ISSN : 0974 - 7451 Volume 8 Issue 4

Environmental Science

An Indian Journal

Trade Science Inc.

Current Research Paper

ESAIJ, 8(4), 2013 [132-141]

Pesticide exposure calculation of eggplant farmers in Sta Maria, Pangasinan

Jinky Leilanie Lu

National Institutes of Health, University of the Philippines Manila, NIH Bldg, Pedro Gil St., Manila, (PHILIPPINES)

E-mail : jinky_lu@yahoo.com

ABSTRACT

The study was conducted to investigate the exposure of eggplant farmers in Sta. Maria, Pangasinan to various types of pesticides, as well as the risk factors associated with increased pesticide exposure. There was a total of fifty eight farmers interviewed in the conduct of the study coming from five communities. Survey questionnaires were used to gather information regarding personal background of the farmers and farming practices. Data showed that 91% of the farmers used Prevathon (chlorantraniliprole). This was followed by Malathion (78%), Mospilan (acetamiprid) (28%), Lannate (methomyl) (22%), and Hosthathion (triazophos) (22%). The pesticides with the highest amount used in liters were Siga (chlorpyrifos) at 0.53 liters, Triband (chlorphenahyr) at 0.48 liters, Magnum (cypermethrin) at 0.40 liters, Lannate (methomyl) at 0.37 liters, Brodan (chlorpyrifos), Hercules (triazophos), Solomon (imidacloprid + betacyfluthrin + cyclohexane) at 0.26 liters each. The average amount used per application was 0.18 liters (s.d. 0.16). The pesticides with the highest liter-years of exposure were Solomon (imidacloprid + betacyfluthrin + cyclohexane) at 5.40 liter-years, Lannate (methomyl) at 4.93 liter-years, and Magnum (cypermethrin) at 4.44 liter years. The study further showed that most of the farmers have experienced pesticide spills during application (95%). The body parts that were commonly spilled by pesticides were the back, legs, arms, shoulders, hands, and face. The other risk factors shown in the data were non use of PPE by farmers (41%), wiping sweat with pesticide-resiude contaminated cloth (50%), spraying against the wind (47%), and re-entering previously sprayed area (48%). Pesticide spillage is also a common experience of farmers. Most of the farmers experienced pesticide spillage due to leaking backpack sprayer (76%), while spraying (72%), and while mixing (74%). The study showed that there is significant exposure to pesticides of various types among eggplant farmers in Pangasinan.

KEYWORDS

Eggplant farmers;
Pesticide exposure;
Risk factors to pesticide exposure.

INTRODUCTION

Many chemicals used intensively in most developing countries are found toxic and environmentally persistent. Pesticide usage accounts for about 20% of the global chemicals[9,31]. Pesticides ar widely used in agriculture, and vegetable farming is a form of income-generating livelihood in most developing countries. As modern agriculture develops, vegetable farming has becoming highly pesticide dependent[24]. Several studies have shown that exposure of farmers and agricultural workers to pesticides posed adverse health effectssuch as irritation of the eyes, excessive salivation, dermatitis, asthma, burning sensations in eyes/face, skin irritation, headache, dizziness, and respiratory effects[2,7,21-23,26,28,29,32]. Prolonged exposure has been noted to cause chronic health problems, i.e. cancer and reproductive and developmental health disorders to farmers[1]. In worst cases, pesticide exposure can even cause fatality. Deaths due to pesticide exposure have been recorded in many parts of the world[10,14,25-27].

This study looked into the pesticide use of eggplant farmers, and the risk factors associated with pesticide exposure. Pangasinan was chosen because it is the largest eggplant producer in the Philippines. The production value of eggplant was 3,142.9 million pesos in the year 2009[5]. The total area planted to eggplant is about 21.2 thousand hectares, and eggplant cultivation is one of the main sources of livelihood of small-scale farmers in the country[12].

MATERIALS AND METHODS

This was a cross-sectional study that involved eggplant farmers in Sta Maria, Pangasinan as the target population. Based on random sampling calculation, 58 farmers were selected for the study coming from 5 barangays of Sta Maria, Pangasinan from May to September 2011.

Pangasinan was chosen because it is the largest eggplant producer in the Philippines with a production volume of 62,842.08 metric tons for 2010. This study was conducted for the baseline data gathering for the insecticide residue determination of eggplant samples in Pangasinan. Survey questionnaires were used to gather information regarding personal background of the farmers (i.e., age, educational attainment, marital status, length of stay in present address, etc.), farming practices (i.e. planting, applying insecticides, and harvesting), insecticides used, and exposure variables. The questionnaires included inquiries about agricultural and farming activities such as the number of years the farmer has been using pesticides, the kinds of pesticides used, the amount of pesticides used per application of each kind of pesticide, the spraying frequencies of using pesticides (i.e., hours per day, days per week, weeks per month, months per year, year per cropping season), and the kinds of farming activities performed. Informed consent was duly undertaken. Another data analysis used included descriptive statistics such as frequency distribution, mean and standard deviation. The study did not involve intrusive measures nor health intervention among subjects. Ethical consideration consisted of informed consent by the respondents. This project was submitted and registered with the Research Administration Grants Office of the National Institutes of Health, University of the Philippines Manila.

