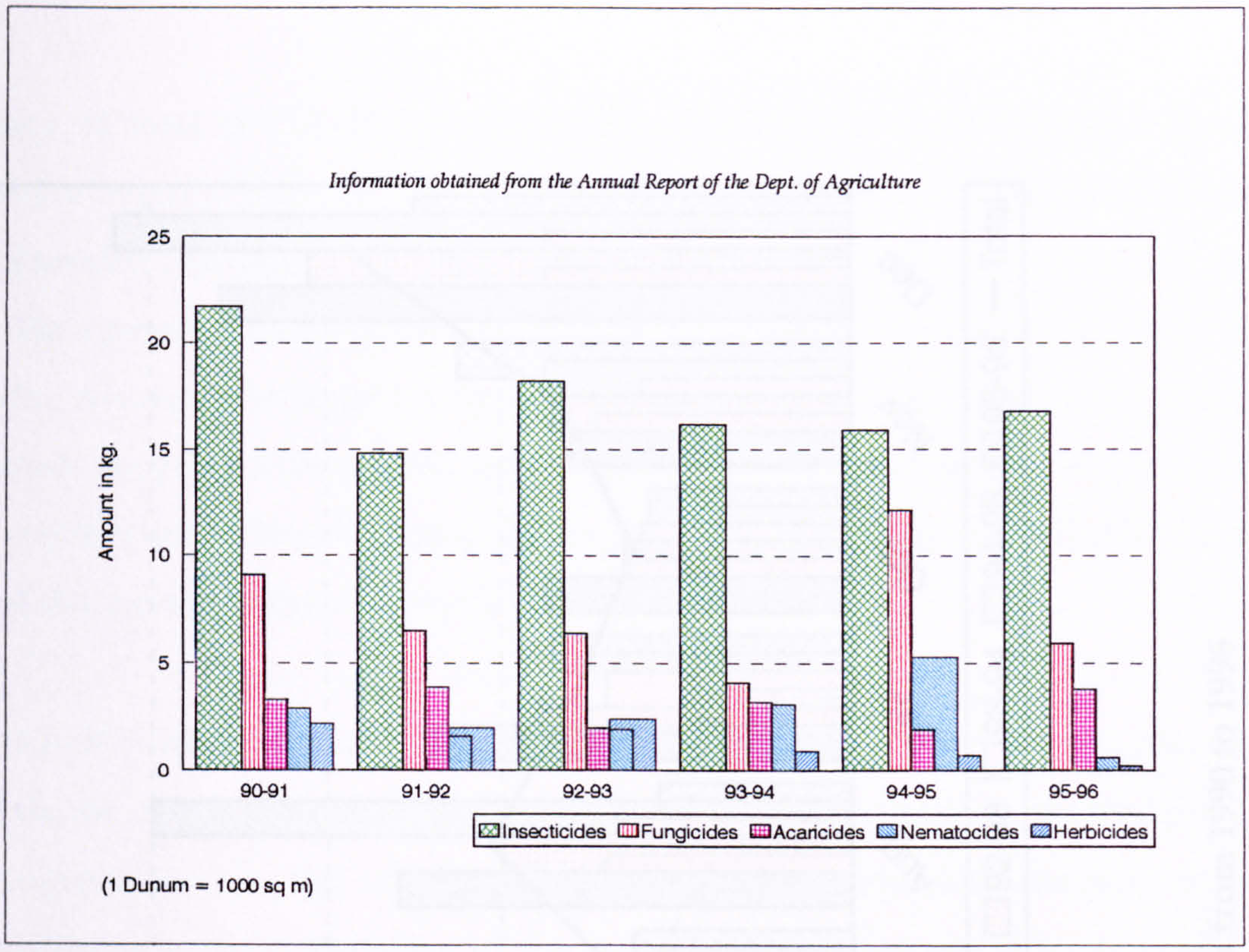


Fig. 4-3: Total amounts of pesticides used by type per 100 dunnum from 1990 to 1996 in Al-Ain

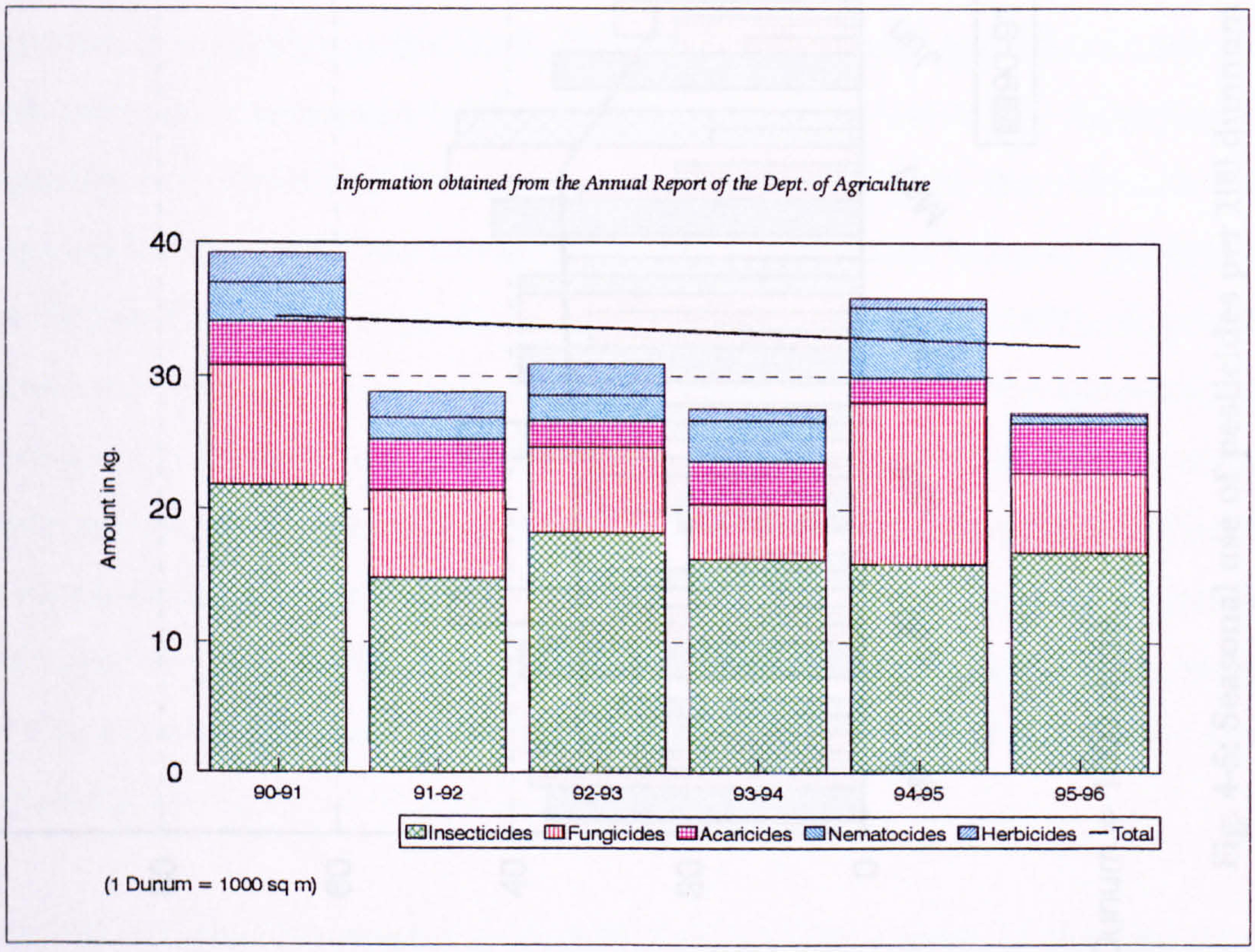


Fig. 4-4: Trends in pesticide usage by type per 100 dunnum from 1990 to 1996

Information obtained from the Annual Report of the Dept. of Agriculture

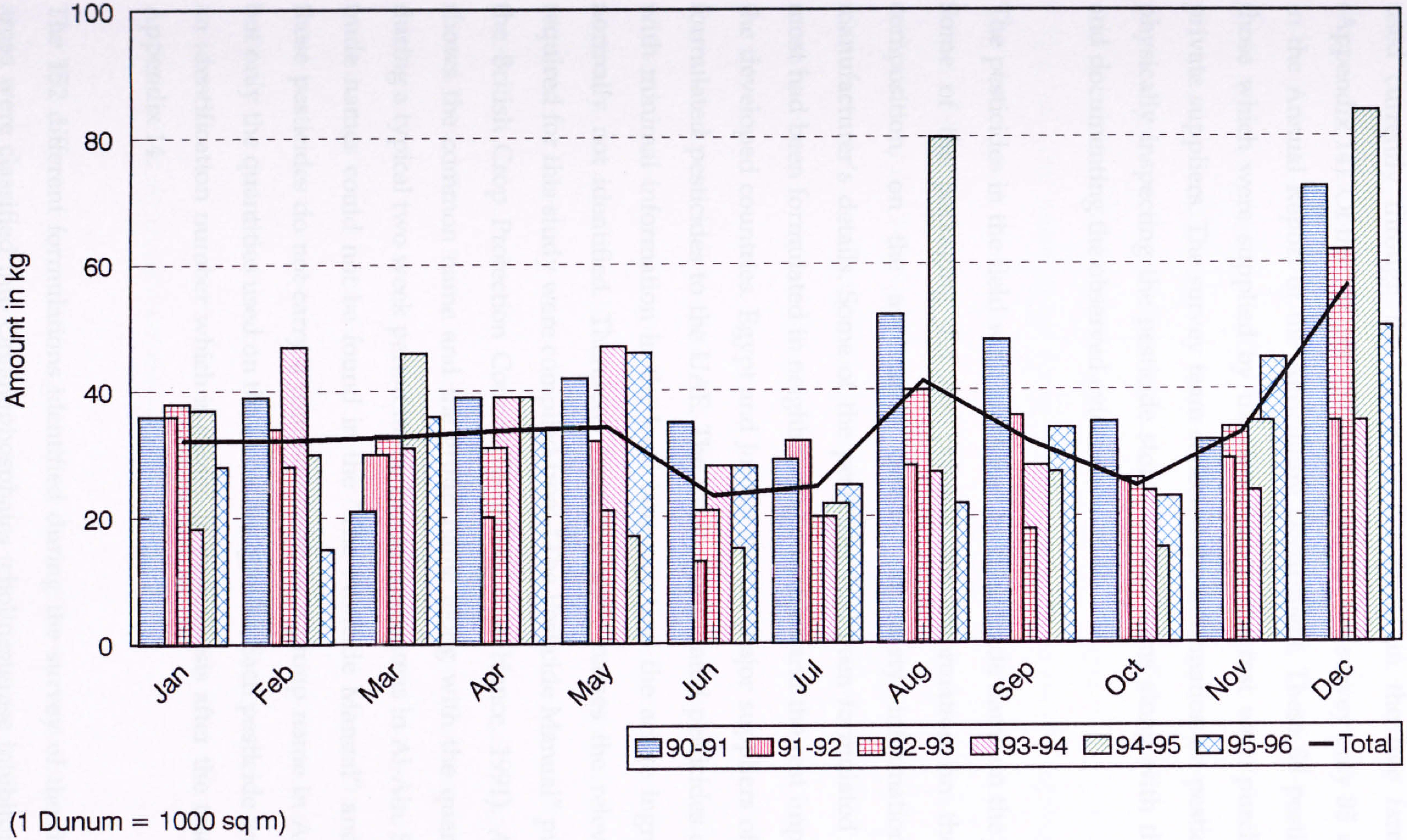


Fig. 4-5: Seasonal use of pesticides per 100 dunnum in Al-Ain from 1990 to 1996

thirty. A total of 152 different types of pesticides were identified and listed as used currently through the survey of 221 farms in the five farming areas (Appendix 14). Of the 152 pesticides identified in the survey only 85 were found in the Annual Report of the Agriculture Department. These 85 pesticides were those which were supplied by the department, the rest were purchased from private suppliers. The survey team collected the information on pesticide use by physically inspecting the pesticide stores on the farms along with the foremen and documenting the observed evidence.

The pesticides in the field were identified by their trade name on the packaging. Some of the packaging did not provide any information on the pesticide composition, on the application details, on safety information, nor on manufacturer's details. Some of the pesticides had been formulated locally but most had been formulated in neighbouring countries and the rest imported from the developed countries. Egypt and Jordan are the major suppliers of regionally formulated pesticides to the UAE. The locally formulated pesticides carry labels with minimal information in the local language and the active ingredients are normally not identified. Therefore, from the trade names the relevant details required for this study were compiled from "The Pesticide Manual" published by the British Crop Protection Council (Worthing and Hance, 1991). Appendix14 shows the common name and the group name along with the quantities used during a typical two week period in the five farming areas in Al-Ain. Some of the trade names could not be found in the "The Pesticide Manual" and therefore, these pesticides do not carry a common name or a group name in Appendix 14 but only the quantities used on the farms are quoted. Each pesticide was assigned an identification number which is shown in parenthesis after the trade name in Appendix 14.

The 152 different formulations identified during the survey of the five farming areas were classified into Organophosphates (cholinesterase inhibitors and non-inhibitors), Carbamates (cholinesterase inhibitors and non-inhibitors), Pyrethroids, Organochlorines, Other halogenated pesticides and Others. The latter category includes those compounds which were not included in any of the other categories and those which could not be identified by their trade names. The pesticide usage by type of compound for every two weeks by each of the farms in the five farming areas is shown in Appendix 15. A summary of the usage of all types of pesticides in the five farming areas is shown in Table 4-3. During the farming season the mean usage of all pesticides, for every two weeks, in the five farming areas was 6.81 g/m^2. The mean usage of all pesticides in Hayer was 5.50 g/m^2, Ramah 8.10 g/m^2, Gumadh 6.75 g/m^2, Waggan 6.79 g/m^2 and Sleimat 6.85 g/m^2. The mean usage for all the five farming areas of Organophosphates was 2.11 g/m^2, Carbamates was 0.69 g/m^2, Pyrethroids was 1.28 g/m^2, Organochlorines was 0.09 g/m^2, Other halogenated compounds was 0.80 g/m^2 and Others was 1.84 g/m^2. The use of Carbamates was significantly higher in the Hayer farming area compared to the other areas and the use of Organochlorines was significantly higher in Hayer compared to the other areas.

The mean usage of all pesticides in the farming areas of Ramah and Sleimat in the western region were higher compared to all the other areas. The usage of Organochlorines, Other halogenated and Others was also higher in these areas compared to the other areas. The reason for the increased usage of pesticides in these areas compared to the other three areas is not known, but, since the use of pesticides is left up to the foremen and the farmworkers it is possible that these workers in the two areas spray more often than others. The geography of the western region of Al-Ain does not warrant increased risk of pest invasion, nor do these areas cultivate crops specific to these areas which require increased usage of pesticides. It has also been observed in Chapter V that the farmworkers in these two areas tend to suffer from increased morbidity and also have lower erythrocyte acetylcholinesterase activity levels.

The Agriculture Department supplies the individual farms with pesticides from their stock, however, the individual farms with the recommendation of the Agriculture Department purchase the extra quantities of the same pesticides and

Table 4-3: Pesticide usage by weight and by type used every two weeks in g/m^2 in the five farming areas in Al-Ain, 1994-95

Type of pesticides	Hayer n=34 g/m^2	Ramah n=36 g/m^2	Gumadh n=42 g/m^2	Waggan n=50 g/m^2	Sleimat n=59 g/m^2	Total n=221 g/m^2
All pesticides*	5.50	8.10	6.75	6.79	6.85	6.81
Organophosphates*	1.81	2.32	1.99	2.54	1.88	2.11
Carbamates*	1.05	0.78	0.42	0.81	0.53	0.69
Pyrethroids	1.38	1.57	1.68	0.97	1.01	1.28
Organochlorines*	0.01	0.47	0.02	0.0	0.04	0.09
Other halogenated	0.55	0.74	0.98	0.80	0.85	0.80
Others*	0.70	2.21	1.67	1.68	2.53	1.84

* $p<0.05$ (Levene Test for homogeneity of variances)

also new ones not available at the Agriculture Department. The decision on how often to spray and how much to spray is taken by the foreman along with the other farmworkers. It is for this reason that different farms use varying amounts of pesticides even though the crops are similar. Individual preferences and beliefs, ambiguous definitions of pesticides and fertilizers and ignorance possibly results in the increased usage of some types of pesticides and less of others and increased usage in some areas compared to others.

4.4: Expatriate farmworkers involved in the agricultural activity

The farm owners in the UAE do not work on the farm, but employ expatriate workers from the Indian sub-continent, sub-Saharan Africa and the neighbouring Gulf countries to work on the farms. The owner of the farm sponsors the application of the farmworkers for a work permit to work on the farm, which entitles them to stay in the country and take up employment on the farm. Work permits are issued by the Ministry of Interior after the workers have been granted a preventive medicine health clearance certificate by the Ministry of Health. The health clearance certificate certifies that these workers do not carry any infectious or contagious diseases and are issued to workers between twenty four to fifty years of age. These certificates do not certify the fitness of an individual to work in the employment mentioned on the work permit application form. The work permit has a validity of two years and at the end of this period workers wishing to stay in the country have to obtain a new preventive medicine health clearance certificate and renew their work permit.

A medium sized farm typically employs three to four farmworkers. One of these is an experienced farmworker and is employed as the foremen. He runs the farm on a day to day basis and liases with the Agriculture Department to collect seedlings, fertilizers and pesticides, which are provided by the department. The foreman allocates areas of the farm for different crops. Depending on the variety of seedlings obtainable from the Agriculture Department, each farm cultivates, on average, three to four different types of vegetable crops. Bigger farms produce about ten to fifteen varieties of vegetables. The foreman also has responsibility for the preparation of the pesticides for spraying and for the spraying process. However, he can delegate these duties to other farmworkers along with their routine chores which include tilling, planting, pruning, irrigation, harvesting and packing the produce into crates for dispatching it to the produce collection point. In small farms the foreman takes the produce to the collection point, whereas, in large and extra-large farms one of the farmworkers who is employed as driver takes the produce along with the foreman. Most of the small farms and almost all the medium, large and extra large farms possess their own truck for use in connection with the farm business. Those who do not own a truck, share one with a neighbouring farm.

At the peak of the agricultural season, when it is time to harvest the produce, extra workers are hired by the farms to handle the harvest and manage the produce. These workers are not sponsored by the farm owner and, therefore, move from one farm to another and one area to another in search of jobs, some of these workers stay illegally in the country and do not possess any work permit. These workers are also expatriates and are migratory, unlike the sponsored workers who are expatriates, but not migratory. The un-sponsored workers are paid on an hourly basis and most of these people do not have any farming background, but during their tenure on the farm they undertake all duties required of them. In the survey of the farms both the farmworkers who were sponsored by the farm owner and those who were not sponsored were included. The sponsored workers lived on the farm and the un-sponsored workers during the tenure of the work also lived on the same farm they worked.

To meet the demand for agricultural workers created primarily by the establishment of new farms, on an average about 2227 new farmworkers are brought into the country every year. These are estimated numbers for some workers may be brought into the country to work in the farms but may then be transferred to work on camel breeding farms or as house-helps. In 1996, according to the statistical records of the Ministry of Health there were 16,660 workers employed in the agricultural sector.

Chapter 5

Adverse health effects among immigrant farmworkers

5.0 *Introduction*

5.1 *Survey of immigrant farmworkers in Al-Ain*

5.2 *Work practices and use of personal protective equipment*

5.3 *Morbidity patterns among farmworkers*

5.4 *Biomarkers of exposure to pesticides*

5.0 *Introduction*

Agricultural activity in the United Arab Emirates (UAE) has been successful so far because of the initiatives and support provided by the government. The government having provided the interested citizens with a farming plot also provides the farm owners with subsidized electricity for use on the farm and pesticides, fertilizers and seeds. However, there being a shortage in the labour required to cultivate the farms the government has provided facilities to the farm owners to recruit farm labourers from other countries. Expatriate (immigrant) farm workers from the Indian sub-continent, sub-Saharan Africa (Other Arabs) and the neighbouring countries in the Arabian Gulf are hired to work on the farms. Some of these hired workers have previous farming experience in their home country, however, majority of the workers who have been hired have never worked in farms and are economic migrants in search of money and better life in oil rich countries like the UAE.

The immigrant farmworkers in the UAE are contract workers and are provided with a free accommodation on the farm and a monthly salary. The hired farmworkers do not have to undergo a fitness-to-work assessment and do not have the facility of a health clinic. If required they have to purchase the facility from the government primary health clinic which they normally refrain from, because of the fear of being reported to the Ministry of Health and being considered as unfit for work. The Ministry of Health has to provide them a health clearance certificate so as to renew their work permit on expiry. The work permits required to work on the farms are issued by the Department of Immigration subject to the issue of a Health Certificate by the Department of Health certifying that these workers do not carry any communicable diseases and are valid for two years. The work permits could be renewed at the end of the two years for a further two-year period, non-renewal of which could end in repatriation of the farmworkers to their home country.

The health status of the immigrant farmworkers in the UAE have not been profiled and very little information was available on the health status of similar workers worldwide. This chapter reports on the health survey conducted among the farmworkers in Al-Ain; demographic profile and the work practices among these workers have also been reported and discussed. The erythrocyte acetylcholinesterase (AChE) activity was measured and the neuromuscular co-ordination and memory were assessed using the Aiming Test (AT) and the Digit Symbol Test (DST), these results have also been reported in this chapter. The AChE activity levels among the farmworkers and a control group have been reported by Gomes *et al*, (1997). The morbidity profile among farmworkers from long term exposure to pesticides was identified and associated with the AChE activity levels, these findings have been reported by Gomes *et al*, (1998a). The use of personal protection while handing pesticides was studied and the influence of personal protection, environmental hygiene and exposure to pesticides on the health of immigrant farmworkers has been reported by Gomes *et al,* (1999a).

5.1 Survey of immigrant farmworkers in Al-Ain

Results of the survey of the farmworkers, comprising foremen and farm labourers are described in the following sections for the foremen and the farm labourers.

5.1.1 Demographic profile of foremen

The mean±standard deviation (SD) age of all the surveyed foremen in the five farming areas was 40.53±3.48 years, mean±SD systolic blood pressure was 119.64±8.45 mm of Hg, mean±SD diastolic blood pressure was 81.02±8.82 mm of Hg and mean±SD body mass index (BMI) was 24.22±2.84. The BMI was calculated as the ratio of weight in kilograms and height in meters squared. The mean period of service in this country for foremen was 1.93±1.59 years, while their total period of prior service as farmworkers, in their home country, was 5.33±2.47 years. The mean age, blood pressure and body mass index for the foreman in the five farming areas are shown in Table 5-1.

The foremen in Ramah were the oldest compared to the other farming areas. The foremen in Gumadh were borderline obese with the BMI closer to 25.00, while those in Hayer were the leanest. The systolic and the diastolic blood pressures of the foremen in Hayer were higher compared to the foremen in all the other four areas. These foremen also had longer service period in the UAE. Hayer was one of the oldest farming areas in Al-Ain. The foremen in Gumadh though not the oldest had longer period of service in farming compared to those in the other areas.

5.1.2 Pesticide handling on the farm

Pesticides were always collected from the agriculture department or the private supplier by the foreman, but at the farm other farmworkers were also involved in

Table 5-1: Age, blood pressure and body mass index of foremen in the five farming areas.

	Hayer n=34	Ramah n=36	Gumadh n=42	Sleimat n=59	Waggan n=50
Age (years)	40.71±2.10	43.11±4.04	40.29±2.77	39.29±3.32	40.22±3.65
BMI	23.63±2.79	24.19±2.10	24.96±3.35	24.43±3.08	23.78±2.50
Systolic bp (mm of Hg)	123.53±9.1	117.77±6.8	117.38±7.3	121.36±8.2	118.20±9.2
Diastolic bp (mm of Hg)	85.00±8.26	77.08±8.48	80.00±9.37	81.02±8.85	82.00±7.83
Service in UAE (years)	2.44±1.85	2.22±1.71	2.07±2.08	1.61±1.20	1.64±1.08
Prior service (years)	4.26±1.97	4.83±2.50	7.38±2.48	4.42±2.21	5.74±1.88

BMI = (weight in kg) / (height in m)^2

storing the pesticides or handling them for application under the guidance of the foremen. The agriculture department usually (86%) provided advice on the selection of pesticides for use on the farm, however private suppliers advised less often (11%). The foremen mostly (80%) prepared the pesticides for spraying, but less often (20%) actually applied the pesticides to the crops themselves. Most of the time (77%) they delegated this duty to the other farmworkers. In 29% of the cases the agriculture department was involved in training the farmworkers to apply the pesticides to the crops. However, most (64%) of the time the foremen gave advice to the other farm labourers on the application of pesticides. The foremen on 62% of the farms were not trained in handling pesticides. Among those who had some training in handling pesticides, 20% had received the training in their home country prior to coming to the UAE and 18% had been instructed by the agriculture department on how to protect themselves when handling pesticides. Neither the agriculture department in Al-Ain, nor the Municipality currently have any programmes designed to train agricultural workers in the handling of pesticides.

During the survey it was observed that at most farms unused stocks of pesticides were not being appropriately stored with 11% of the farms keeping pesticides in the same room as they lived, 84% keeping pesticides in a room adjacent to their living room, and only 5% keeping the pesticides in a separate room on the farm. The inhabited area on the farm usually consisted of two or three rooms. Where there were two rooms, one was normally used as a store and a kitchen with the other used for leisure and sleeping purposes. In those farms with three inhabited rooms, one was usually used as a sleeping room, the other as a kitchen and the third as a farm store, where all the fertilizers, pesticides and other farm materials were kept. On three farms, the pesticides were stocked along with the groceries in the kitchen. The preparation of the pesticides for application by spraying was usually (94%) carried out on the farm, however, in 6% of the farms the pesticides were prepared on the patio of the living area. Figure 5-1 shows one such farm where the mixing of the pesticides was done on the patio and the mixing tank was just adjacent to the living quarters.

There were no guidelines regarding the disposal of excess amounts of prepared pesticides. The farmworkers disposed of excess pesticides by over-spraying in 85% of the farms, while in the rest of the farms the tank was just emptied indiscriminately on the farm land. The farmworkers also had no knowledge of how to dispose of spent pesticide packing materials and most (84%) of the time these were discarded on the farm or burnt on the farm, while at other times they were thrown into the home garbage and then dumped in one corner of the farm. There is no garbage collection system in any of the farming areas and the farm garbage is either dumped in one corner of the farm by the farmworkers or burnt on the farm. The disposal of the spent packing materials on the farms is shown in Figs. 5-2, where the materials were disposed dumping them in one corner of the farm. Almost all (97%) of the farms had kept separate vessels and ladles for use in the preparation of pesticides for spraying. However, 3% of the farms made dual use of these articles by using them in pesticide preparation and also at home for cooking or other personal use. None of the farmworkers were aware that the

Fig. 5-1: Typical living quarters of farmworkers on a farm; the pesticides are mixed on the tiled patio and then poured into the spraying tank.

Fig. 5-2: The spent pesticide packing disposed of in one corner of the farm.

pesticides used on the farms are dangerous and could potentially harm them, though most of them complained of general ill-health on the farm, but could not explain the cause. General morbidity among farmworkers has been discussed in Section 5-3.

5.1.3 Demographic profile of farm labourers

Most (98%) of the farm labourers had terminated their studies before finishing primary school and could not read and write. Only 2% had completed primary school and had left school at secondary level. Farm labourers always handled the tasks that were assigned to them by the foremen and 99% handled any work that had to be done on the farm including application of pesticides and harvesting. When asked if they had been trained in handling pesticides, 85% had never received any training in their current job not even in their home country, 2% of the farm labourers said that they had received instructions from the agriculture department and 13% had been instructed by the foremen. Regarding the application of pesticides, 25% of the farm labourers said that they were always involved in this job and 52% said they usually (50-90%, as defined in the questionnaire) and often (10-50%, as defined in the questionnaire) were asked to spray pesticides onto the crops.

The age, blood pressure and body mass index (BMI) of the farm labourers in the five farming areas are shown in Table 5-2. The mean±SD age of the farm labourers was 31.4±7.2 years and their mean years of service in Al-Ain was 3.7±3.7 years, while their prior service in the farming industry in their own country was 3.1±2.6 years. Mean±SD for the BMI was 23.8±2.0 and mean systolic and diastolic blood pressures were 115.9±7.6 mm of Hg and 75.9±6.9 mm of Hg respectively.

The mean age of the farm labourers was the highest in the Waggan farming area compared to the other areas. These workers in Waggan also had the highest systolic blood pressure and the longest period of service in the UAE. The BMI

Table 5-2: Age, blood pressure, body mass index (BMI) and period of service of the farm labourers in the five farming areas.

	Hayer n=50	Ramah n=67	Gumadh n=68	Sleimat n=58	Waggan n=68
Age (years)	31.88±7.07	32.09±8.18	29.37±5.84	30.48±6.34	33.03±7.63
BMI	24.46±1.38	23.08±2.55	23.83±1.51	23.78±2.14	23.51±2.15
Systolic bp (mm of Hg)	115.40±5.4	115.97±7.8	114.41±5.6	116.0±10.8	118.01±6.8
Diastolic bp (mm of Hg)	74.90±5.75	74.63±6.98	75.29±5.98	77.67±8.44	77.43±6.88
Service in UAE (years)	3.76±4.98	3.34±3.72	3.85±4.29	3.60±3.24	4.06±2.77
Prior service (years)	3.66±2.62	3.60±3.16	2.47±1.98	3.0±2.64	2.98±2.45

BMI = (weight in kg) / (height in m)²

was the highest in the workers from Hayer, these workers also had the longest service in farming in their home country prior to coming to the UAE. The diastolic blood pressure was highest among the farm labourers in Sleimat. These differences were not statistically significant.

5.1.4 Summary and discussion of the survey of foremen and farm labourers

The mean age of the foremen in all the areas was higher than the mean age of the farm labourers by about 9 years. The farm labourers had worked longer in Al-Ain compared to the foremen, but the foremen had worked longer in their home prior to coming to the UAE compared to the farm labourers. The BMI was higher in foremen and so were the systolic and diastolic blood pressures compared to farm labourers. These differences could partially be explained by the age differences. However, the systolic and diastolic blood pressures for the farm labourers were higher in the Sleimat and Waggan farming areas compared to the other farming areas, while the systolic and diastolic blood pressures for the foremen in Hayer were the highest. The analysis of variances of the age, BMI and the systolic and the diastolic blood pressures for the foremen and the farm labourers in the five farming areas did not reach statistical significance. However, it can be observed that the foremen with higher systolic and diastolic blood pressures in Hayer had been the longest in farming in that area, and similarly the farm labourers with higher systolic and diastolic blood pressures in Waggan had been the longest in that area. Environmental conditions, pesticide exposure and long residence in the farming areas could be some of the confounders of the higher systolic and diastolic blood pressures.

The majority of the foremen and the farm labourers were not trained in handling pesticides in the UAE nor in their home country. The foremen were mainly responsible for the application of the pesticides, however, this duty was usually assigned to the farm labourers by the foremen. The preparation of pesticides for application by spraying was usually carried out on the farm, however, in some cases it was carried out on the patio near the living quarters. No specific guidelines are given by the agriculture department in the disposal of the unused pesticides and also in the disposal of spent pesticide packing materials. The unused pesticides prepared for spraying were disposed of either by over-spraying on the crops or emptying the spraying tank on the farm land. The spent pesticide packing materials were disposed by throwing on the farm or in the home garbage or burnt on the farm. The pesticides on the farm were stored either in the room adjacent to the living room or in the same room as the living room and sometimes in the kitchen.

5.2 *Work practices and use of personal protective equipment*

A normal working day for a farmworker (foremen and farm labourers), begins at 7.00 am and ends at 6.30pm with a lunch break from 12.00 noon to 3.30pm. They may also take short breaks in between to have snacks or tea. These snacks or tea are usually taken on the farm and the farmworkers may or may not have a wash prior to eating and / or drinking. Those farmworkers who smoke do so during the break time and normally do not wash their hands before smoking. The farm owner does not provide any protective equipment to the farmworkers for use on the farm. Those farmworkers who can afford, use shoes and also normally set aside a set of clothes to be used on the farm. However, others do not differentiate between work clothes and their routine home-use clothes and do not wear any shoes. Head scarves used by men in Arabian countries to cover their heads are used by farmworkers to protect themselves from the heat of the sun, and this item of clothing also doubles up as a face mask during pesticide application.

5.2.1 Use of personal protective equipment by foremen

The foremen were asked questions on two aspects of safety in dealing with pesticides: 1) personal hygiene in handling pesticides and 2) use of protective measures when applying pesticides. Regarding personal hygiene, when asked about change of clothes at the end of the working day, 90% of the foremen said that they always changed their clothes, while 10% said they changed usually (50-90%, as defined in the questionnaire) or often (10-50%, as defined in the questionnaire). The foremen were more likely (93%) to consistently take a bath / shower after work, but 7% failed to take bath regularly at the end of the day even though they had handled pesticides during that day. Fewer (90%) of the foremen said that they always had a wash during breaks, while the rest did not regularly have a wash. Since no formal training has been provided to the foremen, the practice of personal hygiene and the use of personal protection was poor among these workers. The foremen did not make use of the pictograms on some of the pesticide formulations because a sense of safety and hygiene had not been inculcated in them and because of illiteracy. In the survey the foremen were asked if they used separate clothes for work including gloves, shoes and a scarf to cover their mouth and nose. Among the foremen only 27% always used gloves in handling pesticides, 3% kept separate clothes for work, 56% used a scarf to cover their mouth and nose while spraying pesticides and 74% always wore shoes while working on the farm. Details on personal hygiene and use of protective equipment while at work for the five farming areas are shown in Table 5-3. Very few foremen drank water, ate any food or smoked during the working hours and during the breaks.

Table 5-3: Personal hygiene and use of protective equipment as always practised by foremen in the five farming areas.

Hygiene Measures / Protective equipment	Hayer n=34 n (%)	Ramah n=26 n (%)	Gumadh n=42 n (%)	Sleimat n=59 n (%)	Waggan n=50 n (%)	Total n=221 n (%)
Personal hygiene						
Change clothes	29(85)	26(72)	40(95)	55(93)	44(88)	200(90)
Shower	29(85)	32(89)	36(86)	59(100)	49(98)	205(93)
Wash	25(74)	32(89)	39(93)	57(97)	45(90)	198(89)
Drink at work	10(29)	3(8)	2(5)	0(0)	0(0)	15(7)
Eat at work	2(6)	3(8)	1(2)	0(0)	0(0)	6(3)
Smoke at work	2(6)	2(6)	0(0)	0(0)	3(6)	7(3)
Protective equipment						
Gloves	11(32)	11(31)	7(14)	11(19)	11(22)	51(23)
Clothes to work	4(12)	4(11)	1(2)	1(2)	0(0)	10(4)
Scarf	14(41)	10(28)	18(43)	44(75)	30(60)	116(52)
Shoes	19(56)	29(81)	30(71)	52(89)	36(74)	166(76)

The practise of personal hygiene by the foremen in Hayer and Ramah was poor compared to the other areas. Fewer foremen in Hayer compared to the other areas, took shower after work, had a wash at break time or used shoes at work. Significantly greater number of foremen in Hayer had a drink while at work. Fewer foremen in Ramah changed clothes after work or used a scarf to cover their nose and mouth and more of them ate and smoked at work. The foremen in almost all the areas do not keep separate set of clothes for use at work but instead worked in their casual clothes. The climatic conditions in Al-Ain require the workers to have access to water during work. However, except for workers in Hayer and a few workers in Ramah and Gumadh, the workers in the other areas avoided drinking water during working hours. Eating of any snacks was avoided by foremen in Gumadh and Sleimat farming areas and in the rest of the areas very few of the foremen took snacks. Except for a few foremen in Hayer, Ramah and Waggan the foremen in the rest of the areas did not smoke during the working hours.

Table 5-4: Personal hygiene and use of protective equipment as always practised by *farm labourers* in the five farming areas.

Hygiene Measures/ Protective equipment	Hayer n=50 n (%)	Ramah n=67 n (%)	Gumadh n=68 n (%)	Sleimat n=58 n (%)	Waggan n=68 n (%)	Total n=311 n (%)
Personal hygiene						
Change clothes	28(56)	41(61)	66(97)	55(95)	62(91)	252(81)
Shower	28(56)	46(69)	66(97)	50(86)	56(82)	276(89)
Wash	29 (58)	46 (68)	50 (73)	43 (74)	45 (66)	213(68)
Drink at work	43(86)	60(90)	65(96)	57(98)	64(94)	289(93)
Eat at work	14(28)	32(48)	61(90)	39(67)	61(90)	207(67)
Smoke at work	16(24)	18(27)	16(24)	19(33)	29(43)	97(31)
Protective equipment						
Gloves	16(32)	20(30)	46(68)	26(45)	26(38)	134(43)
Clothes to work	16(32)	25(37)	60(88)	37(64)	48(71)	186(60)
Scarf	6(12)	18(27)	14(21)	34(59)	26(38)	98(32)
Shoes	44(88)	40(60)	63(93)	48(83)	60(88)	255(82)

5.2.1 Use of personal protective equipment by farm labourers

Information was collected from the farm labourers on their personal hygiene and the use of protective equipment. Ignorance to the hazards associated with pesticides was evident among this group of workers with 81% indicating that they always changed clothes after work, 89% always taking a shower after work and 68% always having a wash at break time. Although these responses were not very different from those provided by the foremen, higher percentages of farm labourers had a drink while at work (93%), ate at work (67%) and smoked at work (31%). With regard to the use of personal protective equipment, gloves were always used by 43% of the farm labourers when handling pesticides, 60% kept a separate set of clothes for work, 32% always used a scarf when spraying pesticides and 82% always used shoes when working on the farm. Table 5-4 shows the details of personal hygiene and use of protective equipment as practised by farm labourers in the five farming areas.

In the farming areas of Hayer and Ramah the lowest percentages of farm labourers changed clothes after work, took a shower and had a wash at break time. In these farming areas lowest percentages of farm labourers used gloves or used separate clothes to work on the farm. Eating, drinking and smoking while at work was practiced less often by the workers in the farming areas of Hayer and Ramah. Fewer farmworkers in Hayer used scarf to cover their nose and mouth and fewer workers in Ramah used shoes while on the farm.

The farm labourers in Hayer and Ramah displayed poorer personal hygiene and used protective measures less frequently compared to their counterparts in the other farming areas. Higher percentages of farm labourers taking a drink while at work, compared to the foremen, is understandable because of the climatic conditions. Moreover, these workers are also more hardworking than the foremen and therefore may need to take a drink and have a snack more often. However, the less frequent use of protective equipment could only be explained by their ignorance of the health hazards. The type of gloves available in this region makes it difficult for these workers to wear them at all times because of the high humidity and temperature. Secondly, since these items are not provided by the farm owner, the user has to bear the cost of providing these items for self-protection. The effect of poor personal hygiene and minimal use of personal protection while handling pesticides have been described by Gomes *et al*, (1998).

5.2.2 Summary and discussion of the use of protective measures and practice of personal hygiene on the farm

The different items of protective equipment were worn regularly by only a minority of the farmworkers (foremen and farm labourers) - gloves were used by 35% of the farmworkers, coveralls at work by 36% of the farmworkers, scarf for covering of the head and face by 39% of the farmworkers and shoes at work by 79% of the farmworkers. The use of protective equipment by farmworkers varied between the different farming areas and are shown in Fig. 5-3. Farmworkers in areas Ramah and Gumadh were significantly less likely than those in other areas to be self-protective by (Fig. 5-3) using coveralls ($p<0.0001$), by partly covering the face and mouth with a scarf while spraying ($p<0.0001$), by changing clothes ($p<0.0001$) and by taking a shower after work ($p<0.0001$). The use of shoes (p<0.001) by the farmworkers in Ramah and Gumadh was also less compared to the other farming areas.

Awareness to personal hygiene was higher than awareness to domestic hygiene among the farmworkers. For measures of personal hygiene, clothing was changed after work by 83% of the farmworkers and showering after work was practised by 83% of the farmworkers. For measures of domestic hygiene, articles of domestic use, such as spoons, ladles and buckets were used by 11% of the farmworkers in the preparation of pesticides for spraying, pesticide containers were disposed of by throwing them on the farmland by 59% of the farmworkers, drinking water or tea and eating snacks on the farm while at work was practised by 63% and 46% respectively and among the smokers 79% of the smokers smoked on the farm. The practise of domestic hygiene (Fig. 5-4) by farmworkers in Ramah and Gumadh was poor as compared with that by the workers in the other three areas. The farmworkers in the farming areas Ramah and Sleimat employed articles of domestic use more frequently in the preparation of pesticides (p<0.0001) and workers in Ramah and Gumadh and smoked

Table 5-5: Pearson correlation coefficients for AChE and HAChE activity levels and use of personal protection measures and practice of hygiene

Parameters	AChE		HAChE	
	PCC	p-value	PCC	p-value
Gloves	0.097	0.03	0.167	0.002
Coverall	0.200	0.0001	0.229	0.0001
Scarf	0.085	0.05	0.120	0.003
Shoes	0.062	NS	0.095	0.03
Having a drink while at work	-0.144	0.001	-0.521	0.0001
Having to eat while at work	-0.182	0.0001	-0.216	0.0001
Having a smoke while at work	-0.116	0.007	-0.092	0.03
Changing of clothes after work	-0.007	NS	-0.101	0.02
Use of domestic articles on farm	-0.033	NS	0.107	0.01
Discarding containers on the farm	-0.127	0.003	-0.099	0.02
Frequency of spraying pesticides	-0.155	0.0001	-0.173	0.0001
Training	0.145	0.001	0.103	0.02

PCC Pearson correlation coefficients

frequently while working on the farm ($p<0.05$) (Fig. 5-4). Workers in Ramah and Gumadh also had a drink on the farm very often ($p<0.05$) while workers in Hayer ate more frequently while at work ($p<0.0001$).

The preparation of pesticides for spraying was usually (96%) done on the farm. Most workers (96%) were asked (either always or frequently) to prepare pesticides for spraying, although fewer (61%) were required to spray the pesticides on the crops; moreover, only around half of them (53%) had received some formal relevant training. Farm labourers were usually given training by the foremen, who had in turn been verbally instructed at one time by governmental agencies on the precautions to be taken during the preparation and spraying of pesticides. Prepared pesticides left unused were usually (96%) disposed of by over-spraying on the crops. Differences in these practices were observed between the individual farming areas in the handling of pesticides (Fig. 5-5). Fewer farmworkers in Ramah and Gumadh had been trained in the handling of pesticides ($p<0.0001$) and were required to prepare the pesticides significantly less frequently ($p<0.0001$) compared with the other three farming areas. Farmworkers in Ramah and Gumadh also prepared pesticides on the farm significantly less frequently ($p<0.0001$) than those in the other three farming areas. In Hayer and Gumadh the spent pesticide packings were more often discarded on the farm or the home garbage (Fig. 5-5).

AChE levels showed significantly positive correlation with the use of gloves ($p=0.03$), of work coveralls ($p=0.0001$) and of a face scarf ($p=0.05$) and with the extent of training ($p=0.0001$) but revealed negative correlation with the habit of drinking while at work ($p=0.0001$), eating while at work ($p=0.0001$), smoking ($p=0.007$) and discarding of used pesticide containers on the farm ($p=0.003$), with the frequency of spraying of pesticides ($p=0.0001$) and having been trained ($p=0.001$) (Table 5-5). HAChE levels showed positive correlation with the use of work coveralls ($p=0.0001$), a face scarf ($p=0.003$) and shoes ($p=0.03$) and with

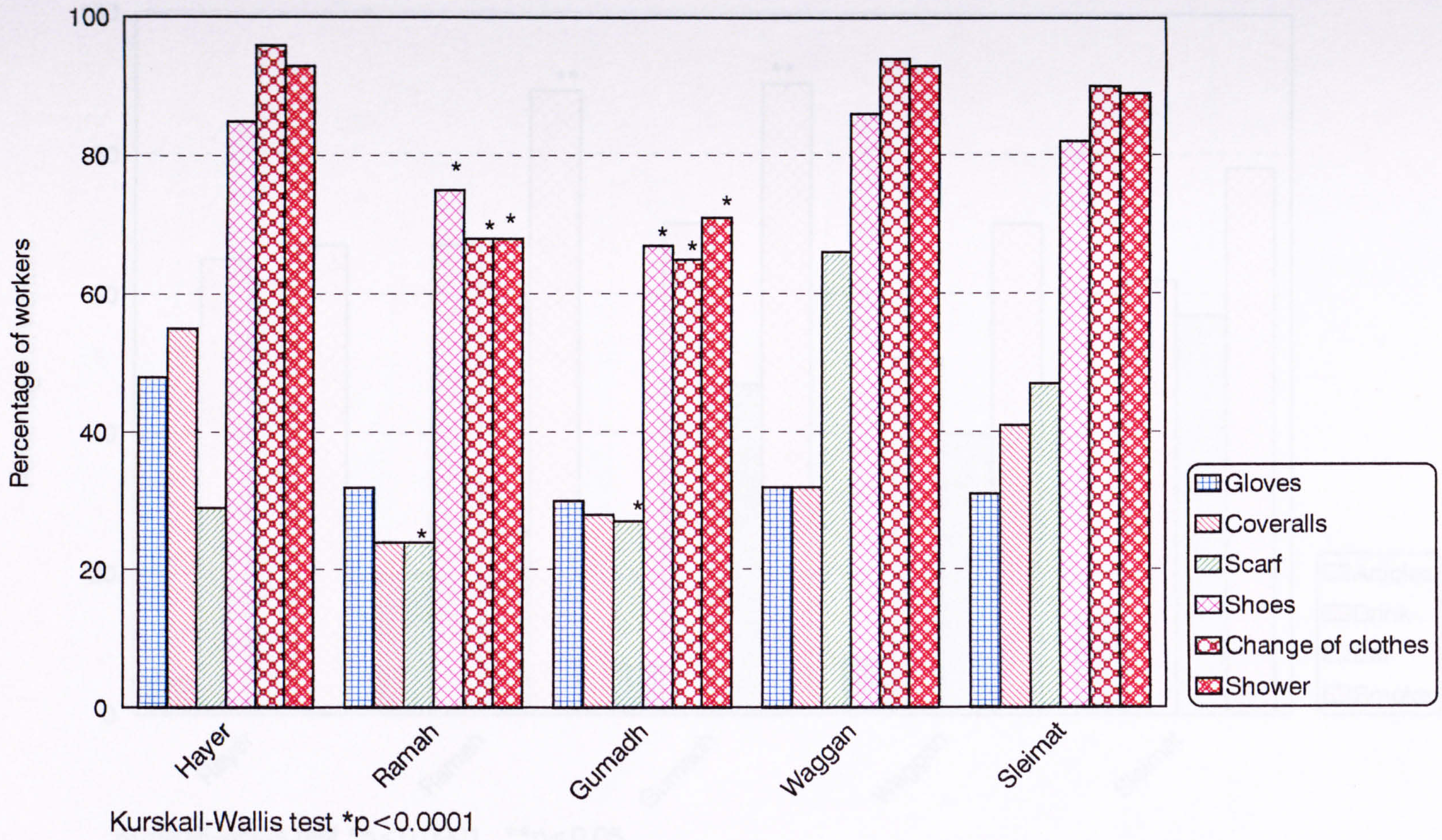
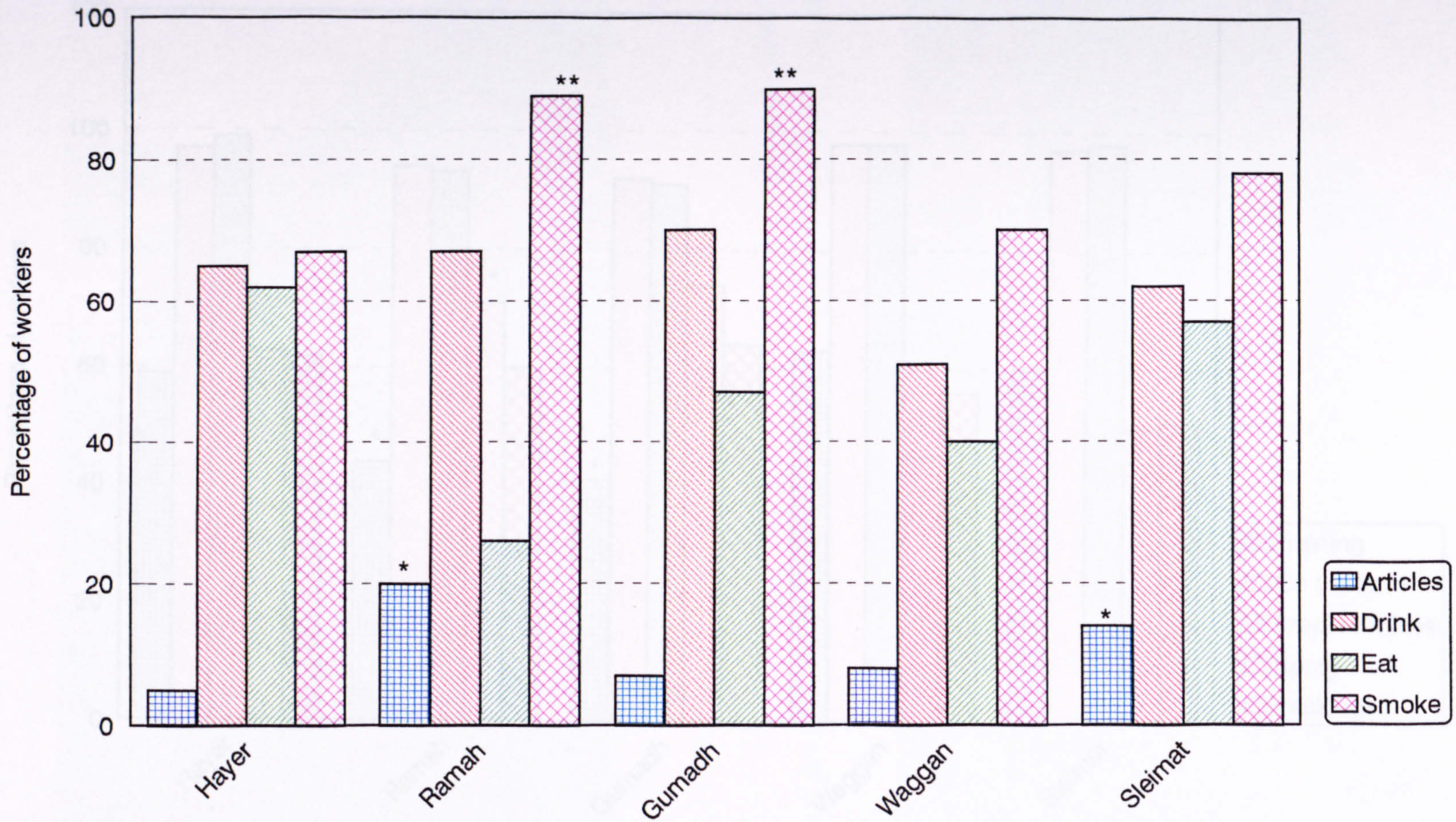


Fig. 5-3: Use of protective equipment by farmworkers reported as used always



Kurskall-Wallis test *p<0.0001, **p<0.05

Fig. 5-4: Personal practices on the farm reported as used always

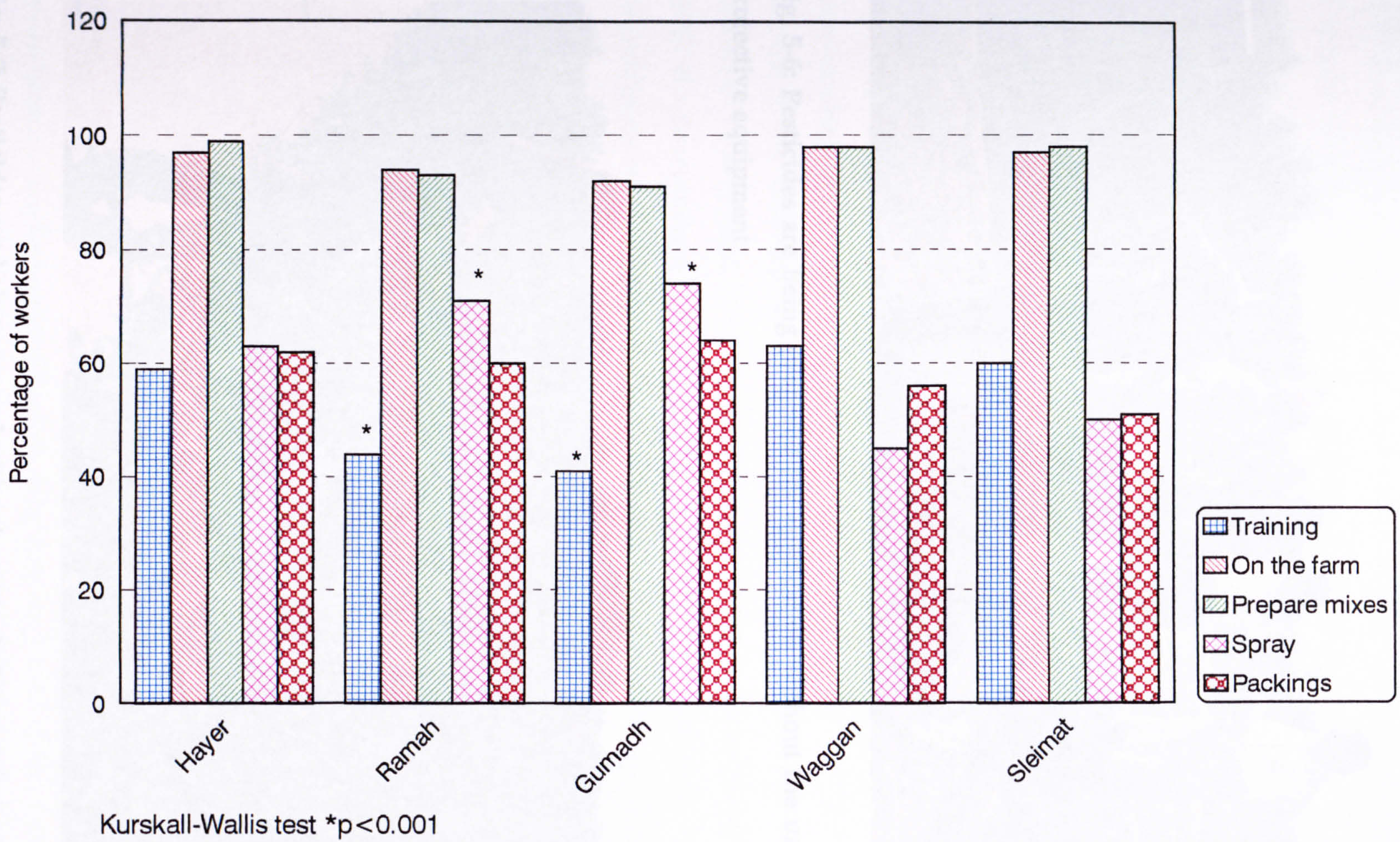


Fig. 5-5: Training and handling of pesticides on the farm reported as trained and engage in jobs always

Fig. 5-6: Pesticides are being prepared for application without the use of any protective equipment

Fig. 5-7: Pesticides are being sprayed without any protective equipment.

being formally trained (p=0.01) but negative correlation were found with the habit of eating (p=0.0001), habit of drinking (p=0.0001), smoking while at work (p=0.03), disposal of used pesticide containers on the farm (p=0.02), application of articles of domestic use in the preparation of pesticides (p=0.01) and the frequency of spraying of pesticides (p=0.0001). The application of the logistic regression model indicated that the AChE activity level was significantly predicted by the non-use of coveralls and of scarf while at work, the lack of training and the long period of exposure. Non-significant contributors to the model included the spraying of pesticides, the in-frequency of the use of gloves and the drinking of water while at work.

Farming has not been recognised locally as a hazardous industry, and the possibility of pesticide use being detrimental to the farmworkers' health has not been considered as reported in other studies (Maddy *et al,* 1990; London and Meyers, 1995). Illiteracy and a lack of proper training have been two great handicaps among these workers. As happens elsewhere (Sivayoganathan *et al,* 1995), the farmworkers viewed personal protective equipment as non-essential and cumbersome. The reluctance to wear protective equipment was reinforced by the tropical and semi-desert type of environment, which encouraged workers to operate with minimal clothing and with their hands and faces exposed (Fig. 5-8 and Fig. 5-9). It was fortunate that the scarf, which is culturally a part of the local attire, was readily convertible into a face mask and head cover, for despite its limitations, its use was one of the factors that gave significant protection against the pesticide exposure.

AChE activity levels were used as a marker of pesticide exposure for assessment of the use of protective measures and safety procedures on the farms (Rama and Jaga, 1992; Gomes *et al,* 1997). The association between AChE depletion and the non-use of personal protection confirmed that the lack of safety and hygiene procedures on the farm was adversely affecting the health of the farmworkers. The greater depletions of the enzyme in Ramah and Gumadh correlated well with less use of personal hygiene and higher frequency of spraying of pesticides on the crops. The absence of significant differences in the literacy levels in the five farming areas showed that it was not realistic to expect that some of the workers would use their literacy for reading of pictograms and labels to enable the group as a whole to follow the safety and hygiene procedures adequately. In Ramah and Gumadh, examples of extremely bad practice were noted - four cases where pesticides were kept on kitchen shelves next to food and two cases where pesticides were stored under beds. However, dramatically harmful consequences were not observed in any of these cases.

The farmworkers require instructions in basic hygiene in understanding of the pictograms and in pesticide toxicity. Farmworkers in general also tend not to follow instructions on the containers (London, 1992); in this study this failure was inevitable due to the widespread illiteracy and lack of basic safety instructions. The deficiencies in personal hygiene were not unique to this study, because the habit of eating and drinking without first washing the hands and the face has been observed in farms in other developing countries (London and Meyers, 1995). Proper training in handling of pesticides, education on the hazards of pesticide exposure and the use of the appropriate protective equipment would diminish substantially the health hazards currently facing these workers, thereby reducing the probability of consequent illness (Wiklund *et al,* 1989; Al-Saleh, 1994; Kogevinas *et al,* 1995; Viel and Chablier, 1995).

5.3 *Morbidity patterns among farmworkers*

The farmworkers (foremen and farm labourers) voluntarily came forward to participate in the study when they were requested to do so and this is reflected by the very high compliance rates. The farmworkers were interested in knowing if their health was being adversely affected by exposure to pesticides while working on the farm. However, they were reluctant to discuss the status of their health, which could be because of the following reasons. Firstly, they were afraid that their health condition might be reported to the farm owner and that they may lose their job for complaining. Secondly, they wished to know if there was a medical doctor available in the survey team and if the team was in a position to provide medical drugs for their condition. It is for this reason that it was decided that, in order to get a correct assessment of the health of the farmworkers it would be necessary to get the farmworkers to a clinic and to conduct the medical assessment confidentially.

5.3.1 *Results of the morbidity profile*

The study population consisted of 226 established farmworkers (almost all of whom had been given appointment to visit the clinic during the field visit), 92 new farmworkers and 226 unexposed workers. The established farmworkers were matched with unexposed for age and nationality. The response rate was 99%; six people (one control, one farmworker and 4 new farmworkers) did not participate in the study because of lack of communication skills or because they were afraid to provide a blood sample. The study population, which was mainly ethnic Asians, comprised Pakistanis (30%), Indians (29%), Bangladeshis (28%), Egyptians (9%) and Others (4%: Iranians, Jordanians, Sudanese, Syrians and Yemenis). The mean and standard deviations of the systolic and diastolic blood pressures of the study population were 119.1±15.5 mm of Hg and 80.4±11.7 mm of Hg respectively. Systolic and diastolic blood pressures and pulse were not statistically different between the three groups of the study population.

Many of the morbidity parameters showed statistically significant differences between the established farmworkers, new farmworkers and controls. Higher percentages of farmworkers than controls reported (often or sometimes) irritated conjunctiva (47% compared to 16%), watery eyes (52% to 4%), blurred vision (63% to 7%), running nose (36% to 9%), wheeze (18% to 6%) and chest tightness (18% to 5%). Table 5-6 shows these differences which were all statistically highly significant. Among the 108 farmworkers who sometimes experienced blurred vision, 14% (15/108) reported sometimes experiencing double vision. For the 35 farmworkers who often experienced blurred vision 40% (14/35) reported the same experience.

Established farmworkers also reported, in significantly higher numbers, dizziness (55% compared to 14%), headache (64% to 18%), restlessness (41% to 0%) and sleeplessness (48% to 4%). These differences among established farmworkers, new farmworkers and controls are reported in Table 5-7. Muscular pain, abdominal pain and weakness were more frequently experienced by established farmworkers than controls (often or sometimes) in the previous month, 69% compared to 8%, 61% to 4% and 77% to 10% respectively. Table 5-8 shows these differences among the three groups of workers.

The type of job (farming or non-farming) was a highly significant predictor of weakness, abdominal pain, blurred vision, muscle pain, restlessness and to a lesser extent sleeplessness in the affected population (Table 5-9). AChE depletion (described in Section 5.4) significantly predicted weakness and blurred vision highly significantly and less significantly muscular pain, headache and chest tightness.

5.3.2 Summary and discussion of morbidity profile among farmworkers

Greater percentages of farmworkers reported or were observed to have irritated conjunctiva, watery eyes and / or blurred vision compared to the new farmworkers and controls. Running nose and respiratory problems were reported as experienced more often by greater percentages of farmworkers compared to the new farmworkers and the control population. Skin rash was reported by about 8% of the farmworkers compared to about 4% of the control population. Details of skin problems were not collected, however, Fig. 5-8 shows a medically diagnosed dermatitis case in Hayer. Dizziness, headache, restlessness and sleeplessness were reported in significantly greater numbers by farmworkers compared to the control and the new farmworkers. Muscle pain, abdominal pain and weakness were also reported in significantly greater numbers by farmworkers compared to the control and the new farmworkers. Pain in the extremities and breathlessness were reported in marginally greater numbers by farmworkers compared to the controls and the new farmworkers. The level of

Table 5-6: Eye problems, respiratory problems and skin allergy among Unexposed, Established Farmworkers and New Farmworkers

		Unexposed No. (%)	Farmworkers No. (%)	New Farmworkers No. (%)	p-value*
Conjunctiva	Irritated	36 (15.9)	107 (47.3)	16 (17.4)	
	Normal	190 (84.1)	119 (52.7)	76 (82.6)	p<0.0001
Watery eyes	No	217 (96.0)	108 (47.8)	92 (100)	
	Sometimes	9 (3.9)	108 (47.8)	0 (0.0)	
	Often	0 (0.0)	10 (4.4)	0 (0.0)	p<0.0001
Blurred Vision	No	210 (92.9)	83 (36.7)	92 (100)	
	Sometimes	15 (6.6)	108 (47.8)	0 (0.0)	
	Often	1 (0.4)	35 (15.5)	0 (0.0)	p<0.0001
Running Nose	No	205 (90.7)	143 (63.3)	89 (96.7)	
	Sometimes	21 (9.3)	78 (34.5)	3 (3.3)	
	Often	0 (0.0)	5 (2.2)	0 (0.0)	p<0.0001
Respiratory Problems	Normal	201 (88.9)	145 (64.2)	92 (100)	
	Wheezy	14 (6.2)	41 (18.1)	0 (0.0)	
	Tightness	11 (4.9)	40 (17.7)	0 (0.0)	p<0.0001
Skin Rash	No	217 (96.0)	209 (92.5)	92 (100)	
	Yes	9 (3.9)	17 (7.5)	0 (0.0)	NS

* Chi square test between Unexposed, Farmworkers and New Farmworkers for either presence or absence of the morbidity parameter.
NS - Statistically not significant

Table 5-7: Dizziness, Headache, Restlessness and Sleep Disturbances among Unexposed, Established Farmworkers and New Farmworkers

		Unexposed No. (%)	Farmworkers No. (%)	New Farmworkers No. (%)	p-value*
Dizziness	No	194 (85.8)	101 (44.7)	90 (97.8)	
	Sometimes	30 (13.3)	107 (47.3)	2 (2.2)	
	Often	2 (0.9)	8 (7.9)	0 (0.0)	p<0.0001
Headache	No	186 (82.3)	82 (36.3)	89 (96.7)	
	Sometimes	33 (14.6)	110 (48.7)	3 (3.3)	
	Often	7 (3.1)	34 (15.0)	0 (0.0)	p<0.0001
Restlessness	No	226 (100)	134 (59.3)	92 (100)	
	Sometimes	0 (0.0)	92 (40.7)	0 (0.0)	p<0.0001
Sleeplessness	No	217 (96.0)	118 (52.2)	92 (100)	
	Sometimes	9 (3.9)	101 (44.7)	0 (0.0)	
	Often	0 (0.0)	7 (3.1)	0 (0.0)	p<0.0001

* Chi square test between Unexposed, Farmworkers and New Farmworkers for either presence or absence of the morbidity parameter.

Table 5-8: Muscle and Abdominal Pain and Weakness among Unexposed, Established Farmworkers and New Farmworkers

		Unexposed No. (%)	Farmworkers No. (%)	New Farmworkers No. (%)	p-value*
Muscle Pain	No	207 (91.6)	71 (31.4)	92 (100)	
	Sometimes	17 (7.5)	127 (56.2)	0 (0.0)	
	Often	2 (0.9)	28 (12.4)	0 (0.0)	p<0.0001
Abdominal Pain	No	218 (96.5)	88 (38.9)	92 (100)	
	Sometimes	8 (3.5)	125 (55.3)	0 (0.0)	
	Often	0 (0.0)	13 (5.8)	0 (0.0)	p<0.0001
Weakness	No	204 (90.3)	53 (23.5)	89 (96.7)	
	Sometimes	20 (8.8)	120 (53.1)	3 (3.3)	
	Often	2 (0.9)	53 (23.5)	0 (0.0)	p<0.0001

* Chi square test between Unexposed, Farmworkers and New Farmworkers for either presence or absence of the morbidity parameter.

Table 5-9: Prediction of morbidity parameters for Farm work and Erythrocyte Acetylcholinesterase (AChE) activity depletion by multiple regression analysis.

Parameters	Farm work			AChE depletion		
	B*	95% CI**	p=***	B*	95% CI**	p=***
1. Weakness	0.261	0.165-0.359	0.0001	-0.209	-0.179--0.036	0.003
2. Abdominal pain	0.315	0.190-0.440	0.0001	0.005	-0.087-0.098	NS
3. Blurred vision	0.182	0.077-0.286	0.0001	-0.098	-0.175--0.023	0.01
4. Muscle pain	0.170	0.055-0.062	0.002	-0.045	-0.124-0.034	NS
5. Restlessness	0.379	0.222-0.535	0.0001	0.044	-0.072-0.159	NS
6. Headache	0.034	-0.058-0.128	NS	-0.065	-0.133-0.001	0.05
7. Sleeplessness	0.142	0.012-0.273	0.03	0.049	-0.046-0.143	NS
8. Chest tightness	0.032	-0.051-0.114	NS	-0.055	-0.131-0.065	0.05
9. Watery eyes	0.059	-0.076-0.194	NS	-0.033	-0.076-0.079	NS
10. Dizziness	0.023	-0.511--0.28	NS	0.001	-0.076-0.079	NS

NS - Not significant
* Slope of regression line
** 95% confidence interval
*** Two tailed observed significance level

activity and the living conditions among the farmworkers and the control were pretty much similar though the farmworkers lived on the farms and the control population either lived in industrial camps or rented and shared rooms in community centers. Weakness, abdominal pain, blurred vision, muscle pain, restlessness and sleeplessness were significant predictors of farm work as identified by multiple regression analysis.

There is a tendency among farmworkers to disregard health and safety measures and treat pesticides and any toxic chemicals as harmless substances and are therefore, potential targets for exposure and for subsequent adverse health effects (London and Meyers, 1995). Any sub-clinical morbidity they experience is usually discounted as general malaise which will pass away the following day. They are also reluctant to seek medical advice because of the fear of losing their jobs (Lantz *et al,* 1994). Chronic health effects are under-reported and usually are not linked in their minds with ill-health from pesticide exposure, even though the exposure is occupational (McDougall *et al,* 1993). Statistically significant negative relationships have been observed between the use of protective measures and symptoms experienced within hours of exposure after the application of pesticides on a farm (Sivayoganathan *et al,* 1995). Anxiety, nausea, vomiting, weakness, headache and dizziness have been suggested as potential predictors of pesticide illness (Sivayoganathan *et al,* 1995; Lessenger *et al,* 1995). In this study a wide range of symptoms experienced often or sometimes by farmworkers but not by controls were restlessness, sleeplessness, weakness, headache, muscular pain, abdominal pain, pain in the extremities, allergic reactions including irritated conjunctiva, watery eyes, blurred vision, running nose, wheeze and chest tightness. Similar allergic reactions among farmworkers have been reported by Ihelin and Hoglund (1994). Gupta *et al,* (1995) have reported a similar morbidity pattern pertaining to the central nervous system, skin and eyes from exposure to pesticides.

Morbidity patterns among farmworkers constituted higher frequencies of restlessness, sleeplessness, weakness, headache, muscular pain, abdominal pain,

Fig. 5-8: Dermatitis of the hand in a farmworker in Gumadh from exposure to pesticides.

Fig. 4-9: Members of the survey team are seen taking a blood sample for erythrocyte acetylcholinesterase activity measurement and applying a questionnaire to another worker in Hayer.

blurred vision, chest tightness and allergic reactions including irritated conjunctiva, watery eyes, running nose and wheeze. This list of health complaints could be used to monitor the health status of the farmworkers and to assess the effectiveness of the use of protective measures by these workers. Monitoring of these parameters could help to identify sub-clinical toxicity at an early stage and thereby prevent the clinical manifestations at a later date (Gomes *et al,* 1998). Low level exposure to pesticides induces a state of sensitization (Assini *et al,* 1994) among farmworkers, who therefore reduce their exposure and thereby reduce the possibility of mild chronic intoxication. Manifestations of acute clinical toxicity are not commonly seen in farmworkers, but sub-clinical toxicity is prevalent, which could culminate in a debilitating pesticide-related chronic disease. Monitoring the parameters identified in this study could help in identifying sub-clinical toxicity at an early stage and thereby prevent the clinical manifestation of a pesticide-related chronic disease at a later date.

5.4 Biomarkers of exposure to cholinesterase-inhibiting pesticides

Exposure to pesticides poses a significant risk in rural farming populations of developing countries in particular, because the users do not understand pesticide packing labels, are not persuaded to follow any instructions and are not trained in farm hygiene or in the use of protective equipment (Helmers *et al,* 1990, McDougall *et al,* 1993). In developing countries like the UAE, these workers are all expatriates from third world countries and tend to be socio-economically disadvantaged. These workers are reluctant to demand any protection or even seek medical treatment because of the fear of losing their jobs and being deported to their home country. Increased efforts are required to study chronic exposure effects, particularly neuro-behavioural effects, long term neurological dysfunction (Moses *et al,* 1993) and other symptoms and signs compatible with cholinesterase inhibition (Markowitz, 1992). A dose response relationship between exposure and cholinesterase depression has been reported by Rama and Jaga (1992) and Yamanaka *et al,* (1993).

Erythrocyte acetylcholinesterase activity (AChE) in the red blood cells and butarylcholinesterase activity in plasma have been used to monitor the extent of organophosphate and carbamate exposure (Rama, 1994; Marrs, 1993). The use of AChE as a useful biomarker for chronic pesticide toxicity has been reported by Walker (1992), Meuling *et al,* (1992), and McConnell and Magnotti (1994). London *et al,* (1995) reported excellent sensitivity and specificity for AChE using a spectrofluorometric field kit. Neurodegenerative diseases have also been suggested from chronic exposure to pesticides (Cannes *et al,* 1992) and postural sway has been used in the assessment of neurological dysfunction (Sack *et al,* 1993). Memory disorders have also been reported (Sereda and Gromov, 1994) in subjects from chronic exposure to organophosphorus pesticides at pesticide manufacturing plants. Aiming Tests (AT) and Digit Symbol Tests (DST) have been reported to have been used in assessing neuromuscular dysfunction in workers occupationally exposed to organic solvents (Foo *et al,* 1994) but not in farmworkers.

In this study the use of AChE measurement to assess the level of exposure among the farmworkers from chronic exposure to cholinesterase-inhibiting pesticides and to determine the suitability of this biomarker in the local environmental conditions and across different nationalities. Inter-individual variability of the AChE activity have been reported but inter-ethnic differences had not been explored. The use of AT and DST have been made for the first time, in this study, in the assessment of neurological dysfunction, memory disorder and loss of neuromuscular co-ordination. Therefore AChE, AT and DST have been proposed as possible markers for the assessment of chronic exposure to cholinesterase-inhibiting pesticides.

5.4.1 Acetylcholinesterase activity levels among farmworkers

The population of 532 farmworkers and 532 unexposed workers comprised Bangladeshis (38%), Egyptians (28%), Pakistanis (17%), Indians (13%) and Others (Iranians, Syrians, Palestinians, Sudanese and Sri Lankans, 4%) The mean±SD ages of the farmworkers and the unexposed population were 35.2±7.4 and

34.6±7.1 years, respectively. The mean systolic blood pressure (mm Hg) of the farmworkers and unexposed subjects were 117.5±8.2 and 117.3±13.49 and the mean diastolic blood pressures were 78.1±8.2 and 78.9±11.3 respectively. The mean haemoglobin levels for the exposed and unexposed groups were 12.96±1.47 g/dl and 12.93±0.83 g/dl, the mean AChE activities were 3.89±0.64 UI/ml and 4.15±0.29 UI/ml and haemoglobin adjusted erythrocyte acetylcholinesterase (HAChE) levels were 29.9±4.14 UI/g and 32.1±2.26 UI/g respectively.

The total combined period of work for farmworkers in their home country and in the UAE was 5.33±2.5 years for foremen and 3.12±2.6 years for farm labourers and 4.12±4.7 years for the unexposed. In the UAE alone their mean periods of service were 1.99±1.6 years and 3.72±3.7 years for foremen and farm labourers respectively. Table 5-10 shows the means for the age, years of exposure and AChE activity levels for the foremen, the farm labourers and the unexposed population. AChE and HAChE levels in foremen were statistically significantly lower than the levels in farm labourers, which in turn were significantly lower than in the controls (unexposed). The foremen, presumably had greater and a longer contact with pesticides and hence were subjected to greater exposure compared to the farm labourers and the unexposed subjects. Fig. 5-9 shows the application of the AChE test under field conditions.

Demographic characteristics and enzyme differences between the farmworkers working in greenhouses and open farms did not show any statistical significance. The AChE, haemoglobin and HAChE activity levels among the foremen and farm labourers in the five farming areas are shown in Table 5-11. The differences in AChE and HAChE activity levels were significant in the five farming areas compared with the population mean. Hayer and Ramah had the lowest AChE and HAChE activity for foremen and farm labourers. Among all the farmworkers the AChE and the HAChE activity levels were also significantly lower in Hayer and Ramah and Gumadh. The AChE activity levels for the foremen, farm labourers and the farmworkers were significantly lower in all the five farming

Table 5-10: The mean ages, years of service and the enzyme profiles among the foremen, farm labourers and the unexposed workers.

	Foremen	Farm labourers	Unexposed	95%CI for diff. Foremen & farm labourers	95% CI for diff. Foremen & Unexposed	95% CI for diff farm labourers & Unexposed
Age (yrs)	40.53±3.4	31.37±7.2	34.58±3.2	-10.08, -8.24	5.19, 6.71	-4.22, -2.21
Years of service (yrs)	5.33±2.5	3.12±2.61	4.12±2.2	-2.65, -1.77	0.69, 1.72	-1.50, -0.52
AChE (UI/ml)	3.76±0.69	3.99±0.59	4.15±0.78	0.12, 0.34*	-0.49, -0.28*	-0.23, -0.09*
Haemoglobin (g/dl)	12.78±1.74	13.08±1.22	12.93±1.33	0.04, 0.57*	-0.39, 0.09*	-0.00, 0.03*
HAChE (UI/ml)	29.19±4.37	30.51±3.88	32.10±3.50	0.59, 2.0*	-3.52, -2.29*	-2.07, -1.12*

* p-value <0.0001

Table 5-11: The enzyme activity levels and haemoglobin levels for foremen, farm labourers and farmworkers in the five farming areas.

	Hayer n=34 farms	Ramah n=36 farms	Gumadh n=42 farms	Sleimat n=59 farms	Waggan n=50 farms
Foremen	n=34	n=36	n=42	n=59	n=50
AChE (UI/ml)	3.54±0.59*	3.62±0.68*	3.70±0.96*	3.94±0.55*	3.84±0.56*
HAChE (UI/ml)	27.99±3.93*	28.10±4.19*	28.40±5.96*	30.52±3.38***	29.97±3.78***
Haemoglobin (g/dl)	12.36±2.93	12.43±2.20	13.29±1.15	12.96±1.26	12.66±0.98
Farm labourers	n=78	n=49	n=59	n=58	n=67
AChE (UI/ml)	3.87±0.66*	3.83±0.54*	4.07±0.52***	4.04±0.61***	4.09±0.58***
HAChE (UI/ml)	28.97±3.49*	28.75±3.78*	30.49±3.21***	31.89±4.04***	32.20±3.64
Haemoglobin (g/dl)	13.37±1.22	13.23±1.26	13.32±1.23	12.87±0.99	12.68±1.24
Farmworkers	n=112	n=85	n=101	n=117	n=117
AChE (UI/ml)	3.73±0.74***	3.70±0.58*	3.79±0.66*	3.99±0.58***	3.98±0.58***
HAChE (UI/ml)	29.58±4.60*	28.78±3.62*	28.47±3.96*	31.20±3.77	31.25±3.85
Haemoglobin (g/dl)	13.30±1.10	12.80±2.10	13.10±1.70	12.90±1.10	12.70±1.10

* p-value <0.0001 (ANOVA)
*** p-value <0.05 (ANOVA)

areas compared to the corresponding levels in the unexposed population. The HAChE activity levels were also lower for all the workers in all the areas except for farm labourers in Waggan compared to the corresponding levels in the unexposed population.

The AChE activity levels, haemoglobin levels, HAChE activity levels and the period of exposure among the foremen and farm labourers according to their nationalities are shown in Table 5-11. The AChE and the HAChE activity levels differed widely among the different nationality groups for foremen, farm labourers and the controls and so did the exposure periods. The relationships between nationality and AChE activity, haemoglobin levels, HAChE activity and years of exposure are reported by Gomes *et al,* (1997). Indian foremen and farm labourers showed least enzyme depletion and also lowest exposure periods except the Others. Pakistanis and Egyptians foremen and farm labourers showed higher depletions and were also exposed for longer periods. The foremen in each of the nationality groups showed lower AChE activity levels and also had longer exposure compared to the farm labourers. The inter-nationality differences between the AChE and the HAChE activity levels for the foremen, farm labourers and the controls were statistically significant and so were the farming exposures. Within each nationality groups the foremen showed lowest AChE activity followed by farm labourers. The differences in the AChE and HAChE activity levels showed marginal variability in the control group. The differences in the haemoglobin levels were not statistically significant for the different nationality groups.

The farms in each area though showed considerable homogeneity in terms of crops, type of soil, type of pests, type of pesticides and frequency of pesticide usage, but wide inter-farming-area differences were noted. The types of individual pesticides used varied from area to area, but within the same generic groups of Organophosphates, Carbamates, Pyrethroids and Organochlorines there were broad similarities. The frequency of pesticide usage and the dilution

Table 5-12: Enzyme characteristics and years of service for foremen, farm labourers and unexposed workers according to their nationalities.

Nationalities	AChE (UI/ml)			Haemoglobin (g/dl)			HAChE (UI/g)			Service period (yrs)		
	Mean	Median	95%CI	Mean	Median	95%CI	Mean	Median	95% CI	Mean	Median	95% CI
Bangladeshi												
Foremen (n=54)	3.99	3.94	3.84-4.14	12.72	12.80	12.42-13.02	31.20	31.40	30.29-32.11	4.93	5.00	4.40-5.45
Farmlabo (n=153)	4.06	4.04	3.96-4.16	12.98	13.00	12.78-13.19	31.19	31.40	30.53-31.85	2.83	2.00	2.44-3.21
Controls (n=207)	4.16	4.20	4.11-4.20	12.88	12.90	12.75-13.01	32.20	32.50	31.83-32.58	2.85	2.00	2.16-3.54
Egyptians												
Foremen (n=109)	3.69	3.64	3.56-3.83	12.97	13.00	12.58-13.35	28.03	28.30	27.13-28.93	5.39	5.00	4.86-5.91
Farmlabo (n=39)	3.79	3.83	3.62-3.95	13.20	13.00	12.80-13.60	28.99	28.70	27.92-30.06	4.77	4.00	3.68-5.86
Controls (n=148)	4.33	4.30	4.25-4.40	13.10	13.00	12.75-13.44	33.20	32.70	32.67-33.73	0.87	0.00	0.03-1.72
Indians												
Foremen (n=12)	4.03	3.73	3.58-4.48	13.09	13.00	12.17-14.01	30.95	30.60	29.21-32.69	4.92	5.00	3.32-6.51
Farmlabo (n=57)	4.09	4.01	3.96-4.23	13.59	13.70	13.28-13.90	30.17	29.70	29.37-30.97	2.49	2.00	2.00-2.98
Controls (n=69)	4.15	4.18	4.11-4.19	13.01	12.90	12.88-13.14	31.99	31.90	31.66-32.32	5.23	4.00	4.59-5.86
Pakistanis												
Foremen (n=39)	3.55	3.75	3.32-3.77	12.23	12.50	11.66-12.80	29.13	29.50	27.80-30.47	5.59	5.00	4.99-6.19
Farmlabo (n=49)	3.80	3.65	3.63-3.97	12.88	12.80	12.60-13.16	29.57	29.20	28.49-30.64	3.78	3.00	2.92-4.63
Controls (n=88)	4.12	4.08	4.07-4.17	12.87	12.80	12.76-12.98	31.95	31.90	31.59-32.30	4.32	3.00	3.52-5.11
Others												
Foremen (n=7)	3.74	3.55	3.23-4.24	12.81	12.90	12.18-13.45	29.26	28.80	26.59-31.93	6.71	7.00	3.44-9.99
Farmlabo (n=13)	3.91	3.79	3.62-4.21	12.47	12.20	11.74-13.20	32.01	34.40	29.28-34.74	1.77	2.00	1.21-2.33
Controls (n=20)	4.02	3.96	3.89-4.16	12.48	12.60	11.99-12.97	32.40	31.90	31.17-33.62	3.18	0.00	0.48-6.85

Table 5-13: Prediction of significant contributors of the erythrocyte acetylcholinesterase (AChE) activity using multiple regression analysis.

Variables	B	SE B	Beta	t	p-value
Dependent variable:	AChE				
Independent variables:					
Pesticide usage	0.100	0.0133	0.303	7.57	0.0001
Intensity of exposure	0.066	0.0325	0.095	2.05	0.05
Nationality	0.033	0.0147	0.071	2.25	0.05
Period of exposure	0.017	0.0068	0.091	2.59	0.01
Haemoglobin	0.212	0.0128	0.497	16.5	0.0001
Dependent variable:	HAChE				
Independent variables:					
Pesticide usage	0.949	0.1010	0.432	9.41	0.0001
Intensity of exposure	0.779	0.2470	0.169	3.16	0.001
Period of exposure	0.097	0.0516	0.075	1.87	0.06

B *Slope of regression curve*
SE B *Standard error of B*
Beta *Standardized regression coefficient*
t *Student's t-test*
p *Two tailed observed significance level*

ratios also differed in the different farming areas, probably depending on the prevalence of the pests and the type of crops currently under cultivation. While the usage of pesticides by type remained broadly similar in the different farming areas the pesticide usage by weight differed with Ramah and Sleimat using the highest amounts.

To assess the statistical significance of the contribution by the covariates of pesticide exposure, a regression model was designed and tested using AChE and HAChE activity levels as the dependent variables. The Statistical Package for Social Sciences (SPSS) was used to assess the significance of the model. Significant predictors of low AChE activity levels were farming areas (pesticide usage), type of job (intensity of exposure), nationality, period of exposure and type of farm, while age was a non-significant predictor. The different statistical parameters of the multiple regression model with AChE and HAChE as dependent variables are shown in Table 5-13. With HAChE as the dependent variable, the significant predictors were pesticide usage ($p<0.0001$) and intensity of exposure at $p<0.0001$ and period of exposure was a non-significant ($p=0.06$) predictor in the model. The pesticide usage per unit area were high in the farming areas of Ramah and Sleimat. The type of job identified as foremen or farm labourer was associated with the pesticide exposure, the highest exposure, as measured through the AChE depletion, was observed in the foremen followed by farm labourers. No depletions in the AChE activity was observed among the unexposed because of no occupational exposure to pesticides. Nationality was associated with the type of job on the farms, the Egyptians and Pakistanis were more likely to be employed as foremen compared to the other nationalities, and hence were observed to show higher depletions in the AChE activity levels.

