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Health Risk Assessment of Pesticide Usage in Menia El-Kamh Province of Sharkia Governorate in Egypt

Paul B. Tchounwou[1], Bassem A. Ashour[2], Curtina Moreland-Young[3], Didair A. Ragheb[2], Ahmed A. Romeh[2], El-Adarosy Goma[2], Sayed El-Sheikh[2], Frances P. Lidell[3], Olurominiyi Ibitayo[3], and Jean-Claude Assad[4]

[1]Environmental Toxicology Research Laboratory, NIH-Center for Environmental Health, Jackson State University, School of Science and Technology, Jackson, Mississippi, USA. Email: paul.b.tchounwou@jsums.edu
[2]Department of Plant Protection, Faculty of Agriculture, University of Zagazig, Egypt.
[3]Department of Public Policy, School of Liberal Arts, Jackson State University, Jackson, Mississippi, USA
[4]Department of Business Administration, School of Business, Jackson State University, Jackson, Mississippi, USA.

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Abstract: Menia El-Kamh province of the Sharkia Governorate constitutes one of the largest agricultural areas in Egypt. About 88% of the nearly 472,000 people living in this province rely on agricultural activities for subsistence. Several pesticides including organochloride, organophosphorus, carbamate, and pyrethroid insecticides, fungicides, and herbicides are commonly used in citrus, vegetable and other crop-growing areas to increase agricultural productivity. However, their use has also been associated with several cases of pesticide poisoning. In this research, we conducted a field survey to assess the knowledge, attitudes, and practices of the farmer's community regarding the safe use of pesticides. We also evaluated the residual concentrations of selected pesticides in water, soil, milk, fish, and orange samples, and estimated the potential health risks associated with the exposure to these pesticides. Data obtained from the field survey indicate that more than 95% of farm workers do not practice safety precautions during pesticide formulation and application; leading to a considerable prevalence of pesticide-related illnesses in this agricultural community. Pesticide residues in various environmental samples varied greatly; from below detection levels (3-5 ng) to as high as 325 ppb depending on the matrix of interest, and the specific pesticide of concern. The analysis of health risk estimates indicated that chlorpyrifos, DDT, dimethoate, methomyl, and larvin did not pose a direct hazard to human

health, although present in water, milk, orange, and/or fish. However, aldicarb, and carbosulfan levels exceeded the reference doses, indicating a great potential for systemic toxicity, especially in children who are considered to be the most vulnerable population subgroup. The upper-bound values of cancer risk from DDT exposure were estimated to be about 8 (adults), and 55 (children) excess cancers in a population of one million.

Keywords: Pesticides, rural communities, Egypt, health risk assessment.

Introduction

The agricultural sector is a very important part of the Egyptian economy. The total area of agricultural land in Egypt is 7.6 million feddans, and the population exceeds 60 million. Agriculture accounts for about 20% of both gross and domestic products and total exports, and for about 34% of total employment. The agricultural sector greatly contributes to the overall food needs of the country and provides the domestic industry with agricultural raw materials. It promotes industrial development through expanding the market for industrial goods such as pesticides, chemical fertilizers, equipment and machines. Moreover, agriculture helps to finance economic and social development through the net capital from agriculture to other sectors of the economy [1].

Menia El-Kamh province of the Sharkia Governorate constitutes one of the largest agricultural areas in Egypt. About 88% of the nearly 472,000 people living in this province rely on agricultural activities for subsistence. Several pesticides including organochloride, organophosphorus, carbamate, and pyrethroid insecticides, fungicides, and herbicides are commonly used in citrus, vegetable and other crop-growing areas to increase agricultural productivity. The use of such synthetic chemicals has led to increased production of food and fiber, and increased profitability in agriculture [2]. However, their use has also been associated with several concerns, including the risks to human health, the death of farm animals, and the alteration of the local environment [3-6].

Residual levels of pesticides in Egyptian foods often average higher than those found in developed countries, either because the number of skilled technicians available to enforce the laws concerning pesticide usage are inadequate or because of the lack of adequate financial resources. Several Egyptian studies investigating the residual levels of pesticides in foods have reported hazardous concentrations in potato tubers, milk samples, fruits and vegetables [5-8].