RESULTS AND DISCUSSION

Socio-demographic profile

The study was conducted in five communities of Sta. Maria Pangasinan, namely, Cal-litang, Cauplasan, Samon, Pilar, and Namagbagan. Majority of the respondents were from Samon (28 respondents). Two (2) respondents each were from Namagbagan and Pilar, seven (7) respondents from Cal-litang, and 19 respondents from Cauplasan. Among the respondents, 53 were males and five (5) were females. The average age of the farmer-respondents was 45 (standard deviation, 10.098). Majority belonged to ages 41-45 years old (24%). Majority of the respondents were able to attain secondary (high school) education (40%). The average number of household members of the farmers was 5 (s.d. 1.612) persons, and majority having 4-5 household members (55%). The farmers have been staying in their present address on an average of 36 (s.d. 16.287) years. The average distance of their farm to their houses was 320 (s.d. 330.380) meters. Others noted that their farms were about 100 to 200 meters away from their houses (34%). The household members of the farmers were also involved in pesticide application (34%).

Among the respondents who said that their household members were involved in pesticide application, nine (9) wives, 12 adults, 13 older children, and two (2) young children were found involved and exposed to pesticide in the farm. Take home epsticides were observed by bringing home the used containers, pesticide applicators and clothings.

The average area of farms was 1 hectare (s.d. 0.658). Farmers managed a farm of about 0.5 hectares (43%). The most common eggplant diseases were the fruit and shoot borer, bacterial wilt, aphids, and blight.

Pesticide spillage and other risk factors in farming activity

There are many risk factors that may increase pesticide exposure of farmers such as pesticide spillage, improper disposal of pesticide containers, cocktailing of pesticides, and route of pesticide exposure.

For pesticide spillage, most of the farmers experienced this during application (95%). The body parts that were commonly spilled with pesticides were the back, legs, arms, shoulders, hands, and face. Many farmers were not using proper PPE (41%). Instead, they used makeshift PPEs such as long sleeves, and T-shirt which they used to cover their face. Other risk factors included not bathingimmediately after they were spilled with pesticide on their body (7%), using pesticide-residue contaminated cloth in wiping their sweat (50%), spraying against the wind (47%), and re-entering previously sprayed area (48%).

As for the activity that farmer was performing when pesticide spills occurred, 76% were spilled due to leaking backpack sprayer, 72% while spraying, and 74% while mixing (TABLE 1).

Disposal of pesticide container is also another factor in pesticide exposure. In this study, majority of the farmers (53%) sold their used pesticide containers. Some (41%) destroyed them and threw with other trash while others (9%) buried or burned (7%) them (TABLE 2).

TABLE 1 : Distribution of farmers by risk factors

Risk Factors	Frequency	Percentage
Experienced spill on the body from mixing insecticides	55	95
Spill due to leaking backpack sprayer	44	76
Spill while mixing	43	74
Spill while spraying	42	72
Wiping off Sweat with Fabric	29	50
Re-entry to a Previously Sprayed Area	28	48
Spraying against the wind	27	47
Improper PPE	24	41
Not taking a bath immediately	4	7

***multiresponse**

TABLE 2 : Distribution of farmers by disposal of used pesticide containers

Disposal Practices	Frequency	Percentage
Sell	31	53
Destroy	24	41
Bury	5	9
Burn	4	7

***multiresponse**

As for the route of pesticide exposure, the farmers noted that it was mainly via dermal (95%), followed by respiratory (86%), ocular (21%), and then oral (3%) (TABLE 3).

TABLE 3 : Distribution of farmers by route of pesticide exposure

Route	Frequency	Percentage
Dermal	55	95
Respiratory	50	86
Ocular	12	21
Oral	2	3

***multiresponse**

Pesticide exposure

The farmers in Pangasinan used a mixture of insecticides such as carbamates, organophosphates, and pyrethroids. Based on the study, 91% of the farmers used Prevathon (chlorantraniliprole). This was followed by Malathion (78%), Mospilan (acetamiprid) (28%), Lannate (methomyl) (22%), and Hosthathion (triazophos) (22%). The pesticides with the highest amount used in liters were Siga (chlorpyrifos) at 0.53 liters, Triband (chlorphenahyr) at 0.48 liters, Magnum (cypermethrin) at 0.40 liters, Lannate (methomyl) at 0.37 liters, Brodan (chlorpyrifos), Hercules (triazophos), and Solomon (imidacloprid + betacyfluthrin + cyclohexane) at 0.26 liters each. The average amount used per application was 0.18 liters (s.d. 0.16) (TABLE 4).