5.4.2 Summary and discussion of enzyme depletion among farmworkers

A total of 532 farmworkers and an equal number of unexposed controls matched by age and nationality comprising Bangladeshis, Egyptians, Pakistanis, Indians and Others were studied for AChE activity. The mean AChE and the HAChE activity levels among the farmworkers were 3.89±0.64 UI/ml and 29.96±4.14 UI/g haemoglobin respectively and corresponding activity levels among the unexposed workers were 4.2±0.29 UI/ml and 32.10±2.30 UI/g haemoglobin respectively. The enzyme activity levels among the farmworkers were significantly lower compared to the unexposed workers in the UAE. The mean ages for the farmworkers and the unexposed workers were 35.3±7.5 years and 34.6±7.1 years respectively and the mean haemoglobin levels for these workers were 12.9±1.5 g/dl and 12.9±0.8 g/dl respectively. The differences in the age and haemoglobin levels for the exposed and unexposed workers were not statistically significant. The mean period of exposure to pesticides among the farmworkers was 2.9±3.1 years compared to none among the unexposed. The AChE and the HAChE activity levels in foremen were statistically significantly lower than the levels in farm labourers, which in turn were significantly lower than in the control group.

The AChE and the HAChE activity levels varied statistically significantly among the foremen, farm labourers and farmworkers in the five farming areas in Al-Ain. Lowest AChE and HAChE activity levels were observed in Hayer and Ramah. There was very little variability in the AChE and HAChE activity levels among the different nationality groups for the control population, however, significant differences were observed in the AChE and the HAChE activity levels among the different nationality groups for the foremen and the farm labourers. The lowest levels for the foremen were for Pakistanis followed by Egyptians and among the farm labourers Egyptians had the lowest values followed by Pakistanis. Nationality was associated with the type of job on the farms, Egyptians and Pakistanis were more likely to be employed as foremen compared to other nationalities, hence the lower enzyme activity levels. The usage of pesticides on the farms, intensity of exposure and period of exposure were significant predictors of depletion of AChE and HAChE activity levels.

The AChE and the HAChE depletions among the farmworkers were strongly influenced by the area of work, i.e. the farming areas which showed differences in the frequency of usage and the amount of pesticides used per unit area. The type of job i.e. foremen or farm labourers, also contributed significantly in the AChE and the HAChE depletions as evidenced by foremen showing lower activity levels compared to the farm labourers and the farm labourers showing lower levels compared to the unexposed workers. The AChE activity monitoring has been used as a biological marker for the sub-clinical effects of organophosphates and carbamate type pesticides (Rama and Jaga, 1992). In this study also the AChE activity has been identified as a good indicator of cholinesterase-inhibiting pesticide exposure among different nationality groups (Gomes *et al*, 1997).

The depletion of AChE has been reported as identified in this study, to follow a dose response relationship from exposure to cholinesterase-inhibiting organophosphorus and carbamate pesticides (Karr *et al*, 1992; Rama and Jaga, 1992). Higher AChE depletions observed among foremen compared to the farm labourers suggests a dose response relationship, similar findings have been reported by McConnell *et al,* (1994) and Ciesielski *et al,* (1994) with foremen who handled cholinesterase inhibiting pesticides for a longer period and more frequently than the farm labourers showing higher depletions. These findings are also in agreement with the findings of Lopez-Carillo and Lopez-Cervantes (1993), Coye *et al,* (1986) and Faustini *et al,* (1992). The AChE depletions among the farmworkers in the UAE showed good correlation with the frequency of usage and length of usage as reported by Yamanaka *et al,* (1993), Spiegiel *et al,* (1981) and Robinson *et al,* (1993).

The depletion in AChE and HAChE activity levels in the farmworkers were strongly influenced by the farming areas they worked, the intensity and the frequency of use of pesticides and the period of exposure. Hayer and Ramah showed higher depletions in the enzyme levels, among these farming areas, Ramah was observed to have poor personal hygiene and poor use of protective equipment. Ramah was also found to have the highest per unit area usage of all pesticides. Sleimat showed lower depletion of AChE and good personal hygiene and good use of personal protective equipment. Sleimat though showed a higher per unit area usage of all pesticides, good sense of personal hygiene has reduced the exposure to pesticides and protected the farmworkers.

5.4.3 Neurological and muscular dysfunction results

The mean AChE, HAChE, AT and the DST values for the farmworkers were 3.47±0.50 UI/ml, 28.41±6.26 UI/g of haemoglobin, 7.17±0.80 and 0.90±0.26 respectively and the corresponding values for the unexposed workers were 4.12±0.31 UI/ml, 31.54±2.31 UI/g, 18.98±1.23 and 5.97±0.78 respectively. The comparative values for the new farmworkers (4.23±0.21 UI/ml, 33.24±1.73 UI/g, 7.99±1.59 and 0.74±0.30) were lower than the values for the unexposed population. The mean AChE, HAChE, AT and DST for the farmworkers and new

Table 5-14: Mean age, years of service and Aiming Test and Digit Symbol Test scores among the exposed (farmworkers and new farmworkers) and the unexposed populations

	Farmworkers	New farmworkers	Unexposed workers	95%CI for diff. Farmworkers & Unexposed	95% CI for diff. New farmworkers & Unexposed	95% CI for diff Farmworkers & New farmworkers
Age (yrs)	40.53±3.4	31.37±7.2	34.58±3.2	-10.08, -8.24	5.19, 6.71	-4.22, -2.21
Years of service (yrs)	5.04±3.62	0.06±0.46	6.31±4.54	0.52, 2.03*	5.31, 7.18*	-5.45, -4.99
AChE (UI/ml)	3.47±0.50	4.23±0.21	4.12±0.31	0.57, 0.73*	-0.18, -0.04*	0.68, 0.83*
HAChE (UI/ml)	28.41±6.26	33.24±1.73	31.54±2.31	2.3, 4.01*	-2.22, -1.17*	3.93, 5.72*
AT	7.17±0.80	7.99±1.59	18.98±1.23	8.92, 14.71*	6.7, 15.3*	-2.7, 4.34
DST	0.90±0.26	0.74±0.30	5.97±0.78	3.45, 6.68*	2.8, 7.66*	-1.04, 0.71

* p-value <0.0001

farmworkers were significantly lower compared to the unexposed population. Between the established farmworkers and new farmworkers the AChE, HAChE levels and the AT scores were lower for the established farmworkers. The DST scores was non-significantly lower among new farmworkers. A significantly negative correlation was observed between the AChE activity depletion and the AT and DST scores. Multiple regression analysis was used to test the association of AChE depletion and farmwork with the AT and DST scores among the three groups of study population. Farm work significantly ($p<0.0001$) predicted low AT and DST scores and low AChE activity levels, while AChE depletion significantly ($p<0.0001$) predicted low HAChE activity levels and farmwork (Table 5-15). AT and DST were non-significant contributors to the regression model for the prediction of AChE depletion.

To our knowledge the use of the AT and the DST has not been reported in the context of assessing neuromuscular dysfunction among farmworkers, although these and other similar tests have been used in assessing the health effects from solvent exposures (Foo *et al,* 1994). In this study the AChE activity which has been identified as a good indicator of pesticide exposure (Gomes *et al,* 1997), showed positive correlation with the AT and DST scores. The low AT and DST scores among farmworkers suggested neurological and memory disorders and supported the hypothesis, that sub-clinical neurological dysfunction and memory disorders are present among farmworkers. Neurological dysfunction in agricultural workers exposed to pesticides was confirmed using the postural sway and the length of sway measurements by Sack *et al,* (1993). Farmworkers with long exposure to pesticides are therefore potential targets for neurological and memory disorders.

Farmworkers in Al-Ain are at a disadvantage because of their low socio-economic status, low literacy level and lack of training in safety and hygiene on the farms. These workers are forced to ignore their long term health, so that they

Table 5-15: Prediction of neuromuscular dysfunction biomarkers through multiple regression analysis

Biomarkers	Farmwork			AChE		
	B	95% CI	p-value	B	95% CI	p-value
Aiming test	-0.012	-0.016, -0.008	0.0001	-0.001	-0.004, -0.001	NS
Digit symbol test	-0.015	-0.023, -0.008	0.0001	-0.002	-0.006, 0.002	NS
HAChE	-0.008	-0.023, 0.005	NS	0.034	0.027, 0.042	0.0001
AChE/Farmwork	-0.902	-1.03, -0.772	0.0001	-0.283	-0.0325, -0.0243	0.0001

NS - Not significant

can retain their jobs and send money to their needy dependent families in their home countries, since they are economic migrants from the backward sectors of the developing countries. There is a need to monitor the health status of the immigrant farmworkers in the developing countries such as the UAE. Monitoring of cholinesterase-inhibiting pesticide exposure through the enzyme activity level measurements, morbidity profile, AT and DST assessments could help in identifying sub-clinical toxicity at an early stage and thereby preventing the clinical manifestation of a pesticide-related disease at a later date. The migrant farmworkers in countries like the UAE could be health liabilities in their advanced non-productive years to their home governments because of increased risk of neurological, muscular, immunological and reproductive diseases and cancers.

Chapter 6

Pesticide residues in the farm water and soil and the locally grown vegetables

6.0 Introduction

6.1 Pesticide residues in farm water

6.2 Pesticide residues in farm soil

6.3 Pesticide residues in locally grown vegetables

6.4 Pesticide residues in vegetables from Hayer

6.5 Pesticide residues in vegetables from Ramah

6.6 Pesticide residues in vegetables from Gumadh

6.7 Pesticide residues in vegetables from Waggan

6.8 Pesticide residues in vegetables from Sleimat

6.9 Summary and discussion of pesticide residues in vegetables

6.10 Maximum residue limit (MRL) for pesticides in vegetables

6.0 Introduction

Pesticides have been beneficial in agriculture in controlling the pests that attack and destroy crops. However, improper and excessive use have contaminated the environment with pesticide residues. The use of pesticides on a farm leaves pesticide residues in the farm soil, farm water and the farm produce (Goedicke *et al*, 1989). The crops grown on pesticide contaminated soils and irrigated with pesticide contaminated water absorb the pesticide residues from the soil and water. The farm produce therefore, becomes contaminated with the pesticide residues from the farm environment and also from the sprayed pesticides. The contamination of the soil and water at a significantly high level could adversely affect the flora and fauna and also contaminate the air and the food chain. Pesticide contaminated agricultural soils, ground water and farm produce, both directly and indirectly increase the exposure of the animals and humans to pesticides.

The environmental conditions, such as temperature, winds, humidity, etc. play a significant role in determining the extent of contamination of the agricultural soils, water and the farm produce. The applications of pesticides in Al-Ain (Chapter IV) have often been excessive as farmworkers were not trained in the use of pesticides (Chapter V). To assess the level of contamination of the farm soil, agricultural water and the farm produce, laboratory analyses were carried out to determine the pesticide residues in these media. This chapter describes the sample collection of farm water, farm soil and the farm produce for chemical analysis for pesticide residues and the extraction and analysis of the pesticide residues from each of these media.

6.1 *Pesticide residues in farm water*

Pesticides can reach the groundwater in three ways: firstly, through spills of large amounts of concentrated pesticides, secondly through careless use such as overspraying and disposal of unused pesticides and thirdly by the leaching of the pesticides deposited on the soil into ground water. In the agricultural use of pesticides, the second and third method of groundwater contamination have been suggested to predominate (Fawell, 1991). However, persistence and mobility of the pesticide compound and the environmental conditions play a key role in the leaching process (Botoni and Funari, 1992). Persistence and mobility are pesticidal compound dependent factors, and are therefore, constant for a given formulation. Hence for a specific pesticide, environmental conditions will be the most important factor influencing the contamination of the groundwater. The very hot, dry conditions will not encourage much leaching to take place. Most of the compounds would have volatilised before they could leach into the below-ground water table. However, the high porosity of the farm soil could leach a substantial portion of the pesticide residue on the soil surface.

The water used in the agricultural farms is mainly obtained from bore holes. A number of these bore holes are dug in each farming area and the water is collected in common overhead water tanks. The water from the overhead tanks is then supplied to about five to ten farms in the immediate neighbourhood. The water from this ground level tank is pressurized and fed to the farm irrigation system. The bore hole water used in agriculture is not potable and the farmworkers residing on the farm have to fetch drinking water from a different source which may be obtained from a bore hole but treated for human consumption or from sea water which has been desalinated.

6.1.1 Results of the analysis of farm water

The different pesticide residues and the pesticide associated compounds which were identified in the water samples are shown in Appendix 17. The pesticide associated compounds were those which were identified to be either the breakdown product of a pesticide or a solvent or other inert substances used in the formulations. The other chemical compounds such as aliphatic hydrocarbons which have been associated with the aquifers and are usually identified in the ground water have not been listed in this table and were not used in calculating the total concentration of the all other chemicals (pesticide associated chemical compounds) in the water sample.

A numbered list of the water samples collected from the individual farms in each of the five farming areas is shown in Appendix 17 together with the concentrations of the pesticides and the pesticide associated chemical compounds in each of the samples. None of the collected water samples were lost during handling, however, four water samples from two farming areas and four different farms could not be collected because there was no water available for technical reasons on the day of the visit. Among the 217 agriculture-use water samples surveyed in the five farming areas, 20% contained either one or two pesticide residues and 76% of the samples contained pesticide associated chemical compounds.

The numbers and percentages of water samples containing pesticide and pesticide associated chemical compounds categorised according to concentration ranges are shown in Table 6-1. Pesticides or pesticide associated chemical compounds were identified in 56% of the samples in Hayer, 81% of the samples in Ramah, 76% of the samples in Gumadh, 72% of the samples in Waggan and 89% of the samples in Sleimat. Overall, 24% of all samples contained no pesticides nor pesticide associated chemical compounds, 15% had low concentrations of pesticide or pesticides associated chemical compounds (<10 μg.l), 26% had medium concentrations (10-30 μg.l) and 35% had high concentrations (>30 μg.l).

The farming areas of Ramah and Sleimat had the highest numbers of samples with pesticides or pesticide associated chemical compounds. These farming areas also had greater numbers of samples with pesticides and pesticide associated chemical compounds in excess of 10 μg/l (64% of the samples in Ramah and 77% of the samples in Sleimat). Gumadh had the highest number of samples (29%) with low concentrations of pesticide residues, Waggan had the lowest number of samples (10%).

The mean concentrations of the measured pesticides and the pesticide associated chemical compounds are shown in Table 6-2 for the five farming areas. The mean[1] value was calculated by averaging across all the farms from which water

Table 6-1: Number and percentage of water samples containing pesticide residues and pesticide associated chemical compounds (according to concentration range).

Farming areas	None n_a/n_b (%)	Low < 10 µg/l n_1/n_2 (%)	Medium 10-30 µg/l n_1/n_2 (%)	High > 30 µg/l n_1/n_2 (%)
Hayer (n=32)	22 /14 (44)	5/3 (9)	5/7 (22)	0/8 (25)
Ramah (n=36)	29/7 (19)	0/6 (17)	7/10 (28)	0/13 (36)
Gumadh (n=42)	35/10 (24)	0/12 (29)	6/4 (10)	1/16 (38)
Waggan (n=50)	42/14 (28)	1/5 (10)	7/20 (40)	0/11 (22)
Sleimat (n=57)	46/6 (11)	0/7 (12)	11/15 (26)	0/29 (51)
Total (n=217)	174/51 (24)	6/33 (15)	36/56 (26)	1/77 (35)

n_a *Number of water samples without pesticides*
n_b *Number of water samples without pesticide associated chemical compounds*
n_1 *Number of water samples with pesticides*
n_2 *Number of water samples with pesticide associated chemical compounds*

samples had been obtained, while for the mean[2] only those farms which contained pesticide residues and/or pesticide associated chemical compounds above the quantification limit of 1ng/l. The mean[1] values for pesticide residues in waters from the farming areas of Ramah and Sleimat were 3.3±1.2 µg/l and 3.0±0.9 µg/l respectively which were higher than the population mean of 2.8±0.4 µg/l. The mean[2] pesticide residues concentrations for the farming areas of Ramah, Gumadh and Sleimat were 16.9±1.3 µg/l, 16.8±3.1 µg/l and 16.2±1.9 µg/l respectively which were higher than the population mean of 14.2±0.9 µg/l. The one way analysis of variance of mean[2] pesticide residues was statistically significant with a p-value of 0.01.

The mean[1] concentration values of the pesticide associated chemical compounds were also higher in Ramah, Gumadh and Sleimat compared to the other farming areas and the population mean (16.8±1.0 µg/l). One way analysis of variance for mean[1] concentration values of the pesticide associated chemical compounds was

Table 6-2: Mean concentrations of pesticide residues, pesticide associated chemical compounds (Other) and total concentrations of pesticide residues and pesticide associated chemical compounds in farm water from the five farming areas.

Farming areas	Pesticide residue		Other		Total	
	Mean[1]±SE µg/l	Mean[2]±SE* µg/l	Mean[1]±SE** µg/l	Mean[2]±SE µg/l	Mean[1]±SE*** µg/l	Mean[2]±SE µg/l
Hayer (n=32)	2.7±0.8 (n=32)	9.3±0.7 (n=10)	10.2±2.1 (n=32)	20.4±2.4 (n=17)	12.9±2.8 (n=32)	24.4±3.4 (n=18)
Ramah (n=36)	3.3±1.2 (n=36)	16.9±1.3 (n=7)	17.0±2.4 (n=36)	21.9±2.3 (n=29)	20.8±3.2 (n=36)	25.9±3.3 (n=29)
Gumadh (n=42)	2.8±1.1 (n=42)	16.8±3.1 (n=7)	17.1±2.5 (n=42)	22.5±2.6 (n=32)	19.9±3.2 (n=42)	26.2±3.5 (n=32)
Waggan (n=50)	2.1±0.7 (n=50)	13.4±1.3 (n=8)	14.6±2.1 (n=50)	20.3±2.3 (n=36)	16.7±2.7 (n=50)	23.3±2.5 (n=36)
Sleimat (n=57)	3.0±0.9 (n=57)	16.2±1.9 (n=11)	22.1±2.1 (n=57)	25.6±2.0 (n=51)	25.2±2.5 (n=57)	29.1±2.5 (n=51)
Total (n=217)	2.8±0.4 (n=217)	14.3±0.9 (n=43)	16.8±1.0 (n=217)	22.1±1.1 (n=165)	19.7±1.3 (n=217)	26.2±1.4 (n=166)

Mean[1] *average concentration relative to all farms within a farming area*
Mean[2] *average concentration relative to those farms within a farming area demonstrating a concentration above the detection limit*
*One way analysis of variance * $p=0.01$; ** $p=0.005$ *** $p=0.03$*

statistically significant (p=0.005). The mean[1] total concentration for the pesticide residues and the pesticide associated chemical compounds for the five farming areas were: Hayer 12.9±2.8 µg/l, Ramah 20.8±3.2 µg/l, Gumadh 19.9±3.2 µg/l, Waggan 16.7±2.7 µg/l and Sleimat 25.2±2.5 µg/l. The mean[1] total concentration for the pesticide residues and pesticide associated chemical compounds for all the five farming areas was 19.7±1.3 µg/l. The one way analysis of variance was for mean[1] total concentration for the pesticide residues and pesticide associated chemical compounds was statistically significant (p=0.03), however, the Levene's test for the homogeneity of variances were not statistically significant for the pesticide residues in farm water from the five farming areas (p=0.125). The mean[2] total concentrations for the pesticide residues and pesticide associated chemical compounds for Sleimat was higher compared to the corresponding total mean for all the farming areas.

6.1.2 Summary and discussion of the pesticide residues in farm water

The mean concentrations of pesticide residues in Ramah (3.3±1.2 µg/l) and Sleimat (3.0±0.9 µg/l) were higher than the mean of all the five farming areas (2.8±0.4 µg/l). These farming areas (Ramah and Sleimat) were identified in Chapter V as those areas which used higher amounts of pesticides in farming. The concentration of pesticide residues, pesticide associated chemical compounds and the total concentration of pesticide residues and pesticide associated chemical compounds shown in Table 6-2, was checked for statistical correlation with the pesticide usage per unit area in Appendix 15. A significant positive correlation with the amount of pesticide used per unit area of the farm and the concentration of pesticide residues (p=0.003) in the farm water, pesticide associated chemical compounds (p=0.000) and the concentration of the total of pesticide residues and pesticide associated chemical compounds (p=0.000) (Table 6-19).

The pesticides used in agricultural spraying are deposited on and physically absorbed to the soil followed by leaching into the underground water. Unlike in soils rich in micro-organisms very little chemical adsorption is possible in sandy soils, therefore, these soils have a higher capacity to leach the pesticides and other contaminants compared to soils with higher clay and rich organic content (Lalah and Wandiga, 1996). The ground water used in agriculture in Al-Ain is obtained from a depth of approximately 200 to 300 feet and because of the sandy nature of the soils the pesticides are able to rapidly leach into the ground water. The climatic conditions in Al-Ain (Chapter IV) indicated high ambient temperatures during the summer and moderate temperatures in the winter months. A major portion of the pesticides deposited on the soil, therefore, will be volatilised because of the high ambient temperatures and the balance portion which is not volatilised will leach into the underground water. There is very little rain in Al-Ain, but even without any significant wash-down of the pesticides, efficient leaching alone is able to transport the pesticides to the ground-water.

Dimethoate, Diazinon, Methamidophos and Methyl parathion have been identified at concentrations well below the levels which produce acute poisoning in watercourses in Venezuela (Brunetto *et al,* 1992). The levels of organophosphorus pesticides reported by these authors were in the range of 4.1 to 15.5 μg/l which are similar to the mean (14.5±3.2 μg/l) value obtained in this study The range of values in this study for the above mean was 4.0 to 25.0 μg/l (Appendix 17). Similar concentrations (0.1 to 13.0 μg/l) of multi-pesticide residues were identified in agricultural wells in New Jersey coastal agricultural plains by Louis and Vowinkel (1989). Brunetto *et al,* (1992) reported that the concentrations of pesticide residues in waters reflected the local usage of pesticides with higher frequencies of occurrence of pesticides being found in areas with higher population densities and where more intensive agricultural activity was practiced. This study identified higher concentrations of pesticides in those areas which used higher amounts of pesticides in agriculture confirming the findings by Brunetto *et al,* (1992).

Multiple pesticide residues have been identified in ground waters in the United States and in stream waters within Swedish agricultural areas (Ritter, 1990; Kreuger, 1998). The contamination of agricultural waters by pesticides has been associated with the annual amount of recharge, soil type, depth of aquifer beneath the surface, level of nitrate contamination and the soil pH (Ritter, 1990). The soils in Al-Ain have very little organic matter, have a lower pH and lower nitrate concentration, the concentration of micro-organisms in the soil is also low, therefore, the potential degradation of the pesticides in the soil is low (Durand and Barcelo, 1992) but the potential for leaching is high (Lalah and Wandiga, 1996). The potential contamination of the ground water will therefore depend on the depth of the water source, the quality of the agricultural soil and the intensity of the pesticide usage. The range of values for the pesticide residues identified in this study for the different farming areas seem to suggest that high usage of pesticides, high leaching capacity and availability of water at a reasonable depth increases the possibility of the contamination of the ground water by pesticide residues and pesticide associated chemical compounds. The pesticides associated chemical compounds could have been formed through thermal degradation or chemical reactions both on the surface of the soil and during the leaching process.

The groundwater from the agricultural areas in Al-Ain is not directly consumed by the farmworkers primarily because of the un-palatable taste and odour. However, this water is being used in the kitchen for washing the dishes and in cooking. The water is unsafe even for the kitchen use because the concentrations of pesticide residues in the ground water are much higher than the limit of 0.5 μg/l for total pesticides allowed by the European Economic Community Drinking water directive (Chiron *et al*, 1995). Pesticide contaminated water may not produce acute toxicity, however, adverse health effects from long term chronic exposure are possible. Chronic exposure to Aldicarb through ground-water contamination has been reported to adversely affect the immune function among women in Wisconsin, USA (Fiore *et al*, 1986).

6.2 *Pesticide residues in farm soil*

The water retention capacity of the farm sand in Al-Ain is poor, because of the sandy nature of the soil, and because of the high ambient temperature and high porosity. Because the sand is very porous and poor in water retention capacity, drip irrigation has been identified as the best method of irrigation so as to conserve the scarce water supplies. Fertilizers and some pesticides are also provided to the plants through the irrigation system. The samples of farm soil collected during the farm survey were always very dry because of the high evaporation rates during both the summer and winter seasons. The scanty rainfall (Chapter 4) does not sink deep into the ground, firstly because of rapid evaporation and secondly because of scanty rainfall. Any contaminants present on the soil are not readily washed out but partly leached to the ground water and mostly thermally dried.

The organic matter (fulvic and humic acids) in the soil plays a major role in the binding of pesticides to the soil and microorganisms in the soil may be involved in degrading the pesticides into other chemical compounds. The original pesticide and/or the degradation products have been reported to be bound to the soil through abiotic or biotic agents (Bollag *et al,* 1992). The persistence of the bound pesticides depends on the net result of the various interactions such as chemical decomposition, microbial degradation, volatilization, runoff, leaching, photo-degradation and uptake by plants (Gomez de Barreda *et al,* 1996). The half life of the pesticides in the type of soil used in agriculture in Al-Ain in the presence of high ambient temperatures have not been reported in the literature. It is therefore expected that the portion of the pesticide which is not volatilised, photo-degraded, leached, decomposed or taken up by plants is possibly adsorbed chemically onto the surface of the soil particles. The frequency and the intensity of pesticide usage are perhaps the key elements in determining the level of pesticide residues in the agricultural soils in Al-Ain.

6.2.1 Results of the analysis of farm soil

The pesticides and pesticide associated chemical compounds which were identified in the sand samples from the different farms are listed in Appendix 18. The number of samples which contained the pesticide residue are also shown against each pesticide. The compounds were identified by using the previously mentioned libraries. The pesticide associated compounds were those identified to be breakdown products of a pesticidal active ingredient or other inert substances used in the pesticidal formulations. There is a possibility that these compounds could have originated from the use of fertilizers or other chemicals on the farm, however, the possibility of them arising from the organic matter of the soil were remote because of the poor organic content of the soil. Those chemical compounds associated with humic or fulvic acids and other hydrocarbons have not been included in the list of chemical compounds in the Appendix 18. In Hayer Bromopropylate and Phenthoate were identified in the highest number of samples, in Ramah Dimethoate was very frequently identified, in Gumadh, Waggan and Sleimat Bromopropylate was frequently identified.

The concentrations of pesticides and other associated compounds for the individual farms are shown in Appendix 18. Five of the collected soil samples were lost in handling and these are marked as "Lost sample" in Appendix 18. A total of 216 farm soil samples were actually analysed for pesticide residues, 46% of the samples were identified with one pesticide residue, 15% with two pesticide residues and 3% with three pesticide residues (Appendix 18). Pesticide associated chemical compounds were identified in 88% of the farm soil samples. In the farming areas of Hayer, Ramah and Gumadh 50% of the soil samples in each area contained one pesticide residue while in Sleimat 52% and Waggan 32% of the contained one pesticide residue. Higher percentages of samples from Gumadh (95%) and Waggan (92%) contained pesticide associated chemical compounds compared to the other three areas (Hayer (85%), Ramah (85%) and Sleimat (84%)).

The total concentrations of the pesticide residues and the pesticide associated chemical compounds in farm sand were categorized as none, less than 10 ng/g, 10-30 ng/g and greater than 30 ng/g. These categories and the number of number of samples in each category for each of the five farming areas for pesticides and pesticides associated chemical compounds are shown in Table 6-3. Among all the analysed soil sample 54% contained no pesticides and 13% contained no pesticide associated chemical compounds. Low (<10 ng/g) concentrations of pesticide associated chemical compounds were identified in 10% of the samples, medium (10-30 ng/g) concentrations in 47% of the samples and high (>30 ng/g) concentrations in 31% of the samples. The farming areas of Gumadh (93%) and Waggan (92%) contained the highest number of samples with pesticides or pesticide associated chemical compounds (Table 6-3). The farming areas of Ramah (82%), Waggan (80%), Sleimat (79%) and Gumadh (78%) contained higher percentages of samples with concentrations of pesticides or pesticide associated chemical compounds in excess of 10 ng/g.

Table 6-3: The number and percentage of soil samples from different farming areas showing the level of the pesticide residues and pesticide associated chemical compounds (according to concentration range).

Farming areas	None n_a/n_b (%)	Low < 10 ng/g n_1/n_2 (%)	Medium 10-30 ng/g n_1/n_2 (%)	High > 30 ng/g n_1/n_2 (%)
Hayer (n=34)	17/6 (18)	8/6 (18)	9/12 (35)	0/10 (29)
Ramah (n=34)	17/5 (15)	7/1 (3)	10/16 (47)	0/12 (35)
Gumadh (n=42)	21/3 (7)	13/6 (14)	8/24 (57)	0/9 (21)
Waggan (n=50)	34/4 (8)	11/6 (12)	5/29 (58)	0/11 (22)
Sleimat (n=56)	27/9 (16)	19/3 (5)	10/20 (36)	0/24 (43)
Total (n=216)	116/27 (13)	58/22 (10)	42/101 (47)	0/66 (31)

n_a *Number of samples without pesticides*
n_b *Number of samples without pesticides or pesticide associated chemical compounds*
n_1 *Number of samples with pesticides*
n_2 *Number of samples with pesticides or pesticides associated chemical compounds*

The mean concentrations for the measured pesticides and the pesticide associated chemical compounds are shown in Table 6-4 for the five farming areas. The mean[1] value was calculated by averaging across all the farms from which a soil sample had been obtained and analysed and the mean[2] value by including only those farms where the concentration of the pesticide residues was above the quantification limit. The mean[1] pesticide residue concentration in the soil samples from Ramah (4.9±0.9 ng/g) and Sleimat (4.8±0.7 ng/g) was greater than the population mean of 4.2±0.4 ng/g and also greater than the mean[1] values for the other three areas (Table 6-4). The mean[2] concentration of pesticide residues in the farming areas of Ramah (10.4±0.9 ng/g) and Sleimat (9.8±0.9 ng/g) was also greater than the population mean of 9.4±0.4 ng/g and greater than the mean[2] values for the other three areas. The mean[1] concentration of pesticide associated chemical compounds in Ramah (16.8±1.9 ng/g) and Sleimat (17.4±1.6 ng/g) was greater than the population mean of 16.7±0.7 ng/g and the mean values of the other three areas. Similar higher mean values were observed for mean[2] concentrations of pesticides associated chemical compounds in the farming areas of Ramah and Sleimat compared to the other three areas. Levene's test for homogeneity of variances was significant for the differences in the pesticide residues ($p=0.06$) in the five farming areas and also for the pesticide associated chemical compounds ($p<0.05$) in Table 6-4.

The mean[1] values of the total concentration of pesticide residues and pesticide associated chemical compounds for the five farming areas were: Hayer 20.5±2.6 ng/g, Ramah 21.6±2.5 ng/g, Gumadh 20.2±1.9 ng/g, Waggan 19.5±1.6 ng/g and Sleimat 22.2±2.1 ng/g. The mean[1] concentrations for Ramah and Sleimat were non-significantly greater compared to the other three areas and to the mean[1] total concentration for the whole population (20.9±0.9 ng/g). Levene's test for homogeneity of variances was significant ($p<0.05$) for the total concentration of the pesticide residues and pesticides associated compounds. The mean[2] concentrations of pesticide residues and pesticide associated chemical compounds were significantly ($p<0.05$) greater for the farming areas of Ramah (26.9±2.2 ng/g) and Sleimat (27.9±1.9 ng/g) compared to the population mean of 24.3±0.9 ng/g and the means of the other three areas.

6.2.2 Summary and discussion of the analysis of farm soil

Pesticide residues were identified in 46% of the samples and pesticide associated chemical compounds in 87% of the samples. The mean[2] concentrations of the pesticide residues in Ramah (10.4±0.9 ng/g) and Sleimat (9.8±0.9 ng/g) exceeded the population mean concentrations of 9.4±0.4 ng/g and also the mean

Table 6.4: Mean concentration of pesticide residues and pesticide associated chemical compounds (Other) in farm soil from the five farming areas.

Farming areas (n)	Pesticide residue		Other		Total	
	$Mean^1$±SE ng/g	$Mean^2$±SE ng/g	$Mean^1$±SE ng/g	$Mean^2$±SE ng/g	$Mean^1$±SE ng/g	$Mean^2$±SE* ng/g
Hayer (n=34)	4.7±0.9 (n=34)	9.5±0.8 (n=17)	15.8±2.2 (n=34)	19.8±2.1 (n=29)	20.5±2.5 (n=34)	24.1±2.6 (n=29)
Ramah (n=36)	4.9±0.9 (n=34)	10.4±0.9 (n=17)	16.8±1.9 (n=34)	20.8±1.6 (n=29)	21.6±2.5 (n=34)	26.9±2.2 (n=29)
Gumadh (n=42)	4.5±0.8 (n=42)	8.9±1.1 (n=21)	15.9±1.4 (n=42)	17.6±1.2 (n=40)	20.2±1.9 (n=42)	21.7±1.9 (n=39)
Waggan (n=50)	2.6±0.6 (n=50)	8.1±0.8 (n=16)	16.9±1.3 (n=50)	18.4±1.2 (n=46)	19.5±1.6 (n=50)	21.2±1.5 (n=46)
Sleimat (n=57)	4.8±0.7 (n=56)	9.8±0.9 (n=29)	17.4±1.6 (n=56)	21.9±1.4 (n=47)	22.2±2.1 (n=56)	27.9±1.9 (n=47)
Total (n=217)	4.2±0.4 (n=216)	9.4±0.4 (n=100)	16.7±0.7 (n=216)	19.7±0.7 (n=191)	20.9±0.9 (n=216)	24.3±0.9 (n=190)

$Mean^1$ *average concentration relative to all farms within a farming area*
$Mean^2$ *average concentration relative to those farms within a farming area demonstrating a concentration above the detection limit*
n *number of soil samples*
* *$p=0.04$ (One way analysis of variance)*

concentrations in the other three farming areas. The mean[2] concentrations of pesticide associated chemical compounds in the farming areas of Ramah (20.8±1.6 ng/g) and Sleimat (21.9±1.4 ng/g) were greater than the population mean of 19.7±0.7 ng/g and the means for the other three areas. Similar pattern for the combined concentrations of pesticide residues and pesticide associated chemical compounds was observed with the mean concentrations for Ramah and Sleimat being significantly greater than the population mean and the mean values for the other three areas.

The pesticides which are sprayed onto the crops are either deposited on the crop foliage or the soil or drifted away by the wind. A part deposits of the pesticides, following spraying, on both the foliage and the soil may be evaporated depending on the weather conditions. Higher ambient temperatures and windy conditions may enhance thermal decomposition and evaporation or drift. The balance of the deposits on the soil not evaporated or drifted either leach or remain on the sand particles. The concentration of pesticide associated chemical compounds (0.193, p=0.004) and the combined concentration of the total of pesticide residues and pesticide associated chemical compounds (0.193, p=0.004) showed a positive significant correlation with the amount of pesticide used per unit area of the farm (Table 6-19). Similar positive correlation has been observed between the applied dose and the concentration of the pesticide residue in the soils by Singh *et al,* (1997). The results of this study show that a portion of the applied pesticide remains physically adsorbed to the sand particles there being no wash-out of the sand because of the scanty rainfall. The determination of the concentration of the pesticide residues in the topsoil as suggested by Gomez de Barreda *et al,* (1996) would therefore, provide a measure of the pesticide residue adsorbed to the sand particles.

The mean pesticide residue concentration in the sandy soil in this study was observed to be 9.4±0.4 ng/g with a range of 3.1 ng/g and 22.5 ng/g. Analysis of a different type of agricultural soil which had been regularly sprayed with pesticides over a period of 12 years was reported to have contained 22 ng/g of pesticides (Jenks *et al*, 1997). The deposits of pesticide residues in the soil dissipate and degrade with time, the decrease in pesticide concentrations of the different pesticides during the one week period was proportional to the half life of pesticides in the soil, the pH and organic matter in the soil and the environmental conditions (Thapar *et al*, 1995). In this study the soil samples had been collected about a week after the last pesticide spray and the concentrations of the pesticide residues reported in this section are those left over after dissipation and degradation. Durand and Barcelo (1992) reported that the level of contamination of agricultural soils rich in organic matter and silt from regular pesticide use was 30 ng/g, however, persistent pesticides (procymidone) have been observed to exist in greenhouse agricultural soils from regular use in the range of 60 to 140 ng/g dry soil (Nagami, 1996). Except for the laboratory controlled experiments by Lalah and Wandiga (1996) on sandy soil poor in organic matter and silt and with low water retention capacity, no information was available on the level of pesticide residues in desert soils under field conditions. These authors have reported lower absorption and higher leaching in sandy soils compared to clay and silt-rich soils.

Post application, the pesticides deposited on the soils undergo degradation basically by three different processes: i) physical eg photolysis by light and temperature, ii) chemical eg. hydrolysis and iii) biological eg by micro-organism degradation (Coats, 1990). The other factors which need to be considered along with these are the soil condition and the nature of the pesticide formulations. Sandy soils have a lower pH (Lalah and Wandiga, 1996) and hydrolysis of the C-S bonds in pesticides in soil occur at a lower pH (Kaur *et al*, 1997), therefore, the pesticide residues in soil were likely to degrade by this mechanism to metabolites of pesticides (pesticide associated chemical compounds). Degradation of the pesticide residues by micro-organism is limited because of poor organic matter in sandy soils. Lower adsorption of pesticides by sandy soils, higher leaching capacity and higher thermal degradation maintain the pesticide load on the soil at the levels identified in this study.

The deposits of pesticide residues in soil are available for uptake by the crops grown in the soil, vegetable crops like Spinach, Radish root and Radish foliage have been reported to have taken up 8%, 10% and 15% respectively of the available procymidone fungicide (Nagami, 1996) and 19%, 6% and 19% respectively of the available organochlorine insecticides (Suzuki *et al,* 1976). Trifluralin residues in soil have also been reported to have been taken up by carrots grown in the field (Tiryaki *et al,* 1997). The pesticide deposits in the soil also leach into the groundwater and a positive relationship has been reported between the concentration of pesticide residues in the soil and the groundwater (Singh *et al,* 1997). In this study a similar positive correlation was observed between pesticide residues in sand and water (0.134, $p<0.05$), between pesticide associated chemical compounds in sand and water (0.436, $p<0.0001$) and between pesticide residues and pesticide associated chemical compounds in sand and water (0.427, $p<0.0001$) (Table 6-19).

Singh *et al,* (1997) have reported on the dissipation of herbicide Metolachlor under tropical conditions and it was observed that the residues of Metolachlor declined consistently during the first thirty days after application and thereafter disappeared rapidly. Wash-out of the pesticide residues in the farm soil by rain and degradation by the microorganism may play a role in the rapid decline of the pesticide residues in the tropics. However, due to lack of rain and absence of micro-organism the pesticide residues in desert sandy soils persist for a longer time. Therefore, further studies are needed on the persistence of pesticide residues in these soils.

The level of contamination of the farm soil may not be high compared with other studies (Jenks *et al,* 1997; Nagami, 1996), but it is substantial to damage the soil under the environmental conditions of Al-Ain. The life of agricultural soil in Al-Ain is about six to seven years as reported by the farmworkers in Al-Ain. After this period, a one foot deep layer of the topsoil from the farm is removed and replaced by new soil from the desert. The reason given by the farmworkers for changing the farm soil is that the soil becomes wasted through agricultural activity. Within each farm the crops are rotated from area to area, at least every other year if not every year, so that the soil is not exhausted of certain chemical and physical elements and loaded with any single pesticide. This practice has had limited effect and the need to throw out the old soil and bring in new desert soil to take its place is ever necessary to continue with the agricultural activity.

6.3 *Pesticide residues in the locally grown vegetables*

Pesticides (insecticides, fungicides, nematocides, herbicides) are used in agriculture to help the crops as they grow and to keep them in good condition so that they provide abundant produce. Pesticide formulations are designed to sustain the effect of the active ingredient so that the toxic action lasts longer and provides better crop protection. Therefore, the pesticide residues on the crops build up from one pesticide application to the other, gradually achieving significantly high proportions especially when applied very frequently. Pesticides leave residues on the surface and/or in the flesh of the produce. Surface residues derive from pesticides sprayed onto the crops whereas residues in the flesh come from systemic pesticides which may be sprayed or provided to the crops with the fertilisers or irrigation water. Systemic pesticides are designed to work within the plants as they grow and provide the produce. The residues on the surface may be reduced after washing or peeling or cooking, while the residues in the flesh may only be altered after cooking.

Government agencies have been monitoring the pesticide residue levels in agricultural produce originating in the developed countries. The Pesticide Safety Directorate within the United Kingdom Ministry of Agriculture Fisheries and Food and the United States Agriculture Department in the Environment Protection Agency are two such governmental monitoring agencies. In a 1992-1993 survey carried out by the US Food and Drug Administration, 84% of the domestic and 91% of the imported tomato samples had detectable residues. Methamidophos was the most frequently identified insecticide in the tomatoes.

Acephate residues in excess of the US tolerance limits were identified in 3% of the domestic and 3% of the imported tomatoes (Roy *et al*, 1995). Corvi and Vogel (1993) have reported that in 1989 and 1990, 59% of the agricultural samples in Switzerland had no residues, 35% had detectable but low residues and 6% of the samples had residues in excess of the Swiss tolerance levels.

Regular monitoring of agricultural produce in the United Arab Emirates for pesticide residues has not been done routinely, though nearly all of it's agricultural produce requirements has been imported. In recent years, however, agricultural activity in the UAE has gained momentum and domestic produce has been sold on the local market. Despite this, monitoring of the local produce for pesticide residues has not yet been undertaken on a regular basis. The neigbouring countries (Oman and Saudi Arabia) with similar climates also have agricultural programmes and these countries also do not routinely monitor their agricultural produce. This investigation was undertaken, therefore, to assess the level of pesticide residues in the locally grown vegetables.

6.3.1 Results of analysis of vegetables

All the vegetable samples collected from the farms were processed, SFE extracted and analysed using GC-MS technique. To facilitate the reporting of the results and to obtain an overall semi-quantitative picture of a farming area, the total concentrations of the pesticides and the pesticide associated chemical compounds in the vegetable samples were categorised as none (non detected), less than 1 mg/kg, 1-3 mg/kg and greater than 3 mg/kg. The concentrations of the pesticide residues and the pesticide associated chemical compounds were also statistically analysed and the mean and standard error for each of the vegetable types were calculated and reported for each of the farming areas.

6.4 *Pesticide residues in vegetables from Hayer*

The different pesticides identified in the vegetables in Hayer are listed in Appendix 19 (Table 1), along with the pesticide associated chemical compounds. The number of samples which contained the pesticide residue are also shown alongside each pesticide in this Appendix. Organophosphorus and carbamate pesticides were the most frequently identified pesticides in the vegetable samples from Hayer. Dimethoate, Heptenophos, Triadimefon, Carbaryl and Pyridate were identified in at least two vegetable samples each. A list of all the samples which were analysed from the Hayer farming area are shown in Appendix 19 (Table 1) together with the concentrations of pesticides and pesticide associated chemical compounds (others) identified in the different vegetable samples. One sample each of Cauliflower, Corn and Tomatoes were found to contain three pesticides each, while one sample each of Potatoes, Aubergines and Cauliflower were identified with two pesticides each and the rest of the samples contained just one pesticide or none. Triadimefon, Pyridate and Dimethoate were the most

Table 6-5: The levels of pesticide residues and pesticide associated chemical compounds contamination in vegetable samples collected from Hayer.

Vegetables	None n^a/n^b	< 1 mg/kg n^1/n^2	1-3 mg/kg n^1/n^2	> 3 mg/kg n^1/n^2	Total n (%)
Aubergines	2/0	1/0	0/2	0/1	3 (9)
Cabbage	1/0		0/1		1 (3)
Capsicum	1/0		0/1		1 (3)
Cauliflower		1/1	1/1		2 (6)
Corn			1/0	0/1	1 (3)
Cucumber		1/0		0/1	1 (3)
Marrow		1/0	2/3		3 (9)
Potato		2/1	1/2		3 (9)
Radish		1/1			1 (3)
Tomato	5/1	5/0	5/10	1/5	16 (50)
Total	9/1	12/3	10/20	1/8	32

n^a *number of samples without any pesticide residues*
n^b *number of samples without any pesticide residues and pesticide associated chemical compounds*
n^1 *number of samples with pesticide residues*
n^2 *number of samples with pesticide residues and pesticide associated chemical compounds*

frequently identified pesticides in Tomatoes and Heptenophos was most commonly found in Potatoes. Pyridate was the most commonly (5/23) identified pesticide in the vegetable samples from Hayer followed by Heptenophos (4/23) and Methidathion (4/23) and then Triadimefon (3/23) and Aminocarb (3/23). The number of vegetable samples of each commodity with pesticide residues in the Hayer farming area were: Aubergines - 1/3 (33%), Cauliflower - 2/2 (100%), Corn - 1/1 (100%), Cucumber - 1/1 (100%), Potatoes - 3/3 (100%), Radish - 1/1 (100%), Marrow - 3/3 (100%) and Tomatoes 11/16 (69%). Cabbage and Capsicum did not contain any pesticide residues.

The number of different vegetable samples collected from Hayer and the levels of pesticide contamination in these samples are shown in Table 6-5 according to concentration ranges. In Hayer 28% (9/32) of all samples had no pesticide residues, 38% (12/32) had pesticides residues at concentrations below 1 mg/kg, 31% (10/32) between 1 to 3 mg/kg and 3% (1/32) had in excess of 3 mg/kg. Pesticide residues between 1 and 3 mg/kg were identified in Cauliflower (50%), Corn (100%), Marrow (67%), Potato (33%) and Tomato (31%). Among the Tomato samples 6% (1/16) were observed to have contained in excess of 3 mg/kg, none of the other vegetables were found to have contained pesticide residues in excess of 3 mg/kg.

The mean±standard error of the pesticide contamination of the vegetable samples collected from Hayer was 1.02±0.18 mg/kg and 1.61±0.24 mg/kg for the pesticide associated chemical compounds. The mean total concentration of pesticides and pesticide associated chemical compounds in the Hayer samples was 2.63±0.28 mg/kg (Table 6-6). The mean concentration of pesticide residues was highest in Corn (2.00 mg/kg), followed by Cauliflower (1.30±0.50 mg/kg), Tomato (1.19±0.25 mg/kg), Marrow (0.93±0.06 mg/kg), Cucumber (0.80 mg/kg) and Aubergines (0.80 mg/kg). Potatoes (0.67±0.37 mg/kg), and Radish (0.40 mg/kg) contained lower concentrations of pesticide residues, whereas, Cabbage and Capsicum did not contain any pesticide residues.

Table 6-6: Mean pesticide residue, pesticide associated chemical compound and total pesticide concentrations in vegetable samples from Hayer

Vegetables (n)	Pesticides Mean±SE mg/kg	Others Mean±SE mg/kg	Total Mean±SE mg/kg
Aubergines (3)	0.80	2.03±0.52	2.30±0.70
Cabbage (1)	0.0	1.00	1.00
Capsicum (1)	0.0	1.50	1.50
Cauliflower (2)	1.30±0.50	0.0	1.30±0.31
Corn (1)	2.00	1.00	3.00
Cucumber (1)	0.80	2.30	3.10
Marrow (3)	0.93±0.06	1.27±0.23	2.20±0.30
Potatoes (3)	0.67±0.37	0.67±0.29	1.33±0.51
Radish (1)	0.40	0.40	0.80
Tomatoes (16)	1.19±0.25	1.54±0.27	2.43±0.35
Mean	1.02±0.18	1.61±0.24	2.63±0.28

In summary eight of the ten vegetable commodities, in Hayer, analysed for pesticide residues were identified to have contained pesticide residues in varying amounts. Cabbage and Capsicum though did not contain any pesticide residues, were found to contain pesticide associated chemical compounds. Corn, Cauliflower and Tomatoes, identified with high concentrations of pesticide residues, were the highly contaminated vegetable commodities in the Hayer farming area, compared to the other commodities in this area. Although only 69% (the lowest percentage of samples among those commodities with pesticide residues) of the Tomato samples were identified with pesticide residues, these samples contained substantially higher amounts of pesticide residues compared to commodities like Aubergines, Cabbage, Capsicum, Cucumber, Potatoes and Radish.

6.5 *Pesticide residues in vegetables from Ramah*

The pesticide residues identified in the different vegetable samples from Ramah are shown in Appendix 19 (Table 2), along with the pesticide associated chemical compounds (Others) identified in the same samples. The number of samples identified to have contained the identified pesticide residue are shown against each pesticide in the same Appendix. Organophosphorus and carbamate pesticides were the most frequently identified pesticides in the vegetable samples from Ramah. Ethidimuron and Butocarboxim were each identified in three samples of Aubergines, Triadimefon in two samples of Green leafy vegetables, Phenthoate in three samples and Profenofos in two samples of Onion and

Table 6-7: The levels of pesticide residues in the different vegetable samples collected from Ramah.

Vegetables	None n^a/n^b	< 1 mg/kg n^1/n^2	1-3 mg/kg n^1/n^2	> 3 mg/kg n^1/n^2	Total n (%)
Aubergines	1/0	3/0	2/6		6 (10)
Cabbage	1/0	2/1	0/2		3 (5)
Carrot	3/2	1/1	0/1		4 (7)
Cauliflower		2/0	0/2		2 (3)
Chilli		1/1	1/0	0/1	2 (3)
Corn		1/0	1/2		2 (3)
Green leafy vegs		2/0	0/2		2 (3)
Marrow	2/0	1/0	0/3		3 (5)
Onion	5/1	2/2	3/6	0/1	10 (17)
Potato	1/0		0/1		1 (2)
Tomato	6/1	4/1	13/13	1/9	24 (41)
Total	19/4	19/6	20/38	1/11	59

n^a *number of samples without any pesticide residues*
n^b *number of samples without any pesticide residues and pesticide associated chemical compounds*
n^1 *number of samples with pesticide residues*
n^2 *number of samples with pesticide residues and pesticide associated chemical compounds*

Pyridate, Triadimefon and Bromacil, each, in five samples of Tomatoes. Overall, Pyridate, Triadimefon and Phenthoate were the most frequently identified pesticides in Ramah and were found in 9, 8 and 7 vegetable samples respectively.

A list of all the samples which were analysed for pesticides from the Ramah farming area are shown in Appendix 19 (Table 2) and the concentrations of the pesticide residues and the pesticide associated chemical compounds (others) in the different vegetable samples are also shown in this Table. Among the individual vegetable samples pesticide residues were identified in 83% (5/6) of Aubergines, 66% (2/3) of Cabbage, 25% (1/4) of Carrots, 100% (2/2) of Cauliflower, 100% (2/2) of Chillies, 100% (2/2) of Corn, 100% (2/2) of Green leafy vegetables, 33% (1/3) of Marrow, 50% (5/10) of Onion and 75% (18/24) of Tomatoes.

Table 6-8: Mean pesticide residue and pesticide associated chemical compound concentrations in vegetable samples from Ramah

Vegetables	Pesticides Mean±SE mg/kg	Others Mean±SE mg/kg	Total Mean±SE mg/kg
Aubergines (6)	0.80±0.11	1.17±0.21	1.83±0.23
Cabbage (3)	0.50±0.30	0.97±0.32	1.30±0.51
Carrots (4)	0.60±0.0	0.80±0.0	1.10±0.30
Cauliflower (2)	0.30±0.10	0.80±0.0	1.20±0.21
Chilli (2)	1.30±1.10	1.10±0.70	2.40±1.08
Corn (2)	0.60±0.40	1.80±0.0	2.40±0.40
Green leafy vegs (2)	0.60±0.40	0.60±0.20	1.65±0.40
Marrow (3)	0.40±0.0	1.37±0.37	1.50±0.50
Onion (10)	0.90±0.17	1.04±0.41	1.58±0.25
Potatoes (1)	0.0	1.00	1.00
Tomatoes (24)	1.70±0.21	1.63±0.12	2.87±0.27
Mean	1.59±0.25	2.26±0.27	3.91±0.43

A total of 59 different vegetable samples comprising eleven different vegetable types were analysed from this farming area. Among these samples 32% (19/59) had no pesticide residues in them and a further 32% (19/59) of the samples had pesticide residues below 1 mg/kg (Table 6-7). Pesticide residues between 1 to 3 mg/kg were identified in 34% (20/59) of the samples and a further 2% (1/59) of the samples contained above 3 mg/kg. Aubergines (33%, 2/6), Corn (50%, 1/2) Chillies (50%, 1/2), Onion (30%, 3/10) and Tomatoes (58%, 14/24) were found to contain pesticide residues in excess of 1 mg/kg of the vegetable. One sample of Tomatoes had pesticide residues in excess of 3 mg/kg.

The mean ± standard error of the pesticide residue contamination of the vegetable samples from Ramah was 1.59±0.25 mg/kg and 2.26±0.27 mg/kg for the pesticide associated chemical compounds. The total concentration of pesticides and pesticide associated chemical compounds in the Ramah samples was 3.91±0.43 mg/kg (Table 6-8). Tomatoes (1.70±0.21 mg/kg) and Chillies (1.30±1.10 mg/kg) were found to contain the highest concentrations of pesticide residues. The highest concentration of pesticide associated chemical compounds were observed in Corn (1.80±0.00 mg/kg) and Tomatoes (1.63±0.12 mg/kg). It was also observed that Chillies (2.40±1.08 mg/kg), Corn (2.40±0.40 mg/kg) and Tomatoes (2.87±0.27 mg/kg) contained the highest concentrations of pesticide residues and pesticide associated chemical compounds.

In summary, in the Ramah farming area ten of the eleven vegetable commodities were identified with pesticide residues. Pesticide residues in excess of 1 mg/kg were identified in Aubergines (33%), Chillies (50%), Corn (50%), Onion (30%) and Tomatoes (58%). The mean concentrations of pesticide residues in all the vegetable commodities in Ramah was 1.59±0.25 mg/kg and the mean concentration of pesticide residues and pesticides associated chemical compounds was 3.91±0.43 mg/kg. Among those commodities which contained pesticide residues Chillies (1.30±1.10 mg/kg) and Tomatoes (1.70±0.21 mg/kg) had the highest concentration of pesticide residues.

6.6 *Pesticide residues in vegetables from Gumadh*

The pesticide residues and the pesticide associated chemical compounds (Others) identified in the different vegetable samples from Gumadh are shown in Appendix 19 (Table 3). As in the other two farming areas, organophosphorus and carbamate pesticides were the most frequently identified pesticides in the vegetable samples. Pyridate, Triadimefon, Bendiocarb and Captan were the most frequently identified pesticides in the vegetables from this farming area. Pyridate was identified in four samples of Aubergines and Ethidimuron, Butocarboxim and Triadimefon were each identified in two samples. Pyridate and Triadimefon were each identified in three samples of Tomatoes and Bromacil in two samples. In Chillies, Bendiocarb was identified in three samples and Demeton, Tolyfluanid, Vamidothion, Phosphamidon and Triadimefon in two samples each.

The concentrations of pesticide residues and the pesticide associated chemical compounds (others) in the different vegetable samples are shown in Appendix 19 (Table 3) for each of the farms from which a sample was collected. A total of 43 different samples of vegetables comprising Aubergines, Capsicum, Chilli, Corn, Cucumbers, Green leafy vegetables, Marrow, Onion and Tomatoes were analysed for pesticide residues and pesticide associated chemical compounds. The types and numbers of different vegetable samples collected from Gumadh represented the number of farms cultivating those crop. Aubergines, Chillies, Tomatoes and Cucumbers were the most frequently grown crops in Gumadh, as represented by 30% of Aubergine samples, 21% of Chilli samples, 16% of Tomato samples and 14% of Cucumber samples.

A number of different organophosphorus and carbamate pesticides were identified in the vegetable samples from Gumadh. One sample of chillies was identified with a maximum of six different pesticide residues, one sample of cucumbers was identified with five different pesticide residues and a sample of aubergines was identified with four different pesticide residues. Six vegetable samples were found to contain three different pesticides each and 13 samples were found with no pesticide residues. Triadimefon was the most commonly identified pesticide being identified in 12 samples followed by Pyridate identified in 11 samples. Demeton, Captan and Bendiocarb were each identified in three samples. Among the individual vegetable commodities pesticide residues were identified in 69% (9/13) of Aubergines, 100% (2/2) of Capsicum, 67% (6/9) of Chillies, 50% (3/6) of Cucumber, 100% (1/1) of Green leafy vegetables, 100% (3/3) of Marrow and 86% (6/7) of Tomatoes.

The levels of pesticide contamination in the different vegetable samples collected from Gumadh and categorised as not detected, less than 1 mg/kg, 1 to 3 mg/kg and above 3 mg/kg are shown in Table 6-9. In this farming area 30% (13/43) of the samples had no detectable pesticide residues and 7% (3/43) of the samples contained no detectable pesticide associated chemical compounds. Pesticide residues less then 1 mg/kg were identified in 26% (11/43), pesticide residues between 1 to 3 mg/kg were identified in 35% (15/43) of the samples and pesticide residues in excess of 3 mg/kg were identified in 9% (4/43) of the samples. Among the individual commodities pesticide residues in excess of 1 mg/kg were identified in 31% (4/13) of Aubergines, 67% (6/9) of Chillies, 33% (2/6) of Cucumbers, 100% (1/1) of Green leafy vegetables, 100% (3/3) of Marrow and 43% (3/7) of Tomatoes. Pesticide associated chemical compounds in excess of 3 mg/kg were identified in Aubergines (8%), Capsicum (50%), Chillies (33%), Cucumbers (33%), Marrow (67%) and Tomatoes (29%) (Table 6-9).

For the Gumadh farming area, the mean ± standard error of the pesticide residue contamination for all the vegetable samples was 1.26±0.23 mg/kg and 1.85±0.24 mg/kg for the pesticide associated chemical compounds (Table 6-10). The total concentration of pesticide residues and pesticide associated chemical compounds for this farming area was 3.11±0.39 mg/kg. The mean concentrations of pesticide residues in Chillies (2.33±0.49 mg/kg), Cucumbers (1.93±0.93 mg/kg), Green leafy vegetables (1.80±0.0 mg/kg)), and Marrow (1.33±0.24 mg/kg) were greater than the population mean of 1.26±0.23 mg/kg. Pesticide residue and pesticide

Table 6-9: The levels of pesticide residue and pesticide associated chemical compound contamination in vegetable samples collected from Gumadh.

Vegetables	None n^a/n^b	< 1 mg/kg n^1/n^2	1-3 mg/kg n^1/n^2	> 3 mg/kg n^1/n^2	Total n (%)
Aubergines	4/0	5/0	4/12	0/1	13 (30)
Capsicum	0/0	2/0	0/1	0/1	2 (5)
Chilli	3/1	0/0	3/5	3/3	9 (21)
Corn	1/0	0/0	0/1	0/0	1 (2)
Cucumbers	3/1	1/0	1/3	1/2	6 (14)
Green leafy vegs	0/0	0/0	1/1	0/0	1 (2)
Marrow	0/0	0/0	3/1	0/2	3 (7)
Onion	1/0	0/0	0/1	0/0	1 (2)
Tomatoes	1/1	3/0	3/4	0/2	7 (16)
Total	13/3	11/0	15/29	4/11	43

n^a *number of samples without any pesticide residues*
n^b *number of samples without any pesticide residues and pesticide associated chemical compounds*
n^1 *number of samples with pesticide residues*
n^2 *number of samples with pesticide residues and pesticide associated chemical compounds*

associated chemical compound concentrations were highest for Chillies (3.30±0.55 mg/kg) and Marrow (3.00±0.46 mg/kg) followed by Corn (2.80±0.00 mg/kg), Cucumbers (2.74±0.78 mg/kg) and Capsicum (2.50±0.50 mg/kg).

In Gumadh, pesticide residues were identified in seven of the nine vegetable commodities and greater percentages of samples of Green leafy vegetables, Chillies, Cucumbers and Marrow were found to contain pesticide residues. The mean concentration of pesticide residues for vegetables in this farming areas was 1.26±0.23 mg/kg. For individual commodities the mean concentrations of pesticide residues were the highest for Green leafy vegetables, Chillies, Marrow and Cucumbers. The number of samples of Marrow, Chillies and Corn which

Table 6-10: Mean pesticide residue and pesticide associated chemical compound concentrations in vegetable samples from Gumadh

Vegetables	Pesticides Mean±SE mg/kg	Others Mean±SE mg/kg	Total Mean±SE mg/kg
Aubergines	1.61±0.40	1.49±0.20	2.29±0.40
Capsicum	0.65±0.50	1.85±0.45	2.50±0.50
Chilli	2.33±0.49	1.55±0.14	3.30±0.55
Corn	0.0	2.80	2.80
Cucumber	1.93±0.93	1.58±0.17	2.74±0.78
Green leafy vegs	1.80	1.30	2.10
Marrow	1.33±0.24	1.67±0.38	3.00±0.46
Onion	0.0	1.20	1.2
Tomatoes	0.83±0.17	1.31±0.45	2.15±0.47
Area mean	1.26±0.23	1.85±0.24	3.11±0.39

contained pesticide residues in detectable amounts were 100%, 67% and 100% respectively. Triadimefon and Pyridate were the most commonly identified pesticides in this farming area.

6.7 *Pesticide residues in vegetables from Waggan*

The pesticide residues and the pesticide associated chemical compounds identified in the different vegetable samples from Waggan are shown in Appendix 19 (Table 4). Butocarboxim, Pyridate and Demephion were identified in 43% (6/14), 36% (5/14) and 36% (5/14) of the Aubergine samples respectively. In green leafy vegetable samples, Promecarb and Triadimefon were each identified in 25% (2/8) of the samples. Pyridate and Triadimefon were identified in 25% (5/20) of the onion samples and in Tomatoes, Pyridate was identified in 50% (4/8) of the samples, while Bromacil, Amadithion, Triadimefon and Aminocarb were each identified in 25% (2/8) of the samples. Overall, Pyridate (17/57), Triadimefon (11/57) and Butocarboxim (8/57) appeared to be the most frequently used pesticides in the Waggan farming area according to the identified residues.

A list of all the vegetable samples collected from the Waggan farming area and the concentrations of pesticides and pesticide associated chemical compounds is given in Appendix 19 (Table 4). A total of 42 (74%) vegetable samples were found to contain at least one pesticide and 15 (26%) samples were identified without any pesticide residues. Pesticide residues were identified in 93% (13/14) of Aubergines, 100% (1/1) of Cabbage, 88% (7/8) of Green leafy vegetables, 100% (3/3) of Marrow, 50% (10/20) of Onion and 100% (8/8) of Tomatoes. One sample of Tomatoes from this farming area was identified with four pesticides and two other samples (Aubergines and Tomatoes) were each found to contain three different pesticide residues.

Table 6-11: The levels of pesticide residues and pesticide associated chemical compounds in vegetable samples collected from Waggan.

Vegetables	None n^a/n^b	< 1mg/kg n^1/n^2	1-3 mg/kg n^1/n^2	> 3 mg/kg n^1/n^2	Total n (%)
Aubergines	1/0	10/2	3/9	0/3	14 (25)
Cabbage	0/0	1/1	0/0	0/0	1 (2)
Chillies	1/0	0/0	0/1	0/0	1 (2)
Cucumbers	2/0	0/0	0/2	0/0	2 (4)
Green leafy vegs	1/0	6/2	1/6	0/0	8 (14)
Marrow	0/0	2/1	1/1	0/1	3 (5)
Onion	10/0	6/2	4/17	0/1	20 (35)
Tomatoes	0/0	5/2	3/5	0/1	8 (14)
Total	15/0	30/10	12/41	0/6	57

n^a *number of samples without any pesticide residues*
n^b *number of samples without any pesticide residues and pesticide associated chemical compounds*
n^1 *number of samples with pesticide residues*
n^2 *number of samples with pesticide residues and pesticide associated chemical compounds.*

The levels of contamination in vegetable samples from Waggan, categorised as none, less than 1 mg/kg, 1 - 3 mg/kg and above 3 mg/kg are shown in Table 6-11. In this farming area, of the 74% (42/57) of the vegetable samples identified with pesticide residues 71% (30/42) contained pesticide residues less than 1 mg/kg and 29% (12/42) contained pesticide residues between 1 and 3 mg/kg (Table 6-27). None of the samples contained pesticide residues in excess of 3 mg/kg. Pesticide residues in excess of 1 mg/kg were identified in Aubergines (21%), Green leafy vegetables (13%), Marrow (33%), Onion (20%) and Tomatoes (38%). None of the samples of Cucumbers and Chillies, from this farming area, contained any pesticide residues in the detectable range.

The mean concentration of pesticide residues and pesticide associated chemical compound in the different vegetable samples from Waggan are shown in Table 6-12. The mean pesticide concentration for this area was 0.87±0.15 mg/kg and for the pesticide associated chemical compounds was 2.02±0.23 mg/kg. The mean concentration of pesticide residues and pesticide associated chemical compounds

Table 6-12: Mean pesticide residue and pesticide associated chemical compound concentrations in vegetable samples from Waggan.

Vegetables	Pesticides Mean±SE mg/kg	Others Mean±SE mg/kg	Total Mean±SE mg/kg
Aubergines (14)	0.81±0.14	1.36±0.24	2.11±0.25
Cabbage (1)	0.80	0.00	0.80
Chillies (1)	0.00	1.00	1.00
Cucumbers (2)	0.00	1.30±0.01	1.30±0.01
Green leafy vegs (8)	0.51±0.16	1.25±0.23	1.63±0.25
Marrow (3)	0.70±0.15	0.90±0.44	1.60±0.93
Onion (20)	0.75±0.14	1.29±0.09	1.75±0.15
Tomatoes (8)	1.01±0.34	1.13±0.80	2.01±0.52
Area mean	0.87±0.15	2.02±0.23	2.93±0.33

was 2.93±0.33 mg/kg. Higher concentrations of pesticide residues were observed for Tomatoes (1.01±0.34 mg/kg), Aubergines (0.81±0.14 mg/kg), Cabbage (0.80 mg/kg), Onion (0.75±0.14 mg/kg) and Marrow (0.70±0.15 mg/kg) compared to the other vegetable samples from this area. The combined concentrations of pesticide residues and pesticide associated chemical compounds were observed to be high for Aubergines (2.11±0.26 mg/kg), Tomatoes (2.01±0.52 mg/kg), Onion (1.75±0.15 mg/kg), Green leafy vegetables (1.63±0.25 mg/kg), and Marrow (1.60±0.93 mg/kg).

In Waggan six of the eight vegetable commodities were observed to have pesticide residues in the detectable range. Pesticide residues were identified in 74% of all samples and pesticides associated chemical compounds in 100% of the samples. Pyridate, Triadimefon and Butocarboxim were the most commonly identified pesticide residues in this farming area. The mean concentration of pesticide residues in vegetables from this area was 0.87±0.15 mg/kg. Among the individual commodities Tomatoes, Cabbage, Marrow and Aubergines contained the highest concentrations of pesticide residues. Aubergines, Tomatoes, Green leafy vegetables, Onion, Marrow and Cucumbers were also observed to have contained higher concentrations of pesticides and pesticides associated chemical compounds.

6.8 Pesticide residues in vegetables from Sleimat

The different pesticide residues and the pesticide associated chemical compounds identified in the vegetable samples from Sleimat are shown in Appendix 19 (Table 5). The number of samples which contained pesticides are indicated against each pesticide in this Table. In Aubergines, Butocarboxim and Demephion were each identified in 40% (4/10) of the samples and Triadimefon, Ethidimuron and Formothion were each identified in 20% (2/10) samples. A large number of pesticide residues were identified in just four Corn samples, however most of the residues were identified in just one sample. The only pesticide residues which occurred in more than one sample of Corn were

Thiometon and Phenthoate, which were identified in 50% (2/4) of the Corn samples. In the Green leafy vegetables, Triadimefon was identified in 50% (2/4) of the samples whereas the rest of the residues were identified in just one sample. Triadimefon was identified in 50% (2/4) of the samples of Marrow and Bendiocarb in 25% (1/4) of the samples. The pesticide residues which were identified in more than one sample of Onion were Triadimefon (36%, 10/28), Phenthoate 29%, 8/28), Fenobucarb (18%, 5/28), Pyridate (11%, 3/28), Dimethoate (11%, 3/28), Captan (11%, 3/28), Profenofos (7%, 2/28) and Ethidimuron (7%, 2/28). The most frequently used pesticides in the Sleimat farming area were Triadimefon (34%, 18/53), Phenthoate (21%, 11/53), Butocarboxim, Fenobucarb, Demephion and Pyridate each (9%, 5/53) and Dimethoate (8%, 4/53).

A list of all the vegetable samples collected from the Sleimat farming area and the concentration of pesticide residues and pesticide associated chemical compounds

Table 6-13: The levels of pesticide residues and pesticide associated chemical compounds in vegetable samples from Sleimat.

Vegetables	None n^a/n^b	< 1 mg/kg n^1/n^2	1-3 mg/kg n^1/n^2	> 3 mg/kg n^1/n^2	Total n (%)
Aubergines	1/0	6/0	3/8	0/2	10 (19)
Corn	1/0	2/0	0/3	1/1	4 (8)
Green leafy vegs	1/0	2/0	1/4	0/0	4 (8)
Marrow	1/0	2/0	1/4	0/0	4 (8)
Onion	7/2	9/1	10/20	2/5	28 (53)
Tomatoes	0/0	1/0	2/1	0/2	3 (6)
Total	11/2	22/1	17/40	3/10	53

n^a *number of samples without any pesticide residues*
n^b *number of samples without any pesticide residues and pesticide associated chemical compounds*
n^1 *number of samples with pesticide residues*
n^2 *number of samples with pesticide residues and pesticide associated chemical compounds*

is shown in Appendix 19 (Table 5). The highest combined pesticide residue concentrations were found in a sample of Corn (5.0 mg/kg) and a sample of Onion (3.0 mg/kg). The lowest level of pesticide residue above the detectable range was 0.2 mg/kg and was identified in one sample each of Marrow and Tomatoes. In Sleimat 79% (42/53) of all the vegetable samples contained pesticide residues. The percentages of different vegetable commodities which contained pesticide residues were; Aubergines 90% (9/10), Corn 75% (3/4), Green leafy vegetables 75% (3/4), Marrow 75% (3/4), Onion 75% (21/28) and Tomatoes 100% (3/3).

The levels of contamination of Sleimat vegetables with pesticide residues categorised as none (non-detectable), less than 1 mg/kg, 1 - 3 mg/kg and in excess of 3 mg/kg are shown in Table 6-13. Eleven samples (21%) out of the 53 samples which were analysed for pesticide residues contained pesticides below the detectable levels. Among those vegetables which contained pesticides, 42% contained pesticides below 1 mg/kg, 32% between 1 - 3 mg/kg and 6% in excess of 3 mg/kg. Pesticide residues in excess of 1 mg/kg were identified in

Table 6-14: Mean pesticide residue and pesticide associated chemical compound concentrations in vegetable samples from Sleimat

Vegetables	Pesticides Mean±SE mg/kg	Others Mean±SE mg/kg	Total Mean±SE mg/kg
Aubergines (10)	0.87±0.17	1.90±0.14	2.68±0.27
Corn (4)	2.07±1.47	1.58±0.22	3.13±1.29
Green leafy vegs (4)	0.93±0.32	1.15±0.09	1.83±0.33
Marrow (4)	0.80±0.35	1.45±0.17	2.05±0.41
Onion (28)	1.18±0.16	1.61±0.09	2.57±0.21
Tomatoes (3)	0.93±0.37	1.90±0.36	3.14±0.41
Area mean	1.20±0.21	2.14±0.21	3.34±0.37

Aubergines (30%), Corn (25%), Green leafy vegetables (25%), Marrow (25%), Onion (43%) and Tomatoes (67%). Pesticides and pesticides associated chemical compounds were identified in 96% of all vegetable samples from the Sleimat farming area.

The concentrations of pesticide residues in Corn (2.07±0.47 mg/kg) and Onion (1.18±0.16 mg/kg) were the highest and were also higher than the area sample mean of 1.20±0.21 mg/kg (Table 6-14). The mean concentrations of pesticide associated chemical compounds for this farming area was 2.14±0.21 mg/kg and the mean total concentration of pesticide residues and pesticide associated chemical compounds was 3.34±0.37 mg/kg. Higher concentrations of pesticide associated chemical compounds were observed in Aubergines (1.90±0.14 mg/kg) and Tomatoes (1.90±0.36 mg/kg). Corn (3.13±1.29 mg/kg), Tomatoes (3.14±0.41 mg/kg), Aubergines (2.68±0.27 mg/kg) and Onion (2.57±0.21 mg/kg) had higher concentrations of combined pesticide residues and pesticide associated chemical compounds.

In the Sleimat farming area six out of the six vegetable commodities analysed for pesticide residues were identified with pesticides. Pesticide residues were identified in 79% of all vegetable samples from this area. Higher percentages of samples from Aubergines (90%), Onion (75%) and Tomatoes (100%) were found with pesticides. Triadimefon and Phenthoate were the most commonly identified pesticides in this farming area followed by Demephion, Butocarboxim and Fenobucarb. The mean pesticide residue concentrations for the vegetables in this farming area were 1.20±0.21 mg/kg. The highest mean concentrations of pesticide residues were observed in Corn, Onion, Tomatoes and Green leafy vegetables. The mean concentrations of the combined pesticide residues and pesticide associated chemical compound were observed to be higher for Corn, Tomatoes, Aubergines and Onion.

6.9 *Summary and discussion of the pesticide residues in locally grown vegetables*

The number of the samples and the mean concentrations of pesticide residues identified by type in the different types of vegetable samples from the five farming areas are shown in Appendix 20. Organophosphates and Carbamates including Others (Dinitrophenol herbicides, Pyridazine herbicides, Conazole fungicide, Diphenyl ether herbicides, Phthalimide fungicide, Methylcarbamate insecticide, Carbamoyloxime fungicide, Organochlorine insecticides and Bromacil-lithium) were the major types of pesticides identified in the vegetable samples. Among the different vegetable commodities from the five farming areas pesticide residues were identified in 82% of Aubergines, 60% of Cabbage, 67% of Capsicum, 25% of Carrots, 100% of Cauliflower, 67% of Chillies, 75% of Corn, 44% of Cucumbers, 87% of Green leafy vegetables, 81% of Marrow, 53% of Onion, 75% of Potatoes, 100% of Radish and 79% of Tomatoes (Appendix 20).

A total of 37 samples of Aubergines were identified with pesticide residues and Butocarboxim (43%), Pyridate (30%), Ethidimuron (27%), Demephion (24%) were the most frequently found pesticides in Aubergines. The number of samples of Cabbage, Capsicum, Carrots and Radish were small and therefore a pattern for the most frequently identified pesticide residues did not emerge, however, pesticide residues were identified in all these vegetable samples. All samples of Cauliflower contained pesticide residues and Carbaryl (75%) was the most frequently identified pesticide in Cauliflower. In Chillies, Bendiocarb was identified in 38% of the samples and Captan, Demephion, Tolyfluanid, Vamidothion and Phosphamidon were each identified in 25% of the samples of Chillies. Phenthoate was identified in 50% of the Corn samples and Demeton-S-methyl, Pyridate, Disulfoton and Thiometon were identified in 33% of the samples. Captan and Triadimefon were each identified in 50% of the Cucumber samples which contained pesticide residues. The other pesticides (Methidathion, Ethoprofos, Pyridate, Demephion and Monocryptofos) were identified in one sample each of Cucumbers. In Green leafy vegetables, Triadimefon (54%) and Promecarb (23%) were the most frequently identified pesticides. Phenthoate

(15%) and Captan (15%) were less frequently identified and the others were identified in just one sample. Triadimefon (52%), Phenthoate (39%), Pyridate (19%), Fenobucarb (16%), Profenofos (13%) and Butocarboxim (10%), Dimethoate (10%) and Captan (10%) were the frequently identified pesticides in Onion. Heptenophos was identified in all three samples of Potatoes and in Tomatoes Pyridate (37%), Triadimefon (28%), Bromacil (22%), Aminocarb (11%), Dimethoate (9%) and Phenthoate (9%) were the most frequently identified pesticides.

Among the Aubergine samples the highest concentrations of organophosphorus pesticide residues were from Demephion (0.81 mg/kg) and Acephate (0.60 mg/kg) and the highest concentrations of carbamates and other pesticides were from Butocarboxim (0.67 mg/kg) and Triadimefon (0.54 mg/kg). The highest concentrations of organophosphorus pesticide residues in Cabbage were from Formothion (0.80 mg/kg) and Dimethoate (0.60 mg/kg) and in Capsicum were from Triadimefon (0.80 mg/kg). Higher concentrations of carbamates and other pesticides residues were contained in Carrots and Cauliflower. The concentration of Pyridate (0.4 mg/kg) was higher in Carrots and Methidation (0.40 mg/kg), Phosphamidon (0.40 mg/kg), o,p-DDE (0.40 mg/kg) and Carbaryl (0.55 mg/kg) contributed higher amounts in Cauliflower. In Chillies, Vamidothion (1.20 mg/kg) and Captan (1.70 mg/kg), Tolyfluanid (1.60 mg/kg) and Desmethryn (2.40 mg/kg) were identified in higher concentrations among organophosphorus and carbamates and other pesticides. Pyridate (1.00 mg/kg) and Triadimefon (1.00 mg/kg) were also identified in higher concentrations in Chillies. Demethon-S-methyl (1.30 mg/kg), Demephion (0.80 mg/kg), Disulfoton (0.60 mg/kg) and Aminocarb (0.60 mg/kg) concentrations were higher in Corn and in Cucumbers Methidathion (0.80 mg/kg), Demephion (0.80 mg/kg), Captan (1.20 mg/kg) and Triadimefon (1.10 mg/kg) concentrations were higher. Green leafy vegetables contained highest concentrations of Phenthoate (0.90 mg/kg), Pirimiphos-methyl (0.80 mg/kg) and Captan (0.65 mg/kg) and Marrow contained highest concentrations of Methidathion (0.80 mg/kg), Triamiphos (1.00 mg/kg) and Aminocarb (1.00 mg/kg). Among organophosphorus pesticides, Profenofos (1.30

mg/kg) concentrations and among carbamates and other pesticides, Isoprocarb (0.80 mg/kg) and Butocarboxim (0.60 mg/kg) concentrations were the highest in Onion. Potatoes contained higher concentrations of Ethidimuron (1.00 mg/kg) and Tomatoes contained highest concentrations of Formothion (1.80 mg/kg), Phosphamidon (1.30 mg/kg), Pirimiphos-methyl (1.20 mg/kg) and Demephion (1.10 mg/kg) among organophosphorus pesticides and Bromacil (1.04 mg/kg) and Triadimefon (1.00 mg/kg) among carbamates and other pesticides.

Pyridate was the most commonly identified pesticide in the vegetables and was identified in all the five farming areas and in all types of vegetables except Potatoes. Triadimefon was identified in Aubergines, Capsicum, Chillies, Cucumbers, Green leafy vegetables, Marrow, Onion and Tomatoes. Captan has was identified in Chillies, Cucumbers, Green leafy vegetables, Onion and Tomatoes. Phenthoate was identified in Corn, Green leafy vegetables, Onion and Tomatoes and Bendiocarb was identified in Chillies, Onion and Tomatoes. Among the frequently identified pesticides, Dimethoate, Captan, Carbaryl and Demeton-S-methyl have been described as mutagenic and/or carcinogenic (Watterson, 1991). These pesticides were identified either singly or along with others in Aubergines, Cabbage, Carrots, Cauliflower, Chillies, Corn, Cucumbers, Green leafy vegetables, Onion and Tomatoes. The use of Carbaryl has been banned in Germany and Bromacil in Sweden because of adverse effects on animals and human (Watterson, 1991). Bromacil was identified in 22% of Tomatoes and Carbaryl in 8% of Aubergines and Cauliflower. Demephion has been suspended from being manufactured because of its environmental and human toxicity. However, old stockpiles of unused Demephion have been exported by manufacturers and have been used in countries like the United Arab Emirates. Demephion was identified in Aubergines (24%), Chillies (25%), Corn (17%), Cucumber (25%), Green leafy vegetables (13%) and Tomatoes (4%). Aminocarb, Amidithion, Chlorfenson, Demeton-S-methyl, Ethiolate and Triamiphos have also been superseded and are no longer manufactured. However, these pesticides were identified, some in greater concentrations than others, in different locally grown vegetables in this study.

Pesticide residues in excess of 0.1 mg/kg were identified in Radish (100%), Cauliflower (100%), Potatoes (75%), Capsicum (67%), Chillies (67%) and Cabbage (60%)(Table 6-15). However, the sample size for all these commodities was small. Green leafy vegetables, Aubergines, Marrow, Onion, Tomatoes and Corn were other commodities which were analysed in greater numbers. Pesticide residues in excess of 0.1 mg/kg were identified in greater numbers of samples of Green leafy vegetables (87%), Aubergines (80%), Marrow (81%), Onion (61%), Tomatoes (79%) and Corn (75%). A total of 172 (70%) samples of the different vegetable types were identified with pesticide residues in excess of 0.1 mg/kg. The highest numbers of samples with pesticide residues were identified in Sleimat (79%) followed by Waggan (74%). The corresponding numbers of samples for the other areas were 68%, 68% and 70% for Hayer, Ramah and Gumadh respectively.

The mean pesticide residue concentrations in the different types of vegetables from the five farming areas are shown in Table 6-16, the pesticide associated chemical compound concentrations in Table 6-17 and the sum total of pesticide residue and pesticide associated chemical compound concentrations in Table 6-18. The mean pesticide residue concentrations (mean±SE) for the farming areas of Ramah (1.59±0.25 mg/kg), Gumadh (1.26±0.23 mg/kg) and Sleimat (1.20±0.21 mg/kg) were higher than the sample mean of 1.19±0.09 mg/kg. The mean concentrations of pesticide residues in Chillies (2.07±0.44 mg/kg), Corn (1.57±0.73 mg/kg), Cucumber (1.65±0.69 mg/kg) and Tomatoes (1.33±0.13 mg/kg) were higher compared to the other commodities (Table 6-16). The mean concentrations of pesticide associated chemical compounds in Ramah (2.26±0.27 mg/kg), Sleimat (2.14±0.21 mg/kg) and Waggan (2.02±0.23 mg/kg) was higher than the sample mean of 1.99±0.11 mg/kg. The farming areas of Ramah (3.91±0.43 mg/kg) and Sleimat (3.34±0.37 mg/kg) also had higher concentrations of pesticide residues and pesticide associated chemical compounds compared to the sample mean of 3.21±0.17 mg/kg.

The mean concentrations of pesticide residues in the locally grown Chillies, Corn, Cucumbers, Onion and Tomatoes were all in excess of 1 mg/kg and were only slightly less than 1 mg/kg in Aubergines, Cauliflower and Marrow (Table 6-16). Organochlorine pesticide residues in excess of 1 mg/kg have been reported in Indian agriculture produce (Kannan *et al*, 1997). Pesticide residue (Methidation) concentrations between 0.1 and 2.2 mg/kg in Peppers, Cucumbers and Tomatoes have been identified in more than 70% of the produce analysed by Torres *et al*, (1997). Similar higher percentages of samples of Broccoli (100%), Cabbage (80%) and Cucumber (71%) have been reported to contain pesticide residues above the tolerance limits (Ahmad *et al*, 1996). The percent residue contamination of locally grown vegetables in Belgium has been reported to be in the range of 56% to 75% for Carrots and 49% to 95% for Tomatoes (Dejonckheere *et al*, 1996a).

In the United Arab Emirates the focus has been on producing crops in large quantities and the use of pesticides in agriculture has been left to the discretion of the farmworkers who tend to use excessive amounts of pesticides as a preventive measure to pre-empt pest attack. A significant positive correlation was observed between the use of pesticides per unit cultivated area (Chapter IV) and the mean concentration of pesticide residues in vegetables (0.133, $p<0.05$) and pesticide residues in farm water (0.202, $p<0.01$) (Table 6-19). A non-significant positive correlation was observed between the use of pesticide per unit cultivated area and pesticide residues in sand (0.116, $p=0.087$). A significant positive correlation was also observed between the mean concentration of pesticide residues in sand and water (0.134, $p<0.05$) (Table 6-19). The correlation between the mean concentration of pesticide residues in the vegetables and mean concentration of pesticide residues in sand and water was not significant except for the farming areas of Hayer (0.226, $p=0.003$ for water and 0.299, $p=0.001$ for sand) and Ramah (0.216, $p=0.005$ for water and 0.193, $p=0.004$ for sand).

Agricultural produce has been routinely monitored in the developed countries, however, in the UAE, like in the other developing countries the agricultural produce in not monitored. The purpose of monitoring is to assess the suitability of the produce for human consumption, therefore, in this process, foods exceeding the Maximum Residue Limits (MRL) is declared unsafe and removed from trade. MRL has been recommended by the Codex Alimentarius Commission (Codex Alimentarius, 1993) and used world wide, but some countries like United States of America, Canada and most of the European countries have established national tolerance limits. Routine monitoring of agricultural foods in USA was reported to have found pesticide residues in 40% of domestic produce and 26% of imported produce (Yess, 1991a; Yess *et al* 1991b). According to Yess (1991a) the concentration levels of the pesticide residues were low compared to the federal tolerance levels, only 2.8% of the produce exceeded the tolerance levels. During 1978-1982, in the United States of America 45% of the domestic produce and 56% of the imported produce were reported to contain pesticides, among these samples 3% and 7% of the domestic and imported produce exceeded the federal tolerance levels (Yess *et al,* 1991b). However, during 1983-1986, pesticide residues were identified in 40% and 52% of the domestic and imported produce and tolerance levels were exceeded in 3% and 5% of the domestic and imported produce (Yess *et al,* 1993c). Agri-Food, Canada routinely monitors domestic and imported agricultural produce for pesticide contamination. Pesticide residues were identified in 12% of the domestic produce of which only 0.55% exceeded the Canadian maximum residue limits, among the imported produce 16% contained pesticide residues of which 2.86% exceeded the national maximum residue limits (Neidert and Saschenbrecker, 1996). A large number of pesticide residues, by type of pesticides, have been identified in Switzerland but mostly in very small quantities. However, federal tolerance levels were exceeded in 6% of the analysed samples of agricultural produce (Corvi and Vogel, 1993). In the UAE study 73% (177/244) of the analysed vegetable samples contained pesticide residues and 96% (234/244) contained pesticide residues and pesticide associated chemical compounds in excess of 0.1 mg/kg (Table 6-15).