A higher proportion of pesticide poisoning and illness in Egypt occurs in remote agricultural areas where there are inadequate occupational safety standards, insufficient enforcement of pesticide-related legislation, poor labeling of pesticide containers, illiteracy, inadequate protective clothing and washing facilities, and user's lack of knowledge of pesticide hazards [5-8]. The highest levels of pesticide exposure occur in pesticide applicators, farm workers, and people living closer to heavily treated agricultural lands. Because farmers and farm workers directly handle more than 70% of all pesticides

used, they constitute the population subgroups at high risk of pesticide poisoning. However, there exists a very limited amount of epidemiological data concerning the risks to farmer's health. In a study of the health profile of 300 occupationally exposed pesticide workers in the formulating industry in Egypt, Amer [9] reported several disease conditions including hypertension, hepathomegaly, dermatosis, and chromosomal abberations. Pesticide exposure has also been associated with elevated cancer risks, and reproductive dysfunctions in agricultural workers [10,11].

Based on the above information, the purpose of this research was trifold: 1) to assess the knowledge, attitudes, and practices of the farmers' community in Menia El-Kamh province regarding the safe use of pesticides; 2) to evaluate the residual concentrations of selected pesticides in water, soil, milk, fish and citrus specimen collected from the province; and 3) to estimate the potential health risks associated with the use of these pesticides.

Materials and Methods

Field Investigations

A field survey was conducted between February and September 2001, during which a questionnaire was developed and administered to a total of 187 farmers who were heads of randomly selected households from several agricultural districts in Menia El-Kamh province of the Sharkia Governorate in Egypt. The questionnaire focused on the assessment of knowledge, attitudes and practices of these farm workers regarding the safe use of pesticides, and the identification of the most prominent health-related issues in the area.

During the field survey, several environmental samples were collected for the analysis of pesticide residuals. Soil samples were collected from eight different locations including the Aboutwila, Banykoriesh, Kafreldair, Mohamadia, Seneta, Shembara, Taliene, and Walaga districs. Water samples were collected from surface and covered drainages, rice fields, canals, and taps. Water samples were grab samples (10 cm depth) while soil samples were the top layers (10 cm) of soil obtained using a stainless steel dredge instrument. Latex surgical gloves were worn during sample collection and preservation. Citrus fruits, fresh tilapia fish, and cow/buffalo milk were purchased from six different market places in the province.

Sample Extraction

Pesticide residues extraction and clean-up were performed according to standard protocols. Citrus fruit samples were extracted according to guidelines of the Codex Committee on Pesticide Residues [12]. Two hundred grams of soil or edible fish tissue were placed in a 4-liter stainless steel blender, and homogenized successively with 150 mL and 400 mL of acetone-methanol (9:1 v/v) for 5 min, respectively. For water samples, 1 L was placed in a 2 L separatory funnel, then 10 mL of saturated sodium chloride were added to the sample and extracted with 60 mL of 15% methylene chloride in hexane. The sample extract was filtered through anhydrous sodium sulfate. The solvent was

evaporated and the residues were dissolved in 50 mL of chloroform. Sample clean-up was done by transferring the extract to florisil columns, each containing 4 inches of florisil and 1 inch of anhydrous sodium sulfate. The columns were eluted with 200 mL 15% methylene chloride in hexane. The collected solutions were evaporated at 40 ^{o}C to dryness, and the residues were brought-up in 10 mL acetone prior to analysis.

Sample Analysis

Samples were analyzed for thirteen pesticides including two organochloride insecticides (dichloro-diphenyl-trichloryethane-DDT, and lindane), five organo-phosphorus insecticides (anilifos, chlorpyrifos, chlorpyrifos-methyl, dimethoate, and sumithion), five carbamate insecticides (aldicarb, carbosulfan, dithiocarb-Larvin, methomyl and pirimicarb), and one fungicide (diniconazole). Organochloride insecticides were analyzed by gas chromatography following the EPA-recommended Method-8081 [13]. Redidues of DDT and lindane were identified and quantified using a PYE UNICAM gas chromatograph equipped with Ni-63 electron capture detector, and a glass column (4mmm internal diameter, and 7 ft long) packed with 1.5% OV.17+1.95 OV-210 on Gas Chromosorb-Q (80-100 mesh). The column, injection port, and detection temperature were 220, 230, and 230 ^{o}C, respectively. Nitrogen gas was used as a carrier gas at a flow rate of 120 mL/min [14].

Organophosphates, carbamates and fungicides determinations were done by high performance liquid chromatography [15] using a Beckman chromatograph with the following characteristics: dual delivery solvent pump model-406, UV detector model-166, integrator spectra physics model-4270, attenuation-8, char speed-0.5 cm/min, and stainless steel column (10/250 mm) packed with C-18. The analysis conditions included the following: flow rate-0.7, wavelength-254 nm, mobile phase-50/50 water/methanol. The Codex committee's criteria for quality assurance were followed to determine the performance of the multiresidue analysis protocol [12]. The detection limits were 3-5 ng. Percent recoveries in spiked samples were 89-96%. Accordingly, the sample analysis data were corrected for these recoveries. The coefficients of variation were 1-19%.