The study results also showed that the average spraying time was 2 (s.d. 0.36) hours/day, 4 (s.d. 1.74) days/week, 4 (s.d. 1.10) weeks/month, 5 (s.d. 0.88) months/years and1.10 (s.d.0.23) year/cropping season (TABLE 5).

TABLE 4 : Distribution of farmers by the type of pesticides used and the amount of pesticides used per application

Brand Name	Active Ingredient	Type of Pesticides	Toxicity Class	Freq.	Percentage	Amt used/ application (in L)
Prevathon	Chlorantraniliprole	Anthranilic diamide	Insecticide 4	53	91	0.14
Malathion	Malathion	Organophosphate	Insecticide 4	45	78	0.13
Mospilan	Acetamiprid	Neonicotinoid	Insecticide 3	16	28	0.13
Lannate	Methomyl	Carbamate	Insecticide 2	13	22	0.37
Hosthathion	Triazophos	Organophosphate	Insecticide 2	13	22	0.13
Decis	Deltamethrin	Pyrethroid	Insecticide 4	12	21	0.14
Brodan	Chlorpyrifos	Organophosphate	Insecticide 2	10	17	0.26
Magnum	Cypermethrin	Pyrethroid	Insecticide 4	9	16	0.40
Pegasus	Diafenthiuron	Thiourea	Insecticide 2	8	14	0.17
Tamaron	Methamidophos	Organophosphate	Insecticide 1	5	9	0.03
Siga	Chlorpyrifos	Organophosphate	Insecticide 2	5	9	0.53
Solomon	Imidacloprid +betacyfluthrin + cyclohexane	Neonicotinoid + Pyrethroid + Petroleum derivative	Insecticide 2	4	7	0.26
Hercules	Triazophos	Organophosphate	Insecticide 2	3	5	0.26
Voliam flexi	Chlorantraniliprole + Thiametoxam	Anthranilic diamide + Neonicotinoid	Insecticide 4	3	5	0.004
Triband	Cartap hydrochloride	Carbamate	Insecticide 3	2	3	0.48
Kotetsu	Chlorphenapyr	Organophosphate	Insecticide 3	2	3	0.17
Selecron	Profenofos	Organophosphate	Insecticide 2	2	3	0.03
Padan	Cartap hydrochloride	Carbamate	Insecticide 4	1	2	0.02
Ultimate	Profenofos	Organophosphate	Insecticide 2	1	2	0.03
Super cartap	Cartap hydrochloride	Carbamate	Insecticide 3	1	2	0.02
Extreme	Cartap hydrochloride	Carbamate	Insecticide 3	1	2	0.005
Mean						0.18
Sd						0.16

The pesticides with the highest liter-years of exposure were Solomon (imidacloprid + betacyfluthrin + cyclohexane) at 5.40 liter-years, Lannate (methomyl) at 4.93 liter-years, and Magnum (cypermethrin) at 4.44 liter years. The pesticides with the highest liter-years of exposure per percentage of pesticide used were Prevathon (chlorantraniliprole) at 1.60, Malathion at 1.56, and Lannate (methomyl) at 1.08 (TABLE 6).

As shown in TABLE 6, the farmers in Pangasinan have been using pesticides for a long time with an average of 14 (9.07) years. The farmers sprayed their crops on an average of 2 (s.d. 0.36) hours/day, 4 (s.d. 1.74) days/week, 4 (s.d. 1.10) weeks/month, 5 (s.d. 0.88) months/years and 1.10 (s.d.0.2)

DISCUSSION

The farmers in Pangasinan used a variety of insecticides such as carbamates, organophosphates, and pyrethroids. They also used some newly registered active ingredients of pesticides such as acetamiprid, imidacloprid, and thiametoxam that belong to the group of neonicotinoids and chlorantraniliprole, as well as diafenthiuron that belongs to the group of anthranilic diamide and thiourea, respectively[11].

The data above also show that household members are exposed to pesticide application. The other farmers' family members, those who were not involved in pesticide application, can be exposed to pesticides. This is due to para-occupational exposure or take home exposure. Para-occupational exposure includes washing and cleaning pesticide-contaminated clothes with the other clothes, returning home wearing the clothes used during pesticide application, mixing and storing pesticides inside or near the house, and cleaning the equipments used in pesticide application (i.e., backpack sprayer, mixing tools, etc) at home[17]. The farmers in Pangasinan were observed returning home with