Roy *et al,* (1995) have reported that Methamidophos and Acephate were identified most frequently in both domestic and imported Tomatoes and 1.9%

Table 6-15: The levels of pesticide residue contamination of vegetable samples in the five farming areas.

Crops	Hayer		Ramah		Gumadh		Waggan		Sleimat		Total	
	None n^a/n^b	>.1mg/kg n^1/n^2	None n^a/n^b	>.1mg/kg n^1/n^2	None n^a/n^b	>.1mg/kg n^1/n^2	None n^a/n^b	>.1mg/kg n^1/n^2	None n^a/n^b	>.1mg/kg n^1/n^2	None n^a/n^b	>.1 mg/kg n^1/n^2
Aubergines	2/0	1/3	1/0	5/6	4/0	9/13	1/0	13/14	1/0	9/10	9/0	37/46
Cabbage	1/0	0/1	1/0	2/3			0/0	1/1			2/0	3/5
Capsicum	1/0	0/1			0/0	2/2					1/0	2/3
Carrots			3/2	1/2							3/2	1/2
Cauliflower	0/0	2/2	0/0	2/2							0/0	4/4
Chillies			0/0	2/2	3/1	6/8	1/0	0/1			4/1	8/11
Corn	0/0	1/1	0/0	2/2	1/0	0/1			1/0	3/4	2/0	6/8
Cucumber	0/0	1/1			3/1	3/5	2/0	0/2			5/1	4/8
Green leafy vegs			0/0	2/2	0/0	1/1	1/0	7/8	1/0	3/4	2/0	13/15
Marrow	0/0	3/3	2/0	1/3	0/0	3/3	0/0	3/3	1/0	3/4	3/0	13/16
Onion			5/1	5/9	1/0	0/1	10/0	10/20	7/2	21/26	23/3	36/56
Potatoes	0/0	3/3	1/0	0/1							1/0	3/4
Radish	0/0	1/1									0/0	1/1
Tomato	5/1	11/15	6/1	18/23	1/1	6/6	0/0	8/8	0/0	3/3	12/3	46/55
Total	9/1	23/31	19/4	40/55	13/3	30/40	15/0	42/57	11/2	42/51	67/10	177/234

n^1:number of samples with pesticide residues; n^2:number of samples with pesticide resides and pesticide associated chemical compounds
n^a:number of samples without pesticide residues; n^b:number of samples without pesticide associated chemical compounds

Table: 6-16: Mean±standard error concentrations of pesticide residues in vegetables from the five farming areas

Vegetables	Hayer mg/kg	Ramah mg/kg	Gumadh mg/kg	Waggan mg/kg	Sleimat mg/kg	Mean mg/kg
1. Aubergines	0.80±0.0	0.80±0.11	1.16±0.40	0.81±0.14	0.87±0.17	0.91±0.12
2. Cabbage	0.0	0.50±0.30		0.80		0.60±0.20
3. Capsicum	0.0		0.65±0.05			0.65±0.30
4. Carrots		0.60±0.0				0.60±0.0
5. Cauliflower	1.30±0.50	0.30±0.10				0.80±0.36
6. Chillies		1.30±1.10	2.33±0.49	0.0		2.07±0.44
7. Corn	2.00	0.60±40	0.0		2.07±1.47	1.57±0.73
8. Cucumber	0.80		1.93±0.93	0.0		1.65±0.69
9. Green leafy vegs		0.60±0.40	1.80	0.51±0.16	0.93±0.32	0.74±0.16
10. Marrow	0.93±0.06	0.40±0.0	1.33±0.24	0.70±0.55	0.80±0.35	0.89±0.16
11. Onion		0.90±0.17	0.0	0.73±0.14	1.18±0.16	1.01±0.11
12. Potatoes	0.67±0.37	0.0				0.67±0.37
13. Radish	0.40					0.40
14. Tomatoes	1.19±0.25	1.70±0.21	0.83±0.17	1.01±0.34	0.93±0.37	1.33±0.13
Area means*	1.02±0.18	1.59±0.25	1.26±0.23	0.88±0.15	1.20±0.21	1.19±0.09

* Levene Test for homogeneity of variances ($p<0.05$)

Table: 6-17: Mean±standard error concentrations of pesticide associated chemical compounds in vegetables from the five farming areas

Vegetables	Hayer mg/kg	Ramah mg/kg	Gumadh mg/kg	Waggan mg/kg	Sleimat mg/kg	Mean mg/kg
1. Aubergines	2.03±0.52	1.17±0.21	1.49±0.20	1.36±0.24	1.90±0.14	1.54±0.11
2. Cabbage	1.00	0.97±0.32		0.0		0.78±0.26
3. Capsicum	0.0	1.50	1.85±0.45			1.73±0.28
4. Carrots		0.80±0.0				0.80±0.0
5. Cauliflower		0.80±0.0				0.80±0.0
6. Chillies		1.10±0.70	1.55±0.14	1.00		1.41±0.15
7. Corn	1.00	1.80±0.0	2.80		1.58±0.2	1.72±0.20
8. Cucumber	2.30		1.58±0.17	1.30±0.01		1.60±0.15
9. Green leafy vegs		0.60±0.04	1.30	1.25±0.23	1.15±0.09	1.17±0.14
10. Marrow	1.27±0.23	1.37±0.37	1.67±0.38	0.90±0.44	1.45±0.17	1.33±0.14
11. Onion		1.04±0.14	1.20	1.29±0.09	1.61±0.09	1.39±0.07
12. Potatoes	0.67±0.29	1.00				0.75±0.14
13. Radish	0.40					0.40
14. Tomatoes	1.46±0.27	1.63±0.12	1.35±0.45	1.13±0.80	1.90±0.36	1.49±0.11
Area means	1.61±0.24	2.26±0.27	1.85±0.24	2.02±0.23	2.14±0.21	1.99±0.11

Table: 6-18: Mean±standard error of total concentration of pesticide residues and pesticide associated chemical compounds in vegetables from the five farming areas

Vegetables	Hayer mg/kg	Ramah mg/kg	Gumadh mg/kg	Waggan mg/kg	Sleimat mg/kg	Mean mg/kg
1. Aubergines	2.30±0.70	1.83±0.23	2.29±0.40	2.11±0.26	2.68±0.27	2.26±0.16
2. Cabbage	1.00	1.30±0.51		0.80		1.14±0.29
3. Capsicum	1.50		2.50±0.50			2.17±0.44
4. Carrots		1.10±0.30				1.10±0.30
5. Cauliflower	1.30±0.31	1.10±0.14				1.20±0.21
6. Chillies		2.40±1.80	3.30±0.55	1.0		2.93±0.51
7. Corn	3.00	2.40±0.40	2.80		3.13±1.29	2.89±0.61
8. Cucumber	3.10		2.74±0.78	1.30±0.01		2.43±0.53
9. Green leafy vegs		1.00±0.0	2.10	1.63±0.25	1.85±0.33	1.69±0.18
10. Marrow	2.20±0.30	1.50±0.50	3.00±0.46	1.60±0.93	2.05±0.41	2.07±0.24
11. Onion		1.58±0.25	1.20	1.75±0.15	2.57±0.21	2.07±0.24
12. Potatoes	1.33±0.51	1.00				1.25±0.23
13. Radish	0.80					0.80
14. Tomatoes	2.24±0.35	2.87±0.27	2.15±0.47	2.01±0.52	3.17±0.41	2.51±0.18
Area means	2.63±0.28	3.91±0.43	3.11±0.39	2.93±0.33	3.34±0.37	3.21±0.17

Table 6-19: Correlation of pesticide residues in farm water, sand, vegetables and the use of pesticides per unit area of the farm

	P_{veg}	PA_{veg}	T_{veg}	P_{water}	PA_{water}	T_{water}	P_{sand}	PA_{sand}	T_{sand}
P_{veg}	1.00								
PA_{veg}	0.383*	1.00							
T_{veg}	0.798*	0.844*	1.00						
P_{water}	-0.068	-0.049	-0.032	1.00					
PA_{water}	0.013	0.012	0.037	0.505*	1.00				
T_{water}	-0.011	-0.006	0.019	0.724*	0.961*	1.00			
P_{sand}	-0.066	-0.034	-0.018	0.134*	0.292*	0.276*	1.00		
PA_{sand}	-0.016	-0.003	0.004	0.222*	0.436*	0.419*	0.441*	1.00	
T_{sand}	-0.017	-0.015	-0.031	0.219*	0.447*	0.427*	0.724*	0.938*	1.00
Unit use	0.133*	0.125	0.128	0.202*	0.0347*	0.342*	0.116	0.193*	0.193*

P: pesticide residues; PA: Pesticide associated chemical compounds;
T: Pesticides and pesticides associated chemical compounds
** correlation significant at =<0.05*

and 7.0% of the domestic and imported Tomatoes exceeded the national tolerance limits. Methamidophos and Acephate have been used in the UAE, however, only Acephate was identified in the laboratory analysis of Tomatoes in this study (Appendix 20). Omethoate and Carbendazim were the most frequently identified pesticides in agricultural produce in Holland, often the concentration levels exceeded the tolerance limits (deVos *et al,* 1984). These pesticides were not identified in the vegetable samples in the UAE. No pesticide residues exceeding the national tolerance limits were found in the agricultural produce monitored in Italy, except for the 1.1% of the samples which were withdrawn from the market (Camoni *et al,* 1991). In a similar report Camoni *et al,* (1993) reported that during 1988-1989 in Italy, pesticide residues were identified in 10% of the agricultural produce and 1.5% of these samples exceeded the national tolerance limits. The percentage of samples exceeding the MRL in this study are discussed in the next section (Maximum residue limits).

The most frequently identified pesticides in agricultural produce in Spain were DDT and BHC and the concentration levels varied from undetectable to less than 100 mg/kg (Carrasco *et al,* 1976). In the study in the UAE, only DDE was identified in 25% of the Cauliflower samples. The residues of organochlorine pesticides were translocated from the insecticide-contaminated field soils to the vegetables through their roots (Suzuki *et al,* 1976). The systemic pesticide residues in the flesh of the vegetables could therefore occur from the current usage of pesticides and from what is available for uptake through the roots from the farm soil and farm water. In this study all the vegetable samples were spot samples, however, a better picture of the pesticide residues in the locally grown vegetables could be obtained from continuous monitoring of the local produce. Continuous monitoring could also provide more information on the use of banned pesticides in vegetable farming.

6.10 *Maximum residue limit (MRL) of pesticides in vegetables*

The Maximum Residue Limit (MRL) has been defined as the maximum concentration of a pesticide residue (expressed as mg/kg), recommended by the

Codex Alimentarius Commission to be legally permitted in food commodities and animal feeds (Codex Alimentarius, 1993). The Codex MRLs which are derived from estimations made by the Joint (FAO/WHO) Meeting on Pesticide Residues (JMPR), are primarily intended to apply for international trade. Foods derived from commodities that comply with the respective MRLs are supposed to be toxicologically acceptable and safe for human consumption. However, different countries interpret the significance of these limits and how they may be breached in different ways. In the United Kingdom, the MRLs do not indicate the safety of food and are not viewed as the limits between healthy and dangerous foods. In Sweden, government agencies prohibit trading and consumption of food in which the MRLs have been exceeded (Watterson, 1991). Different countries, therefore, have their own food monitoring programmes and have set up different tolerance levels for pesticide residues in the agricultural produce which are different from the CAC MRL. The United States Environment Protection Agency and the Food and Drug Agency have established pesticide residue control standards on many foods which are between 2 and 50 times stricter than those set down by the CAC MRLs (Watterson, 1991).

In the United Arab Emirates, the Food Control Laboratories of the Municipalities do not routinely monitor agricultural produce for pesticide residues, but do generally monitor processed foods for the presence of additives and for shelf life. The government, therefore, does not have it's own MRLs but, in principle, accepts the CAC MRLs. Agriculture is in it's infancy in this region and the focus is not on providing quality produce to its population but is directed towards firstly in greening the desert and secondly in testing the viability and feasibility of the agricultural experiment. In spite of the foray of the local government into agriculture almost all the agricultural produce requirements of the UAE are imported.

The Codex Alimentarius Commission (CAC) has established MRL values of a number of pesticides commonly identified in agricultural food commodities. The MRL values can be easily adopted for a single pesticide residue identified in a vegetable commodity, however, when multiple pesticide residues are identified in a single vegetable commodity, identification and adoption of a single MRL value is difficult and complicated. Many of the vegetable commodities in the UAE were identified with multiple pesticide residues. For example, in Aubergines 16 different types of pesticide residues were identified as shown in Appendix 21. The CAC-MRLs values for those pesticides for which they are available are also shown in this Table. However, for many of the pesticides CAC-MRL values were not available (Appendix 21). The CAC-MRL values were not available for Demephion, Isoxathion, Ethiolate, Heptenophos, Butocarboxim, Ethidimuron, Pyridate, Dinoseb acetate, Captafol, Phenmedipham, Desmethryn, Bifenox, Triamiphos, Aminocarb, Profenofos, Isoprocarb, Bromacil, Chlorfenson and Amidathion and therefore no comparisons of the actual concentrations were possible. Among those pesticides for which MRL values were available the actual concentrations of pesticide residues were higher compared to the MRL values for all the pesticides except for Carbaryl in Aubergines and Cauliflower, Captan in Chillies, Green leafy vegetables, Onion and Tomatoes, Pirimiphos methyl in Green leafy vegetables and Tomatoes, Disulfoton in Aubergines, Tolyfluanid in Chillies, Pyrethrin and Allethrin in Green leafy vegetables, Bendiocarb in Onions and Acephate and Chlorpyrifos in Tomatoes.

To estimate the MRL value for the multiple pesticide residues in the different vegetable commodities the JMPR "median-residue" value approach was used. For each of the vegetable commodity the median of all the available MRLs for those pesticide residues identified in that commodity was calculated to be used as a benchmark for comparison with the actual pesticide residue levels in the locally grown vegetables. These median values are shown in Table 6-20 along with the actual mean of the pesticide residues. The Joint Meeting on Pesticide Residues (JMPR) in calculating the MRL values uses a "supervised trial median residue" as a basis of estimating the amount of pesticide residue present in each food subject to a Codex MRL. The same rationale has been used in calculating the MRLs for multiple pesticide residues in this study.

Table 6-20 Mean concentrations of all pesticide residues, pesticide associated chemical compounds, organophosphorus and carbamate pesticide residues in vegetables and the median MRLs for all pesticides, organophosphates and carbamates.

Vegetables	Pesticide and Other residues				OP residues		Carb/Othrs residues	
	Pesticide residue[1] mg/kg	Other residues[2] mg/kg	Pesticides +Others[3] mg/kg	Median MRLs mg/kg	Pesticide residue mg/kg	Median MRLs mg/kg	Pesticide residue mg/kg	Median MRLs mg/kg
Aubergines	0.91±0.12	1.54±0.11	2.26±0.16	0.50	0.62±0.07	0.50	0.66±0.09	2.75
Cabbage	0.60±0.20	0.78±0.26	1.14±0.29	0.20	0.53±0.18	0.20	0.20	NA
Capsicum	0.65±0.30	1.73±0.28	2.17±0.44	0.50	--		0.40	0.50
Carrot	0.60±0.0	0.80±0.0	1.10±0.30	0.05	0.20	0.05	0.40	NA
Cauliflower	0.80±0.36	0.80±0.0	1.20±0.21	0.10	0.40	0.10	0.60±0.27	2.50
Chillies	2.07±0.44	1.41±0.15	2.93±0.51	0.35	1.05±0.39	0.15	1.55±0.45	1.25
Corn	1.57±0.73	1.72±0.20	2.89±0.61	0.50	1.90±1.03	0.50	0.60±0.31	NA
Cucumber	1.65±0.69	1.60±0.15	2.43±0.53	0.10	0.93±0.35	0.02	1.27±0.53	0.50
Green leafy vegs	0.74±0.16	1.17±0.14	1.69±0.18	1.00	0.87±0.18	0.50	0.55±0.10	1.00
Marrow	0.89±0.16	1.33±0.14	2.07±0.24	0.10	0.80	0.10	0.90±0.19	0.28
Onion	1.01±0.11	1.39±0.07	2.07±0.24	0.50	0.81±0.17	0.05	0.81±0.07	0.50
Potato	0.67±0.37	0.75±0.14	1.25±0.23	NA	0.33±0.06	NA	1.00	NA
Radish	0.40	0.40	0.80	0.10	0.40	0.10	--	
Tomato	1.33±0.13	1.49±0.11	2.51±0.18	0.30	1.04±0.17	0.08	1.18±0.12	0.50
Mean	1.19±0.09	1.99±0.11	3.21±0.17	0.33	1.23±0.22	0.19	1.15±0.31	1.08

NA *not available*
1 *Mean concentrations of all pesticides*
2 *Mean concentrations of pesticides associated chemical compounds*
3 *Mean concentrations of pesticides and pesticides associated chemical compounds*

The actual mean concentrations of pesticide residues identified in the local (UAE) vegetables were higher for all commodities except for Capsicum and Green leafy vegetables compared to the median MRLs calculated for multiple pesticide residues. The actual pesticide residue concentrations in Cucumbers were 17 times, in Carrots 12 times, in Marrow 9 times and Cauliflower 8 times higher than the median MRL values. The levels in Radish and Tomatoes were 4 times, Cabbage, Corn 3 times and Aubergines and Onion were 2 times higher than the median MRLs. The MRL values for Potatoes could not be calculated because the MRLs for Heptenophos and Ethidimuron, the two contaminants of Potatoes, were not available from the CAC literature. Overall, the mean concentration of all pesticide residues for all the vegetables was approximately 4 times higher than the corresponding MRL.

The mean organophosphorus concentrations for all vegetables exceeded the MRL values by approximately 6 times (Table 6-20). The mean organophosphorus pesticide residue concentration exceeded the MRL values for Cucumbers by approximately 47 times, for Onion by 16 times and for Tomatoes by 13 times. The mean concentrations of the organophosphorus pesticide residues also exceeded the MRL values in Chillies by 10 times, in Marrow by 8 times, Carrots, Cauliflower, Corn and Radish by 4 times and in Cabbage and Green leafy vegetables by 2 times. The mean concentrations of carbamates and other pesticide residues exceeded the MRL values by approximately three times for Marrow and two times for Cucumbers, Onion and Tomatoes. The mean residue concentrations were lower than the MRL values for Aubergines, Capsicum, Cauliflower, Chillies and Green leafy vegetables. The MRL values for carbamates and the other pesticides identified in Cabbage, Carrots, Corn and Potatoes were not available, therefore the mean pesticide concentrations in these commodities could not be compared with the MRL values.

Chapter 7

Dietary habits and pesticide residues intake by the ethnic and farming populations

7.0 *Introduction*

7.1 *Survey of dietary habits of ethnic and farming populations*

7.2 *Dietary habits of ethnic and farming populations*

7.3 *Estimation of dietary intake of fresh vegetables*

7.4 *Estimation of dietary intake of locally grown vegetables*

7.5 *Dietary intake of multiple pesticide residues through vegetables*

7.0 *Introduction*

Environmental contamination by pesticides is ubiquitous and different compartments of the environment have been contaminated by pesticides to varying degrees depending on the use of pesticides. The level of pesticide contamination of the environment, food and the human body is greater in the developing countries compared to that in the developed countries because of several factors such as lack of legislation, lack of knowledge on the harmful effects of pesticides among the users of pesticides, lack of training among the users in the correct procedures for using pesticides, and greater numbers of people being involved in the use of pesticides in agriculture because of the non-availability of farm machinery (Sivayoganathan *et al*, 1995; McDougall *et al*, 1993).

Many of the more hazardous pesticides, banned in the developed countries, are sold in the developing countries and these include not only environmentally persistent organochlorines, but organophosphates and carbamates which are less persistent but more toxic. Some of the pesticides used in agriculture in the UAE have been identified to have been banned in the developed countries and the pesticide residues of these banned pesticides have been identified in the environment (soil, water and agricultural produce) in the UAE (Chapter VI).

The developed countries regularly monitor agricultural produce for pesticide contamination and either allow the food for human consumption if the levels are within the tolerance limits or destroy the food if the levels exceed the tolerance levels (Dinham, 1995). In the developing countries without any monitoring programmes, the agricultural produce, whether contaminated or not, is always in demand. Consumption of contaminated agricultural produce has been shown to increase the dietary exposure to pesticides above the expected values (Melnyk *et al*, 1997). In India, sporadic incidences of pesticide residue concentrations in excess of 1 mg/kg have been measured in locally grown vegetables (Kannan .*et al*, 1997). Results of a four year study in Pakistan showed that 39% of all vegetable samples were found to be contaminated with organochlorines and organophosphates of which 14% exceeded the CAC MRLs (Dinham, 1995). The daily intake of pesticide residues from agricultural produce in Finland has been reported to have decreased from 16.9 g to 3.7 g from 1977 to 1993 as a result of controlled use of pesticides in agriculture (Penttila and Siivinen, 1996).

Estimates of the dietary intake of pesticide residues through the consumption of locally grown vegetables in the UAE have not been calculated for various reasons. Having estimated the pesticide residue concentrations in the locally grown vegetables, the survey reported in this chapter was designed to collect information on the intake of locally grown vegetables and thence, to estimate the daily intake of pesticide residues. The local ethnic population, which has been residing in the country all their life, was compared with the immigrant farming population which has been in the country for only a few years, with regard to their intakes of pesticide residues through locally grown vegetables. The food habits of the ethnic and the farming populations and the dietary intake of pesticide residues are described and discussed in the following sections.

7.1 *Survey of dietary habits of ethnic and farming populations*

Traditions, culture and environment are some of the important predictors of the dietary habits of people in a country. Therefore, ethnic origin is of particular importance in determining the food habits of a population. Similar foods may be prepared differently and consumed differently depending on the ethnic background (Al-Moussa, 1995). During the last three decades, following the discovery of oil in the Gulf countries, there have been increased trends in urbanization, manpower migration from other parts of the world and better living conditions with increased incomes. There have also been changes in the dietary habits of the people resulting in a shift in nutritional levels. The consumption of traditional foods, which consisted of dates, rice, milk and fish, has changed to Indian or Western foods and from simple hygienic foods to rich and less hygienic foods (Musaiger and Radwan, 1995).

The National Nutrition Survey in the UAE in 1992, showed that 70% of the ethnic population consumed fast foods more often and the traditional foods less often. The latter foods included rice with meat, chicken or fish, grilled meat and vegetables (Musaiger, 1992). The traditional diet of dates, buttermilk, rice, bread, fresh vegetables and fish had become diversified and red meats, eggs, fast foods and various processed foods had become important items in the diet of the ethnic local population (Musaiger, 1987).

However, in spite of these few studies on food habits in the United Arab Emirates, information on the dietary habits of the ethnic population is scanty and moreover, baseline information on certain defined segments of the ethnic population was not available (Musaiger and Radwan, 1995). The survey described here on the dietary habits of university students in the age group of 16 to 30 years of age and among immigrant farmworkers hired to work on the farms, was conducted to study the intake of different types of foods, the frequency of food intake and the intake of locally grown vegetables in particular. The study was also designed to collect information on the sources of vegetable produce so that the consumption of locally grown produce could be estimated and thence the intake of total pesticide residues could be determined and the dietary exposure estimated in the ethnic and the immigrant farming populations.

7.1.1 Demographic profile of the study populations

The response rate for females was 86% (324/375) and for males 82% (205/250) with an overall response rate of 85% (529/625) for the total population. The mean±standard deviation ages of the surveyed ethnic population was 20.7±2.4 years with the ages of the female and male ethnic populations being 20.2±2.0 years and 21.5±2.8 years respectively. The Body Mass Index (BMI) for the female population was 21.8±3.8 and for the male population was 23.7±4.3. For the farming population the mean age±standard deviation was 32.4±6.5 years, BMI was 21.8±3.1 and the period of service in the UAE was 5.2±3.1 years. These workers were mainly from the Indian sub-continent followed by North Africa and comprised Indians (13%), Pakistani (32%), Bangala deshi (34%), Sri Lankan (6%) and Egyptians (14%). These workers typically lived on the farm in a two room hut made of corrugated metal sheets and cooked their own food in one of the rooms.

7.2 *Dietary habits of ethnic and farming populations*

Information on the types and quantities of food consumed by the study populations together with the frequencies of consumption was collected and analyzed. The percentages of the number of meals taken by ethnic males, females and the total ethnic population on a normal day are shown in Table 7-1. The mean number of meals consumed daily by the ethnic population was 2.9±0.7 meals. The frequency of food intake by females was less than that of the males with a mean number of meals consumed by females being 2.8±0.7 compared to 3.1±0.6 meals by males. The mean intake of food by the farming population was

3.0±0.0 meals per day. The frequency of food intake by the farmworkers being 3 meals a day, they did not take any snacks in between meals but took either black tea or water during breaks. In addition, the smokers smoked during the break times.

7.2.1 Frequency of consumption of different types of food

Arabic, Indian and Western were the main types of foods identified as being consumed regularly through the questionnaires completed by the ethnic population. The frequency of intake of each type of food was categorized as never, once to three times a month, once a week, twice or three times a week and daily. The numbers and percentages of ethnic females and males consuming each type of food and the frequencies of intake are shown in Table 7-2. The majority of

Table 7-1: The number of meals per day taken by the ethnic population

Number of meals	Females n (%)	Males n (%)	Total n (%)
One	9 (3)		9 (2)
Two	63 (20)	19 (9)	82 (16)
Three	207 (66)	151 (74)	358 (68)
Four	33 (7)	22 (11)	45 (9)
Five and more	10 (3)	11 (5)	21 (4)

the population (76%) consumed Arabic food daily with only 2% taking it rarely or never. Indian food was the next most consumed food with 44% of the population eating this type of food either weekly or one to three times a month. Western food was consumed rarely by the ethnic population; 4% of the population consumed it on a daily basis and 52% never consumed it. There were no differences between females and males in the consumption of Arabic food, however, males consumed Indian food more frequently than females and 26% of the males took Indian food either daily or every other day. Females consumed Western foods more frequently than males with 14% of the females partaking of this type of food almost every other day compared to 7% of the males. Among the farming population there was no choice in the cuisine and the food was a combination of Arabic and Indian foods.

The mean weekly intakes of Arabic food by the ethnic females and males were 4.6±0.8 and 4.7±0.7 meals respectively. The comparable numbers for Indian food intakes were 2.2±1.2 meals by females and 2.5±1.3 meals by males. Western food intake was 1.9±1.3 meals by females and 1.9±1.2 meals by males and the intake of other foods was 0.4±1.3 meals by females and 0.2±0.9 meals by males.

Breakfast, lunch and dinner were the main meals for the farmworkers and they never indulged in snacks. In between meals apart from drinking tea or water and smoking they occasionally ate the farm produce (Cucumbers, Tomatoes and Carrots) whenever available. The farmworkers cooked their food in the farm-house where they lived. The type of food they cooked was a combination of their ethnic (Indian) food and Arabic food, because of the Egyptian influence. The intake of rice, lentils and vegetables was high but the intake of red or white meat was very low. The staple diet of the farm workers from the Indian sub-continent was rice and for those from Egypt rice and Arabian pitta bread (kubbus). The farm workers were not vegetarians but tended to eat mainly vegetables because of the availability on their farm or on the neighbouring farms. The commonly used vegetables were Aubergines, Cabbage, Cauliflower, Carrots, Cucumber, Green leafy vegetables (Spinach, Molokia, Lettuce), Marrow, Potatoes, Onion and Tomatoes.

7.2.2 Sources of purchase of groceries and meals

The sources of purchase of groceries for the ethnic population were the local market (75%), supermarket (19%) and local agricultural market (6%). The sources of purchase of vegetables were similar, local market (75%), supermarket (19%) and local agricultural market (6%). The farmworkers purchased their groceries from the vegetable market (71%), superstore (19%) which was located in the farm

Table 7-2: Type of foods and frequency of intake of each type of food by the ethnic population

	Arabic food			Indian food			Western food		
Frequency of intake	Female n (%)	Male n (%)	Total n (%)	Female n (%)	Male n(%)	Total n(%)	Female n (%)	Male n (%)	Total n (%)
Never	8 (3)	1 (.5)	9 (2)	114 (36)	61 (30)	175 (34)	161 (51)	108 (54)	269 (52)
1-3 times a month	6 (2)	6 (3)	12 (2)	71 (23)	44 (22)	115 (22)	61 (19)	44 (22)	105 (20)
Weekly	13 (4)	8 (4)	21 (4)	72 (23)	43 (21)	115 (22)	38 (12)	27 (13)	65 (13)
2-3 times a week	49 (16)	31 (16)	80 (16)	38 (12)	37 (18)	75 (15)	44 (14)	15 (7)	59 (11)
Daily	239 (76)	156 (77)	395 (76)	13 (4)	17 (8)	30 (6)	11 (4)	8 (4)	19 (4)

area and other stores (10%). Because of the long distance of the farming areas from the town centre, the farmworkers had to rely mostly on the shopping facilities in the immediate neighbourhood. Almost all the farmworkers (97%) consumed any vegetable that was available on the farm, the rest of them purchased it from the local vegetable market.

A high percentage (63%) of the ethnic population ate between 6 to 9 meals each week at home. This was most common among the females (72%) compared to the males (48%). During the week higher numbers of both females (74%) and males (73%) were less likely to eat at the student hostel and usually took their meals at home, with friends or in restaurants. About 18% of the population took between 12 to 15 meals each week at the hostel and about 30% of the population took the same number of meals at a restaurant. Differences between females and males in their pattern of eating at the hostel and restaurants were small. Sometimes the food was brought from restaurants or take-away shops to the hostel or home and about 48% of the population took between 6 to 15 meals a week in this manner. About 6% of females and males, each had between 6 to 9 meals a week at a friend's or relative's house. The males could eat more frequently at home because they were allowed to drive anywhere within the UAE, whereas females from other Emirates were not allowed to drive around in Al-Ain. The farmworkers always had their meals at their homes on the farm and very rarely ate at a restaurant in the town centre. Very rarely they visited their friends on other farms and stayed and ate with them.

The different items of food listed by the ethnic population as consumed at breakfast, dinner, supper and as snacks were grouped according to the constituents of the food item (dish). The different groups along with the food items are shown in Table 7-6. Breakfast, dinner, supper and snacks were the major meals during the day. Some of the subjects skipped meals while others took snacks more often. The range for the number of daily meals taken by females was 1 to 7, and for males 2 to 6. Snacks were more likely to be missed by

Table 7-3: Items of food consumed by the ethnic population during the day

No.	Group name	Individual food items
1	Milk	Milk, laban, yoghurt, cheese
2	Bread	Bread, kubbus, samun
3	Sandwich	Fatayer, threed, fareed
4	Lentils	Falafyl, toma
5	Homus	Beans,
6	Rice	Rice, pasta, macaroni, noodles
7	Biryani	Biryani, makhboos, kabsa, harees
8	Salad	Green salad, fatoosh, taboule
9	Fruits	All types of fruits
10	Vegetables	Vegetables cooked as a dish
11	Eggs	Eggs
12	Meat	Mutton, beef, hamburgers
13	Chicken	Chicken
14	Fish	Fish grilled, cooked or fried
15	Potato salad	Potato salad
16	Coffee	Coffee and tea
17	Drinks	Canned fizz drinks, canned juices
18	Honey	Honey
19	Dates	Dates
20	Chocolates	Chocolates and Arabic sweets

Kubbus	*pitta bread Arabic type*
Samun	*oblong soft bread like hamburger bun*
Fatayer	*a type of puff pastry with cheese, spinach or meat*
FatooshTaboule	*green salad with mint, parsley, broccoli, coriander finely chopped*
Threed / Fareed	*a type of pizza with tomato, onion, carrots, potatoes and peas*
Falafyl	*deep fried balls of lentil halves, onion, coriander*
Makboos/kabsa	*rice based dish with carrots, tomatoes, mushrooms and potatoes*
Harees	*dish with bulgar, tomatoes, capsicum and chicken*

females (13%) compared to 9% of the males. Breakfast, dinner or supper were likely to be missed by 6% of the population.

7.2.3 Total daily consumption of the different food groups

The total number of portions of different food groups consumed by the study populations at breakfast, dinner, supper and as snacks were summed up and divided by the number of people consuming them to obtain the number of portions consumed per person. The consumption of different food groups per person by portion during the course of the day from all meals (breakfast, dinner, supper and snacks) is shown in Table 7-4. The per person consumption of Group 2 (bread), Group 3 (sandwiches), Group 8 (salad), Group 12 (meat) and Group 17 (drinks) were in excess of one and a half portions of each every day for the ethnic population. For the farmworkers the consumption of Group 10 (2.62 portions) was the highest followed by Group 8 and Group 16. The consumption of the other groups was between one and one and half portion with the exception of Group 15.

Within the ethnic population, females consumed more bread and bread products (2.11 portions) which included biscuits and cakes, compared to the males. The other food items consumed more by females were green salad (1.92 portions) and potato salad (1.18 portions). Males, on the other hand tended to take more lentils (0.40 portions), homus (0.27 portions), biryani (1.46 portions), eggs (0.80 portions), red meat dishes (2.62 portions), chicken (1.63 portions), fish (1.17 portions), honey (0.16 portions), dates (0.13 portions) and chocolates and sweets (0.39 portions) compared to the female population. The farmworkers consumed more vegetable based dishes (2.69 portions), followed by salad (1.79 portions), other food groups consumed more than a portion each by these workers were bread (1.37 portions), rice (1.24 portions), coffee and (1.64 portions) and milk (1.11 portions). The relatively high consumption of cooked vegetables per day is relevant in this population group because of their high dependence on vegetables.

7.2.4 Summary and discussion of dietary habits of the study population

The mean number of meals consumed on a daily basis by the ethnic population daily was 2.9±0.7 meals and by the farming population 3.0±0.0 meals. The majority of ethnic females (66%) had three meals per day and so did the males (74%). Higher percentages of males (5%) took five or more meals each day compared with females (3%). Also 3% of the females took just one meal a day

Table 7-4 Consumption of different food groups by portions per person per day

Food groups	Females portions		Males portions		Total portions		Farmworkers portions	
	Total no.	Per head	Total no.	Per head	Total no.	Per head	Total no.	Per head
1. Milk	430	1.46	299	1.55	729	1.49	229	1.11
2. Bread	623	2.11	357	1.85	980	2.00	702	1.37
3. Sandwich	550	1.86	438	2.27	988	2.02		
4. Lentils	36	0.12	77	0.40	113	0.23		
5. Homus	40	0.14	53	0.27	93	0.19		
6. Rice	403	1.37	289	1.50	692	1.42	651	1.24
7. Biryani	294	0.99	282	1.46	576	1.18	33	1.00
8. Salad	566	1.92	286	1.48	852	1.75	587	1.79
9. Fruits	50	0.17	48	0.25	98	0.20		
10. Vegetables	105	0.36	75	0.39	180	0.37	650	2.69
11. Eggs	117	0.40	155	0.80	272	0.56		
12. Meat	423	1.43	506	2.62	929	1.90	54	1.00
13. Chicken	365	1.24	315	1.63	680	1.39	64	1.00
14. Fish	133	0.45	225	1.17	358	0.73	84	1.00
15. Potato salad	348	1.18	132	0.68	480	0.98	137	0.91
16. Coffee	337	1.14	230	1.19	567	1.16	1149	1.64
17. Drinks	530	1.80	366	1.90	896	1.84	57	1.01
18. Honey	18	0.06	31	0.16	49	0.10		
19. Dates	23	0.08	25	0.13	48	0.10		
20. Chocolates	78	0.26	76	0.39	154	0.32		

NB The mean of the number of females, males and total ethnic population consuming breakfast, dinner, supper and snacks was used compared to none among the males. Arabic food (76%) was most commonly consumed by the ethnic population whereas among the farming population it was a combination of both Arabic and Indian cuisine. Arabic food has also been reported to have been consumed by the Kuwaiti, Bharaini and Omani populations (Al-Moussa, 1995; Mussiger *et al*, 1986; Mussaiger, 1995a; Mussaiger 1995b).

Breakfast, dinner and supper were the main meals of the day for the ethnic and the farming populations which is consistent with observations among the Kuwaiti population (Al-Shawi, 1985). A medium breakfast consisting of at least three food groups was taken by 50% of the ethnic population while 74% of the farming population took a light breakfast consisting of two or three items. The food groups most commonly consumed during breakfast were Group 1 (64%), Group 2 (37%), Group 3(54%) and Group 17 (61%) among the ethnic population and Group 2 (68%), Group 10 (61%) and Group 16 (92%) among the farming population. The majority (63%) of the ethnic population took a medium dinner consisting of four to five food groups, while the majority (78%) of the farming population took a light dinner consisting of two to three food groups. At dinner, the ethnic population consumed items from the following food groups; Group 1 (12%), Group 7 (45%), Group 8 (77%), Group 12 (43%), Group 13 (44%) and Group 14 (30%) whereas the farming population consumed Group 2 (44%), Group 6 (89%), Group 8 (77%) and Group 10 (35%). Among the ethnic and the farming populations 64% and 66% respectively took a medium meal at supper consisting of four to five items. Food groups commonly consumed by the ethnic population at this meal were Group 1(26%), Group 2 (71%), Group 3 (20%), Group 8 (27%), Group 12 (61%), Group 13 (41%), Group 15 (18%) and Group 17 (19%), while the farming population selected items from Group 1 (24%), Group 2 (54%), Group 6 (68%), Group 8 (69%), Group 10 (45%) and Group 16 (66%). Snacks were consumed by 89% of the ethnic population and food groups consumed between main meals were Group 3 (49%), Group 16 (47%) and Group 17 (62%). The food consumption pattern in terms of the types of food consumed by the Emirati population at breakfast, dinner and supper were similar to the pattern observed among the adult Omani population (Musaiger, 1992).

The intake of fresh vegetables varied slightly among the ethnic populations of the Arabian Gulf states of Bahrain, Oman, Saudi Arabia, Kuwait and the UAE because of the similarities in the dietary habits of the people from these countries (Musaiger, 1995a; Musaiger, 1995b; Madani, 1995 and Al-Moussa, 1995). The usage of vegetables in the preparation of different food items among the Bharaini and the Omani populations were similar to the UAE usage (Musaiger, 1995a and Madani, 1995). The usage of vegetables in the preparation of different food items by the ethnic population of the UAE is discussed in the next section.

7.3 *Estimation of the dietary intake of fresh vegetables*

The results of the dietary survey reported in the previous sections have been used to calculate the dietary intake of vegetables. From the list of all the food groups shown in Table 7-3, those groups which contained vegetables either as a main item in the dish or as a supplementary item were identified and listed in Table 7-5. This table also mentions the names of dishes and the different vegetable commodities against each group. The recipes for individual food dishes involving the vegetables from each of the food groups listed in Table 7-5 were obtained and the vegetable components of the food dishes were identified and summed up to obtain the total vegetable content in these dishes. The vegetable content in each dish was divided by the number of persons it is supposed to serve to obtain the intake of vegetables per person. The different food groups and the dishes which contained vegetables together with an estimation of the vegetable content in the different dishes are shown in Appendix 23 (*Vegetables in local dishes*). The mean of the values for the vegetable content for all the dishes in the food group was obtained as a representative value of the vegetable content for that group. These mean values for the vegetable content of each of the food groups containing vegetables are shown in Table 7-6. The vegetable content of each of the food group was multiplied the average number of portions consumed (Table 7-4) to obtain the total daily intake of vegetables through the consumption of different food groups (Table 7-6). The per capita daily intakes among the ethnic population of different vegetable containing food groups were: Group 3, 191.9 g; Group 4, 20.7 g; Group 5, 29.5 g; Group 7, 100.3 g; Group 8, 96.3 g; Group 10, 50.7 g; Group 12, 209.0 g; Group 13, 132.1 g; Group 14, 69.4 g; and Group 15, 117.6 g. Among the farming populations the daily intakes of vegetable containing food groups were Group 7, 85.0 g; Group 8, 98.5 g; Group 10, 368.5 g; Group 12, 110.0 g; Group 13, 95.0 g, Group 14, 95.0 g and Group 15, 109.2 g.

7.3.1 *Pattern in the dietary intake of vegetable containing food groups*

The percentages of the ethnic and the farming population consuming different food groups containing vegetables are shown in Table 7-7. The study population was asked during the dietary survey to list their intake of different foods on a typical day. Information on these intakes for the vegetable containing food groups is shown in Table 7-7. Food items from Groups 3, 10 and 4 were consumed for breakfast by 54%, 18% and 4% respectively of the ethnic population. Items from food Groups 7, 12, 13 and 14 were consumed for dinner by a higher percentage (45%, 43%, 44% and 30% respectively) of the ethnic population. These items were also consumed for supper by a higher percentage (16%, 61%, 41% and 8% respectively) of the ethnic population. Analysis of the trend in consumption showed that only one food item was consumed from the food Groups 7, 12, 13 or 14 at dinner and supper. It was also observed that there was less likelihood of the same item being consumed at dinner and supper. The second item of food consumed at dinner and supper was selected from the food Groups 5, 8, 10 and 15. Higher percentages of the ethnic population consumed items from these groups at dinner and supper compared to items from other food groups. Food items from Groups 3 and 15 were more likely to be had at snack time, but these items were not consumed at snack time if they had been consumed at breakfast.

Food items from Group 10 were consumed for breakfast by 61% of the farming population. For dinner and supper items from food Groups 13 or 14 were consumed by a higher percentage of farmworkers. Items from food Groups 7 and

Table 7-5: Food groups identified as containing vegetables

a) Group 3	Sandwiches	Cheese, falafyl or meat sandwiches always contained either fresh salad or deep fried or cooked vegetables which included lettuce, cucumber, carrots, aubergines, cauliflower, potatoes, onion, capsicum, coriander and tomatoes.
b) Group 4	Lentils	Falafyl, fatayer and toma included tomatoes, onion, coriander, cauliflower, cucumber, capsicum, carrots, green leafy vegetables and lentils
c) Group 5	Homus	Homus included or is served with peas, onion, tomatoes, coriander, carrots, cucumber, lettuce, capsicum and olive oil
d) Group 7	Biryani	Makbous, mahsi and malfoof included potatoes, onion, tomatoes, coriander, peas, cauliflower, capsicum, chillies and cabbage
e) Group 8	Salad	Green salad included lettuce, cucumbers, carrots, tomatoes, onion and pepper; fatoosh included parsley, mint, broccoli and coriander, tomatoes and onion and taboule included parsley, mint, tomatoes, coriander, onion and bulgar
f) Group 10	Vegetables	Marrow, cauliflower, aubergines, cabbage, okra, carrots, potatoes, spinach, molokia, tomatoes, onion chillies, coriander, parsley
g) Group 12	Meat	Mutton and beef were usually cooked with aubergines, marrow, potatoes, okra, tomatoes, onion carrots, chillies and capsicum
h) Group 13	Chicken	Chicken was usually cooked or served with okra, tomatoes, carrots, chillies and onion
i) Group 14	Fish	Tomatoes, onion, carrots, chillies, cucumber and lettuce
j) Group 15	Potato salad	Potatoes, tomatoes, onion, parsley, peas and coriander

Table 7-6: The mean vegetable content of food groups containing vegetables and the possible daily consumption of vegetables through the intake of each of these food groups among the total ethnic and farming populations.

	Females g x portions	**Males** g x portions	**Total ethnic** g x portions	**Farmworkers** g x portions
Group 3 (*sandwiches*)	95 x 1.86 = 176.7	95 x 2.27 = 215.7	95 x 2.02 = 191.9	
Group 4 (*lentils*)	90 x 0.12 = 10.8	90 x 0.40 = 36.0	90 x 0.23 = 20.7	
Group 5 (*homus*)	155 x 0.14 = 21.7	155 x 0.27 = 41.9	155 x 0.19 = 29.5	
Group 7 (*biryani*)	85 x 0.99 = 84.2	85 x 1.46 = 124.1	85 x 1.18 = 100.3	85 x 1.00 = 85.0
Group 8 (*salad*)	55 x 1.92 = 105.6	55 x 1.48 = 81.4	55 x 1.75 = 96.3	55 x 1.79 = 98.5
Group 10 (*vegetables*)	137 x 0.36 = 49.3	137 x 0.39 = 53.4	137 x 0.37 = 50.7	137 x 2.69 = 368.5
Group 12 (*meat*)	110 x 1.43 = 157.3	110 x 2.62 = 288.2	110 x 1.90 = 209.0	110 x 1.00 = 110.0
Group 13 (*chicken*)	95 x 1.24 = 117.8	95 x 1.63 = 154.9	95 x 1.39 = 132.1	95 x 1.00 = 95.0
Group 14 (*fish*)	95 x 0.45 = 42.8	95 x 1.17 = 111.2	95 x 0.73 = 69.4	95 x 1.00 = 95.0
Group 15 (*potato salad*)	120 x 1.18 = 141.6	120 x 0.68 = 81.6	120 x 0.98 = 117.6	120 x 0.91 = 109.2

12 were very rarely or never consumed by the farmworkers. The second major food item for dinner and supper was selected from food Groups 8 or 10 by most (group 8 by 77% and group 10 by 45% for dinner and group 8 by 69% and group 10 by 45% for supper) of the farming population. Vegetable containing food items were never consumed by the farming population during the snack time.

As has been observed in Table 7-7, among the ethnic population, certain food groups were more likely to be taken at certain meals than at others ie. Groups 3 or 4 were more likely to be taken at breakfast and Groups 7, 12, 13 or 14 were more likely to be taken at dinner or supper. The dietary survey of the ethnic population also revealed that among those food items which could be taken at breakfast or dinner or supper were only taken at any one meal i.e. Group 10 was taken either at breakfast or supper, never at both times. A similar pattern was also observed among the farming population. However, lower percentages of the farming population consumed food items from Groups 13 or 14 and none or very few consumed food items from Groups 7 or 12. Therefore, higher percentages of farmworkers regularly opted for dishes from Groups 8 or 10 at dinner and supper.

The food groups containing vegetables listed in Tables 7-6 and 7-7 could therefore, be divided into three categories because of the greater possibility by the study subjects going for medium meals to select at least one food group from each category at every meal. An average three-food-item meal for the ethnic population will therefore, have at least one item from each category. Two or more food items from the same category were consumed by only those who had a heavy meal. The farmworkers also followed a similar pattern, except that the number of people consuming food from food Groups 7, 12, 13 and 14 being very small, these workers opted for two items from food Groups 5, 8, 10 and 15.

The three food categories were:

Category A: Group 3 and Group 4,

Category B: Group 7, Group 12, Group 13 and Group 14 and

Category C: Group 5, Group 8, Group 10 and Group 15

Food groups from category A were mostly consumed at breakfast and food groups from category B and C were consumed at dinner and supper.

The possible daily consumption of each of the food groups by the ethnic and the farming populations is shown in Table 7-6. These consumption values for each of the food groups have been used to obtain typical total daily intake of vegetables per person, by calculating the consumption of each of the food categories mentioned above. The consumption values for the food groups in each category were averaged to estimate the mean vegetable consumption for the category. The mean vegetable consumption for each of the food category are shown in Table 7-8, the total daily consumption of vegetables per person, calculated as a total for the three categories is also shown in this Table.

The total vegetable consumption among the ethnic females and males was 273.9 g/day and 360.1 g/day respectively and 307.6 g/day for the whole ethnic population. These estimates of the consumption of vegetables have been made on the assumption that at least one food item from each of the food categories (Table 7-7) has been consumed during the day. Among the farming population the intake of food from Category B was low, with an average consumption of one meal per week of food groups from this category. The total daily consumption of vegetables among this population was 288.4 g/day, with the assumption that at least one meal from each category was taken, however, a more realistic estimate of intake would be 384.2 g/day because of the greater likelihood of taking two meals from Category C and none from Category B.

The different vegetables which have been used in the preparation of dishes from the different vegetable containing food groups (Table 7-6) were: Aubergines, Broccoli, Cabbage, Capsicum, Carrots, Cauliflower, Chillies, Coriander, Cucumber, Lettuce, Marrow, Mint, Molokia, Okra, Onion, Parsley, Peas, Pepper, Potatoes, Spinach and Tomatoes. The quantities of each of these individual

Table 7-7: The number and percentages of the daily intake of the food groups at different meals by the study population

Food groups with vegetables	Ethnic population				Farming population		
	Breakfast n (%)	Dinner n (%)	Supper n (%)	Snack n (%)	Breakfast n (%)	Dinner n (%)	Supper n (%)
Group 3 *(sandwiches)*	261 (54)	19 (4)	103 (20)	228 (49)			
Group 4 *(lentils)*	45 (9)	1 (0.2)	18 (4)	23 (5)			
Group 5 *(homus)*	9 (2)	7 (1)	44 (9)	2 (0.4)			
Group 7 *(biryani)*	1 (0.2)	225 (45)	80 (16)	2 (0.4)		15 (5)	18 (6)
Group 8 *(salad)*	24 (5)	369 (74)	136 (27)	4 (0.8)		238 (77)	215 (69)
Group 10 *(vegetables)*	87 (18)	10 (2)	24 (5)	5 (1)	190 (61)	140 (45)	139 (45)
Group 12 *(meat)*	9 (2)	217 (43)	308 (61)	24 (5)		22 (7)	28 (9)
Group 13 *(chicken)*		219 (44)	205 (41)	6 (1)		31 (10)	33 (11)
Group 14 *(fish)*	3 (0.6)	152 (30)	40 (8)	2 (0.4)		37 (12)	47 (15)
Group 15 *(potato salad)*		5 (0.9)	93 (18)	69 (15)	37 (12)	67 (22)	109 (35)

vegetable commodities used in the different dishes are shown in Appendix 23 for the different vegetable containing food groups. The amounts of each of these vegetable commodities used in different vegetable containing food groups and categories are shown in Table 7-9. For those food groups which consisted of more than one dish (Group 3, Group 7, Group 8 and Group 10) the means of the amounts of the vegetables used to prepare each of the dishes in that food group have been reported (Table 7-9).

Table 7-8: The daily mean consumption of vegetables through the Categories A, B and C and the total daily intake of vegetables among the study population (g/day)

Categories	Females g/p/day	Males g/p/day	Ethnic g/p/day	Farmworkers g/p/day
Category A	93.8±117.3	125.9±127.1	106.3±121.1	
Category B	100.5±48.7	169.6±81.2	127.7±59.9	96.3±10.3
Category C	79.6±54.1	64.6±20.1	73.6±40.5	192.1±152.8
Totals	273.9	360.1	307.6	288.4 (384.2)

The consumption of the individual vegetable commodities among the ethnic and farming populations was calculated as a product of the consumption pattern of different vegetable containing food groups (Table 7-4) and the amount of the vegetable commodity used in these food groups (Table 7-9). The possible daily consumption of the different vegetable commodities by females is shown in Table 7-10, by males in Table 7-11, by the total ethnic population in Table 7-12. The corresponding data for the farming population is shown in Table 7-13. The daily consumption patterns have also been calculated for the three food categories for the ethnic males and females in Table 7-14 and for the total ethnic and farming populations in Table 7-15.

7.3.2 Summary and discussion of the dietary intake of fresh vegetables

The different food groups which contained dishes which used fresh vegetables were identified and the different vegetables which were used in these dishes have been listed in Table 7-5 and Appendix 23. The total vegetable content of these food groups was calculated, and on the basis of their consumption pattern they were grouped into three categories. Food groups from Category A were mainly consumed at breakfast and food groups from Category B and C were consumed at dinner or supper. The total vegetable consumption rates among the ethnic females and males were 273.9 g/day and 360.1 g/day respectively and for the whole ethnic population the value was 307.6 g/day. The total consumption from the three food categories among the farming population was 384.2 g/day.

The dietary intake of fresh vegetables among the local UAE population has not been reported previously, however, Mussaiger and Al-Nasser (1995) have reported of fresh vegetable consumptions of 280.5 g/day among the local Baharaini population and 341.1 g/day among the expatriate population resident in Baharain during 1983-1984. Among the Saudi Arabian population during 1974-1976, the consumption of fresh vegetables was reported to be 155.7 g/day and this had increased to 307.0 g/day during the period 1987-1989 (Madani, 1995). The dietary habits of the Baharaini and the Saudi Arabian populations are similar to those of the Emirati (UAE) population, firstly because of the geographical proximity and secondly, because of ethnic, cultural and traditional similarities. It can also be observed from the study by Madani (1995) that the dietary intake of fresh vegetables had almost doubled during a thirteen-year period. The dietary intake of fresh vegetables of 307.6 g/day among the Emirati population, though lower than the dietary intake of the Saudi Arabian population and higher than that of the Baharaini population, is representative of the Arabian peninsula. The dietary intake of fresh vegetables among the Emirati males (360.1 g/day) was observed to be higher than the population mean while the intake among the Emirati females (273.9 g/day) was lower. Dietary intakes of fresh vegetables for males and females among other populations of the Arabian peninsula have not been reported in the literature. The dietary intakes among the total ethnic and the farming populations, as identified in this study, were well below the World Health Organization (WHO)/Food and Agriculture Organization (FAO)

Table 7-9: The amounts of different vegetables used in the different food groups and categories by weight (g).

Vegetables	Food Categories										Total g
	Category A		Category B				Category C				
	Group3 g	Group 4 g	Group 7 g	Group 12 g	Group 13 g	Group 14 g	Group 5 g	Group 8 g	Group 10 g	Group 15 g	
Aubergines	30			60					70		160
Broccoli								10			10
Cabbage			65						50		115
Capsicum	5	5	15	5			5				35
Carrots	10	5		10	15	10	15	15			80
Cauliflower	30	10	15						80		135
Chillies			5	5	5	5			5		25
Coriander	5	5	10				5		5	5	35
Cucumber	10	10				10	20	10			60
Green leafy	10	5				10	10	10	70		115
Marrow				60					70		130
Mint								5			5
Okra				60	40				60		160
Onion	10	20	15	10	15	30	10	5	15	10	130
Parsley								25	5	10	40
Lentils/Peas		20	10				80			5	115
Potatoes	30		15	60	40				20	80	245
Tomatoes	15	10	17	20	20	30	10	10	35	10	177
Group totals*	95	90	85	110	95	95	155	55	137	120	

** Group totals have been obtained by summing up the quantities consumed through a dish (Appendix 20)*
If a group contained more than one dishes then the totals quantities of all the dishes were averaged and used to obtain the group total

Table 7-10: The possible consumption of different vegetables by weight (g) by an ethnic female per day

Vegetables	Food Categories									
	Category A		Category B				Category C			
	Group3 x 1.86 g	Group 4 x 0.12 g	Group 7 x 0.99g	Group 12 x 1.43 g	Group 13 x 1.24 g	Group 14 x 0.45 g	Group 5 0.14 g	Group 8 x 1.92 g	Group 10 x 0.36 g	Group 15 x 1.18 g
Aubergines	55.8			85.8					25.2	
Broccoli								19.2		
Cabbage			64.4						18.0	
Capsicum	9.3	0.6	14.9	7.2			0.7			
Carrots	18.6	0.6		14.3	18.6	4.5	2.1	28.8		
Cauliflower	55.8	1.2	14.9						28.8	
Chillies			4.9	7.2	6.2	2.3			1.8	
Coriander	9.3	0.6	9.9				0.7		1.8	5.9
Cucumber	18.6	1.2				4.5	2.8	19.2		
Green leafy	18.6	0.6				4.5	1.4	19.2	25.2	
Marrow				85.8					25.2	
Mint								9.6		
Okra				85.8	49.6				21.6	
Onion	18.6	2.4	14.9	14.3	18.6	13.5	1.4	9.6	5.4	11.8
Parsley								48.0	1.8	11.8
Lentil/Peas		2.4	9.9				11.2			5.9
Potatoes	55.8		14.9	85.8	49.6				7.2	94.4
Tomatoes	27.9	1.2	16.8	28.6	24.8	13.5	1.4	19.2	12.6	11.8
Group totals*	176.7	10.8	84.2	157.3	117.8	42.8	21.7	105.6	49.3	141.6
Catgr mean**	93.8		100.5				79.6			

** Group totals have been obtained from Appendix 20*

*** Category means have been obtained by averaging the group totals comprising the category*

Table 7-11: The possible consumption of different vegetables by weight (g) by an ethnic male per day

Vegetables	Food Categories									
	Category A		Category B				Category C			
	Group3 x 2.27 g	Group 4 x 0.40 g	Group 7 x 1.46 g	Group 12 x 2.62 g	Group 13 x 1.63 g	Group 14 x 1.17 g	Group 5 0.27 g	Group 8 x 1.48 g	Group 10 x 0.39 g	Group 15 x 0.68 g
Aubergines	68.1			157.2					27.3	
Broccoli								14.8		
Cabbage			94.9						19.5	
Capsicum	11.4	2.0	21.9	13.1			1.4			
Carrots	22.7	2.0		26.2	24.5	11.7	4.1	22.2		
Cauliflower	68.1	4.0	21.9						31.2	
Chillies			7.3	13.1	8.2	5.9			1.9	
Coriander	11.4	2.0	14.6				1.4		1.9	3.4
Cucumber	22.7	4.0				11.7	5.4	14.8		
Green leafy	22.7	8.0				11.7	2.7	14.8	27.3	
Marrow				157.2					27.3	
Mint								7.4		
Okra				157.2	65.2				23.4	
Onion	22.7	8.0	21.9	26.2	24.5	35.1	2.7	7.4	5.9	6.8
Parsley								37.0	1.9	6.8
Lentils/Peas		8.0	14.6				21.6			3.4
Potatoes	68.1		21.9	157.2	65.2				7.8	54.4
Tomatoes	34.1	4.0	24.8	52.4	32.6	35.1	2.7	14.8	13.7	6.8
Group totals*	215.7	36.0	124.1	288.2	154.9	111.2	41.9	81.4	53.4	81.6
Catgr mean**	125.9		169.6				64.6			

* *Group totals have been obtained from Appendix 20*

** *Category means have been obtained from the group totals comprising the category*

Table 7-12: The possible consumption of different vegetables by weight (g) per person per day among the total ethnic population.

Vegetables	Food Categories									
	Category A		Category B				Category C			
	Group3 x 2.02 g	Group 4 x 0.23 g	Group 7 x 1.18 g	Group 12 x 1.90 g	Group 13 x 1.39 g	Group 14 x 0.73 g	Group 5 x 0.19 g	Group 8 x 1.75 g	Group 10 x 0.37 g	Group 15 x 0.98 g
Aubergines	60.6			114.0					25.9	
Broccoli								17.5		
Cabbage			76.7						18.5	
Capsicum	10.1	1.2	17.7	9.5			1.0			
Carrots	20.2	1.2		19.0	20.9	7.3	2.9	26.3		
Cauliflower	60.6	2.3	17.7						29.6	
Chillies			5.9	9.5	6.9	3.7			1.9	
Coriander	10.1	1.2	11.8				1.0		1.9	4.9
Cucumber	20.2	2.3				7.3	3.8	17.5		
Green leafy	20.2	1.2				7.3	1.9	17.5	25.9	
Marrow				114.0					25.9	
Mint								8.8		
Okra				114.0	55.6				22.2	
Onion	20.2	4.6	17.7	19.0	20.9	21.9	1.9	8.8	5.6	9.8
Parsley								43.8	1.9	9.8
Lentils/Peas		4.6	11.8				15.2			4.9
Potatoes	60.6		17.7	114.0	55.6				7.4	78.4
Tomatoes	30.3	2.3	20.1	38.0	27.8	21.9	1.9	17.5	12.9	9.8
Group totals*	191.9	20.7	100.3	209.0	132.1	69.4	29.5	96.3	50.7	117.6
Catgr mean**	106.3		127.7				73.5			

* *Group totals have been obtained from Appendix 20*

** *Category means have been obtained from the group totals comprising the category*

Table 7-13: The possible consumption of different vegetables by weight (g) per person per day among the farming population.

Vegetables	Food Categories									
	Category A		Category B				Category C			
	Group3 g	Group 4 g	Group 7 x 1.00 g	Group 12 x 1.00 g	Group 13 x 1.00 g	Group 14 x 1.00 g	Group 5 g	Group 8 x 1.79 g	Group 10 x 2.69 g	Group 15 x 0.91 g
Aubergines				60.0					188.3	
Broccoli								17.9		
Cabbage			65.0						134.5	
Capsicum			15.0	5.0						
Carrots				10.0	15.0	10.0		26.9		
Cauliflower			15.0						215.2	
Chillies			5.0	5.0	5.0	5.0			13.5	
Coriander			10.0						13.5	4.6
Cucumber						10.0		17.9		
Green leafy						10.0		17.9	188.3	
Marrow				60.0					188.3	
Mint								8.9		
Okra				60.0	40.0				161.4	
Onion			15.0	10.0	15.0	30.0		8.9	40.4	9.1
Parsley								44.8	13.5	9.1
Lentils/Peas			10.0							4.6
Potatoes			15.0	60.0	40.0				53.8	72.8
Tomatoes			17.0	20.0	20.0	30.0		17.9	94.2	9.1
Group totals*			85.0	110.0	95.0	95.0		98.5	368.5	109.2
Catgr mean**			96.3				192.1			

** Group totals have been obtained from Appendix 20*

*** Category means have been obtained from the group totals comprising the category*

Table 7-14: Possible daily intake of vegetables by the ethnic male and female population (g/day)

Vegetables	Category A		Category B		Category C		Totals	
	Males g	Females g	Males g	Females g	Males g	Females g	Males g	Females g
Aubergines	68.1	55.8	157.2	85.8	27.3	25.2	252.6	166.8
Broccoli					14.8	19.2	14.8	19.2
Cabbage			94.9	64.4	19.5	18.0	114.4	82.4
Capsicum	6.7	5.0	17.5	11.1	1.4	0.7	25.6	16.8
Carrots	12.4	9.6	20.8	12.5	13.2	15.5	46.4	37.6
Cauliflower	36.1	28.5	21.9	14.9	31.2	28.8	89.2	72.2
Chillies			8.6	5.2	1.9	1.8	10.5	7.0
Coriander	6.7	5.0	14.6	9.9	2.2	2.8	23.5	17.7
Cucumber	13.4	9.9	11.7	4.5	10.1	11.0	35.2	25.4
Green leafy	15.4	9.6	11.7	4.5	14.9	15.3	42.0	29.4
Marrow			157.2	85.8	27.3	25.2	184.5	111.0
Mint					7.4	9.6	7.4	9.6
Okra			111.2	67.7	23.4	21.6	134.6	89.3
Onion	15.4	10.5	26.9	15.3	5.7	7.1	48.0	32.9
Parsley					15.2	20.5	15.2	20.5
Lentils/Peas	8.0	2.4	14.6	9.9	12.5	8.6	35.1	20.9
Potatoes	68.1	55.8	81.4	50.1	31.1	50.8	180.6	156.7
Tomatoes	19.1	14.6	36.2	20.9	9.5	11.3	64.8	46.8
Category mean*	125.9	93.8	169.6	100.5	64.6	79.6	360.1	273.9

* *Category means have been obtained from Tables 7-19 and 7-20*

Table 7-15: Possible daily intake of vegetables by the total ethnic and farming populations (g/day)

Vegetables	Category A		Category B		Category C		Totals	
	Ethnic g	Farming g	Ethnic g	Farming g	Ethnic g	Farming g	Ethnic g	Farming g
Aubergines	60.6		114.0	60.0	25.9	188.3	200.5	248.3
Broccoli					17.5	17.9	17.5	17.9
Cabbage			76.7	65.0	18.5	134.5	95.2	199.5
Capsicum	5.7		13.6	10.0	1.0		20.3	10.0
Carrots	10.7		15.7	11.7	14.6	26.9	41.0	38.6
Cauliflower	31.5		17.7	15.0	29.6	215.2	78.8	230.2
Chillies			6.5	5.0	1.9	13.5	8.4	18.5
Coriander	5.7		11.8	10.0	2.6	9.1	20.1	19.1
Cucumber	11.3		7.3	10.0	10.7	17.9	29.3	27.9
Green leafy	10.7		7.3	10.0	15.1	103.1	33.1	113.1
Marrow			114.0	60.0	25.9	188.3	139.9	248.3
Mint					8.8	8.9	8.8	8.9
Okra			84.8	50.0	22.2	161.4	107.0	211.4
Onion	12.4		19.9	17.5	6.5	19.5	38.8	37.0
Parsley					18.5	22.5	18.5	22.5
Lentils/Peas	4.6		11.8	10.0	10.1	4.6	26.5	14.6
Potatoes	60.6		62.4	38.3	42.9	63.3	165.9	101.6
Tomatoes	16.3		26.9	21.3	10.5	40.4	53.7	61.7
Category mean*	106.3		127.7	96.3	73.6	192.1	307.6	384.2

* *Category means have been obtained from Tables 7-21 and 7-22*

recommended intake value of 400 g/person/day (Guidelines for predicting the dietary intakes of pesticide residues, 1989). However, considering our limitations in choosing the ethnic population a better indicator of the dietary intake of vegetables would be a national survey of the ethnic population for their dietary habits.

The possible daily intakes of vegetables were estimated through the consumption of different food groups for the ethnic males and females (Table 7-14) and for the total ethnic and the farming populations (Table 7-15). The possible daily intake of vegetables among the males (360.1 g/day) was higher compared to the females (273.9 g/day). The consumption of Aubergines, Cabbage, Cauliflower, Marrow, Okra, Potatoes and Tomatoes was higher among both the male and female populations compared to the other commodities. It was observed among the ethnic population that the consumption of Aubergines (200.5 g/day), Cabbage (95.2 g/day), Cauliflower (78.8 g/day), Marrow (139.9 g/day), Okra (107.0 g/day), Potatoes (165.9 g/day) and Tomatoes (53.7 g/day) was higher compared to the other commodities. The possible dietary intake among the farming population of Aubergines (248.3 g/day), Cabbage (199.5 g/day), Cauliflower (230.2 g/day), Green leafy vegetables (113.1 g/day), Marrow (248.3 g/day), Okra (211.4 g/day), Potatoes (101.6 g/day) and Tomatoes (60.7 g/day) was higher compared with the other commodities. These estimates of the dietary intake of vegetable commodities among the ethnic and the farming populations are 'possible dietary intakes' because all the vegetable commodities are not necessarily consumed each day. However, within the total daily intake of all vegetables of 307.6 g/day for ethnic and 384.2 g/day for the farming populations, the different vegetable commodities are consumed as they are included in the dishes consumed on that day.

7.4 *Estimation of dietary intake of locally grown vegetables*

The ethnic population obtained their vegetables from the local vegetable market (75%), supermarket (19%) and local agriculture market (6%) while the farmworkers obtained their vegetables from the farm where they worked or from a neighbouring farm (93%) and local vegetable market (7%). The fresh vegetable produce at the local vegetable market was either imported or was brought in from the local agricultural farms. The produce at the local vegetable market from the local agricultural farms was marketed directly by the farm owners and the vendors mixed the imported and the local produce prior to selling. The local produce marketed by the farm owners at the vegetable market had been privately diverted away from the government collection centres. Although the local produce at the vegetable market fetched lower prices than those the government would have offered, the farm owners were able to earn quick money, which they did not have to account for with the government.

The produce collected by the government at the collection centres is marketed through the government marketing machinery at special local agricultural markets maintained and run by the government. These local agricultural markets sold only the locally grown produce and did not sell imported produce, however, the supermarkets and the local vegetable markets sold both the local and imported produce. The supply of the local produce to the vegetable markets was seasonal but substantial compared to the imported produce. The agricultural produce from Oman, Saudia Arabia and Jordan was brought into the country without trade licenses and sold along with the local produce at the local vegetable market and possibly at some supermarkets. The figures for the percentage of the agricultural produce requirement of the country which is imported could not be easily obtained for only that what is imported from South Asian and other countries in the West was recorded. The Ministry of Agriculture reported that during 1994-1996 only 15% (Table 4-1, Chapter 4) of the locally grown vegetables were consumed, as fresh agricultural produce, by the ethnic population and the expatriate population resident in the UAE. This estimate does not include the locally grown vegetables which had been privately sold in the local vegetable market. However, the expatriate population did not include the farmworkers, who are the major (93%) consumers of the locally grown vegetables. The Ministry of Agriculture estimates included the 6% of the ethnic population who purchased the vegetables from the local agricultural market, as was identified in the dietary survey. Among the 6% ethnic population were 8% females and 4% males who reported that they purchased the locally grown vegetables from the local agricultural market.

The estimates of dietary intake of the locally grown vegetables shown below, therefore, directly apply to 6% of the ethnic population and 93% of the farming population, for these populations always consumed locally grown vegetables. The dietary intake of vegetables among 94% of the ethnic population and 7% of the farming populations was a mixture of locally grown and imported vegetables including the produce imported from the Gulf Co-operating Council (GGC) countries, ie. Oman, Saudia Arabia. However, the estimation of the percentages of the local and imported produce consumed by these two populations is unfeasible because of two reasons, firstly, the supply of local produce to the local vegetable markets is unrecorded and depends on the farm-owners and farm-personnel, secondly, the commodities are mixed prior to selling, so one cannot tell which is which. The cost of the local produce and the GCC produce being lower for the vendors compared to the imported produce, they always give preference to this produce over imported produce. The local produce will therefore be sold in preference to the imported produce and in the latter variety, only those commodities not grown locally or in the GCC countries will be sold. This practice is more likely to be practised by the vendors at the local vegetable market compared to the supermarkets. It is therefore possible that 75% (who purchased vegetables at the local vegetable market) of the ethnic and 7% of the farming populations consume significantly higher percentages of locally grown or the GCC commodities and lower percentages of imported produce, if that commodity is locally or in the region. Therefore, the estimates for the locally grown vegetables realistically applied for 81% (6%; who purchased at the local agriculture market+75%; who purchased at the local vegetable market) of the ethnic population and 100% (93%; who obtained from the farms+7%; who purchased from the local vegetable market) of the farming population. Broccoli, Coriander, Mint, Okra, Parsley and Peas are either grown locally at experimental stations or not grown at all and are therefore not available commercially in the local market as local produce.

The total vegetable content of the locally grown vegetables was calculated for all the food groups which contained vegetables and is shown in Table 7-16. The derivation of the vegetable content for the locally grown vegetables is shown in Appendix 23. These calculations are based on two assumptions, firstly, that the concentrations of pesticide residues in local produce including the GCC produce and the imported produce were similar and secondly, that the percentage consumption of the locally grown vegetables including the GCC produce was significantly higher compared to the consumption of the imported produce. As described in the previous section the different food groups in Table 7-16 were categorised into three categories according to the pattern of consumption of these food groups. The three categories and the total daily consumption of vegetables through these categories are shown in Table 7-17. The mean intakes of locally grown vegetables among males for Categories A, B and C were 115.2 g/day, 149.9 g/day and 43.9 g/day respectively and similar intakes among the females were 87.6 g/day, 87.6 g/day and 56.4 g/day respectively. The mean intakes of locally grown vegetables among the ethnic population for Categories A, B and C were 98.4 g/day, 112.1 g/day and 51.4 g/day respectively and among the farming population the mean intake for Categories B and C were 85.8 g/day and 156.4 g/day respectively. The total daily intakes of locally grown vegetables among the females, males and total ethnic population were 231.6 g/day, 309.0 g/day and 261.9 g/day respectively. Similar intakes among the farming population were 312.8 g/day based on the assumption that they are more likely to take two meals from Category C and none from Category B.

The dietary intake of locally grown vegetables (Aubergines, Cabbage, Capsicum, Carrots, Cauliflower, Chillies, Cucumbers, Green leafy vegetables, Marrow, Onion, Potatoes and Tomatoes) among the Emirati males and females are shown

Table 7-16: The mean vegetable content of food groups containing locally grown vegetables and the possible daily consumption of the locally grown vegetables through the intake of each of these food groups among the ethnic and farming populations.

	Females g x portions	Males g x portions	Total g x portions	Farmworkers g x portions
Group 3 *(sandwiches)*	90 x 1.86 = 167.4	90 x 2.27 = 204.3	90 x 2.02 = 181.8	
Group 4 *(lentils)*	65 x 0.12 = 7.8	65 x 0.40 = 26.0	65 x 0.23 = 14.9	
Group 5 *(homus)*	70 x 0.14 = 9.8	70 x 0.27 = 18.9	70 x 0.19 = 13.3	
Group 7 *(biryani)*	75 x 0.99 = 74.3	75 x 1.46 = 109.5	75 x 1.18 = 88.5	75 x 1.00 = 75.0
Group 8 *(salad)*	28 x 1.92 = 53.8	28 x 1.48 = 41.4	28 x 1.75 = 49.0	28 x 1.79 = 50.1
Group 10 *(vegetables)*	122 x 0.36 = 43.9	122 x 0.39 = 47.6	122 x 0.37 = 45.1	122 x 2.69 = 328.2
Group 12 *(meat)*	98 x 1.43 = 140.1	98 x 2.62 = 256.8	98 x 1.90 = 186.2	98 x 1.00 = 98.0
Group 13 *(chicken)*	75 x 1.24 = 93.0	75 x 1.63 = 122.3	75 x 1.39 = 104.3	75 x 1.00 = 75.0
Group 14 *(fish)*	95 x 0.45 = 42.8	95 x 1.17 = 111.2	95 x 0.73 = 69.4	95 x 1.00 = 95.0
Group 15 *(potato salad)*	100 x 1.18 = 118.0	100 x 0.68 = 68.0	100 x 0.98 = 98.0	100 x 0.91 = 91.0

Table 7-17: The daily mean consumption of locally grown vegetables through the Categories A, B and C and the total daily intake of locally grown vegetables among the study population (g/day)

Categories	Females g/p/day	Males g/p/day	Total g/p/day	Farmworkers g/p/day
Category A	87.6±112.9	115.2±126.1	98.4±118.0	
Category B	87.6±40.7	149.9±71.5	112.1±51.4	85.8±12.5
Category C	56.4±45.2	43.9±20.2	51.4±34.9	156.4±150.2
Totals	231.6	309.0	261.9	242.2 (312.8)

in Table 7-18 and similar intakes among the ethnic and the farming populations in Table 7-19. The last two columns in Table 7-18 show the total consumption of vegetables among males and females and is obtained by adding up the intakes for the three categories (A, B and C) for males and females respectively. The last two columns in Table 7-19 were obtained in a similar manner for the total ethnic and the farming populations. The dietary intake was higher for those vegetable commodities which were cooked as a main dish in one of the food groups, with other commodities like onion and tomatoes added in smaller proportions, compared to the other commodities like capsicum, carrots and cucumbers which were more likely to be used in smaller proportions in different dishes. The consumption of Aubergines, Cabbage, Cauliflower, Marrow, Potatoes and Tomatoes was higher among the Emirati males and females compared to the consumption of other commodities in Table 7-18. Also the consumption of these commodities was higher among males, compared with the consumption by the females, which could be because of the greater intake by males. The consumption of Aubergines (200.5 g/day), Cabbage (95.2 g/day), Cauliflower (78.8 g/day), Marrow (139.9 g/day) and Potatoes (165.9 g/day) was higher among the ethnic population compared with the consumption of other commodities in Table 7-19. The consumption of Aubergines (248.3 g/day), Cabbage (199.5 g/day), Cauliflower (230.2 g/day), Green leafy vegetables (113.1 g/day), Marrow (248.3 g/day) and Potatoes (101.6 g/day) was higher among the farmworkers compared to the consumption of the other commodities in Table 7-19. The consumption of Cabbage, Cauliflower, Chillies, Green leafy vegetables, Marrow and Tomatoes was higher among the farming population compared to the consumption by the ethnic population. The absence of any entries in Category A for the farmworkers show that these workers did not take any snacks other than tea or coffee or water during the rest breaks while working on the farm. The vegetable commodities consumed during the day depend on the different dishes consumed during that day and certain vegetable commodities are more likely to be consumed on certain days than others depending on the choice of the dishes. However, all the estimates of the daily intakes of the locally grown vegetables are based on the average consumption on a typical day. The major limitation, however, for the estimate of the dietary intake of the locally grown vegetables for the ethnic population and to a less extent to the farming population is the proper identification of the origin of the vegetables in the local vegetable markets.

7.5 Dietary intakes of multiple pesticide residues through vegetable consumption

The concentrations of pesticide residues in different locally grown vegetables have been calculated in Chapter 6 and are shown in Table 6-23. The dietary intakes of vegetables have been calculated in the previous sections of this chapter and are shown in Tables 7-18 and 7-19 for the ethnic and farming populations. The values of the concentrations of the pesticide residues in vegetables and the intake of the locally grown vegetables are used in this section to calculate the dietary intake of pesticide residues through the consumption of these vegetables. Dietary intake of pesticide residues are calculated for the ethnic males and females, the total ethnic population and the farming population.

The primary objective of the Codex Committee on Pesticide Residues (CCPR) is to develop Codex Maximum Residue Limits (MRLs), in order to facilitate international trade and to protect the health of the consumers. The guidelines described by CCPR in predicting the dietary intake of pesticide residues have been used in this section to estimate the dietary intakes of pesticide residues among the ethnic and the expatriate farming populations (Guidelines for

Table 7-18: Possible daily intakes of locally grown vegetables by the ethnic male and female population (g/day)

Vegetables*	Category A*		Category B*		Category C*		Totals*	
	Males g	Females g	Males g	Females g	Males g	Females g	Males g	Females g
Aubergines	68.1	55.8	157.2	85.8	27.3	25.2	252.6	166.8
Cabbage			94.9	64.4	19.5	18.0	114.4	82.4
Capsicum	6.7	5.0	17.5	11.1	1.4	0.7	25.6	16.8
Carrots	12.4	9.6	20.8	12.5	13.2	15.5	46.4	37.6
Cauliflower	36.1	28.5	21.9	14.9	31.2	28.8	89.2	72.2
Chillies			8.6	5.2	1.9	1.8	10.5	7.0
Cucumber	13.4	9.9	14.6	4.5	10.1	11.0	38.1	25.4
Green leafy	15.4	9.6	11.7	4.5	14.9	15.3	42.0	29.4
Marrow			157.2	85.8	27.3	25.2	184.5	111.0
Onion	15.4	10.5	26.9	15.3	5.7	7.1	48.0	32.9
Potatoes	68.1	55.8	81.4	50.1	31.1	50.8	180.6	156.7
Tomatoes	19.1	14.6	36.2	20.9	9.5	11.3	64.8	46.8
Category mean**	115.2	87.6	149.9	87.6	43.9	56.4	309.0	231.6

* *These values have been obtained from Table 7-14.*

** *Category means have been obtained from Table 7-17.*

Table 7-19: Possible daily intake of locally grown vegetables by the ethnic and farming populations (g/day)

Vegetables*	Category A*		Category B*		Category C*		Totals*	
	Ethnic g	Farming g	Ethnic g	Farming g	Ethnic g	Farming g	Ethnic g	Farming g
Aubergines	60.6		114.0	60.0	25.9	188.3	200.5	248.3
Cabbage			76.7	65.0	18.5	134.5	95.2	199.5
Capsicum	5.7		13.6	10.0	1.0		20.3	10.0
Carrots	10.7		15.7	11.7	14.6	26.9	41.0	38.6
Cauliflower	31.5		17.7	15.0	29.6	215.2	78.8	230.2
Chillies			6.5	5.0	1.9	13.5	8.4	18.5
Cucumber	11.3		7.3	10.0	10.7	17.9	29.3	27.9
Green leafy	10.7		7.3	10.0	15.1	103.1	33.1	113.1
Marrow			114.0	60.0	25.9	188.3	139.9	248.3
Onion	12.4		19.9	17.5	6.5	19.5	38.8	37.0
Potatoes	60.6		62.4	38.3	42.9	63.3	165.9	101.6
Tomatoes	16.3		26.9	21.3	10.5	40.4	53.7	61.7
Category mean**	98.4		112.1	85.8	51.4	156.4	261.9	312.8

* *These values have been obtained from Table 7-15.*

** *Category means have been obtained from Table 7-17.*

predicting dietary intake of pesticide residues, 1989). According to these guidelines "the dietary intake of any pesticide residue in a given food is obtained by multiplying the residue level in the food by the amount consumed of that food". The MRL, which represents the maximum residue level that is expected to occur in a commodity following application of a pesticide according to good agricultural practice, has been used by CCPR as an index to predict the pesticide residue intake. The average daily consumption of food has been used as an index of food consumption by the CCPR and the daily dietary intake of different vegetables for the ethnic and the expatriate farming populations have been discussed in Section 7.4.

The dietary intake of pesticide residues has been calculated by the CCPR to different degrees of accuracy, depending on the information that is available for inclusion into the pesticide residue intake model (Guidelines for predicting dietary intake of pesticide residues, 1989). The Theoretical Maximum Daily Intake (TMDI) is a crude estimate where the food consumption pattern has been derived from a hypothetical global or national diet. A better estimate would be the Estimated Maximum Daily Intake (EMDI), where correction factors for commercial and domestic processing of food have been included into the pesticide residue model, but the food consumption information has still been derived from a hypothetical global or national diet. The best estimate is the Estimated Daily Intake (EDI), which is similar to the EMDI but includes food consumption information which has been calculated for a specific population and also takes into account the consumption of imported or locally grown food. In this study the EDI has been calculated for the Emirati (ethnic) and the expatriate farming populations, using the information collected on field based parameters and the correction factors for residue losses during processing or cooking which have been obtained from JMPR evaluations (Guidelines for dietary intake of pesticide residues, 1989). The EDI of the pesticide residue in this study has been estimated for multi-pesticide residues in the locally grown vegetables.

The estimated daily intake (EDI) is a best realistic estimate of the dietary intake of individual pesticide residues in individual vegetable commodities (Guidelines for predicting dietary intake of pesticide residues, 1989). However, in this study EDI has been employed in the estimation of the daily intake of multi-pesticide residues in individual vegetable commodities. It is calculated using the sum of all the pesticide residue levels in the edible portion of the vegetable commodity, the dietary intake of the locally grown vegetables, the reduction or increase in the residue from commercial processing of the produce prior to selling to the consumer and the reduction or increase in the level of residue on preparation or cooking of the produce prior to consumption. The following model has been used in the estimation of EDI for the Emirati and the expatriate farming populations:

$$EDI = \Sigma R_i \times F_i \times P_i \times C_i$$

where

R_i the actual residue level in the edible portion of the commodity given in mg of pesticide per kg of commodity, these values have been derived in Chapter 6, Table 6-39;

F_i food consumption for the relevant commodity as derived from the dietary survey and given in kg of food per person per day, these values have been derived and discussed in Section 7.4 of this chapter Tables 7-27 and 7-28;

P_i a correction factor that takes into account the reduction or increase in the residue on processing such as milling, etc., since the consumption of fresh locally grown vegetables has been considered in this section, a unit value has been assigned to all the vegetable commodities (Guidelines for predicting dietary intake of pesticide residues, 1989);

C_i a correction factor that takes into account the reduction or increase in the level of residue on preparation for consumption or cooking of the food. A factor of 1 has been assigned to those vegetable commodities which are consumed raw and 0.5 to those commodities which are cooked prior to eating (Guidelines for predicting dietary intake of pesticide residues, 1989).

The EDI values for the dietary intake of multi-pesticide residues for the locally grown vegetables among the ethnic males and females are shown in Table 7-20 for all pesticide residues, in Table 7-21 for organophosphorus pesticide residues and in Table 7-22 for the carbamates and other pesticide residues. The mean EDI of all pesticide residues for the ethnic males and females was 183.9×10^{-3} mg/person/day and 138.0×10^{-3} mg/person/day respectively (Table 7-20). Similar intakes of organophosphorus pesticide residues were 190.0×10^{-3} mg/person/day and 142.7×10^{-3} mg/person/day respectively (Table 7-21) for males and females and for carbamates and other pesticides 177.7×10^{-3} mg/person/day and 133.4×10^{-3} mg/person/day respectively (Table 7-22) for males and females. The EDI for all pesticide residues, organophosphorus pesticides and carbamate and other pesticides for the ethnic population were 155.9×10^{-3} mg/person/day (Table 7-23), 161.1×10^{-3} mg/person/day (Table 7-24) and 150.7×10^{-3} mg/person/day (Table 7-25) respectively. Similar intakes among the expatriate farming population were 186.2×10^{-3} mg/person/day (Table 7-23), 192.5×10^{-3} mg/person/day (Table 7-33) and 179.9×10^{-3} mg/person/day (Table 7-25) respectively for all pesticide residues, organophosphorus pesticides, carbamates and other pesticides. The EDI of all pesticide residues from the consumption of Aubergines, Cabbage, Cauliflower, Cucumber, Marrow, Onion, Potatoes and Tomatoes were higher among the ethnic males and females compared to the EDIs from other vegetable commodities. The EDI of pesticide residues through the consumption of all vegetable commodities were higher among the males compared with the females. The EDI of pesticide residues from the consumption of Aubergines, Cabbage, Cauliflower, Cucumber, Marrow, Onion, Potatoes and Tomatoes were higher among the ethnic population compared with the other vegetable commodities. Among the expatriate farming population the EDI of pesticide residues were higher from the consumption of Aubergines, Cabbage, Cauliflower, Chillies, Green leafy vegetables, Marrow and Tomatoes compared to the ethnic population.