Health Risks Estimation

Health risk estimates were done based on an integration of pesticide analysis data, and exposure assumptions. The following assumptions were made based on the U.S. Environmental Protection Agency's guidelines : a) hypothetical body weights of 10-kg for children and 70-kg for adults; and b) maximum absorption rate of 100% and a bioavailability rate of 100%. Water and food consumption rates were based on the guidelines provided by the Egyptian Institute of Food Technology, and including the following: a) water – 3 L/day; b) milk – 31 g/day; c) fish – 18 g/day; and citrus fruit/juice – 11.2 g/day.

Hence, for each type of exposure, the estimated lifetime exposure dose (mg/kg/day) was obtained by multiplying the residual pesticide concentration (mg/L or mg/kg) in the food of interest times the

food consumption rate (L/day or kg/day), and dividing the product by the body weight (kg) [16]. The hazard indices to children and adults were estimated as ratios between estimated pesticide exposure doses, and the reference doses which are considered to be safe levels of exposure over the lifetime [17]. On the other hand, cancer risks were computed as the product of exposed doses time chemical-specific cancer potency factors, q1* [17-19]. Therefore, q1* is defined as the slope of the dose-response curve expressing the excess risk of cancer as a function of exposed dose. It has also been defined as the plausible upperbound estimate of the probability that an individual will develop cancer if exposure is to a chemical for a lifetime of 70 years [17-19].

Results

Field Survey

The results of field survey regarding the safe use of pesticides indicated that 98.9% of farmers did not wear gloves while 98.4% did not wear eye glasses or goggles when mixing or applying pesticides. About 34% never wear long pants and shoes when applying pesticides. Among the respondents, 31.5% reported that they have ever eaten food, while 66% drunk water, and 38.8% smoked when mixing or applying pesticides. About 84% indicated that they experienced discomfort during pesticide applications.

Among the clinical symptoms of pesticide poisoning which they reported, 53.2%, 13.8%, 45.7%, 12.2%, 9.6%, 15.4%, 33%, 20.2%, 59.6%, 5.3%, 16.5%, 2.1%, 14.9%, and 3.2% were associated with nausea, vomiting, eye irritation, tachycardia, blurred vision, abdominal cramps, dizziness, diarrhea, headache, excessive salivation, wheezing, confusion, sweating, and coma, respectively. As to the common illnesses suffered during the last 10 years, 34.6%, 29.3%, 14.4%, 29.8%, 6.9%, 20%, 8.4%, 22.3%, 57.4%, 27.7%, 6.4%, 13.3%, and 11.2% of respondents indicated that they experienced fever, skin irritation, skin diseases, kidney diseases, respiratory diseases, asthma, cancer, diarrhea, headache, abdominal pain, heart disease, vision disorders, and hypertension, respectively.

Pesticide Analysis

Of the thirteen pesticides analyzed, chlopyrifos-methyl, dimethoate, diniconazole, lindane, and sumithion were not detected in any of the drainage water samples. However, pesticide residues varied from below detection limits-BDLs (3-5 ng) to 98 μg/L for methomyl, 117 μg/L for aldicarb, 19 μg/L for larvin, 276 μg/L for pirimicarb, 76 μg/L for carbosulfan, 32 μg/L for DDT, 30 μg/L for chlorpyrifos, and 58 μg/L for anilofos (Figure 1). In ground water, the pesticide levels ranged from BDLs to 10 μg/L for larvin, 70 μg/L for pirimicarb, 32 μg/L for aldicarb, 29 μg/L for methomyl, and 152 μg/L for carbosulfan (Figure 2). In the soil samples, pesticide levels varied from BDLs to 57 μg/kg for methomyl, 120 μg/kg for aldicarb, 36 μg/kg for pirimicarb, 218 μg/kg for carbosulfan, 464 μg/kg for chlopyrifos, 58 μg/kg for dimethoate, and 18 μg/kg for diniconazole (Figure 3).