TABLE 5 : Distribution of farmers by spraying factors

Brand Name	Active Ingredient	Hours/ day	Days/ week	Weeks/ months	Months/ years	Cropping season
Prevathon	Chlorantraniliprole	1.95	4.08	3.96	4.37	1.14
Malathion	Malathion	1.83	4.03	3.35	4.20	1.13
Mospilan	Acetamiprid	2.16	3.11	2.88	4.50	1.08
Lannate	Methomyl	1.62	3.89	3.30	4.00	1.13
Hosthathion	Triazophos	2.12	6.27	3.00	5.00	1.20
Decis	Deltamethrin	2.09	6.63	4.00	6.00	1.00
Brodan	Chlorpyrifos	1.89	3.72	3.06	4.81	1.00
Magnum	Cypermethrin	1.78	3.25	3.06	5.56	1.00
Pegasus	Diafenthiuron	2.29	3.63	3.29	2.64	1.43
Tamaron	Methamidophos	1.67	5.00	7.00	5.00	1.00
Siga	Chlorpyrifos	2.30	3.75	4.75	6.00	1.00
Solomon	Imidacloprid +betacyfluthrin +cyclohexane	1.88	2.88	2.63	5.25	1.00
Hercules	Triazophos	2.00	3.00	4.00	3.00	2.00
Voliam flexi	Chlorantraniliprole +Thiametoxam	2.00	7.00	4.00	4.50	1.00
Triband	Cartap hydrochloride	1.00	2.75	3.00	4.50	1.00
Kotetsu	Chlorphenaphyr	1.50	7.00	4.00	4.50	1.00
Selecron	Profenofos	1.50	3.50	3.00	5.50	1.00
Padan	Cartap hydrochloride	1.00	7.00	4.00	3.50	1.00
Ultimate	Profenofos	2.00	4.00	4.00	5.00	1.00
Super cartap	Cartap hydrochloride	2.00	7.00	4.00	4.00	1.00
Extreme	Cartap hydrochloride	2.00	1.00	1.00	4.00	1.00
Mean		1.84	4.40	3.58	4.56	1.10
Sd		0.36	1.74	1.10	0.88	0.23

the same clothes they used during pesticide application. Thus, the pesticide residues left on their clothes can be a source of pesticide exposure to the other members of the family. Another possible pathway of exposure of the farmer families is the proximity of their houses to the farms. Majority of the farms were 100 to 200 meters away from their houses. As such, pesticide drift can occur and could possibly cause the potential exposure of the farmer families to pesticides[17]. The farmers in Pangasinan also used cocktailing of pesticides in order to save time in pesticide application as well as to increase effectivity of insecticides. Similarly, among the rice farmers in Vietnam, the improper usage of hazardous pesticides was observed. They mixed 2-5 pesticides simultaneously. In another study, farmers believed that cocktailing increased the effectivity of the pesticide[20].

Due to hot weather condition, most farmers do not practice the proper precautions in working in the field. Likewise, farmers in Pakistan were reported not using any protective equipment because it is uncomfortable and inconvenient to cover their mouth and nose while working in the farm. They only wore long pants and shirts when spraying pesticides[18]. Studies on poor usage of protective equipment showed an increased pesticide residue accumulation in the body[6,30]. Similarly, among the Benguet farmers, the risk factors found were using damaged backpack sprayer, spillage on hands, and spraying against the wind[19].

As also shown in TABLE 4, many chemicals used in developing countries are toxic, persistent and non-patented thus posing adverse health effects to the community and the environment[9]. The farmers in Pangasinan were found using Tamaron, with an active ingredient of methamidophos and classified as Class 1 insecticide (most toxic). Of the 21 brands of insecticides used by the farmers, 9 belonged to Class 2 (moderately toxic). The active ingredients of these Class 2 insecticides were

TABLE 6 : Distribution of farmers by liter-years of exposure and liter-years of exposure per percentage of pesticide used

Brand Name	Active Ingredient	Percentage	Amt used/ Application (in L)	Mean number of years of usage	Liter-years of exposure	Liter-years of exposure perpercentage of pesticide used
Prevathon	Chlorantraniliprole	91	0.14	12.52	1.75	1.60
Malathion	Malathion	78	0.13	15.37	2.00	1.56
Mospilan	Acetamiprid	28	0.13	11.62	1.51	0.42
Lannate	Methomyl	22	0.37	13.33	4.93	1.08
Hosthathion	Triazophos	22	0.13	24.89	3.24	0.71
Decis	Deltamethrin	21	0.14	25.50	3.57	0.75
Brodan	Chlorpyrifos	17	0.26	10.75	2.80	0.48
Magnum	Cypermethrin	16	0.40	11.11	4.44	0.71
Pegasus	Diafenthiuron	14	0.17	13.71	2.33	0.33
Tamaron	Methamidophos	9	0.03	4.00	0.12	0.01
Siga	Chlorpyrifos	9	0.53	1.31	0.69	0.06
Solomon	Imidacloprid +betacyfluthrin +cyclohexane	7	0.26	20.75	5.40	0.38
Hercules	Triazophos	5	0.26	10.00	2.60	0.13
Voliam flexi	Chlorantraniliprole +Thiametoxam	5	0.004	10.10	0.04	0.002
Triband	Cartap hydrochloride	3	0.48	7.50	3.60	0.11
Kotetsu	Chlorphenaphyr	3	0.17	15.00	2.55	0.08
Selecron	Profenofos	3	0.03	15.00	0.45	0.01
Padan	Cartap hydrochloride	2	0.02	40.00	0.80	0.02
Ultimate	Profenofos	2	0.03	20.00	0.6	0.01
Super cartap	Cartap hydrochloride	2	0.02	0.17	0.003	0.00006
Extreme	Cartap hydrochloride	2	0.005	5.00	0.03	0.0006
Mean			0.18	13.70	2.07	0.40
Sd			0.16	9.07	1.69	0.50