The EDI of organophosphorus pesticide residues through the consumption of Aubergines, Cabbage, Cauliflower, Cucumbers, Green leafy vegetables, Marrow, Onion, Potatoes and Tomatoes was higher in males and females compared to the other commodities. The EDI of carbamates was higher among the ethnic males and females through the consumption of Aubergines, Cabbage, Cauliflower, Cucumbers, Marrow, Potatoes and Tomatoes. Among the ethnic population the EDI of organophosphorus pesticides was higher through the consumption of Aubergines, Cabbage, Cauliflower, Marrow and Tomatoes and the EDI of carbamates was higher through the consumption of Aubergines, Cucumbers, Marrow, Onion, Potatoes and Tomatoes. The EDI pattern for organophosphorus and carbamate pesticides among the farmworkers was similar to the ethnic population and in addition Chillies provided more organophosphates and Cabbage, Chillies and Green leafy vegetables provided more carbamates to this population.

The estimated dietary intake (EDI) of individual pesticide residues through the consumption of the locally grown vegetables are shown in Appendix 24. In these estimates only those pesticides identified in at least 10% of the vegetables are included. Among the organophosphorus pesticides, the intakes of Demephion and Acephate were higher from the consumption of Aubergines and the intakes of Formothion and Dimethoate were higher from the consumption of Cabbage among the ethnic and the farming populations. Higher intakes of Methidathion were obtained through Marrow and Profenofos through Onion by the ethnic and the farming populations. The farming population obtained higher intakes of Phenthoate and Pirimiphos-methyl from the consumption of Green leafy vegetables. Among the carbamates and other pesticides, higher intakes of Triadimefon were obtained from the consumption of Marrow and Aubergines, Butocarboxim from Aubergines and Pyridate, Carbaryl from Aubergines, Triamiphos and Aminocarb from Marrow by the ethnic and the farming populations. Higher intakes of Carbaryl were also obtained by the farming

Table 7-20 Estimated daily intake (EDI) of all pesticide residues among ethnic male and female populations

Vegetables	R_i^1 mg/kg	P_i^2	C_i^3	Males		Females	
				F_i^4 kg/p/d	Estimated dietary intake mg/p/d	F_i^5 kg/p/d	Estimated dietary intake mg/p/d
Aubergines	0.91±0.12	1	0.5	0.253	115.1×10^{-3}	0.167	76.0×10^{-3}
Cabbage	0.60±0.20	1	1	0.114	68.4×10^{-3}	0.082	49.2×10^{-3}
Capsicum	0.65±0.30	1	1	0.026	16.9×10^{-3}	0.017	11.1×10^{-3}
Carrots	0.60±0.00	1	1	0.046	27.6×10^{-3}	0.038	22.8×10^{-3}
Cauliflower	0.80±0.36	1	0.5	0.089	35.6×10^{-3}	0.072	28.8×10^{-3}
Chillies	2.07±0.44	1	1	0.011	22.8×10^{-3}	0.007	14.5×10^{-3}
Cucumbers	1.55±0.69	1	1	0.038	62.7×10^{-3}	0.025	41.3×10^{-3}
Green leafy vegs	0.74±0.16	1	0.5	0.042	15.5×10^{-3}	0.029	10.7×10^{-3}
Marrow	0.89±0.16	1	0.5	0.185	82.3×10^{-3}	0.111	49.4×10^{-3}
Onion	1.01±0.11	1	1	0.048	48.5×10^{-3}	0.033	33.3×10^{-3}
Potatoes	0.67±0.37	1	0.5	0.181	60.6×10^{-3}	0.157	52.6×10^{-3}
Tomatoes	1.33±0.13	1	0.5	0.065	43.2×10^{-3}	0.047	31.3×10^{-3}
Mean	1.19±0.09	1	0.5	0.309	183.9×10^{-3}	0.232	138.0×10^{-3}

1 *pesticide residues from vegetables calculated in Chapter 6 (Table 6-26)*
2 *correction factor for commercial processing of vegetables (Guidelines for predicting dietary intake of pesticide residues, 1989)*
3 *correction factor for preparation or cooking of vegetables (Guidelines for predicting dietary intake of pesticide residues, 1989)*
4 *dietary intake of vegetables by males (Table 7-18)*
5 *dietary intake of vegetables by females (Table 7-18)*

Table 7-21 Estimated daily intake (EDI) of organophosphorus pesticide residues among ethnic male and female populations

Vegetables	R_i^1 mg/kg	P_i^2	C_i^3	Males		Females	
				F_i^4 kg/p/d	Estimated dietary intake mg/p/d	F_i^5 kg/p/d	Estimated dietary intake mg/p/d
Aubergines	0.62±0.07	1	0.5	0.253	78.4×10^{-3}	0.167	51.8×10^{-3}
Cabbage	0.53±0.18	1	1	0.114	60.4×10^{-3}	0.082	43.5×10^{-3}
Capsicum		1	1	0.026		0.017	
Carrots	0.20±0.0	1	1	0.046	9.2×10^{-3}	0.038	7.6×10^{-3}
Cauliflower	0.40±0.0	1	0.5	0.089	17.8×10^{-3}	0.072	14.4×10^{-3}
Chillies	1.05±0.39	1	1	0.011	11.6×10^{-3}	0.007	7.4×10^{-3}
Cucumbers	0.93±0.35	1	1	0.038	35.3×10^{-3}	0.025	23.3×10^{-3}
Green leafy vegs	0.87±0.18	1	0.5	0.042	18.3×10^{-3}	0.029	12.6×10^{-3}
Marrow	0.80±0.00	1	0.5	0.185	74.0×10^{-3}	0.111	44.4×10^{-3}
Onion	0.81±0.17	1	1	0.048	38.9×10^{-3}	0.033	26.7×10^{-3}
Potatoes	0.33±0.06	1	0.5	0.181	29.9×10^{-3}	0.157	25.9×10^{-3}
Tomatoes	1.04±0.17	1	0.5	0.065	33.8×10^{-3}	0.047	24.4×10^{-3}
Mean	1.23±0.22	1	0.5	0.309	190.0×10^{-3}	0.232	142.7×10^{-3}

1 *pesticide residues from vegetables calculated in Chapter 6 (Table 6-26)*
2 *correction factor for commercial processing of vegetables (Guidelines for predicting dietary intake of pesticide residues, 1989)*
3 *correction factor for preparation or cooking of vegetables (Guidelines for predicting dietary intake of pesticide residues, 1989)*
4 *dietary intake of vegetables by males (Table 7-18)*
5 *dietary intake of vegetables by females (Table 7-18)*

Table 7-22 Estimated daily intake (EDI) of carbamate and other pesticide residues among ethnic male and female populations

Vegetables	R_i[1] mg/kg	P_i[2]	C_i[3]	Males		Females	
				F_i[4] kg/p/d	Estimated dietary intake mg/p/d	F_i[5] kg/p/d	Estimated dietary intake mg/p/d
Aubergines	0.66±0.09	1	0.5	0.253	83.5×10^{-3}	0.167	55.1×10^{-3}
Cabbage	0.20±0.0	1	1	0.114	22.8×10^{-3}	0.082	16.4×10^{-3}
Capsicum	0.40±0.0	1	1	0.026	10.4×10^{-3}	0.017	6.8×10^{-3}
Carrots	0.40±0.0	1	1	0.046	18.4×10^{-3}	0.038	15.2×10^{-3}
Cauliflower	0.60±0.27	1	0.5	0.089	26.7×10^{-3}	0.072	21.6×10^{-3}
Chillies	1.55±0.45	1	1	0.011	17.1×10^{-3}	0.007	10.9×10^{-3}
Cucumbers	1.27±0.53	1	1	0.038	48.3×10^{-3}	0.025	31.8×10^{-3}
Green leafy vegs	0.55±0.10	1	0.5	0.042	11.6×10^{-3}	0.029	8.0×10^{-3}
Marrow	0.90±0.19	1	0.5	0.185	83.3×10^{-3}	0.111	50.0×10^{-3}
Onion	0.81±0.07	1	1	0.048	38.9×10^{-3}	0.033	26.7×10^{-3}
Potatoes	1.00±0.0	1	0.5	0.181	90.5×10^{-3}	0.157	78.5×10^{-3}
Tomatoes	1.18±0.12	1	0.5	0.065	38.4×10^{-3}	0.047	27.7×10^{-3}
Mean	1.15±0.31	1	0.5	0.309	177.7×10^{-3}	0.232	133.4×10^{-3}

1 *pesticide residues from vegetables calculated in Chapter 6 (Table 6-26)*
2 *correction factor for commercial processing of vegetables (Guidelines for predicting dietary intake of pesticide residues, 1989)*
3 *correction factor for preparation or cooking of vegetables (Guidelines for predicting dietary intake of pesticide residues, 1989)*
4 *dietary intake of vegetables by males (Table 7-18)*
5 *dietary intake of vegetables by females (Table 7-18)*

Table 7-23 Estimated daily intake (EDI) of all pesticide residues among the ethnic and the expatriate farming populations

Vegetables	R_i^1 mg/kg	P_i^2	C_i^3	Ethnic		Farming	
				F_i^4 kg/p/d	Estimated dietary intake mg/p/d	F_i^5 kg/p/d	Estimated dietary intake mg/p/d
Aubergines	0.91±0.12	1	0.5	0.201	91.5×10^{-3}	0.248	112.8×10^{-3}
Cabbage	0.60±0.20	1	1	0.095	57.0×10^{-3}	0.200	120.0×10^{-3}
Capsicum	0.65±0.30	1	1	0.020	13.0×10^{-3}	0.010	6.5×10^{-3}
Carrots	0.60±0.00	1	1	0.041	24.6×10^{-3}	0.039	23.4×10^{-3}
Cauliflower	0.80±0.36	1	0.5	0.079	31.6×10^{-3}	0.230	92.0×10^{-3}
Chillies	2.07±0.44	1	1	0.008	16.6×10^{-3}	0.019	39.3×10^{-3}
Cucumber	1.55±0.69	1	1	0.029	47.8×10^{-3}	0.028	46.2×10^{-3}
Green leafy vegs	0.74±0.16	1	0.5	0.033	12.2×10^{-3}	0.113	41.8×10^{-3}
Marrow	0.89±0.16	1	0.5	0.140	62.3×10^{-3}	0.248	110.4×10^{-3}
Onion	1.01±0.11	1	1	0.039	39.4×10^{-3}	0.037	37.4×10^{-3}
Potatoes	0.67±0.37	1	0.5	0.166	55.6×10^{-3}	0.102	34.2×10^{-3}
Tomatoes	1.33±0.13	1	0.5	0.054	35.9×10^{-3}	0.062	41.2×10^{-3}
Means	1.19±0.09	1	0.5	0.262	155.9×10^{-3}	0.313	186.2×10^{-3}

1 *pesticide residues from vegetables calculated in Chapter 6 (Table 6-26)*
2 *correction factor for commercial processing of vegetables (Guidelines for predicting dietary intake of pesticide residues, 1989)*
3 *correction factor for preparation or cooking of vegetables (Guidelines for predicting dietary intake of pesticide residues, 1989)*
4 *dietary intake of vegetables by males (Table 7-19)*
5 *dietary intake of vegetables by females (Table 7-19)*

Table 7-24 Estimated daily intake (EDI) of organophosphorus pesticide residues among the ethnic and the expatriate farming populations

Vegetables	R_i[1] mg/kg	P_i[2]	C_i[3]	Ethnic		Farming	
				F_i[4] kg/p/d	Estimated dietary intake mg/p/d	F_i[5] kg/p/d	Estimated dietary intake mg/p/d
Aubergines	0.62±0.07	1	0.5	0.201	62.3×10^{-3}	0.248	76.9×10^{-3}
Cabbage	0.53±0.18	1	1	0.095	50.4×10^{-3}	0.200	106.0×10^{-3}
Capsicum		1	1	0.020		0.010	
Carrots	0.20±0.0	1	1	0.041	8.2×10^{-3}	0.039	7.8×10^{-3}
Cauliflower	0.40±0.0	1	0.5	0.079	15.8×10^{-3}	0.230	46.0×10^{-3}
Chillies	1.05±0.39	1	1	0.008	8.4×10^{-3}	0.019	20.0×10^{-3}
Cucumber	0.93±0.35	1	1	0.029	27.0×10^{-3}	0.028	26.0×10^{-3}
Green leafy vegs	0.87±0.18	1	0.5	0.033	14.4×10^{-3}	0.113	49.2×10^{-3}
Marrow	0.80±0.00	1	0.5	0.140	56.6×10^{-3}	0.248	99.2×10^{-3}
Onion	0.81±0.17	1	1	0.039	31.6×10^{-3}	0.037	30.0×10^{-3}
Potatoes	0.33±0.06	1	0.5	0.166	27.4×10^{-3}	0.102	16.8×10^{-3}
Tomatoes	1.04±0.17	1	0.5	0.054	28.1×10^{-3}	0.062	32.2×10^{-3}
Means	1.23±0.22	1	0.5	0.262	161.1×10^{-3}	0.313	192.5×10^{-3}

1 *pesticide residues from vegetables calculated in Chapter 6 (Table 6-26)*
2 *correction factor for commercial processing of vegetables (Guidelines for predicting dietary intake of pesticide residues, 1989)*
3 *correction factor for preparation or cooking of vegetables (Guidelines for predicting dietary intake of pesticide residues, 1989)*
4 *dietary intake of vegetables by males (Table 7-19)*
5 *dietary intake of vegetables by females (Table 7-19)*

Table 7-25 Estimated daily intake (EDI) of carbamate and other pesticide residues among the ethnic and the expatriate farming populations

Vegetables	R_i[1] mg/kg	P_i[2]	C_i[3]	Ethnic		Farming	
				F_i[4] kg/p/d	Estimated dietary intake mg/p/d	F_i[5] kg/p/d	Estimated dietary intake mg/p/d
Aubergines	0.66±0.09	1	0.5	0.201	66.3×10^{-3}	0.248	81.8×10^{-3}
Cabbage	0.20±0.0	1	1	0.095	19.0×10^{-3}	0.200	40.0×10^{-3}
Capsicum	0.40±0.0	1	1	0.020	8.0×10^{-3}	0.010	4.0×10^{-3}
Carrots	0.40±0.0	1	1	0.041	16.4×10^{-3}	0.039	15.6×10^{-3}
Cauliflower	0.60±0.27	1	0.5	0.079	23.7×10^{-3}	0.230	69.0×10^{-3}
Chillies	1.55±0.45	1	1	0.008	12.4×10^{-3}	0.019	29.5×10^{-3}
Cucumber	1.27±0.53	1	1	0.029	36.8×10^{-3}	0.028	35.6×10^{-3}
Green leafy vegs	0.55±0.10	1	0.5	0.033	9.1×10^{-3}	0.113	31.1×10^{-3}
Marrow	0.90±0.19	1	0.5	0.140	63.0×10^{-3}	0.248	111.6×10^{-3}
Onion	0.81±0.07	1	1	0.039	31.6×10^{-3}	0.037	30.8×10^{-3}
Potatoes	1.00±0.0	1	0.5	0.166	83.0×10^{-3}	0.102	51.0×10^{-3}
Tomatoes	1.18±0.12	1	0.5	0.054	31.9×10^{-3}	0.062	36.6×10^{-3}
Means	1.15±0.31	1	0.5	0.262	150.7×10^{-3}	0.313	179.9×10^{-3}

1 *pesticide residues from vegetables calculated in Chapter 6 (Table 6-26)*
2 *correction factor for commercial processing of vegetables (Guidelines for predicting dietary intake of pesticide residues, 1989)*
3 *correction factor for preparation or cooking of vegetables (Guidelines for predicting dietary intake of pesticide residues, 1989)*
4 *dietary intake of vegetables by males (Table 7-19)*
5 *dietary intake of vegetables by females (Table 7-19)*

population from the consumption of Cauliflower. Ethidimuron was obtained in greater amounts from the consumption of Potatoes by the ethnic and the farming populations.

7.5.1 *Summary and discussion of Estimated Daily Intake (EDI) of pesticide residues*

The dietary intakes of pesticide residues from the consumption of locally grown vegetables was estimated for the local ethnic and the immigrant farming populations. The total daily intakes of all pesticide residues among the ethnic males (183.9×10^{-3} mg/person/day) was higher than the intake by ethnic females (138.0×10^{-3} mg/person/day), and this was mainly due to the higher vegetable consumption by the males. The total dietary intakes of all pesticide residues among the ethnic population was 155.9×10^{-3} mg/person/day and among the expatriate farming population was 186.2×10^{-3} mg/person/day. The vegetable commodities which contributed to the higher EDI of all pesticides among the ethnic population were Aubergines, Cabbage, Cauliflower, Cucumbers, Marrow, Onion, Potatoes and Tomatoes. Among the farmworkers the commodities which contributed to the higher EDI of all pesticides were Aubergines, Cabbage, Cauliflower, Chillies, Cucumbers, Green leafy vegetables, Marrow, Onion, Potatoes and Tomatoes. The intakes of organophosphorus pesticides were higher compared to the intakes of all pesticides and carbamates and other pesticides among the ethnic and the farming populations. The vegetable commodities which contributed higher intakes of organophosphorus pesticides among the ethnic and the farming populations were Aubergines, Cabbage, Cucumbers, Onion, Marrow, Potatoes and Tomatoes. In addition to this the farming population also obtained higher pesticide residues from Green leafy vegetables.

Estimated Daily Intakes (EDI) have not been reported for any of the neighbouring populations in the Arabian peninsula, however, the average exposure of an Italian adult to organophosphorus, carbamates and pyrethroid pesticide residues has been reported to be 43 mg/person/day (Dolara, *et al*, 1993). The comparable intake in Spain was 48.7 mg/person/day (Torres, *et al*, 1997). In Finland the dietary intake of pesticides from domestic vegetables during the period 1977-1993 has decreased from 16.9 to 3.7 mg/person/day because of intensive food control and good agricultural practices (Pentilla and Siivinen, 1996). Dietary intakes of organochlorines in Asia have been declining in recent years, however, the current intakes are 5 to 100 fold greater than those in the developed nations (Kannan *et al,* 1997). The total dietary intakes of organophosphorus and carbamate pesticide residues from locally grown vegetables in the UAE have been shown in this study to be approximately 3 and half times the intake reported in Italy, 3 times the intake in Spain and 42 times the intakes in Finland. The total dietary intake of pesticides among the farmworkers were even higher compared to that of the ethnic population of the UAE. The poor governmental control on the use of pesticides, poor agricultural practices and excessive use of pesticides in agriculture in Al-Ain are some of the reasons for the higher concentrations of pesticide residues in vegetables and consequently the higher intake of pesticide residues through the consumption of locally grown agricultural produce. Estimates of dietary intake of vegetables from a national survey and determination of pesticide residues from continuous monitoring would provide a representative estimate for the ethnic population.

It was observed that 73% of all vegetable samples had quantifiable levels of pesticide residues and 95% of the samples had pesticide residues or pesticide associated compounds. The percentage of the non-compliant samples in the UAE were much higher compared to 27.7% of the vegetable samples in Belgium which had detectable levels of pesticide residues but below the MRL (Dejonckheere *et al,* 1996). In Ontario, Canada, 22% of vegetable samples have been identified with pesticide residues below 0.1 mg/kg while in the UAE pesticide residues in excess of 0.1 mg/kg were identified in Radish (100%), Cauliflower (100%), Green leafy vegetables (87%), Marrow (81%), Aubergines (80%), Tomatoes (78%), Corn (75%), Capsicum (67%), Chillies (67%), Potatoes (61%), Onion (61%) and Cabbage (60%). The mean pesticide residue concentration for all the vegetable commodities analysed in this study was 1.19±0.09 mg/kg which is about 12 times the highest observed Canadian levels (Frank *et al,* 1990). Singh and Chawla (1988) have reported that the dietary intake of only organochlorines among Indian vegetarians (14.3 mg/person/day) and non-vegetarians (13.5 mg/person/day) was much higher compared to the intakes in developed countries and also over ten times higher than the CAC-ADI values (Codex Alimentarius, 1993). The average daily intake of pesticide residues among the North American people from the consumption of vegetables have been reported to be within the acceptable levels established by the FDA and the WHO (Gartell *et al,* 1986; Gunderson *et al,* 1988). The dietary intake of pesticide residues in the developing countries are, therefore, still higher than the intake in the developed countries as observed by Kannan *et al,* (1997). The dietary intakes of all pesticide residues in the UAE are higher compared to similar intakes in the developed countries, however, the levels in the UAE are still lower compared to levels in countries like India (Dolara *et al,* 1993; Singh and Chawla, 1988).

The dietary intakes of individual pesticide residues were higher for the organophosphorus pesticides comprising Demephion, Acephate, Formothion, Dimethoate, Methidathion, Profenofos among the ethnic and the farming populations. In addition to these pesticides the intake was also higher for Phenthoate and Pirimiphos-methyl for the farming population. Among the carbamates and other pesticides the intakes were higher for Triadimefon, Butocarboxim, Pyridate, Carbaryl, Triamiphos, Aminocarb and Ethidimuron from the consumption of locally grown vegetables among the ethnic and the farming populations. The intakes of Captan and Desmethryn were higher among the farming population compared with the ethnic population. Until now researchers had focused on the organochlorines for various reasons and dietary intakes of organochlorines have been widely studied and reported. The dietary intakes of organochlorines through different types of foods have been estimated and reported (Kannan *et al,* 1988; Dolara *et al,* 1993; Kuhnlein *et al,* 1995). The dietary intakes of organophosphorus pesticides, however, have been under-reported for the developing countries (Dolara *et al,* 1993; Torres *et al,* 1997). There is a need for more information on the dietary intake of organophosphorus pesticides both in the developed and developing countries.

Chapter 8

Estimated daily intake of pesticide residues and congenital malformations in the ethnic population

8.0 *Introduction*

8.1 *Estimated dietary intake of pesticide residues by the ethnic and farming populations*

8.2 *Determination of acceptable daily intakes of pesticide residues*

8.3 *Adverse health effects from chronic exposures to pesticides*

8.4 *Congenital malformations in the ethnic population*

8.5 *Maximum residue limits for the locally grown vegetables*

8.0 *Introduction*

The Codex Alimentarius Commission (CAC) has established ADI values for pesticide residues from agricultural produce for worldwide use, however, governmental agencies in Europe, North America and Canada have established their own tolerance levels, which are similar to the CAC ADI values for most pesticide residues. Governmental agencies in Europe, North America and Canada routinely monitor the imported and locally grown agricultural produce for pesticide residue and for compliance with the governmental tolerance limits which are similar to the acceptable daily intake (ADI). In some countries like the US the tolerance levels are more stringent than the CAC ADI, while in other countries like the UK, they are more relaxed (Renwick, 1995). The CAC ADI has been defined as a dose of a single pesticide which can be taken daily during one's lifetime without any adverse health effects. However, the ADI's for mixtures and combinations of different pesticides as identified in the agricultural produce in Al-Ain, have not been reported by the CAC and are still being debated (CAC, Pesticide residues in food, 1992).

Because of regular monitoring and the existing governmental regulations in the developed countries, lower percentages of agricultural produce samples have been found to contain pesticide residues. In the United States, the Food and Drug Administration (FDA) in 1994 identified 37% of domestic and 33% of imported agricultural produce samples with pesticide residues and less than 1% of these were above the tolerance limits (Pesticide monitoring program, 1994). In Sweden, over seven thousand samples of agricultural produce were analysed in 1994 and among these, 31% were identified with detectable residues and 2.1% of these samples exceeded the Swedish tolerance levels (Pesticide residues in food of plant origin 1994, 1996). Between 1986 and 1988, 433 samples of locally grown vegetables analysed in Ontario, Canada and 36% were found to have detectable levels of pesticide residues of which 0.7% exceeded the Canadian tolerance limits (Frank *et al*, 1990). In contrast to the developed countries, most of the developing countries do not have any tolerance limits for agricultural produce. In addition, the agricultural produce is not monitored regularly and no governmental regulations exist for the use of pesticides.

Recent reports on chronic low dose exposure to pesticides have indicated disruption in the development of the reproductive, immune, nervous and endocrine systems of animals and humans (Colborn, 1995; Rutherford, 1996; Rawlings *et al*, 1998). Pesticides affect cellular and molecular processes that regulate development, endocrine and immunological functions in the most susceptible segments of the population, i.e. very young children and the developing foetus (Repetto, 1996). Evidence of lowered sperm counts, increases in the incidence of hypospadias, cryptorchidism, congenital malformations involving the nervous, skeletal and hormonal systems and cancers of the breast, testicles has caused concern for these adverse health effects have been associated, to some degree, with chronic pesticide exposure (Rawlings, 1996; Colborn, 1995; Sharpe and Skakkebaek, 1993). Fruits and vegetables are an essential part of any diet but there is increasing concern about the way these foods are produced and the contaminants they carry. Among the different segments of the general population children are at an increased risk both from dietary and environmental exposures to pesticides. In spite of governmental regulations and controlled use of pesticides in the United States alone over a million children, living on farms and in rural areas, are expected to be at an increased risk of chronic low dose exposure to pesticides (Beaumont and Buffin, 1998). In the developing countries the risk to the farmworkers from occupational exposure to pesticides has not been adequately documented (Wasilszewski, 1987). Moreover, pesticide related morbidity and adverse health effects in the farming and the general populations in these countries have not been exclusively associated with pesticide exposure because malnutrition, poverty and living conditions, the major confounders ill-health, are integrally linked with pesticide exposure.

The total pesticide residues in the locally grown vegetables have been compared with the Maximum Residue Levels (MRL) of the Codex Alimentarius Commission (see Chapter 6) to determine the level of contamination of local produce. Eleven out of the 13 vegetable commodities had been found to have exceeded the MRL levels for all pesticide residues. For organophosphorus pesticides all the commodities had exceeded the MRL levels and for carbamates and other pesticides eight out of ten had exceeded the MRL levels. It is therefore expected that the dietary intakes of pesticides as a percentage of Acceptable Daily Intake (ADI) to be high for the locally grown vegetables. In this chapter, having determined the dietary intake of pesticide residues (EDI_{bw}) from the local produce and having compared it with the ADI proposed by the Joint Meeting of the Pesticide Residues (JMPR), new maximum residue limits (tolerance levels) has been estimated for the local produce.

8.1 *Estimated dietary intake of pesticide residues by the ethnic and the farming populations*

The estimated daily intakes of pesticides (EDI) from locally grown vegetables estimated in Chapter 7 have been used in this chapter to determine the Estimated Daily Intake per unit body weight (EDI_{bw}) so as to compare with the ADI values for the ethnic and the farming populations. The calculated EDI_{bw}, for the intake from the individual vegetable commodities and the mean intake from all vegetables, for the ethnic males and females are shown in Table 8-1 for all pesticide residues, Table 8-2 for organophosphorus pesticide residues and Table 8-3 for carbamates and other pesticide residues. The calculated EDI_{bw} for the intake from the individual vegetable commodities and the mean intake from all vegetables, for the ethnic and the farming populations for all pesticides are shown in Table 8-4, for organophosphorus pesticide residues in Table 8-5 and for carbamates and other pesticide residues in Table 8-6. In these calculations average human body weight for males and females has been assumed to be 60 kg, as suggested by the Codex Alimentarius Commission (Guide for predicting dietary intake of pesticide residues, 1989).

The mean EDI_{bw} of all pesticide residues among the ethnic males and females from all vegetable commodities were 30.65×10^{-4} mg/kg body weight and 23.00×10^{-4} mg/kg body weight respectively (Table 8-1). Among the ethnic males higher EDI_{bw} for all pesticides were observed for Aubergines (19.19×10^{-4} mg/kg b w), Cabbage (11.40×10^{-4} mg/kg b w), Cucumbers (10.45×10^{-4} mg/kg b w), Marrow (13.72×10^{-4} mg/kg b w) and Potatoes (10.11×10^{-4} mg/kg b w) the corresponding values for the females from these vegetable commodities were 12.66×10^{-4} mg/kg b w, 8.20×10^{-4} mg/kg b w, 6.88×10^{-4} mg/kg b w, 8.23×10^{-4} mg/kg b w and 8.77×10^{-4} mg/kg b w respectively. The total dietary intake of organophosphorus pesticides among the ethnic males was 31.67×10^{-4} mg/kg body weight and among the females 23.78×10^{-4} mg/kg body weight (Table 8-2). The intakes of organophosphorus pesticides were higher from Aubergines, Cabbage and Marrow compared with other commodities for the ethnic males. Among the females the intakes of organophosphorus pesticides were also higher from Aubergines, Cabbage and Marrow. The intake of organophosphorus pesticides was higher in males compared to females. The dietary intake of carbamates and other pesticide residues was 29.62×10^{-4} mg/kg body weight among males and 22.23×10^{-4} mg/kg body weight among the females. Aubergines, Cucumbers, Marrow and Potatoes contributed higher amounts of carbamates and other pesticides to the total intake of pesticide residues among the ethnic males and females (Table 8-3).

Among the ethnic population the mean EDI_{bw} value was 25.98×10^{-4} mg/kg body weight and among the farming population it was 31.03×10^{-4} mg/kg body weight from the consumption of all vegetable commodities (Table 8-4). The vegetable commodities which can be identified as the major contributors to the total daily intake of pesticide residues were Aubergines (15.24×10^{-4} mg/kg b w), Cabbage (9.50×10^{-4} mg/kg b w), Marrow (10.38×10^{-4} mg/kg b w) and Potatoes (9.27×10^{-4} mg/kg b w) for the ethnic population and Aubergines (18.81×10^{-4} mg/kg b w), Cabbage (20.00×10^{-4} mg/kg b w), Cauliflower (15.33×10^{-4} mg/kg b w) and Marrow (18.39×10^{-4} mg/kg b w) for the farming population. The dietary intake of organophosphorus pesticide residues among the ethnic population was 26.85×10^{-4} mg/kg body weight and among the farming population 32.08×10^{-4} mg/kg body weight (Table 8-5). The intakes of organophosphorus pesticide residues from Aubergines, Cabbage and Marrow were higher than from other commodities among the ethnic population and among the farming population higher intakes of organophosphorus pesticides were provided by Aubergines, Cabbage, Cauliflower, Green leafy vegetables and Marrow. The mean dietary intakes of carbamates and other pesticides among the ethnic and farming populations were 25.12×10^{-4} mg/kg body weight and 29.98×10^{-4} mg/kg body weight respectively (Table 8-6). The consumption of Aubergines, Cauliflower, Marrow and Potatoes contributed higher amounts to the total intake of carbamates among the ethnic population and Aubergines, Cabbage, Cauliflower, Marrow and Potatoes contributed higher amounts to the total carbamate and other pesticide residue intake among the farming population.

8.1.1 Estimates of ethnic and farming populations at risk to the dietary exposure of pesticides from the consumption of the locally grown vegetables

Information on the source of purchase of vegetables had been obtained from the ethnic and the farming populations during the dietary survey and these results have been described in Chapter 7. These results show that most (75%) of the ethnic population obtained their vegetables from the local vegetable market where the imported and the local produce had been sold together, but preference was given by the vendors to the local produce. A further 6% of the ethnic population comprising 8% females and 4% males said that they purchased their produce from the local agricultural market, where only local produce was sold. In contrast 93% of the farmworkers obtained locally grown vegetables from the agricultural farms. A further 7% of the farmworkers obtained their agricultural produce from the local vegetable market. It can therefore be deduced that 81% (75%+6%) of the ethnic population and 100% (93%+7%) of the farming population either purchased and consumed locally grown vegetables or vegetables grown in the region. However, the estimation of the exact percentages is difficult because information on the amounts of each type of vegetables purchased and the number of people purchasing them from the different sources is not available. An estimate is made in this section on the size of the ethnic population who consumed the locally grown vegetables and are therefore exposed to the pesticide residues contained in the locally grown vegetables.

In the UAE, because of the large influx of skilled and unskilled expatriates and heavy dependence on the expatriates by the ethnic people, there is an imbalance in the population pyramid with an excess of males in the 25-50 year age group. Population estimates of the ethnic people have not been made public by the government for many reasons including the political and the national security reasons. However, for the purposes of planning, development and provision of governmental services, 25% of the total (ethnic and expatriate) have been allocated as ethnic population. Using the total population estimates provided by the Ministry of Health and the information obtained through the dietary survey,

Table 8-1: Estimated daily intake of all pesticide residues per unit body weight (EDI_{bw}) among ethnic male and female populations

Vegetables	Males			Females		
	F_i* kg/person/day	EDI** mg/person	EDI_{bw} mg/kg body weight	F_i* kg/person/day	EDI** mg/person	EDI_{bw} mg/kg body weight
Aubergines	0.253	115.1×10^{-3}	19.19×10^{-4}	0.167	76.0×10^{-3}	12.66×10^{-4}
Cabbage	0.114	68.4×10^{-3}	11.40×10^{-4}	0.082	49.2×10^{-3}	8.20×10^{-4}
Capsicum	0.026	16.9×10^{-3}	2.82×10^{-4}	0.017	11.1×10^{-3}	1.84×10^{-4}
Carrots	0.046	27.6×10^{-3}	4.60×10^{-4}	0.038	22.8×10^{-3}	3.80×10^{-4}
Cauliflower	0.089	35.6×10^{-3}	5.93×10^{-4}	0.072	28.8×10^{-3}	4.80×10^{-4}
Chillies	0.011	22.8×10^{-3}	3.79×10^{-4}	0.007	14.5×10^{-3}	2.42×10^{-4}
Cucumbers	0.038	62.7×10^{-3}	10.45×10^{-4}	0.025	41.3×10^{-3}	6.88×10^{-4}
Green leafy vegs	0.042	15.5×10^{-3}	2.59×10^{-4}	0.029	10.7×10^{-3}	1.79×10^{-4}
Marrow	0.185	82.3×10^{-3}	13.72×10^{-4}	0.111	49.4×10^{-3}	8.23×10^{-4}
Onion	0.048	48.5×10^{-3}	8.08×10^{-4}	0.033	33.3×10^{-3}	5.56×10^{-4}
Potatoes	0.181	60.6×10^{-3}	10.11×10^{-4}	0.157	52.6×10^{-3}	8.77×10^{-4}
Tomatoes	0.065	43.2×10^{-3}	7.20×10^{-4}	0.047	31.3×10^{-3}	5.21×10^{-4}
Mean	0.309	183.9×10^{-3}	30.65×10^{-4}	0.232	138.0×10^{-3}	23.00×10^{-4}

* *dietary intake of vegetable commodity (extracted from Table 7-20)*

** *extracted from Table 7-20*

EDI_{bw} = EDI/60 kg (*assumed average human body weight*)

Table 8-2: Estimated daily intake of organophosphorus pesticide residues per unit body weight (EDI_{bw}) among the ethnic male and female populations

Vegetables	Males			Females		
	F_i* kg/person/day	EDI** mg/person	EDI_{bw} mg/kg body weight	F_i* kg/person/day	EDI** mg/person	EDI_{bw} mg/kg body weight
Aubergines	0.253	78.4×10^{-3}	13.07×10^{-4}	0.167	51.8×10^{-3}	8.63×10^{-4}
Cabbage	0.114	60.4×10^{-3}	10.07×10^{-4}	0.082	43.5×10^{-3}	7.24×10^{-4}
Capsicum	0.026			0.017		
Carrots	0.046	9.2×10^{-3}	1.53×10^{-4}	0.038	7.6×10^{-3}	1.27×10^{-4}
Cauliflower	0.089	17.8×10^{-3}	2.97×10^{-4}	0.072	14.4×10^{-3}	2.40×10^{-4}
Chillies	0.011	11.6×10^{-3}	1.93×10^{-4}	0.007	7.4×10^{-3}	1.23×10^{-4}
Cucumbers	0.038	35.3×10^{-3}	5.89×10^{-4}	0.025	23.3×10^{-3}	3.88×10^{-4}
Green leafy vegs	0.042	18.3×10^{-3}	3.05×10^{-4}	0.029	12.6×10^{-3}	2.10×10^{-4}
Marrow	0.185	74.0×10^{-3}	12.33×10^{-4}	0.111	44.4×10^{-3}	7.40×10^{-4}
Onion	0.048	38.9×10^{-3}	6.48×10^{-4}	0.033	26.7×10^{-3}	4.46×10^{-4}
Potatoes	0.181	29.9×10^{-3}	4.98×10^{-4}	0.157	25.9×10^{-3}	4.32×10^{-4}
Tomatoes	0.065	33.8×10^{-3}	5.63×10^{-4}	0.047	24.4×10^{-3}	4.07×10^{-4}
Mean	0.309	190.0×10^{-3}	31.67×10^{-4}	0.232	142.7×10^{-3}	23.78×10^{-4}

* *dietary intake of vegetable commodity (extracted from Table 7-21)*

** *extracted from Table 7-21*

EDI_{bw} = EDI/60 kg (*assumed average human body weight*)

Table 8-3: Estimated daily intake of carbamates and other pesticide residues per unit body weight (EDI_{bw}) among ethnic male and female populations

Vegetables	Males			Females		
	F_i* kg/person/day	EDI** mg/person	EDI_{bw} mg/kg body weight	F_i* kg/person/day	EDI** mg/person	EDI_{bw} mg/kg body weight
Aubergines	0.253	83.5×10^{-3}	13.92×10^{-4}	0.167	55.1×10^{-3}	9.19×10^{-4}
Cabbage	0.114	22.8×10^{-3}	3.80×10^{-4}	0.082	16.4×10^{-3}	2.73×10^{-4}
Capsicum	0.026	10.4×10^{-3}	1.73×10^{-4}	0.017	6.8×10^{-3}	1.13×10^{-4}
Carrots	0.046	18.4×10^{-3}	3.07×10^{-4}	0.038	15.2×10^{-3}	2.53×10^{-4}
Cauliflower	0.089	26.7×10^{-3}	4.45×10^{-4}	0.072	21.6×10^{-3}	3.60×10^{-4}
Chillies	0.011	17.1×10^{-3}	2.84×10^{-4}	0.007	10.9×10^{-3}	1.81×10^{-4}
Cucumbers	0.038	48.3×10^{-3}	8.04×10^{-4}	0.025	31.8×10^{-3}	5.29×10^{-4}
Green leafy vegs	0.042	11.6×10^{-3}	1.93×10^{-4}	0.029	8.0×10^{-3}	1.33×10^{-4}
Marrow	0.185	83.3×10^{-3}	13.88×10^{-4}	0.111	50.0×10^{-3}	8.33×10^{-4}
Onion	0.048	38.9×10^{-3}	6.48×10^{-4}	0.033	26.7×10^{-3}	4.46×10^{-4}
Potatoes	0.181	90.5×10^{-3}	15.08×10^{-4}	0.157	78.5×10^{-3}	13.08×10^{-4}
Tomatoes	0.065	38.4×10^{-3}	6.39×10^{-4}	0.047	27.7×10^{-3}	4.62×10^{-4}
Mean	0.309	177.7×10^{-3}	29.62×10^{-4}	0.232	133.4×10^{-3}	22.23×10^{-4}

* *dietary intake of vegetable commodity (extracted from Table 7-22)*

** *extracted from Table 7-22*

EDI_{bw} = EDI/60 kg (*assumed average human body weight*)

Table 8-4: Estimated daily intake of all pesticide residues per unit body weight (EDI_{bw}) among ethnic and farming populations

Vegetables	Ethnic			Farming		
	F_i* kg/person/day	EDI** mg/person	EDI_{bw} mg/kg body weight	F_i* kg/person/day	EDI** mg/person	EDI_{bw} mg/kg body weight
Aubergines	0.201	91.5×10^{-3}	15.24×10^{-4}	0.248	112.8×10^{-3}	18.81×10^{-4}
Cabbage	0.095	57.0×10^{-3}	9.50×10^{-4}	0.200	120.0×10^{-3}	20.00×10^{-4}
Capsicum	0.020	13.0×10^{-3}	2.17×10^{-4}	0.010	6.5×10^{-3}	1.08×10^{-4}
Carrots	0.041	24.6×10^{-3}	4.10×10^{-4}	0.039	23.4×10^{-3}	3.90×10^{-4}
Cauliflower	0.079	31.6×10^{-3}	5.27×10^{-4}	0.230	92.0×10^{-3}	15.33×10^{-4}
Chillies	0.008	16.6×10^{-3}	2.76×10^{-4}	0.019	39.3×10^{-3}	6.55×10^{-4}
Cucumbers	0.029	47.8×10^{-3}	7.97×10^{-4}	0.028	46.2×10^{-3}	7.70×10^{-4}
Green leafy vegs	0.033	12.2×10^{-3}	2.04×10^{-4}	0.113	41.8×10^{-3}	6.97×10^{-4}
Marrow	0.140	62.3×10^{-3}	10.38×10^{-4}	0.248	110.4×10^{-3}	18.39×10^{-4}
Onion	0.039	39.4×10^{-3}	6.57×10^{-4}	0.037	37.4×10^{-3}	6.23×10^{-4}
Potatoes	0.166	55.6×10^{-3}	9.27×10^{-4}	0.102	34.2×10^{-3}	5.70×10^{-4}
Tomatoes	0.054	35.9×10^{-3}	5.99×10^{-4}	0.062	41.2×10^{-3}	6.87×10^{-4}
Mean	0.262	155.9×10^{-3}	25.98×10^{-4}	0.313	186.2×10^{-3}	31.03×10^{-4}

* *dietary intake of vegetable commodity (extracted from Table 7-23)*

** *Extracted from Table 7-23*

EDI_{bw} = EDI/60 kg *(assumed average human body weight)*

Table 8-5: Estimated daily intake of organophosphorus pesticide residues per unit body weight (EDI_{bw}) among ethnic and farming populations

Vegetables	Ethnic			Farming		
	F_i* kg/person/day	EDI** mg/person	EDI_{bw} mg/kg body weight	F_i* kg/person/day	EDI** mg/person	EDI_{bw} mg/kg body weight
Aubergines	0.201	62.3×10^{-3}	10.39×10^{-4}	0.248	76.9×10^{-3}	12.81×10^{-4}
Cabbage	0.095	50.4×10^{-3}	8.39×10^{-4}	0.200	106.0×10^{-3}	17.67×10^{-4}
Capsicum	0.020			0.010		
Carrots	0.041	8.2×10^{-3}	1.37×10^{-4}	0.039	7.8×10^{-3}	1.30×10^{-4}
Cauliflower	0.079	15.8×10^{-3}	2.63×10^{-4}	0.230	46.0×10^{-3}	7.67×10^{-4}
Chillies	0.008	8.4×10^{-3}	1.40×10^{-4}	0.019	20.0×10^{-3}	3.33×10^{-4}
Cucumbers	0.029	27.0×10^{-3}	4.50×10^{-4}	0.028	26.0×10^{-3}	4.34×10^{-4}
Green leafy vegs	0.033	14.4×10^{-3}	2.39×10^{-4}	0.113	49.2×10^{-3}	8.19×10^{-4}
Marrow	0.140	56.6×10^{-3}	9.33×10^{-4}	0.248	99.2×10^{-3}	16.53×10^{-4}
Onion	0.039	31.6×10^{-3}	5.27×10^{-4}	0.037	30.0×10^{-3}	5.00×10^{-4}
Potatoes	0.166	27.4×10^{-3}	4.57×10^{-4}	0.102	16.8×10^{-3}	2.81×10^{-4}
Tomatoes	0.054	28.1×10^{-3}	4.68×10^{-4}	0.062	32.2×10^{-3}	5.37×10^{-4}
Mean	0.262	161.1×10^{-3}	26.85×10^{-4}	0.313	192.5×10^{-3}	32.08×10^{-4}

* *dietary intake of vegetable commodity (extracted from Table 7-24)*

** *Extracted from Table 7-24*

EDI_{bw} = EDI/60 kg (*assumed average human body weight*)

Table 8-6: Estimated daily intake of carbamate and other pesticide residues per unit body weight (EDI_{bw}) among ethnic and farming populations

Vegetables	Ethnic			Farming		
	F_i* kg/person/day	EDI** mg/person	EDI_{bw} mg/kg body weight	F_i* kg/person/day	EDI** mg/person	EDI_{bw} mg/kg body weight
Aubergines	0.201	66.3×10^{-3}	11.06×10^{-4}	0.248	81.8×10^{-3}	13.64×10^{-4}
Cabbage	0.095	19.0×10^{-3}	3.17×10^{-4}	0.200	40.0×10^{-3}	6.67×10^{-4}
Capsicum	0.020	8.0×10^{-3}	1.33×10^{-4}	0.010	4.0×10^{-3}	0.67×10^{-4}
Carrots	0.041	16.4×10^{-3}	2.73×10^{-4}	0.039	15.6×10^{-3}	2.60×10^{-4}
Cauliflower	0.079	23.7×10^{-3}	3.95×10^{-4}	0.230	69.0×10^{-3}	11.50×10^{-4}
Chillies	0.008	12.4×10^{-3}	2.07×10^{-4}	0.019	29.5×10^{-3}	4.91×10^{-4}
Cucumbers	0.029	36.8×10^{-3}	6.14×10^{-4}	0.028	35.6×10^{-3}	5.93×10^{-4}
Green leafy vegs	0.033	9.1×10^{-3}	1.51×10^{-4}	0.113	31.1×10^{-3}	5.18×10^{-4}
Marrow	0.140	63.0×10^{-3}	10.50×10^{-4}	0.248	111.6×10^{-3}	18.60×10^{-4}
Onion	0.039	31.6×10^{-3}	5.27×10^{-4}	0.037	30.8×10^{-3}	5.00×10^{-4}
Potatoes	0.166	83.0×10^{-3}	13.83×10^{-4}	0.102	51.0×10^{-3}	8.50×10^{-4}
Tomatoes	0.054	31.9×10^{-3}	5.31×10^{-4}	0.062	36.6×10^{-3}	6.10×10^{-4}
Mean	0.262	150.7×10^{-3}	25.12×10^{-4}	0.313	179.9×10^{-3}	29.98×10^{-4}

* *dietary intake of vegetable commodity (extracted from Table 7-25)*

** *Extracted from Table 7-25*

EDI_{bw} = EDI/60 kg *(assumed average human body weight)* the size of the ethnic population usually consuming the locally grown vegetables has been estimated. In the estimation of the ethnic population at risk from the consumption of the locally grown vegetables only those above 10 years of age have been considered, because their consumption is substantially higher compared to those below 10 years of age. It has been observed in Table 8-7 that the size of the ethnic population who is at risk of exposure to pesticide residues from the consumption of the locally grown vegetables was 81% (418, 982) of the total population above ten years of age. The corresponding figures for the females and the males were 88% (218,146) and 74% (199,299) respectively (Table 8-7).

The characteristics of the farming population have been described in Chapter 4. A total of 16,600 farmworkers were reported to have been working on the farms in 1995 (Annual report of the Preventive Medicine Dept., 1996). During the survey of the farms in the five farming areas, a total of 221 foremen and 311 farm labourers were interviewed for the dietary survey. Almost all the farmworkers reported that they always consumed the produce grown on their farms as and when available through the two seasons. Many of the farms, when they did not plant a crop for commerce, kept a kitchen garden for their day to day consumption.

The annual reports of the Department of Agriculture, summarized in Table 4-1 of Chapter IV, showed that in the fiscal year 1995-1996, about 15% of the locally grown produce was sold through the local agricultural markets in the country. However, this figure does not include the amount consumed by the farmworkers and that which was sold privately to the vendors at the local vegetable market, prior to dispatching the produce to the governmental collection centres. The reported 15% of the produce sold through the local agricultural markets have been purchased partly by 6% of the ethnic population described above and partly by the expatriate non-farming population. The unsold produce from the local agricultural markets is dumped as agricultural waste.

Table 8-7: Estimated ethnic population consuming locally grown vegetables

	Females n (%)	Males n (%)	Total n (%)
Total population of UAE[1]	827,800 (33)	1,650,100 (66)	2,477,900
Ethnic population[2]	294,988 (48)	324,486 (52)	619,475 (25)
Ethnic population above 10 years[3]	247,790	269,323	517,262
Population consuming local vegs[4]	19,823	10,773	31,035
Population consuming local vegs[5]	198,232	188,526	387,947
Total population at risk[6]	218,146 (88)	199,299 (74)	418,982 (81)

Source of information Ministry of Health, UAE

1 *Combined ethnic and expatriate populations*

2 *Estimated at 25% of the total population; and then separated into males and females with a male/female ratio of 1.1among the ethnic population*

3 *83% of males, 84% of females and 83.5% of the total ethnic population was over 10 years of age in 1995*

4 *Dietary survey identified 8% of females, 4% of males and 6% of ethnic population as consuming locally grown vegetables*

5 *75% of the ethnic population (above 10 years of age) consuming locally grown vegetables from the local vegetable market. Corresponding percentages for females and males were 80% and 70% respectively (Dietary survey results).*

6 *Total of rows 4 and 5*

8.1.2 Summary and discussion of EDI_{bw} of pesticide residues among ethnic and farming populations

The mean EDI_{bw} values for the ethnic males from all vegetable commodities was 30.65x10^{-4} mg/kg body weight and for the females 23.00x10^{-4} mg/kg body weight. Similar intakes for the total ethnic and the farming populations were 25.98x10^{-4} mg/kg body weight and 31.03 mg/kg body weight respectively. Among the ethnic population higher estimated daily intakes of pesticide residues were observed from the consumption of Aubergines, Cabbage, Cucumbers, Marrow, Onion, Potatoes and Tomatoes. The consumption of these commodities was higher and the concentration of pesticide residues in these commodities being higher the total dietary intake of pesticide residues from these commodities was high. Chillies and Cucumbers also had higher concentrations of pesticide residues compared to the other commodities, but these commodities were consumed less. The daily intake of pesticide residues by the farming population was higher from the consumption of Aubergines, Cabbage, Cauliflower, Chillies, Cucumbers, Green leafy vegetables, Marrow and Tomatoes compared to the other commodities. The consumption of vegetables being more among the ethnic males and the farming population, the daily intakes of pesticide residues was also higher among the ethnic males and the farming population. The size of the ethnic population exposed to the pesticide residues through the consumption of locally grown vegetables was 418,982 (68% of the total ethnic population) and comprised 52% females and 48% males. Among the farming population the whole population was exposed to the pesticide residues identified in the locally grown vegetables.

Among the many studies assessing the level of exposure to pesticides through diet most have concentrated on organochlorines in fatty foods and foods of animal origin. Dogheim *et al,* (1996b) and Lazaro *et al,* (1996) have reported that the intake of organochlorines from agricultural produce was below the ADI levels. Dolara *et al,* (1993) have reported that the dietary intake of organophosphates, carbamates and pyrethroids by an Italian adult through the complete diet were lower than the Italian tolerance levels for each of the pesticides. However, it was also observed that among the Italian adults the total intakes of all pesticide residues was 19.83×10^{-4} mg/kg body weight, but this exposure level was reported not to have induced any genotoxic effects in rats (Dolara *et al,* 1993). The dietary intake of organophosphorus pesticides through the consumption of agricultural produce in Japan was in the range of 0.22×10^{-4} and 0.24×10^{-4} mg/kg body weight during 1980-1984 (Nakagawa *et al,* 1995). In India the average dietary exposure to organochlorines was between 238×10^{-3} mg/kg body weight and 225×10^{-3} mg/kg body weight from the consumption of the locally grown vegetables (Singh and Chawla, 1988). In the UAE since there is no regular monitoring of imported and domestic agricultural products for pesticide residues, estimation of dietary exposure to pesticide from the consumption of imported vegetables was not possible, however, the EDI_{bw} of pesticide residues through the consumption of only locally grown vegetables was 25.98×10^{-4} mg/kg body weight and 31.03×10^{-4} mg/kg body weight for the ethnic and the farming populations respectively. These estimated daily intakes of pesticide residues in the study population were higher compared to the Italian and the Japanese populations. These intakes among the ethnic and the farming populations were higher because of the higher concentrations of pesticide residues in the locally grown vegetables. The dietary intake of all (local and imported) vegetables was lower compared to the WHO/FAO recommended value of 400 g/person/day.

The total daily intakes of organophosphorus pesticides (31.67×10^{-4} mg/kg body weight) and carbamates and other pesticides (29.62×10^{-4} mg/kg body weight) by the ethnic males and by the ethnic females (23.78×10^{-4} mg/kg body weight and 22.23×10^{-4} mg/kg body weight respectively) were lower to the dietary intake of organochlorines by the vegetarians and non-vegetarians in India through the consumption of locally grown vegetables in India (Singh and Chawla, 1988). However, the dietary intake levels in the UAE were higher than the intake of organophosphorus pesticides in the Japanese population. The total daily intake of organophosphorus pesticides by the ethnic population was 26.85×10^{-4} mg/kg body weight and the intake of carbamates and other pesticides was 25.12×10^{-4} mg/kg body weight. Similar intakes in the farming population were 32.08×10^{-4} mg/kg body weight and 29.98×10^{-4} mg/kg body weight. These dietary intakes in the ethnic and farming population were also lower to the intakes of organochlorines by the vegetarian and non-vegetarian populations in India. The total dietary intake of all pesticide residues in the Italian population was 19.83×10^{-4} mg/kg body weight which was lower than the dietary intake of all pesticides from locally grown vegetables by the ethnic males (30.65×10^{-4} mg/kg body weight), ethnic females (23.00×10^{-4} mg/kg body weight), total ethnic population (25.98×10^{-4} mg/kg body weight) and the farming population (31.03×10^{-4} mg/kg body weight).

8.2 *Determination of acceptable daily intake of pesticide residues*

The dietary intake of the locally grown vegetables and the intake of different pesticide residues through these vegetables have been discussed in Chapter VII. However, in Appendix 25, acceptable daily intakes (ADI) those pesticide residues which have been identified in at least ten percent of the samples of each of the vegetable commodities have been shown. Pesticide residues in the different vegetable commodities in Appendix 25 have been classified into two groups; 1) Organophosphorus and 2) Carbamate/Others. The pesticides included in the second group apart from the carbamates were: Carbamoyloxime, Urea herbicides, Pyridazine herbicides, Phthalimide fungicides, N-dichlorofluoromethylthiosulfamide fungicides, Conazole fungicides, Uracil herbicides, Organochlorine insecticides and Chlorbenzenesulfonate insecticides.

Among the commonly identified pesticides listed in Appendix 25, Demephion which was identified in Aubergines and Green leafy vegetables is no longer manufactured and not used anymore in the developed countries. Demephion is therefore on the list of suspended pesticides. However, it is still used in the UAE. Carbaryl which is identified in Cauliflower, has been reported to be an endocrine disrupter and a mutagenic pesticide and has been banned in Germany and its use has been restricted in the United Kingdom (Davis, 1995). Bromacil which was identified in Tomatoes, has been banned in Sweden (Davis, 1995; Weber and Jacob, 1998). In recent reports from the developed countries, Demeton-S-methyl, Captan and Dimethoate have been identified to be carcinogenic and mutagenic (Pesticide News, 1997). Monocrotophos has been linked with massive bird kills in Argentina and has been banned in many countries including Thailand in the South East Asia (Buffin, 1997b). However, it has been used in the UAE on Cucumber crops. Information on the ADI (Acceptable Daily Intake) levels for the pesticides identified in the locally grown vegetables was obtained from the Codex Alimentarius (1993). However, information on the ADI levels for Butocarboxim, Ethidimuron, Pyridate, Promecarb, Fenobucarb and Bromacil was not available, these compounds have been commonly identified in several commodities of the locally grown vegetables. The ADI levels for these compounds have not been reported in the Codex Alimentarius (1993) because these pesticides have not been used and identified in the agricultural produce in the developed countries (Codex Alimentarius, 1993).

The ADI values for individual pesticide residues shown in Appendix 25 have been used to calculate the median values for organophosphorus and carbamate/other pesticide residues and for the all (organophosphorus and carbamate/other) pesticide residues identified in the locally grown vegetables. In Table 8-8 the median value has been used as a measure of central tendency for pesticide residues because the Joint Meeting for Pesticide Residues (JMPR) also uses the same criteria in suggesting the ADI value for a pesticide residue in different commodities of the agricultural produce (Guidelines for dietary intake of pesticide residues, 1989). The ADI_{median} value has been calculated for the locally grown produce as an acceptable daily intake measure for the organophosphorus, carbamates and all pesticide residues in a vegetable commodity (Table 8-8). However, in Table 8-8 mean ADI has also been shown for comparison with the ADI_{median}. It has been observed that the mean values (column 5) were similar to the median values (column 4) for all commodities except for Cauliflower, Chillies and Cucumbers. Because of the large variability of the ADI values for the different pesticide residues within the vegetable commodity, the mean may not be reliable measure of central tendency. Therefore, in the calculations that follow in Tables 8-9 and 8-10 median ADI values (ADI_{median}) are preferred to the mean ADI values (ADI_{mean}).

Gomes *et al,* (1998b) have reported that the LD_{50} for the mixture of the six organophosphorus pesticides as determined through laboratory mice experiments was 0.067 mg. However, the calculated mean and the median LD_{50} values for the six organophosphates were 1.55±2.55mg and 0.50 mg respectively. The LD_{50} value for the mixture of the six organophosphorus pesticides is considerably lower than any of the individual organophosphorus pesticides comprising the mixture. It can also be observed that the LD_{50} dose for the mixture is approximately one-tenth (10^{-1}) of the median value of the six organophosphorus pesticides. This criteria has been employed in estimating the ADI_{median} for mixtures for exposure to mixtures of pesticides through the consumption of different vegetable commodities (Table 8-8). The ADI for mixtures in column 6 of Table 8-8 has therefore, been estimated at 10^{-1} times the ADI for individual pesticides in column 4 of Table 8-8.

The EDI_{bw} values estimated in Tables 8-1 through 8-6 have been compared with the median ADI values calculated in Table 8-8 for organophosphorus, carbamates and all pesticides and for the mixtures to estimate the percentage of ADI for males in Table 8-9, for females in Table 8-10, for the total ethnic population in Table 8-11 and for the farming population in Table 8-12. The daily intake of all pesticide residues as a percentage of ADI in males was 43.99% of organophosphorus pesticides, 7.67% of carbamates/other pesticides and 16.30% of all pesticide residues (Table 8-9). The percentage ADI exposure from Aubergines (19.19%), Cucumbers (20.90%) and Cabbage (11.40%) were in excess of 10% of the ADI values and from Cauliflower (7.91%) and Onion (8.08%) were in excess of 5% of the ADI values for all pesticides and were therefore, higher than the other vegetable commodities. The exposure of organophosphorus pesticide residues in excess of 10% of the ADI value were from Aubergines (13.07%), Cabbage (10.07%), Cauliflower (10.60%), Cucumbers (19.63%), Green leafy vegetables (10.15%) and Marrow (24.67%) and in excess of 5% of the ADI values from Onion (9.97%) for the male population. The percentage ADI values for carbamates and other pesticides were all below 10% of the ADI value and exceeded 5% of the ADI value for Aubergines (6.96%) and Marrow (8.16%). The percentage ADI values for all pesticide residues from the intake of all vegetable commodities (161.32%) was approximately one and a half times the ADI for mixtures. The percentage ADI values for Aubergines (191.86%), Cabbage (114.0%) and Cucumbers (209.0%) exceeded the ADI for mixtures. The percentage ADI value exceeded 50% of the ADI value for mixtures for Cauliflower (74.17%) and Onion (80.80%).

The daily intake of all pesticides as a percentage of ADI for the females were 33.03% for organophosphorus pesticides, 5.76% for carbamates/other pesticides and 12.23% for all pesticide residues (Table 8-10). These percentages were lower compared to the corresponding percentages for the males. The daily intake of all pesticide residues from individual vegetable commodities were in excess of 10% of ADI for Aubergines (12.66%) and Cucumbers (13.75%) and in excess of 5% of the percentage ADI values for Cabbage (8.20%), Cauliflower (6.40%) and Onion (5.56%). The percentage ADI for organophosphorus pesticides were in excess of 10% of ADI value for organophosphorus pesticides for Cucumbers (12.92%) and Marrow (14.80%) and in excess of 5% of ADI value for Aubergines (8.63%), Cabbage (7.24%), Cauliflower (8.57%), Green leafy vegetables (7.01%) and Onion (6.85%). The percentage ADI for carbamates and other pesticides was below 5% for all commodities. The daily intake of pesticide residues as a percentage of ADI for mixtures of pesticides exceeded the ADI for mixtures for Aubergines (126.64%) and Cucumbers (73.40%) and were in excess of 50% of the ADI value for Cabbage (82.0%), Cauliflower (60.0%) and Onion (55.55%). The mean daily intake of all pesticide residues from the intake of all vegetables as a percentage of ADI for mixtures was 121.05% of the ADI for mixtures.

The pattern of exposure for the ethnic population as a percentage of ADI was 37.29% for organophosphorus pesticides, 6.51% for carbamates/other pesticides and 13.82% for all pesticide residues (Table 8-11). The percentage ADI for all pesticides in excess of 10% of ADI value were observed for Aubergines (15.24%) and Cucumbers (15.95%) and in excess of 5% of the ADI value for Cabbage (9.5%), Cauliflower (7.02%) and Onion (6.57%). The percentage ADI of organophosphorus pesticides were in excess of 10% of the ADI value for Aubergines (10.39%), Cucumbers (14.98%) and Marrow (18.67%) and in excess of 5% of the ADI value for Cabbage (8.39%), Cauliflower (9.4%), Green leafy vegetables (7.98%) and Onion (8.1%). The percentage ADI of carbamates and other pesticides was in excess of 5% of ADI for carbamates and other pesticides for Aubergines (5.53%) and Marrow (6.18%). The daily intake of all pesticide residues as a percentage of ADI for mixtures from all vegetables for the ethnic population was 136.74% of the ADI for mixtures value. The percentage ADI for mixtures exceeded the ADI values for Aubergines (152.43%) and Cucumbers (159.5%) and exceeded 50% of the ADI for mixtures for Cabbage (95%), Cauliflower (65.83%) and Onion (65.65%).

Among the farming population the daily intake of pesticides as a percentage of the ADI value for organophosphorus pesticides was 44.56%, for carbamates and other pesticides was 7.77% and from all pesticide residues was 16.51% (Table 8-12). The percentage ADI of all pesticides for Aubergines (18.81%), Cabbage (20.0%), Cauliflower (20.44%) and Cucumbers (15.4%) were in excess of 10% of the ADI value and for Onion (6.23%) were in excess of 5% of the ADI value. Intakes, in excess of 10% of the ADI value, of organophosphorus pesticides occurred from the consumption of Aubergines (12.81%), Cabbage (17.67%), Cauliflower (27.38%), Cucumbers (14.47%), Green leafy vegetables (27.31%) and Marrow (33.07%). Intakes of Carbamates and other pesticides were in excess of 10% of the ADI value for Marrow (10.94%) and in excess of 5% of the ADI value for Aubergines (6.82%). The dietary pesticide exposure in the farming population exceeded the ADI for mixtures for Aubergines (188.07%), Cabbage (200.0%), Cauliflower (191.67%) and Cucumbers (154.0%) and exceeded 50% of the ADI for mixtures for Onion (62.28%). The daily intake of all pesticide residues as a percentage of ADI for mixtures was over one and a half times the ADI value (163.32%).

8.2.1 Dietary intake of individual pesticide residues and acceptable daily intakes

The pesticide residues identified in the different locally grown vegetables are shown in Table 6-21. For those pesticide residues which were identified in excess of 0.40 mg/kg in any vegetable commodity, the estimated dietary intakes were calculated in Appendix 24. The estimated dietary intakes of pesticide residues per unit body weight (EDI_{bw}) through the consumption of different vegetables were calculated using the EDI values from Appendix 24 and are shown in Appendix 26 for the ethnic and the farming populations. Demephion, Acephate, Formothion, Dimethoate, Methidathion, Phenthoate, Pirimiphos methyl, Profenofos, Heptenophos and Phosphamidon were the organophosphorus pesticides identified in excess of 0.40 mg/kg. Among the carbamates and other pesticides used in excess of 0.4 mg/kg were Triadimefon, Butocarboxim, Captan, Pyridate, Desmethryn, Triamiphos, Aminocarb, Isoprocarb, Ethidimuron, Bromacil, Chlorfenson, Tolyfluanid, Bendiocarb and Fenobucarb.

Among the organophosphorus pesticides the highest intake of Demephion and Acephate was through the consumption of Aubergines for both the total ethnic and the farming populations. The intakes of Triadimefon was higher from Aubergines and Marrow, the intake of Formothion was higher from Cabbage and Tomatoes and the intake of Dimethoate was higher from Cabbage for both the ethnic and the farming populations. Higher concentrations of Methidathion were obtained from the consumption of Marrow by the study population and Phenthoate and Pirimiphos-methyl were obtained more by the farming population from the consumption of Green leafy vegetables. The intake of Profenofos was higher in the study population from the consumption of Onion and the intake of Heptenophos and Phosphamidon was higher from the consumption of Tomatoes.

The intakes of Triadimefon and Butocarboxim were higher from the consumption of Marrow and Aubergines among the study population for the carbamate and other pesticides. Carbaryl intake was the highest from the consumption of Aubergines among the ethnic population and from the consumption of Cauliflower among the farming population. Captan was obtained in greater amounts from the consumption of Cucumber by the ethnic population and from the consumption of Green leafy vegetables by the farming population. Higher amounts of Pyridate were obtained from the consumption of Marrow by the study population. The intakes of Triamiphos and Aminocarb were higher among the study population from the consumption of Marrow. Chlorfenson were obtained in greater amounts from the consumption of Tomatoes by the study population and Fenobucarb was obtained from the consumption of Onion. The

Table 8-8: Acceptable Daily Intake (ADI) values for organophosphorus, carbamates and other pesticides and all pesticides and for mixtures of pesticides in different vegetable commodities.

Vegetables	All pesticides[3] ADI_{median} mg/kg bw	All pesticides[4] ADI_{mean} mg/kg bw	OP[1] ADI_{median} mg/kg bw	Carb/Othrs[2] ADI_{median} mg/kg bw	Mixtures[5] ADI_{median} mg/kg bw
Aubergines	100×10^{-4}	151×10^{-4}	100×10^{-4}	200×10^{-4}	10×10^{-4}
Cabbage	100×10^{-4}	116×10^{-4}	100×10^{-4}	-	10×10^{-4}
Capsicum	300×10^{-4}	300×10^{-4}	-	300×10^{-4}	30×10^{-4}
Carrots	100×10^{-4}	100×10^{-4}	100×10^{-4}	-	10×10^{-4}
Cauliflower	75×10^{-4}	89×10^{-4}	28×10^{-4}	150×10^{-4}	8×10^{-4}
Chillies	190×10^{-4}	404×10^{-4}	43×10^{-4}	650×10^{-4}	19×10^{-4}
Cucumbers	50×10^{-4}	276×10^{-4}	30×10^{-4}	650×10^{-4}	5×10^{-4}
Green leafy vegs	300×10^{-4}	323×10^{-4}	30×10^{-4}	400×10^{-4}	30×10^{-4}
Marrow	500×10^{-4}	130×10^{-4}	50×10^{-4}	170×10^{-4}	50×10^{-4}
Onion	100×10^{-4}	294×10^{-4}	65×10^{-4}	300×10^{-4}	10×10^{-4}
Potatoes	NA	NA	NA	NA	
Tomatoes	250×10^{-4}	219×10^{-4}	250×10^{-4}	650×10^{-4}	25×10^{-4}
Means	188×10^{-4}	218×10^{-4}	72×10^{-4}	386×10^{-4}	19×10^{-4}

1 *Median value of organophosphorus pesticide residues*

2 *Median value of carbamates and other pesticide residues*

3 *Median value of all pesticide residues*

4 *Mean values of all pesticide residues (organophosphorus, carbamates and other pesticides)*

5 *ADI values for mixtures of pesticides, Mixtures ADI = ADI_{median} for all pesticide residues x 10^{-1}.*

Table 8-9: Estimated daily intake of pesticide residues per unit body weight (EDI_{bw}) and the acceptable daily intake (ADI) of pesticide residues in the locally grown vegetables as a percentage of ADI for the ethnic male population.

Vegetables	All pesticides		OP pesticides		Carbamates/Others		Mixture
	EDI_{bw}[1] (males) mg/kg bw	Percentage ADI %	EDI_{bw}[3] (males)	Percentage[2] ADI %	EDI_{bw}[4] (males)	Percentage[2] ADI %	Percentage[5] ADI %
Aubergines	19.19×10^{-4}	19.19	13.07×10^{-4}	13.07	13.98×10^{-4}	6.96	191.86
Cabbage	11.40×10^{-4}	11.40	10.07×10^{-4}	10.07	3.80×10^{-4}		114.00
Capsicum	2.82×10^{-4}	0.94			1.73×10^{-4}	0.58	9.39
Carrots	4.60×10^{-4}	4.60	1.53×10^{-4}	1.53	3.07×10^{-4}		46.00
Cauliflower	5.93×10^{-4}	7.91	2.97×10^{-4}	10.60	4.45×10^{-4}	0.30	74.17
Chillies	3.79×10^{-4}	2.00	1.93×10^{-4}	4.48	2.84×10^{-4}	0.44	19.97
Cucumbers	10.45×10^{-4}	20.90	5.89×10^{-4}	19.63	8.04×10^{-4}	1.24	209.00
Green leafy vegs	2.59×10^{-4}	0.86	3.05×10^{-4}	10.15	1.93×10^{-4}	0.48	8.63
Marrow	13.72×10^{-4}	2.74	12.33×10^{-4}	24.67	13.88×10^{-4}	8.16	27.44
Onion	8.08×10^{-4}	8.08	6.48×10^{-4}	9.97	6.48×10^{-4}	2.16	80.80
Potatoes	10.11×10^{-4}		4.98×10^{-4}		15.08×10^{-4}		
Tomatoes	7.20×10^{-4}	2.88	5.63×10^{-4}	2.25	6.39×10^{-4}	0.98	28.87
Mean	30.65×10^{-4}	16.30	31.67×10^{-4}	43.99	29.62×10^{-4}	7.67	161.32

1 *EDI_{bw} values obtained from Table 8-1*

2 *ADI values obtained from Table 8-8, ADI% = (EDI_{bw}/ADI)100*

3 *EDI_{bw} values obtained from Table 8-2*

4 *EDI_{bw} values obtained from Table 8-3*

5 *Mixture percentage, ADI% = (EDI_{bw} for all pesticides/ADI for mixtures)100*

Table 8-10: Estimated daily intake of pesticide residues per unit body weight (EDI_{bw}) and the acceptable daily intake (ADI) of pesticide residues in the locally grown vegetables as a percentage of ADI for the ethnic female population.

Vegetables	All pesticides		OP pesticides		Carbamates/Others		Mixture
	EDI_{bw}[1] (females) mg/kg bw	Percentage[2] ADI %	EDI_{bw}[3] (females) mg/kg bw	Percentage[2] ADI %	EDI_{bw}[4] (females) mg/kg bw	Percentage[2] ADI %	Percentage[5] ADI %
Aubergines	12.66×10^{-4}	12.66	8.63×10^{-4}	8.63	9.19×10^{-4}	4.59	126.64
Cabbage	8.20×10^{-4}	8.20	7.24×10^{-4}	7.24	2.73×10^{-4}		82.00
Capsicum	1.84×10^{-4}	0.61			1.13×10^{-4}	0.38	6.14
Carrots	3.80×10^{-4}	3.80	1.27×10^{-4}	1.27	2.53×10^{-4}		38.00
Cauliflower	4.80×10^{-4}	6.40	2.40×10^{-4}	8.57	3.60×10^{-4}	0.24	60.00
Chillies	2.42×10^{-4}	1.27	1.23×10^{-4}	2.85	1.81×10^{-4}	0.28	12.71
Cucumbers	6.88×10^{-4}	13.75	3.88×10^{-4}	12.92	5.29×10^{-4}	0.81	137.50
Green leafy vegs	1.79×10^{-4}	0.60	2.10×10^{-4}	7.01	1.33×10^{-4}	0.33	5.96
Marrow	8.23×10^{-4}	1.65	7.40×10^{-4}	14.80	8.33×10^{-4}	4.90	16.47
Onion	5.56×10^{-4}	5.56	4.46×10^{-4}	6.85	4.46×10^{-4}	1.49	55.55
Potatoes	8.77×10^{-4}		4.32×10^{-4}		13.08×10^{-4}		
Tomatoes	5.21×10^{-4}	2.08	4.07×10^{-4}	1.63	4.62×10^{-4}	0.71	20.84
Mean	23.00×10^{-4}	12.23	23.78×10^{-4}	33.03	22.23×10^{-4}	5.76	121.05

1 *EDI_{bw} values obtained from Table 8-1*

2 *ADI values obtained from Table 8-8, ADI%=(EDI_{bw}/ADI)100*

3 *EDI_{bw} values obtained from Table 8-2*

4 *EDI_{bw} values obtained from Table 8-3*

5 *Mixture percentage, ADI%=(EDI_{bw} for all pesticides/ADI for mixtures)100*

Table 8-11: Estimated daily intake of pesticide residues per unit body weight (EDI_{bw}) and the acceptable daily intake (ADI) of pesticide residues in the locally grown vegetables as a percentage of ADI for the ethnic population.

Vegetables	All pesticides		OP pesticides		Carbamates/Others		Mixture
	EDI_{bw}[1] (ethnic) mg/kg bw	Percentage[2] ADI %	EDI_{bw}[3] (ethnic) mg/kg bw	Percentage[2] ADI %	EDI_{bw}[4] (ethnic) mg/kg bw	Percentage[2] ADI %	Percentage[5] ADI %
Aubergines	15.24×10^{-4}	15.24	10.39×10^{-4}	10.39	11.06×10^{-4}	5.53	152.43
Cabbage	9.50×10^{-4}	9.50	8.39×10^{-4}	8.39	3.17×10^{-4}		95.00
Capsicum	2.17×10^{-4}	0.72			1.33×10^{-4}	0.44	7.22
Carrots	4.10×10^{-4}	4.10	1.37×10^{-4}	1.37	2.73×10^{-4}		41.00
Cauliflower	5.27×10^{-4}	7.02	2.63×10^{-4}	9.40	3.95×10^{-4}	0.26	65.83
Chillies	2.76×10^{-4}	1.45	1.40×10^{-4}	3.26	2.07×10^{-4}	0.32	14.53
Cucumbers	7.97×10^{-4}	15.95	4.50×10^{-4}	14.98	6.14×10^{-4}	0.94	159.50
Green leafy vegs	2.04×10^{-4}	0.68	2.39×10^{-4}	7.98	1.51×10^{-4}	0.38	6.78
Marrow	10.38×10^{-4}	2.08	9.33×10^{-4}	18.67	10.50×10^{-4}	6.18	20.77
Onion	6.57×10^{-4}	6.57	5.27×10^{-4}	8.10	5.27×10^{-4}	1.76	65.65
Potatoes	9.27×10^{-4}		4.57×10^{-4}		13.83×10^{-4}		
Tomatoes	5.99×10^{-4}	2.39	4.68×10^{-4}	1.87	5.31×10^{-4}	0.82	23.94
Mean	25.98×10^{-4}	13.82	26.85×10^{-4}	37.29	25.12×10^{-4}	6.51	136.74

1 *EDI_{bw} values obtained from Table 8-4*

2 *ADI values obtained from Table 8-8, ADI%=(EDI_{bw}/ADI)100*

3 *EDI_{bw} values obtained from Table 8-5*

4 *EDI_{bw} values obtained from Table 8-6*

5 *Mixture percentage, ADI%=(EDI_{bw} for all pesticides/ADI for mixtures)100*

Table 8-12: Estimated daily intake of pesticide residues per unit body weight (EDI_{bw}) and the acceptable daily intake (ADI) of pesticide residues in the locally grown vegetables as a percentage of ADI for the farming population.

Vegetables	All pesticides		OP pesticides		Carbamates/Others		Mixtures
	EDI_{bw}[1] (farming) mg/kg bw	Percentage[2] ADI %	EDI_{bw}[3] (farming) mg/kg bw	Percentage[2] ADI %	EDI_{bw}[4] (farming) mg/kg bw	Percentage[2] ADI %	Percentage[5] ADI %
Aubergines	18.81×10^{-4}	18.81	12.81×10^{-4}	12.81	13.64×10^{-4}	6.82	188.07
Cabbage	20.00×10^{-4}	20.00	17.67×10^{-4}	17.67	6.67×10^{-4}		200.00
Capsicum	1.08×10^{-4}	0.36			0.67×10^{-4}	0.22	3.61
Carrots	3.90×10^{-4}	3.90	1.30×10^{-4}	1.30	2.60×10^{-4}		39.00
Cauliflower	15.33×10^{-4}	20.44	7.67×10^{-4}	27.38	11.50×10^{-4}	0.77	191.67
Chillies	6.55×10^{-4}	3.45	3.33×10^{-4}	7.73	4.91×10^{-4}	0.76	34.50
Cucumbers	7.70×10^{-4}	15.40	4.34×10^{-4}	14.47	5.93×10^{-4}	0.91	154.00
Green leafy vegs	6.97×10^{-4}	2.32	8.19×10^{-4}	27.31	5.18×10^{-4}	1.29	23.23
Marrow	18.39×10^{-4}	3.68	16.53×10^{-4}	33.07	18.60×10^{-4}	10.94	36.79
Onion	6.23×10^{-4}	6.23	5.00×10^{-4}	7.68	5.00×10^{-4}	1.67	62.28
Potatoes	5.70×10^{-4}		2.81×10^{-4}		8.50×10^{-4}		
Tomatoes	6.87×10^{-4}	2.75	5.37×10^{-4}	2.15	6.10×10^{-4}	0.94	27.49
Mean	31.03×10^{-4}	16.51	32.08×10^{-4}	44.56	29.98×10^{-4}	7.77	163.32

1 *EDI_{bw} values obtained from Table 8-4*

2 *ADI values obtained from Table 8-8, ADI%=(EDI_{bw}/ADI)100*

3 *EDI_{bw} values obtained from Table 8-5*

4 *EDI_{bw} values obtained from Table 8-6*

5 *Mixture percentage, ADI%=(EDI_{bw} for all pesticides/ADI for mixtures)100*

percentage ADI for Phosphamidon in Tomatoes exceeded the ADI value for the ethnic population (117.0%) and for the farming population (134.4%). Among the farming population the percentage ADI exceeded 20% of the ADI value for Methidathion in Marrow, Carbaryl in Onion and Phenthoate in Green leafy vegetables.

8.2.2 Summary and discussion of dietary intake of pesticide residues as a percentage of ADI

The dietary intakes of pesticide residues as a percentage of the ADI value for the different vegetable commodities for the ethnic males, females and the total ethnic and the farming populations are shown in Table 8-13 for organophosphorus pesticides, Table 8-14 for carbamate and other pesticides and Table 8-15 for all pesticides. The mean dietary intake of organophosphorus pesticides as a percentage of ADI were 43.99% for the ethnic males, 33.03% for the ethnic females, 27.29% for the ethnic population and 44.56% for the farming population (Table 8-13). The dietary intakes of organophosphorus pesticides exceeded 5% of ADI from the consumption of Aubergines, Cabbage, Cauliflower, Cucumbers, Green leafy vegetables, Marrow and Onion for the ethnic males, females and total ethnic population. Among the farming population the dietary intake of organophosphorus pesticides exceeded 30% of the ADI value through the consumption of Aubergines, Cabbage, Cauliflower, Cucumbers, Green leafy vegetables and Marrow. The dietary intakes for carbamates and other pesticides were lower compared to the intakes of the organophosphorus pesticides and were 7.67% for the males, 5.76% for the females, 6.51% for the ethnic population and 7.77% for the farming population (Table 8-14). The dietary intakes of carbamate and other pesticides exceeded 5% of ADI value from the consumption of only Aubergines and Marrow for the total ethnic population and also for the farming population. The dietary intakes of all pesticides as a percentage of ADI for the ethnic males, females and the total ethnic population were 16.30%, 12.23% and 13.82% respectively. The corresponding intake among the farming population was 16.51%. The contributors to the total dietary intakes of all pesticide residues exceeding 5% of the ADI value were Aubergines, Cabbage, Cauliflower, Cucumbers and Onion for the ethnic and the farming populations.

The ADI for mixtures was estimated, from the ADI values for individual pesticide residue, to account for exposures to more than one pesticide at one time either through the consumption of any one vegetable commodity or through a number of these commodities. The dietary intakes of pesticide residues as a percentage of ADI for mixtures have been estimated for the ethnic males, females and the total ethnic population and the farming population in Table 8-16. The mean daily dietary intakes of all pesticide residues from all the vegetables exceeded the ADI for mixtures for the ethnic males (161.32%), ethnic females (121.05%), total ethnic population (136.74%) and for the farming population

Table 8-13: Dietary intake of organophosphorus pesticide residues, as a percentage of ADI for the different locally grown vegetable commodities, among the ethnic males, females, the total ethnic population and the farming population

Vegetables	Males	Females	Total	Farming
	Percentage ADI %	Percentage ADI %	Percentage ADI %	Percentage ADI %
Aubergines	13.07	8.63	10.39	12.81
Cabbage	10.07	7.24	8.39	17.67
Capsicum				
Carrots	1.53	1.27	1.37	1.30
Cauliflower	10.60	8.57	9.40	27.38
Chillies	4.48	2.85	3.26	7.73
Cucumbers	19.63	12.92	14.98	14.47
Green leafy vegs	10.15	7.01	7.98	27.31
Marrow	24.67	14.80	18.67	33.07
Onion	9.97	6.85	8.10	7.68
Potatoes				
Tomatoes	2.25	1.63	1.87	2.15
Means	43.99	33.03	37.29	44.56

(163.32%). For the individual vegetable commodities, the percentage ADI for mixtures exceeded the ADI for mixtures for Aubergines and Cucumbers and were higher for Cabbage, Cauliflower and Onion compared to the other commodities consumed by the total ethnic population and exceeded 50% of the ADI for mixtures for each of these commodities. Among the farming population the percentage ADI for mixtures exceeded the ADI for mixtures for Aubergines, Cabbage, Cauliflower and Cucumbers and exceeded 50% of the ADI for mixtures for Onion.

Table 8-14: Dietary intake of carbamate and other pesticides residues, as a percentage of ADI for the different locally grown vegetable commodities, among the ethnic males, females, the total ethnic population and the farming population

Vegetables	Males Percentage ADI %	Females Percentage ADI %	Total Percentage ADI %	Farming Percentage ADI %
Aubergines	6.96	4.59	5.53	6.82
Cabbage				
Capsicum	0.58	0.38	0.44	0.22
Carrots				
Cauliflower	0.30	0.24	0.26	0.77
Chillies	0.44	0.28	0.32	0.76
Cucumbers	1.24	0.81	0.94	0.91
Green leafy vegs	0.48	0.33	0.38	1.29
Marrow	8.16	4.90	6.18	10.94
Onion	2.16	1.49	1.76	1.67
Potatoes				
Tomatoes	0.98	0.71	0.82	0.94
Means	7.67	5.76	6.51	7.77

The ADI has been defined as the daily dose of pesticide which when taken during an entire lifetime, appears to be without appreciable risk of adverse health effects on the basis of all the facts known at the time (Guidelines for dietary intake of pesticide residues, 1989). The inter-individual and ethnic differences have been considered in estimating the ADI by the JMPR, however, exposures to mixtures of pesticides either through a single vegetable commodity or through multiple commodities have not been considered in the implementation of ADI (Environmental Health Criteria 104, 1990). The ADI for mixtures have been calculated in this study through the extrapolation of the results of animal experiments for the purpose of identifying a reference value for estimating the level of dietary exposure to mixtures of pesticides as observed in some of the vegetable commodities in this study. Leoni *et al,* (1989) have suggested that the EDI_{bw} could be better expressed as a percentage of ADI in the assessment of exposure to dietary intake of pesticide residues. This method has been used in this study to determine the level of exposure to dietary intakes of organophosphorus, carbamate and others and all pesticide residues in the ethnic and the farming populations for both the ADI for a single pesticide, and for the first time, ADI for mixtures.

Previous studies assessing the level of dietary exposure to pesticides from organophosphorus and carbamate pesticides have been relatively few compared to those studies which have assessed the intake of organochlorinated pesticides. Estimates of dietary intakes of organochlorines from different categories of food have been reported including the intakes from vegetables (Kuhnlein *et al,* 1995; Nakagawa *et al,* 1995; Singh and Chawla, 1988). The daily dietary intakes of organophosphorus, carbamate and pyrethroid pesticides residues through all foods in an Italian diet have been reported to be 19.83×10^{-4} mg/kg body weight (Dolara *et al,* 1993), which when compared with the ADI levels estimated in this study was 9.9% of the ADI value calculated for those pesticide residues which have been identified in this study. However, Gartell *et al,* (1986), Gunderson (1988) and Corvi and Vogel (1993) have reported that the average daily intake of pesticide residues from all foods were below the ADI levels for the general populations in the United States and Switzerland. The data gathered through the routine monitoring of all foods in the United States of America also showed that in 1989 the intakes of pesticide residues were well below the ADI standards and the EPA set standards (Pesticide residue monitoring program 1984, 1990). Between 1986 and 1988, through a routine monitoring programme, 16 commodities of vegetables were analysed in Toronto, Ontario. Among these commodities, Celery, Lettuce and Tomatoes were identified with higher pesticide residues and 0.7% of these samples were found to have exceeded the MRL values and at the current levels of dietary intakes of these commodities would exceed the ADI standards (Frank *et al,* 1990). Kannan *et al,* (1997) have reported that in the developing countries in Asia the concentrations of organochlorinated pesticides have been five to hundred times more than the corresponding levels in the developed countries. The contamination of agricultural produce at such levels was reported to have exceeded the dietary intakes of these residues by twice the percentage ADI for organochlorines (Singh and Chawla, 1988). However, these levels have been falling in the past two decades more rapidly in the developed countries but gradually in the developing countries.