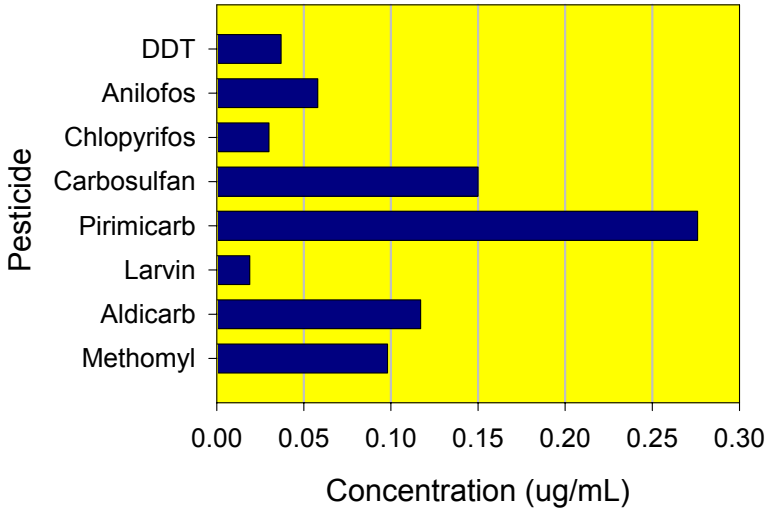

Figure 1. Maximum concentrations of pesticide residues detected in surface waters.

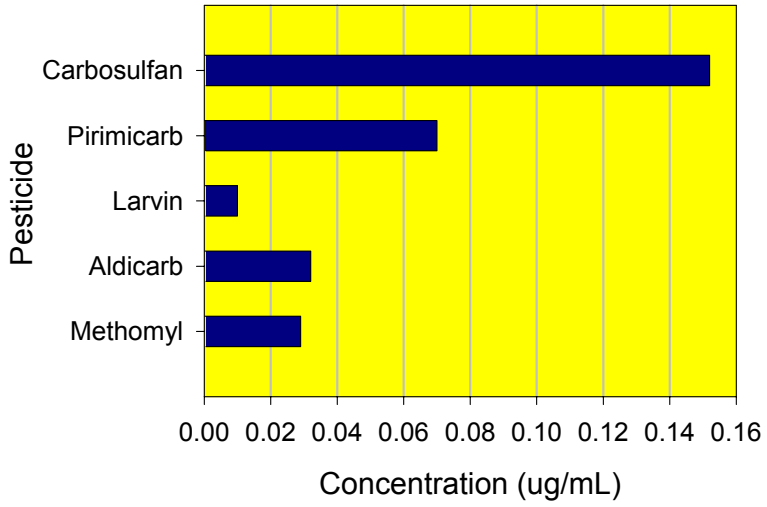

Figure 2. Maximum concentrations of pesticide residues detected in groundwater.

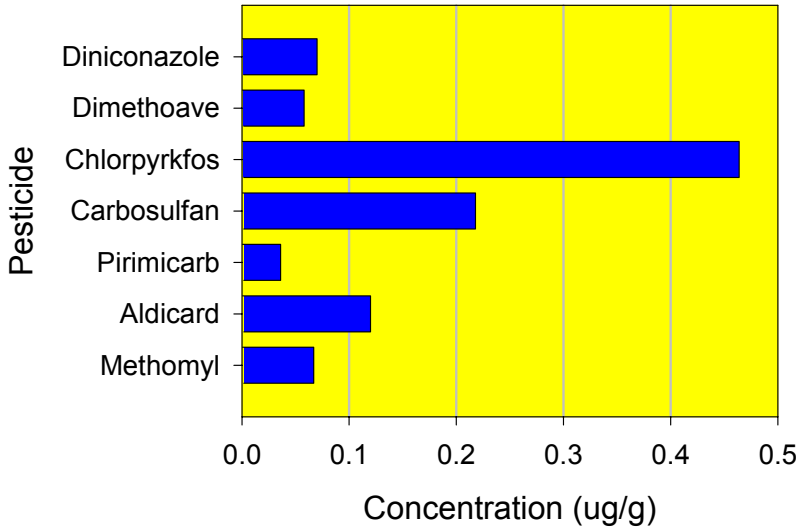

Figure 3. Maximum concentrations of pesticide residues detected in soil samples.

Pesticide residues in edible tissue of fish varied from BDLs to 250 µg/kg for methomyl, 2.5 µg/kg for aldicarb, 2 µg/kg for chlopyrifos, 81 µg/kg for sumithion, and 65 µg/kg for DDT (Figure 4) . In the citrus fruit specimens, carbosulfan and dimethoate were detected at levels ranging from BDLs to 22 µg/kg, and 237 µg/kg, respectively. Although none of the pesticides were detected in human milk, concentrations as high as 67 µg/kg (larvin), 88 µg/kg (anilifos), 138 µg/kg (DDT), and 325 µg/kg (methomyl) were found in cow or buffallo milk (Figure 5).