methomyl, triazophos, chlorpyrifos, diafenthiuron, mixture of imidacloprid, betacyfluthrin, and cyclohexane, and profenofos. Moreover, most of the farmers interviewed were not aware of the band color of the insecticides they used. The band color of insecticides signifies the level of its toxicity or hazardousness. In a similar study, farmers in Vietnam were found using restricted pesticides such as organophosphates categorized by WHO as extremely/ highly hazardous and moderately hazardous pesticides (toxicity classes I and II respectively) . In India, majority of the farmers used chemical insecticides of all major classes (ie., organochlorines, organophosphates, carbamates, and synthetic pyrethroids) to kill the eggplant fruit and shoot borer[4].

One type of insecticides used by the farmers is carbamate. This type of pesticide has the ability to disrupt the enzyme that functions in regulating a neurotransmitter called acetylcholine thus affecting the whole nervous system. Early symptoms of carbamate poisoning include muscle weaknesses, dizziness, sweating, and discomfort. The inhibition of the acetylcholinesterase enzyme can bereversible at the earlier stages[11]. Other symptoms such as headache, salivation, nausea, vomiting, diarrhea, and abdominal are manifestations of higher level of exposure to carbamates. Blurred vision, muscle twitching, and slurred vision are also other symptoms reported caused by exposure to carbamates[13]. Cartap hydrochloride and methomyl are the active ingredients that belong to the group of carbamate pesticides. Both cartap hydrochloride and methomyl were used by the farmers interviewed for this study.

Cartap hydrochoride has a high water solubility which is 200 g/L at 20°C. It is non-volatile based on its vapor pressure which is 1.00 X 10^{-10} mPa at 25°C and Henry's Law of Constant (dimensionless) which is 5.62 X 10^{-20} at 20°C. It is non-persistent given that its soil degradation half-life is 3 days in typical aerobic situation. It has low bioaccumulation potential[16].

Methomyl has a high water solubility which is 55000 mg l^{-1} at 20°C. It is volatile based on its vapor pressure which is 0.72 mPa at 25°C. It is non-volatile in conformity with its Henry's Law of Constant which is at 2.13 X 10^{-06} Pa m^3 mol^{-1} at 25°C. It is non-persistent as its soil degradation half-life which is 7 days in typical aerobic situation. It has stable aqueous photolysis. Its aqueous hydrolysis is very persistent and stable at pH 5 to pH 7 with a half-life of 36 days at pH 9, all at 25 °C. It is a marginal leacher[15], and it is mobile based on its Koc - Organic-carbon sorption constant which is 25.2 ml g^{-1}.

Methomyl has a low bioaccumulation potential, and as such, there was no methomyl residue found. Risk of exposure to methomyl is through dermal absorption, and as such 64% of the farmers said they experienced skin irritation. Moreover, methomyl is a acetylcholinesterase inhibitor, respiratory tract irritant, and eye irritant[16]. I the study, 29% of the farmers said that they experienced eye redness, and 28% reported muscle pain.

Carbamate has a high water solubility of the two active ingredients. Technically, the higher the water solubility, the lower the absorption (dissipation half-life) and so the higher the leaching ability. Hence, this insecticide can contaminate the groundwater. However, other factors such as soil texture (e.g., clay, sandy, loam) and the amount of organic matter present, groundwater depths, pesticide application (e.g. methods, amount, frequency, etc), and irrigation process should also be considered in analysing the possibilities of a certain chemical for groundwater contamination. Though, study of Andreu and Pico[3] noted that pesticides with high water solubility were the most hazardous pesticides. The use of carbamates among Pangasinan farmers should be monitored.

Pyrethroid is another type of insecticides used by the farmers. These are synthetic forms of pyrethrin, a naturally occurring pesticide found in chrysanthemums[11]. These insecticides are one of the least acutely toxic pesticides to mammals since they are readily deactivated by metabolic processes. When exposed to pyrethroids with cyano-groups, burning and itching sensations can be experienced which can be developed to numbness[13]. The farmers in this study used pyrethroids such as deltamethrin (Decis) at 21%, and cypermethrin (Magnum) at 16%.

Deltamethrin has a low water solubility which is 0.2 mg/L at 20°C. It is non-persistent because its soil degradation half-life is 13 days in typical aerobic situation. Its aqueous photolysis is stable with a half-life of 48 days at pH 7. It has low leach ability and is non-mobile, so it has a tendency to adsorb in eggplant fruits or in soil. It has high bioaccumulation potential. Deltamethrin poses slight risk to small children through dietary exposure. This active ingredient is known as endocrine disrupter and neurotoxicant[16], thus affecting the mental development of children. Alpha-cypermethrin also has a high bioaccumulation potential, and its exposure routes include inhalation and dermal contact in occupational setting. In this study, the farmers reported that they experienced respiratory tract symptoms such as coughing (9%), and skin itchiness (28%). This is not uncommon among those exposed to deltamerthin manifesting in respiratory and skin irritations[16]. The high bioaccumulation potential of both deltamerthin and cypermertrin also poses risk to health of consumers of eggplants.