Table 8-15: Dietary intake of all pesticide residues, as a percentage of ADI for the different locally grown vegetable commodities, among the ethnic males, females, the total ethnic population and the farming population

Vegetables	Males Percentage ADI %	Females Percentage ADI %	Total Percentage ADI %	Farming Percentage ADI %
Aubergines	19.19	12.66	15.24	18.81
Cabbage	11.40	8.20	9.50	20.00
Capsicum	0.94	0.61	0.72	0.36
Carrots	4.60	3.80	4.10	3.90
Cauliflower	7.91	6.40	7.02	20.44
Chillies	2.00	1.27	1.45	3.45
Cucumbers	20.90	13.75	15.95	15.40
Green leafy vegs	0.86	0.60	0.68	2.32
Marrow	2.74	1.65	2.08	3.68
Onion	8.08	5.56	6.57	6.23
Potatoes				
Tomatoes	2.88	2.08	2.39	2.75
Means	16.30	12.23	13.82	16.51

The levels of all pesticide residues in the agricultural produce have been falling in the developed countries because of effective governmental control on the use of pesticides and good agricultural practice. In Finland the intakes of pesticides (EDI) from domestic vegetables during the period 1977 to 1993 had decreased from 16.9x10^{-3} mg to 3.7x10^{-3} mg (Penttila and Siivinen, 1996). The dietary intakes of organophosphorus and carbamate pesticides, on the other hand, had been consistently constant in the past few years in Japan and were reported at 2.2% of the ADI (Nakagawa *et al,* 1995). In the developed countries, the regular monitoring of food and the implementation of the Codex Alimentarius Commission recommendations alleviates the food safety concerns of the public. However, in the developing countries, where there is no regular monitoring and no implementation of Codex Alimentarius Commission guidelines, the extent of risk to human health has not been evaluated.

Table 8-16: Dietary intake of all pesticide residues, as a percentage of ADI for mixtures for the different locally grown vegetable commodities, among the ethnic males, females, the total ethnic population and the farming population

Vegetables	Males Percentage ADI %	Females Percentage ADI %	Total Percentage ADI %	Farming Percentage ADI %
Aubergines	191.86	126.64	152.43	188.07
Cabbage	114.00	82.00	95.00	200.00
Capsicum	9.39	6.14	7.22	3.61
Carrots	46.00	38.00	41.00	39.00
Cauliflower	74.17	60.00	65.83	191.67
Chillies	19.97	12.71	14.53	34.50
Cucumbers	209.00	137.50	159.50	154.00
Green leafy vegs	8.63	5.96	6.78	23.23
Marrow	27.44	16.47	20.77	36.79
Onion	80.80	55.55	65.65	62.28
Potatoes				
Tomatoes	28.82	20.84	23.95	27.49
Means	161.32	121.05	136.74	163.32

The daily dietary intakes of individual pesticide residues calculated in this study exceeded the ADI values for Phosphamidon in Tomatoes for the ethnic and the farming populations. The intakes of Methidathion in Marrow, Carbaryl in Cauliflower and Phenthoate in Green leafy vegetables exceeded 20% of the ADI value for the farming population. The mean dietary intakes of all pesticide residues calculated as percentage ADI for mixture exceeded the ADI for mixture value for Aubergines and Cucumbers and were higher for Cabbage, Cauliflower and Onion for the ethnic population. For the farming population the percentage ADI for mixtures exceeded the ADI for mixture value for Aubergines, Cabbage, Cauliflower and Cucumbers and were higher for Onion. The dietary intake of organophosphorus pesticides for the ethnic and farming populations and the dietary intake of all pesticide residues for the ethnic and farming populations were higher than those of the investigated Italian and Japanese populations but lower than the organochlorine pesticide intakes reported for the Indian population (Dolara *et al,* 1993; Nakagawa *et al,* 1995; Singh and Chawla, 1988; Kannan *et al, 1997*). It is only through routine monitoring of the agricultural produce and assessment of the dietary habits of the population at a national level that food safety concerns of the population be reassured. The current agricultural policy of the developing governments is aimed for abundant produce with complete disregard to the quality of the produce in terms of pesticide residues. This focus has to change so that not only abundant food but safe food is made available to its population. Much remains to be done in the developing countries both by the researchers and by the governmental agencies. Information on the possible adverse health effects from dietary exposure to pesticides among the most susceptible segments of the population in the developing countries needs to be collected and associated with the dietary exposure to pesticides.

8.3 *Adverse health effects from chronic exposure to pesticides*

Chronic health effects observed in humans and thought to involve pesticides include carcinogenesis, neurotoxicity and reproductive and developmental effects (Hodgson and Levi 1996). Specific patterns similar to the morbidity pattern identified in this study (Chapter V) have been identified among sheep dip farmers and the Gulf War Veterans which have been linked with organophosphorus pesticides exposure (Sigmund, 1996). Farmworkers in the former Soviet Union, where pesticides had been used heavily, showed immune system abnormalities and increased rates of infection and chronic diseases compared to people living away from the areas of heavy pesticide use (Repetto, 1996). The huge rise in pesticide use since the second world war could be responsible for an untold number of illnesses with a common range of symptoms, such as skin rashes, breathing problems, cancer and birth defects (Howell, 1998). The Royal College of Physicians and the Royal College of Psychiatrists have described the symptoms experienced by sheep dip farmers as genuine symptoms from chronic exposure to organophosphates (Craig, 1998). Immune dysfunction and chronic fatigue have been identified among the Gulf War veterans from chronic exposure to organophosphates (Zhang *et al*, 1999).

Male reproductive health has also been observed to have deteriorated in many countries from increased exposure to pesticides during the last few years with declining sperm counts and semen quality having been reported in Belgium, Denmark, France and Great Britain (Toppari *et al*, 1996). An increase in the incidence of cryptorchidism and hypospadias has been observed in recent years (Toppari *et al*, 1996). A doubling of cryptorchidism which had occurred in the United Kingdom between 1970 and 1987 and other male reproductive disorders have been linked with *in utero* exposure to oestrogenic pesticides (Chilvers e*t al*, 1984; Jackson *et al*, 1986). Exposure to oestrogenic pesticides during prenatal development have been linked to the development of male and female reproductive disorders in humans (Colborn *et al*, 1993). Prenatal and perinatal exposure to xenobiotic pesticides probably have more influence on fertility than any other exposure throughout a lifetime (Colborn *et al*, 1993). Birth defect rates for circulatory, respiratory, urogenital and musculoskletal / integumental birth anomalies have significantly increased in children born to pesticide applicators in western Minnesota, United States (Garry *et al*, 1996). An increased risk of spina bifida was seen in offspring of women in agricultural occupations and also from paternal exposure to pesticides (Blatter and Roeleveld, 1996; Blatter *et al*, 1997). Increased risk was perceived for limb reduction defects in offspring born to agricultural parents in Norway (Kristensen *et al*, 1997).

Reproductive health effects in mice from exposure to six of the most commonly used organophosphorus pesticides in the UAE (Salute, Selecron, Actellic, Dursban, Hostathion and Nogos) have been described (Gomes *et al,* 1998b; Gomes *et al,* 1998c). Litter sizes, resorptions, foetal weights, maternal weight gain during pregnancy and congenital anomalies were adversely affected in mice from acute exposures to the organophosphorus pesticides on the critical days of implantation and differentiation stages of the embryogenesis period. Similar effects were observed from chronic exposure to same suite of organophosphorus pesticides. It can therefore be concluded that the type of adverse effects seen in wildlife and humans could also be induced by the commonly used organophosphorus pesticides as observed in experiments with laboratory mice. However, limited information is available on the adverse reproductive health effects from chronic and acute exposures to organophosphorus pesticides. Having assessed the level of exposure from the dietary intake of pesticide residues through the consumption of locally grown vegetables a literature review was conducted to assess the incidence of congenital malformations in the ethnic population in the UAE; the results of this literature review are described and discussed in the next section.

8.4 *Congenital malformations in the ethnic population*

Congenital malformations, which result from defective embryogenesis or deviation from normal development, have been researched and reported in the UAE for at least three subsets of the ethnic population (Al-Marzouqi, 1997; Al-Neaimi, 1994, Al-Jawadi *et al,* 1987). The pattern and frequency of congenital malformations have been observed to vary from one country to another depending on the geographical, ethnic, environmental and socio-economic characteristics of the studied population (Blatter *et al,* 1997). The UAE which was established in 1971 with the merging of seven Emirates, consisted of sparsely populated settlements, prior to the finding of oil. The settlements consisted of Bedouin and Coastal tribes who had arrived in the region more than a century earlier. The present ethnic population of the UAE is a mixture of different groups defined by tribal origins, tribal traditions and culture. Consanguineous marriages are favoured by the ethnic people for a variety of reasons. The current consanguineous marriage rates for the ethnic population have been reported to be 51% with 30% of the marriages being between first cousins (Abdulrazzaq *et al,* 1997, Fahmy *et al,* 1993). Other consanguinity rates which have been reported for different tribal groups but same ethnic origin were 54% (Al-Gazali *et al,* 1995) and 55% (Al-Marzouqi, 1997). The varying rates of consanguinity suggest different tribal preferences to this practice on the grounds of maintaining tribal wealth and traditions.

The incidence of congenital malformations in the ethnic populations within the first year of life has been reported to be 21.6/1000 births for the population visiting the Tawam hospital in Al-Ain (Topley and Dawodu, 1995). However, the incidence rates for congenital malformations in the first 48 hours of life were reported to be 10.5/1000 births (Al-Gazali *et al,* 1997) and for the first week of life 12.9/1000 births (Al-Jawadi *et al,* 1987) for the whole ethnic population of Al-Ain. However, Al-Marzouqi (1997) has reported congenital malformation incidence rates of 13.8/1000 births and 16.4/1000 birth for locals and non-locals residing in Abu Dhabi (Emirate of UAE) during the first two years of life. In all these studies, the study population was selected on time-after-birth basis and therefore, different congenital malformation rates have been identified. Secondly, the population reported in the Topley and Dawodu (1995) study is a sub-set of the total Al-Ain population and included the late onset malformations. The malformations identified in the first 48 hours of life are more likely to implicate genetic factors including chromosomal abnormalities (Al-Gazali *et al,* 1995). The other (musculoskeletal, gastrointestinal, cardiovascular, genital, urinary and central nervous system) malformations are more likely to manifest themselves during the first one to two years of life as they are not usually noticeable at birth (Al-Marzouqi, 1997, Topley and Dawodu, 1995).

The major congenital malformations identified during the first two years of life among the ethnic population and immigrant populations are shown in Table 8-17. Musculoskeletal and urinary systems congenital malformations were significantly higher in the ethnic population compared to the immigrant population. Conversely, the immigrant population demonstrated significantly higher rates for cardiovascular, central nervous systems and chromosomal malformations (Al-Marzouqi, 1997). However, Topley and Dawodu (1995) reported for the ethnic population visiting the Tawam hospital, incidence rates of 33.0/1000 births for genitourinary anomalies, 16.2/1000 births for cardiovascular system anomalies, 15.6/1000 births for musculoskeletal system anomalies, 14.4/1000 births for gastrointestinal anomalies, 11.4/1000 births for craniofacial anomalies, 4.2/1000 births for chromosomal anomalies and 3.6/1000 births for central nervous system anomalies. These incidence rates of congenital malformations were broadly similar to the ones reported by Al-Marzouqi, (1997) for the Abu Dhabi population, except for the genitourinary system defects which were almost three times higher.

Table 8-17 Congenital malformations by ethnicity per 1000 births

Malformations	Ethnic	Immigrant
Musculoskeletal system	22.3	14.0
Gastrointestinal system	15.7	15.1
Cardiovascular system	11.6	14.8
Chromosomal	9.9	12.2
Central nervous system	6.6	11.8
Urinary system	11.6	6.3
Genital	9.1	8.1
Mean	**12.4**	**11.8**

Source Al-Marzouqi, 1997 (Unpublished report)

It has been observed that the frequency of consanguineous marriages is higher (54%) among the ethnic population compared with the immigrant population for various reasons (Al-Gazali *et al*, 1995). However, consanguinity has been associated with the high rates of syndrome cases (88%) and to a lesser extent multiple malformations (55%) and single or isolated malformation (42%) as observed by Al-Gazali *et al*, (1995) among the ethnic population in Al-Ain. The malformations identified during the first two years of life in children born to consanguineous and non-consanguineous couples are shown in Table 8-18. The mean incidence of congenital malformations among the consanguineous couples was 12.3/1000 births and for non-consanguineous couples 11.4/1000 births. For the consanguineous couples, musculoskeletal system, urinary and genital system malformations were elevated compared to the non-consanguineous couples. Malformations of the gastrointestinal system, cardiovascular system, central nervous system and chromosomes were higher among the offspring of non-consanguineous couples (Al-Marzouqi, 1997).

Table 8-18: Congenital malformations by consanguinity per 1000 births

Malformations	Consanguineous.	Non-consanguineous
Musculoskeletal system	20.9	13.8
Gastrointestinal system	13.7	16.3
Cardiovascular system	11.8	15.1
Chromosomal	6.5	14.6
Central nervous system	7.8	11.7
Urinary system	9.2	7.1
Genital	9.8	7.5
Mean	**12.3**	**11.4**

Source Al-Marzouqi, 1997 (Unpublished report)

Table 8-19 Congenital malformations by sex per 1000 births

Malformations	Females	Males
Musculoskeletal system	21.6	13.1
Gastrointestinal system	16.2	14.4
Cardiovascular system	13.8	14.0
Chromosomal	15.6	8.6
Central nervous system	12.0	9.0
Urinary system	4.2	10.4
Genital	3.0	12.2
Mean	**12.3**	**11.7**

Source Al-Marzouqi, 1997 (Unpublished report)

The distribution of congenital malformations by sex in the offspring of all marriages are shown in Table 8-19. The incidence of congenital malformations in the females (12.3/1000 births) was slightly higher than the incidence of congenital malformations in the males (11.7/1000 births). Females had higher incidence of malformations of the musculoskeletal system, chromosomal and central nervous system compared to the males, while males showed higher incidences of urinary system and genital malformations.

The different types of anomalies identified in the ethnic population by Topley and Dawodu (1995) for each of the biological systems are shown in Table 8-20. The highest incidences of congenital malformation were seen for genitourinary system (33/1000 births), followed by cardiovascular system (16.2/1000 births), musculoskeletal system (15.6/1000 births) and gastrointestinal system (14.4/1000 births). For the genitourinary system, hydrocoele and inguinal hernia were seen in greater numbers, however, hypospadias and cryptorchidism were also observed but in fewer numbers. For the cardiovascular system, atrial and ventricular septal defects were common; for the musculoskeletal system, hip dislocation was common and for the gastrointestinal system, umbilical hernia was common among the offspring born to the ethnic parents in Al-Ain. Genetic factors have been implicated in 67% of the cases, of which 41% were caused by single gene comprising 81% through autosomal recessive gene and 15% through autosomal dominant gene and the rest unknown. Chromosomal abnormalities have been implicated in 24% of the cases (Al-Gazali *et al,* 1995). Consanguinity has been suggested as a causal factor for most types of abnormalities, especially the genetically linked birth defects (Al-Gazali *et al,* 1995). However, other factors such as environmental and dietary exposures to contaminants, i.e. pesticides, during pregnancy need to be explored as pesticide exposures have been linked to a wide variety of congenital malformations (see Section 8.3).

Table 8-20: Anomalies by biological system among the ethnic population visiting the Tawam hospital

System	Anomaly	Anomaly[1] Incidence /1000 births	System[2] Incidence /1000 births
Central nervous system	Anencephaly	0.6	3.6
	Hydrocephaly	1.2	
	Encephalocoele	1.2	
	Hydranencephaly	0.6	
Gastrointestinal system	Umbilical hernia	10.8	14.4
	Anal fistula	1.2	
	Others	2.4	
Genitourinary system	Hydrocoele	12.0	33.0
	Hypospadias	5.4	
	Cryptorchidism	3.6	
	Inguinal hernia	8.4	
	Others	3.6	
Cardiovascular system	Atrial septal defect	4.2	16.2
	Ventricular septal defect	3.6	
	Others	8.4	
Chromosomal	Abnormalities	4.2	4.2
Musculoskeletal system	Hip dislocation	9.6	15.6
	Others	6.0	
Craniofacial	Cleft lip or palate	2.4	11.4
	Choanal atresia	2.4	
	Cranisynostosis	1.8	
	Others	4.8	
Skin	Pigmented naevi	1.8	7.8
	Vascular naevi	2.4	
	Others	3.6	
Miscellaneous	Metabolic disorders	0.6	4.2
	Down's syndrome	1.2	
	Turner's syndrome	0.6	
	Larsen's syndrome	0.6	
	Others	1.2	

Source Topley and Dawodu (1995)

1 *Incidence for individual anomaly*

2 *Total incidence for the system or organs*

8.4.1 Summary and discussion of congenital malformation in the ethnic population

The incidence of congenital malformations among the ethnic population in Al-Ain ranged from 21.6/1000 births to 10.5/1000 births; these rates were slightly higher compared to comparable rates from other countries (Al-Gazali *et al,* 1995; Stevenson *et al,* 1966; International Clearinghouse of birth defects monitoring system report, 1991). Congenital malformations seen in the ethnic population visiting the Tawam hospital in Al-Ain have been reviewed for the different biological systems affected and the most common anomalies seen in this population were hydrocoele, inguinal hernia, hypospadias, cryptorchidism, umbilical hernia, atrial septal defect, ventricular septal defect and hip dislocation (Topley and Dawodu, 1995). Consanguinity has been implicated as one of the major causes of congenital malformations among the ethnic population. However, the rates of consanguineous marriages among ethnic and immigrant populations were not vastly different with 57% for the ethnic population and 51% for the immigrant population of Arabian origin (Al-Gazali *et al,* 1995). The differences between the ethnic and immigrant populations in the pattern of congenital malformations as reported by Al-Marzouqi (1997) showed higher rates for cardiovascular, chromosomal and central nervous systems in the immigrant population compared to higher rates for musculoskeletal and genitourinary systems in the ethnic population.

The laboratory controlled exposures in mice to organophosphorus pesticides showed a causal relationship with the pesticide exposure during pregnancy (Gomes *et al,* 1998b; Gomes *et al,* 1998c). The similarities in birth defects seen in both mice, which have been exposed to pesticides, and humans in whom the exposure to pesticides has not been defined, included anencephaly, cleft palate, inguinal hernia, atrial and ventricular septal defects. However, increased feminization or masculinization was seen in some specific exposures with individual pesticides. If consanguinity is one of the major predictors of certain specific congenital malformations in the human ethnic population, then there is a possibility that chronic exposures to pesticides prior to pregnancy and both chronic and acute exposures during pregnancy could be significant confounders in the high incidence rates for certain defects such as hypospadias, cryptorchidism, inguinal hernia, anencephaly, encephalocoele, cleft palate, atrial septal defects and ventral septal defects. However, further studies are needed to assess the dietary and other exposures to pesticides and to associate them with pregnancy outcome in human populations. Birth defects, similar to the types mentioned above, have been reported among the Norwegian farmers (Kristensen *et al*, 1997).

Higher incidence of birth defects (30/1000 births) involving the circulatory, respiratory, urogenital, musculoskeletal and integumental system were observed in the offspring of pesticide applicators compared to the general population (26.9/1000 births) in Western Minnesota, a major agricultural region. The corresponding birth defects incidence rates for applicators (23.7/1000 births) and the general population (18.3/1000 births) observed in other non-agricultural regions in the United States (Garry *et al*, 1996) were lower. Elevated risk of musculoskeletal, limb abnormalities and orofacial clefts have been associated with maternal environmental exposures to pesticides, maternal residence in the vicinity of farms and paternal exposure to pesticides (Nurminen, 1995). Birth defects affecting the eye, ear, palate, teeth, heart, feet, nipples, genitalia and brain have been observed in the offspring of mothers exposed to Chlorpyrifos during pregnancy (Sherman, 1995; Sherman, 1996). Increased risk of spina bifida has been observed in infants born to women in agricultural occupations (Blatter and Roeleveld, 1996). Paternal exposure to pesticides have also been observed to increase the risk of spina bifida in the offspring (Blatter *et al*, 1997).

The pattern of congenital malformations by consanguinity were similar in the ethnic and immigrant populations in Al-Ain except for abnormalities in the musculoskeletal system, chromosomal and central nervous systems (Table 8-18). There may be common aetiological factors among these populations which are responsible for the similarities and for the differences in the reproductive outcomes. Environmental effects, including dietary exposure to contaminants such as pesticides are broadly similar in both populations for they live in similar environmental conditions and though they may have different dietary habits the food source is practically the same. It is therefore suggested that dietary and environmental exposure to pesticides of the ethnic and immigrant populations could produce similar reproductive outcomes. However, an interplay of consanguinity and environmental factors in the observed incidence of birth defects is not ruled out. Though all the available information on congenital malformations was reviewed, all the incidences have not been reported in the absence of a national birth defects register, therefore, the reviewed information is by no means complete. Moreover, information on the reproductive outcome among the farmworkers was not available because these workers do not have their families in the UAE.

8.5 *Maximum residue limit for the locally grown vegetable produce*

The Codex Committee on Pesticide Residues (CCPR) has defined the Maximum Residue Limit (MRL) as the maximum concentration of a pesticide residue, resulting from the use of a pesticide according to good agricultural practice, that is recognized by the Codex Alimentarius Commission to be legally permitted or accepted in or in a food or agricultural commodity (Codex Alimentarius Commission, 1989). The MRL values have been used mainly in the developed countries with minor modifications in the food monitoring programmes to assess the suitability of food for human consumption. The MRL has therefore, been used as a benchmark in quality control of both imported and local agricultural produce. In the developing countries regular monitoring of food has not been done, moreover the implementation of the Codex Alimentarius Commission has been neglected, because the governments in these countries are faced with major problems like food shortages, natural disasters and reduced agricultural production. From the data generated through the analyses of pesticide residues in the locally grown vegetables, analyses of dietary habits of the ethnic and immigrant farming populations and assessment of Estimated Daily Intake (EDI) of pesticide residues through diet, an effort has been made in this section to suggest MRL levels for the locally grown vegetables to make the produce safe for human consumption.

The development of dietary guidance values for pesticide exposure is based on the calculation of the total intake of pesticides from the complete diet. The process involves the identification of critical effects and pivotal studies which include the derivation of the no observed effect level (NOEL), the application of uncertainty factors and the partitioning of the overall tolerable intake among all possible dietary routes of exposure (Younnes and Sonich-Mullin, 1997). The aim of this procedure is to determine a level of intake (ADI) that is without adverse health effects in the human population. To make the guidance value applicable to the general population in terms of ethnicity, geographical location, age and dietary habits kinetic and dynamic variability must be considered and accounted for in the guidance value. This is usually achieved through the application of an arbitrary safety factor to provide an adequate margin of safety (Olivares and Uauy, 1996). A safety factor of 100 is commonly applied to animal data to derive the ADI for food for humans. This 100-fold factor is considered to represent the product of a 10-fold factor to allow for species differences between the test animals and humans and a 10-fold factor to allow for inter-individual differences (Renwick, 1995).

The desirable level of intake of pesticide residues would be no intake at all, which is unfeasible under the current agricultural practices, harvesting procedures and supply of vegetable commodities to the consumers. However, in the developed countries efforts have been made to reduce the residue levels in agricultural produce to as low as practically achievable. In the United States in 1994, less than 1% of the vegetable samples were identified with pesticide residues in excess of JMPR, MRL (Pesticide residue monitoring program 1994, 1996) and in Sweden only 2.1% of the samples were found to have exceeded the Swedish MRLs (Pesticide residues in food of plant origin 1994, 1996). Denmark and Germany have decided to reduce the use of pesticides in agriculture and introduce good agricultural measures to keep the pesticide residues as low as possible (Lund-Larsen, 1998; Weber, 1998).

In developing countries like the UAE, with no governmental control on the use of pesticides, no regular monitoring of agricultural produce and poor agricultural practices, the concentration of pesticide residues in the agricultural produce has been shown to be high (see Table 6-20). Eleven out of the thirteen commodities were identified to have residues in excess of the JMPR, MRL. The dietary intakes of vegetables among the ethnic and the farming populations as discussed in Chapter 7, has been less than that recommended by the Codex Alimentarius Commission (Codex Alimentarius, 1993). Because of the low dietary intakes of vegetables being low, the EDI_{bw} of pesticide residues did not exceed the ADI levels. However, the organophosphorus pesticides intakes from Aubergines, Cucumbers and Marrow exceeded 10% of the ADI value for the ethnic population. For the farming population the organophosphorus pesticides intakes exceeded 10% of the ADI level for Aubergines, Cabbage, Cauliflower, Cucumbers, Green leafy vegetables and Marrow. The intake of carbamates and other pesticides were below 10% of the ADI level for the ethnic and the farming populations. The intakes of all pesticide residues exceeded 10% of the ADI for Aubergines and Cucumbers for the ethnic population and Aubergines, Cabbage, Cauliflower and Cucumbers for the farming population.

The dietary intakes of pesticide residues as a percentage of ADI for mixtures exceeded the ADI for mixtures for Aubergines and Cucumbers for the ethnic population and for Aubergines, Cabbage, Cauliflower and Cucumbers for the farming population. The intakes of pesticide residues through the consumption of Cabbage, Cauliflower and Onion were in excess of 50% of the ADI for mixtures for the ethnic population and for Onion for the farming population. The two possible avenues of reducing the dietary exposure to pesticides would be to reduce the intake of vegetables and/or to reduce the concentration of pesticide residues in vegetables. Since the intakes of vegetables is below the Codex

Alimentarius Commission suggested levels, it would be advisable to reduce the concentration of pesticide residues in the vegetables.

The concentrations of pesticide residues in the locally grown agricultural produce need to be further reduced to safer levels as shown in the proposed MRL values (Table 8-21). The proposed reductions have been made on the basis of the JMPR MRL values for those pesticide residues identified in the locally grown vegetables. For those pesticides for which MRL values were not available, the published NOEL values from controlled laboratory experiments have been suggested after multiplying these values with the animal to human conversion factor. The following assumptions have been applied in suggesting the proposed pesticide residues in locally grown vegetables:

1) The types of organophosphorus, carbamates and other pesticides is restricted to those currently used in the UAE.
2) When more than one pesticide has been identified in a vegetable commodity, the median value for all the identified pesticides and for which the MRL value was available has been adopted.

Majority (52%, 93/177) of the vegetable samples had two or more pesticide residues and 47% (84/177) had just one pesticide residue. Therefore, on an average every sample of the vegetable which contained pesticide residues had approximately 1.7 (295/177) different types of pesticides in it. The subjects in the study population who consumed more than one vegetable commodity were exposed to multiple pesticides, even those who consumed only one commodity were also exposed to more than one pesticide. Multiple exposures to dietary intake of pesticides is, therefore, common. Therefore, maximum residue levels are proposed for mixtures of pesticides in Table 8-21. The proposed MRL values for mixtures have been fixed at half the MRLs for all pesticides because each sample of a commodity had about two (1.7 pesticides per sample) different pesticides.

Table 8-21: Existing and proposed pesticide residue concentrations of the organophosphorus, carbamates and other pesticides in the locally grown produce.

Vegetables	Existing pesticide residue levels[1]			Proposed pesticide residue levels[2]			
	OP mg/kg	Carb/Othrs mg/kg	All pesticides mg/kg	OP mg/kg	Carb/Othrs mg/kg	All pesticides mg/kg	Mixtures[3] mg/kg
Aubergines	0.62±0.07	0.66±0.09	0.91±0.12	0.50	0.50	0.50	0.25
Cabbage	0.53±0.18	0.20	0.60±0.20	0.20	0.10	0.20	0.10
Capsicum		0.40	0.65±0.30	0.50	0.50	0.50	0.25
Carrots	0.20	0.40	0.60±0.0	0.05	0.10	0.05	0.03
Cauliflower	0.40	0.60±0.27	0.80±0.36	0.10	0.10	0.10	0.05
Chillies	1.05±0.39	1.55±0.45	2.07±0.44	0.15	1.25	0.35	0.18
Cucumbers	0.93±0.35	1.27±0.53	1.65±0.69	0.02	0.50	0.10	0.05
Green leafy vegs	0.87±0.18	0.55±0.10	0.74±0.16	0.50	1.00	1.00	0.50
Marrow	0.80	0.90±0.19	0.89±0.16	0.10	0.28	0.10	0.05
Onion	0.81±0.17	0.81±0.07	1.01±0.11	0.05	0.50	0.05	0.03
Potatoes	0.33±0.06	1.00±0.0	0.67±0.37	0.10	0.10	0.10	0.05
Tomatoes	1.04±0.17	0.95±0.45	1.33±0.13	0.08	0.50	0.30	0.15
Means	1.23±0.22	1.15±0.31	1.19±0.09	0.19	0.45	0.28	0.14

OP *Organophosphorus pesticides*
Carb/Othrs *Carbamates and other pesticides*
1 *The values have been extracted from Appendix 21*
2 *The values have been extracted from Table 6-26 and for those commodities with no pesticides identified, the CAC_MRLs have been suggested*
3 *The value for mixture is half the value of all pesticides*

Chapter 9

Conclusions from this study & suggestions for future work

9.0 Introduction

9.1 Vegetable production and pesticide usage in Al-Ain

9.2 Pesticide residues in the locally grown vegetables

9.3 Pesticide exposure and adverse health effects among farmworkers

9.4 Dietary intake of pesticide residues through the consumption of the locally grown vegetables

9.5 Pesticide exposure and congenital malformations

9.6 Reproductive and genetic toxicity of organophosphorus pesticides

9.0 Introduction

Agriculture in a desert country like the United Arab Emirates (UAE) is a new industry and has been made possible through the visionary ideas of the present government of the UAE. About fourteen to fifteen varieties of major vegetable crops have been cultivated commercially in the UAE using drip and canal irrigation systems. However, the warm and temperate climate in the UAE is a host to many pests which attack the crops and pesticides have been the only weapon against these pests, and against those which also invade the country from the neighbouring countries during the cooler winter months, when agricultural activity is at it's peak. Although farms in the UAE are owned by the local population, the farm work is done by expatriate workers who are hired from the Indian sub-continent and northern Africa. The pesticides used in agriculture in the UAE are all imported from the developed countries or from other countries in the region, such as Egypt, Jordan, India and Pakistan. However, in recent years some pesticides have been formulated within the country, for local agricultural and public health use.

This study aimed to identify the usage of pesticides in agriculture in a desert country and to determine the effects of these pesticides on the health and well being of the expatriate farming and the ethnic populations in the UAE. The information on the cultivation of different crops and the usage of pesticides for agriculture has been collected through a survey of the farms in Al-Ain. Samples of farm soil, water and vegetables were also collected during this survey and analysed for pesticide residues. The health of the farmworkers was assessed through a specifically designed questionnaire, the determination of the AChE activity and assessments of neuromuscular co-ordination and memory through the application of neuromuscular and memory tests. Dietary intakes of pesticide residues through the consumption of locally grown vegetables were estimated for the ethnic and the farming populations and assessed as a percentage of ADI for the organophosphorus pesticides, carbamates and other pesticides and for all pesticides. MRLs have been proposed for those pesticides identified in the locally grown vegetables, so that this produce may be safe for human consumption. The conclusions drawn from the major findings in each of the above mentioned areas of study are summarised in this chapter and suggestions for future research are also proposed in the following sections.

9.1 Vegetable production and pesticide usage in Al-Ain

The major vegetable crops which have been adapted by the local Department of Agriculture to the environmental and soil quality in the UAE include Aubergines, Cabbage, Capsicum, Carrot, Cauliflower, Chillies, Corn, Cucumbers, Green leafy vegetables (Lettuce, Spinach, Molokia), Marrow, Onion, Potatoes, Radish and Tomatoes. Other crops grown to a lesser extent and restricted to certain areas included Beans, Peas, Okra, Turnips and Parsley. The cultivation of these crops is possible only during the cooler winter months from October to April and in those areas where underground water is available and in those areas where soil and water salinity is low and the soil water retention capacity is higher.

Pesticides have been used excessively for agricultural purposes in Al-Ain. A total of 152 different types of pesticides were being used on the 221 surveyed farms, with an application rate of 6.8 g/m^2, for every two weeks for all pesticides. Pesticides were routinely used and not only to prevent an impending pest attack. The term "pesticides" has been used synonymously with fertilisers by the agriculture departments, farms and other agrarian related government departments (Fig. 9-1). Cholinesterase inhibiting and non-inhibiting organophosphorus pesticides were the most commonly used pesticides, followed by cholinesterase inhibiting and non-inhibiting carbamate pesticides. Organochlorine pesticides were still being used, although to a lesser extent than the other pesticides. Bacillus thuringiensis based pesticides have also been used but to a much lesser extent than either the organophosphorus or carbamate pesticides. A large number of other pesticides (Carbamoyloxime, Urea herbicides, Pyridazine herbicides, Phthalimide fungicides, N-dichlorofluoromethylthiosulfamide fungicides, Conazole fungicides, Uracil herbicides and Chlorbenzenesulfonate insecticides) were also used on vegetable crops. The main reason for *ad libitum* use of pesticides was their easy availability from the Department of Agriculture at subsidised prices and as off-the-shelf purchases from the innumerable retailers.

9.1.1 Suggestions for monitoring the use of pesticides and further research on pesticide usage in agriculture in the UAE

A local pesticide register need to be established. The establishment of a register will help in properly assessing and controlling the use of pesticides in both agriculture and in other areas. Secondly, the register will also help in controlling

NCC calls for tighter curbs on pesticides

By Osama Habib

THE National Consultative Council (NCC) has called on the Ministry of Agriculture and Fisheries to tighten measures against the import of fertilisers and pesticides, stressing that current laws have apparently failed to reduce dependence on these dangerous chemicals.

At its weekly session in Abu Dhabi yesterday, attended by Minister of Agriculture and Fisheries Saeed Al Raghabani, NCC members said despite efforts of the ministry to control the use of fertilisers and pesticides in the country, some banned chemicals manage to find their way in, posing a grave threat not only to agricultural crops and the environment, but also to human beings.

A special committee set up by the NCC recommended recommended the formation of a joint committee comprising representatives of the Ministry of Agriculture, Abu Dhabi Municipality and the NCC to study federal laws pertaining to import of chemical fertilisers and pesticides and make necessary revisions and changes to protect both the consumer and the farmer.

Mr Raghabani, however, said: "What we actually need is effective implementation of existing laws and federal guidelines on the import and use of chemical fertilisers and pesticides," the minister said.

He said the existing laws and regulations had been adopted by the government after intensive study and research and were in line with international guidelines on the subject.

The NCC also discussed plans of the Abu Dhabi Municipality and Town Planning to solve the problem of parking space in the capital. "The Municipality is considering the construction of multi-storey parking complexes in the capital," officials said.

The Abu Dhabi Municipality also briefed NCC members on plans to set up four new markets for birds and fodder to replace the existing markets for these products.

Move to ban use of toxic fertilisers

By Ehab S. Shouly

Abu Dhabi

A recent campaign by the National Consultative Council (NCC) to ban the use of pesticides and chemical fertilisers in farming, came after a vegetable shipment was considered unfit for export because of the high level of toxin in them, an NCC member revealed yesterday.

Mohammed bin Abdullah Brook, a member of an NCC committee seeking a ban on the use of such high-toxin substances, told *Gulf News* yesterday that recent tests done by the Al Ain Department of Agriculture and Animal Wealth on vegetables meant for export showed they contained too much toxin.

Brook said the Department's Under Secretary Ahmed bin Sultan bin Matar Al Hallami, an NCC member, reported the matter to other members who decided to take action to ban the use of toxic fertilisers and pesticides on farms in Abu Dhabi.

The committee member, a prominent UAE national, said that a technical committee would be set up at the Ministry of Agriculture and Fisheries to study the harmful effects of the use of these substances on farm crop.

"We reviewed the results of the tests conducted independently in various farms which showed that some chemical fertilisers were poisoning the crop because of their high levels of toxin," Brook pointed out.

He said the panel also recommended the use of natural biological fertilisers on all farms because of its effect in improving the quality and taste of the crop.

The NCC members demanded that the Ministry ban and withdraw from the market all chemical fertilisers which contain a dangerous level of toxin, noting that there are many substitute brands which are not toxic.

"We also asked the Ministry to properly examine all agricultural produce, both vegetables and fruits, before they are sold on the market to ensure that they have not been poisoned by toxin, which could pose a threat to public health," he said.

The NCC had warned earlier this month against the excessive use of chemical fertilisers and pesticides in agriculture and set up a committee to liaise with the Abu Dhabi Government on the matter.

At the Eighth Session here at the beginning of the month, the NCC discussed the dangerous impact of chemical fertilisers and pesticides on both humans and plants, especially if used by farmers without supervision.

Al Hallami had told the Council that a special panel to study the impact of the excessive use of chemical fertilisers in agriculture has been set up to draft plans to minimise the use of dangerous fertilisers as much as possible.

Fig. 9-1: News of pesticide residues in vegetables in the local newspapers and statements made by the Minister for Agriculture

the import of banned pesticides from the western manufacturers and assist in monitoring the formulation of pesticides locally within the country. The third and the most important benefit from the register will be the ability to regulate the use of certain required pesticides in agriculture and ban the use of those pesticides proved to adversely affect the environment and contaminate the food chain.

Further work needs to be done by the governmental research station, possibly in collaboration with both local and foreign universities, to identify crops which will need less support from pesticides and yet will grow under the local environmental conditions. Crop rotation methods also need to be investigated by the governmental research station so that crops could be rotated within the different farming areas. Crop rotation could be doubly advantageous, firstly, it could reduce the soil fatigue from continuous cultivation of the same crop and secondly, by keeping the pests away.

The different techniques employed in growing crops without pesticides include organic farming, genetic farming, integrated pest management (IPM) and integrated crop management (ICM). The use of many of these technologies in many of the developing countries has not yet begun and still traditional methods of farming with pesticides have been practised. The different governmental research and advisory agencies should take leadership by directing their research activities towards harnessing the use of these newer methods of farming to local conditions. The local university and other research agencies should be encouraged to conduct basic and applied research in the development of farming without pesticides and make the results available to the individual farmers. The benefits of organic food are that these foods are grown without synthetic pesticides and hence are pesticide free and secondly, these foods are believed to be nutritionally superior because they are grown on healthy non-contaminated soils. However, the practicalities of organic farming in soils with poor organic content need to be investigated. Additionally the impact of genetically modified crops on non-genetically modified crops, pests, agro-ecosystem and development of pesticide resistant weeds and pests is unpredictable and therefore, the suitability of using genetically modified crops needs to be systematically investigated and researched.

Integrated methods of farming could be implemented in the UAE, however, collaborative efforts of the local government, local governmental research units and the department of agriculture are needed. The small farms operated by the local farm owners under the partial supervision and guidance of the Department of Agriculture provide a good organizational setup for experimenting with the IFS.

Formal training of the farmworkers in the use of pesticides should be the first and the foremost task of the government in the implementation of it's policy of reduced usage of pesticides. The different ethnic and cultural backgrounds and illiteracy levels should be taken into consideration in developing training materials for use in the training of the farmworkers.

9.2 *Pesticide residues in the locally grown vegetables*

Pesticide residues were identified in 73% of the samples of locally grown vegetables comprising Aubergines, Cabbage, Capsicum, Cauliflower, Chillies, Corn, Green leafy vegetables (Spinach, Lettuce, Molokia), Marrow, Onion, Potatoes, Radish and Tomatoes. The mean concentrations of pesticide residues in the locally grown vegetables were higher in Chillies, Corn, Tomatoes, Cucumbers, Cauliflower, Green leafy vegetables and Marrow compared to the other vegetable commodities (Cabbage, Capsicum, Carrots, Onion, Potatoes and Radish). The mean concentrations of all pesticide residues exceeded the mean MRL value by approximately four times. The mean concentrations of all pesticide residues levels in Cucumber (17 times), Carrots (12 times), Marrow (9 times), Cauliflower (8 times), Chillies (6 times), Radish and Tomatoes (4 times), Cabbage (3 times) and Aubergines and Onion (2 times) higher than the corresponding MRLs. The mean concentrations of organophosphorus pesticide residues in Cucumbers (47 times), Onion (16 times), Tomatoes (13 times), Chillies (10 times), Marrow (8 times), Cauliflower, Carrots, Radish (4 times), Cabbage and Green leafy vegetables (2 times) were higher than the corresponding MRLs. The mean concentrations of carbamates and other pesticides were higher in Marrow (3 times) and Cucumbers, Onion and Tomatoes (2 times) than the corresponding MRLs. The MRL values were not available for the pesticide residues identified in Potatoes.

Dimethoate, Phenthoate, Formothion, Methidation, Demephion, Phosphamidon, Ethoprofos and Profenofos were the most commonly identified organophosphates and Bendiocarb, Butocarboxim and Aminocarb were the most commonly identified carbamates. Triadimefon, Pyridate, Bromacil, Ethidimuron and Captan were the other pesticides which were commonly identified. Demephion, Carbaryl, Demeton-S-methyl, Captan, Bromacil and Dimethoate which have been banned in several developed countries have still been used in the UAE and were identified in the locally grown vegetables. Excessive use of pesticides during the cultivation of vegetable crops resulted in excessive pesticide residues in the produce. The consumer ingests a considerable amount of the pesticide residues through the consumption of the contaminated produce. It is therefore necessary to reduce the concentration of pesticide residues in the locally grown vegetables and the following methods have been suggested to make the locally grown vegetable produce safe to the consumer:

9.2.1 Suggestions for reduction of pesticide residues in vegetables

1) In addition to establishment of a pesticide register, the government should formulate and implement the policy of minimizing the use of pesticides in agriculture. The existing laws need to be revised and properly implemented so as to reduce and if possible eliminate the contamination of the locally grown agricultural produce. It is also necessary to stop the supply of free pesticides and avoid those pesticides banned in the developed countries.

2) For the governmental policy to be successful and effective in minimizing the use of pesticides in agriculture, alternative pest management policies must be introduced. The international organizations like the CAC and FAO with expertise

in the tried and tested technologies such as IPM and the ICM should be invited by the government to participate in ventures such as this. Preferential use of less toxic pesticides and pesticides which leave very little residues in produce should be encouraged.

3) The government should provide financial and other support to the local research groups to develop new techniques in sustainable agriculture which will succeed in the local environmental conditions. Such actions by the government will not only strengthen the government's resolve to green the desert but provide a cleaner environment and safer agricultural produce to the population.

4) Training programmes for the farmworkers need to be developed to educate these workers in the implementation of the new farming techniques and in the use of instructions in handling pesticides. Moreover, these training programmes need to consider the ethnic, cultural and local agricultural customs.

5) Organic farming has been suggested as an alternative to growing food without pesticides, however, the harnessing of organic farming in countries like the UAE need to be studied further, because of the poor organic content of the soil used in agriculture.

5) The development and application of techniques such as the Integrated Farming System (IFS) need to be undertaken with the participation of FAO by the local government because of the multifaceted approach of this system.

9.3 *Pesticide exposure and adverse health effects among farmworkers*

Farmworkers in the UAE are immigrant workers from the Indian sub-continent and sub-Saharan Africa. Many of these workers are illiterate and are untrained in the use of pesticides and proper agricultural practices. The foremen are expected to be the most knowledgeable persons on the farm and are supposed to train other farmworkers. However, in practice the foremen are usually not trained and in many cases are unable to read and write. The Agriculture Department does not provide any training either in the correct handling of pesticides or in the appropriate practice of safety and hygiene on the farm. These workers, though many had farming experience in their home countries prior to coming to the UAE, were never trained in handling pesticides.

The lack of knowledge of the practice of safety and hygiene when handling pesticides on farms, puts these workers at a disadvantage. Furthermore, no personal protective equipment is provided to the farmworkers by the farm owners and thus such measures are rarely used. To alleviate the general day to day feeling of malaise and to protect themselves against exposure to pesticides, a few farmworkers frequently used some of the available custom-made protective measures, such as using a scarf to cover nose and mouth and wearing a separate set of clothes at work. Less often, gloves were used at work during the harvesting of produce. Almost all the farmworkers handled, prepared and sprayed pesticides without any protective equipment. Other unsafe and unhygienic actions included eating, drinking and smoking while at work and failing to wash hands prior to handling food. Most of the farmworkers were ignorant of the fact that pesticides could harm them and produce ill-health. Some farmworkers informed their co-workers that they had been doing the job for many years and that they had suffered no adverse health effects and they persuaded others to disregard any discomfort or general malaise on the grounds that it would soon pass away and that such discomfort and malaise came as part of the job of a farmworker.

Farmworkers in Al-Ain were found to experience symptoms such as headache, dizziness, restlessness, sleeplessness, weakness, muscular pain, abdominal pain, blurred vision and chest tightness and allergic reactions which included conjunctiva, watery eyes, running nose and respiratory problems in significantly greater numbers than the new farmworkers and unexposed non-farmworkers as described by Gomes *et al*, (1998). Weakness, abdominal pain, blurred vision, muscular pain, restlessness and sleeplessness were significant predictors of farmwork and weakness, blurred vision, headache and chest tightness were significant and abdominal pain, muscular pain, restlessness, sleeplessness were non-significant predictors of AChE depletion.

The levels of exposure to pesticides among farmworkers have been assessed by determining the AChE depletion. Intensity of exposure and period of exposure were significant predictors of AChE and HAChE depletion. Farmworkers in those farms with high pesticide usage and poor hygiene measures showed highest depletions of AChE and HAChE. Neurological and neuromuscular dysfunction measured among farmworkers and a control population using the Aiming and Digit symbol tests showed lower scores among farmworkers compared to the non-farmworkers. These tests significantly predicted farm-work and exposure to pesticides.

9.3.1 Adverse health effects among farmworkers and suggestions for future work

1) There is a need for the illiterate immigrant farmworkers in countries like the UAE to be trained in the safe use of pesticides. Proper training materials need to be developed taking into consideration the existing cultural, environmental and literacy factors.

2) Training in the use of protective measures and the practice of safety and hygiene on the farm should be made compulsory for the workers prior to their employment on farms. Training should be made a requirement of their seeking jobs abroad by their local governments. The effectiveness of the training could be assessed by monitoring the AChE activity levels during the period of their employment and hence the use or non-use of protective measures. The measurement of AChE activity levels could also be included in the pre-employment screening.

3) The farmworkers do not use protective equipment while using pesticides firstly because such equipment is unavailable or is not provided by the farm owner and secondly, because of the discomfort of wearing coveralls, gloves and

mask in the warm humid climate of the tropics. There is an increasing need to develop newer protective equipment which could be worn in tropical countries without any discomfort. Such equipment should also be made available at a reasonably cheap price so that the owners of small farms and the hired farmworkers can afford it. The local universities and research units should include the development of such protective equipment for tropical climates in their research programmes with the support from the local governments and international organizations such as the FAO, World Health Organisation (WHO) and International Labour Organisation (ILO).

4) The morbidity profile identified among farmworkers in this study needs to be investigated further and developed into a tool for use by an occupational physician in an occupational clinic. The occupational physician would then be able to apply the morbidity profile along with the AChE activity profile to determine the level of exposure to pesticides among the farmworkers. The use of these tools by the occupational physician would place him in a better position to suggest possible measures to protect the farmworker from developing chronic adverse health effects and to monitor their recovery from exposure.

5) The results of the Aiming Test (AT) and the Digit Symbol Test (DST) suggested neuromuscular dysfunction and memory loss in farmworkers. These tests (AT and DST) could therefore, be used in the assessment of neurological damage from organophosphorus pesticide exposure among farmworkers. However, they will have to be tested on a larger sample of farmworkers and a control group with different ethnic background before being accepted in the routine monitoring of farmworkers. Changes will have to be introduced in these tests to account for illiteracy and ethnic background.

6) No information was available on the dose response relationship of pesticide exposure and for exposures to mixtures of organophosphorus pesticides. Further research is needed on point mutations, deletions and translocation events and the activity of the oncogenes and suppresser oncogenes following chronic exposure

to pesticides. Information is also needed on somatic and sex-chromosome linked mutations, deletions and translocations following chronic exposure to mixtures of pesticides.

7) The pattern of adverse reproductive health effects such as declining sperm counts in males, reduced fecundability in females, increased time to pregnancy among parents working in agriculture, increased incidence of birth defects in the offspring of farmworkers in the developing countries need to be investigated and reported.

8) Hepatic toxicity and amino acid profile among farmworkers have not been conclusive in terms of exposure and the level of hepatic injury. Further studies are needed among farmworkers to identify the level of hepatic toxicity and amino acid disorder following chronic exposure to pesticides and to associate this with the AChE activity levels (Gomes *et al*, 1999b).

9) Mixtures of pesticides have been observed to show enhanced toxicological effects compared to the individual pesticides used to prepare the mixture. Further research in the toxicology of mixtures of organophosphorus pesticides needs to be carried out. It is believed the inert ingredients and other constituents in a formulation enhance and prolong the effect of the active ingredient. Very little toxicological information is available on formulations of pesticides. Further research needs to be conducted on adverse health effects from pesticide formulations and mixtures of formulations.

9.4 *Dietary intake of pesticide residues through the consumption of locally grown vegetables*

The total daily consumption of the locally grown vegetables by the ethnic and the farming populations at 261.9 g/p/day and 312.8 g/p/day respectively were lower than the daily intake of vegetables recommended by the FAO. The corresponding dietary intake of vegetables among the ethnic males and females were 309.0 g/p/day and 231.6 g/p/day respectively. The estimated dietary intakes of all pesticide residues per unit body weight (EDI_{bw}), from the consumption of locally grown vegetables, for the ethnic males and females were 30.65×10^{-4} mg/kg body weight and 23.00×10^{-4} mg/kg body weight respectively and for the total ethnic and farming populations were 25.98×10^{-4} mg/kg body weight and 31.03×10^{-4} mg/kg body weight respectively.

The dietary intake of all pesticide residues as a percentage of ADI was estimated for the study populations and it was observed that the intakes did not exceed the ADI for the males (16.30%), females (12.23%), total ethnic population (13.82%) and the farming population (16.51%). However, the dietary intake of all pesticides as a percentage of ADI for mixtures exceeded the ADI for mixtures for the ethnic males (161.32%), females (121.05%), total ethnic population (136.74%) and the farming population (163.32%). The exposures to all dietary intakes of pesticides were the highest in the farmworkers followed by the ethnic males. These estimates for the exposure to mixtures of pesticides have been estimated on the basis of laboratory experimentation with mice and the observation that the consumer is exposed to a large number of pesticide residues through the consumption of the locally grown vegetables.

The dietary intakes of pesticide residues through the consumption of locally grown vegetables did not exceed the ADI values for the organophosphates, carbamates and other pesticides or for all pesticides for the ethnic males, females, total ethnic population and the farming population. However, the dietary intakes of all pesticides exceeded the ADI for mixtures for Aubergines, Cabbage and Cucumbers among the ethnic males and for Aubergines and Cucumbers for the females and the total ethnic population. Among the farming population the intakes of all pesticides exceeded the ADI for mixtures for Aubergines, Cabbage, Cauliflower and Cucumbers. It is therefore necessary to regularly monitor the local agriculture produce for pesticide residues and to assess the suitability of this produce for local consumption.

Documentary evidence on the adverse health effects from the exposure to mixtures of pesticides in animals or humans have been very limited for two reasons. Firstly, until recently attention had been focused on exposure to individual pesticides and secondly, assessments of exposure to multiple pesticides in wildlife and humans has not been practical. However, as a result of this study it has been observed that the toxicity of a mixture of pesticides is about 10 times or even more potent than each of the constituents of the mixture. Multiple pesticide exposures such as these, could have far reaching consequences for the susceptible segments of the population such as very young children, pregnant women and the developing foetuses. It is therefore, necessary to conduct further research on the adverse health effects of the mixtures of pesticides, even though individual pesticides have shown very little toxicity.

9.4.1 Suggestions for controlling the dietary intake of pesticides

1) All vegetables should be properly washed and cooked or steamed even though some of the commodities could be eaten raw (eg. Cabbage, Cauliflower, Pepper and Carrots). It has been reported that most pesticide residues are reduced during cooking or such procedures as steaming or boiling (Schattenberg *et al,* 1996).

2) All locally grown vegetables should be consumed in moderation, especially by vegetarians, so that the dietary exposure is kept to a minimum. However, it must be remembered that dietary exposure through the consumption of locally grown vegetables is just one of the routes of dietary intakes of pesticide residues.

3) Further research is needed to assess the toxicity of the dietary intakes of mixture of pesticides identified in the locally grown vegetables. Cytogenetic toxicity from the mixture of pesticides identified in the local produce needs to be studied to assess the risk to the susceptible components of the local population.

4) Risk assessments of the dietary exposure along with occupational exposure among farmworkers need to be carried out. Trans-generational laboratory

experiments are needed with laboratory animals to predict trans-generational adverse effects in the offspring of the farmworkers.

9.5 *Chronic pesticide exposure and congenital malformations*

Assessments of the dietary intakes of pesticide residues in the ethnic population showed that the exposure did not exceed the ADI for individual pesticides, but exceeded the ADI for mixtures of pesticides. However, further studies are needed to monitor the dietary intakes of pesticide residues both before and during pregnancy and to associate this with the outcome of the pregnancy. Presently with the very little information available on the pattern of congenital malformations among the ethnic population and their dietary intake of pesticide residues. Evidence is not conclusive enough to establish a causal relationship between birth defects and pesticide exposure. Information on the total dietary intake of all pesticide residues and other sources of pesticide exposure among the ethnic population also need to be explored.

The dietary exposure to pesticide residues among the farming population was observed to be higher than the dietary exposure in the ethnic population. However, the non-dietary exposure among farmworkers is also expected to be high although such information was not available. Estimation of such exposures is difficult because of lack of information on the frequency of exposure, the intensity of exposure, nature of exposure and the type of exposure. The adverse health effects seen in farmworkers through the pattern of morbidity profiles identified for the first time for these workers could have partly been caused by the dietary intake of pesticide residues but mainly by the occupational exposure among these workers. However, further research needs to be carried out on the incidence of congenital malformations in the offspring of the farmworkers. Studies on sperm counts, infertility and cancers such as testicular, liver, brain, stomach and non-Hodgkin's lymphoma among the immigrant farmworkers could provide information on the prevalence of pesticide associated chronic diseases among these workers in the developing countries.

Pesticide exposure during the embryogenesis period possibly through multifactorial inheritances manifests itself in birth defects. However, the exact mechanism leading to a birth defect is still *"terra incognito"*. It is therefore essential to explore the pesticide induced genotypic error in the developing embryos which may result in a birth defect. Further studies are needed to explore the incidence and nature of genotypic errors from exposure to mixtures of pesticides in laboratory animals.

9.6 Reproductive and genetic toxicity of organophosphorus pesticides

Exposures to pesticides during pregnancy have been associated with congenital malformations and stillbirths in laboratory mice (Gomes *et al,* 1998c). These studies indicate the direct effects of exposure to pesticides on the developing foetus. It is, therefore, possible that in acute exposures during the embryogenesis period pesticides are able to cross the placental barrier and interfere with the meiosis leading to an incorrect amount of genetic material being carried by the conceptus, thereby disturbing and distorting the normal growth pattern. However, further studies are needed to explore the effect of pesticides on the developing embryo.

Chronic exposures to pesticides during the pre-pregnancy and the pregnancy periods in humans could adversely affect the embryo through the combined action of environmental influences (exposures) and two or more mutant genes resulting in additive effects and leading to multifactorial disorders. The mutant genes could have been supplied by either or both parents who earlier in their life had experienced mutant gene development from environmental exposures to pesticides. Chromosomal aberrations (CA) and sister chromatid exchanges (SCE) from chronic exposure to pesticides at different dose levels need to be investigated in laboratory animals to determine the dose response relationship between the level of exposure and cytogenetic effects.

In human studies, significantly higher numbers of DNA adducts have been observed in floriculturists from chronic exposure to pesticides. Bolognesi *et al,* (1994) have reported that commercial formulations of methomyl significantly increased the DNA adducts compared to those induced by the active ingredient methomyl, thereby indicating that formulations act differently from active ingredients such that the effects of the active ingredient can be enhanced. In the study of toxicity of pesticides it is therefore essential to study the toxicity of the formulations and also to use these formulation in studying the mixtures of pesticides.

Cytogenetic studies have shown that the chromosomal aberrations frequently occurring in the agricultural workers have been the 5q, 7q, 17p, 11q and trisomy and translocations of 16q, 6p, 7p and 11p (Fagioli *et al,* 1992). Other chromosomal changes in the exposed agricultural workers were rearrangements leading to total or partial monosomy, 17p, structural aberrations involving the band 16q22 and breaks involving bands 6p23, 7p14 and 11q13. Similar cytogenetic observations have been made in non-Hodgkin's lymphoma and acute myeloid leukemia patients. It may therefore be surmised without being presumptuous that the cytogenetic changes induced by pesticides from chronic exposures are precursors to the expression of chronic diseases such as cancer. Stomach, kidney, rectal, pancreatic, prostate and colon cancers observed in greater numbers among farmworkers may be caused through the pathway of cytogenetic changes induced by pesticides. The relationship between chronic exposure to pesticides and the DNA adduct formation needs to be investigated further so that the series of precursor events leading up to the chronic diseases could be established.

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Appendix 1

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Erythrocyte cholinesterase activity levels in desert farm workers

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In this study we have examined 532 migrant farm workers engaged mainly in the cultivation of vegetable crops, in both greenhouses and openfarms, and an equal number of controls. Erythrocyte acetylcholinesterase activity (AChE) was measured to determine the degree of toxicity due to exposure to organophosphate and carbamate pesticides in the farm workers employed either as foremen (41.5%) or farmers (58.5%). The mean ages of the farm workers and controls were 35.2 ± 7.4 (mean ± SD) years and 34.6 ± 7.1 years. AChE activity of the farm workers and controls was 3.89 ± 0.64 UI/ml (mean ± SD) and 4.15 ± 0.29 UI/ml. The haemoglobin adjusted erythrocyte cholinesterase activity (HAChE) was 29.96 ± 4.14(mean ± SD) for farm workers and 32.10 ± 2.26 for controls. AChE activity was very highly significantly lower for the foremen (3.76 ± 0.69) compared to farmers (3.98 ± 0.59) (Student's *t*-test = 4.13, $p = 0.0001$). HAChE was also very highly significantly lower for foremen (29.24 ± 4.37) compared to farmers (30.46 ± 3.88) (Student's *t*-test = 3.64, $p = 0.0001$). The poorly controlled use of pesticides in the farms appeared to have caused sub-clinical intoxication in the farm workers and indicated the need for training and implementation of hygiene practices.

Key words: Agricultural workers; carbamates; erythrocyte acetylcholinesterase; farm workers; greenhouses; haemoglobin; haemoglobin adjusted erythrocyte cholinesterase; openfarms; organophosphates; pesticides.

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INTRODUCTION

Occupational exposure to pesticides has been shown to be significant in at least two groups of workers: farm workers and workers at pesticide production factories. The main route of exposure in unprotected farm workers has been by inhalation, transdermally and by ingestion.[1–4] Morbidity patterns in farm workers have been identified as headache, weakness, abdominal pain, ataxia and anorexia.[5,6] Organophosphates and carbamates inhibit acetylcholinesterase which causes accumulation of acetylcholine at nerve endings resulting in a cholinergic or hypersecretory syndrome.[7] Organophosphate pesticides produce irreversible inhibition because of phosphorylation of the enzyme, and it may take 4–6 months for acetylcholinesterase to return to normal levels. Carbamates cause reversible inhibition by physically blocking the active receptor sites but this effect may be rectified in 48–72 hours.[6,7]

Farm workers have been identified as a high risk group for occupational poisoning. Wasseling *et al.*[8] reported that cholinesterase inhibitors caused 71% of the reported occupational accidents, 63% of hospitalizations and 36% of deaths in Costa Rica. Coye *et al.*[6] identified mixers, loaders and application operatives working in farming and public health areas as high risk groups. Exposure to pesticides poses a significant risk in rural farming populations of developing countries in particular, because the users cannot understand pesticide packing labels and colour codes, are not persuaded to follow any instructions and are not trained in farm hygiene or in using protective equipment.[1,2] In developing countries like the UAE, these workers are mostly expatriates from third world countries and tend to be socio-economically disadvantaged.

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Beliefs that pesticides are toxic and can cause health hazards are not very common among these farm workers[9] because of their insufficient training. Those who would use protective equipment if provided are reluctant to demand such protection or even seek medical treatment because of the fear of losing their jobs and being deported to their home country.

There have been few research studies of farm workers occupationally exposed to pesticides, and hence data on acute and chronic health effects related to their toxic exposures are lacking. Increased efforts are needed to study chronic exposure effects, particularly neurobehavioural effects, long term neurological dysfunction[10] and other symptoms and signs compatible with cholinesterase inhibition.[3] A dose response relationship between exposure and cholinesterase depression has been reported by Rama and Jaga[11] and Yamanaka *et al.*[12]

Acetylcholinesterase activity (AChE) in the red blood cells and butarylcholinesterase activity in plasma have been used to monitor the extent of organophosphate and carbamate exposure.[11–14] However, Coye *et al.*[6] suggested inhibition of AChE as the better indicator of biological effects. The use of AChE as a useful biomarker for chronic pesticide toxicity has been reported by Walker,[16] Meuling *et al.*[17] and McConnell and Magnotti.[18] London *et al.*[19] reported excellent sensitivity and specificity for AChE using a spectrofluorometric field kit.

Farming is a new industry in the UAE and is rapidly growing, with the farm employees being migrant workers, most of whom have low educational attainments and possess little training in the use of pesticides or other farm practices. The study described in this paper was undertaken in an effort to determine the pattern of AChE and HAChE levels from low dose, chronic exposure in the farm workers. The determination of pre-exposure enzyme levels was not feasible because crops are grown both in summer and winter seasons. Therefore, we compared the pattern of the post-exposure enzyme activity in two populations exposed to pesticides at different levels and also in controls who are supposed to have had no occupational exposure. We have used the acetylcholinesterase enzyme activity in the control population as the reference activity and have attempted to determine the level of occupational exposure by using AChE and HAChE as biological markers.[17]

MATERIALS AND METHODS

Multi-stage sampling technique was used to sample five of the twenty-five sampling areas, and in each of these areas one-fifth of the farms were included in the study. The control population was selected from the expatriate workers attending the labour clinic routinely to certify their good health so that they could renew their work permit and who were not occupationally exposed to pesticides, *i.e.* had never worked in farms or pesticide related industries. The exposed (farmers and foremen) and unexposed (controls) populations were matched for nationality, age and socio-economic status (salary and living conditions). The response rate of the study population was 100%.

The study population consisted of 221 farms comprising both open farms (84.1%) and greenhouses (15.9%), and the sampled employees included 221 (41.5%) foremen and 311 (58.5%) farmers and these two categories formed subgroups by probable degree of exposure. The foremen conducted day-to-day management of the farm and delegated duties to the farmers; they were also responsible for stocking the pesticides, preparing the diluted mixtures for spraying and spraying the pesticides. The farmers, on the other hand, undertook labouring jobs which included tilling the soil, harvesting the produce, giving occasional help to the foremen in spraying the pesticides and cleaning and putting aside the implements used in spraying; the involvement of the farmer in handling pesticides depended on the foremen and these duties were allocated only occasionally.

A specifically designed questionnaire was applied to those farm workers who agreed to participate in the study. A 10ml capillary blood sample was then collected from these workers to estimate AChE, HAChE and haemoglobin levels. A Testmate Cholinesterase kit[15,17,21] (EQM Research, Cincinnati, OH, USA) was used to analyze the capillary blood for haemoglobin and enzyme activity level. Blood pressure was measured using a close fitting cuff and aneroid sphygmomanometer. Body Mass Index (BMI) was calculated using the formula BMI = wt/ht^2, where weight is measured in kilograms and height in meters

The data were analyzed using Statistical Package for Social Sciences (SPSS) for Windows version 6.1.[22] Analysis of data included computations of statistical parameters and comparisons of the sample means using the Student's *t*-test. Inter-group differences were measured using Analysis of Variance (ANOVA), and linear regression was used to find the association of AChE and HAChE independently with period of exposure (length of service in Al-Ain), type of job (categorized as foreman, farmer or control) and area of work (categorized into different farming areas), type of farm (categorized into greenhouse or openfarm), nationality (Bangladeshi, Egyptians, Indians, Pakistanis and Others), systolic and diastolic blood pressures and BMI.

RESULTS

The population of 532 farm workers and 532 controls comprised Bangladeshis (38.1%), Egyptians (27.8%), Indians (12.9%), Pakistanis (16.5%) and Others (3.8%) (Iranis, Syrians, Palestinians, Sudanese and Sri Lankans). The mean ages of the farm workers and controls were 35.2 ± 7.4 and 34.6 ± 7.1 years respectively. The mean systolic blood pressure (mm Hg) of the farm workers and controls were 117.5 ± 8.2 and 117.3 ± 13.49 and the mean diastolic blood pressures were 78.1 ± 8.2 and 78.9 ± 11.3 respectively. The mean haemoglobin levels (g/dl) for the exposed and unexposed were 12.96 ± 1.47 and 12.93 ± 0.83, the mean AChE (UI/ml) were 3.89 ± 0.64 and 4.15 ± 0.29 and HAChE (UI/g haemo.) were 29.96 ± 4.14 and 32.10 ± 2.26.

Many workers had been previously employed as farm workers such that the total period of work in their home country and in the UAE as farm workers was 5.33 ± 2.5 years for foremen and 3.12 ± 2.6 years for farmers and 4.12 ± 4.7 years for controls, while in the UAE alone their mean periods of work were 3.7 ± 3.7 years and 1.9 ± 1.6 years for foremen and farmers respectively. Table 1 shows age, years of exposure and enzyme activity levels for foremen, farmers and controls. AChE, haemoglobin and HAChE levels in foremen (*i.e.* the most exposed group) were statistically significantly lower than the levels in farmers which in turn were statistically significantly lower than in the controls.

Demographic characteristics and enzyme differences between the farm workers working in greenhouses and open farms did not show any statistical significance. Internationality differences for AChE activity, haemoglobin and HAChE and years of exposure are shown in Table 2. The differences for AChE and HAChE were statistically significantly different for foremen, farmers and controls among the five nationality groups. Indian foremen, farmers and controls showed least enzyme depletion while Egyptian foremen and farmers showed the highest.

The farms in each area showed considerable homogeneity in terms of crops, type of soil, type of pests, type of pesticides and frequency of pesticide usage, but wide inter-area differences were noted. The types of pesticides used also varied from area to area, within the same generic groups of organophosphates, carbamates, pyrethroids and organochlorines. The frequency of pesticide usage and the dilution ratios also differed in different areas depending on the prevalence of the pest and the type of crop currently under

Table 1. Age, years of service and enzyme pattern among farm workers and controls

	Foremen	*Farmers*	*Controls*	*95%CI for diff*	*95%CI for diff*	*95%CI for diff*
	Mean	*Mean*	*Mean*	*Foremen & Farmers*	*Foremen & Controls*	*Farmers & Controls*
Age (yrs)	40.53	31.37	34.58	−10.08, −8.24	5.19, 6.71	−4.22, −2.21
Years of service (yrs)	5.33	3.12	4.12	−2.65, −1.77	0.69, 1.72	−1.50, −0.52
AchE (UI/ml)	3.76	3.99	4.15	0.12, 0.34*	−0.49, −0.28*	−0.23, −0.09*
Haemoglobin (g/dl)	12.78	13.08	12.93	0.04, 0.57*	−0.39, 0.09*	−0.00, 0.30*
HAChE (UI/g)	29.19	30.51	32.10	0.59, 2.0*	−3.52, −2.29*	−2.07, −1.12*

* p-value < 0.0001

Table 2. Enzyme characteristics and years of service for foremen, farmers and controls according to their nationalities

	AChE (UI/ml)*			*Haemoglobin (g/dl)*			*HAChE* (UI/g)*			*Exposure (yrs)*		
	Mean	*(Median)*	*95% CI*	*Mean*	*(Median)*	*95% CI*	*Mean*	*(Median)*	*95% CI*	*Mean*	*(Median)*	*95% CI*
Bangladeshi												
Foremen ($n = 54$)	3.99	(3.94)	3.84–4.14	12.72	(12.8)	12.42–13.02	31.20	(31.4)	30.29–32.11	4.93	(5.0)	4.40–5.45
Farmers ($n = 153$)	4.06	(4.04)	3.96–4.16	12.98	(13.0)	12.78–13.19	31.19	(31.4)	30.53–31.85	2.83	(2.0)	2.44–3.21
Controls ($n = 207$)	4.16	(4.20)	4.11–4.20	12.88	(12.9)	12.75–13.01	32.20	(32.5)	31.83–32.58	2.85	(2.0)	2.16–3.54
Egyptians												
Foremen ($n = 109$)	3.69	(3.64)	3.56–3.83	12.97	(13.0)	12.58–13.35	28.03	(28.3)	27.13–28.93	5.39	(5.0)	4.86–5.91
Farmers ($n = 39$)	3.79	(3.83)	3.62–3.95	13.20	(13.0)	12.80–13.60	28.99	(28.7)	27.92–30.06	4.77	(4.0)	3.68–5.86
Controls ($n = 148$)	4.33	(4.30)	4.25–4.40	13.10	(13.0)	12.75–13.44	33.20	(32.7)	32.67–33.73	0.87	(0.0)	0.03–1.72
Indians												
Foremen ($n = 12$)	4.03	(3.73)	3.58–4.48	13.09	(13.0)	12.17–14.01	30.95	(30.6)	29.21–32.69	4.92	(5.0)	3.32–6.51
Farmers ($n = 57$)	4.09	(4.01)	3.96–4.23	13.59	(13.7)	13.28–13.90	30.17	(29.7)	29.37–30.97	2.49	(2.0)	2.00–2.98
Controls ($n = 69$)	4.15	(4.18)	4.11–4.19	13.01	(12.9)	12.88–13.14	31.99	(31.9)	31.66–32.32	5.23	(4.0)	4.59–5.86
Pakistanis												
Foremen ($n = 39$)	3.55	(3.75)	3.32–3.77	12.23	(12.5)	11.66–12.80	29.13	(29.5)	27.80–30.47	5.59	(5.0)	4.99–6.19
Farmers ($n = 49$)	3.80	(3.65)	3.63–3.97	12.88	(12.8)	12.60–13.16	29.57	(29.2)	28.49–30.64	3.78	(3.0)	2.92–4.63
Controls ($n = 88$)	4.12	(4.08)	4.07–4.17	12.87	(12.8)	12.76–12.98	31.95	(31.9)	31.59–32.30	4.32	(3.0)	3.52–5.11
Others												
Foremen ($n = 7$)	3.74	(3.55)	3.23–4.24	12.81	(12.9)	12.18–13.45	29.26	(28.8)	26.59–31.93	6.71	(7.0)	3.44–9.99
Farmers ($n = 13$)	3.91	(3.79)	3.62–4.21	12.47	(12.2)	11.74–13.20	32.01	(34.4)	29.28–34.74	1.77	(2.0)	1.21–2.33
Controls ($n = 20$)	4.02	(3.96)	3.89–4.16	12.48	(12.6)	11.99–12.97	32.40	(31.9)	31.17–33.62	3.18	(0.0)	0.48–6.85

* $p < 0.01$; ** $p < 0.001$

cultivation. The type of crops varied from area to area except for one or two common crops. Multiple regression analysis, with AChE as the dependent variable and covariates significantly associated with pesticide exposure as independent variables, showed that farming area (pesticides usage), type of job (intensity of exposure), nationality, period of exposure and type of farm were very significant predictors of AChE activity depletion (Table 3). Age was a nonsignificant contributor to the multiple regression model. When a similar model was computed for HAChE, with HAChE as dependent variable and all the covariates of AChE as independent variables, pesticides usage and intensity of exposure were very highly significant predictors, while period of exposure was a nonsignificant (p = 0.06) contributor to the model.

DISCUSSION

Farm workers described in this study lived on the farm and their diet consisted almost entirely of the produce of the farm. Most farms did not have a separate or isolated room to store fertilizers, pesticides and farm equipment and so these were stored either in a room adjacent to the living quarters or, in some instances, in the living area itself. Most of the farm workers kept a set of clothes to use on the farm during work while others used their casual clothes and even went to sleep wearing these clothes. The majority of the workers did not use any protective equipment, not even shoes, while some used gloves during harvesting. As has been found in other studies[2] the farm workers did not complain of the lack of protective equipment because they were unaware of the dangers of the different types of exposure to pesticides. The farm workers had not been trained in constituting pesticides nor in spraying, and their minimal educational achievements prevented them from being able to read instructions or decipher any colour codes on the pesticide packages. As with other studies[9] there was no belief among these workers that pesticides are toxic and cause health problems; hence these workers did not take any precautions while handling pesticides, thereby maximizing their exposure. The controls were exposed to pesticides only in the form of food residues and, less probably, as drift from pesticide spray if this occurred in the area in which they resided. The significant differences among farm workers and controls reflected the differences in exposure to pesticides, all else being similar.

AChE and HAChE levels were significantly lower in farm workers compared to the control population than in nonfarm workers; a dose response relationship was evident in the lowest values being found among those involved most frequently in applying pesticides, *i.e.* foremen. Similar findings have been previously reported[18,23] with foremen who handled cholinesterase inhibiting pesticides for a longer period and more intensely than farmers and who experienced greater reductions in AChE activity. These findings are also supported by the work of Lopez-Carillo and Lopez-Cervantes,[24] Coye *et al.*,[6] McConnell *et al.*[4] and Faustini *et al.*[25] The depletion of AChE reported in the UAE workers occupationally exposed to cholinesterase inhibiting pesticides correlated well with the frequency of usage and length of use, thereby confirming similar findings elsewhere[12,26,27] which have reported that the depletion of cholinesterase activity was proportional to the type of pesticides used and period of exposure. Brown *et al.*,[28] Spiegiel *et al.*[26] and Lopez-Carillo and Lopez-Cervantes[24] reported that fluctuations in cholinesterase depletion corresponded with changes in the use of organophosphate pesticides during the farming season.

In summary, the findings reported in this paper have confirmed that the use of cholinesterase inhibiting pesticides on the farms caused the depletion of AChE and HAChE in the farm workers. The depletions in AChE and HAChE levels were strongly influenced by the area of work. The type of pesticides used in different areas varied, as did also the amount used and the frequency of use; this pattern of pesticide usage was reflected by significant differences in AChE and HAChE patterns between the workers in different areas. Farm workers in farming area Hayer showed the highest depletions while Sleimat the lowest, which

Table 3. Significance of independent variables in multiple regression analysis

Dependent variable	*Independent variable*	*B*	*SE B*	*Beta*	*t*	*p-value*
AChE	Pesticide usage	0.100	0.0133	0.303	7.57	0.0001
	Intensity of exposure	0.066	0.0325	0.095	2.05	0.05
	Nationality	0.033	0.0147	0.071	2.25	0.05
	Period of exposure	0.017	0.0068	0.091	2.59	0.01
	Haemoglobin	0.212	0.0128	0.497	16.54	0.0001
HAChE	Pesticide usage	0.949	0.1010	0.432	9.41	0.0001
	Intensity of exposure	0.779	0.2470	0.169	3.16	0.001
	Period of exposure	0.097	0.0516	0.075	1.87	0.06

B = Slope of regression line
SE B = Standard error of B
Beta = Standardized regression coefficient
t = Student's t-test
p Two tailed observed significance level

correlated well with the higher per dunnum (1,000 m^2) usage[29] in Hayer than in Sleimat. The type of job also contributed significantly in depleting AChE and HAChE levels as evidenced by foremen showing lower values compared to farmers and farmers showing lower values compared to controls. Nationality and period of exposure significantly predicted AChE depletion and nonsignificantly HAChE. Covariates of both AChE and HAChE suggested that the persistent usage of pesticides without any protective equipment and also without implementation of farm hygiene might eventually affect the health of these farm workers. Our findings support similar reports by other investigators.[4,6,11,13,27] It is clear that education and training of farm workers in handling pesticides in an appropriate way and use of protective equipment are needed to reduce their exposure and hence the long term risks to their health.

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Morbidity among farm workers in a desert country in relation to long-term exposure to pesticides

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Gomes J, Lloyd O, Revitt MD, Basha M. Morbidity among farm workers in a desert country in relation to long-term exposure to pesticides. *Scand J Work Environ Health* 1998;24(3):213—219.

Objectives Farm workers chronically exposed to low levels of pesticides seldom show signs and symptoms of clinical significance. This study investigates subclinical morbidity patterns among male farm workers in a desert country.
Methods Migrant-established farm workers (N=226) were compared with referents (N=226) and with new farm workers (N=92) who had just entered the country to work on farms. Acetylcholinesterase activity was measured, the aiming test and digit symbol test were applied, and a morbidity profile was collected with a questionnaire.
Results The erythrocyte acetylcholinesterase activity and hemoglobin-adjusted erythrocyte acetylcholinesterase activity were significantly depleted in the established farm workers. The results of the aiming and digit symbol tests were also significantly lower for the established farm workers. For the morbidity profile, irritated conjunctiva (47.3%), watery eyes (52.2%), blurred vision (63.3%), dizziness (55.2%), headache (63.7%), muscular pain (61.1%), and weakness (76.6%) were reported by established farm workers in statistically significantly higher numbers than by the referents and new farm workers.
Conclusions Morbidity patterns, such as the health complaints and objective parameters suggested in this study, would be suitable as criteria for identifying farm workers most at risk from pesticide toxicity and as criteria for initiating measures to control and reduce exposure.

Key terms aiming test, digit symbol test, erythrocyte acetylcholinesterase, hemoglobin-adjusted erythrocyte cholinesterase, organophosphates.

Crop losses have been effectively controlled through the use of pesticides. However, their use has caused widespread concern over direct exposure during their handling (mixing and spraying) and also during indirect exposure through pesticide residues in food and the general environment (1). Reports of adverse health effects on agricultural workers and the community have generated calls for the most judicious use of pesticides in agriculture and public health (2, 3). However, the improper use of pesticides, especially in developing countries, has raised suspicions of increasing morbidity rates for agricultural workers (2). Lack of control and training in the proper use of pesticides on farms has resulted in the exposure of farm workers to toxicologically significant quantities (1, 4). Although only a small percentage of those exposed receive doses high enough to cause acute severe effects, the majority are at risk of developing subclinical damage to their health (5).

As reported by pesticide handlers elsewhere, the most common symptoms from chronic low-dose exposure are headache, dizziness, anxiety, vertigo, nausea, and vomiting (2, 3). Farm workers subjected to chronic pesticide exposure are also at risk of developing mood disorders, mainly depression, which can be manifested as significantly high suicide rates (4). Cytogenetic effects have also been observed for farm workers chronically exposed to pesticides (5). A 3-fold increase in chromatid breaks has been detected for sprayers at the end of the spraying season in a comparison with unexposed workers (5). Gudumak et al (6) reported that prolonged exposure to pesticides alters the amino acid profile in agricultural pesticide handlers. Significant alterations in amino acids produced clinical manifestations of ill-health in occupationally and chronically exposed agricultural workers (6). Certain cancers, namely, gastric, renal, skin and blood (leukemia and non-Hodgkin lymphoma), have tended to increase (7, 8).

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Decreased conduction velocities have been observed for the motor and sensory fibers by Ruijten et al (9). Autonomic nerve function was also decreased in resting sinus arrhythmia. Acetylcholinesterase activity levels have been reported to be lower in workers exposed to organophosphorus compounds than in unexposed workers (10).

Dose-response relationships to pesticides are difficult to determine among agricultural workers because of the heterogeneity of the pesticides used, the variability of the methods of application, the lack of information on the use of protective measures, and the lack of adequate exposure data (11). Migrant agricultural workers in particular are at increased risk since they do not carry any exposure history with them and most migrant farm workers are unaware that pesticides are toxic and could cause health problems (12). Few comprehensive epidemiologic studies have assessed the magnitude of occupational health problems among farm workers in developing countries, and data on acute and chronic health effects related to their toxic exposures are generally lacking (13—16).

This study aimed at collecting information on some of the key morbidity parameters (both those reported elsewhere and others) among migrant-established farm workers and those working in nonpesticide-related industry. Farm workers who had worked on farms in other countries and who had come to the United Arab Emirates to commence farm work were also studied. Erythrocyte acetylcholinesterase (AChE) activity and neurological and muscular dysfunction were measured in the study population, and the results were correlated with their AChE level and the type of job. The morbidity parameters identified in this study were assessed for their ability to predict the depletion of AChE, the type of job engaged in, and the period of occupational exposure to pesticides.

Subjects and methods

Subjects

A population of 544 male expatriate workers recruited from developing countries to work on farms, in industry, and as domestic help in the United Arab Emirates took part in this study. The study population was selected from workers attending the occupational health clinic of the Preventive Medicine Department, Ministry of Health; they attended this clinic to obtain a health certificate to renew their residence permit, which would allow them to stay in the country and work in the designated industry. The population consisted of 226 established farm workers, 226 referents matched for age and nationality, and 92 unmatched new farm workers. Both the farm workers and the referents were selected on the basis that they had worked, at least for the past 2 years, in the country in their present jobs. The farm workers lived on the farms and handled tilling, the spraying of pesticides, and the harvesting of farm crops. The selection criteria for the referents were that they had never been occupationally exposed to pesticides or handled pesticides for domestic use; they were employed as domestic workers or in retail shops or in offices or industry. The new farm workers were selected from men who had just come into the country to work on farms and had previously worked for at least 2 years in the farming industry in their home country. The response rate was 99%; 6 people (1 referent, 1 farm worker and 4 new farm workers) did not participate because of a lack of communication skills or because they were afraid to provide a blood sample. The study population, which was mainly ethnic Asians, comprised Pakistanis (30%), Indians (29%), Bangladeshis (28%), Egyptians (9%) and others (4%) (Iranians, Jordanians, Sudanese, Syrians and Yemenis). The means of the systolic and diastolic blood pressures of the population were 119.08 (SD 15.54) mm Hg [15.84 (SD 2.07) kPa] and 80.36 (SD 11.65) mm Hg [10.69 (SD 1.55) kPa], respectively, and the mean and standard deviation of the hemoglobin level was 13.27 (SD 7.92) g/dl. The body mass index (BMI), systolic and diastolic blood pressures, and heart rate did not differ between the 3 groups (table 1).

Table 1. Demographic characteristics of the study population.

Parameter	Referents		Farm workers		New farm workers	
	Mean	SD	Mean	SD	Mean	SD
Body mass index (kg/m²)	23.24	3.54	21.75	3.13	20.54	3.35
Systolic blood pressure (mm Hg)[a]	118.80	15.5	120.78	17.07	115.61	10.33
Diastolic blood pressure (mm Hg)[a]	80.27	12.53	81.66	11.46	77.39	9.20
Heart rate (beats/min)	70.49	12.79	68.90	11.65	64.67	7.51

[a] 1mm Hg = 0.133 kPa.

Questionnaire

A specifically designed questionnaire was applied to the surveyed population to elicit information on demographic characteristics, health status, work, and dietary habits. Blood pressure was measured using a close-fitting cuff and an aneroid sphygmomanometer. Height and weight were measured, and the BMI was calculated by using the formula BMI = weight (kg)/height² (m).

Analyses

A 10-µl capillary blood sample was collected to measure AChE and the hemoglobin level (17, 18). A Testmate Cholinesterase Kit (19) (EQM Research, Cincinnati, OH, USA) was used to analyze the blood sample for AChE and hemoglobin. In the assessment of neurological dysfunction, memory disorder and loss of neuromuscular coordination status, the digit symbol test and the aiming

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test (20) were applied under controlled and comfortable conditions. The test instructions were given in the relevant native language, and, after a practice session, 1 minute was allowed for the completion of each test. All the subjects were then examined by an occupational physician, who was "blind" to their jobs, to collect information on their past and present health status according to a predesigned checklist.

Morbidity data

The morbidity pattern was compiled using the 30-day recall information provided by the study population. The checklist for the past health effects included complaints described in previous studies and also other complaints on the basis of protection from presumed toxicologic actions. They included watery eyes, blurred vision, runny nose, itchy skin, dizziness, headache, restlessness, sleeplessness, muscle pain, abdominal pain, weakness, wheeze, and chest tightness. The subjects were also asked to report on any parameter which they experienced while at work or soon after work. The responses to each parameter were classified as experienced "often", "sometimes", or "never". The current health status was assessed from the following observations: conjunctiva (irritated or normal), vision test, wheezy chest, and skin condition of the hands.

Statistical analysis

The data were analyzed using the statistical package for the social sciences (SPSS) for Windows (21). Student's t-test was used to test the significance of the difference in the categorical variables, and an analysis of variance (ANOVA) was used to test the significance of the difference between the means among the different groups. Multiple regression analysis was used to test the association between AChE depletion and farm work from the results of the aiming and digit symbol tests and the different parameters from the morbidity pattern. The period of exposure of the farm workers was also tested as a dependent variable.