It is important to note that the data presented in Figures 1-5 represent the maximum concentrations of pesticide residues in various environmental samples. Because of the need for a conservative approach in dealing with risk assessment of multiple chemical compounds, it was more appropriate to consider the maximum levels of detection of specific pesticides instead of their mean concentrations.

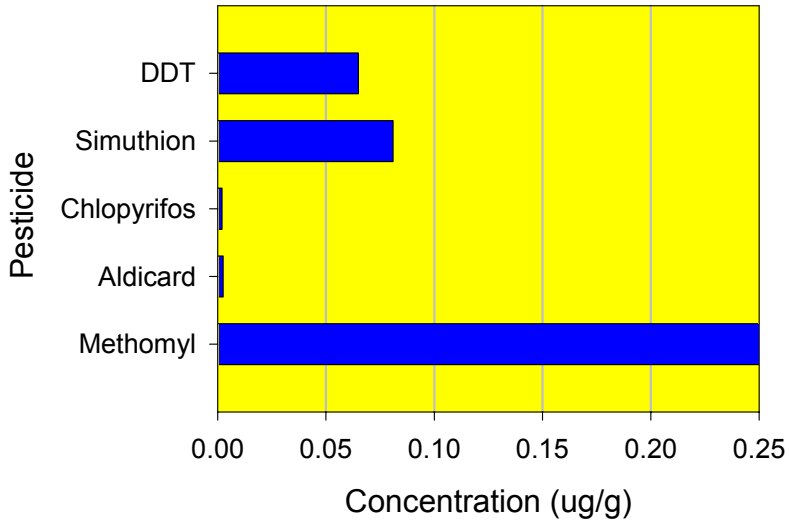

Figure 4. Maximum concentrations of pesticide residues detected in edible tissues of tilapia fish.

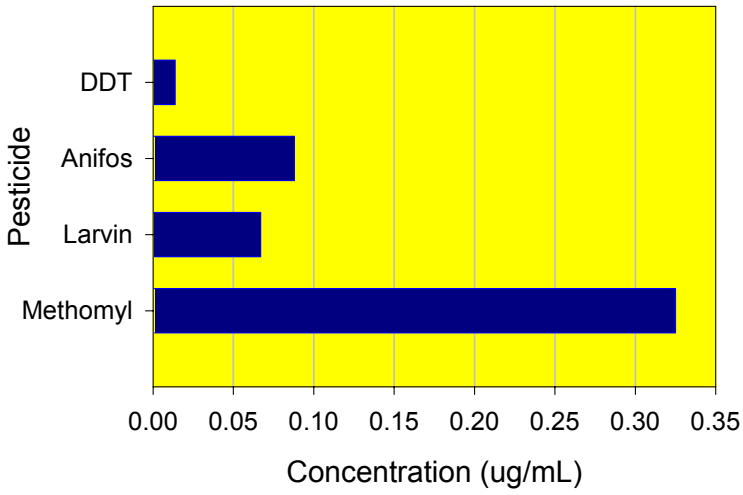

Figure 5. Maximum concentrations of pesticide residues detected in cow or buffalo milk.

Health Risk Estimates

Table 1 presents the risks for systemic effects associated with pesticide residues in groundwater, fish, milk, and citrus fruits. As shown in this table, hazard indices of 0.05, 1.08, 0.65, 0.002, 0.30, and 0.04 were computed for the adult population; respectively for methomyl, aldicarb, carbosulfan, chlorpyrifos, dimethoate, and DDT. In children, hazard indices of 0.34, 7.23, 4.50, 0.001, 2.0 and 0.40 were computed for methomyl, aldicarb, carbosulfan, chlorpyrifos, dimethoate, and DDT, respectively. Cancer risk estimates from DDT exposure indicated risk levels of 8 and 55 excess cancers per 1 million adults and children, respectively.

Table 2 compares the groundwater concentrations of selected pesticides with lifetime health advisories. As shown in this table, margins of exposure of 0.15, 3.20, and 3.80 were computed for methomyl, aldicarb, and carbosulfan, respectively; indicating a potential health risk from aldicarb and carbosulfan contamination of the ground water supply.

Table 1. Health Risk Estimates for Systemic Effects Associated with Pesticide Residuals in Citrus Fruit, Fish, Milk, and Water.