Another type of pesticide is the organophosphate. Organophosphate pesticides have the ability to affect the nervous system by disrupting the acetylcholinesterase enzyme[11]. As a result of acetylcholinesterase inhibition, early symptoms such as headache, nausea, dizziness, sweating, and salivation are manifested. Other symptoms such as vomiting, weakening, muscle twitching, abdominal cramps, and diarrhea implied aggravating cases[13]. In this study, farmers reported of headache (22%), nausea (10%), dizziness (14%), and weakening (17%).

The organophosphate insecticides used by Pangasinan farmers were malathion, triazophos, chlorpyrifos, methamidophos, chlorfenapyr, and profenofos. Malathion has a moderate water solubility which is 148 mg l^{-1} at 20°C. It is volatile as its vapor pressure which is 3.1 mPa at 25°C. It has low bioaccumulation potential. This active ingredient is known as acetylcholinesterase inhibitor and neurotoxicant[16]. On the other hand, Triazophos has a low water solubility which is 35 mg l^{-1} at 20°C. It is marginal leacher[15]. This insecticide is an acetylcholinesterase inhibitor, neurotoxicant, respiratory tract irritant, skin irritant, and eye irritant[16].

Another group of pesticides used by Pangasinan farmers were the chlorpyrifos compounds. Chlorpyrifos has high bioaccumulation potential. This compound has been known to cause reproductive and development problems, acetylcholinesterase inhibition, and eye and skin irritations[16].

Methamidophos has a high water solubility which is 200 g/L at 20°C. It is volatile based on its vapor pressure which is 2.3 mPa at 25°C. It is non-volatile according to its Henry's Law of Constant which is at 1.60×10^{-06} Pa m^3 mol^{-1} at 25°C. It is non-persistent based on its soil degradation half-life which is 3.5 days in typical aerobic situation. Its aqueous photolysis is stable with a half-life of 90 days at pH 7. Its aqueous hydrolysis is non-persistent with a half-life of 5 days at 20°C and pH 7. It is a marginal leacher based on its Groundwater Ubiquitous Score (GUS) leaching potential index which is 2.18[15]. It is very mobile with 1 ml g^{-1} Koc - Organic-carbon sorption constant. It has low bioaccumulation potential. Methamidophos can be absorbed through ingestion, inhalation and skin contact in occupational setting. This active ingredient is known as aectylcholinesterase inhibitor, neurotoxicant, and mutagen[16].

Organophosphates are the most frequently used type of insecticide among Pangasinan farmers. Of all the listed active ingredients that were used by the farmers, the most toxic active ingredients belonged to this group. Methamidophos, which is the most toxic of all the active ingredients, has high water solubility and very mobile. It can therefore contaminate groundwater. Chlorpyrifos, which was used by the farmers in largest amount has a high bioaccumulation potential, thus, putting the community at high risk for possible poisoning.

Neonicotinoid is the group of insecticides newly registered. Neonicotinoids were developed after the natural insecticide, nicotine. Neonicotinoids act on specific neuron pathway in insects which eventually lead to death. Minor eye reddening is manifested when exposed to neonicotinoids. No studies yet were documented regarding human poisoning caused by neonicotinoids[13]. The active ingredients belonging to this group are imidacloprid, thiametoxam, and acetamiprid. These active ingredients under the neonicotinoid group have high water solubility, and therefore, can contaminate the water table.

Anthranilic diamide is a new class of insecticide that acts on specific insects' muscle cell receptors that eventually causes death of the insect. Anthranilic diamides are regarded as extremely safe to mammals[33]. Chlorantraniliprole which has active ingredient Anthranilic diamide were the most frequently used insecticide by the brand name of Prevathon. Fifty three percent of eggplant farmers in Pangasinan used Prevathon.

Data also show that farmers are at risk of cumulative exposure. Similarly, the farmers in India sprayed an average of 54 times during winter season. In Vietnam, the farmers were observed spraying their crops too many times with very high dosages of pesticides throughout the season. It was also observed that farmers in Vietnam sprayed one day before harvest to make their produce and crops look good and smooth. Some farmers in Pangasinan also practiced the same pre-harvest method. This significantly increases health risks to the consumers particularly those who eat raw vegetables.