Results

Measured parameters

The values for AChE, hemoglobin-adjusted AChE, the aiming test, the digit symbol test, and the period of service for the referents differed highly significantly ($P<0.0001$) from the respective values of the established and new farm workers (table 2). But between the 2 groups of farm workers only the difference for AChE was highly significant, those for the hemoglobin-adjusted AChE value and the aiming test being significant and those for the digit symbol test and the period of service being nonsignificant.

Reported parameters

Many of the morbidity parameters showed statistically significant differences between the established farm workers, the new farm workers, and the referents. Higher percentages of farm workers than referents reported (often or sometimes) irritated conjunctiva (47% versus 16%), watery eyes (52% versus 4%), blurred vision (63% versus 7%), runny nose (36% versus 9%), wheeze (18% versus 6%), and chest tightness (18% versus 5%) in the past month; these differences were all statistically highly significant (table 3). Greater numbers of farm workers than referents reported dizziness (55% versus 14%), headache (63% versus 18%), restlessness (41% versus 0%), and sleeplessness (48% versus 4%); these differences were also highly statistically significant (table 4). Muscular pain, abdominal pain, and weakness were more frequently experienced by the farm workers than by the referents often or sometimes in the past month (69% versus 8%, 61% versus 4%, and 77% versus 10%, respectively); these differences were all highly significant (table 5).

Regression analysis

The type of job was a highly significant predictor of weakness, abdominal pain, blurred vision, muscular pain, restlessness, and, to a less extent, sleeplessness in the affected population (table 6). Farm work also predicted low

Table 2. Enzyme pattern and neurological function for the referents, established farm workers, and new farm workers. (95% CI= 95% confidence interval, AchE = erythrocyte acetylcholinesterase, HAChE = hemoglobin-adjusted erythrocyte acetylcholinesterase)

Parameter	Referents		Farm workers		New farm workers		95% CI for difference		
	Mean	SD	Mean	SD	Mean	SD	Referents versus farm workers	Referents versus new farm workers	Farm workers versus new farm workers
AChE (UI/ml)	4.12	0.31	3.47	0.50	4.23	0.21	0.57—0.73*	-0.18—-0.04*	0.68—0.83*
HAchE (UI/g hem)	31.54	2.31	28.41	6.26	33.24	1.73	2.3—4.01*	-2.22—-1.17*	3.93—5.72**
Aiming test	18.98	18.55	7.17	12.05	7.99	15.24	8.92—14.71*	6.7—15.3*	-2.7—4.34**
Digit symbol test	5.97	11.70	0.90	3.83	0.74	2.89	3.45—6.68*	2.8—7.66*	-1.04—-0.71
Period of service	6.31	4.54	5.04	3.62	0.06	0.46	0.52—2.03*	5.31—7.18*	-5.45—-4.99

* P-value< 0.01, ** P-value< 0.001.

scores on the aiming and digit symbol tests and low AChE activity levels with a high level of statistical significance. AChE depletion significantly predicted weakness and blurred vision highly significantly and less significantly muscular pain, headache, and chest tightness. Among the 108 farm workers who sometimes experienced blurred vision, 14% (15 of 108) reported sometimes experiencing double vision, while 40% (14 of 35) reported this symptom as being experienced often. AChE also predicted a low hemoglobin-adjusted AChE activity in the exposed population significantly and identified the exposed population highly significantly.

Discussion

Migrant farmers have a low level of literacy and are therefore unable to read the instructions on the labels of pesticide packing (22). These workers, who also disregard

Table 3. Eye problems, respiratory problems, and skin allergy among the referents, established farm workers, and the new farm workers. (NS=not significant)

Symptom	Referents		Farm workers		New farm workers		
	N	%	N	%	N	%	P-value[a]
Conjunctiva							
Irritated	36	15.9	107	47.3	16	17.4	
Normal	190	84.1	119	52.7	76	82.6	<0.0001
Watery eyes							
No	217	96.0	108	47.8	92	100	
Sometimes	9	3.9	108	47.8	-	0.0	
Often	-	0.0	10	4.4	-	0.0	<0.0001
Blurred vision							
No	210	92.9	83	36.7	92	100	
Sometimes	15	6.6	108	47.8	-	0.0	
Often	1	0.4	35	15.5	-	0.0	<0.0001
Runny nose							
No	205	90.7	143	63.3	89	96.7	
Sometimes	21	9.3	78	34.5	3	3.3	
Often	-	0.0	5	2.2	-	0.0	<0.0001
Respiratory problems							
Normal	201	88.9	145	64.2	92	100	
Wheezy	14	6.2	41	18.1	-	0.0	
Tightness	11	4.9	40	17.7	-	0.0	<0.0001
Skin rash							
No	217	96.0	209	92.5	92	100	
Yes	9	3.9	17	7.5	-	0.0	NS

[a] Chi-square test between the referents, farm workers, and new farm workers for either the presence or absence of the morbidity parameter.

Table 4. Dizziness, headache, restlessness, and sleep disturbances among referents, established farm workers, and new farm workers.

Symptom	Referents		Farm workers		New farm workers		
	N	%	N	%	N	%	P-value[a]
Dizziness							
No	194	85.8	101	44.7	90	97.8	
Sometimes	30	13.3	107	47.3	2	2.2	
Often	2	0.9	8	7.9	-	0.0	<0.0001
Headache							
No	186	82.3	82	36.3	89	96.7	
Sometimes	33	14.6	110	48.7	3	3.3	
Often	7	3.1	34	15.0	-	0.0	<0.0001
Restlessness							
No	226	100	134	59.3	92	100	
Sometimes	-	0.0	92	40.7	-	0.0	<0.0001
Sleeplessness							
No	217	96.0	118	52.2	92	100	
Sometimes	9	3.9	101	44.7	-	0.0	
Often	-	0.0	7	3.1	-	0.0	<0.0001

[a] Chi-square test between the referents, farm workers, and new farm workers for either the presence or absence of the morbidity parameter.

health and safety measures and treat pesticides and any toxic chemicals as harmless substances, are therefore potential targets for exposure and for subsequent adverse health effects (15). Any subclinical morbidity they experience is usually discounted as general malaise which will pass away the following day. They are also reluctant to seek medical advice because of the fear of losing their jobs (12). Chronic health effects are underreported and usually are not linked in their minds with ill-health from pesticide exposure, even though the exposure is occupational (22). Statistically significant negative relationships have been observed between the use of protective measures and symptoms experienced within hours of exposure after the application of pesticides on a farm (2). Anxiety, nausea, vomiting, weakness, headache, and dizziness have been suggested as potential predictors of pesticide illness (2, 3). In our study, we identified a wide range of symptoms and parameters that were experienced often or sometimes by farm workers but not by referents (ie, restlessness, sleeplessness, weakness, headache, muscular pain, abdominal pain, pain in the extremities, allergic reactions including irritated conjunctiva, watery eyes, blurred vision, runny nose, wheeze, and chest tightness). Ihelin & Hoglund (23) reported similar allergic reactions among farm workers who were chronically exposed to pesticides on farms and who were wanting to change jobs. Similar morbidity patterns pertaining to the central nervous system, skin, and eyes were found to be associated with exposure to pesticides by Gupta et al (24). We suggest, therefore, that this list of complaints and measures be used as a checklist for monitoring the health of farm workers exposed to chronic low doses of pesticides and for advising them on the use of protective measures.

Cholinesterase monitoring has been used as a biological marker for the subclinical effects of organophosphate pesticides (25). The depletion of AChE has been reported to follow a dose-response relationship from exposure to organophosphorus pesticides (10, 25), and among farm

Table 5. Muscular and abdominal pain and weakness among the referents, established farm workers, and new farm workers.

Symptom	Referents		Farm workers		New farm workers		
	N	%	N	%	N	%	P-value[a]
Muscular pain							
No	207	91.6	71	31.4	92	100	
Sometimes	17	7.5	127	56.2	-	0.0	
Often	2	0.9	28	12.4	-	0.0	<0.0001
Abdominal pain							
No	218	96.5	88	38.9	92	100	
Sometimes	8	3.5	125	55.3	-	0.0	
Often	-	0.0	13	5.8	-	0.0	<0.0001
Weakness							
No	204	90.3	53	23.5	89	96.7	
Sometimes	20	8.8	120	53.1	3	3.3	
Often	2	0.9	53	23.5	-	0.0	<0.0001

[a] Chi-square test between the referents, farm workers, and new farm workers for either the presence or absence of the morbidity parameter.

Table 6. Prediction of morbidity parameters for the farm workers and the erythrocyte acetylcholinesterase activity (AchE) depletion by multiple regression analysis. (NS = not significant)

Parameters	Farm work			AChE depletion		
	B	95% CI	P-value	B	95% CI	P-value
Weakness	0.261	0.165—0.359	0.0001	-0.209	-0.179—-0.036	0.003
Abdominal pain	0.315	0.190—0.440	0.0001	0.005	-0.087—0.098	NS
Blurred vision	0.182	0.077—0.286	0.0001	-0.098	-0.175—-0.023	0.01
Muscular pain	0.170	0.055—0.062	0.002	-0.045	-0.124—0.034	NS
Restlessness	0.379	0.222—0.535	0.0001	0.044	-0.072—0.159	NS
Headache	0.034	-0.058—0.128	NS	-0.065	-0.133—0.001	0.05
Sleeplessness	0.142	0.012—0.273	0.03	0.049	-0.046—0.143	NS
Chest tightness	0.032	-0.051—0.114	NS	-0.055	-0.131—0.065	0.05
Watery eyes	0.059	-0.076—0.194	NS	-0.033	-0.076—0.079	NS
Dizzyness	0.023	-0.511—-0.28	NS	0.001	-0.076—0.079	NS
Aiming test	-0.012	-0.016—-0.008	0.0001	-0.001	-0.004—-0.001	NS
Digit symbol test	-0.015	-0.023—-0.008	0.0001	-0.002	-0.006—0.002	NS
Hemoglobin-adjusted AchE	-0.008	-0.023—-0.005	NS	0.034	0.027—0.042	0.0001
AChE / farm work	-0.902	-1.03—-0.772	0.0001	-0.283	-0.0325—-0.0243	0.0001

workers the depletion has been related to the intensity of exposure (25, 26). Among the adverse health effects from pesticide exposure, dementia has been identified in patients chronically exposed to pesticides, and this finding may suggest a clue to the etiology of some neurodegenerative diseases (27). Postural sway, used in the assessment of neurological dysfunction, has been observed to be significantly affected by exposure to pesticides (28). Memory disorders from chronic exposure to organophosphorus pesticides have been reported (29). The significant depletions of AChE and hemoglobin-adjusted AChE in our study were therefore consistent with the finding elsewhere, and it indicated the possibility of subtle diminution of neuromuscular functional integrity.

In our study the positive association of the aiming and digit symbol test results with AChE activity depletion supported the hypothesis of the presence of subclinical neurological dysfunction and memory disorders among established farm workers and, to a less extent, among new farm workers. These test results therefore showed good agreement with the observations of postural sway and the length of sway used to assess neurological dysfunction in agricultural workers exposed to pesticides (28). Agricultural workers with long exposure to pesticides are therefore potential targets for neurological and memory disorders.

To our knowledge the use of the aiming and digit symbol tests has not been reported in the context of assessing neuromuscular dysfunction among farm workers employed on open farms, although these and other similar tests have been used in assessing health effects from solvent exposure (30). In our study, AChE activity, which has been identified as a good indicator of pesticide exposure (26), also showed positive associations with the results of the aiming and digit symbol tests. Low-level exposure to pesticides induces a state of sensitization (31) among farm workers, who therefore reduce their exposure and, thereby, reduce the possibility of severe intoxication but do not avoid the possibility of mild chronic intoxication. Manifestations of acute clinical toxicity are therefore not commonly seen in farm workers, but subclinical toxicity is prevalent, and it could culminate in a debilitating pesticide-related disease. We therefore suggest that, by monitoring the parameters identified in our study, it may be possible to identify subclinical toxicity at an early stage and thereby prevent the clinical manifestation of a pesticide-related disease at a later date.

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ORIGINAL ARTICLE

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The influence of personal protection, environmental hygiene and exposure to pesticides on the health of immigrant farm workers in a desert country

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Abstract **Objectives:** Farm workers in developing countries tend not to use protective measures while handling pesticides. This study investigates the use of personal protection equipment and the practice of safety and hygiene procedures in the handling of pesticides in agriculture. **Methods:** Through a multi-stage sampling technique, one-fifth of the farms in a region were selected and all the farm workers at these farms were included in the study. A comparison population matching in age, socio-economic status and stay in the region was selected. A specifically designed questionnaire was used to collect information on the use of protective measures and the practice of safety and hygiene during work and on the disposal of empty pesticide containers. Blood pressure and erythrocyte acetylcholinesterase (AChE) activity were measured in the exposed and the unexposed populations. **Results:** Protective equipment was worn by a minority of farm workers – gloves, by 35%; work coveralls, by 36%; a scarf to cover the nose and mouth, by 39%; and shoes at work, by 79%. With regard to personal hygiene measures, 83% of the workers changed clothes after work and the same proportion took a shower after work; 63% and 46% drank and ate while at work respectively; and 11% used articles of domestic use in the preparation of pesticides on the farm. Most of the farm workers (96%) were asked to prepare pesticides for spraying by the foreman and 61% were asked to spray the pesticides on the crops. AChE activity was highly significantly depleted in the exposed population as compared with the unexposed population. **Conclusions:** AChE depletion was found to be negatively associated with the use of gloves, of work coveralls, and of a scarf to cover the nose and mouth and with the implementation of safety and hygiene procedures on the farm. AChE depletion was positively associated with the frequency of pesticide spraying.

Key words Pesticides · Protective equipment · Safety · Hygiene · Acetylcholinesterase activity

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Introduction

Agricultural chemicals used in crop production constitute potential occupational hazards for farm workers (London 1992; Gomes et al. 1997), who are the prime targets for pesticide toxicity (Labonte 1989; Albertson and Cross 1993). Though the potential for chronic exposure to pesticides in farming is significant, such exposure has not been well characterised (London and Meyers 1995; Albertson and Cross 1993; Brouwer et al. 1994). Morbidity among farm workers in most parts of the world has also been under-reported (Brouwer et al. 1994), and pesticide illness in developing countries has not been recognised as a high priority by public health officials because of a lack of concrete data on the actual as opposed to estimated number of cases (Waliszeweski 1987)

Many deficiencies in agricultural hygiene have been identified in developing countries. Examples include the laxity of the safekeeping of agricultural chemicals on farms, the careless disposal of empty pesticide containers (London and Meyers 1995), the lack of equipment for personal protection or the failure to use it (Sivyoganathan et al. 1995), deficiencies in safety training among farm workers (London 1994), and the careless application of pesticides and weaknesses in occupational health legislation (London and Meyers 1995). Although some farm workers may be aware of the need for protective measures when applying pesticides, it is thought that they usually do not use such measures either because of discomfort (Sivyoganathan et al. 1995) or because the protective equipment is not available.

In the rapidly developing countries of the Arabian peninsula, farm workers are usually immigrants who may move from one farm to another and from one area to another. They are paid on a daily basis and usually reside in a hut on the farm premises. The farm workers are uneducated, and for this reason, they do not (or cannot) read the labels on pesticide containers (McDougall et al. 1993) and, thus, do not follow instructions in the proper handling of those pesticides (McConnell et al. 1992; Forget 1991). Furthermore, the language on the labels is local or English, which is foreign to most of the workers; secondly, the lack of safety training inhibits their use of the pictograms on the labels, which are present on some labels only; and lastly, the non-availability of personal protection equipment and correct gadgets for the preparation of pesticides for spraying on site makes them improvise with what is available (usually inappropriately). Farm workers are also not trained formally in the handling of pesticides and they learn farm work practices and techniques from colleagues at work (London 1994). Any ill-health from pesticide exposure that they may experience is not ascribed by them to the pesticide exposure, for many do not believe that pesticides could harm them (Forget 1991; Baker 1992).

A few epidemiology studies have assessed the use of protective measures (Sivyognathan et al. 1995) among farm workers and the level of exposure among unprotected workers (Hussein et al. 1990; Iorizzol et al. 1996). The lack of information on the use of protective measures and of exposure data inhibits an accurate assessment of the extent of their exposure (Albertson and Cross 1993). Erythrocyte acetylcholinesterase activity (AChE) depletion has been identified as a good indicator of exposure to organophosphorus and carbamate pesticides among farm workers (Gomes et al. 1997). Although accurate assessments of the exposure among farmers have been difficult to obtain because of the under-reporting of morbidity among these workers (London and Meyers 1995), only a small proportion of farmers are thought to be receiving doses high enough to cause severe and acute effects on their health. In contrast, most of them are thought to be receiving chronic exposure to low doses (Al-Saleh 1994) and, thus, could develop adverse outcomes such as cancers, immunological effects and reproductive abnormalities (Cannas et al. 1992; Zaham and Blair 1992; Faustini et al 1993; Forastiere et al. 1993; Strohmer et al. 1993; Viel and Richardson 1993).

This study was designed for several purposes: firstly, to identify the behaviour of farm workers regarding the agricultural use of pesticides in a farming region of a semi-desert country; secondly, to determine the use and availability of protective equipment for them during the handling of pesticides and to ascertain the types of activities through which the farm workers become exposed to pesticides; and finally, to determine the relationship between the use or non-use of various protective measures and the depletion of AChE activity.

Materials and methods

Multi-stage sampling techniques were used to select 5 farming areas from the 25 farming areas located in the region of our study. One-fifth of the farms in the selected areas was sampled, and all the farm workers available on the day of the field-work visit were invited to participate in the survey. If the selected farm was not under cultivation or no farm worker was available, the adjacent farm was chosen. Unexposed workers were selected from those attending the local preventive medicine clinic for administrative purposes, i.e. to obtain a health certificate so as to renew their work permit. The unexposed population had never worked on farms, had never been occupationally exposed to pesticides, had been working in the country for at least 2 years and had been matched for age (to within 1 year) and nationality to the test population.

A specifically designed questionnaire was used to collect information from the farmers concerning their demographic profiles, their use of protective measures and equipment while at work, the details of their work practices on the farm and the practice of safety and hygiene on the farm particularly during the handling of pesticides and the disposal of empty pesticide containers. The local practice of using a scarf to cover their head has been adapted by some farmers to cover their heads and face while at work. This is mainly to provide protection from the heat of the sun, although some farm workers also use the scarf to cover the nose and mouth while spraying. For this reason its use has been categorised as a protective measure, although its ability to protect the worker is debatable. The questionnaire was applied by an interviewer who capable of communicating in all the languages understood by the farm workers, including those of the different ethnic backgrounds encountered on the Indian subcontinent.

After the subject had relaxed for half an hour after completing the questionnaire, measurements were taken of the systolic and the diastolic blood pressure and of the weight and height. The body mass index (BMI) was calculated using the formula $BMI = weight\ (kg)/height^2\ (m)$. A sample of capillary blood was collected and analysed immediately for AChE, haemoglobin-adjusted erythrocyte acetylcholinesterase activity (HAChE) and haemoglobin using the Testmate Cholinesterase Kit (Meuling et al. 1992; EQM Research 1991). The blood pressure, BMI, AChE, HAChE and haemoglobin were also measured for the unexposed group of workers.

Student's *t*-test was applied to assess the differences between two independent groups and the chi-square test was used to determine the significance of differences in proportions of categorical variables between two or more groups. The Fischer exact test was used when the sample size was small. Analysis of variance (ANOVA) was used to test the significance of the difference between the means among the different groups from the different farming areas and between the exposed and unexposed groups. The Kruskall-Wallis test was used to assess the significance of the distribution of categorical variables among the different farming areas; all assessments were carried out at the 95% confidence level. For assessment of the influence on the measured AChE activity due to exposure resulting from the extent of use of different items of protective equipment, from the degree of training in the handling of pesticides and from the frequency of contact during the preparation and spraying of pesticides a multiple regression model was built and tested using the Statistical Package for Social Sciences (Norusis 1983).

Results

A total of 211 farms were sampled in the 5 farming areas (identified as areas 1, 2, 3, 4 and 5); 532 farm workers, comprising 221 foremen and 311 farm labourers, were interviewed. The exclusion of three farm workers from the study because of their fear of providing a blood sample gave a participation rate of 99.4%. The types of jobs performed by foremen and farm labourers were similar except that the former were responsible for taking decisions about planting and spraying, for the preparation of pesticides for spraying and for spraying them on the farm. However, the foremen often delegated the last two of these duties to the farm labourers. The other general work on the farms included tilling of the soil, digging of furrows for irrigation, laying of drip tubes for irrigation, planting, weeding, and the harvesting and packing of the produce into crates to be transported to the collection point for sale to the government marketing system. The unexposed group of workers worked as domestic servants or drivers or as salesmen in retail shops; their socio-economic status was similar to that of the farm workers.

The percentages of farm workers contributing to the survey from each of the five farming areas were broadly similar: 21% came from area 1; 16%, from area 2; 19%, from area 3; 22%, from area 4; and 22%, from area 5. Two of the farming areas (areas 2 and 3) were relatively longer established in that crops had been grown there for over 5 years. These areas were characterised by the small size and poor layout of their farming plots and by the little support they received from the central agricultural advisory department. In contrast, the other three areas (areas 1, 4 and 5) were newer, had a better layout and received considerable support and advice. Most of the farms in the survey were open farms (83%), and the remainder were greenhouses. The workers belonged to six ethnic groups – the major groups being Bangladeshis (39%), Egyptians (28%), Pakistanis (16%) and Indians (13%) and the small group ("Others", 4%) consisting of Iranians, Syrians, Sudanese and SriLankans. The literacy level was low, with 98% of the exposed population having had little primary schooling, if any. The percentages recorded for illiteracy in the five farming areas were 100%, 94%, 98%, 100% and 100%, respectively. The few workers in areas 2 and 3 (6% and 2% respectively) who had completed primary schooling in their mother tongue had initially been employed as domestic servants and had later been transferred to farm work.

Most of the different items of protective equipment were worn regularly by only a minority of the farm workers – gloves, by 35%; coveralls at work, by 36%; a scarf for covering of the head and face, by 39%; and shoes at work, by 79%. For the measures of personal hygiene, higher figures were obtained; clothing was changed after work by 83% of workers and showering after work was practised by 83%. The use of protective equipment by farmers varied between the different farming areas (Fig. 1). Workers in areas 2 and 3 were significantly less likely than those in other areas to be self-protective by using coveralls ($P < 0.0001$), by partly covering the face and mouth with a scarf while spraying ($P < 0.0001$), by changing clothes ($P < 0.0001$) and by taking a shower after work ($P < 0.0001$).

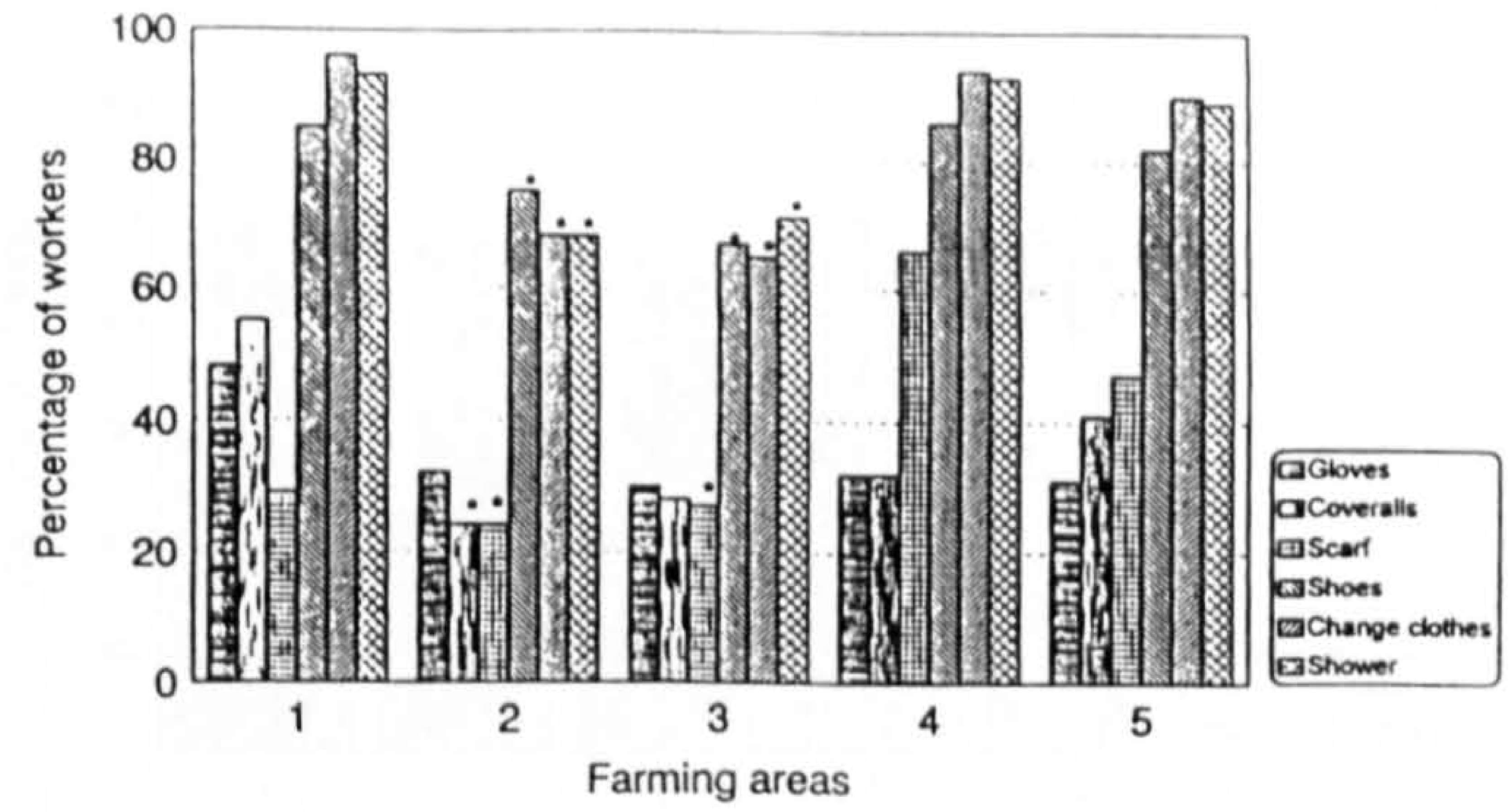

Fig. 1 Use of protective measures by farmers, reported as always used. (Kruskall-Wallis test $*P < 0.0001$)

Awareness of the importance of domestic hygiene was consistently low. Articles of domestic use, such as spoons, ladles and buckets, were used by 11% of the farm workers in the preparation of pesticides for spraying; 59% disposed of their pesticide containers by throwing them on the farmland; and 63% and 46% of them drank and ate, respectively, while at work on the farm. Of the farm workers, 25% were smokers; and of the smokers, 79% smoked while at work. The practice of domestic hygiene (Fig. 2) by workers in areas 2 and 3 was poor as compared with that by the workers in the other three areas. These workers employed articles of domestic use more frequently in the preparation of pesticides ($P < 0.0001$), ate more frequently while at work ($P < 0.0001$), had a drink on the farm very often ($P < 0.05$) and smoked frequently while working on the farm ($P < 0.05$)

The preparation of pesticides for spraying was usually (96%) done on the farm. Most workers (96%) were asked (either always or frequently) to prepare pesticides for spraying, although fewer (61%) were required to spray the pesticides on the crops; moreover, only around half of them (53%) had received some formal relevant

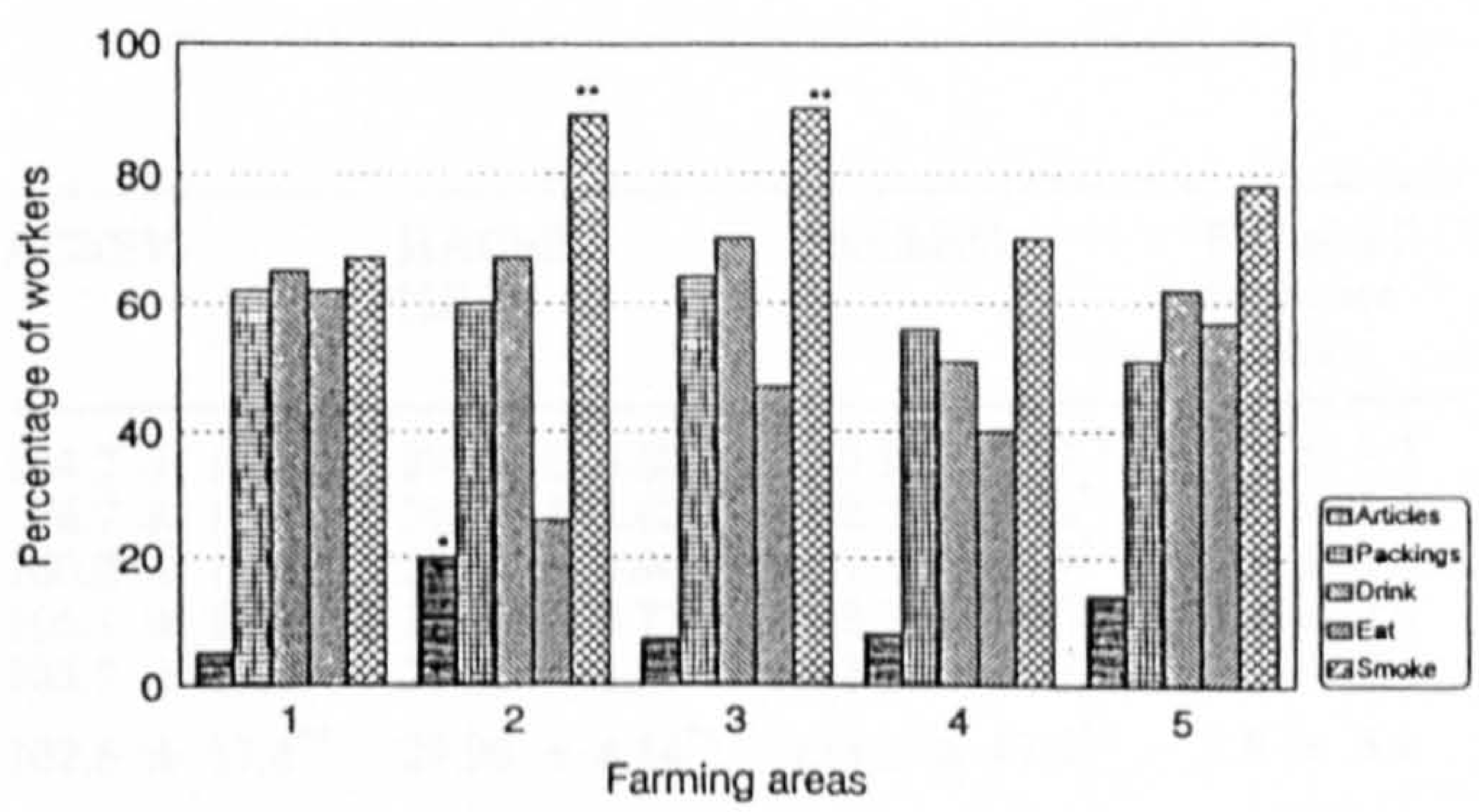

Fig. 2 Personal practices on the farm, reported as always practised. Kruskall-Wallis test $*P < 0.0001$, $**P < 0.05$

training. Farm labourers were usually given training by the foreman, who had in turn been verbally instructed at one time by governmental agencies on the precautions to be taken during the preparation and spraying of pesticides. Prepared pesticides left unused were usually (96%) disposed of by overspraying on the crops. Differences in these practices emerged between the individual farming areas (Fig 3). As compared with the other three areas, highly significantly fewer farm workers in areas 2 and 3 had been trained in the handling of pesticides ($P < 0.001$) and were required to prepare the pesticides significantly less frequently ($P < 0.0001$); nevertheless, they were required to spray the pesticides highly significantly more frequently ($P < 0.0001$). Workers in areas 2 and 3 also prepared pesticides on the farm significantly less frequently ($P < 0.0001$) than did those in to the other areas.

The mean age, blood pressure, and haemoglobin values recorded for the exposed and unexposed workers did not differ significantly, but the BMI was significantly higher among the exposed workers (Table 1). No statistically significant difference emerged between the mean values noted for these parameters among the exposed workers from the different farming areas.

The activities recorded for both AChE and HAChE among all the farm workers were highly significantly lower than those noted among the unexposed population (Table 2). The severity of AChE depletion varied between the farming areas; all the depletions were significantly high as compared with that observed in the unexposed group, particularly in areas 2 and 3 (Table 2). AChE levels showed significantly positive correlations with the use of gloves ($P = 0.03$), of work coveralls ($P = 0.0001$) and of a face scarf ($P = 0.05$) and with the extent of training ($P = 0.001$) but revealed negative correlations with the habits of drinking while working ($P = 0.001$), smoking ($P = 0.007$) and discarding of used pesticide containers on the farm ($P = 0.003$) and with the frequency of spraying of pesticides ($P = 0.0001$). HAChE levels showed positive correlations with changing of clothes after work ($P = 0.02$); with the use of work coveralls ($P = 0.0001$), a face scarf

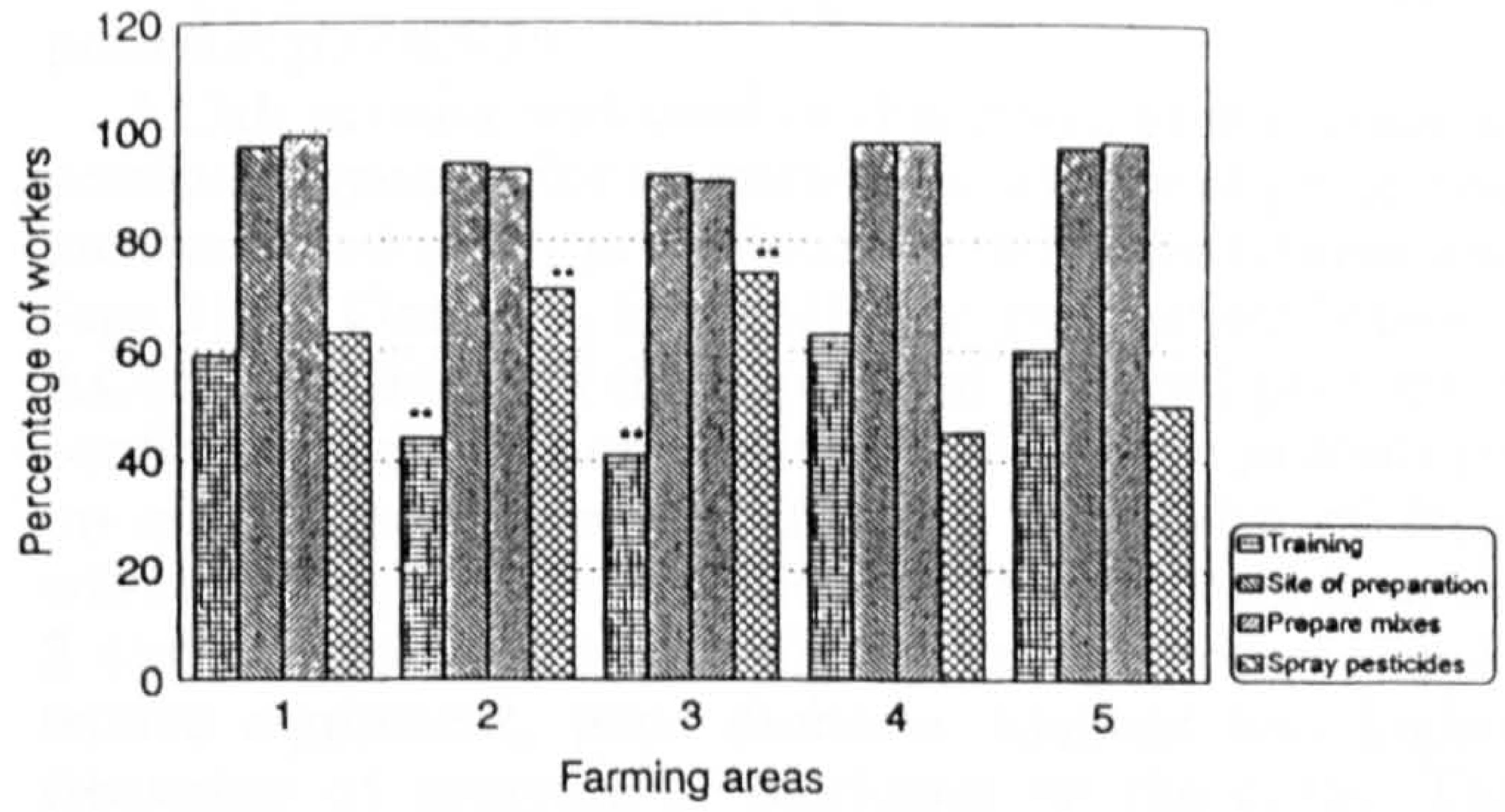

Fig. 3 Training and handling of pesticides on the farm, reported as always trained and engaged in jobs. Kruskall-Wallis test ** $P < 0.001$

Table 1 Age and health profiles of the exposed (according to farming area) and unexposed populations (*BMI* Body mass index, *bp* blood pressure)

Area	Age (years)	BMI	Systolic bp (mmHg)	Diastolic bp (mmHg)	Haemoglobin (units) (g/dl)
1	33.4 ± 7.2	24.3 ± 1.5	115.6 ± 6.4	77.2 ± 7.9	13.3 ± 1.1
2	35.8 ± 7.2	23.8 ± 2.3	118.9 ± 9.4	78.8 ± 9.2	12.8 ± 2.1
3	35.8 ± 9.0	23.7 ± 1.9	116.4 ± 6.1	75.6 ± 6.9	13.1 ± 1.7
4	35.1 ± 6.6	24.0 ± 3.1	118.7 ± 9.9	79.4 ± 8.7	12.9 ± 1.1
5	36.1 ± 7.5	24.2 ± 2.7	118.1 ± 7.8	79.4 ± 7.6	12.7 ± 1.1
Exposed (average for areas 1–5)	35.3 ± 7.5	24.0 ± 2.4*	117.5 ± 8.1	78.1 ± 8.2	12.9 ± 1.5
Unexposed	34.6 ± 7.1	22.3 ± 3.7*	117.3 ± 13.5	78.9 ± 11.3	12.9 ± 0.8

* $P < 0.0001$ (ANOVA)

Table 2 Levels of AChE and HAChE detected among pesticide-exposed and unexposed workers

Area	AchE (UI/ml)	AChE%	HAChE (UI/g)	HAChE%	Period of exposure (years)
1	3.93 ± 0.74*3	104.2 ± 18.4*2	29.58 ± 4.60*1	110.9 ± 19.0*1	3.2 ± 3.7
2	3.70 ± 0.58*1	96.7 ± 17.0*1	28.78 ± 3.62*1	108.2 ± 16.2*1	3.3 ± 3.5
3	3.79 ± 0.66*1	100.2 ± 17.3*1	28.47 ± 3.96*1	107.3 ± 18.7*1	2.9 ± 3.7
4	3.99 ± 0.58*3	106.1 ± 15.5*3	31.20 ± 3.77	118.3 ± 14.6	2.6 ± 2.0
5	3.98 ± 0.58*3	103.9 ± 17.4*3	31.25 ± 3.85	118.9 ± 14.7	3.0 ± 2.5
Exposed (Average for Area 1–5)	3.89 ± 0.64*1	102.6 ± 17.4*1	29.96 ± 4.14*1	113.2 ± 17.3*1	2.9 ± 3.1
Unexposed	4.2 ± 0.29*1	110.4 ± 8.8*1	32.10 ± 2.30*1	121.3 ± 8.7*1	–

*1 $P < 0.0001$; *2 $P < 0.001$; *3 $P < 0.05$ (ANOVA)

(P = 0.003) and shoes (P = 0.02); with showering after work (P = 0.05); and with being formally trained (P = 0.01), but negative correlations were found with the habit of drinking while at work (P = 0.0001), smoking while at work (P = 0.03), disposal of used pesticide containers on the farm (P = 0.02), application of articles of domestic use in the preparation of pesticides (P = 0.01) and the frequency of spraying of pesticides (P = 0.0001). The application of the logistic regression model indicated that the AChE activity level was significantly predicted by the non-use of coveralls and of scarf while at work, the lack of training and the long period of exposure. Non-significant contributors to the model included the spraying of pesticides, the infrequency of the use of gloves and the drinking of water while at work.

Discussion

In this study of immigrant workers in a semi-desert region the extremely high rates of illiteracy, irrespective of ethnic background, constituted an intrinsic obstacle that prevented the workers from directly informing themselves about the dangers of the pesticides directly from the labels on the containers, even when the information was available in the form of pictograms in some cases. This handicap was exacerbated by the failure of the mechanisms of training; new farm workers learned about their activities from their co-workers, such that the instructions were handed down with all the convictions and beliefs based on varying degrees of ignorance, which ultimately results in unsafe attitudes and dangerous practices. One good example of this was the custom of overspraying of the crops with left-over pesticide in the belief that it was protective rather than harmful. Farming has not been recognised locally as a hazardous industry, and the possibility of pesticide use being detrimental to the farm workers' health has not been considered as in other studies (Maddy et al. 1990; London and Meyers 1995). Illiteracy and a lack of proper training have been two great handicaps among these workers.

As happens elsewhere (Sivyognathan et al. 1995), the farmworkers viewed personal protective equipment as non-essential and cumbersome. The reluctance to wear protective equipment was reinforced by the tropical and semi-desert type of environment, which encouraged workers to operate with minimal clothing and with their hands and faces exposed. It was fortunate that the scarf, which is culturally a part of the local attire, was readily convertible into a face mask and head cover, for this study showed that, despite its limitations, its use was one of the factors that gave significant protection against enzyme depletion. Nevertheless, the substantial variation in the extent of utilization of personal protection by workers in the different areas indicated the potential for improvement of compliance in some of the areas, particularly if the employers could be persuaded to supply both proper training and the protective items needed for personal protection.

AChE activity was used in this study as a marker of pesticide exposure for assessment of the use of protective measures and safety procedures on the farms (Rama and Jaga 1992; Gomes et al. 1997). The association between AChE depletion and the non-use of personal protection confirmed that the lack of safety and hygiene procedures on a farm was adversely affecting the health of farm workers. The greater depletions of the enzymes in areas 2 and 3 correlated well with less use of personal protective equipment, poor domestic hygiene and higher frequency of spraying of pesticides on the crops. The absence of significant differences in the literacy levels in the five farming areas showed that it was not realistic to expect that some of the workers would use their literacy for reading of pictograms and labels to enable the group as a whole to follow the safety and hygiene procedures adequately. This view was confirmed by the finding that protective equipment was not used more frequently by the slightly better-educated group during handling of pesticides, and their being educated in their native language was thus of no benefit when it was the local language that was being used at work and on the labels and instructions. In areas 2 and 3, examples of extremely bad practice were noted – four cases where pesticides were kept on kitchen shelves next to food and two cases where pesticides were stored under beds. However, dramatically harmful consequences were not observed in any of these cases.

Many measures could be taken to improve the health and safety of the farm workers. Chronic morbidity conditions arising from long-term exposure to pesticides need to be addressed through specialised health clinics. The farm workers require instructions in basic hygiene, in understanding of the pictograms and in pesticide toxicity. Farm workers in general also tend not to follow instructions on the containers (London 1992); in the present survey this failure was inevitable due to the widespread illiteracy and lack of basic safety instructions. The deficiencies in personal hygiene were not unique to this study, because the habit of eating and drinking without first washing the hands and the face has been observed in farms in other developing countries (London and Meyers 1995). Proper training in handling of pesticides, education on the hazards of pesticide exposure and the use of the appropriate protective equipment would diminish substantially the health hazards currently facing these workers, thereby reducing the probability of consequent illness and of their becoming an economic liability for their country of origin in later years (Wiklund et al. 1989; Al-Saleh 1994; Kogerinas et al. 1995; Viel and Chablier 1995).

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Appendix 4

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Hepatic injury and disturbed amino acid metabolism in mice following prolonged exposure to organophosphorus pesticides

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1 Chronic occupational exposure to organophosphorus and carbamate-type pesticides significantly inhibits acetylcholinesterase activity and causes morbidity. This study on mice was designed to evaluate their amino profile and to identify signs of hepatic dysfunction following their chronic exposure to mixtures of organophosphorus pesticides.

2 Laboratory mice were exposed to a formulated mixture of the six organophosphorus pesticides (Dimethoate, Chlorpyrifos, Profenofos, Pirimiphos methyl, Triazophos and Dimethoate) most commonly used in agriculture in this region of the Middle East. Doses (10% of LD_{50} of the mixture) were given once a week by gavage in corn oil for 7 weeks; the control group was given only corn oil. At the end of the exposure period, mice were culled and blood samples were collected to determine erythrocyte acetylcholinesterase activity, biochemical markers of liver function and concentrations of serum amino acids.

3 Erythrocyte acetylcholinesterase activity and total serum proteins decreased significantly in the exposed group. Serum concentrations of alanine aminotransferase and aspartate aminotransferase, alanine, glutamic acid, glycine, isoleucine, leucine, methionine, ornithine, proline, serine, threonine and valine were significantly increased in the exposed mice, while serum levels of cystine were decreased significantly. There were also non-significant increases in serum alkaline phosphatase, gama-glutamyl transpeptidase and some of the other amino acids.

4 Chronic exposure to mixtures of organophosphorus pesticides is associated with decreased acetylcholinesterase activity, hepatic dysfunction and disturbance of amino acids profile. Biochemical indices of hepatocellular injury and disturbed amino acid metabolism may be of value as markers of chronic exposure to such pesticides.

Keywords: amino acids; erythrocyte acetylcholinesterase activity; hepatic dysfunction; organophosphorus pesticides

Introduction

Pesticides include a wide variety of chemicals with great differences in their mode of action, uptake by the body, metabolism and elimination from the body and toxicity to humans. The main hazard of pesticides with lower acute toxicity, but a strong tendency to accumulate in the body even at comparatively small doses, is related to the duration of exposure. Those pesticides which are rapidly eliminated also present a hazard with long-term, low-dose exposure because of the persistence of the biological effects induced by these pesticides.[1] Exposures of animals or humans to pesticides have been associated with pathological changes in the kidney.[2] Retrospective epidemiological studies have suggested a significantly lower serum protein concentration with higher percentage of gamma-globulins and lower albumins and alpha-2-globulins.[3] Ultrasound anatomical examination of the kidney in subjects suspected of having been occupationally exposed to pesticides for a long period of time revealed a higher incidence of gross abnormalities of the kidneys, further investigations of which showed discrete inflammatory lesions of the kidney.[4]

The diagnosis of mild-to-moderate health effects in farmworkers resulting from their chronic, low dose exposure to pesticides is difficult because the signs and symptoms of exposure are non-specific,[5] the low-dose exposure cannot be quantified over a period of time because of the diversity and non-specificity of the exposure, and the manifestations of health effects are often subtle. The workers also tend to disregard any mild-to-moderate signs of pesticide-related illness as something normal which will resolve eventually.[6] Chronic, low-dose pesticide exposure, when left unattended for long periods of time, could induce adverse biochemical changes. Biochemical systems often affected from exposure to dioxin-type chemicals and pesticides are lipoprotein lipases, low-density lipoprotein

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receptors and glucose transporter proteins (GLUTs).[7] Vitamin C uptake and insulin secretion have also been shown by Matusumura[7] to be adversely affected by exposure to persistent organochlorine-type pesticides. Studies of amino acid metabolism in pesticide-exposed workers showed decreased levels of taurine, cysteine, methionine and alanine and increased levels of phenylalanine;[8] however, the level of exposure was not known among these workers and the degree of alteration of the amino acids was related neither to the duration of exposure nor to the specific types of pesticides.

Assessment of liver function in workers at a pesticide-producing plant showed decreased levels of serum proteins, albumin and alpha-2-globulin.[3] Serum concentrations of alanine and aspartate aminotransferase activities have been reported to be significantly elevated in workers exposed to pesticides; ultrasound examination of the hepatic structure revealed liver steatosis in these workers.[3] Generally, however, few data are available on biochemical and metabolic changes induced by long-term, low-dose exposures to mixtures of organophosphorus pesticides which are used by farmworkers routinely on the farms. In this study, therefore, we investigated the effects of long term exposure of laboratory mice to mixtures of organophosphorus pesticides, commonly used in agriculture in this region,[9] on the plasma amino acid metabolism, hepatic function and the activity of acetylcholinesterase in whole blood.

Method

Male and female laboratory mice (ca 30 g) of TO strain were exposed to a mixture of organophosphorus pesticide formulations for a period of 8 weeks. Six organophosphorus formulations obtained commercially were mixed in the proportions of their LD_{50} doses determined previously. The dose, equivalent to 10% of the LD_{50} for the mixture of pesticides, was administered according to the body weight in corn oil by gavage. Unexposed mice were given only corn oil. The six organophosphorus pesticide formulations used in the preparation of the mixture and their LD_{50} values were: Salute (Dimethoate+Chlorpyriphos, 0.16 mg), Dursban (Chlorpyriphos, 0.67 mg), Hostathion (Triazophos, 0.16 mg), Nogos (Dichlorvos, 0.33 mg), Actellic (Pirimiphos methyl, 6.67 mg) and Selecron (Profenofos, 1.33 mg).

The dose was given once a week, and water and pellet food were made available *ad libitum*. The mice were weighed weekly and food and water consumption was monitored during the period of exposure. At the end of the exposure period, the mice were culled and blood samples were collected in lithium heparin and plain tubes. A 10 μl sample of blood was collected in a heparinised capillary tube for the determination of erythrocyte acetylcholinesterase activity (AChE). The blood samples in lithium heparin and plain tubes were spun at 2000 r.p.m. for 10 min to separate plasma and serum from the red cells. The supernatant serum was separated and stored at −10°C until analyzed. The supernatant plasma was deproteinised with 50% sulphosalicylic acid and centrifuged at 10 000 r.p.m. for 10 min at −4°C to separate the deproteinised plasma which was then stored at −10°C until analysis.

AChE activity was determined immediately after collecting the sample using Testmate field kit.[10] The plasma amino acid concentrations were determined by the ion exchange chromatography technique using Beckman 6300, Beckman Instrüments Ltd., according to Speckma.[11] The following plasma amino acids were measured: taurine (Tau), aspartic acid (Asp), threonine (Thr), serine (Ser), aspargine (Asn), glutamic acid (Glu), glutamine (Gln), proline (Pro), glycine (Gly), alanine (Ala), valine (Val), cystine (Cys), methionine (Met), isoleucine (Ile), leucine (Leu), tyrosine (Tyr), phenylalanine (Phe), tryptophan (Try), ornithine (Orn), lysine (Lys), histidine (His) and arginine (Arg). Hepatic function was assessed by measuring serum albumin (Alb), total bilirubin (TBIL) and total proteins (TP) and hepatocellular damage was examined by measuring the concentration of alkaline phosphatase (AP), alanine aminotransferase (ALT), aspartate aminotransferase (AST) and gama-glutamyl transpeptidase (GGT) using a clinical chemistry autoanalyser (Dimension, AR Dupont).

The results were analyzed using the Statistical Package for Social Sciences (SPSS).[12] The significance of the differences between the mean values of the serum concentrations of amino acids, liver enzymes and other markers of liver function and whole blood enzymes in the two groups were assessed by the *t*-test and Levene's test for homogeneity of variances. Regression analysis was used to determine the relationships of the different enzymes, markers of liver function and amino acids in the exposed and the unexposed animals.

Results

The AChE and haemoglobin adjusted erythrocyte acetylcholinesterase activity (HAChE) were highly significantly lower ($P<0.0001$) in the exposed group than in the unexposed (Table 1). Net depletions were 47.3% for AChE and 43.2% for HAChE. Haemoglobin levels in the exposed animals were also significantly lower compared to the unexposed animals.

The serum ALT and AST markers of hepatocellular functions were significantly increased in the exposed animals, while serum AP had increased non-significantly (Table 2). Among the other markers of hepatic function, TP showed a significant decrease and Alb showed a non-significant decrease in the exposed animals.

Substantial differences were found between the plasma amino acid concentrations of the exposed and the unexposed groups of mice. Of the non-polar acids (hydrophobic), Ala, Ile, Leu, Met, Pro and Val were significantly higher, Phe and Tyr were non-significantly higher and Try was non-significantly lower among the exposed animals (Table 3). Among the polar amino acids (hydrophilic), Glu, Gly, Ser and Thr were significantly higher, Cys was significantly lower and Arg, Gln, His and Lys were non-significantly higher among the exposed ani-

Table 1 Erythrocyte acetylcholinesterase (AChE) activity and hemaglobin levels among the organophosphorus pesticide exposed and the unexposed mice

Enzyme	*Exposed Mean±s.d. (95% CI for mean) (n=10)*	*Unexposed Mean±s.d. (95% CI for mean) (n=10)*	*Significance* P *value*
AChE (UI/ml)	0.49±0.14 (0.39, 0.59)	0.93±0.10 (0.86, 1.00)	<0.0001
HAChE (UI/g Haem)	4.2±0.9 (3.53, 4.89)	7.4±0.9 (6.72, 8.08)	<0.0001
Haemoglobin (g/dl)	11.5±0.6 (11.07, 11.97)	12.5±0.7 (11.98, 13.07)	<0.005

Table 2 Serum markers of hepatic toxicity and hepatic function among the organophosphorus pesticide exposed and the unexposed mice

Test	*Exposed Mean±s.d. (n=10)*	*Unexposed Mean±s.d. (n=10)*	*Significance* P *value*
Alanine aminotransferase (ALT)	61.2±7.1	42.0±7.5	0.0001
Aspartate aminotransferase (AST)	203.1±19.7	160.0±16.7	0.0001
Alkaline phosphatase (AP)	61.4±17.4	55.9±9.2	NS
Gama-glutamyl transpeptidase (GGT)	7.4±0.8	7.2±0.9	NS
Albumin (Alb)	6.7±4.9	6.2±2.3	NS
Total bilirubin (TBIL)	0.4±0.8	0.6±0.7	NS
Total protein (TP)	53.0±2.3	57.8±2.4	0.0003

One way analysis of variance; NS=Not significant

Table 3 Amino acid profile among the organophosphours pesticide exposed and the unexposed mice

Amino acids	*Exposed Mean±s.d. (n=10)*	*Unexposed Mean±s.d. (n=10)*	*Percent change (%)*	*Significance* P *value*
Hydrophobic amino acids				
1 Alanine (Ala)	309.8±50.27	228.2±42.07	+35.8	0.001
2 Isoleucine (Ile)	120.5±12.1	98.4±14.4	+22.5	0.001
3 Leucine (Leu)	185.4±22.5	145.4±24.2	+27.5	0.001
4 Methionine (Met)	114.2±24.0	96.2±14.7	+18.7	0.05
5 Phenylalanine (Phe)	78.8±15.1	76.2±28.9	+3.4	NS
6 Proline (Pro)	148.4±42.1	82.8±20.5	+79.8	0.0003
7 Tryptophan (Try)	64.4±11.7	70.8±7.6	−9.0	NS
8 Tyrosine (Tyr)	99.0±30.8	83.8±24.6	+18.1	NS
9 Valine (Val)	263.8±31.2	221.6±33.6	+19.0	0.009
Hydrophilic amino acids				
10 Arginine (Arg)	178.5±45.7	153.5±60.8	+16.3	NS
11 Cystine (Cys)	18.4±10.1	37.0±4.8	−50.3	0.0001
12 Glutamine (Gln)	395.6±36.1	377.8±49.9	+4.7	NS
13 Glutamic acid (GLu)	93.9±48.0	64.2±14.4	+46.3	0.05
14 Glycine (Gly)	325.7±51.9	231.8±31.2	+40.5	0.0001
15 Histidine (His)	86.7±15.6	78.2±8.9	+10.9	NS
16 Lysine (Lys)	318.2±63.7	276.6±60.1	+15.0	NS
17 Serine (Ser)	139.6±29.1	90.8±17.9	+53.7	0.0003
18 Threonine (Thr)	212.9±41.8	139.4±21.8	+52.7	0.0001
Other amino acids				
19 Citruline (Cit)	100.2±35.1	115.4±39.5	−13.2	NS
20 Ornithine (Orn)	148.0±33.1	108.8±41.4	+36.0	0.03
21 Taurine (Tau)	230.9±64.1	247.2±25.9	−6.6	NS

One way analysis of variance; NS=Not significant mals. Of the other amino acids Orn was significantly higher among the exposed animals.

AChE and HAChE showed a significant positive correlation with Cys (0.871, $P<0.0001$) and negative correlations with Ala (-0.703, $P<0.0001$), Glu (-0.655, $P<0.001$), Gly (-0.829, $P<0.0001$), Ile (-0.574, $P<0.05$), Leu (-0.606, $P<0.05$), Orn (-0.498, $P<0.05$), Pro (-0.806, $P<0.0001$), Ser (-0.732, $P<0.0001$) and Val (-0.462, $P<0.05$). Both AChE and HAChE also showed positive correlations with ALT (0.779, $P<0.0001$), AST (0.660, $P<0.001$) and TP (0.689, $P<0.0001$). Regression analysis showed that exposure was a highly significant predictor of amino acids disorder in mice (Table 4).

Discussion

The abnormal activities of the liver enzymes and the disturbed plasma amino acid profile in the animals exposed to the mixtures of organophosphorus pesticides suggested hepatocellular dysfunction in the exposed animals. In a similar study in rats exposed to individual pesticides, Gudumak[8] described marked increases in Ser, Glu, Gly, Ala, Val, Ile, Tyr and Phe and a decrease in Cys. In the same study, reduced levels of Tau, Cys, Met, Ala and increased levels of Phe were observed in chemical plant workers who had experienced prolonged exposures to pesticides. However, the nature of exposure, both in terms of the type of pesticides and the levels of exposure, among the chemical plant workers had not been adequately defined. An epidemiological survey of rural agricultural workers by Allazov[4] reported a high incidence of infectious inflammatory lesions of the liver among those workers compared to a control population. Though exposures to pesticides were implicated in this study, the possibility of other biological toxicological agents in agriculture causing similar hepatic injury from concurrent exposures during farming existed. Hepatic dysfunction has also been reported by Kossman and Magner-Krezel[3] among workers at a pesticide manufacturing facility. Hepatocyte apoptosis has been described in animals from dietary exposure to organochlorines.[13]

Significant depletions in the AChE activity have been observed in farmworkers from long-term exposure to pesticides.[6] A similar pattern of AChE depletions has also been observed in this study from chronic exposure to mixtures of organophosphorus pesticides. A significant positive correlation between AChE, HAChE and the markers of liver function and the amino acids suggested that the abnormalities in the liver enzymes and the amino acid profile might have resulted from chronic exposures to mixtures of organophosphorus pesticides. Exposure to organophosphorus pesticides have been shown to inhibit all the cytoplasmic proteases and some of the lysosomal proteases in the liver tissue, the major site for pesticide metabolism.[14] The increase of free and branched chain amino acids could possibly be due to hepatic toxicity and increased transamination over deamination of the amino acids.[15,16] The decrease in total proteins could possibly result from decreased hepatic synthesis which could also cause reductions in the haemoglobin concentrations as observed in this study and could also have been caused by increased proteolysis.[17] It is likely that the increase in alanine and aspartate aminotransferase might have been caused by the pesticide induced stress on the liver.[18] Pesticides have been

Table 4 Regression analysis of the amino acid profile among the exposed and the unexposed mice

Amino acids	*B*	*SE B*	*Beta*	*T*	*Sig T*
1 Arginine (Arg)	−0.01275	1.6630E-09	−1.3398	−766802	0.0001
2 Alanine (Ala)	−0.00342	1.1371E-09	−0.41070	−301078	0.0001
3 Citruline (Cit)	3.61956E-04	1.7371E-09	0.026213	206145.7	0.0001
4 Cystine (Cys)	−0.05368	1.2761E-08	−1.2849	−420710	0.0001
5 Glutamine (Gln)	−8.8819E-04	1.1595E-09	−0.07513	−766000.8	0.0001
6 Glutamic acid (Glu)	−0.1680	2.9549E-09	−1.2364	−568848	0.0001
7 Glycine (Gly)	0.002135	2.4297E-09	0.265160	878702.3	0.0001
8 Histidine (His)	−0.01914	3.8366E-09	−0.48995	−498994	0.0001
9 Lysine (Lys)	0.007769	1.3610E-09	0.968137	5708255	0.0001
10 Methionine (Met)	0.026147	4.0381E-09	1.09351	6475060	0.0001
11 Ornithine (Orn)	0.001722	1.6709E-09	0.139860	1030471	0.0001
12 Phenylalanine (Phe)	0.013390	4.5722E-09	0.586990	2928550	0.0001
13 Proline (Pro)	−0.00564	2.2591E-09	−0.51253	−249828	0.0001
14 Serine (Ser)	−0.01631	5.6674E-09	−1.0926	−287943	0.0001
15 Taurine (Tau)	0.005055	1.1274E-09	0.476346	4483388	0.0001
16 Tryptophan (Try)	0.002319	6.2160E-09	0.045694	373117.3	0.0001
17 Tyrosine (Tyr)	−0.00460	3.1878E-09	−0.25361	−144583	0.0001
18 Valine (Val)	−0.01134	2.1748E-09	−0.84519	−521463	0.0001

Isoleucine (Ile), Leucine (Leu) and Threonine (Thr) were non-significantly represented in the model and were therefore not included in the equation. B, Slope of regression line; SE B, Standard error of B; Beta, Standardized regression coefficient; *t*, Student's *t*-test; *P*, Two tailed observed significance level

Fifth SETAC-Europe Congress

Copenhagen 25–28 June 1995

ENVIRONMENTAL SCIENCE
AND VULNERABLE ECOSYSTEMS

SETAC

Programme and abstract book – Contents

P206

PARITY OF MALE AND FEMALE AMONG NEWLY FORN IN RADIACTIVELY POLLUTED SIBERIAN REGIONS

Nicolai N. Ilyinskikh, E.N.Ilyinskikh, I.N.Ilyinskikh, D.P.Kudriavtsev
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The analysis of the number of newly-born boys and girls was carried out in people living in the regions affected by Semipalatinsk atomic ground and Siberian chemical combine (Tomsk-7). The data of family analysis of 325789 people living in Altai region near Semipalatinsk atomi ground were studied. The explosions on Semipalatinsk atomi ground occured from 1949 till 1962. Authentic increase of the number of girls among newly-born has been observed since 1951. This tendency finished in 1965 in mothers of large families the large part of newly-born boys was during the period till 1949. The peak of newly-born girls was observed in 1955-1961. In the region of Siberian chemical combine (Tomsk-7) the increase among newly-born girls has been marked since 1964 and this disproportion is being saved till 1994.

P207

Pattern of erythrocyte cholinesterase activity level among farm workers.

J. Gomes[1], O. Lloyd[1], M. Revitt[2], Dept. of Community Medicine, UAE University, P.O. Box 17666, UAE, [2]Middlesex University, Bounds Green, London, N11 2NQ.

Farm employees in Al-Ain, UAE, are migrant workers, most of whom had not been involved in any farming activity in their home country prior to taking up jobs in the UAE. These workers are not educated and have not been trained in the use of pesticides or in other farm practices. In this study we examined 451 farm workers engaged in crops of tomatoes, cucumbers, onions, brinjals, squash, watermelon, yellowmelon, molkia and lettuce. The farm workers were either foremen (42.8%) or farmers (57.2%). The age of the surveyed population was 34.92±7.11 years (mean±SD) and their Body Mass Index (BMI) was 24.01±2.22 (mean±SD). Five farming areas were sampled to represent the farming activity in Al-Ain The farm workers surveyed in our study comprised Bangladeshi (35.3%), Egyptians (28.2%), Indians (14.6%), Pakistanis (17.7%) and Others (Iranians, Srilankan and Syrian) (4.2%). Workers in both greenhouses (18.8%) and openfarms (81.2%) were surveyed. Greenhouses produced only tomatoes and cucumbers, whereas open farms planted whatever they chose to or the Agriculture Department offered them. Erythrocyte Acetylcholinesterase (AChE) was measured to determine the toxicity due to exposure to organophosphate, carbamate and pyrethroid insecticides. AChE activity during the farming season was 3.89±0.67 UI/ml of blood (median±SD). Haemoglobin level was 13.0±1.60 g/dL Hgb (median±SD), blood pressure was (systolic/diastolic) 117.99±7.65 / 78.45±7.92 (median±SD) and haemoglobin corrected cholinesterase was 30.0±6.06 UI/g Hgb (median±SD). AChE activity was significantly lower for the foremen (x=3.77, 95% CI=3.67 - 3.88) whose main job was handling pesticides compared to the farmers (x=4.0, 95% CI=3.93 - 4.08) who did general jobs on the farm (student's t=3.67, p=.000). Haemoglobin corrected cholinesterase was non-significantly (student's t=1.35, p=0.178) lower for the foremen (x=29.68, 95% CI=28.55 - 30.81) compared to farmers (x=30.46, 95% CI=29.95 - 30.96). The poorly controlled use of pesticides in the farms appears to have caused subclinical intoxication in the farm workers and indicates the need for training and implementation of hygiene practices.

Sixth SETAC-Europe Annual Meeting

Giardini Naxos Taormina, Sicily (Italy)
19-22 May 1996

ENVIRONMENTAL THRESHOLDS AND POLLUTANT STRESS

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Programme and abstract book

RISK ASSESSMENT AT THE FARM-SCALE: WHAT CONSTITUTES AN ECOLOGICALLY SIGNIFICANT EFFECT?

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Pesticides may cause side-effects on non-target invertebrates. These effects have been relatively well-researched in short-term studies in Europe. However, short-term studies cannot identify cumulative effects of repeated exposure to one or a number of chemicals, which may prevent recovery of the exposed populations between treatments. Therefore, studies have been conducted at larger spatial (e.g. whole farm) and longer temporal scales (e.g. over 5 years) so as to allow the consequences of pesticide applications to be determined under more agriculturally and ecologically realistic conditions. To investigate long-term effects of pesticide use at the farm-scale, the U.K. Ministry of Agriculture set up the "Boxworth" (1981-1991) and "SCARAB" (1990-1997) projects in England. The findings from both these long-term experiments revealed that intensive use of broad spectrum pesticides, especially insecticides, was harmful to non-target invertebrates. The effects included disappearance of some species in the higher pesticide treatment fields. However, these findings raise important questions, such as what constitutes an ecologically significant effect, is it important if a few species disappear in an arable ecosystem, and what factors (e.g. ecological, economic, public perception) determine the acceptability of pesticide effects? In this talk, we discuss balancing the ecological effects on non-target invertebrates with other priorities.

ORGANOHALOGEN PESTICIDE USAGE IN A DESERT COUNTRY

James Gomes[1], O Lloyd[1], M Revitt2, SV Anilal[1]; [1]Dept. of Community Medicine, UAE University, UAE, [2]Urban Pollution Research Center, Middlesex University, London, UK.

Organohalogen pesticides are known for their effectivity, but this group of pesticides persists in the environment and biota and are xenobiotic. The Clean Water Act, International Joint Commission for Great Lakes, Paris Convention, Barcelona Convention and the Rio Earth Summit have emphasized the need to reduce and wherever possible to eliminate the use of organohalogens.
Al-Ain, an oasis city in the United Arab Emirates and located on its northern border with Oman, is very green. Both ornamental and agricultural greenery is a common sight in Al-Ain and agriculture is its major industry. We analyzed the information from the Dept. of Agriculture on pesticide usage in Al-Ain from 1990 to 1994. Results indicated that the use of halogenated insecticides, fungicides and herbicides has each doubled in this period while in the same period the number of farms has increased by 18% and the total farming area has increased by 23%. The use of all halogenated pesticides has also increased by 50% in the last five years. Al-Ain being a desert country has recorded temperatures from 36.2°C ± 0.2 to 18.0°C ± 0.9, relative humidity from 65.8% ± 7.5 to 33.3% ± 5.7 and wind-speed from 10.7m/sec ± 6.5 to 3.8m/sec ± 0.8. Annual rainfall ranged from 10 mm to 20 mm during this period.
The amount of halogenated pesticides partitioned to the atmosphere is high due to climatic conditions and these pesticides reside in the environment for a long period due to lack of any cleansing processes. The high residence time of halogenated pesticides could potentially increase the exposure among the non-target human population. Increased exposure increases the risk in susceptible sections of the population viz. children and expecting mothers.

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CANADA

Book of Abstracts

P 169 CANCER IN AGRICULTURAL SETTLEMENTS (KIBBUTZIM); PRELIMINARY REPORT

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Background. Two kibbutzim (A and B) in the Negev (South) of Israel, with apparent cancer increases were compared in a case-referent study with two nearby kibbutzim, (C) with no apparent increased incidence of cancer. Expected age-sex specific cancer incidence from the Israel Cancer Registry, was compared with the incidence based on a preliminary questionnaire. In Kibbutz A, Obs\Exp ratios were 17\12.7; in B, 7\8.0, and in C, 9\8.9. At ages 0-39, A had significant excess (7/1.6), and in all three, percent of lymphoproliferative CA was 28.2%, significantly ($p<0.001$) more than the 7.1% for all Israeli Jews.
Methods. A detailed questionnaire on demography,exposure, and health was prepared and tested. One comparison subject was drawn for the same kibbutz and a second from population C. Thirty-two cases and 64 referents had completed interviews. Analyses used Chi square with correction or Fisher exact test.
Results. Case-referents on the same kibbutz show non-significant odds ratio (OR) of about three for orchard work and about 9 for early age of orchard work; for both referents, pipe smoking OR = 2.3-2.7 (nonsig). For A and B compared to C, referents number of identified chemical exposures was significantly elevated. Cases from C for which referents were taken from A or B, show an OR of 21 ($p=0.02$) for orchard work. Each kibbutz has its own industrial facility, and as numbers of cases are small, specific agent exposures estimates may be seriously biassed.
Conclusions. Cancer excess at young ages in A is confirmed and overall lymphoproliferative cancer increase is found. Orchard work and industrial chemical exposures seem involved.

P 170 REPRODUCTIVE HEALTH IN A GROUP OF PESTICIDE APPLICATORS: PRELIMINARY OBSERVATIONS.

PETRELLI G*, TRAINA ME*, MUCCI N**, TROPEANO R*, PASQUALI M*, SIEPI G*, URBANI E*, CINI C***, FIGÀ-TALAMANCA I***. *Istituto Superiore di Sanità Rome; **Istituto Superiore per la Prevenzione e Sicurezza del Lavoro, Rome; ***University of Rome "La Sapienza", Italy.

Experimental data suggest that pesticides can affect the male reproductive system (MRS). However, their possible impact on human male fertility is still largely unknown.
The aim of this study is to identify the presence of active ingredients (A.I.) with possible adverse effects on MRS among the pesticides used for disinfestation and verify their possible impact on the fertility of occupationally exposed men. The information on male fertility has been collected by an "ad hoc" questionnaire, including detailed data on occupational history of pesticide exposure and on reproductive history to evaluate the time to pregnancy. A pilot study to assess the questionnaire has been conducted on 33 workers, with a mean age of 55 years and 21 years mean work exposure. The toxicological examination of the pesticides used by these workers highlights the presence of 4 A.I. with irreversible effects (carcinogenic and genotoxic) and 3 with adverse effects on reproduction as assessed by some national and international scientific organizations. In particular, warfarin has been allocated by the EU in category 1, with the risk phrase "R 61, may cause harm to the unborn child".
Due to the small group of workers, the time to pregnancy has not been evaluated. However, the present questionnaire appears to be suitable for this study since it allowed us to perform some preliminary observations. All the workers interviewed have children and 42% of them have declared at least one miscarriage by their partner. These miscarriages represent 27% of the total pregnancies. These observations suggest that more attention should be paid to the reproductive outcomes and not only to male fertility effects.

P 171 MORBIDITY IN FARM WORKERS FROM CHRONIC EXPOSURE TO PESTICIDES

GOMES J*, LLOYD O*, PUGH RNH*, REVITT M**, BASHA M***. *Dept. of Community Medicine, Faculty of Medicine & Health Sciences, UAE University, UAE; **Urban Pollution Research Center; Middlesex University, London UK; ***Preventive Medicine Dept., Ministry of Health, UAE.

A general health survey was carried out among three sets of expatriate male workers in Al-Ain, an oasis city, to determine the health impact from chronic [often excessive] occupational exposure to a variety of pesticides. The study population included farmers who had worked on farms for at least two years (36.5%), new-farmers who had just been hired from overseas to work on the farms (18.4%) and controls (45.1%). Mean systolic and diastolic blood pressures in the farmers were statistically significantly higher compared to new-farmers and controls ($p<0.05$ for systolic and diastolic blood pressure). Body mass index was in the desirable range (WHO classification) in all three groups; but within the groups, controls had the highest mean followed by farmers and new-farmers.
Acetylcholinesterase activity and haemoglobin adjusted acetylcholinesterase activity were significantly lower among farmers compared to the other two groups ($p<0.0001$ for both acetylcholinesterase and haemoglobin adjusted cholinesterase).
The aiming-test scores for the farmers were less than one-third the scores for the controls and were also significantly less than the scores for the new-farmers. The digit symbol test results were similar with farmers sconng significantly less than controls but higher than new farmers. Highly significant differences were observed among the three sets of workers for pain in the chest, irritated conjunctiva, dizziness, headache, loss of muscle strength, running nose, abdominal pain, wheezy chest, chest tightness, general weakness or fatigue and watery eyes.

P 172 EFFECT OF EXPOSURE TO DDVP ON LUNG FUNCTION, SERUM BIOCHEMISTRY AND IMMUNE INDICES IN PESTICIDE MANUFACTURING WORKERS

HU ZL, TANG GF. Department of Labour Hygiene and Occupational Disease, Anhui Medical University, Hefei, 230032, Anhui, China.

Background. That organophosphoric pesticides may inhibit cholinesterase (ChE) is well known. However, other possible effects have not been studied.
Methods. Lung function, serum ChE, alkaline phosphatase (AKP), and IgM were determined in 47 workers (m:25, f:22) who were exposed to DDVP at a concentration of 1-4 mg/m^3 in a pesticide factory as well as in 46 administrators of the same factory (control A), and in 30 workers of an electric motor factory (control B).
Results. Serum ChE level was lower in the exposed group (2.75 $\pm$ 0.42 mol/0.02 mL) than in control A (3.11 $\pm$ 0.20 mol/0.02 mL), $p<0.05$. FEV1 and FEF 25-75% (values of O/E%) were 83.4 $\pm$ 14.5% and 76.3 $\pm$ 21.2% in the exposed group, being lower than 89.4 $\pm$ 7.0% and 86.5 $\pm$ 14.4% control A, all $p<0.05$. The observed values of FEV1 and FEF 25-75% in the exposed group, were 2.70 $\pm$ 0.65 L/S and 2.62 $\pm$ 0.89 L/S immediately after workshift being significantly lower than those (2.91 $\pm$ 0.63, and 2.83 $\pm$ 0.97 L/S, all $p<0.01$) before working. However, there was no significant change of FEV1 and FEF 25-75% before and after workshift in control B. Serum total cholesterol level was 142.5 $\pm$ 30.3 mg% in the exposed group, being lower than 166.2 $\pm$ 65.2 mg% in control A ($p<0.05$). However, serum AKP and IgM in the exposed group (8.96 $\pm$ 2.43 and 2.13 $\pm$ 0.11 mg/mL) were significantly higher than those in control A (7.62 $\pm$ 2.46 and 1.79 $\pm$ 0.09 mg/mL, all $p<0.05$).
Conclusions. Low-level occupational exposure to DDVP, in addition to the inhibition of ChE, might influence lung function and other biochemical parameters.

FOURTH INTERNATIONAL SYMPOSIUM

"RURAL HEALTH AND SAFETY IN A CHANGING WORLD"

BOOK of ABSTRACTS

the centre for Agricultural Medicine

UNIVERSITY OF SASKATCHEWAN

October 18 - 22, 1998

Saskatoon, Canada

Appendix 8

REPRODUCTIVE TOXICITY FROM ORGANOPHOSPHORUS PESTICIDES I: LOW BIRTH WEIGHT. Gomes J, Revitt DM, Padmanaban R, Anilal SV, Lloyd O. Faculty of Medicine, UAE University, Dept. of Community Medicine, Faculty of Medicine, P. O. Box 17666, Al-Ain, UAE.

Objectives: The reproductive outcome in mouse dams exposed to a mixture of six organophosphorus pesticides most widely used in agriculture.
Methods: Pregnant laboratory mice (TO) strain were given a specifically prepared mixture of organophosphates in corn oil by gavage on either the seventh or the eighth day of pregnancy. Food and water were provided ad libitum until the eighteenth day, when they were culled, live embryos were collected, counted and weighed and the number of resorptions were recorded. The exposed group was compared with the control (corn oil) and reference group.
Results: Dams exposed to low dose (3%LD50) or high dose (30%LD50) either on the seventh or the eighth day of pregnancy gained less weight during pregnancy, but had significantly higher implantations and resorptions and the fetal weight of live embryos was significantly reduced. Low dose exposure on the seventh day of pregnancy led to significantly lower weight gain during pregnancy, but the numbers of implantations, live fetuses and resorptions were significantly higher and the fetal weights were significantly lower. There were no changes in these observations for low dose exposure on the eighth day. High dose exposure on the seventh or eighth day produced similar results but that no increase or decrease in the number of implantations and live embryos per litter.
Conclusions: At low dose exposure significant increases in the litter size and resorptions were observed. Significant decreases in the fetal weights and maternal weight gains were observed at low and high dose exposures.

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Appendix 9

07.

REPRODUCTIVE TOXICITY FROM ORGANOPHOSPHORUS PESTICIDES II: CONGENITAL MALFORMATIONS. Gomes J, Lloyd O, Padmanaban R, Anilal SV, Revitt DM. Faculty of Medicine, UAE University, Dept.of Community Medicine, Faculty of Medicine, P. O. Box 17666, Al-Ain, UAE.

Objectives: The pattern of congenital malformations in mouse embryos from maternal exposure to organophosphorus pesticides most commonly used in local agriculture.

Methods: Pregnant dams were given a specifically prepared mixture of six organophosphates in corn oil by gavage on the seventh or eighth day of their pregnancy. Embryos were collected, sized, sexed and preserved for anatomical observations of the head, ears, eyes, tongue, upper and lower jaws, front and hind limbs, gastro-intestinal tract and tail.

Resutlts: Maternal low dose (3%LD50) exposure on day seven of pregnancy induced significantly hgiher incidences of low set microtia, proturuding tongue, maxillary and mandibular hypoplasia and stunted growth in the embryos. For the eighth day of exposure the pattern was the same except for the low set microtia. High dose (30%LD50) exposure on day seven resulted in a significantly higher incidences of low set microtia, exopthalmia, protruding tongue, maxillary and mandibular hypoplasia, stunted growth and two cases of exomphalos and three cases of intra-ventral septal defects (IVSD). High dose exposure on day eight produced the same pattern, but no cases of exomphalos embryos but two cases of IVSD.

Conclusions: Significant increases in the incidences of congenital malformations from exposure to cholinesterase inhibiting pesticides were observed. Intestinal and heart defects were observed only at high-dose exposures.

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Appendix 10

HEPATIC INJURY AND DISTURBED AMINO ACID METABOLISM FOLLOWING PROLONGED EXPOSURE TO PESTICIDES. Gomes J, Dawodu AH, Lloyd O, Revitt DM, Anilal SV. Faculty of Medicine, UAE University, Dept. of Community Medicine, Faculty of Medicine, P. O. Box 17666, Al-Ain, UAE.

Objectives: Low dose chronic occupational exposure to organophosphorus pesticides causes general malaise. This study on mice was designed to evaluate the amino acid profile and identify hepatic toxicity which could be induced by chronic exposure to organophophorus.

Methods: Laboratory mice were exposed to a formulated mixture of six organophosphates most commonly used in agriculture in this region. Doses were given once a week by gavage in corn oil; control group was given only corn oil. At the end of a seven week exposure period, mice were culled and blood samples were collected to determine erythrocyte acetylcholinesterase activity, biochemical markers of liver function and serum amino acids concentrations.

Results: Erythrocyte acetylcholinesterase activity and total serum proteins decreased significantly in the exposed group. Serum concentrations of alanine and aspartate aminotranferases, alanine, glutamic acid, glycine, isoleucine, leucine, methionine, ornithine, proline, serine, threonine, and valine increased significantly, while serum concentrations of cystine decreased significantly in the exposed mice. There was a non-significant increase in serum alkaline phosphatase and gama-glutamyl transpeptidase.

Conclusions: Chronic exposure to organophosphates inhibited acetylcholinesterase activity and adversely affected the liver function. Biochemical indices of hepatocellular injury and disturbed amino acid metabolism could serve as markers of chronic exposure to organophosphorus pesticides.

Department of Community Medicine

Public Health & Occupational Medicine
Faculty of Medicine & Health Sciences
United Arab Emirates University

Research & Development Programme
January - March 1995

8th. Seminar

Entitled

" Impact of Halogenated Organocompounds on Animal & Human Health"

by

Mr. James Gomes,
Dept. of Community Medicine

at

The Bin Ham Main Conference Room

Monday, 13th Mar. 1995
1300 - 1400 P.M.

All Are Welcome

Faculty of Medicine & Health Sciences,
Dept. of Public Health & Occupational Medicine

Faculty of Agricultural Sciences
Dept. of Food Sciences & Nutrition
Dept. of Plant Production

Project: **Occupational health and safety practices on the farm.**
Data collection format for the occupational health and safety practices by the management of the site.

I. Information by the management (Foreman / Supervisor) **Serial No. ________**

Foreman / Supervisor

A) Nationality of the Foreman: ____________________

B) Is the foreman a paid employee or a investor in the farm: ______ **(1. Yes 0. No)**

C) Who makes decisions on the crops and chemicals used: ____________
1. Foreman 2. Others: ______________________________ *(specify)*

D) Is the foreman trained in the use of agrichemicals:_____ **(1. Yes 0. No)**

E) If yes specify where he is trained:_________
1. MOH of UAE 2. MOA of UAE 3. Outside UAE 4. Other : ________________ *(specify)*.

II. Information on the site

1. Location of the site: ___________________________ *(give the name of the area)*

1.1 Identification name of the farm: ____________________

2. Type of site: ________________
1. Greenhouse 2. Open farm 3. Preparation center

3. Name the activities of the site: ______________
1. Crop production 2. Nursery 3. Preparation of organic chemicals for use
4. Others *(specify)*: _______________

4. No. of full time employees at the site ____________ *(give total number working full time)*

5. No.of part time employees at the site ________ *(give number of part time/daily wagers)*

6. If crop production is the main job at the site name all the produce during the last two years:

Crops produced during the last two years

6.1 Winter : 1. ________________ 2. ________________ 3. ________________
September. - April
4. ________________ 5. ________________ 6. ________________

7. ________________ 8. ________________ 9. ________________

6.2 Summer: 1. ________________ 2. ________________ 3. ________________
May - August
4. ________________ 5. ________________ 6. ________________

7. ________________ 8. ________________ 9. ________________

7. If crop production is the main job at the site:
Name all chemicals used for plant protection and for ensuring good yields:

Type of crop	Chemicals used	Dilution ratio	Method of use	Qty used /week	No. of times / week	Qty. prepared	Qty. used
7.1 ______	______	______	______	______	______	______	______
7.2 ______	______	______	______	______	______	______	______
7.3 ______	______	______	______	______	______	______	______
7.4 ______	______	______	______	______	______	______	______
7.5 ______	______	______	______	______	______	______	______
7.6 ______	______	______	______	______	______	______	______
7.7 ______	______	______	______	______	______	______	______
7.8 ______	______	______	______	______	______	______	______
7.9 ______	______	______	______	______	______	______	______

Notes: Comments on the general state of the farm, technology used at the farm.