Pesticide	Reference dose (mg/kg/day)	Estimated dose (mg/kg/day)	Hazard index	Health risk
Aldicarb	0.0013	0.0014 – Adults	1.08	Yes
		0.0094 – Children	7.23	Yes
Carbofulfan	0.0100	0.0065 – Adults	0.65	No
		0.0450 – Children	4.50	Yes
Chlorpyrifos	0.0030	5×10^{-7} – Adults	2×10^{-4}	No
		4×10^{-6} – Children	1×10^{-3}	No
DDT	0.0005	2×10^{-5} – Adults	4×10^{-2}	No
		2×10^{-4} – Children	4×10^{-1}	No
Dimethoate	0.0002	6×10^{-5} – Adults	0.30	No
		4×10^{-4} – Children	2.00	Yes
Methomyl	0.0300	0.0015 – Adults	0.05	No
		0.0102 – Children	0.34	No

Table 2. Comparison of Pesticide Concentrations in Ground Water with Lifetime Drinking Water Health Advisories

Pesticide	Lifetime health advisory (A-µg/L)	Ground water concentration (B-µg/L)	Margin of exposure (C = B/A)	Health risk
Aldicarb	10	32	3.20	Yes
Carbofulfan	40	152	3.80	Yes
Larvin	—	10	—	—
Methomyl	200	29	0.15	No
Pirimicarb	—	72	—	—

Discussion

Field Survey

Data obtained from the field survey indicate that a very high proportion of farmers are at high risk of pesticide poisoning from occupational exposure. Survey analysis shows that more than 95% of farmers do not wear protective devices, nor do they apply safety measures during pesticide formulation and application. Pesticide exposure may be exacerbated by the fact that a good proportion of these agricultural workers eat, drink, and/or smoke during pesticide application.

As a result of pesticide exposure, about 86% of farmers experience various kinds of discomfort including nausea, vomiting, eye irritation, tachycardia, blurred vision, abdominal cramps, dizziness, diarrhea, headache, excessive salivation, wheezing, confusion, sweating, and coma. Several pesticides including organochloride, organophosphorus and carbamate insecticides, and fungicides have been linked to severe health conditions in humans including neurological damage, hypertension, cardiovascular diseases, and skin disorders [3,4,20,21]. Some pesticides have been found to cause infertility and sterility, and birth defects. Other have been linked to allergies, hematologic disorders, mutagenicity and cancer [22-26]. It is therefore not surprising that a good proportion of the farmers interviewed reported that over the past ten years they had suffered from several health problems including fever (34.6%), skin irritation (29.3%), skin disease (14.4%), respiratory problems (6.9%), kidney diseases (29.8%), asthma (20%), diarrhea (22.3%), headache (57.4%), abdominal pain (27.7%), heart disease (6.4%), vision disorders (13.3%), hypertension (11.2%), and cancer (8.4%). The relatively higher cancer rate in this community may be attributed partly to the prevalence of schistosomiasis and hepatitis-B viral infection in the study area [27].

Pesticide Analysis

Chlopyrifos-methyl, dimethoate, diniconazole, lindane, and sumithion were not detected in any of the drainage water samples. However, residues of several other pesticides including methomyl, aldicarb, larvin, pirimicarb, carbosulfan, DDT, chlorpyrifos, and anilofos were detected. Most of these pesticides including the fungicide diniconazole were also detected in fish, citrus fruit, buffalo/cow milk, and soil samples; with concentrations ranging from BLDs to as high as 325 μg/L depending on the type of matrix, and the pesticide of concern. Our results support the findings of previous investigations reporting pesticide contamination in many agricultural areas of Egypt [5-9,28]. In a study of pesticide residues in canals, boreholes, and tapwater during chemical control of cotton pest in Egypt, Youssef et al. [14] reported that contamination of canal water is inevitable under Egyptian spraying conditions. Twenty two of the 55 water samples tested proved to be contaminated with relatively high levels of pesticides [14]. In similar studies done in Egypt, organochloride, organophosphorus, carbamate, and pyrethroid insecticides residues have been detected in several fruits including apple, cantaloupe, grape, guava, mango, orange, and peach, as well as in many vegetables

including cabbage, cauliflower, carrot, courgette, cucumber, eggplant, green beans, green peas, strawberries, tomatoes. The rate of contamination of these fruits varied from 0 to as high as 86% [29].

Health Risk Assessment

Data analysis of health risk estimates indicated that chlorpyrifos, DDT, dimethoate, methomyl, and larvin do not pose a direct hazard to human health, although present in water, milk, orange, and/or fish. However, aldicarb, and carbosulfan levels exceeded the reference doses, indicating a great potential for systemic toxicity, especially in children who are considered to be the most vulnerable population subgroup [30,31]. The upper-bound values of cancer risk from DDT exposure were estimated to be about 8 (adults), and 55 (children) excess cancers in a population of one million. It was not possible to estimate the cancer risk associated with exposure to the other studied pesticides because of the lack of published data regarding the cancer potency factors of these compounds.