CONCLUSION

This study showed that eggplant farmers in Pangasinan were exposed to different kinds of insecticides. The active ingredients of the insecticides were shown to have adverse health effects on humans and the environment. Most of the insecticides the Pangasinan farmers used belong to organophosphates. Based on the survey, the farmers were not using proper protective equipment when handling pesticides and they were exposed to various risk factors such as spillage during mixing, loading, and spraying, re-entry to previously sprayed area, and using pesticide-residue-contaminated cloth in wiping sweat. Farmers were found frequently experiencing skin itchiness, eye redness, muscle pain, and headache. These frequently self-reported health symptoms of the farmers may be linked to their prolonged and improper use of insecticides as shown in related studies.

The study recommends that local programs should be implemented in the area to promote good agricultural practices, reduced pesticide use, and information dissemination on adverse effects of pesticides to human health and the environment.

Acknowledgement is cited for International Service for the Acquisition of Agri-biotech Applications that gave the funding support for this project.

REFERENCES

[1] J.M.Antle, P.L.Pingali; Pesticides, Productivity, and Farmer Health, A Philippine Case Study, American Journal of Agricultural Economics, **76 (3)**, 418-430 **(1994)**.

[2] T.Abu Mourad; Adverse impact of insecticides on the health of Palestinian farm workers in the Gaza Strip, a hematologic biomarker study, Int.J.Occup Environ Health, http://www.ncbi.nlm.nih.gov/pubmed/15875890, April 1, 2011, **11**, 144-149 **(2005)**.

[3] V.Andreu, Y.Pico; Determination of pesticides and their degradation products in soil, critical review and comparison of methods, Trends Anal.Chem., http://cat.inist.fr/?aModele=afficheN&cpsidt=16376827, April 1, 2011, **23(10-11)**, 772-789 **(2004)**.

[4] K.Baral, B.C.Roy, K.M.B.Rahim, H.Chatterjee, P.Mondal, D.Mondal, D.Ghosh, N.S.Talekar; Socio-economic parameters of pesticide use and assessment of impact of an IPM strategy for the control of eggplant fruit and shoot borer in West Bengal, India, Technical Bulletin No.37, AVRDC publication number 06-673, AVRDC – The World Vegetable Center, Shanhua, Taiwan, http://www.avrdc.org/publications/technical_bulletin/TB37.pdf, April 1, 2011, 36 **(2006)**.

[5] [DA-BAS] Department of Agriculture-Bureau of Agricultural Statistics, Selected Statistics on Agriculture, Quezon City, Philippines. April 1, 2011, **(2010)**.

[6] J.Coble, T.Arbuckle, W.Lee, M.Alavanja, M.Dosemeci; The validation of a pesticide exposure algorithm using biological monitoring results, J.Occup Environ.Hyg., http://www.ncbi.nlm.nih.gov/pubmed/15764542, April 1, 2011, **2(3)**, 194-201 **(2005)**.

[7] J.L.Del Prado-Lu; Pesticide exposure, risk factors and health problems among cutflower farmers, a cross sectional study, J.Occup.Med.Toxicol., http://www.ncbi.nlm.nih.gov/pubmed/17877808, April 1, 2011, **2**, 9 **(2007)**.

[8] N.H.Dung, T.C.Thien, N.V.Hong, N.T.Loc, D.V.Minh, T.D.Thau, H.T.L.Nguyen, N.T.Phong, T.T.Son; Impact of Agro-Chemical Use on Productivity and Health in Vietnam, Available from http://203.116.43.77/publications/research1/ACF122.html. Accessed on March 18, 2011, **(1997)**.

[9] D.J.Ecobichon; Pesticide use in developing countries, Toxicology, http://siteresources.worldbank.org/INTEAER/Resources/5991606-1251483570919/Vietnam_Country_Background_jv.pdf, April 1, 2011, **160**, 27-33 **(2001)**.

[10] El Sebae AH; Special problems experienced with pesticide use in developing countries, Regul Toxicol Pharmacol, http://www.ncbi.nlm.nih.gov/pubmed/8337421, April 1, 2011, **17**, 287-291 **(1993)**.

[11] Environmental Protection Agency (EPA), Type pf Pesticides, http://www.epa.gov/pesticides/about/types.htm, March 18, 2011, **(2011)**.

[12] R.A.Fernandez; The Development and Regulation of Bt Brinjal in India (Eggplant/Aubergine), The Philippine Star 2010, http://www.isaaa.org, April 1, 2011, **(2010)**.

[13] F.Fishel; Pesticide Toxicity Profiles series, Pesticide Information Office, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, http://edis.ifas.ufl.edu, April 1, 2011, **(2005)**.

[14] G.Forget; Pesticides and the Third World, J.Toxicol.Environ.Health, http://www.ncbi.nlm.nih.gov/pubmed/1987360, April 1, 2011, **32**, 11-31 **(1991)**.

[15] J.Gan; Pesticide and Groundwater Quality, http://www.pw.ucr.edu/textfiles/PesticideWiseWinter2002.htm March 30, 2011, **(2002)**.

[16] [IUPAC]International Union of Pure and Applied Chemistry, Global Availability of Information on Agrochemicals, http://sitem.herts.ac.uk/aeru/iupac/index.htm, March 22, 2011, **(2011)**.