8. If preparation of organic chemicals is the main job at the site:
Name all the end chemicals prepared, the solvent used and loaded into:

	Chemical	Solvent used	Dilution ratio	Qty prepared	Loaded into
8.1	________	________	________	______	________
8.2	________	________	________	______	________
8.3	________	________	________	______	________
8.4	________	________	________	______	________
8.5	________	________	________	______	________
8.6	________	________	________	______	________

8.7 Frequency of use of public health chemicals to control pests.

	Time	Chemicals used / No of times		
8.7.1	1st Quarter	____________	____________	____________
8.7.2	2nd Quarter	____________	____________	____________
8.7.3	3rd Quarter	____________	____________	____________
8.7.4	4th Quarter	____________	____________	____________

III. Use of chemicals

9. How are the chemicals transported to the farm: ______
1. In farm car 2. Dealer transports 3. Ministry transports 4. Other: ______

10. Who is assigned to receive and store the chemicals at the site: ______
1.One of the workers identified for this job 2. Anybody on site 3. Other: ______

11. Who trains personnel on handling stock chemicals: ______
1. Foreman 2. Ministry personnel 3. Nobody 4. Other: ______

12. Is preparation of chemicals done by: **(1. Yes 0. No)**
12.1 Personnel kept aside specifically for this task _____
12.2 Anybody available on the site _____
12.3 Personnel is hired only for this job when required _____
12.4 Other (*specify*): ________________________

13. Is spraying of chemicals done by: **(1. Yes 0. No)**
13.1 Personnel kept aside specifically for this task _____
13.2 Anybody available on the site _____
13.3 Personnel is hired only for this job when required _____
13.4 Other (*specify*): ________________________

14. Is personal protective equipment available on site: *(management will be asked to show it)*

1. Always (90 - 100%) 2.Usually (50 - 90%) 3. Often (10 - 50%) 4. Never (<10%)

14.1 Overalls ____
14.2 Scarf ____
14.3 Hat ____
14.4 Shoes ____
14.5 Face mask ____ give type: ____________________ *(give commercial name)*
14.6 Gloves ____ give type: ____________________ *(give commercial name)*
14.7 Apron ____ give type: ____________________ *(give commercial name)*
14.8 Goggles ____
14.9 Other ____

15. Is personal protective equipment utilised when preparing/using the chemicals:

1. Always (90 - 100%) 2.Usually (50 - 90%) 3. Often (10 - 50%) 4. Never (<10%)

15.1 Overalls ____
15.2 Scarf ____
15.3 Hat ____
15.4 Shoes ____
15.5 Face mask ____ give type: ____________________ *(give commercial name)*
15.6 Gloves ____ give type: ____________________ *(give commercial name)*
15.7 Apron ____ give type: ____________________ *(give commercial name)*
15.8 Goggles ____
15.9 Other ____

16. Do you use the following personal hygiene practices:

1. Always (90 - 100%) 2.Usually (50 - 90%) 3. Often (10 - 50%) 4. Never (<10%)

16.1 Take shower after work ____
16.2 Change clothes after work ____
16.3 Wash after work ____
16.4 Eat during work ____
16.5 Smoke during work ____
16.6 Drink during work ____

17. Where do you prepare the chemicals to be used in the field: **(1. Yes 0. No)**

17.1 In a closed room ____
17.2 In an open area ____
17.3 On the patio ____
17.4 Other (specify): ____________________

18. If the chemicals are prepared in a closed room, does it have: **(1. Yes 0. No)**

18.1 A working exhaust fan ____
18.2 Doors and/or windows diametrically opposite ____
18.3 Other *(specify)* ____________________

19. Where are the stock chemicals stored? **(1. Yes 0. No)**

19.1 In the same room as the people ____
19.2 In a separate room adjoining the living area ____
19.3 In an isolated room ____
19.4 On the patio ____
19.5 Other (specify): ____________________

20. How are the spent packing materials disposed off ? **(1. Yes 0. No)**
20.1 Throwing away on the farm _____
20.2 Throwing away in the home garbage _____
20.3 Discarding into garbage after packing in garbage bags _____
20.4 Other (*specify*) ________________

21. How are the unused chemicals disposed off? **(1. Yes 0. No)**
21.1 Spraying repeatedly on the farm ______
21.2 Discarding on the farm ______
21.3 Pouring in the sewage in the farm ______
21.4 Keep it for future use in the store ______
21.5 Else *(specify)* ____________________________

22. Are all the articles used in preparing the chemicals: **(1. Yes 0. No)**
22.1 Kept only for this work ______
22.2 Washed and used at home ______
22.3 Used at home if needed ______
22.4 Other (*specify*): _______________

23. What are the sources of water for use at the site for agricultural purposes? **(1. Yes 0. No)**
23.1 Local well _____
23.2 Recycled sewage _____
23.3 Fountain water _____
23.4 Desalinated water _____
23.5 Other (*specify*) ________________

24. What are the sources of water for use at the site for cooking/drinking purposes: **(1. Yes 0. No)**
24.1 Local well _____
24.2 Recycled sewage _____
24.3 Fountain water _____
24.4 Desalinated water _____
24.5 Other (*specify*) ________________

25. Who provides special training in preparation of chemicals: **(1. Yes 0. No)**
25.1 Foreman of the farm ______
25.2 People from the ministry ______
25.3 Other *(specify)* ___________________
25.4 Not applicable ______

26. Who provides special training in application of chemicals: **(1. Yes 0. No)**
26.1 Foreman of the farm ______
26.2 People from the ministry ______
26.3 Other *(specify)* ____________________
26.4 Not applicable ______

27. Is any advice provided in choosing the chemicals for use? **(1. Yes 0. No)**
27.1 By the ministry _____
27.2 By the municipality ______
27.3 By the company selling the chemicals ______
27.4 Other (*specify*): _____________________

28. Is training provided in the selection and method of use of chemicals? **(1. Yes 0. No)**
28.1 By the ministry _____
28.2 By the municipality ______
28.3 By the company selling the chemicals ______
28.4 Other (*specify*): ______________________

29. Is information on safety and hazard provided on the use of chemicals by: **(1. Yes 0. No)**
29.1 Ministry of Health _____
29.2 Ministry of Agriculture _____
29.3 Preventive Medicine _____
29.4 Others (specify): ______________________

Faculty of Medicine & Health Sciences,
Dept. of Public Health & Occupational Medicine

Faculty of Agriculture
Dept. of Food Sciences & Nutrition
Dept. of Plant Production

Project: Occupational health and safety practices on the farm.

Data collection format for the occupationally exposed **Serial No.** ________
This will be an interviewer administered questionnaire to the individual workers.

Farmers / Farm workers

1. Location of the site of work: __________________________ (*give the name of the area*)

1.1 Identification name of the farm: ______________________

2. Type of farm: (**1. Yes** **0. No**)
2.1 Greenhouse _____
2.2 Open farm _____
2.3 Public health _____
2.4 Others (*specify*) _______________

3. Name of the worker: ___________________________________

4. Nationality: ________________ Age: ______

5. Education: _________ *(indicate the highest level achieved)*
1. Primary 2. Secondary 3. High school 4. Graduate 5. Post-graduate

6. Total length of service in the present job: _______ (*write number of completed years*)

7. Total lengths of service previously in similar jobs: ______ (*write number of completed years*).

8. What type of jobs do you carry out at the farm?
1. Always (90 - 100%) **2.Usually (50 - 90%)** **3. Often (10 - 50%)** **4. Never (<10%)**

8.1 Applicator of chemicals (knapsack) _____

8.2 Applicator of chemicals (tractor) _____

8.3 Preparation/loader _____

8.4 Greenhouse sprayer _____

8.5 Vector control operator _____

8.6 Harvesting the crop _____

8.7 Greenhouse picker _____

8.8 General works on the farm _____

9. Are you are involved in the preparation of chemicals? _____ (1. Yes 0. No)

10. If yes, give details of the chemicals and solvents used, else go to question 14:

	Chemical (Active Ing.) used	Dilution ratio	Method of use	No. of times / week	Qty. used / week
10.1	_______	_______	_______	_______	_______
10.2	_______	_______	_______	_______	_______
10.3	_______	_______	_______	_______	_______
10.4	_______	_______	_______	_______	_______

11. Where do you prepare the chemicals for use? (1. Yes 0. No)
11.1 In a closed room _____
11.2 In an open room _____
11.3 On the patio _____
11.4 Other (*specify*) _______________

12. How are the used packing materials disposed off ? (1. Yes 0. No)
12.1 By throwing away in the farm _____
12.2 By throwing away in the home garbage _____
12.3 By discarding into garbage after packing in garbage bags _____
12.4 Other (specify) _______________

13. Are all the articles used in preparing the chemicals ? (1. Yes 0. No)
13.1 Kept only for this work _____
13.2 Washed and used at home _____
13.3 Used at home if needed _____
13.4 Other (specify): _______________

14. How many cigarettes do you smoke each day while at work? _____ (*write 99 if a non-smoker*)

15. For how long you have been smoking? _____ (*give completed years*).

16. Alcohol consumption: _______________________
(*give details of beers/hard liqour/wine consumed during the week*)

17. What is the frequency of your alcohol consumption? _____
1. Daily 2. 3 times a week 3. 1-2 times a week
4. Not applicable.

18. What are the sources of water for drinking and cooking purposes? (1. Yes 0. No)
18.1 Local well _____
18.2 Recycled sewage _____
18.3 Fountain water _____
18.4 Desalinated water _____
18.5 Other (*specify*): _______________

19. Personal consumption of produce from the farm:

	Produce	Quantity per week	Cooked / Uncooked
19.1	________	________	________
19.2	________	________	________
19.3	________	________	________
19.4	________	________	________
19.5	________	________	________

20. Do you use any of the following personal protective equipment when working at the farm?
1. Always (90 - 100%) 2.Usually (50 - 90%) 3. Often (10 - 50%) 4. Never (<10%)

20.1 Overalls ____
20.2 Scarf ____
20.3 Hat ____
20.4 Shoes ____
20.5 Face mask ____ give type used ________________ (*give commercial name*)
20.6 Gloves ____ give type used ________________ (*give commercial name*)
20.7 Apron ____ give type used ________________ (*give commercial name*)
20.8 Goggles ____
20.9 Others ________________

21. Do you follow any of the following personal hygiene practices?
1. Always (90 - 100%) 2.Usually (50 - 90%) 3. Often (10 - 50%) 4. Never (<10%)

21.1 Take shower after work ____
21.2 Change clothes after work ____
21.3 Wash after work ____
21.4 Eat during work ____
21.5 Smoke during work ____
21.6 Drink during work ____

22. Have you received special training in personal hygiene from? **(1. Yes 0. No)**

22.1. Ministry of Health ____
22.2. Ministry of Agriculture ____
22.3. Local Municipality ____
22.4. Social worker ____
22.5. Other (*specify*) ________________

23. Have you suffered intoxication from chemicals while at work? ____ **(1.Yes 0. No)**

24. If yes
24.1 Have you been admitted to hospital ?____ **(1. Yes 0. No)**
24.2 Have you been released from work ?____ **(1. Yes 0. No)**

Enzyme determinations:

Cholinesterase: (U/ml blood) ________ ________ (% Normal)

Hemoglobin: (g/dl Hgb) ________ ________ (% Normal)

Hemoglobin corrected cholinesterase (U/g Hgb) ________ ________(% Normal)

Plasma cholinesterase (U/ml blood) ________ ________ (% Normal)

Pesticides used in the production of vegetable crops in the five farming areas in Al-Ain, 1994-95.

Trade Name	Common Name	Group Name	Number of farms using it	Amount used g / 2 weeks
Acrelate Forte (1)	Endothal sodium	Cyclohexane 1,2-dicarboxylic acid herbicide	75	1,532.80
Aflix (2)	Formothion	Organophosphate insecticide, ChE	28	432.40
Afugan (3)	Pyrazophos	Organophosphate fungicide	39	749.60
Airone (4)	Propineb	Carbamate fungicide	71	1,874.80
Antracol (5)	Propineb	Propylenebis(dithiocarbonate) fungicide	5	160.80
Applaud (6)	Buprofezin	Thiadiazine insect growth regulator	74	1,778.40
Actellic (51)	Pirimiphos methyl	Organophosphate insecticide, ChE	51	1,187.20
Action 51 (52)	Penthoate Cypermethrin		8	138.80
Acrex super (84)	Dinobuton	Dinobuton	1	14.40
Afitox AD (120)	Dimethoate 30% Acephate 10%	Organophosphate insecticide, ChE Organophosphate insecticide, ChE	2	36.80
Apportafung (122)			1	19.20
Alternil (143)	Chlorothalonil		1	24.00
Aracusan (146)	Copper oxychloride Zineb		2	
Bactucide (7)	Bacillus thuringiensis	Bacterial insecticide	10	176.00
Baythroid (8)	Cyfluthrin	Pyrethroid insecticide	75	1,518.00
Benlate (9)	Benomyl	Benzimidazole fungicide	9	259.20
Benomyl (10)	Benomyl	Benzimidazole fungicide	6	87.36
Bavistin (53)	Carbendazim phosphate	Benzimidazole fungicide	20	683.20
Bromopropylate (79)	Bromopropylate	Benzilate acaricide	1	16.80
Banrot (88)	Thiophanate-methyl Etridiazole	o-Phenylenebis (thioallophanate) fungicide 1,2,4-thiodiazole fungicide	1	12.00
Basta (109)	Glufosinate	Phosphinic acid herbicide	1	14.40

continued on the next page

Trade Name	Common Name	Group Name	Number of farms using it	Amount used g / 2 weeks
Bordeux (144)			1	4.80
Brimosal (149)			1	12.80
Brimocal (150)			1	12.80
Cidial Oil (11)	Phenthoate 5%	Organophosphate insecticide, ChE	2	43.20
Cupertine Super (12)	Copper sulphate Cymoxanil		4	65.60
Calixin (81)	Tridemorph	Morphiline fungicide	1	16.00
Cryptonol (112)	Potassium hydroxyquinoline sulphate	Hydroxyquinoline fungicide	7	156.80
Cuproxat (125)			1	12.00
Cuprosan (127)	Pyrifenox	Oxime fungicide	1	25.60
Cyperkill (128)	Cypermethrin	Pyrethroid insecticide	1	16.00
Cymbush (133)	Cypermethrin	Pyrethroid insecticide	1	19.20
Citowet (137)	Alkylaryl polyglycol ether		1	16.00
Cimatox (141)			1	9.60
Captan (147)			1	16.00
Delfin (13)	Bacillus thuringiensis	Bacterial insecticide	1	9.60
Dimilin (14)	Diflubenzuron	Benzoylurea insecticide, Chitin synthesis	25	735.60
Dipel Up (15)	Bacillus thuringiensis	Bacterial insecticide	19	334.40
Dursban (16)	Chlorpyriphos	Organophosphate insecticide, ChE	63	1,331.60
Dimethoate (54)	Dimethoate	Organophosphate insecticide, ChE	1	16.00
Dithane (55)	Mancozeb	Ethylenebis(dithiocarbamate) fungicide	1	32.00
Dacutrin (74)			1	4.50
Dicopaz (83)			2	43.20
Dinobuton (48)	Dinobuton	Dinobuton	1	28.80
Demecor (93)			5	104.80
Daconil (98)	Chlorothalomil	Chlorophenyl fungicide	1	24.00

continued on the next page

Trade Name	Common Name	Group Name	Number of farms using it	Amount used g / 2 weeks
Dimenox (100)	Phosphamidon	Organophosphate insecticide, ChE	1	16.00
Daskor (101)	Cypermethrin	Synthetic pyrethroid	1	24.00
Dantox hyperkill (117)	Dimethoate 40% Cypermethrin 5%	Organophosphate insecticide, ChE Pyrethroid insecticide	1	16.00
Dicofol (118)	Dicofol	Organochlorine acaricide	2	36.00
Evisect (17)	Thiocyclam 50%	Thiocyclam hydrogen oxalate	6	86.40
Euparen (56)	Dichlofluanid	Sulfamide fungicide	3	132.00
Enduro (105)			2	40.00
Ekalux (107)	Quinalphos	Organophosphate insecticide, ChE	1	48.00
Ferrous Shellat (18)			1	19.20
Fensyp (73)			1	74.40
Fencep (95)			1	50.00
Gallent (106)	Haloxyfop	(2,4-aryloxyphenoxy) alkanoic acid	1	20.00
Galben (113)	Benalaxyl	Acylalaninne fungicide	6	119.20
Gamaxene (140)			1	20.00
Hostathion (19)	Triazophos	Organophosphate insecticide, ChE	39	922.00
Hostaquick (57)	Heptenophos	Organophosphate insecticide, ChE	18	920.00
Hyspray (132)			4	82.40
Insegar (20)	Fenoxycarb 25%	Carbamate insecticide	12	211.36
Irol (136)	Nonyl phenol		2	52.00
Karate (21)	Lambda-cyhalothrin	Pyrethroid insecticide	134	3,213.60
Karphos (58)	Isoxathion	Organophosphate insecticide, ChE	1	19.20
KT22 (59)	Dicofol Tetradifon	Organochlorine acaricide Bridged diphenyl acaricide	15	412.40

continued on the next page

Trade Name	Common Name	Group Name	Number of farms using it	Amount used g / 2 weeks
Kumulus (116)	Sulphur	Inorganic sulphur	1	16.00
KT27 (129)	Dicofol Tetradifon	Organochlorine acaricide Bridged diphenyl acaricide	1	12.00
Knox out (145)	Diazinon		2	36.00
Lannate (22)	Methomyl	Carbamoyloxime insecticide, ChE	26	513.60
Laitri (130)	Dicofol 250g Dinocap 120g Tetradifon 90g	Organochlorine acaricide Dinitrophenyl acaricide & fungicide Bridged diphenyl acaricide	1	10.00
Malathion (23)	Malathion	Organophosphate insecticide, ChE	8	115.60
Marshal (24)	Carbosulfan	Carbamate insecticide, ChE	40	980.80
Metofan (60)			2	26.00
Murfotox (61)	Mecarbam	Organophosphate insecticide, ChE	1	16.00
Murfothrin (62)	Mecarbam Cypermethrin	Organophosphate insecticide, ChE Pyrethroid insecticide	11	214.40
Methamidophos (80)	Methamidophos	Organophosphate insecticide, ChE	1	20.00
Methomyl (85)	Methomyl	Carbamoyloxime insecticide, ChE	1	7.20
Mancarb Plus (87)	Maneb Carbendazime Chlorothalonil	Ethylenebis(dithiocarbamate) fungicide Benzimidazole fungicide Chlorophenyl fungicide	8	146.40
Methyl bromide (97)	Methyl bromide	Alkyl halide nematicide	2	25.60
Microzul (99)	Chlorophacinone	2(p-chlorophenyl) phenylacetyl 1,3-indandione rodenticide	1	11.20
Mitac 20 (104)	Amitraz	Amidine insecticide and acaricide	4	106.40
Metasystox (115)	Demeton-S-methyl	Organphsphate insecticide	1	20.00
Mitigan Mix (124)	Dicofol	Organochlorine acaricide	1	16.00
Metendox (126)	Endosulfan Methomyl		3	55.20

continued on the next page

Trade Name	Common Name	Group Name	Number of farms using it	Amount used g / 2 weeks
Neoron (25)	Bromopropylate	Benzilate acaricide	72	1,858.00
Nissorun (26)	Hexythiazox	Isothiazolidinone acaricide	33	697.60
Nomolt (27)	Teflubenzuron	Benzylurea insecticide, Chitin synthesis inhibitor	23	371.20
Numolt (63)	Teflubenzuron	Benzylurea insecticide, Chitin synthesis inhibitor	1	10.0
Neotox (82)			1	16.00
Nabu (94)	Sethoxydim	Oxime herbicide, Mitosis inhibitor	4	60.00
Nogos (102)	Dichlorvos	Organophosphate insecticide	3	64.80
Nemamort (119)	DCIP	Chloroalkyl ether nematicide	7	140.00
Nutrain (135)	Methyl diethyl phenyl metoxylate alaninate		1	40.00
Novistin (152)			1	16.00
Ofunack (64)	Pyridaphenthion	Organophsphate insecticide	2	41.60
Omite (72)	Propargite	Sulfite acaricide	8	108.00
Pillaron (28)	Methamidophos	Organophosphate insecticide, ChE	8	206.40
Pirimor (29)	Primicarb	Dimethylcarbamate insecticide,ChE	18	371.60
Polyram (30)	Metiram	Ethylenebis(dithiocarbamate) fungicide	21	
Polytrin (31)	Profenphos Cypermethrin	Pyrethroid insecticide	42	740.40
Prevex (32)	Propamocarb hydrochloride	Carbamate insecticide	7	216.00
Previcur (33)	Prothiocarb	Carbamate insecticide	1	10.0
Perimicid (65)			10	192.00
Padan (71)	Cartap hydrochloride	Nereistoxin analogue insecticide	1	24.00
Peropal (86)	Azocyclotin	Organotin acaricide	1	12.00
Perfekthion (90)	Dimethoate	Organophosphate insecticide	2	32.00
Payrofan (103)			1	9.60
Perifix (111)			1	20.00

continued on the next page

Trade Name	Common Name	Group Name	Number of farms using it	Amount used g / 2 weeks
Predex DM (131)	Dichlorvos Malathion	Organophosphate insecticide Organophosphate insecticide, ChE	1	10.0
Remiltine (34)	Cymoxanil Mancozeb Manganese		7	135.20
Ridomil (35)	Metalaxyl	Acylalanine fungicide	64	1,838.80
Rizolex T (36)	Tolclofos-methyl	Organophosphate insecticide	21	542.00
Rolfan (66)			4	64.80
Ronilan (75)	Vinclozolin	3,5-dichloroanilide fungicide	2	10.40
Rovral (77)	Iprodione	3,5-dichloroanilide fungicide	1	14.40
Raydex (89)			1	4.80
Rogor (110)	Dimethoate	Organophsphate insecticide	1	24.00
Rogodial (138)	Dimethoate Ventopate		1	16.00
Roudup (139)	Isopropyl amine		1	19.20
Raydor (151)	Carbendazim Maneb		1	20.00
Salut (37)	Dimethoate Chlorpyriphos	Organophosphate insecticide Organophosphate insecticide	124	3,311.60
Selecron (38)	Profenphos	Organophosphate insecticide	54	1,322.40
Superlancord (39)	Alpha Cypermethrin Methomyl	Pyrethroid insecticide Carbamoyloxime insecticide, ChE	39	
Superlancord (39)	Smethyl Nmethyl carbonyl phenoxy benzoyl Dichlorvos Apha cyhalomethrin		40	748.40
Sipcam (67)			1	16.00

continued on the next page

Trade Name	Common Name	Group Name	Number of farms using it	Amount used g / 2 weeks
Supracide (68)	Methidathion	Organophosphate insecticide	2	72.00
Sumi alpha (78)	Esfenvalerate	Pyrethroid insecticide	4	77.60
Suprac (50)			1	38.40
Sumisclex (91)	Procymidone	3,5-dichloroanilide fungicide	1	16.00
Sulfan (92)			1	12.00
Sandovit (108)			1	20.00
SB super (134)	Amine polyoxyester		1	27.20
Tachigaren (40)	Hymexazol	Isoxazole fungicide	18	398.40
Tamaron (41)	Methamidophos	Organophsphate insecticide	19	628.40
Terali (42)			5	9.60
Torque (43)	Fenbutatin oxide	Organotin acaricide	49	1,181.60
Trigard (44)	Cyromazine	1,3,5-triazine insect growth regulator	2	21.60
Tri Miltox Forte (45)	Mancozeb Copper dihydroxide Copper sulphate Copper oxychloride	Ethylenebis(dithiocarbamate) insecticide Copper carbonate dihydroxide Copper sulphate Copper oxychloride	38	676.00
Talstar (69)	Bifenthrin	Pyrethroid insecticide	14	265.60
Tedion V-18 (70)	Tetradifon	Bridged diphenyl acaricide	24	504.80
Topspin (76)	Thiophenate	Carbamate insecticide	1	20.00
Tetradifon (49)	Tetradiphon	Bridged diphenyl acaricide	2	48.00
Trebon (96)	Etofenprox		1	12.80
Trimidal (47)	Nuarimol	Organochlorine insecticide	1	7.20
Thiodan (114)	Endosulphan	Organochlorine insecticide	1	19.20
Terlai (121)	Chloramphenicol Copper oxyquinolate Quinosol	Chloramphenicol Copper oxyquinolate Quinosol	1	16.00

continued on the next page

Trade Name	Common Name	Group Name	Number of farms using it	Amount used g / 2 weeks
Totalene (123)			1	19.20
Vydate (46)	Oxamyl	Carbamoyloxime insecticide	3	83.20
Wuxal (148)			1	16.00

ChE Acetylcholinesterase inhibitor

Pesticide usage per week by type of pesticides by individual farms in the five farming areas in Al-Ain

Farming area/ Farm number	Organo-chlorines g/m²	Organo-phosphates g/m²	Carbamates g/m²	Pyrethroids g/m²	Halogenated g/m²	Others gm/m²	Unit usage gm/m²
Hayer							
1	0.0	0.51	0.0	0.17	0.26	0.0	0.94
2	0.37	0.56	0.74	0.99	0.0	0.74	3.40
3	0.0	4.95	3.09	2.78	1.24	1.24	13.30
4	0.0	1.18	0.41	0.78	0.37	0.45	3.18
5	0.0	4.59	3.06	2.76	0.0	0.0	10.41
6	0.0	5.00	0.0	2.81	1.25	0.0	9.06
7	0.0	3.19	0.0	0.71	0.71	0.71	5.32
8	0.0	3.55	1.29	1.29	0.0	0.0	6.13
9	0.0	2.72	2.72	0.73	0.73	0.0	6.90
10	0.0	2.42	2.57	2.12	2.87	1.97	
11	0.0	0.61	0.0	0.73	0.0	0.0	1.33
12	0.0	3.16	1.86	0.74	2.79	2.05	10.60
13	0.0	0.0	0.60	3.17	0.60	0.75	5.13
14	0.0	1.05	0.75	0.75	0.60	0.75	3.91
15	0.0	2.33	1.79	1.97	2.15	1.08	9.33
16	0.0	0.75	1.26	2.51	0.0	0.75	5.28
17	0.0	0.85	1.56	0.57	0.0	1.42	4.39
18	0.0	2.33	2.56	0.93	0.0	0.0	5.81
19	0.0	4.12	1.87	6.37	1.87	2.25	16.49
20	0.0	7.26	3.77	1.16	0.0	0.0	12.19
21	0.0	3.66	2.61	4.71	0.0	2.88	13.86
22	0.0	1.11	0.0	0.74	0.0	0.0	1.86
23	0.0	1.25	0.0	0.87	0.38	0.0	2.50
24	0.0	0.0	0.0	1.47	0.53	0.53	2.53
25	0.0	0.99	0.0	1.97	0.0	0.0	2.96
26	0.0	0.50	0.0	0.84	0.0	0.92	2.26

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Farming area / Farm number	Organo-chlorines g/m²	Organo-phosphates g/m²	Carbamates g/m²	Pyrethroids g/m²	Halogenated g/m²	Others gm/m²	Unit usage gm/m²
27	0.0	0.37	0.0	0.62	0.0	0.68	1.67
28	0.0	0.48	0.96	0.48	0.38	1.24	3.54
29	0.0	0.35	0.35	0.28	0.55	0.90	2.42
30	0.0	0.19	0.86	0.24	0.33	0.53	2.15
31	0.0	0.12	0.10	0.15	0.18	0.66	1.21
32	0.0	0.0	0.0	0.0	0.25	0.0	0.25
33	0.0	1.04	0.0	0.35	0.35	0.0	1.73
34	0.0	0.35	0.88	0.44	0.35	0.0	3.18
Ramah							
35	0.0	0.86	0.86	0.86	1.08	1.35	5.02
36	0.87	1.73	1.90	2.60	0.87	0.87	8.83
37	0.0	0.40	0.0	0.40	0.0	0.40	1.20
38	0.0	0.31	0.35	0.0	0.0	0.0	0.66
39	0.0	2.16	1.94	3.24	0.0	0.86	8.20
40	2.87	6.31	0.0	1.72	2.87	6.03	19.80
41	0.94	1.88	0.0	0.94	0.0	1.88	5.65
42	1.07	2.14	2.35	3.21	0.0	1.93	10.70
43	0.77	2.48	0.0	1.55	2.17	2.94	9.91
44	0.0	8.92	3.38	1.54	3.08	6.15	23.06
45	0.0	3.46	0.0	1.39	0.69	4.05	9.59
46	0.0	4.57	2.22	1.39	1.25	0.69	10.11
47	0.69	4.29	0.0	2.08	0.55	3.05	10.66
48	0.0	0.69	1.52	1.52	0.0	1.52	5.26
49	0.0	0.43	0.95	1.04	0.0	0.95	3.38
50	0.0	1.56	1.04	1.25	0.0	4.67	8.52
51	1.39	4.43	0.0	0.0	2.77	6.93	15.51
52	1.73	3.46	1.73	6.93	2.08	5.54	21.47
53	1.30	2.60	1.30	5.19	1.56	3.12	15.06
54	0.97	0.97	0.0	2.90	0.77	2.90	8.51

continued on the next page

Farming area / Farm number	Organo-chlorines g/m^2	Organo-phosphates g/m^2	Carbamates g/m^2	Pyrethroids g/m^2	Halogenated g/m^2	Others gm/m^2	Unit usage gm/m^2
55	0.0	9.29	1.93	1.93	2.32	3.87	19.35
56	0.0	2.32	0.77	0.77	0.93	0.62	5.42
57	0.38	0.38	0.76	0.76	0.69	1.22	4.19
58	0.37	0.37	0.75	0.75	0.67	1.20	4.12
59	0.0	1.74	0.0	0.58	0.0	0.70	3.02
60	0.65	0.0	0.0	1.95	0.52	0.0	3.11
61	0.0	4.54	1.08	3.03	0.0	0.0	8.65
62	0.79	2.36	0.0	1.58	0.79	2.68	8.19
194	1.19	1.31	0.0	0.0	0.0	1.79	4.30
195	0.60	2.03	0.0	1.05	0.24	1.56	5.48
196	0.0	1.84	1.67	0.83	0.0	3.71	8.05
197	0.0	0.63	0.57	0.29	0.0	1.27	2.76
198	0.0	0.97	0.0	1.24	0.28	0.34	2.84
199	0.0	0.0	0.48	0.0	0.0	0.96	1.43
200	0.0	0.57	0.60	0.0	0.0	1.62	2.79
201	0.48	1.55	0.0	2.03	0.48	2.10	6.64
Gumadh							
63	0.67	1.25	0.0	1.43	0.86	1.91	6.13
64	0.0	0.48	0.12	0.48	1.19	1.05	3.32
65	0.0	0.96	0.0	1.24	0.0	1.37	3.57
66	0.0	1.58	0.0	1.19	0.0	1.67	4.44
67	0.0	4.57	1.85	3.74	0.94	2.86	13.96
68	0.0	0.80	0.0	0.92	1.83	0.92	4.46
69	0.0	0.93	0.10	0.47	0.39	1.62	3.51
70	0.0	0.22	0.0	1.12	0.0	0.45	1.78
71	0.0	1.95	0.0	1.40	0.46	1.59	5.4
72	0.0	5.40	0.0	1.92	2.24	4.92	14.48
73	0.0	2.13	0.91	4.50	1.14	2.78	11.47
74	0.0	0.95	0.0	0.65	0.0	0.65	2.25

continued on the next page

Farming area / Farm number	Organo-chlorines g/m²	Organo-phosphates g/m²	Carbamates g/m²	Pyrethroids g/m²	Halogenated g/m²	Others gm/m²	Unit usage gm/m²
75	0.0	0.54	0.0	1.36	1.63	0.54	4.08
76	0.0	2.08	0.90	2.36	0.84	1.18	7.36
77	0.0	1.31	0.81	1.40	2.27	2.72	8.51
78	0.0	3.27	0.0	1.08	1.67	1.58	7.58
79	0.0	3.11	0.66	2.52	0.62	0.62	7.53
80	0.0	3.16	0.0	3.08	2.03	3.20	11.47
81	0.0	1.93	0.0	1.71	0.94	1.50	6.07
82	0.0	1.49	0.0	0.0	0.41	1.12	3.03
83	0.0	3.31	1.43	3.82	1.61	2.03	12.20
84	0.0	6.58	1.03	3.59	0.55	2.32	14.07
85	0.0	3.54	1.83	2.34	4.04	3.10	14.85
86	0.0	1.29	0.86	1.14	0.86	1.36	5.51
87	0.0	1.00	0.67	0.89	0.67	1.06	4.29
88	0.0	0.0	0.0	0.90	0.0	3.16	4.07
89	0.0	0.0	0.0	0.53	0.0	1.84	2.37
90	0.0	0.0	0.0	0.14	0.38	0.26	0.77
91	0.0	0.24	0.0	0.90	0.60	0.21	1.95
92	0.0	1.33	1.16	1.33	1.62	1.51	6.96
93	0.0	0.60	0.0	1.77	0.90	3.77	7.05
94	0.0	1.88	0.0	1.85	0.63	0.0	4.36
95	0.0	2.47	0.93	3.34	2.72	0.93	10.38
96	0.0	0.0	1.06	3.06	1.13	3.29	8.55
97	0.0	3.07	0.0	1.91	1.43	1.39	7.80
98	0.0	3.34	0.93	1.21	0.72	1.05	7.25
99	0.0	2.03	0.0	1.05	0.52	1.29	4.89
100	0.0	2.81	0.0	1.07	0.48	1.00	5.36
101	0.0	2.27	0.72	2.65	0.72	1.31	7.67
102	0.0	1.40	0.0	1.32	0.34	0.0	3.06
103	0.0	3.70	0.0	2.62	0.48	1.15	7.94
104	0.0	4.46	1.68	0.63	1.26	3.91	11.94

continued on the next page

Farming area / Farm number	Organo-chlorines g/m^2	Organo-phosphates g/m^2	Carbamates g/m^2	Pyrethroids g/m^2	Halogenated g/m^2	Others gm/m^2	Unit usage gm/m^2
Waggan							
105	0.0	0.86	0.92	1.73	0.0	0.0	3.51
106	0.0	2.66	1.78	1.25	1.27	1.21	8.17
107	0.0	0.0	1.15	0.69	0.0	0.58	2.42
108	0.0	2.43	2.01	0.35	2.59	0.58	7.95
109	0.0	3.59	0.0	3.31	2.24	1.35	10.48
110	0.0	9.42	0.59	1.05	0.79	1.98	13.83
111	0.0	3.19	0.0	0.0	0.0	0.0	3.19
112	0.0	2.59	1.29	2.16	0.0	0.0	6.04
113	0.0	4.82	0.0	0.0	1.75	0.88	7.46
114	0.0	2.34	0.0	2.50	1.40	0.0	6.24
115	0.0	1.52	1.04	0.0	3.81	1.04	7.41
116	0.0	0.0	1.52	0.0	0.0	1.01	2.53
117	0.0	0.57	0.0	0.88	0.42	0.99	2.86
118	0.0	4.61	1.06	1.06	0.42	2.65	9.80
119	0.0	3.67	1.06	1.06	1.41	2.12	9.33
120	0.0	0.0	0.71	0.0	0.0	0.0	0.71
121	0.0	0.69	0.89	0.0	0.0	0.0	1.58
122	0.0	0.0	2.17	0.0	0.0	0.0	2.17
123	0.0	0.0	1.35	0.0	0.0	0.0	1.35
124	0.0	5.35	1.32	0.99	0.0	1.39	9.04
125	0.0	2.90	0.97	1.77	0.0	1.93	7.57
126	0.0	4.77	1.09	1.67	1.06	2.34	10.94
127	0.0	6.20	1.46	1.76	1.76	3.27	14.15
128	0.0	3.47	0.0	1.39	1.16	1.16	7.17
129	0.0	5.82	0.83	3.29	0.0	2.25	12.19
130	0.0	2.96	0.99	0.0	0.0	0.82	4.76
131	0.0	3.16	1.58	1.13	0.0	1.62	7.49
132	0.0	4.29	1.58	1.13	1.13	1.13	9.25

continued on the next page

Farming area / Farm number	Organo-chlorines g/m^2	Organo-phosphates g/m^2	Carbamates g/m^2	Pyrethroids g/m^2	Halogenated g/m^2	Others gm/m^2	Unit usage gm/m^2
133	0.0	5.28	0.0	1.67	0.0	1.62	8.56
134	0.0	2.04	0.86	1.90	0.72	1.73	7.25
135	0.0	0.72	0.0	0.72	1.44	2.19	5.06
136	0.0	0.72	0.0	0.72	1.44	2.19	5.06
137	0.0	2.33	0.72	0.72	0.72	1.29	5.78
138	0.0	1.84	1.47	3.11	2.96	1.87	11.25
139	0.0	2.30	0.58	0.69	0.0	1.58	5.15
140	0.0	0.0	1.38	0.0	0.86	1.58	3.83
141	0.0	4.80	1.58	1.27	1.73	2.13	11.50
142	0.0	2.04	1.73	0.72	1.44	1.38	7.31
143	0.0	1.73	1.58	1.41	0.86	1.73	7.31
144	0.0	0.72	0.86	1.58	0.0	0.0	3.16
202	0.0	1.19	0.0	0.48	0.60	0.48	2.75
203	0.0	0.0	0.0	0.0	0.81	3.48	4.29
204	0.0	1.13	1.41	1.13	0.0	2.77	6.45
205	0.0	0.0	0.0	0.0	0.0	2.21	2.21
206	0.0	3.31	0.0	0.58	2.01	0.83	6.73
207	0.0	7.62	0.0	2.86	1.52	18.67	30.69
208	0.0	1.56	0.0	0.0	0.0	1.30	2.86
209	0.0	1.73	0.0	0.0	0.0	0.81	2.53
210	0.0	1.73	0.0	0.0	0.58	1.87	4.17
211	0.0	2.13	0.72	0.0	0.86	2.16	5.87
Sleimat							
145	0.0	1.40	0.0	0.76	0.0	1.33	3.48
146	0.0	1.02	0.38	1.02	0.53	1.17	4.13
147	0.0	2.16	0.19	1.14	0.0	3.10	6.59
148	0.0	2.93	0.0	0.0	0.0	1.42	4.35
149	0.0	1.14	0.0	1.25	0.68	0.95	4.01
150	0.0	2.14	0.0	5.60	0.0	5.03	12.77
151	0.45	0.45	0.0	0.0	0.47	1.70	5.07

continued on the next page

Farming area/ Farm number	Organo-chlorines g/m²	Organo-phosphates g/m²	Carbamates g/m²	Pyrethroids g/m²	Halogenated g/m²	Others gm/m²	Unit usage gm/m²
152	0.0	2.39	0.0	0.0	1.70	0.34	4.44
153	0.0	3.01	0.0	1.28	1.33	0.66	6.28
154	0.0	2.92	0.0	1.51	2.46	0.81	7.71
155	0.0	2.34	0.0	0.0	0.0	0.95	3.28
156	0.47	1.57	0.0	0.0	1.56	1.25	4.86
157	0.0	2.88	0.61	0.17	0.57	2.50	6.72
158	0.0	2.83	0.0	1.09	0.65	3.24	7.81
159	0.0	1.19	1.39	2.47	0.0	3.04	8.09
160	0.0	2.73	0.40	0.0	0.0	0.60	3.73
161	0.0	2.67	0.0	0.0	1.27	1.12	4.93
162	0.0	2.95	0.0	1.27	0.0	5.26	9.48
163	0.0	0.69	0.0	0.0	0.46	3.83	4.98
164	0.0	1.68	0.0	1.83	0.0	1.73	5.23
165	0.0	1.50	0.0	2.30	0.0	0.58	4.37
166	0.0	1.04	1.15	0.86	1.61	3.60	8.25
167	0.0	4.71	2.54	0.76	1.40	4.04	13.46
168	0.0	1.96	0.92	1.70	2.33	1.38	8.28
169	0.0	3.36	0.0	1.87	0.86	5.68	11.78
170	0.0	2.06	0.91	0.86	1.71	2.00	7.54
171	0.0	0.69	0.0	0.0	0.86	3.16	4.72
172	0.0	2.67	0.0	2.16	0.0	2.30	7.13
173	0.0	1.75	0.0	1.07	0.0	1.68	4.50
174	0.0	1.98	0.0	1.21	0.0	1.73	4.92
175	0.0	3.48	0.92	2.07	1.08	1.38	8.93
176	0.0	1.78	0.72	0.86	1.44	0.86	5.67
177	0.0	1.33	0.89	0.53	0.0	2.07	4.82
178	0.0	4.17	1.73	2.30	2.36	3.09	13.65
179	0.0	0.86	0.92	0.46	2.04	2.70	6.99
180	0.51	0.51	0.0	0.0	1.78	1.02	4.57

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Farming area / Farm number	Organo-chlorines g/m^2	Organo-phosphates g/m^2	Carbamates g/m^2	Pyrethroids g/m^2	Halogenated g/m^2	Others gm/m^2	Unit usage gm/m^2
181	0.0	0.0	0.92	0.86	0.86	4.66	7.31
182	0.0	2.46	0.0	1.31	0.0	1.67	5.43
183	0.0	3.74	0.69	1.55	1.50	3.62	11.10
184	0.0	0.58	1.78	0.86	0.0	1.58	4.80
185	0.0	0.58	2.36	1.44	1.04	3.34	8.74
186	0.0	2.99	2.01	1.21	1.32	3.85	11.39
187	0.0	1.36	0.91	0.55	0.60	1.75	5.17
188	0.0	0.86	1.64	1.87	1.04	3.74	9.15
189	0.0	0.46	1.84	2.88	0.0	1.38	6.56
190	0.99	2.17	1.42	0.57	2.13	3.66	10.94
191	0.0	1.87	0.0	0.86	0.46	1.44	4.63
192	0.0	0.0	0.0	0.69	0.69	0.0	1.38
193	0.0	3.65	1.15	1.04	0.46	1.41	7.71
212	0.0	0.57	0.47	0.0	1.40	3.92	6.36
213	0.0	3.13	0.0	2.53	0.52	0.46	6.64
214	0.0	0.46	0.46	0.0	1.56	5.35	7.83
215	0.0	0.58	0.58	0.0	1.96	7.05	10.15
216	0.0	1.21	0.0	0.0	0.0	1.75	2.97
217	0.0	2.16	0.58	0.58	2.99	6.18	12.48
218	0.0	2.85	0.86	0.72	1.44	7.42	13.29
219	0.0	0.58	0.0	0.86	1.41	4.00	6.84
220	0.0	1.01	0.0	1.01	0.0	0.86	2.88
221	0.0	0.0	0.0	0.0	0.0	3.02	3.02

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Faculty of Medicine & Health Sciences
Dept. of Public Health & Occupational Medicine

Ministry of Health
Dept. of Preventive Medicine

Screening of farmers for exposure to pesticides
(This questionnaire will be applied to farmers, new employees and non-farmers)

Serial No. _______

I. Personal data

Name of the farmer: ______________________________

Nationality: _______________

Age: _______ *(99 if unknown)* Sex: _______ **(1. Male 2. Female)**

Education: _________ *(indicate the highest level achieved)*
0. None 1. Primary 2. Secondary 3. High school 4. Graduate

Type of job doing at present: ______________ *(enter present job only if working there for at least one year, else enter previous job)*
1. Farming 2. Sales 3. Industry 4. Office 5. House help
6. Other: __________________ *(specify)*

Total length of service in the present job: _________ *(write number of completed years, else 99)*

Total length of service with pesticide exposure: __________ *(write number of years else 99)*

Total length of stay in Al-Ain: _________ *(write number of completed years)*

Name of the area where farm / industry is located: _________________

Identification name / number of the farm / industry: ___________________ *(name of sponsor)*

II Consumption of fresh fruits and vegetables

Do you eat fruits _____ **1. Yes 0. No**

What **fruits** do you consume **every week**?

1. Regularly	**2. Seasonally**	**3. Sometimes**
Apples	Apples	Apples
Oranges	Oranges	Oranges
Bananas	Bananas	Bananas
Melons	Melons	Melons
Dates	Dates	Dates
_________	_________	_________

Do you use any of the following methods very frequently prior to eating?
(0. Never 1. Sometimes 2. Always)

.1 Wash the fruits under the tap with water: ______
.2 Do not wash but wipe: _____
.3 Do not wash and do not wipe: ______

From where do you usually purchase your fruits? (0. Never 1. Sometimes 2. Always)
.1 Supermarket ______
.2 Vegetable market ______
.3 From the farm ______

What **vegetables** do you consume **every week?**

	Regulary	Sometimes	Seasonally
.1	Cucumber	Cucumber	Cucumber
.2	Lettuce	Lettuce	Lettuce
.3	Tomatoes	Tomatoes	Tomatoes
.4	Cabbage	Cabbage	Cabbage
.5	Brinjals	Brinjals	Brinjals
.6	Gourd	Gourd	Gourd
.7	Green leafy vegs.	Green leafy vegs.	Green leafy vegs.
.8	Potatoes	Potatoes	Potatoes
.9	Raddish	Raddish	Raddish
.10	Carrots	Carrots	Carrots
.11	Cauliflower	Cauliflower	Cauliflower
.12	__________	__________	__________

Which **vegetables** do you **eat without cooking?**

.1	Cucumber	.4	Tomatoes
.2	Lettuce	.5	Cabbage
.3	Green leafy vegetables	.6	Carrots
.7	Raddish	.8	__________
.9	________________		

Which **vegetables** do you **eat after cooking?**

.1	Tomatoes	.4	Cauliflower
.2	Cabbage	.5	______________
.3	Lady fingers	.6	______________
.7	_________	.8	______________

Which of the following methods do you use most frequently prior to eating / cooking the vegetables?
(0. Never 1. Sometimes 2. Always)

.1 Wash the vegetables under the tap with cold water: _____
.3 Do not wash but wipe: _____
.4 Do not wash and do not wipe: _____

From where do you purchase your vegetables? **(0. Never 1. Sometimes 2. Always)**
.1 Supermarket _____
.2 Vegetable market _____
.3 From the farm _____

Please ask the subject to complete the following two tests now:

1) Aiming test

2) Digit symbol test

NB: It is important that the test is explained to the subject properly and asked to do the trial test before he takes the actual test.

Then transfer the subject to the examining physician to undergo physical examination.

After the physical examination the subject will have to proceed to the laboratory to give 5 ml of venous blood sample for analysis.

Please provide the subject with an appropriate form to help him give his blood sample to the laboratory.

Thank you for your co-operation.

Questionaire for Symptoms and Signs
Code : 0 - No. 1 - Sometimes 2 - Often

1.	Headache صداع		
2.	Dizziness أرهاق		
3.	Weekness or fatigue الضعف أو الارهاق		
4.	Difficulty concenterating صعوبة التركيز		
5.	Confusion or disorientation الارتباك أو تشتت الفكر		
6.	Difficulty remembering ضعف الذاكرة		
7.	Irritability without reason الهيجان بدون أسباب		
8.	Restlessness الضجر والملل		
9.	Depression without reason الشعور بالاحباط بلا سبب		
10.	Heart palpitaion without exertion خفقان القلب بسرعة دون مسبب		
11.	Seizures توالى نوبات المرض		
12.	Sleep disturbances النوم المتقطع		
13.	Difficulty with balance صعوبة الاتزان		
14.	Loss of muscle strength in extremities ضعف عضلات الاطراف		
15.	Presence of cramps in legs وجود تشنج بالارجل		
16.	Persistent numbnes, tingling, or pins in extremities الشعور بالخدر او الوخذ المتواصل بالاطراف		
17.	Double or blurred vision ضبابية الرؤية أو أزدواجيتها		
18.	Problems with hearing صعوبة السمع		
19.	Increasing salivation زيادة سيلان اللعاب		
20.	Watery eyes زيادة دموع العينين		
21.	Excess sweating زيادة أفراز العرق		
22.	Unusual taste in mouth الاحساس بطعم غير طبيعي بالفم		

23.	Change in bowel habits (bleeding, cramps, diarrhoea, constipation) تغير طباع الاحشاء (نزيف ، تشنج ، اسهال ، امساك)		
24.	Loss of appetite فقـدان الشهيـة		
25.	Abdominal pain وجـود آلام بالبطـن		
26.	Nausea الشعـور بالغثيان		
27.	Vomiting الاسـتفراغ		
28.	Pain in chest آلام الصـدر		
29.	Runny nose سـيلان الانـف		
30.	Difficult or abnormal breathing صـعوبة التنفـس		
31.	Cough or respiratory secretions السعال أو وجود أفرازات تنفسـية		
32.	Conjunctiva irritation الشعور بحكة فى غشاء الجفن		
33.	Frequent micturition كثرة التبـول		

مع خالص الشكـر والتقدير لتعاونكـم معنـا ، ،، ،

Thank you for your cooperation

Aiming Test

Name: ______________________ ID No. ________ Date: ______________

This is a test of your ability to make quick and accurate movements with the hand.

When the examiner gives the signal you are to place a pencil dot in as many "O"s as you can in one minute. Begin on the top left of the page and work your way through to the right of the page and go down one O on the right, then proceed to the left of the page and go down one O and repeat the process again. Work as rapidly as you can but do not let the dots touch the sides of the "O"s. Your dots need not be heavy but make sure they can be easily seen. Practice placing the dots in the "O"s below until you are told to turn the page.

Practice

```
O O O O O O O O O O O O O O O O O O O
                                     O
O O O O O O O O O O O O O O O O O O O
O
O O O O O O O O O O O O O O O O O O O
                                     O
O O O O O O O O O O O O O O O O O O O
O
```

Are there any questions?

Do not turn the page until given the signal to begin

Score: 1. ____________ 2. _____________ Mean: _____________

Examiner: _____________________

Thank you for your co-operation.

Aiming Test

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120 O
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O 150
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180 O
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O 210
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240 O
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O 270
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300 O
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O 330
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360 O
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O 390
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420 O
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O 450
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480 O
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540 O
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600 O
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O 630
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660 O
O O O O O O O O O O O O O O O O O O O O O O O O O O O O O
O 690
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720 O
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O 750
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780 O
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O 810

CORE PROTOCOL

DIGIT SYMBOL (WAIS)

Name ______________________ ID No. ________ Date ______________

1Q. DIGIT SYMBOL

1	2	3	4	5	6	7	8	9
—	⊥	⊐	L	U	O	Λ	X	=

SCORE

SAMPLES

2	1	3	7	2	4	8	2	1	3	2	1	4	2	3	5	2	3	1	4	5	6	3	1	4

1	5	4	2	7	6	3	5	7	2	8	5	4	6	3	7	2	8	1	9	5	8	4	7	3

6	2	5	1	9	2	8	3	7	4	6	5	9	4	8	3	7	2	6	1	5	4	6	3	7

9	2	8	1	7	9	4	6	8	5	9	7	1	8	5	2	9	4	8	6	3	7	9	8	6

REVISED FORM

To be filled by the examining physician

Please convince the subject that all the information provided by him will be treated confidentially and will not be disclosed to his employer under any circumstances.

1. Height (cm) ____________ *(999 if unknown)*

2. Weight (kg) ____________ *(999 if unknown)*

3. Blood pressure measurement:

Pulse: _________ Systolic: ________ mmHg Diastolic: _______mmHg

Medical observations:

4. Eyes Pupils aspect ______Equal ______Nonequal

5. Eyes Pupil size ______Regular ______Small

6. Eyes Conjuctiva ______Normal ______Irritated

7. Hearing (Whispering test) ______ *(Mark normal if able to hear at 1m distance, normal tone)*
1. Normal 2. Sufficient 3. Insufficient

8. Nose, mouth, neck
Major pathological findings: ________________________________ *(Specify)*

9. Respiratory system
Major pathological findings: ________________________________ *(Specify)*

History of asthma / wheezing before this occupation: ________

Development of asthma / wheezing after this occupation: ________

10. Skin
Major pathological findings: ________________________________ *(Specify)*

History of red and swollen hands / feet before this occupation: ________*(while at work)*

Development of red and swollen hands / feet after this occupation: ________ *(while at work)*

11. History of neurological / psychiatric problems before this occupation: ________

12. Development of neurological / psychiatric problems after this occupation: ________

13. Family history of (1 Yes, 0 No)

13.1	Neurological disease	____
13.2	Psychiatric disease	____
13.3	Diabetes mellitus	____
13.4	Diagnosed chronic diseases	____

14.0 If you have any specific comments regarding the subject which will help in this study please make them on the lines below. *Your comments will be treated confidentially as are the rest of the responses.*

14.1____

14.2____

14.3____

14.4____

14.5____

14.6____

Please complete the attached questionnaire for signs and symptoms.

Thank you very much for your co-operation.

Concentration of pesticides and pesticides associated chemical compounds in the farm water in individual farms

Farm number	Pesticide 1 (µg/l)	Pesticide 2 (µg/l)	Others (µg/l)	Total (µg/l)
Hayer	*n=10 (31%)*	*n=2 (6%)*	*n=17 (53%)*	
1				0.0
2	Omethoate (6.0)			6.0
3	Dimethoate (4.0)	Thiometon (4.0)	32.0	40.0
4			10.0	10.0
5	Omethoate (12.0)		35.0	47.0
6	Trichlorfon (6.0)		18.0	24.0
7	Thiometon (8.0)		15.0	23.0
8			10.0	10.0
9			26.0	26.0
10	*No Sample*			
11				0.0
12	Thiometon (11.0)		25.0	36.0
13			7.0	7.0
14			10.0	10.0
15	Omethoate (11.0)		20.0	31.0
16			8.0	8.0
17				0.0
18			30.0	30.0
19	Omethoate (8.0)	Phosphamidon (4.0)	27.0	39.0
20	Dimethoate (10.0)		35.0	45.0
21	Trichlorfon (9.0)		28.0	37.0
22				0.0
23				0.0
24				0.0
25			10.0	10.0
26				0.0
27				0.0
28				0.0
29				0.0
30				0.0
31				0.0
32	*No Sample*			
33				0.0
34				0.0
Ramah	*n=7 (19%)*	*n=0*	*n=29 (81%)*	
35			10.0	10.0
36			15.0	15.0
37				0.0
38				0.0
39			25.0	25.0
40			35.0	35.0
41			5.0	5.0
42	Phosphamidon (11.0)		35.0	46.0
43			33.0	33.0

continued on next page

Farm number	Pesticide 1 (µg/l)	Pesticide 2 (µg/l)	Others (µg/l)	Total (µg/l)
44			37.0	37.0
45	Thiometon (18.0)		36.0	54.0
46	Dimethoate (18.0)		34.0	52.0
47	Profenofos (18.0)		35.0	53.0
48			10.0	10.0
49			8.0	8.0
50			38.0	38.0
51	Phosphamidon (21.0)		35.0	56.0
52	Thiometon (19.0)		26.0	45.0
53			33.0	33.0
54			28.0	28.0
55	Omethoate (13.0)		34.0	47.0
56			7.0	7.0
57			10.0	10.0
58			8.0	8.0
59				0.0
60			22.0	22.0
61			22.0	22.0
62			5.0	5.0
194			5.0	5.0
195			30.0	30.0
196			28.0	28.0
197				0.0
198				0.0
199				0.0
200				0.0
201			10.0	10.0
Gumadh	n=7 (17%)	n=1 (2%)	n=32 (76%)	
63			8.0	8.0
64				0.0
65				0.0
66			10.0	10.0
67			35.0	35.0
68			8.0	8.0
69				0.0
70				0.0
71			8.0	8.0
72			35.0	35.0
73	Dimethoate (15.0)		46.0	61.0
74				0.0
75			7.0	7.0
76			36.0	36.0
77	Thiometon (14.0)		36.0	50.0
78	Dimethoate (12.0)		34.0	48.0
79	Dimethoate (10.0)		32.0	42.0
80			38.0	38.0
81			10.0	10.0
82				0.0
83			78.0	78.0
84	Omethoate (10.0)	Methamidophos (25.0)	41.0	76.0

continued on next page

Farm number	Pesticide 1 (µg/l)	Pesticide 2 (µg/l)	Others (µg/l)	Total (µg/l)
85			35.0	35.0
86			8.0	8.0
87			8.0	8.0
88			5.0	5.0
89				0.0
90				0.0
91				0.0
92			10.0	10.0
93			7.0	7.0
94			8.0	8.0
95	Omethoate (17.0)		31.0	48.0
96			33.0	33.0
97			32.0	32.0
98			7.0	7.0
99			8.0	8.0
100			8.0	8.0
101			30.0	30.0
102				0.0
103			21.0	21.0
104	Thiometon (15.0)		36.0	51.0
Waggan	*n=8 (16%)*	*n=1 (2%)*	*n=36 (72%)*	
105				0.0
106	Omethoate (18.0)		54.0	72.0
107				0.0
108			32.0	32.0
109	Omethoate (10.0)	Amidathion (8.0)	57.0	75.0
110			10.0	10.0
111				0.0
112			10.0	10.0
113			15.0	15.0
114			8.0	8.0
115			11.0	11.0
116				0.0
117				0.0
118			13.0	13.0
119			21.0	21.0
120				0.0
121				0.0
122				0.0
123				0.0
124	Amidathion (10.0)		25.0	35.0
125	Omethoate (8.0)		31.0	39.0
126	Trichlorfon (11.0)		62.0	73.0
127	Phosphamidon (13.0)		33.0	46.0
128			23.0	23.0
129	Omethoate (13.0)		31.0	44.0
130			7.0	7.0
131			10.0	10.0
132			15.0	15.0
133			15.0	15.0

continued on next page

Farm number	Pesticide 1 (μg/l)	Pesticide 2 (μg/l)	Others (μg/l)	Total (μg/l)
134			18.0	18.0
135			13.0	13.0
136			8.0	8.0
137			10.0	10.0
138	Omethoate (16.0)		35.0	51.0
139			10.0	10.0
140			10.0	10.0
141			41.0	41.0
142			13.0	13.0
143			18.0	18.0
144				0.0
202				0.0
203			8.0	8.0
204			6.0	6.0
205				0.0
206			10.0	10.0
207			51.0	51.0
208				0.0
209				0.0
210			15.0	15.0
211			12.0	12.0
Sleimat	*n=11 (19%)*	*n=0*	*n=51 (89%)*	
145				0.0
146			48.0	48.0
147			10.0	10.0
148			5.0	5.0
149	*No Sample*			
150	Omethoate (15.0)		42.0	57.0
151			8.0	8.0
152			10.0	10.0
153			10.0	10.0
154	Dimethoate (18.0)		26.0	44.0
155				0.0
156			10.0	10.0
157	Omethoate (10.0)		21.0	31.0
158			34.0	34.0
159			36.0	36.0
160				0.0
161			8.0	8.0
162	Amidathion (20.0)		38.0	58.0
163			8.0	8.0
164			10.0	10.0
165			10.0	10.0
166	Thiometon (15.0)		37.0	52.0
167	Thiometon (15.0)		34.0	49.0
168	Omethoate (10.0)		37.0	47.0
169			38.0	38.0
170			38.0	38.0
171			10.0	10.0

continued on next page

Farm number	Pesticide 1 (µg/l)	Pesticide 2 (µg/l)	Others (µg/l)	Total (µg/l)
172			36.0	36.0
173			10.0	10.0
174			10.0	10.0
175	Trichlorfon (15.0)		38.0	53.0
176			5.0	5.0
177			5.0	5.0
178	Omethoate (25.0)		35.0	60.0
179			36.0	36.0
180			30.0	30.0
181			30.0	30.0
182			10.0	10.0
183			43.0	43.0
184			10.0	10.0
185			40.0	40.0
186			48.0	48.0
187			7.0	7.0
188			51.0	51.0
189			40.0	40.0
190			47.0	47.0
191			10.0	10.0
192	*No Sample*			
193			30.0	30.0
212			20.0	20.0
213			20.0	20.0
214	Omethoate (10.0)		20.0	20.0
215	Dimethoate (15.0)		35.0	35.0
216				0.0
217			38.0	38.0
218			39.0	39.0
219			35.0	35.0
220				0.0
221				0.0
	n=43 (20%)	n=4 (2%)	n=165 (76%)	

end of table

Pesticides and pesticide associated compounds identified in the water samples from the farms.

Pesticides (n)	Pesticide associated compounds
Omethoate (17)	Phosphoric acid, 2-ethylhexyl diphenyl ester
Posphamidon (3)	1,2-benzenedicarboxylic acid, bis(1-methylheptyl)ester
Trichlorfon (4)	1,2-benzenedicarboxylic acid, dicyclohexyl ester
Amidathion (2)	1,2-benzenedicarboxylic acid butyl cyclohexyl ester
Profenfos (1)	2-phenazinecarboxylic acid, 3-amino-, methyl ester
Methamidofos (1)	Benzenesulfonamide, 4-methoxy-N-[S-2(methylpropyl)-1,2,4-thiadizol-2-yl
Thiometon (8)	Propanoic acid 2-methyl-1(1,1-dimethyl) 2-ester
Dimethoate (8)	Phosphoramidic acid, dimethyl ester
	1,2-benzenedicarboxylic acid dibutyl ester
	Phosphorochlorodithoic acid, o,o-dimethyl ester
	4 bromo-2-chlorophenol
	Propane 1,2,3-trichloro

n *number of samples with the pesticide residue*

Concentrations of pesticides and pesticides related compounds in farm soil from the individual farms

Farm number	Pesticide 1 (ng/g)	Pesticide 2 (ng/g)	Pesticide 3 (ng/g)	Others ng/g	Total ng/g
Hayer	*n=17 (50%)*	*n=8 (24%)*	*n=2 (6%)*	*n=29 (85%)*	
1					0.0
2				16.0	16.0
3				15.0	15.0
4	Azinophos (5.0)			15.0	20.0
5	Bromopropylate (7.0)	Azinophos (5.0)		24.0	36.0
6	Dimethoate (12.0)			33.0	45.0
7	Heptenophos (9.0)	Bromopropylate (5.0)		30.0	44.0
8				26.0	26.0
9				32.0	32.0
10	Mirex (7.0)			15.0	22.0
11				7.0	7.0
12				45.0	45.0
13	Bromopropylate (8.0)			35.0	43.0
14	Fenoxycarb (4.0)			30.0	34.0
15	Acephate (3.0)	Heptenophos (4.0)		20.0	27.0
16	Bromopropylate (7.0)	Dimethoate (5.0)		20.0	32.0
17					0.0
18	Methidathion (5.0)			25.0	30.0
19	Azinophos (10.0)	Endosulfan (3.0)		35.0	48.0
20	Endosulfan (8.0)	Bromopropylate (4.0)		30.0	48.0
21				5.0	5.0
22					0.0
23					0.0
24					0.0
25				15.0	15.0

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Farm number	Pesticide 1 (ng/g)	Pesticide 2 (ng/g)	Pesticide 3 (ng/g)	Others ng/g	Total ng/g
26	Phenthoate (10.0)			15.0	25.0
27	Phenthoate (8.0)			0.0	8.0
28				15.0	15.0
29	Phenthoate (8.0)			0.0	8.0
30	Bifenox (5.0)	Dimethoate (4.0)	Methidathion (4.0)	5.0	18.0
31	Benlaxyl (4.0)	Bromopropylate (4.0)	Phenthoate (4.0)	5.0	17.0
32				8.0	8.0
33				10.0	10.0
34				8.0	8.0
Ramah	*n=17 (50%)*	*n=7 (21%)*	*n=1 (3%)*	*n=29 (85%)*	
35				40.0	40.0
36				10.0	10.0
37				8.0	8.0
38				12.0	10.0
39	Aldoxycarb (8.0)	Azinophos (4.0)	Bromopropylate (4.0)	10.0	26.0
40	*Lost sample*				
41	Formothion (7.0)	Dimethoate (4.0)		18.0	29.0
42	Bromopropylate (6.0)			32.0	38.0
43	Bromopropylate (12.0)			38.0	50.0
44	Dimethoate (12.0)			28.0	40.0
45	Endosulfan (9.0)			21.0	30.0
46	Dichlorvos (5.0)			21.0	26.0
47	Formothion (10.0)			31.0	41.0
48	Dimethoate (7.0)			18.0	25.0
49				13.0	13.0
50				18.0	18.0
51				23.0	23.0
52	Dimethoate (7.0)			24.0	31.0
53				23.0	23.0
54				18.0	18.0

continued on next page

Farm number	Pesticide 1 (ng/g)	Pesticide 2 (ng/g)	Pesticide 3 (ng/g)	Others ng/g	Total ng/g
55	Dimethoate (12.0)	Chlorpyrifos (7.0)		26.0	45.0
56	Chlorpyrifos (5.0)			16.0	21.0
57				12.0	12.0
58	*Lost sample*				
59					0.0
60				10.0	10.0
61	Dimethoate (6.0)			22.0	28.0
62				12.0	12.0
194	Pyridate (6.0)	Bifenox (6.0)		24.0	36.0
195	Fenoxycarb (7.0)	Disulfoton (6.0)		30.0	43.0
196	Pyridate (4.0)	Endosulfan (10.0)		25.0	44.0
197					0.0
198					0.0
199					0.0
200					0.0
201	Dibenzofuran (6.0)	Chlorpyrifos (6.0)		21.0	33.0
Gumadh	*n=21 (50%)*	*n=5 (12%)*	*n=0*	*n=40 (95%)*	
63	Bromopropylate (4.0)			6.0	12.0
64				8.0	8.0
65				7.0	7.0
66				10.0	10.0
67	Bromopropylate (10.0)			18.0	28.0
68	Dimethoate (8.0)			19.0	27.0
69	Methyl bromide (6.0)	Fenoxycarb (4.0)		14.0	24.0
70					0.0
71	Bromopropylate (8.0)			18.0	26.0
72				8.0	8.0
73	Phenthoate (5.0)			12.0	17.0
74				8.0	8.0
75				10.0	10.0

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Farm number	Pesticide 1 (ng/g)	Pesticide 2 (ng/g)	Pesticide 3 (ng/g)	Others ng/g	Total ng/g
76	Mirex (6.0)			15.0	21.0
77	Dimethoate (10.0)			20.0	30.0
78	Bromopropylate (8.0)			12.0	20.0
79				22.0	22.0
80	Fenoxycarb (12.0)			23.0	35.0
81	Azinophos (8.0)	Dimethoate (5.0)		27.0	40.0
82	Mirex (8.0)	Endosulfan (13.0)		32.0	53.0
83				0.0	0.0
84				20.0	20.0
85				36.0	36.0
86				22.0	22.0
87				10.0	10.0
88	Bifenox (4.0)			15.0	19.0
89	Tetradifon (8.0)			0.0	8.0
90	Bifenox (5.0)			28.0	33.0
91					0.0
92				15.0	15.0
93				15.0	15.0
94				18.0	18.0
95	Bromopropylate (5.0)			26.0	31.0
96				18.0	18.0
97				26.0	26.0
98				28.0	28.0
99	Bifenox (10.0)	Dimethoate (12.0)		32.0	54.0
100	Phoxim (5.0)			19.0	24.0
101				15.0	15.0
102	Fenoxycarb (5.0)			4.0	9.0
103	Quintozul (6.0)			23.0	29.0
104	Phenthoate (6.0)	Quintozul (6.0)		21.0	33.0

continued on next page

Farm number	Pesticide 1 (ng/g)	Pesticide 2 (ng/g)	Pesticide 3 (ng/g)	Others ng/g	Total ng/g
Waggan	*n*=16 (32%)	*n*=2 (4%)	*n*=1 (2%)	*n*=46 (92%)	
105				10.0	10.0
106				22.0	22.0
107				6.0	6.0
108	β-HCH (2.0)	γ-HCH (2.0)	Bromopropylate (10.0)	27.0	41.0
109	Bromopropylate (8.0)			28.0	36.0
110				26.0	26.0
111				10.0	10.0
112				18.0	18.0
113				14.0	14.0
114				12.0	12.0
115				6.0	6.0
116				8.0	8.0
117				8.0	8.0
118				25.0	25.0
119				28.0	28.0
120					0.0
121					0.0
122				32.0	32.0
123	Methidation (10.0)			32.0	38.0
124				32.0	32.0
125					0.0
126				28.0	28.0
127	Bromopropylate (6.0)			32.0	38.0
128				18.0	18.0
129	Bromopropylate (8.0)			33.0	41.0
130				10.0	10.0
131				22.0	22.0
132				18.0	18.0
133	Endosulfan (8.0)			24.0	32.0

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Farm number	Pesticide 1 (ng/g)	Pesticide 2 (ng/g)	Pesticide 3 (ng/g)	Others ng/g	Total ng/g
134	Azinophos (5.0)			15.0	20.0
135				21.0	21.0
136	Fenoxycarb (5.0)			10.0	15.0
137				18.0	18.0
138	Bromopropylate (10.0)			22.0	32.0
139				12.0	12.0
140				16.0	16.0
141				28.0	28.0
142				19.0	19.0
143				16.0	16.0
144	Bromopropylate (10.0)			24.0	34.0
202				15.0	15.0
203	Bromopropylate (6.0)			15.0	23.0
204	Azinophos (8.0)			18.0	26.0
205					0.0
206	Profenofos (6.0)			13.0	19.0
207	Diquat (10.0)	Methamidophos (6.0)		19.0	35.0
208				10.0	10.0
209				6.0	6.0
210	β-HCH (4.0)			4.0	8.0
211	Bromopropylate (6.0)			15.0	21.0
Sleimat	*n=29 (52%)*	*n=11 (20%)*	*n=2 (4%)*	*n=47 (84%)*	
145	Methamidophos (8.0)			44.0	52.0
146				35.0	35.0
147				0.0	
148				10.0	10.0
149					0.0
150	*Lost sample*				
151				32.0	32.0
152	Bromopropylate (5.0)			18.0	23.0

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Farm number	Pesticide 1 (ng/g)	Pesticide 2 (ng/g)	Pesticide 3 (ng/g)	Others ng/g	Total ng/g
153					0.0
154				21.0	21.0
155				22.0	22.0
156	Acephate (4.0)			13.0	17.0
157				14.0	14.0
158				5.0	5.0
159	*Lost sample*				
160					0.0
161				6.0	6.0
162				0.0	
163				9.0	9.0
164				13.0	13.0
165				10.0	10.0
166	Bromopropylate (7.0)			27.0	34.0
167	Bifenox (5.0)	Ethoprofos (4.0)		24.0	33.0
168	Bifenox (7.0)			32.0	39.0
169	Phenthoate (8.0)			23.0	31.0
170				36.0	36.0
171	Bromopropylate (6.0)			28.0	34.0
172				15.0	15.0
173				10.0	10.0
174	Bromopropylate (6.0)	Dimethoate (6.0)		26.0	38.0
175	Endosulfan (8.0)			28.0	70.0
176	Dimethoate (6.0)			20.0	26.0
177	*Lost sample*				
178	Fenoxycarb (6.0)	Ultracid (8.0)		23.0	37.0
179	Demeton (8.0)	Profenofos (6.0)		30.0	44.0
180	Bromopropylate (6.0)	Methidation (8.0)	Ultracid (8.0)	5.0	27.0
181	Chlorpyrifos (8.0)			23.0	31.0
182	Bromopropylate (4.0)	Fenoxycarb (6.0)		25.0	35.0

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Farm number	Pesticide 1 (ng/g)	Pesticide 2 (ng/g)	Pesticide 3 (ng/g)	Others ng/g	Total ng/g
183	Disulfoton (8.0)	Demeton (10.0)	Pyrifos (6.0)	24.0	48.0
184				14.0	14.0
185	Dimethoate (8.0)			32.0	40.0
186	Azinophos (8.0)			26.0	34.0
187	Azinophos (8.0)			30.0	38.0
188	Phenthoate (6.0)	Dimethoate (8.0)		38.0	52.0
189	Pyrifos (7.0)			15.0	22.0
190	Ultracid (8.0)	Disulfoton (6.0)		28.0	42.0
191				10.0	10.0
192					0.0
193				16.0	16.0
212	Ethoprofos (6.0)			15.0	21.0
213	Dimethoate (6.0)			18.0	24.0
214				17.0	17.0
215	Fenoxycarb (6.0)	Chlorpyrifos (8.0)		27.0	41.0
216					0.0
217	Azinophos (8.0)	Phenthoate (6.0)		32.0	46.0
218	Acephate (6.0)			36.0	42.0
219	Pyridate (7.0)			22.0	29.0
220					0.0
221					0.0
	n=100 (46%)	*n=33 (15%)*	*n=6 (3%)*	*n=191 (88%)*	

Pesticides and pesticide associated compounds identified in the farm sand samples.

Pesticides (n)	Chemical compounds possibly arising from the pesticide formulations or breakdown products
Farming area: Hayer	
Bromopropylate (6)	N,N-di-isopropyl-2, 2-dibromo-1-methyl cylcopropane carboximide
Fenoxycarb (1)	1,2-benzenedicarboxylic acid, bis(2-methylpropyl ester
Azinophos ethyl (3)	1,2-benzenedicarboxylic acid, bis(1-methylheptyl)ester
Heptenophos (1)	1,2-benzenedicarboxylic acid, butyl ester
Mirex (1)	Propanoic acid 2-methyl-1(1,1-dimethyl) 2-ester
Dibenzofuran (1)	O-(4-bromo-2-chlorophenyl)-o,o-diethyl s[2-methylamino]-2-oxyethyl ester
Dimethoate (3)	Phosphoric acid tributyl acid
Acephate (1)	Phosphorochlorodithoic acid, o,o-dimethyl S[2-(methylamino)-2-oxoethyl] ester
Methidathion (2)	4 bromo-2-chlorophenol
Endosufan sulfate (2)	N-methyl 1-hydrocarbazole
Phenthoate (4)	Ethyldibenzothiophene
Bifenox (1)	Benzeneacetic acid, 4-bromo-alpha-(4-bromophenyl)-alpha, hydroxy 1 methyl ester
Benlaxyl (1)	6-bromo-7-nitro-2,3-naphthalene dicarbamate
	O,O-diethyl-O-(3,5,6 trichloro-2-pyridyl) ester phosphorothioic acid
Farming area: Ramah	
Phenthoate (1)	1,2-benzenedicarboxylic acid, butyl ester
Azinophos methyl (1)	Propanoic acid 2-methyl-1(1,1-dimethyl) 2-ester
Dimethoate (6)	N-phenyl-4-piperidinecarboxamide
Bromopropylate (3)	Propanoic acid, 2 methyl 1,-(1,1-dimethylethyl)-2-methyl-1,3-propanediyl ester
Aldoxycarb (1)	Ethyldibenzothiophene
Dichlorvos (1)	Benzamine, 4-chloro
Chlorpyrifos (3)	Phenol, 4-chloro-3,5-dimethyl
Fenoxycarb (1)	1,2-benzenedicarboxylic acid, butylcyclohexyl ester

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Pesticides (n)	Chemical compounds possibly arising from the pesticide formulations or breakdown products
Endosufan (2)	Propanoic acid, 2-methyl-1(1,1-dimethylethyl)-2-methyl-1,3-propanediyl ester
Disulfoton (1)	1,2-benzenedicarboxylic acid, butylcyclohexyl ester
Dibenzofuran (1)	O-(4-bromo-2-chlorophenyl)-o,o-diethyl s[2-methylamino]-2-oxyethyl ester
Formothion (2)	Phosphorochlorodithoic acid, o,o-dimethyl S[2-(methylamino)-2-oxoethyl] ester
Bifenox (1)	Benzeneacetic acid, 4-bromo-alpha-(4-bromophenyl)-alpha, hydroxy 1 methyl ester
Pyridate (1)	
Farming area: Gumadh	
Phoxim (1)	1,2-benzenedicarboxylic acid, bis(1-methylheptyl)ester
Dimethoate (4)	4 bromo-2-chlorophenol
Phenthoate (2)	Propanoic acid 2-methyl-1(1,1-dimethyl) 2-ester
Mirex (2)	1,2-benzenedicarboxylic acid, butylcyclohexyl ester
Endosulfan (1)	Phosphorothoic acid o,o-diethyl-o-(3,5,6-trichloro-2-pyridyl) ester
Tetradifon (1)	2-ethyldibenzothiophene
Azinophos ethyl (1)	Acetamide, 2-chloro-N[1-(1-cyno-2-methylpropyl) hydroxyamino] -2-methyl propyl
Bromopropylate (5)	Phenol, 4-chloro-3,5-dimethyl
Methyl bromide (1)	Propanoic acid, 2-methyl-1(1,1-dimethylethyl)-2-methyl-1,3-propanediyl ester
Fenoxycarb (3)	Phenol, 2-chloro-4,5-dimethyl-5, methylcarbamate
Bifenox (3)	O-(4-bromo-2-chlorophenyl)-O-ethylester of propylthio phosphoric acid
Quintozul (2)	N-methyl -1-hydroxycarbazole
Farming area: Waggan	
β-HCH (2)	Ethanone, 2-bromo-1-(4 bromo phenyl)
γ-HCH (1)	Furan, 2,5-dihydro-2,5-dimethoxy
Diquat (1)	1,2-benzenedicarboxylic acid, bis(2-ethylhexyl)ester
Endosulfan (1)	Butane 1,2,3,4-tetracholoro -1,1,2,3,4,4-hexafluro
Bromopropylate (8)	Diisopropylnaphthalene

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Pesticides (n)	Chemical compounds possibly arising from the pesticide formulations or breakdown products
Azinophos-ethyl (2)	Propanoic acid, 2-methyl-1-(1,1-dimethylethyl)-2-methyl -1, 3-propanediyl ester
Profenofos (1)	1,2-benzenedicarboxylic acid, bis(2-methylpropyl ester
Methidathion (1)	1,2-benzenedicarboxylic acid, bis(1-methylheptyl)ester
Fenoxycarb (1)	Propanoic acid 2-methyl-1(1,1-dimethyl) 2-ester
Methamidophos (1)	N,N-diisopropyl -2,2-dibromo -1-methylcyclopropane carboxamide
	4-bromo-2-chlorophenol -o-ethyl ester of propylthio phosphoric acid
	Phenol, 4-chloro-3,5-dimethyl
	Methyl thiofuran
	Benzofuran 3-chloro-4, 5-dimethyl phenol
Farming area: Sleimat	
Bifenox (2)	Phenol, 2-chloro -4,5-dimethyl -methyl carbamate
Ethoprofos (2)	Benzene, pentachloro nitro
Endosulfan (1)	Phenol, 4-chloro -3,5-dimethyl
Fenoxycarb (2)	Phosphoramidothioic acid, acetyl-, o,s-dimethyl ester
Bromopropylate (5)	Benzothiozole 2-methyl
Methamidophos (2)	Methyl thiofuran
Acephate (2)	Phosphoric acid, 2-chloro, -3-(diethylamino) -1-methyl-3oxo-1-propenyl dimethyl ester
Phenthoate (3)	N,N-diisopropyl-2, 2-dibromo -1-methyl cyclopropane carboxamide
Dimethoate (5)	Phosphorothioic acid o,o-diethyl -o-(3,5,6-trichloro-2-pyridyl) ester
Azinophos-methyl (3)	3-chloro -4,5-dimethyl phenol
Ethofumesate (1)	Propanoic acid, 2-methyl-1-(1,1-dimethylethyl)-2-methyl -1, 3-propanediyl ester
Profenofos (1)	O, O-diethyl-O-(3,5,6-trichloro-2pyridyl) ester phosphorothioic acid
Disulfoton (2)	1,2-benzenedicarboxylic acid, butyl 8-methylnonyl ester
Demeton-S-Methyl (2)	1,2-benzenedicarboxylic acid, butyl 2-methylpropyl ester
Pyridate (1)	Benzeneacetic acid, 4-bromo-alpha-(4 bromophenyl)-alpha-hydroxy 1-methylethyl ester
Pyriphos (1)	Oxirane, trichloromethyl
Chlorpyrifos (2)	Benzenesulfonic acid, 4-chloro, 4-chlorophenyl ester
Methidathion (1)	Acetyl choline
Ultracid (3)	4H-1-benzopyran-6-carboxyaldehyde, 7-hydroxy-5-methoxy-2-methyl-4-oxo

(n) number of occurrences of each pesticide

Table 1: Pesticide residues and pesticide associated chemical compound concentrations in Hayer

S. No.	Farm Number	Produce	Pesticide 1 mg/kg	Pesticide 2 mg/kg	Pesticide 3 mg/kg	Others mg/kg	Total mg/kg
1	2	Tomatoes	Formothion (1.80)			1.50	3.30
2	3	Tomatoes	Heptenophos (1.00)			0.50	1.50
3	3	Cauliflower	O,p-DDE (0.40)	Methidathion (0.40)	Carbaryl (1.00)		1.80
4	4	Tomatoes	Pyridate (0.20)			1.00	1.20
5	6	Radish	Methidathion (0.40)			0.40	0.80
6	7	Tomatoes				1.00	1.00
7	8	Tomatoes	Triadimefon (0.80)			0.20	1.00
8	10	Tomatoes	Triadimefon (1.60)			0.80	2.40
9	10	Potatoes	Heptenophos (0.40)			0.50	0.90
10	11	Tomatoes	Pyridate (1.20)				1.20
11	12	Tomatoes	Triadimefon (1.50)	Aminocarb (1.20)	Pyridate (0.80)	1.50	5.00
12	13	Tomatoes				1.00	1.00
13	13	Corn	Aminocarb (0.60)	Demeton-S-methyl (0.80)	Pyridate (0.60)	1.00	3.00
14	14	Marrow	Methidathion (0.80)			0.800	1.60
15	15	Marrow	Triamiphos (1.00)			1.50	2.50
16	15	Potatoes	Heptenophos (0.20)			1.00	1.20
17	17	Tomatoes	Dimethoate (0.50)			1.50	2.00
18	17	Aubergines				25.0	25.0
19	18	Marrow	Aminocarb (1.00)			1.50	2.50
20	19	Potatoes	Heptenophos (0.40)	Ethidimuron (1.00)		0.50	1.90
21	21	Aubergines	Ethidimuron (0.20)	Butocarboxim (0.60)		2.60	3.40
22	21	Cabbage				1.00	1.00
23	23	Tomatoes				0.0	0.0
24	23	Cauliflower	Phosphamidon (0.40)	Carbaryl (0.40)			0.80
25	25	Tomatoes				1.00	1.00

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S. No.	Farm Number	Produce	Pesticide 1 mg/kg	Pesticide 2 mg/kg	Pesticide 3 mg/kg	Others mg/kg	Total mg/kg
26	25	Capsicum				1.50	1.50
27	26	Tomatoes	Dimethoate (1.20)			3.00	4.20
28	27	Tomatoes	Triamiphos (0.80)			1.00	1.80
29	28	Tomatoes	Pyridate (0.50)			3.50	4.00
30	30	Tomatoes				3.00	3.00
31	32	Cucumber	Methidathion (0.80)			2.30	3.10
32	33	Aubergines				1.00	1.00

Table 2: Pesticide residues and pesticide associated chemical compound concentrations in Ramah

S. No.	Farm Number	Produce	Pesticide 1 mg/kg	Pesticide 2 mg/kg	Pesticide 3 mg/kg	Others mg/kg	Total mg/kg
1	35	Tomatoes	Pyridate (0.4)			1.50	1.90
2	35	Onion				1.20	1.20
3	36	Tomatoes	Bromacil (1.40)			2.40	3.80
4	38	Aubergines	Ethidimuron (0.40)	Ethoprofos (0.20)	Butocarboxim (0.40)	1.50	2.50
5	39	Carrots				0.0	0.0
6	40	Tomatoes	Demephion (1.80)	Triadimefon (1.00)		2.50	5.30
7	41	Tomatoes	Pyridate (0.60)			1.40	2.00
8	43	Aubergines	Pyridate (0.40)	Butocarboxim (0.60)		0.60	1.60
9	43	Tomatoes	Triadimefon (1.50)			3.00	4.50
10	43	Chillies	Captan (2.40)			1.80	4.20
11	45	Marrow				1.00	1.00
12	46	Tomatoes				1.00	1.00
13	46	Green onion	Phenthoate (0.40)			0.80	1.20
14	47	Potatoes				1.00	1.00
15	47	Aubergines	Ethidimuron (0.20)	Disulfoton (0.20)		1.00	1.40
16	47	Green leafy vegs	Triadimefon (0.40)			0.60	1.00
17	48	Corn	Acephate (0.20)			1.80	2.00
18	48	Onion				0.80	0.80

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S. No.	Farm Number	Produce	Pesticide 1 mg/kg	Pesticide 2 mg/kg	Pesticide 3 mg/kg	Others mg/kg	Total mg/kg
19	49	Aubergines				1.50	1.50
20	49	Chillies	Phenmedipham (0.20)			0.40	0.60
21	52	Tomatoes	Phosphamidon (1.80)	Phenthoate (1.00)		1.00	3.80
22	53	Tomatoes	Pirimiphos methyl (1.20)	Triadimefon (1.20)	Bromacil (0.80)	1.80	5.00
23	54	Tomatoes	Bromacil (1.20)	Pyridate (0.20)		1.50	2.90
24	54	Marrow				1.00	1.00
25	55	Aubergines	Ethidimuron (0.20)	Butocarboxim (0.60)		0.60	1.40
26	55	Tomatoes				1.00	1.00
27	56	Tomatoes				1.40	1.40
28	56	Carrots				0.0	0.0
29	57	Tomatoes				1.20	1.20
30	57	Marrow	Pyridate (0.40)			2.10	2.50
31	57	Green onions	Profenofos (0.60)			0.60	1.20
32	59	Tomatoes	Phenthoate (1.00)	Phosphamidon (0.80)		1.80	3.60
33	59	Aubergines	Isoxathion (0.40)	Dinoseb acetate (0.40)		1.80	2.60
34	59	Onion				1.50	1.50
35	60	Green onion	Phenthoate (1.00)			0.80	1.80
36	60	Tomatoes				0.0	0.0
37	60	Corn	Phenthoate (0.20)	Disulfoton (0.40)	Heptenophos (0.40)	1.80	2.80
38	61	Tomatoes	Phenthoate (1.40)			1.50	2.90
39	62	Onion				0.80	0.80
40	62	Green onion	Triadimefon (0.20)	Carbetamide (0.20)	Promecarb (0.40)	1.50	2.30
41	62	Carrots				0.80	0.80
42	62	Tomatoes				2.20	2.20
43	194	Tomatoes	Pyridate (0.80)	Bromacil (2.10)		1.80	4.70
44	195	Tomatoes	Pyridate (0.80)			1.90	2.70
45	196	Tomatoes	Bromocil (0.40)	Triadimefon (0.60)		1.00	2.00
46	196	Cabbage	Methidathion (0.20)			0.40	0.60
47	197	Tomatoes	Captan (1.00)	Chlorfenson (0.80)		0.80	2.60
48	197	Cauliflower	Pyridate (0.20)			0.80	1.00