Conclusions

From the results of this study, it can be concluded that 1) the farmer communities of Menia El-Kamh province of Sharkia Governorate in Egypt do not follow appropriate safety precautions with regard to pesticide formulation and application; 2) substantial amounts of pesticides are inappropriately used by these farmers, leading to several clinicopathological conditions including nausea, vomiting, eye irritation, tachycardia, blurred vision, abdominal cramps, dizziness, diarrhea, headache, excessive salivation, wheezing, confusion, sweating, and coma, and cancer in some cases; 3) human exposure during pesticide application is exacerbated by water, food, and environmental contamination; and 4) there exists a potential risk for systemic and carcinogenic health effects associated with pesticide use in Menia El-Kamh province. Since about 88% of the population relies on agriculture for subsistence, it is highly recommended that a health education program with regard to the safe use of pesticides and crop management be designed and implemented. Risk prevention should focus on reducing the volume of pesticides, and substitution for safer compounds; establishing effective protective measures; and ensuring that these measures are enforced. Farm workers should also be educated about alternative forms of pest control, and incentives should be provided to encourage their use.

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References

1. Nassar, S. The strategy of agricultural development in Egypt in the 1990s. Crop Health Conference: Future of Integrated Pest Management in Crop Health and Sustainable Agriculture. Fayoum, Egypt, 1994.
2. Zalom, F. G. Pesticide use practices in integrated pest management. In *Handbook of Pesticide Toxicology;* Krieger, R.; Doull, J.; Ecobichon, D.; Gammon, D.; Hodgson, E.; Reiter, L.; Ross, J., Eds.; Academic Press: New York, NY, 2nd Ed., 2001, pp 275-283.
3. Calvert, G. M.; Sanderson, W. T.; Barnett, M.; Blondell, J. M.; Melher, L. N. Surveillance of pesticide-related illness and injury in humans. In *Handbook of Pesticide Toxicology;* Krieger, R.; Doull, J.; Ecobichon, D.; Gammon, D.; Hodgson, E.; Reiter, L.; Ross, J., Eds.; Academic Press: New York, NY, 2nd Ed., 2001, pp 603-641.
4. Snodgrass, W. R. Diagnosis and treatment of poisoning due to pesticides. In *Handbook of Pesticide Toxicology;* Krieger, R.; Doull, J.; Ecobichon, D.; Gammon, D.; Hodgson, E.; Reiter, L.; Ross, J., Eds.; Academic Press: New York, NY, 2nd Ed., 2001, pp 589-602.
5. Ashour, M. B-A. Residual Effects of Certain Soil Pesticides. M. Sc. Thesis. Zagaziz University, Egypt, 1976.
6. Ashour, M. B-A. Side Effects of Organophosphorus Insecticides on Plants. Ph. D. Thesis. Zagaziz University, Egypt, 1979.
7. Ashour, M. B-A.; Ramadan, R. A.; Ragheb, D. A.; Gomaa, A. A.; Monrad, S. J. Thiodicarb and aldicarb residues in potatoes. Proc. 2nd National Conference on Pest Diseases of Vegetables and Fruits. Ismailia, Egypt, 1987, pp 501-513.
8. Dogheim, S. M.; Nasr, E. N.; Almaz, M. M.; El-Tohamy, M. M. Pesticide residues in milk and fish collected from two Egyptian Governorates. *J. Official Anal. Chem.* **1990**, *73*, 19-21.
9. Amer, M. M. Pesticide intoxication in Egypt. Crop Health Conference: Future of Integrated Pest Management in Crop Health and Sustainable Agriculture. Fayoum, Egypt, 1994.
10. Horrigan, L.; Lawrence, R. S.; Walker, P. How sustainable agriculture can address the environmental and human health harms of industrial agriculture. *Environ. Health Perspect.* **2002**, *110*, 445-456.
11. Raschke, A. M.; Burger, A. E. C. Risk assessment as a management tool used to assess the effects of pesticide use in an irrigation system situated in a semi-desert region. *Arch. Environ. Contam. Toxicol.* **1997**, *32*, 42-49.