[17] Y.Issa, F.Sham'a, K.Nijem, E.Bjertness, P.Kristensen; Pesticide use and opportunities of exposure among farmers and their families, cross-sectional studies 1998-2006 from Hebron governorate, occupied Palestinian territory, Environmental Health, http://www.ncbi.nlm.nih.gov/pubmed/20959000, April 1, 2011, **9**, 63 **(2010)**.

[18] D.A.Khan, S.Shabbir, M.Majid, T.A.Naqvi, F.A.Khan; Risk assessment of pesticide exposure

on health of Pakistani tobacco farmers, Journal of Exposure Science and Environmental Epidemiology, **20**, 196-204 **(2010)**.

[19] J.D.Lu; Comparison of Pesticide Exposure and Physical Examination, Neurologic Assessment, and Laboratory Findings between Full-time and Part-time Vegetable farmers in the Philippines, Environmental Health and Preventive Medicine **(2009)**.

[20] T.Mendoza; Organic Agriculture, The logical sequence to modern chemical agriculture in the Philippine context, Ann.Trop.Med., **32(1)**, 112-129 **(2010)**.

[21] J.Miranda, R.McConnell, E.Delgado, R.Cuadra, M.Keifer, C.Wesseling, E.Torres, I.Lundberg; Tactile vibration thresholds after acute poisonings with organophosphate insecticides, Int.J.Occup.Environ.Health, http://www.ncbi.nlm.nih.gov/pubmed/12358077, April 1, 2011, **8**, 212-219 **(2002)**.

[22] J.Miranda, R.McConnell, C.Wesseling, R.Cuadra, E.Delgado, E.Torres, M.Keifer, I.Lundberg; Muscular strength and vibration thresholds during two years after acute poisoning with organophosphate insecticides, Occup.Environ.Med., http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1757809/, April 1, 2011, **61**, 4 **(2004)**.

[23] G.J.A.Ohayo-Mitoko, H.Kromhout, J.M.Simwa, J.S.M.Boleij, D.J.J.Heederik; Self reported symptoms and inhibition of acetylcholinesterase activity among Kenyan agricultural workers, Occup.Environ.Med., http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1739922/, April 1, 2011, **57**, 195-200 **(2000)**.

[24] M.J.Perry, P.M.Layde; Source, routes, and frequency of pesticide exposure among farmers, J.Occup.Environ.Med., http://www.ncbi.nlm.nih.gov/pubmed/9729752, April 1, 2011, **40**, 697-701 **(1998)**.

[25] J.M.Safi; The state of environment in Gaza Strip, Alexandria Science Exchange, http://site.iugaza.edu.ps/arabou/files/2010/02/Pesticide_Use_in_Gaza_Strip.pdf, April 1, 2011, **19**, 137-150 **(1998)**.

[26] J.M.Safi; Association between chronic exposure to pesticides and recorded cases of human malignancy in Gaza Governorates (1990-1999), Sci.Total.Environ, http://www.ncbi.nlm.nih.gov/pubmed/11846176, April 1, 2011, **284**, 75-84 **(2002)**.

[27] J.M.Safi, El-Nahhal YZ, S.A.Soliman, El-Sebae AH; Mutagenic and carcinogenic pesticides used in the agricultural environment of Gaza Strip, Sci.Total.Environ, http://www.ncbi.nlm.nih.gov/pubmed/8475373, April 1, 2011, **132**, 371-380 **(1993)**.

[28] P.R.Salameh, I.Baldi, P.Brochard, C.Raherison, S.B.Abi, R.Salamon; Respiratory symptoms in children and exposure to pesticides, Eur.Respir.J., http://erj.ersjournals.com/content/22/3/507.full, April 1, 2011, **22**, 507-512 **(2003)**.

[29] M.D.Sanborn, D.Cole, A.Abelsohn, E.Weir; Identifying and managing adverse environmental health effects, 4, Pesticides, CMAJ, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC111218/, April 1, 2011, **166**, 1431-1436 **(2002)**.

[30] B.Thompson, G.D.Coronado, J.E.Grossman, K.Puschel; Pesticide take-home pathway among children of agricultural workers, study design, methods, and baseline findings, J.Occup.Environ.Med., http://www.ncbi.nlm.nih.gov/pubmed/1255317, April 1, 2011, **45(1)**, 42-53 **(2003)**.

[31] [WHO] World Health Organization, The WHO Recommended Classification of Pesticides by Hazard, www.who.int/ipcs/publications/pesticides_hazard_rev_3.pdf, October 1, 2010, **(2010)**.

[32] A.Yassi, T.Kjellström, T.de Kok, T.Guidotti; Basic environmental health, In World Health Organization, NY, Oxford University Press, **(2001)**.

[33] R.Youngman, M.Goatley, L.Curt; Commercial Turfgrass IPM, Novel Insecticides for Managing White Grubs and Cutworms, http://web.ento.vt.edu/ento/project.jsp?projectID=101, April 1, 2011, **(2007)**.