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S. No.	Farm Number	Produce	Pesticide 1 mg/kg	Pesticide 2 mg/kg	Pesticide 3 mg/kg	Others mg/kg	Total mg/kg
49	198	Cabbage	Formothion (0.80)			1.50	2.30
50	198	Tomatoes	Ethidimuron (0.40)			1.20	1.60
51	199	Tomatoes	Demephion (0.40)	Bromacil (1.60)	Methidathion (0.80)	1.80	3.60
52	199	Onion	Profenofos (1.60)			1.80	3.40
53	199	Cabbage				1.00	1.00
54	199	Carrots	Dimethoate (0.20)	Pyridate (0.40)		0.80	1.40
55	200	Tomatoes	Dimethoate (0.80)	Captan (0.40)	Chlorfenson (1.40)	0.0	2.60
56	200	Green onion	Triadimefon (0.60)	Phenthoate (0.40)		0.60	1.60
57	201	Tomatoes	Aminocarb (0.40)	Triadimefon (1.40)		2.10	3.90
58	201	Cauliflower	Carbaryl (0.40)			0.80	1.20
59	201	Onion				0.0	0.0

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Table 3: Pesticide residues and pesticide associated chemical compound concentrations in Gumadh

S. No.	Farm Number	Produce	Pesticide 1 mg/kg	Pesticide 2 mg/kg	Pesticide 3 mg/kg	Others mg/kg	Total mg/kg
1	63	Tomatoes	Pyridate (0.40)	Bromacil (0.80)		2.40	3.60
2	64	Tomatoes	Phenthoate (0.40)			0.60	1.00
3	65	Tomatoes	Triadimefon (0.80)			0.60	1.40
4	65	Aubergines				1.20	1.20
5	67	Tomatoes	Bifenox (0.20)	Triadimefon (0.80)	Pyridate (0.40)	0.0	1.40
6	67	Cucumber				0.0	0.0
7	68	Tomatoes				0.0	0.0
8	69	Cucumber				1.40	1.40
9	71	Chillies				1.80	1.80
10	73	Chillies				1.90	1.90
11	74	Green leafy vegs	Triadimefon (0.30)	Captan (0.30)	Phenthoate (1.20)	1.30	2.10
12	75	Chillies	Demeton (0.80)	Tolyfluanid (0.40)		1.50	2.70

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S. No.	Farm Number	Produce	Pesticide 1 mg/kg	Pesticide 2 mg/kg	Pesticide 3 mg/kg	Others mg/kg	Total mg/kg
13	75	Capsicum	Triadimefon (0.80)			2.30	3.10
14	75	Corn				2.80	2.80
15	76	Chillies	Vamidothion (1.80)	Phosphamidon (0.40)	Tolyfluanid (0.80)	1.60	4.60
16	76	Tomatoes	Bromacil (0.80)	Triadimefon (0.60)		2.80	4.20
17	77	Chillies	Pyridate (1.00)			1.00	2.00
18	77	Aubergines				1.80	1.80
19	78	Marrow	Pyridate (1.00)			1.10	2.10
20	80	Cucumbers	Captan (0.80)	Triadimefon (1.00)	Ethoprofos (0.40)	1.90	4.10
21	81	Aubergines	Ethidimuron (0.20)			2.10	2.30
22	81	Cucumbers	Pyridate (0.20)			1.00	1.20
23	82	Capsicum	Pyridate (0.20)			1.40	1.60
24	82	Cucumbers				1.90	1.90
25	83	Aubergines	Pyridate (0.20)	Ethidimuron (0.40)		1.20	1.80
26	84	Aubergines	Acephate (0.60)	Butocarboxim (2.00)	Phosphamidon (0.60)		
			Triadimefon (0.60)			3.10	6.90
27	84	Tomatoes	Acephate (0.20)	Pyridate (0.20)		1.50	1.90
28	86	Aubergines	Pyridate (0.40)	Carbaryl (0.60)	Ethiolate (1.20)	0.0	2.20
29	87	Aubergines	Pyridate (0.60)			1.20	1.80
30	88	Chillies	Bendiocarb (1.00)	Vamidothion (0.60)		1.20	2.80
31	89	Marrow	Pyridate (1.20)			2.40	3.60
32	89	Cucumber	Demeton (0.80)	Monocryptos (0.20)	Triadimefon (1.20)		
			Ethofumesate (0.60)	Captan (0.60)		1.70	5.10
33	90	Chillies				0.0	0.0
34	90	Aubergines				1.80	1.80
35	91	Aubergines	Butocarboxim (0.60)	Triadimefon (0.60)		0.80	2.00
36	92	Marrow	Pyridate (1.00)	Triadimefon (0.80)		1.50	3.30
37	93	Aubergines	Pyridate (0.20)			1.80	2.00
38	94	Chillies	Bendiocarb (0.40)	Triadimefon (0.80)	Desmethryn (2.40)	2.20	5.80
39	95	Chillies	Phosphamidon (0.20)	Triadimefon (1.20)	Bifenox (0.40)		
			Demeton (0.40)	Bendiocarb (0.40)	Captan (1.00)	1.20	4.80

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S. No.	Farm Number	Produce	Pesticide 1 mg/kg	Pesticide 2 mg/kg	Pesticide 3 mg/kg	Others mg/kg	Total mg/kg
40	96	Aubergines	Butocarboxim (0.60)	Triadimefon (0.80)		1.40	2.80
41	100	Aubergines				1.20	1.20
42	101	Aubergines	Ethidimuron (0.20)			1.80	2.00
43	103	Onion				1.20	1.20

Table 4: Pesticide residues and pesticide associated chemical compound concentrations in Waggan

S. No.	Farm Number	Produce	Pesticide 1 mg/kg	Pesticide 2 mg/kg	Pesticide 3 mg/kg	Others mg/kg	Total mg/kg
1	105	Onion	Pyridate (0.40)	Butocarboxim (0.80)		0.50	2.70
2	106	Onion				1.20	1.20
3	106	Tomatoes	Pyridate (0.20)	Bromacil (0.40)		0.10	0.70
4	112	Green onion				0.80	0.80
5	113	Aubergines	Pyridate (0.40)			0.60	1.00
6	115	Onion	Pyridate (0.20)	Triadimefon (1.00)		1.50	2.70
7	117	Onion	Triadimefon (1.40)			0.80	2.20
8	117	Marrow	Ethidimuron (0.20)			0.10	0.30
9	120	Green onion	Pyridate (0.30)			1.20	1.50
10	120	Green leafy vegs	Pyridate (0.10)	Captan (1.00)		0.80	1.90
11	121	Onion				0.80	0.80
12	122	Onion	Ethidimuron (0.20)	Phenthoate (0.20)		1.00	1.40
13	124	Green leafy vegs	Promecarb (0.20)			0.20	0.40
14	125	Onion				1.20	1.20
15	127	Onion	Bendiocarb (0.40)	Triadimefon (0.80)		2.10	3.30
16	128	Tomatoes	Pyridate (0.10)			1.20	1.30
17	128	Chillies				1.00	1.00
18	128	Marrow	Pyridate (1.00)	Triadimefon (0.80)		1.60	3.40
19	131	Green leafy vegs	Pirimiphosmethyl (0.80)	Demethion (0.10)		1.60	2.50
20	133	Cucumbers				1.40	1.40

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S. No.	Farm Number	Produce	Pesticide 1 mg/kg	Pesticide 2 mg/kg	Pesticide 3 mg/kg	Others mg/kg	Total mg/kg
21	133	Green leafy vegs	Promecarb (0.10)	Triadimefon (0.80)		1.20	2.10
22	135	Onion				1.80	1.80
23	135	Aubergines	Demephion (0.80)			1.20	2.00
24	137	Aubergines	Butocarboxim (0.40)	Demephion (0.80)	Ethidimuron (0.10)	1.00	2.30
25	137	Cucumbers				1.20	1.20
26	137	Aubergines	Demephion (0.60)	Butocarboxim (0.40)		1.30	2.30
27	138	Aubergines	Heptenophos (0.20)	Butocarboxim (0.60)		2.80	3.60
28	139	Aubergines	Butocarboxim (0.20)			0.10	0.30
29	140	Aubergines	Pyridate (0.40)			0.10	0.50
30	140	Onion	Pyridate (0.10)			1.10	1.20
31	141	Green onion	Triadimefon (0.10)	Butocarboxim (0.40)		1.60	2.10
32	141	Aubergines				3.50	3.50
33	142	Green onion				1.40	1.40
34	143	Green onion	Pyridate (0.40)			1.90	2.30
35	144	Aubergines	Butocarboxim (0.80)	Demephion (1.00)		1.50	3.30
36	202	Green leafy vegs				1.40	1.40
37	202	Tomatoes	Dimethoate (0.40)	Amidathion (0.10)	Triadimefon (0.10)	0.0	0.60
38	202	Onion				1.00	1.00
39	202	Aubergines	Demephion (0.60)	Captafol (0.10)		1.20	1.90
40	203	Onion	Triadimefon (0.60)			1.00	1.60
41	203	Tomatoes	Chlorpyrifos (0.40)	Pyridate (0.40)	Aminocarb (0.20)		
			Triadimefon (1.80)			2.40	5.20
42	203	Aubergines	Pyridate (0.20)			1.40	1.60
43	204	Marrow	Bendiocarb (0.10)			1.00	1.10
44	205	Green leafy vegs	Pyrethrin (0.10)			1.80	1.90
45	206	Aubergines	Ethidimuron (0.20)	Pyridate (0.30)		1.60	2.10
46	206	Tomatoes	Triadimefon (0.80)	Bromacil (1.40)		1.60	2.80
47	207	Cabbage	Dimethoate (0.60)	Pyridate (0.20)		0.0	0.80
48	207	Green leafy vegs	Triadimefon (0.40)			2.20	2.60
49	208	Green leafy vegs	Allethrin (0.10)			0.80	0.90

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S. No.	Farm Number	Produce	Pesticide 1 mg/kg	Pesticide 2 mg/kg	Pesticide 3 mg/kg	Others mg/kg	Total mg/kg
50	209	Tomatoes	Pyridate (0.60)	Aminocarb (0.40)		0.80	1.80
51	209	Onion				1.50	1.50
52	209	Aubergines	Pyridate (0.10)	Butocarboxim (1.20)		1.60	2.90
53	210	Onion				1.80	1.80
54	210	Tomatoes	Amidathion (0.20)			1.40	1.60
55	210	Aubergines	Dimethoate (0.10)			1.20	1.30
56	211	Tomatoes	Triadimefon (0.60)			1.50	2.10
57	211	Onion				1.50	1.50

Table 5: Pesticide residues and pesticide associated chemical compound concentrations in Sleimat

S. No.	Farm Number	Produce	Pesticide 1 mg/kg	Pesticide 2 mg/kg	Pesticide 3 mg/kg	Others mg/kg	Total mg/kg
1	145	Aubergines	Triadimefon (0.40)			1.50	1.90
2	146	Marrow	Triadimefon (0.20)			1.00	1.20
3	146	Aubergines	Butocarboxim (1.00)	Demephion (1.00)		2.60	4.60
4	147	Green leafy vegs	Phenthoate (0.60)			1.40	2.00
5	148	Green onion	Pyridate (0.80)			1.90	2.70
6	149	Green onion	Phenthoate (0.80)	Triadimefon (0.80)		2.30	3.90
7	150	Onion	Triadimefon (1.00)			2.50	3.50
8	158	Onion				1.20	1.20
9	160	Corn				1.80	1.80
10	161	Onion	Fenobucarb (0.80)			1.20	2.00
11	162	Onion				1.50	1.50
12	163	Onion	Fenobucarb (0.40)			1.30	1.70
13	164	Green leafy vegs	Demeton-methyl (0.40)	Thiometon (0.40)	Triadimefon (0.80)	1.00	2.60
14	165	Onion	Triadimefon (0.60)	Phenthoate (0.40)		0.80	1.80
15	165	Green leafy vegs	Triadimefon (0.60)			1.20	1.80

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S. No.	Farm Number	Produce	Pesticide 1 mg/kg	Pesticide 2 mg/kg	Pesticide 3 mg/kg	Others mg/kg	Total mg/kg
16	166	Onion				0.80	0.80
17	167	Aubergines				2.20	2.20
18	168	Onion				0.0	0.0
19	171	Onion	Triadimefon (0.80)	Dimethoate (0.60)		2.00	3.40
20	171	Corn	Thiometon (0.60)	Demephion (0.80)	Disulfoton (0.80)		
			Phenthoate (1.00)	Demeton-methyl (1.80)		2.00	6.00
21	172	Onion	Profenofos (1.00)	Triadimefon (1.60)	Phenthoate (0.60)	2.10	5.30
22	173	Onion				1.60	1.60
23	176	Corn	Thiometon (0.40)	Phenthoate (0.40)		1.00	1.80
24	180	Onion				1.30	1.30
25	183	Onion	Phenthoate (0.60)			2.20	2.80
26	184	Green onion	Phenthoate (0.60)	Triadimefon (0.60)		1.70	2.90
27	185	Green leafy vegs				1.00	1.00
28	186	Onion	Ethidimuron (0.40)	Captan (0.40)		1.20	2.00
29	187	Onion	Phenthoate (0.40)	Captan (0.40)		1.50	2.30
30	189	Onion				0.0	0.0
31	190	Onion	Phenthoate (1.00)	Profenofos (2.00)		1.80	4.80
32	192	Onion	Triadimefon (0.40)	Fenobucarb (0.60)		1.80	2.80
33	192	Marrow	Triadimefon (1.00)	Bendiocarb (0.40)		1.50	2.90
34	212	Tomatoes	Pyridate (0.20)			1.20	1.40
35	212	Green onion	Triadimefon (0.80)	Dimethoate (0.40)		1.00	2.20
36	213	Onion	Pyridate (0.60)	Triadimefon (0.40)		1.80	2.80
37	213	Aubergines	Ethidimuron (0.20)	Demephion (1.00)		1.60	2.80
38	214	Onion	Ethidimuron (0.60)	Captan (0.40)		2.40	3.40
39	214	Aubergines	Demephion (0.80)			1.80	2.60
40	215	Corn	Butocarboxim (0.20)	Pyridate (0.20)		1.50	1.90
41	216	Green onion	Triadimefon (0.60)	Fenobucarb (0.60)	Isoprocarb (0.80)	1.40	3.40
42	216	Tomatoes	Bromacil (1.20)			2.10	3.30
43	217	Onion	Phenthoate (0.80)			1.70	2.50
44	217	Aubergines	Butocarboxim (0.60)	Formothion (0.40)	Dimethoate (0.20)	2.40	3.60

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S. No.	Farm Number	Produce	Pesticide 1 mg/kg	Pesticide 2 mg/kg	Pesticide 3 mg/kg	Others mg/kg	Total mg/kg
45	218	Tomatoes	Ultracid (0.40)	Heptenophos (0.20)	Aminocarb (0.40)		
			Isoprocarb (0.40)			2.40	3.80
46	218	Onion	Fenobucarb (0.40)			2.10	2.50
47	218	Aubergines	Ethidimuron (0.20)	Butocarboxim (0.30)		2.10	2.60
48	219	Aubergines	Formothion (0.30)	Pyridate (0.20)		1.20	1.70
49	219	Marrow				1.50	1.50
50	220	Onion	Pyridate (0.40)	Dimethoate (0.40)		1.00	1.80
51	220	Aubergines	Butocarboxim (0.20)	Demephion (0.60)		1.60	2.40
52	221	Aubergines	Triadimefon (0.40)			2.00	2.40
53	221	Marrow	Pyridate (0.80)			1.80	2.60

Table 1: Pesticides and pesticide associated compounds identified in vegetable samples from Hayer.

	Pesticides (n)	Pesticide associated chemical compounds
Aubergines	Ethidimuron (1) Butocarboxim (1)	Phosphonic acid, dioctadecyl ester 4-methyl 2-phenylindole 5-Flurodeoxyuridine 3-chloro-1,2,4-triazine-1-oxide 1-butene, 4,4-dichlorohexafluoro
Cabbage		1H-indole-3-carboxaldehyde 1-butene, 4-isothiocynate
Capsicum		1,2-benzenedicarboxilic acid, bis (2-methylpropyl) ester 1,3-bezodioxole, 4,7-dimethoxy-5-(2-propenyl)
Cauliflower	O,p-DDE (1) Methidathion (1) Phosphamidon (1) Triamiphos (1) Carbaryl (2)	Benzeneacetic acid, alpha, 3,4-tris[(trimethylsilyl)oxy] - trimethyl ester 2-amino-5-ethyl-6 propylpyridine-3-carbonitrile Phenol, 2.6-dichloro-4-nitro 1,3,4 -thiadiazol-2 amine, 5-ethyl
Corn	Aminocarb (1) Demeton-s-methyl (1) Pyridate (1)	Benzoic acid, 2,4-bis[(trimethylsilysl)oxy] -trimethylsilyl ester Benzaldehyde, 4-methoxy, -(4-nitrophenol) hydrazine
Cucumber	Methidathion (1)	Benzaldehyde, 4-methoxy, -(4-nitrophenol) hydrazine 1,3-dioxolane,4-ethly-5-oxtyl-2,2bis(trifluoromethyl) Azetudube 1-benzyl-3,3-dimethyl-2-phenyl 1,2-benzenedicarboxylic acid, bis(2ethylhexyl) ester
Potatoes	Ethidimuron (1) Heptenophos (3)	Benzeneacetic acid, alpha, 3,4[(trismethylsilyl)oxy]-trimethyl silyl ester

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	Pesticides (n)	Pesticide associated chemical compounds
Radish	Methidathion (1)	1,2-benzenedicarboxylic acid, bis(2ethylhexyl) ester
		Phenol 2-bromo-4-chloro
Marrow	Methidathion (1)	1H-indole-3-carboxaldehyde
	Aminocarb (1)	5-nitro-1-methylpyrazole
	Triamiphos (1)	Benzene, 1-(chloromethyl)-4-(2-propenyl)
		1,2-benzenedicarboxylic acid bis (2-ethylhexyl) ester
Tomatoes	Dimethoate (2)	Dodecane 1,2-dibromo
	Aminocarb (1)	Benzene 1,3-dimethyl
	Triadimefon (3)	Phenol 2-bromo-4-chloro
	Pyridate (4)	Benzofuran, 2,3-dihydro
	Isoxathion (1)	Phenol, 2.6-dichloro-4-nitro
	Heptenophos (1)	1,5-dimethoxy-2,4-bis(3-methyl phthalidyl) benzol
	Formothion (1)	Propanoic acid, 2-methyl, 1-(1,1-dimethylethyl)-2-methyl-1,3-propanediyl ester
		1,2-benzenedicarboxilic acid, bis (2-methylpropyl) ester
		Benzeneacetic acid, alpha, 3,4-tris[(trimethylsilyl)oxy] - trimethyl ester

(n) number of samples containing the given pesticide residue

Table 2: Pesticides and pesticide associated compounds identified in vegetable samples from Ramah

	Pesticides (n)	Pesticide associated compounds
Aubergines	Pyridate (1)	2,3,5-timethyl furan
	Demephion (1)	s-methyl thiosufonate
	Disulfoton (1)	Phosphoric acid, 2-chloro-3-(diethylamino) -1-methyl -3-oxo-1-propenyl dimethyl ester
	Ethidimuron (3)	Acetamide, 2-chloro-N,N-diethyly
	Ethofumesate (1)	Benzeneacetic acid, alpha, 3,4 -tris[(trimethylsilysl) -trimethylsilyl] ester

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	Pesticides (n)	Pesticide associated chemical compounds
	Butocarboxim (3) Isoxathion (1) Dinoseb acetate (1)	Phosphoric acid, 2-chloro-3-(diethylamino)-1-methyl-3-oxo-1-propenyl dimethyl ester Benzene 1-fluoro-2-methyl-4-nitro Napthalene decahedro-2,6-dimethyl
Cabbage	Methidathion (1) Formothion (1)	Phosphorodithoic acid, o,o-dimethyl 2,2-dimethyl -6-(prop-2-enyl) benzofuran -4,7(2H, 3H) -dione s-methyl thiosufonate 1,2-benzenedicarboxylic acid, bis (2-methylpropyl) ester Morphine bis(o-trimethylsilyl)
Cauliflower	Pyridate (1) Carbaryl (1)	1,2-benzenedicarboxylic acid, bis (2-methylpropyl) ester Benzeneacetic acid, alpha, 3,4 -tris[(trimethylsilysl) -trimethylsilyl] ester
Carrots	Pyridate (1) Formothion (1)	
Corn	Phenthoate (1) Disulfoton (1) Demeton-s-methyl (1) Acephate (1)	1,2-benzenedicarboxylic acid, bis (2-methylpropyl) ester
Chilli	Captan (1) Phenmedipham (1)	2,2-dimethyl-6-(prop-2-enyl) benzofuran-4,7-dione
Greens leafy vegs	Triadimefon (2) Carbetamide (1) Promecarb (1)	Benzene 1,2,3-trimethoxy -5-(2-propenyl) Propanoic acid, 2-methyl-1,2-phenylethyl

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	Pesticides (n)	Pesticide associated compounds
Marrow	Pyridate (1)	N-difluorophosphinodimethylhydroxylamine
		oxirane trichloromethyl
		1,2-benzenedicarboxylic acid diethyl ether
		trivinyl-s-triazine-2,4,6-trione
		Phosphoric acid-2-chloro-3-(diethylamino)-1-methyl-3-oxo-1-proppenyl dimethyl ester
Onion	Profenofos (2)	Furan, 2-methyl -s-(methylthio)
	Phenthoate (3)	Thiophene 2,4-dimethyl
	Triadimefon (1)	4-bromo-2-chlorophenol
		1,2-benzenedicarboxylic acid, bis (2-methylpropyl) ester
		N-difluorophosphinodimethylhydroxylamine
		1-mercapto-2-heptadecanone
Potatoes		Benzeneacetic acid, alpha, 3,4 -tris[(trimethylsilysl) -trimethylsilyl] ester
Tomatoes	Bromacil (5)	Phenol, 2,6-dichloro-4-nitro
	Pyridate (5)	Benzofuran 2,3-dihydro
	Triadimefon (5)	Benzene 1-fluoro-2-methyl-4-nitro
	Demephion (2)	2-benzofuranone, 5,6,7,7a-tetrahydro -4,4,7a-trimethyl
	Phenthoate (3)	1,5-dimethoxy -2,4-bis (3-methylphthalidyl) benzol
	Pirimiphos methyl (1)	Phosphonic acid, dioctadecly ester
	Demeton-s-methyl(1)	Cobalt(II) bis (diethyldithiophosphate)
	Chlorfenson (2)	4-bromo-2-chlorophenol
	Captan (2)	Propanoic acid, 2-methyl-, 1-(1,1-dimethylethyl)-2-methyl1,3-propanediyl ester
	Dimethachlor (1)	1,2-benzenedicarboxylic acid, bis (2-methylpropyl) ester
	Phosphamidon (2)	Benzeneacetic acid, alpha, 3,4 -tris[(trimethylsilysl) -trimethylsilyl] ester
	Aminocarb (1)	Propanoic acid, 2-phenylethyl ester
	Ethidimuron (1)	1,2-benzenedicarboxylic acid, bis (2-methylpropyl) ester
		Methyl 5-nitro-2,11-dioxo-cycloundecane-1-carboxylate
		Benzene 1,2,3-trimethoxy-5-(2-propyenyl)

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Table 3: **Pesticides and pesticide associated chemical compounds identified in vegetable samples from Gumadh**

	Pesticides (n)	Pesticide associated compounds
Aubergines	Pyridate (4)	1,5-dimethoxy -2,4-bis (3-methylphthalidyl) benzol
	Ethidimuron (1)	Benzene, 1-fluoro -2-methyl-4-nitro
	Phosphamidon (1)	Naphthalene decahydro-1,6-dimethyl
	Acephate (1)	Cyclohexamethyl dichloroacetate
	Ethiolate (1)	S-methyl methylthiosulfonate
	Carbaryl (1)	Phosphonic acid dioctadecyl ester
	Butocarboxim (2)	Benzoic acid, 2-hydroxy methyl ester
	Triadimefon (2)	5-phenoxy -2, 2-dimethyl hexane
		4(1H)-isobenzofuranone, hexahydro-3a, 7a-dimethyl
		Benzeneacetic acid, alpha, 3,4-tris[(trimethylsilyl)oxyl]-trimethylsilyl ester
		1,2-benzenedicarboxylic acid, bis(2-methylpropyl) ester
Capsicum	Triadimefon (1)	Phosphoric acid, dimethyl 1-methyl-3-(methylamino) -3-oxo -1-propenyl ester
	Pyridate (1)	Benzeneacetic acid, alpha, 3,4-tris[(trimethylsilyl)oxyl]-trimethylsilyl ester
		1,2-benzenedicarboxylic acid, bis(2-methylpropyl) ester
Chilli	Bendiocarb (3)	1,5-dimethyl-2,4-bis(3 methylphthalidyl) benzol
	Triadimefon (2)	Benzene 2-fluoro-2-methyl-4-nitro
	Desmethyl norflurazon (1)	Benzoyl chloride
	Demeton (2)	N-(4 hydroxy-3-methoxy benzyl) -8-methyl
	Pyridate (1)	Phenol, 4-ethyl-2-methoxy
	Vamidothion (2)	2-methoxy-3methyl-5-(1-pyranolidinyl) 1,4-benzoquinone
	Tolyfluanid (2)	1,2,4-triazole[4,3-a] pyrazine
	Bifenox (1)	
	Phosphamidon (1)	
	Captan (1)	

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	Pesticides (n)	Pesticide associated compounds
Corn		Thiophene, 3-(methylthio) 3-chloro-1,2,4-traiazine-1-oxide
Cucumber	Pyridate (1) Demeton (1) Monocryptophos (1) Triadimefon (2) Ethofumesate (1) Captan (1)	Benzeneacetic acid, alpha, 3,4-tris[(trimethylsilyl)oxyl]-trimethylsilyl ester 1,2-benzenedicarboxylic acid, bis(2-methylpropyl) ester 3-(4-N,N-dimethyylamino phenyl) propanoic acid
Greens	Triadimefon (1) Captan (1) Phenthoate (1)	Benzaldehyde, 4-hydroxy-3-methoxy 1,2-benzendicarboxylic acid, bis(2-methyl propyl) ester
Marrow	Pyridate (1) Triadimefon (1)	Phosphoric acid, dimethyl 1-methyl-3-(methylamino)-3-0x0-1-propenyl ester 4-(alpha-hyroxybenzyl)-2-phenyl-6H-phenaleno[1,9-bc]pyran-6-one
Onion		Benzeneacetic acid, alpha, 3,4-tris[(trimethylsilyl)oxyl]-trimethylsilyl ester 1,2-benzendicarboxylic acid, bis(2-methyl propyl) ester
Tomatoes	Bromacil (2) Triadimefon (3) Bifenox (1) Ethidimuron (1) Pyridate (3) Phenthoate (1)	Propanoic acid, 2-methyl-, 2-phenylethyl ester Isopropyl ester of N-ethyl thiocarbamic acid Phosphoroamidothioic acid, acetyl -,s-dimethyl ester Benzene 1-fluoro, -2methyl-4-nitro 5,6,8,9-tetramethoxy-2-methyl pepero(3,4,5-JK)-9,10-dihydrophenanthracene Benzene 1,3 dimehtyl Benzeneacetic acid, alpha, 3,4-tris[(trimethylsilyl)oxyl]-trimethylsilyl ester NN-isopropyl-2,2-dibrom-1-methyl

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	Pesticides (n)	Pesticide associated compounds
		O,O-diethyl-o-(3,5,6-tirchloro-2-pyridyl) ester phosphorothioic acid 1,2-benzenedicarboxylic acid, bis(2-methylpropyl) ester 4H-pyran-4-one, 2,2-isopropylidenebis[3-methoxy-6-emthyl]

(n) number of samples with pesticide residue

Table 4: Pesticides and pesticide associated compounds identified in vegetable samples from Waggan

	Pesticides (n)	Pesticide associated compounds
Aubergines	Pyridate (5) Butocarboxim (6) Dimethoate (1) Ethidimuron (2) Demephion (5) Captafol (1)	Propanoic acid, 2-methyl-, 1-(1,1-dimethylethyl) -2-methyl -1,3-propanediyl ester 1,2-benzenedicarboxylic acid, bis (2-methylpropyl) ester Benzene acetic acid alpha, 3,4-tris[(trimethylsilyl)oxy], trimethylsilyl ester Benzoic acid, 2,5-bis(trimethyl silyoxy) 6 octadecanoic acid methyl ester Methyl ester of N-vinyl carbamic acid 3-(4-N,N-dimethylaminophenol) propenoic acid Dodecane, 1,2-dibromo Hydrazinecarboximide, 2-cyclohexylide 2,5-dimethyl-3-hydroxy-p-benzoquinone Naphthalenedecahedro 2,3-dimethyl Benzamine, -N-phenyl
Cabbage	Dimethoate (1) Pyridate (1)	5-methyl -2-octyl -2H-furan-3-one
Cucumber		N-difluorophosphinodimethylhydroxylamine 1,3-benzadioxole, 4,7-dimethoxy -5-(2-propenyl)

continued on the next page

	Pesticides (n)	Pesticide associated compounds
		Propenoic acid 3-(pentafluorophenyl) Thiophene, 2-methoxy-5-methyl 1H-Indole, 5 methyl-2-phenyl
Greens	Pyrethrin (1) Allethrin (1) Triadimefon (2) Promecarb (2) Pyridate (1) Captan (1) Pirimiphos methyl (1) Demethion (1) Anthraquinone (1)	1,2-benzenedicarboxylic acid, bis (2-methylpropyl) ester 2(4H)benzofuranone, 5,6,7,7a-tetrahydro-4,4,7a-trimethyl Oxirane tetradecyl 1,3-benzodioxole, 4-methoxy-6-(2-propenyl)
Marrow	Bendiocarb (1) Pyridate (1) Triadimefon (1) Ethidimuron (1)	N-difluorophosphinodimethylhydroxylamine Trivinyl-s-triazine -2,4,6-(1H, 3H, 5H) -trione Phosphonic acid, dioctadecyl ester Phosphorodithioic acid, o,o-dimethyl s-[(2-methylamino) 2-oxoethyl] ester Thiophene 2,4-dimethyl Phosphonic acid dioctadecyl ester Benzne, 1-(chloromethyl)-4-(2-propenyl) Acetyl choline
Onion	Ethidimuron (1) Phenthoate (1) Triadimefon (5) Pyridate (5) Methylthiofuran (1) Butocarboxim (2) Bendiocarb (1)	N-difluorophosphinodimethylhydroxylamine Propanoic acid, 2-methyl-, 1-(1,1-dimethylethyl) -2-methyl -1,3-propanediyl ester 4-Imidzolidinone, 2-thioxo Thiophene, 2,4-dimethyl Phosphonic acid dioctyl ester N-diflorophosphinodimethylhydroxylam Pentadecanoic acid, 2,2-dimethyl, dimethyl ester

continued on the next page

	Pesticides (n)	Pesticide associated compounds
		Thiazole, 4,5-dimethyl
		Methyl ester of N-vinyl carbamic acid
		4,6-dimethyl-2-(2-methylcyclohexyl) phenol
Tomatoes	Dimethoate (1)	O,o-diethyl -o-(3,5,6-trichloro -2-pyridyl) ester phosphorothioic acid
	Amidathion (2)	Propanoic acid, 2-methyl-, 1-(1,1-dimethylethyl) -2-methyl -1,3-propanediyl ester
	Triadimefon (2)	Phenol, 2-bromo-4-chloro
	Pyridate (4)	1,2-benzenedicarboxylic acid, bis (2-methylpropyl) ester
	Bromacil (2)	4-bromo-2-chlorophenol
	Chlorpyrifos (1)	Benzene, (3 nitropropenyl)
	Aminocarb (2)	Benzo[b]naphth [2,3-d] furan
		2(4H)-benzofuranone, 5,6,7,7a-tetrahydro-4,4,7a-trimethyl
		4,6-dimethyl-2,(2-methylcyclohexyl)phenol
		1,3-dioxolone, 4-ethyl-5-octyl-2,2-bis(trifluoromethyl)-trans

(n) number of samples with pesticide residue

Table 5: Pesticides and pesticide associated compounds identified in vegetable samples from Sleimat

	Pesticides (n)	Pesticide associated compounds
Aubergines	Butocarboxim (4)	Phosphorodithioic acid, 0,0-dimethyl
	Dimethoate (1)	O-(4-bromo-2-chlorophenyl) -o-ethyl ether
	Acephate (1)	1,2-benzene dicarboxilylic acid, bis(2-methyl)
	Formothion (2)	4-Imidazolidinone, 2-thioxo
	Pyridate (1)	1-mercapto-2-heptadecanone
	Ethidimuron (2)	Isopropyl, 2-benzyl-2-propenylether
	Demephion (4)	Naphthalene, decahedro-1,6-dimethyl

continued on the next page

	Pesticides (n)	Pesticide associated compounds
	Triadimefon (2)	1,5-dimethoxy-2,4-bis(3-methylphthalidyl)benzol N-phenyl, N-deutero-carbamic acid trideuteromethyl ester Cycle hexane, isothiocynato Acetylcholine
Corn	Thiometon (2) Pyridate (1) Disulfoton (1) Phenthoate (2) Demeton-s-methyl (1) Butocarboxim (1) Demephion (1)	3-methoxy-1,2,3 -triazine Phosthorodithioic acid, 0,0-dimethyl Isopropyl, 2-benzyl-2-propenylether
Greens leafy vegs	Demeton-s-methyl (1) Thiometon (1) Triadimefon (2) Phenthoate (1)	1,3-benzodioxole, 4-methoxy-6-(2-propenyl) 1,2-benzenedicarboxylic acid, bis(2-ethylhexyl) ester
Marrow	Triadimefon (2) Pyridate (1) Bendiocarb (1)	Phosophonic dodecyl ester Benzaldehyde, 4-hydroxy-3-methoxy Thiophene, 2,4-dimethyl N-difluorophosphinodimethylhydroxylamine Phosphonic acid dioctadecyl ester Methyl ester of N-vinyl carbamic acid 1-mercapto-2-heptadecanone

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	Pesticides (n)	Pesticide associated compounds
Onion	Triadimefon (10)	1,2-benzenedicarboxylic acid, bis(2-ethylhexyl) ester
	Pyridate (3)	N-difluorophosphinodimethylhydroxylamine
	Ethidimuron (2)	Furan methylthio
	Captan (3)	Propanoic acid, 2-methyl -2,2-dimethyl -1-(2-hydroxy-1-methylethyl) propyl ester
	Dimethoate (3)	Phenol, 2-bromo-4-chloro
	Phenthoate (8)	Thiophene 2,4-dimethyl
	Fenobucarb (5)	1,5-dimethoxy-2,4-bis(3-methylphthalidyl) benzol
	Isoprocarb (1)	1-mercapto-2-heptadecanone
	Profenofos (2)	1H-Indole, 5-methyl-2-phenyl
		Phosphonic acid, diocatadecyl
		Phenol, 2,2-[(1-methyl-1, 2-ethanediyl) bis(nitrilomethylidyne) bis
		4-bromo-2-chlorophenol
		3-methoxy-1, 2, 4-triazine
		Thiazole, 4,5-dimethyl
		Dodecane 1, 2-dibromo
		Thiophene, 2-methoxy-5-methyl
Tomatoes	Pyridate (1)	1,3-dioxalone, 4-ethyl-5-octyl -2, 2-bis(trifluoromethyl) -trans
	Ultracid (1)	Benzo(b)naotho(2,3-d) furan
	Heptenophos (1)	Benzeneacetic acid, alpha, 3,4-tris[
	Bromacil (1)	Benzoic acid, 2-hydroxy, -methyl ester
	Aminocarb (1)	1H-Indole, 2-methyl-3-phenyl
	Isoxathion (1)	2-ethyl-6-phenyl-benzothiozole

(n) *number of samples with pesticide residue*

Pesticides (number and concentrations) identified in the vegetables from the five farming areas

Produce/ Pesticides	Hayer n (m)	Ramah n (m)	Gumadh n (m)	Waggan n (m)	Sleimat n (m)	Total n(m)
***Aubergines** (pesticide residues identified in 37/45 samples)*						
Organophosphorus pesticides: n=19 (51%)						
Demephion				5 (0.76)	4 (0.85	9 (0.81)
Formothion					2 (0.35)	2 (0.35)
Dimethoate				1 (0.10)	1 (0.20)	2 (0.15)
Ethoprofos		1 (0.20)				1 (0.20)
Disulfoton		1 (0.20)				1 (0.20)
Isoxathion		1 (0.40)				1 (0.40)
Acephate			1 (0.60)			1 (0.60)
Ethiolate			1 (1.20)			1 (1.20)
Heptenophos				1 (0.20)		1 (0.20)
Carbamates and others pesticides: n=44 (119%)						
Triadimefon			2 (0.67)		2 (0.40)	4 (0.54)
Butocarboxim	1 (0.60)	3 (0.53)	2 (1.07)	6 (0.60)	4 (0.53)	16 (0.67)
Ethidimuron	1 (0.20)	3 (0.27)	2 (0.33)	2 (0.15)	2 (0.20)	10 (0.23)
Pyridate		1 (0.40)	4 (0.35)	5 (0.28)	1 (0.20)	11 (0.31)
Dinoseb acetate		1 (0.40)				1 (0.40)
Carbaryl			1 (0.60)			1 (0.60)
Captafol				1 (0.10)		1 (0.10)
***Cabbage** (pesticide residues identified in 3/5 samples)*						
Organophosphorus pesticides: n=3 (100%)						
Methidathion		1 (0.20)				1 (0.20)
Formothion		1 (0.80)				1 (0.80)
Dimethoate				1 (0.60)		1 (0.60)
Carbamate and other pesticides: n=1 (33%)						
Pyridate				1 (0.20)		1 (0.20)
***Capsicum** (pesticide residues identified in 2/3 samples)*						
Carbamate and other pesticides: n=2 (100%)						
Triadimefon			1 (0.80)			1 (0.80)
Pyridate			1 (0.20)			1 (0.20)
***Carrots** (pesticide residues identified in 1/4 samples)*						
Organophosphorus pesticides: n=1 (100%)						
Dimethoate		1 (0.20)				1 (0.20)
Carbamates and other pesticides: n=1 (100%)						
Pyridate		1 (0.4)				1 (0.4)
***Cauliflower** (pesticide residues identified in 4/4 samples)*						
Organophosphorus pesticides: n=2 (50%)						
Methidathion	1 (0.40)					1 (0.40)
Phosphamidon	1 (0.40)					1 (0.40)
Carbamates and other pesticides: n=5 (125%)						
o, p-DDE	1 (0.40)					1 (0.40)
Carbaryl	2 (0.70)	1 (0.20)				3 (0.55)
Pyridate		1 (0.20)				1 (0.20)

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Produce/Pesticides	Hayer n (m)	Ramah n (m)	Gumadh n (m)	Waggan n (m)	Sleimat n (m)	Total n(m)
***Chillies** (pesticide residues identified in 8/12 samples)*						
Organophosphorus pesticides: n=6 (75%)						
Demephion			2 (0.60)			2 (0.60)
Vamidothion			2 (1.20)			2 (1.20)
Phosphamidon			2 (0.30)			2 (0.30)
Carbamates and other pesticides: n=163 (100%)						
Captan		1 (2.40)	1 (1.00)			2 (1.70)
Phenmedipham		1 (0.20)				1 (0.20)
Tolyfluanid			2 (0.60)			2 (0.60)
Pyridate			1 (1.00)			1 (1.00)
Bendiocarb			3 (0.60)			3 (0.60)
Triadimefon			2 (1.00)			2 (1.00)
Desmethryn			1 (2.40)			1 (2.40)
Bifenox			1 (0.40)			1 (0.40)
***Corn** (pesticide residues identified in 6/8 samples)*						
Organophosphorus pesticides: n=11 (183%)						
Demeton-S-methyl	1 (0.80)				1 (1.80)	2 (1.30)
Phenthoate		1 (0.20)			2 (0.70)	3 (0.45)
Disulfoton		1 (0.40)			1 (0.80)	2 (0.60)
Heptenophos		1 (0.40)				1 (0.40)
Thiometon					2 (0.50)	2 (0.50)
Demephion					1 (0.80)	1 (0.80)
Carbamates and other pesticides: n=4 (67%)						
Aminocarb	1 (0.60)					1 (0.60)
Pyridate	1 (0.60)				1 (0.20)	2 (0.40)
Butocarboxim					1 (0.20)	1 (0.20)
***Cucumber** (pesticide residues identified in 4/9 samples)*						
Organophosphorus pesticides: n=4 (100%)						
Methidathion	1 (0.80)					1 (0.80)
Ethoprofos			1 (0.40)			1 (0.40)
Demephion			1 (0.80)			1 (0.80)
Monocryptofos			1 (0.20)			1 (0.20)
Carbamate and other pesticides: n=5 (125%)						
Captan			2 (1.20)			2 (1.20)
Triadimefon			2 (1.10)			2 (1.10)
Pyridate			1 (0.20)			1 (0.20)
***Green leafy vegs** (pesticide residues identified in 13/15 samples)*						
Organophosphorus pesticides: n=6 (46%)						
Phenthoate			1 (1.20)		1 (0.60)	2 (0.90)
Pirimiphos-methyl				1 (0.80)		1 (0.80)
Demephion				1 (0.10)		1 (0.10)
Demeton-S-methyl					1 (0.40)	1 (0.40)
Thiometon					1 (0.40)	1 (0.40)
Carbamate and other pesticides: n=16 (123%)						
Triadimefon		2 (0.30)	1 (0.30)	2 (0.60)	2 (0.60)	7 (0.45)
Carbetamide		1 (0.20)				1 (0.20)
Promecarb		1 (0.40)		2 (0.15)		3 (0.28)
Captan			1 (0.30)	1 (1.00)		2 (0.65)

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Produce/Pesticides	Hayer n (m)	Ramah n (m)	Gumad n (m)	Waggan n (m)	Sleimat n (m)	Total n(m)
Pyridate				1 (0.10)		1 (0.10)
Pyrethrin				1 (0.10)		1 (0.10)
Allethrin				1 (0.10)		1 (0.10)
***Marrow** (pesticide residues identified in 13/16 samples)*						
Organophosphorus pesticides: n=1 (8%)						
Methidathion	1 (0.80)					1 (0.80)
Carbamates and other pesticides: n=10 (77%)						
Triamiphos	1 (1.00)					1 (1.00)
Aminocarb	1 (1.00)					1 (1.00)
Pyridate		1 (0.40)		1 (1.00)		2 (0.70)
Ethidimuron				1 (0.20)		1 (0.20)
Triadimefon				1 (0.80)	2 (0.60)	3 (0.70)
Bendiocarb				1 (0.10)	1 (0.40)	2 (0.25)
***Onion** (pesticide residues identified in 31/59 samples)*						
Organophosphorus pesticides: n=19 (61%)						
Profenofos		2 (1.10)			2 (1.50)	4 (1.30)
Phenthoate		3 (0.60)		1 (0.20)	8 (0.63)	12 (0.48)
Dimethoate					3 (0.47)	3 (0.47)
Carbamates and other pesticides: n=37 (119%)						
Triadimefon		1 (0.20)		5 (0.78)	10 (0.76)	16 (0.51)
Pyridate				5 (0.28)	1 (0.60)	6 (0.44)
Butocarboxim				2 (0.60)		2 (0.60)
Ethidimuron				1 (0.20)	2 (0.50)	3 (0.35)
Bendiocarb				1 (0.20)		1 (0.20)
Fenobucarb					5 (0.56)	5 (0.56)
Captan					3 (0.47)	3 (0.47)
Isoprocarb					1 (0.80)	1 (0.80)
***Potatoes** (pesticide residues identified in 3/4 samples)*						
Organophosphorus pesticides: n=3 (100%)						
Heptenophos	3 (0.33)					3 (0.33)
Carbamates and other pesticides: n=1 (33%)						
Ethidimuron	1 (1.00)					1 (1.00)
***Radish** (pesticide residues identified in 1/1 sample)*						
Organophosphorus pesticides: n=1 (100%)						
Methidathion	1 (0.40)					1 (0.40)
***Tomatoes** (pesticide residues identified in 46/58 samples)*						
Organophosphorus pesticides: n=19 (41%)						
Formothion	1 (1.80)					1 (1.80)
Heptenophos	1 (1.00)				1 (0.20)	2 (0.60)
Dimethoate	2 (0.70)	1 (0.80)		1 (0.40)		4 (0.63)
Demephion		2 (1.10)				2 (1.10)
Phosphamidon		2 (1.30)				2 (1.30)
Phenthoate		3 (1.00)	1 (0.40)			4 (0.70)
Pirimiphos-methyl		1 (1.20)				1 (1.20)
Methidathion		1 (0.80)			1 (0.40)	1 (0.40)
Acephate			1 (0.20)			1 (0.20)
Chlorpyrifos				1 (0.40)		1 (0.40)

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Produce/Pesticides	Hayer n	Ramah n	Gumadh n	Waggan n	Sleimat n	Total n(%)
Carbamates and other pesticides: n=54 (117%)						
Pyridate	4 (0.67)	5 (0.56)	3 (0.33)	4 (0.33)	1 (0.20)	17 (0.42)
Triadimefon	3 (1.30)	5 (1.14)	3 (0.73)	2 (0.83)		13 (1.00)
Aminocarb	1 (1.20)	1 (0.40)		2 (0.30)	1 (0.40)	5 (0.58)
Triamiphos	1 (0.80)					1 (0.80)
Bromacil		5 (1.25)	2 (0.80)	2 (0.90)	1 (1.20)	10 (1.04)
Captan		2 (0.70)				2 (0.70)
Chlorfenson		2 (0.80)				2 (0.80)
Ethidimuron		1 (0.40)				1 (0.40)
Bifenox			1 (0.20)			1 (0.20)
Amidithion				2 (0.15)		2 (0.15)
Isoprocarb					1 (0.40)	1 (0.40)

n *number of samples with pesticide residue*
m *mean concentration of the pesticide residue in mg/kg*

Appendix 21

Mean concentrations of organophosphorus, carbamates and other pesticide residues and the maximum residue limits for the different locally grown vegetables

Organophosphorus pesticides			Carbamates and other pesticides		
Produce/ Pesticides	Actual residues mg/kg	CAC-MRL mg/kg	Produce/ Pesticides	Actual residues mg/kg	CAC-MRL mg/kg
Aubergines					
Demephion	0.81	NA	Triadimefon	0.54	0.50
Formothion	0.35	0.20	Butocarboxim	0.67	NA
Dimethoate	0.15	0.05	Ethidimuron	0.23	NA
Ethoprofos	0.20	0.02	Pyridate	0.31	NA
Disulfoton	0.20	0.50	Dinoseb acetate	0.40	NA
Isoxathion	0.40	NA	Carbaryl	0.60	5.00
Acephate	0.60	0.50	Captafol	0.10	NA
Ethiolate	1.20	NA			
Heptenophos	0.20	NA			
Cabbage					
Methidathion	0.20	0.10	Pyridate	0.20	NA
Formothion	0.80	0.20			
Dimethoate	0.60	0.05			
Capsicum					
			Triadimefon	0.80	0.50
			Pyridate	0.20	NA
Carrots					
Dimethoate	0.20	0.05	Pyridate	0.40	NA
Cauliflower					
Methidathion	0.40	0.10	o,p-DDE	0.40	0.10
Phosphamidon	0.40	0.10	Carbaryl	0.55	5.00
			Pyridate	0.20	NA

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Organophosphorus pesticides			Carbamates and other pesticides		
Produce/ Pesticides	Actual residues mg/kg	CAC-MRL mg/kg	Produce/ Pesticides	Actual residues mg/kg	CAC-MRL mg/kg
Chillies					
Demephion	0.60	NA	Captan	1.70	15.00
Vamidothion	1.20	0.20	Phenmedipham	0.20	NA
Phosphamidon	0.30	0.10	Tolyfluanid	0.60	2.00
			Pyridate	1.00	NA
			Bendiocarb	0.60	0.05
			Triadimefon	1.00	0.50
			Desmethryn	2.40	NA
			Bifenox	0.40	NA
Corn					
Demeton-S-methyl	1.30	NA	Aminocarb	0.60	NA
Phenthoate	0.45	0.05	Pyridate	0.40	NA
Disulfoton	0.60	0.50	Butocarboxim	0.20	NA
Heptenophos	0.40	NA			
Thiometon	0.50	0.50			
Demephion	0.80	NA			
Cucumbers					
Methidathion	0.80	0.10	Captan	1.20	15.0
Ethoprofos	0.40	0.02	Triadimefon	1.10	0.50
Demephion	0.80	NA	Pyridate	0.20	NA
Monocryptofos	0.20	0.05			
Green leafy vegetables					
Phenthoate	0.90	0.05	Triadimefon	0.45	0.50
Pirimiphos methyl	0.80	2.00	Carbetamide	0.20	NA
Demephion	0.10	NA	Promecarb	0.28	NA
Demeton-S-methyl	0.40	NA	Captan	0.65	15.0
Thiometon	0.40	0.50	Pyridate	0.10	NA
			Pyrethrin	0.10	1.00
			Allethrin	0.10	1.00

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Organophosphorus pesticides			Carbamates and other pesticides		
Produce/ Pesticides	Actual residues mg/kg	CAC-MRL mg/kg	Produce/ Pesticides	Actual residues mg/kg	CAC-MRL mg/kg
Marrow					
Methidathion	0.80	0.10	Triamiphos	1.00	NA
			Aminocarb	1.00	NA
			Pyridate	0.70	NA
			Ethidimuron	0.20	NA
			Triadimefon	0.70	0.50
			Bendiocarb	0.25	0.05
Onion					
Profenofos	1.30	NA	Triadimefon	0.51	0.50
Phenthoate	0.48	0.05	Pyridate	0.44	NA
Dimethoate	0.47	0.05	Butocarboxim	0.60	NA
			Ethidimuron	0.35	NA
			Bendiocarb	0.40	0.50
			Captan	0.47	15.0
			Isoprocarb	0.80	NA
Potatoes					
Heptenophos	0.33	NA	Ethidimuron	1.00	NA
Tomatoes					
Formothion	1.80	0.20	Pyridate	0.42	NA
Heptenophos	0.60	NA	Triadimefon	1.00	0.50
Dimethoate	0.63	0.05	Aminocarb	0.58	NA
Demephion	1.10	NA	Triamiphos	0.80	NA
Phosphamidon	1.30	0.10	Bromacil	1.04	NA
Phenthoate	0.70	0.05	Captan	0.70	15.0
Pirimiphos methyl	1.20	2.00	Chlorfenson	0.80	NA
Methidathion	0.80	0.10	Ethidimuron	0.40	NA
Acephate	0.20	0.50	Bifenox	0.20	NA
Chlorpyrifos	0.40	0.50	Amidathion	0.15	NA
			Isoprocarb	0.40	NA

NA not available

UAE University
Faculty of Medicine & Health Sciences
Department of Community Medicine

Agreement of participation in the Food Consumption Survey

The information provided by me will be treated in confidence and will not be divulged to any other person or agency, for any other use except for the purpose of this survey. I understand that the information will be used for the purpose of this survey only and therefore consent to its usage in compiling results for this survey without revealing my identity directly or indirectly. I shall answer all the questions to the best of my knowledge and ability. I shall also provide a 5 ml blood sample to test for pesticide residue. I hope to have a copy of the results of the test on my blood sample. I consent that the results be used in compiling the survey report without revealing my identity.

I have no other questions at the moment, however, if I have any further question I will contact Mr. Gomes or Prof. Lloyd at 669584.

I consent to participate in this survey and in approval of my participation in this survey I shall sign my name here:

____
Please sign your name here

Food consumption survey Questionnaire

A) Demographic information

S. No. ______

1. Age _______ *(write the number of completed years)*

2. Sex ______ *(M - Male, F - Female)*

3. Nationality: _________________

4. Resident of Emirate of _______________

1. Abu Dhabi *2. Dubai*
3. Sharjah *4. Ajman*
5. Umm Al-Quwain *6. Ras Al-Khaima*
7. Fujairah

Please turn over

5. Educational qualifications ______

1. None *2. Primary School*
3. High School *4. Technical School*
5. Graduate *6. Post graduate and above*
7. Others: ______________ *(specify)*

6. Approximate income from all sources per year ________

1. < Dhs. 60,000 *2. Between Dhs. 60, 000 and Dhs. 120,000*
3. Between Dhs. 120,000 and Dhs. 250,000
4. Above Dhs. 250,000

7. Type of housing _____

1. Traditional arabic house *2. Modern villa*
3. Flat *4. Others:* ______________ *(specify)*

8. Occupation _______

1. Student *2. Business*
3. Government employment *4. Private employment*
5. Housewife *6.Military / Police service*
7. Others: ______________ *(specify)*

B) Family information

1. Number of family members constituting your family ________

1. Less than 5 *2. Between 5 and 10*
3. Between 10 and 20 *4. Above 20*

2. How many times do you take your meals in a week at:

	No.of times a week
1. Your own home	_________
2. Restaurant	_________
3. Hostel / School	_________
4. Friend's / Relative's house	_________
5. Others: _____________ *(specify)*	_________

3. How many times a week is your food at home:

	No. of times a week
1. Cooked at home	_________
2. Brought from the restaurants	_________
3. Supplied by relatives / friends	_________
4. Others: _____________ *(specify)*	_________

Please turn over

C) Food information

1. Type of food you eat usually:

1) Never *2) 1-3 times a month* *3) Once a week* *4) 2-3 times a week* *5) Daily*

1.1. Arabic: ______

1.2. Indian / Pakistani: ______

1.3. Western: ______

1.4. Others: ____________ *(specify)* ______

1.5. Others: ____________ *(specify)* ______

2. Number of meals you normally take daily including breakfast, lunch and dinner _

1. One *2. Two*

3. Three *4. Four*

5. Five *6. Others:* ____________ *(specify)*

3. List all the foods you usually consume at breakfast:

	Food material	*Quantity consumed*	*Remarks*
for ex.	*Sandwich*	*one*	*mutton with salad*
	Tea	*small cup*	*without milk*
	____________	____________	____________
	____________	____________	____________
	____________	____________	____________
	____________	____________	____________
	____________	____________	____________

4. List all the foods you usually consume at lunch:

	Food material	*Quantity consumed*	*Remarks*
for ex.	*Salad*	*medium portion*	*labanese salad*
	Biryani	*large portion*	*chicken with curry*
	Kubbus	*one large*	*Irani kubbus*
	____________	____________	____________
	____________	____________	____________

Please turn over for more space

Food material	*Quantity consumed*	*Remarks*
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________

5. List all the foods you usually consume at supper:

	Food material	*Quantity consumed*	*Remarks*
for ex.	*Mutton with gravy*	*medium portion*	*with curry*
	Fish	*one medium fish*	*fried*
	Kubbus	*one large*	*labanese type*
____________		____________	____________
____________		____________	____________
____________		____________	____________
____________		____________	____________
____________		____________	____________
____________		____________	____________

6. Provide details on all the other meals and snacks you usually consume during a routine day (leaving aside your main meals):

	Food materials	*Quantity consumed*	*Remarks*
fox ex.	*Sandwich*	*one medium*	*falafil with salad*
	Chips	*one medium portion*	*fresh fried chips*
	Pepsi/ Sprite	*two of each*	
	Coffee	*five small cups*	*arabic coffee*
	Tea	*three medium cups*	*without milk*
____________		____________	____________

Please turn over for more space

Food materials	*Quantity consumed*	*Remarks*

7. Provide details on all the fruits you usually consume during a normal day:

	Fruits	*Quantity consumed*	*Remarks*
for ex.	*Dates*	*10 - 15 dates*	*processed*
	Oranges	*two oranges*	*fresh*
	Apples	*two apples*	*fresh*
	Pineapples	*one medium portion*	*canned*

8. Please provide details on all the vegetables consumed during the last 24 hours.

	Vegetables	*Preparation*	*Quantity consumed*
for ex.	*Cucumber*	*green salad*	*medium portion*
	Potatoes	*cooked with meat*	*two servings*
	Cabbage	*cooked*	*small portion*
	1. Cucumber		

Please turn over

Vegetables	*Preparation*	*Quantity consumed*
2. Lettuce	______	______
3. Cabbage	______	______
4. Other green leafy vegetables	______	______
5. Tomatoes	______	______
6. Brinjals	______	______
7. Gourd	______	______
8. Potatoes	______	______
9. Raddish	______	______
10. Carrots	______	______
11. Cauliflower	______	______
12. ______	______	______
13. ______	______	______
14. ______	______	______

9. Where do you usually buy your vegetables: ______

1. Local market *2. Supermarket*
3. Agricultural market

10. Where do you usually buy your fruits: ______

1. Local market *2. Supermarket*
3. Agricultural market

Please turn over

12. How many times do you consume the following foods:

1) Never 2) 1-3 times a month 3) Once a week 4) 2-3 times a week 5) Daily

12.1 Mutton: ______
12.2 Beef ______
12.3 Chicken ______
12.4 Camel meat ______
12.5 Fish ______

D. Height in cm: ________

E. Weight in kg: ________

Thank you for providing the details on your food habits.

If you would like to make any comments regarding your food habits or regarding this questionnaire / survey, please put it down hereunder: Thank you

____

____

____

Bon Appetite

Vegetables in local dishes

Group 3 (*Sandwich*)
The sandwiches are made with pitta bread or Samun (Arabic hot dog bun). Sandwiches at breakfast time are usually vegetable based sandwiches and are made with one major vegetable (potatoes, cauliflower, aubergines), green salad and pickled vegetables (cucumbers, chillies, carrots)

The following ingredients and quantities have been used to make one sandwich either with pitta bread or Samun. The ingredients for green salad were the same for the ethnic and the farming populations.

1. Potato sandwich

Potatoes		30g
Green salad	Tomatoes	15g
	Cucumber	10g
	Lettuce	10g
	Carrots	10g
	Onion	10g
	Capsicum	5g
	Coriander	5g
Total		**95g**

2. Aubergine sandwich

Aubergines		30g
Green salad	Tomatoes	15g
	Cucumber	10g
	Lettuce	10g
	Carrots	10g
	Onion	10g
	Capsicum	5g
	Coriander	5g
Total		**95g**

3. Cauliflower sandwich

Cauliflower		30g
Green salad	Tomatoes	15g
	Cucumber	10g
	Lettuce	10g
	Carrots	10g
	Onion	10g
	Capsicum	5g
	Coriander	5g
Total		**95g**

Total for the group 95g *(mean of all the three sandwiches)*
Total for the group (locally grown vegetables) 90g
(underlined commodities not included in the totals, because it is not grown locally)

Group 4 (*Lentils*)
This group includes items like falafyl, fatayer etc. These items are normally consumed at breakfast; falafyl is usually made into a sandwich (as in group 3) while fatayer is eaten as it is. Sometimes falafyl is used in the group 3 sandwiches along with other vegetables.

The following ingredients and quantities have been used in making a serving for one person, which will be 2 falafyls or fatayers.

Lentils	20g	
Onion	20g	
Tomato	10g	
Cauliflower	10g	
Cucumber	10g	
Coriander	5g	
Capsicum	5g	
Carrots	5g	
Green leafy vegs	5g	(spinach, parsley)

Group total 90g
Group total (locally grown vegetables) **65g**

Group 5 (*Homus*)
Homus is a dish by itself and is normally served with green salad, used in sandwiches or served on it's own.

The following ingredients and quantities have been used for one serving of homus.

Peas (chick)	80g
Carrots	15g
Cucumber	20g
Lettuce	10g
Onion	10g
Tomatoes	10g
Pepper	5g
Coriander	5g

Group total 155g
Group total (locally grown vegetables) 70g

Group 7 (*Biryani*)
This food group is a cereal based dish with vegetables. Three dishes; makbous, mahsi and malfoof are some of the most commonly consumed dishes among the ethnic population. The recipes given below have been adapted for one serving by dividing the quantities in the original recipes by the number of people it was meant to serve.

The vegetable ingredients for makbous, mahsi and malfoof are shown below for each of the dishes.

1. Makbous

	Tomatoes	15g
	Onion	15g
	Coriander	10g
	Peas	10g
Total		**50g**

Total (locally grown vegetables) 30g

2. Mahsi

	Cauliflower	15g
	Capsicum	15g
	Potatoes	20g
	Tomatoes	20g
	Onion	15g
	Coriander	10g
	Chillies	5g
Total		**95g**

Total (locally grown vegetables) 85g

3. Malfoof

	Cabbage	65g
	Capsicum	15g
	Tomatoes	15g
	Onion	15g
Total		**110g**

Total (locally grown vegetables) **110g**

Group total 85g
Group total (locally grown vegetables) 75g

Group 8 (*Salad*)
In this group three types of salads (green salad, taboule and fatoosh) were considered. These were the most commonly consumed salads among the ethnic population, while the farming population consumed only green salad

The ingredients and quantities for the three types of salads have been given below:

1. Green salad

Lettuce	10g
Tomatoes	10g
Cucumber	10g
Carrots	15g
Pepper	5g
Onion	5g
Total	**55g**

Total (locally grown vegetables) **55g**

2. Taboule

Mint	5g
Parsley	30g
Tomatoes	10g
Coriander	5g
Onion	5g
Total	**55g**

Total (locally grown vegetables) **15g**

3. Fatoosh

Mint	5g
Parsley	20g
Broccoli	10g
Coriander	5g
Tomatoes	10g
Onion	5
Total	**55g**

Total (locally grown vegetables) **15g**

Group total **55g**
Group total (locally grown vegetables) **28g**

Group 10 (*Vegetables*)
The different vegetable dishes in this group have been cooked without any meat and include one vegetable as a major component and others are added to taste as required

The ingredients and quantities of the different vegetable dishes are as follows:

1. Marrow

Marrow	70g
Onion	15g
Tomatoes	20g
Chillies	5g
Coriander	5g
Parsley	5g
Total	**120g**

Total (locally grown vegetables) **110g**

2. Cauliflower

Cauliflower	80g
Onion	15g
Tomatoes	20g
Chillies	5g
Coriander	5g
Potatoes	20g
Total	**145g**

Total (locally grown vegetables) **140g**

3. Cabbage

Cabbage	50
Onion	15g
Tomatoes	60g
Chillies	5g
Coriander	5g
Total	**135g**

Total (locally grown vegetables) **130g**

4. Aubergines

Aubergines	70g
Onion	15g
Tomatoes	60g
Chillies	5g
Potatoes	20g
Total	**170g**

Total (locally grown vegetables) **170g**

5. Okra

Okra	60g
Onion	15g
Tomatoes	20g
Chillies	5g
Coriander	5g
Parsley	5g

Total **110g**
Total (locally grown vegetables) **40g**

6. Spinach / Molokia

Spinach	70g (or Molokia 70g)
Onion	15g
Tomatoes	30g
Chillies	5g
Potatoes	20g
Total	**140g**

Total (locally grown vegetables) **140g**

Group mean **137g**
Group mean (locally grown vegetables) **122g**

Group 12 (*Mutton*)
In this group vegetables were cooked with mutton as the main ingredient.

The following vegetables have been used in these dishes.

1. Dish with Okra

Okra	60g
Tomatoes	20g
Onion	10g
Carrots	10g
Chillies	5g
Capsicum	5g
Total	**110g**

Total (locally grown vegetables) **50g**

2. Dish with Aubergines

Aubergines	60g
Tomatoes	20g
Onion	10g
Carrots	10g
Chillies	5g
Capsicum	5g
Total	**110g**

Total (locally grown vegetables) **110g**

3. Dish with Marrow

Marrow	60
Tomatoes	20g
Onion	10g
Carrots	10g

Chillies	5g
Capsicum	5g
Total	**110g**

Total (locally grown vegetables) **110g**

4. Dish with Potatoes

Potatoes	60
Tomatoes	20g
Onion	10g
Carrots	10g
Chillies	5g
Capsicum	5g
Total	**110g**

Total (locally grown vegetables) **110g**

Group total 110g
Group total (locally grown vegetables) **98g**

Group 13 (*Chicken*)

In this group vegetables were cooked with chicken as the main ingredient.

The following vegetables have been used in these dishes.

1. Dish with Okra

Okra	40g
Tomatoes	20g
Onion	15g
Carrots	15g
Chillies	5g
Total	**95g**

Total (locally grown vegetables) **55g**

2. Dish with Potatoes

Potatoes	40g
Tomatoes	20g
Onion	15g
Carrots	15g
Chillies	5g
Total	**95g**

Total (locally grown vegetables) **95g**

Group total 95g
Group total (locally grown vegetables) **75g**

Group 14 (*Fish*)
In this group vegetables were cooked with fish as the main ingredient.

The following vegetables have been used in these dishes.

Tomatoes	30g
Onion	30g
Carrots	10g
Chillies	5g
Cucumber	10
Lettuce	10
Total	**95g**

Group total 95g
Group total (locally grown vegetables) **95g**

Group 15 (*Potato salad*)
In this group potato has been used as the main ingredient.

The following vegetables have been used in this dish.

Potatoes	80g
Tomatoes	10g
Onion	10g
Coriander	5g
Parsley	10g
Peas	5g
Total	**120g**

Group total 120g
Group total (locally grown vegetables) **100g**

Estimated daily intake (EDI) of individual pesticide residues among the ethnic and the farming populations

Pesticides*/ Vegetables	*Ri*[1] mg/kg	*Pi*[2]	*Ci*[3]	Ethnic population *Fi*[4] kg/p/d	Ethnic population EDI mg/p/d	Farming population *Fi*[5] kg/p/d	Farming population EDI mg/p/d
Demephion							
Aubergines	0.81	1	0.5	0.201	81.40	0.248	100.40
Chillies	0.60	1	1	0.008	4.80	0.019	11.40
Cucumbers	0.80	1	1	0.029	23.20	0.028	22.40
Tomatoes	1.10	1	0.5	0.054	29.70	0.062	34.10
Acephate							
Aubergines	0.60	1	0.5	0.201	60.30	0.248	74.4
Triadimefon							
Aubergines	0.54	1	0.5	0.201	54.30	0.248	66.90
Capsicum	0.80	1	1	0.020	16.00	0.010	8.00
Chillies	1.00	1	1	0.008	8.00	0.019	19.00
Marrow	0.70	1	0.5	0.140	49.00	0.248	86.80
Tomatoes	1.00	1	0.5	0.054	27.00	0.062	31.00
Onion	0.51	1	1	0.039	19.90	0.037	18.90
Butocarboxim							
Aubergines	0.67	1	0.5	0.201	67.30	0.248	83.10
Onion	0.60	1	1	0.039	23.40	0.037	22.20
Carbaryl							
Aubergines	0.60	1	0.5	0.201	60.30	0.248	74.40
Cauliflower	0.55	1	1	0.079	43.50	0.230	126.50
Formothion							
Cabbage	0.80	1	1	0.095	76.00	0.200	160.0
Tomatoes	1.80	1	0.5	0.054	48.60	0.062	55.80

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Pesticides*/ Vegetables	*Ri*[1] mg/kg	*Pi*[2]	*Ci*[3]	Ethnic population		Farming population	
				Fi[4] kg/p/d	EDI mg/p/d	*Fi*[5] kg/p/d	EDI mg/p/d
Dimethoate							
Cabbage	0.60	1	1	0.095	57.00	0.200	120.0
Tomatoes	0.63	1	0.5	0.054	17.00	0.062	19.50
Captan							
Chillies	1.70	1	1	0.008	13.60	0.019	32.30
Cucumbers	1.20	1	1	0.029	34.80	0.028	33.60
Green leafy vegs	0.65	1	0.5	0.033	10.70	0.113	36.70
Tomatoes	0.70	1	0.5	0.054	18.90	0.062	21.70
Pyridate							
Chillies	1.10	1	1	0.008	8.80	0.019	20.90
Marrow	0.70	1	0.5	0.140	49.00	0.248	86.80
Desmethryn							
Chillies	2.40	1	1	0.008	19.20	0.019	45.60
Tolyfluanid							
Chillies	0.60	1	1	0.008	4.80	0.019	11.40
Bendiocarb							
Chillies	0.60	1	1	0.008	4.80	0.019	11.40
Methidathion							
Cucumbers Marrow	0.80 0.80	1 1	1 0.5	0.029 0.140	23.20 56.00	0.028 0.248	22.40 99.20
Tomatoes	0.70	1	0.5	0.054	18.90	0.062	21.70
Phenthoate							
Green leafy vegs	0.90	1	0.5	0.033	14.90	0.113	50.90
Tomatoes	0.70	1	0.5	0.054	18.90	0.062	21.70
Pirimiphosmethyl							
Green leafy vegs	0.80	1	0.5	0.033	13.20	0.113	45.20
Tomatoes	1.20	1	0.5	0.054	32.40	0.062	37.20
Triamiphos							
Marrow	1.00	1	0.5	0.140	70.00	0.248	124.00
Tomatoes	0.80	1	0.5	0.054	21.60	0.062	24.80

continued on the next page

Pesticides*/ Vegetables	Ri^1 mg/kg	Pi^2	Ci^3	Ethnic population		Farming population	
				Fi^4 kg/p/d	EDI mg/p/d	Fi^5 kg/p/d	EDI mg/p/d
Aminocarb							
Marrow	1.00	1	0.5	0.140	70.00	0.248	124.00
Tomatoes	0.58	1	0.5	0.054	15.70	0.062	17.90
Isoprocarb							
Onion	0.80	1	1	0.039	31.20	0.037	29.60
Profenofos							
Onion	1.30	1	1	0.039	50.70	0.037	48.10
Ethidimuron							
Potatoes	1.00	1	0.5	0.166	83.00	0.102	51.00
Heptenophos							
Tomatoes **Phosphamidon**	0.60	1	0.5	0.054	16.20	0.062	18.60
Tomatoes	1.30	1	0.5	0.054	35.10	0.062	40.30
Bromacil							
Tomatoes	1.04	1	0.5	0.054	28.10	0.062	32.20
Chlorfenson							
Tomatoes	0.80	1	0.5	0.054	21.60	0.062	24.80
Fenobucarb							
Onion	0.56	1	1	0.039	21.80	0.037	20.7

* *Pesticides identified in at least 10% of the samples*

1 *Pesticide residues in vegetables calculated in Chapter 6 (Table 6-33)*

2 *Correction factor for commercial processing of vegetables (Guidelines for predicting dietary intake of pesticide residues, 1989)*

3 *Correction factor for preparation or cooking of vegetables (Guidelines for predicting dietary intake of pesticide residues, 1989)*

4 *Dietary intake of vegetables by the ethnic population (Table 7-32)*

5 *Dietary intake of vegetables by the farming population (Table 7-32)*

Pesticide residues by type in the different vegetable commodities

Vegetable commodities	Organophosphorus pesticides	ADI mg/kg bw	Carbamate / Other pesticides	ADI mg/kg bw	All pesticides ADI_{median} mg/kg bw	All pesticides ADI_{mean} mg/kg bw
Aubergines	Demephion	S	Triadimefon	0.03		
	Formothion	0.02	Butocarboxim	NA		
	Dimethoate	0.01	Ethidimuron	NA		
	Ethoprofos	0.003	Pyridate	NA		
	Disulfoton	0.003	Dinoseb acetate	NA		
	Isoxathion	NA	Carbaryl	0.01		
	Acephate	0.03	Captafol	NA		
	Ethiolate	NA				
	Heptenophos	NA				
Median/mean values		*100x10^{-4}*		*200x10^{-4}*	*100x10^{-4}*	*151x10^{-4}*
Cabbage	Methidation	0.005	Pyridate	NA		
	Formothion	0.02				
	Dimethoate	0.01				
Median/mean values		*100x10^{-4}*		*NA*	*100x10^{-4}*	*116x10^{-4}*
Capsicum			Triadimefon	0.03		
			Pyridate	NA		
Median/mean values		-		*300x10^{-4}*	*300x10^{-4}*	*300x10^{-4}*
Carrots	Dimethoate	0.01	Pyridate	NA		
Median/mean values		*100x10^{-4}*		*NA*	*100x10^{-4}*	*100x10^{-4}*
Cauliflower	Methidathion	0.005	Carbaryl	0.01		
	Phosphamidon	0.0005	Pyridate	NA		
			o,p-DDE	0.02		
Median/mean values		*28x10^{-4}*		*150x10^{-4}*	*75x10^{-4}*	*89x10^{-4}*
Chillies	Demephion	S	Captan	0.1		
	Vamidothion	0.008	Tolyfluanid	0.1		
	Phosphamidon	0.0005	Bendiocarb	0.004		
			Pyridate	NA		

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Vegetable commodities	Organophosphorus pesticides	ADI mg/kg bw	Carbamate / Others pesticides	ADI mg/kg bw	All pesticides ADI_{median} mg/kg bw	All pesticides ADI_{mean} mg/kg bw
			Phenmedipham	NA		
			Triadimefon	0.03		
			Desmethryn	NA		
			Bifenox	NA		
Median/mean values		*43x10⁻⁴*		*650x10⁻⁴*	*190x10⁻⁴*	*404x10⁻⁴*
Corn	Demeton-S-methyl	0.0003	Pyridate			
	Phenthoate	0.003				
	Disulfoton	0.003				
	Thiometon	0.003				
Median/mean values		*30x10⁻⁴*		*NA*	*30x10⁻⁴*	*23x10⁻⁴*
Cucumbers	Methidathion	0.005	Captan	0.1		
	Ethoprophos	0.003	Triadimefon	0.03		
	Demephion	S	Pyridate	NA		
	Monocrotophos	0.00005				
Median/mean values		*30x10⁻⁴*		*650x10⁻⁴*	*50x10⁻⁴*	*276x10⁻⁴*
Green leafy vegs	Phenthoate	0.003	Triadimefon	0.03		
	Pirimiphos-methyl	0.01	Promecarb	NA		
	Demephion	NA	Captan	0.1		
	Demeton-S-methyl	NA	Pyridate	NA		
	Thiometon	0.003	Pyrethrin	0.04		
			Allethrin	0.04		
Median/mean value		*30x10⁻⁴*		*400x10⁻⁴*	*300x10⁻⁴*	*323x10⁻⁴*
Marrow	Methidathion	0.005	Triadimefon	0.03		
			Bendiocarb	0.004		
			Pyridate	NA		
			Ethidimuron	NA		
			Triamiphos	NA		
			Aminocarb	NA		
Median/mean		*50x10⁻⁴*		*170x10⁻⁴*	*500x10⁻⁴*	*130x10⁻⁴*

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Vegetable commodities	Organophosphorus pesticides	ADI mg/kg bw	Carbamate / Others pesticides	ADI mg/kg bw	All pesticides ADI_{median} mg/kg bw	All pesticides ADI_{mean} mg/kg bw
Onion	Phenthoate	0.003	Triadimefon	0.03		
	Profenofos	NA	Pyridate	NA		
	Dimethoate	0.01	Ethidimuron	NA		
			Fenobucarb	NA		
			Captan	0.1		
			Butocarboxim	NA		
			Bendiocarb	0.004		
			Isoprocarb	NA		
Median/mean values		*65x10⁻⁴*		*300x10⁻⁴*	*100x10⁻⁴*	*294x10⁻⁴*
Potatoes	Heptenophos	NA	Ethidimuron	NA		
Median/mean values		*NA*		*NA*	*NA*	*NA*
Tomatoes	Dimethoate	0.01	Pyridate	NA		
	Phenthoate	0.003	Triadimefon	0.03		
	Formothion	0.02	Bromacil	NA		
	Heptenophos	NA	Aminocarb	S		
	Demephion	NA	Triamiphos	NA		
	Phosphamidon	0.0005	Captan	0.1		
	Pirimiphos-methyl	0.01	Chlorfenson	NA		
	Methidathion	0.005	Ethidimuron	NA		
	Chlorpyrifos	0.01	Bifenox	NA		
	Acephate	0.03	Isoprocarb	NA		
			Amidathion	NA		
Median/mean values		*250x10⁻⁴*		*650x10⁻⁴*	*250x10⁻⁴*	*219x10⁻⁴*

NA *information not available*

S *the manufacture and use of this compound has been discontinued in the developed countries*

Dietary intakes (EDI_{bw}) and acceptable daily intakes (ADI) of pesticide residues and percentage (ADI) for the ethnic and farming populations

Pesticides/ Vegetables	Ethnic population				Farming population			
	EDI[1] mg/p/d	EDI_{bw}[2] mg/kg/bw	ADI[3] mg/kg/bw	Percentage ADI[4]	EDI[1] mg/p/d	EDI_{bw}[2] mg/kg/bw	ADI[3] mg/kg/bw	Percentage ADI[4]
Demephion								
Aubergines	81.40×10^{-3}	13.57×10^{-4}	NA	-	100.4×10^{-3}	16.73×10^{-4}	NA	-
Chillies	4.80×10^{-3}	8.00×10^{-4}	NA	-	11.40×10^{-3}	1.90×10^{-4}	NA	-
Cucumbers	23.20×10^{-3}	3.87×10^{-4}	NA	-	22.40×10^{-3}	3.73×10^{-4}	NA	-
Tomatoes	29.70×10^{-3}	4.95×10^{-4}	NA	-	34.10×10^{-3}	5.68×10^{-4}	NA	-
Acephate								
Aubergines	60.30×10^{-3}	10.05×10^{-4}	300×10^{-4}	3.33	74.40×10^{-3}	12.40×10^{-4}	300×10^{-4}	4.13
Triadimefon								
Aubergines	54.30×10^{-3}	9.05×10^{-4}	300×10^{-4}	3.02	66.90×10^{-3}	11.15×10^{-4}	300×10^{-4}	3.72
Capsicum	16.00×10^{-3}	2.67×10^{-4}	300×10^{-4}	0.89	8.00×10^{-3}	1.33×10^{-4}	300×10^{-4}	0.44
Chillies	8.00×10^{-3}	1.33×10^{-4}	300×10^{-4}	0.44	19.00×10^{-3}	3.17×10^{-4}	300×10^{-4}	1.06
Marrow	49.00×10^{-3}	8.17×10^{-4}	300×10^{-4}	2.72	86.80×10^{-3}	14.47×10^{-4}	300×10^{-4}	4.82
Tomatoes	27.00×10^{-3}	4.50×10^{-4}	300×10^{-4}	1.50	31.00×10^{-3}	5.17×10^{-4}	300×10^{-4}	1.72
Onion	19.90×10^{-3}	3.32×10^{-4}	300×10^{-4}	1.11	18.90×10^{-3}	3.15×10^{-4}	300×10^{-4}	1.05
Butocarboxim								
Aubergines	67.30×10^{-3}	11.22×10^{-4}	NA	-	83.10×10^{-3}	13.85×10^{-4}	NA	-
Onion	23.40×10^{-3}	3.90×10^{-4}	NA	-	22.2×10^{-3}	3.70×10^{-4}	NA	-
Carbaryl								
Aubergines	60.30×10^{-3}	10.05×10^{-4}	100×10^{-4}	10.05	74.40×10^{-3}	12.40×10^{-4}	100×10^{-4}	12.40
Cauliflower	43.50×10^{-3}	7.25×10^{-4}	100×10^{-4}	7.25	126.5×10^{-3}	21.08×10^{-4}	100×10^{-4}	21.08
Formothion								
Cabbage	76.00×10^{-3}	12.67×10^{-4}	200×10^{-4}	6.03	160.0×10^{-3}	26.67×10^{-4}	200×10^{-4}	13.33
Tomatoes	48.60×10^{-3}	8.10×10^{-4}	200×10^{-4}	4.05	55.80×10^{-3}	9.30×10^{-4}	200×10^{-4}	4.65

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Pesticides/ Vegetables	Ethnic population				Farming population			
	EDI[1] mg/p/d	EDI_{bw}[2] mg/kg/bw	ADI[3] mg/kg/bw	Percentage ADI[4]	EDI[1] mg/p/d	EDI_{bw}[2] mg/kg/bw	ADI[3] mg/kg/bw	Percentage ADI[4]
Dimethoate								
Cabbage	57.00×10^{-3}	9.50×10^{-4}	100×10^{-4}	9.50	120.0×10^{-3}	20.0×10^{-4}	100×10^{-4}	20.0
Tomatoes	17.00×10^{-3}	2.83×10^{-4}	100×10^{-4}	2.83	19.50×10^{-3}	3.25×10^{-4}	100×10^{-4}	3.25
Captan								
Chillies	13.60×10^{-3}	2.27×10^{-4}	1000×10^{-4}	0.23	32.30×10^{-3}	5.38×10^{-4}	1000×10^{-4}	0.54
Cucumbers	34.80×10^{-3}	5.80×10^{-4}	1000×10^{-4}	0.58	33.60×10^{-3}	5.60×10^{-4}	1000×10^{-4}	0.56
Green leafy vegs	10.70×10^{-3}	1.78×10^{-4}	1000×10^{-4}	0.18	36.70×10^{-3}	6.12×10^{-4}	1000×10^{-4}	0.61
Tomatoes	18.90×10^{-3}	3.15×10^{-4}	1000×10^{-4}	0.32	21.70×10^{-3}	3.57×10^{-4}	1000×10^{-4}	0.36
Pyridate								
Chillies	8.80×10^{-3}	1.47×10^{-4}	NA	-	20.90×10^{-3}	3.48×10^{-4}	NA	
Marrow	49.00×10^{-3}	8.17×10^{-4}	NA	-	86.80×10^{-3}	14.47×10^{-4}	NA	
Desmethryn								
Chillies	19.20×10^{-3}	3.20×10^{-4}	NA	-	45.60×10^{-3}	7.60×10^{-4}	NA	
Tolyfluanid								
Chillies	4.80×10^{-3}	0.80×10^{-4}	1000×10^{-4}	0.08	11.40×10^{-3}	1.90×10^{-4}	1000×10^{-4}	0.19
Bendiocarb								
Chillies	4.80×10^{-3}	0.80×10^{-4}	40×10^{-4}	2.00	11.40×10^{-3}	1.90×10^{-4}	40×10^{-4}	4.75
Methidathion								
Cucumbers	23.20×10^{-3}	3.87×10^{-4}	50×10^{-4}	7.74	22.40×10^{-3}	3.73×10^{-4}	50×10^{-4}	7.46
Marrow	56.00×10^{-3}	9.33×10^{-4}	50×10^{-4}	18.66	99.20×10^{-3}	16.53×10^{-4}	50x10-4	33.06
Tomatoes	18.90×10^{-3}	2.70×10^{-4}	50×10^{-4}	5.40	21.70×10^{-3}	3.62×10^{-4}	50×10^{-4}	7.24
Phenthoate								
Green leafy vegs	14.90×10^{-3}	2.48×10^{-4}	30×10^{-4}	8.27	50.90×10^{-3}	8.48×10^{-4}	30×10^{-4}	28.27
Tomatoes	18.90x10-3	3.15×10^{-4}	30×10^{-4}	10.5	21.70×10^{-3}	3.62×10^{-4}	30×10^{-4}	12.07
Pirimiphosmethyl								
Green leafy vegs	13.20×10^{-3}	2.20×10^{-4}	100×10^{-4}	2.20	45.20×10^{-3}	7.53×10^{-4}	100×10^{-4}	7.53
Tomatoes	32.40×10^{-3}	5.40×10^{-4}	100×10^{-4}	5.40	37.20×10^{-3}	6.20×10^{-4}	100×10^{-4}	6.20
Triamiphos								
Marrow	70.00×10^{-3}	11.67×10^{-4}	NA	-	124.0×10^{-3}	20.67×10^{-4}	NA	
Tomatoes	21.60×10^{-3}	3.60×10^{-4}	NA	-	24.80×10^{-3}	4.13×10^{-4}	NA	

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Pesticides/ Vegetables	Ethnic population				Farming population			
	EDI[1] mg/p/d	EDI_{bw}[2] mg/kg/bw	ADI[3] mg/kg/bw	Percentage ADI[4]	EDI[1] mg/p/d	EDI_{bw}[2] mg/kg/bw	ADI[3] mg/kg/bw	Percentage ADI[4]
Aminocarb								
Marrow	70.00×10^{-3}	11.67×10^{-4}	NA	-	124.0×10^{-3}	20.67×10^{-4}	NA	
Tomatoes	15.70×10^{-3}	2.62×10^{-4}	NA	-	17.90×10^{-3}	2.98×10^{-4}	NA	
Isoprocarb								
Onion	31.20×10^{-3}	5.20×10^{-4}	NA	-	29.60×10^{-3}	4.93×10^{-4}	NA	
Profenofos								
Onion	50.70×10^{-3}	8.45×10^{-4}	NA	-	48.10×10^{-3}	8.07×10^{-4}	NA	
Ethidimuron								
Potatoes	83.00×10^{-3}	13.83×10^{-4}	NA	-	51.00×10^{-3}	8.50×10^{-4}	NA	
Heptenophos								
Tomatoes	16.20×10^{-3}	2.70×10^{-4}	NA	-	18.60×10^{-3}	3.10×10^{-4}	NA	
Phosphamidon								
Tomatoes	35.10×10^{-3}	5.85×10^{-4}	5×10^{-4}	117.0	40.30×10^{-3}	6.72×10^{-4}	5×10^{-4}	134.40
Bromacil								
Tomatoes	28.10×10^{-3}	4.68×10^{-4}	NA	-	32.20×10^{-3}	5.37×10^{-4}	NA	-
Chlorfenson								
Tomatoes	21.60×10^{-3}	3.60×10^{-4}	NA	-	24.80×10^{-3}	4.13×10^{-4}	NA	-
Fenobucarb								
Onion	21.80×10^{-3}	3.60×10^{-4}	NA	-	20.70×10^{-3}	3.50×10^{-4}	NA	-

1 *Extracted from Table 7-35 (Chapter 7)*

2 *EDI_{bw} = EDI/60 (average weight of an adult)*

3 *Extracted from Table 8-8*

4 *Percentage ADI = (EDI_{bw}/ADI)100*