12. FAO/WHO. Report of the Thirty-Fourth Session of the Codex Committee on Pesticide Residues. Food and Agriculture Organization of the United Nations / World Health Organization. The Hague, Netherlands, May 2002.
13. U.S. EPA. Test Methods for Evaluating Solid Wastes SW-846. Volume IA-Laboratory Manual: Physical and Chemical Methods. United States Environmental Protection Agency. Office of Solid Waste and Emergency Response. Washington, D.C., 1994.
14. Youssef, S. H.; Samaan, M. A.; El-Shemy, M. K. H. Monitoring pesticide residues in canals, boreholds and tapwater during chemical control of cotton pest in Egypt. *Egypt. J. Appl. Sci.* **1992**, *7(7),* 171-180.
15. Ramadan, R. A.; Saleh, M. A.; El-Shemy, M. K. Residues of some pesticides on and in cucumber, green pepper, and eggplant fruits under plastic green house conditions. *Egypt. J. Appl. Sci.* **1992**, *7(8),* 861-870.
16. U.S. EPA. Exposure Assessment Handbook. United States Environmental Protection Agency. Office of Health and Environmental assessment. Washington, D.C, 1989.
17. U.S. EPA. Integrated Risk Information System. United States Environmental Protection Agency. Office of Health and Environmental assessment. Washington, D.C., 1996.
18. Tchounwou, P. B.; Abdelghani, A. A.; Pramar, Y. V.; Heyer, L. R.; Steward, C. M. Assessment of potential health risks associated with ingesting heavy metals in fsh collected from a hazardous waste contaminated wetland in Louisiana. *Rev. Environ. Health* **1996**, *11(4),* 1-13.
19. Tchounwou, P. B.; Abdelghani, A. A.; Pramar, Y. V.; Heyer, L. R. Health risk assessment of hexachlorobenzene and hexachlorobutadiene residues in fish collected from a hazardous waste contaminated wetland in Louisiana. *Environ. Toxicol. Risk Assess.* **1996**, *1333,* 368-382.
20. Turusov, V.; Rakitsky, V.; Tomatis, L. Dichlorodiphenyltrichloroethane (DDT): ubiquity, persistence and risks. *Environ. Health Perspect.* **2002***, 110(2),* 125-128.
21. Wesseling, C.; Van Wendel de Joode B.; Ruepert, C.; Leon, C.; Monge, P.; Hermosillo, H.; Partanen, T. J. Paraquat in developing countries. *Int. J. Occup. Environ. Health* **2001***, 7(4),* 275-286.
22. Raminez, V.; Cuenca, P. Micronuclei frequency in lymphocytes of individuals occupationally exposed to pesticides. *Rev. Biol. Trop.* **2001***, 49(1),* 1-8.
23. Arbuckle, T. E.; Lin, Z.; Mery, L. S. An exploratory analysis of the effect of pesticide exposure on the risk of spontaneous abortion in an Ontario farm population. *Environ. Health Perspect.* **2001***, 109(8)*, 851-857.
24. Rojas, A.; Ojeda, M. A.; Barraza, X. Congenital malformations and pesticide exposure. *Rev. Med. Chil.* **2000***, 128(4),* 399-404.
25. McDuffite, A. H.; Pahwa, P.; McLaughlin, J. R.; Spinelli, J. J.; Fincham, S.; Dosman, J. A.; Robson, D.; Skinnider, L.F.; Choi, N. W. Non-Hodgskin's lymphoma and specific pesticides exposure in men: Cross Canada study of pesticides and health. *Cancer Epidemiol. Biomarkers Prev.* **2001***, 10(11),* 1155-1163.
26. Payne, J.; Scholze, M.; Koetenkamp, A. Mixtures of organochlorides enhance huamn breast cancer cell proliferation. *Environ. Health Perspect.* **2001***, 109(4)*, 391-397.

27. Badawi, A. F.; Michael, M. S. Risk factors of hepatocellualr carcinoma in Egypt: The role of hepatitis-B viral infection and schistosomiasis. *Anticancer Res.* **1999***, 19(5),* 4565-4569.
28. Shalaby, A. A. Residues of some of some insecticides on and in broad bean plants. *Egypt. J. Appl. Sci.* **1992***, 7(11),* 531-539.
29. Doghein, S. M.; Gadd Alla, S. A.; El-Marsafy, A. M.; Fahmy, S. M. Monitoring pesticide residues in Egyptian fruits and vegetables in 1995. *J. Assoc. Official Analyt. Chemists Intl.* **1999***, 82(4)*, 948-955.
30. Goldman, L. R.; Koduru, S. Chemicals in the environment and developmental toxicity to children: a public health and policy perspective. *Environ. Health Perspect.* **2001***, 109(9)*, 412-413.
31. Bruckner, J. V. Differences in sensitivity of children and aduls to chemical toxicity: The NAS panel report. *Regul. Toxcicol. Pharmacol.* **2000***, 31(3)*, 280-285.