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Pyrethroid Pesticides of Cabbage-Grown Area in Dalaguete, Cebu, Philippines

CALINAWAN Armstrong[1], PAULE Heide Brigette S.[1], ADARNA Leonila[1], VILLEGAS Lora Mae G.[1] and MENDOZA Concepcion S.[1, 2*]

[1]Chemistry Dept., University of San Carlos, Cebu City, Philippines
[2]Department of Applied Sciences, Higher College of Technology, Muscat, Oman
**Corresponding author*
E-mail: concepcionsmendoza@yahoo.com

Abstract

This study evaluated the presence of synthetic pyrethroid pesticides, specifically the residue levels of deltamethrin and lambda-cyhalothrin in soil, water, and cabbage samples from an agricultural farm in Manlapay, Mantalongon, Dalaguete, Cebu, using Gas Chromatography-Electron Capture Detector technique. Samples analyzed were collected from October 2013 to November 2013. Other environmental parameters such as pH, total organic carbon (TOC) and cation exchange capacity (CEC) using standard methods were also done on the samples.

The detected deltamethrin residue concentrations in the cabbage (< 0.001–0.029 ppm), soil samples (0.007–0.008 ppm) and water samples (< 0.0005 ppm) were all below international guideline limits. Lambda-cyhalothrin residue was detected only in cabbage (0.006–0.007 μg/g) and was below the Environmental Protection Agency, Food and Agriculture Organization and World Health Organization maximum residue limit of 0.4 μg/g. Results of the analyses of pH, CEC, TOC, season and daily temperature showed that these factors affected the persistence, movement and degradation of deltamethrin and lambda-cyhalothrin once applied into the environment.

The lack of awareness of the farmers on pesticide application and use may have contributed to the presence of pesticide residues. The pesticides found in cabbage and in soil were in very low concentrations may pose health hazards to the consumers and to the environment. Enhancing the awareness of vegetable farmers on proper use and management of pesticides and a robust monitoring program for pollutants in Cebu area is needed, to develop and maintain an adequate level of environmental protection.

Key words: Cebu, Philippines, deltamethrin, lambdba-cyhalothrin, pyrethroid, cabbage

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Introduction

Cebu is an island province and one of the most developed provinces in the Philippines. Cebu is the main center of commerce, trade, education and industry in the Central Philippines (Visayas area). Cebu, being one of the mostly densely populated islands in the Philippines, is serving over 3.5 million people, as of 2010 (NSO 2010); of which 2.3 million live in Metro Cebu. Cebu's central location, proximity to unusually exotic tourist destination, ready access to a diversity of plant, animal and geological wonders within the island, beaches, coral islands and rich fishing ground and remoteness from earthquake and typhoon activity are some of the special attributes of Cebu.

About 84 kilometers south of Cebu City, is the town of Dalaguete, producing high quality vegetables the whole year round and supplied to restaurants, hotels and supermarkets and other consumers within Cebu province and neighboring islands. Cabbage is one of their vegetable products, a popular table vegetable; consumed as raw or cooked. Farmers in this area depend heavily on the use of pesticides for their crop protection. The misuse and misapplication of pesticides may pose risks to humans and the environment—causing water pollution, resistance of pests to pesticides and negative impact to non-target organisms. The effect of pesticide application can affect the health of the farmers, the people living in rural communities and other populations which consume contaminated food and water.

The use of pyrethroids pesticides had surpassed the more toxic organochlorines, organophosphates and carbamates as the insecticide of choice (PAP *et al*. 1996) by applicators including farmers in Cebu Island. The increasing use of pyrethroids has generated public concerns. Though, pyrethroids are less toxic to humans, non-target mammals and birds than organophosphates and carbamates but present a high toxicity to honey bees and a wide range of aquatic organisms (PÁREZ-FERNÁNDEZ *et al*. 2010, LUO and ZHANG 2011). Various formulations of pyrethroids are often combined with other chemicals, known as synergists, to increase potency and persistence in the environment (MUELLER-BEILSCHMIDT 1990).

With the continually increasing use of pesticides in Philippine agriculture (DAVIS 1993, MENDOZA 2004), there is still an inadequate pesticide research (DAVIS 1993) on distribution, occurrence, fate, and environmental impacts resulting from its use has been done in the Philippines. Likewise, little attention or perhaps, unpublished data are available on pesticide studies in Cebu Island. Pesticide treatment history on a large number of samples is unknown. There is also an urgent need for prevention, monitoring and careful assessment of the benefits and risks of pesticides in this island. This study aims to present some pesticide-related concerns in Cebu, as a consequence of continued use of pesticides to sustain its agricultural based economy and for increased food production. Specifically, the present study is aimed: 1) to determine the pyrethroids pesticide residues (deltamethrin and lambda-cyhalothrin) in soil, water and cabbage from Mantalongon, Dalaguete, Cebu, towards a start in a systematic approach of pesticide pollution prevention in a specific area and, 2) to look into the practices of local farmers of Dalaguete during pesticide use and application. Likewise, this paper endeavors to support the pesticide monitoring program by information-sharing the obtained analytical findings about pesticide residues and also to know about the awareness level of farmers regarding pesticides and their use. With the trans-boundary nature of the Cebu aquatic environment, there is the need of collaborative analysis and sharing of accurate data for effective pesticide management strategies in the region.

Materials and Methods

Description of sampling site and sample collection

The Municipality of Dalaguete has fertile agricultural areas, abundant water and sun; and thus, has kept agriculture as its most important activity and livelihood. High quality vegetables, crops and other products are produced the whole year round. The use of pesticides in this agricultural area is a common practice to sustain productivity and enhance the quality of farm products.

Specifically, the research area considered is an agricultural farm in Manlapay, Mantalongon, Dalaguete, Cebu, as shown in Fig. 1, producing cabbages and other vegetables. The farm uses terracing techniques to prevent soil erosion and rapid nutrient leaching. Table 1 shows the GPS coordinates of the sampling sites.

Fresh matured cabbages samples, soils and water samples were randomly collected at the farm site, once a month from August 2013 to November 2013; about a week after pesticide application and few days prior harvesting. Four matured cabbages, heads and roots, were randomly collected. Soil strongly bound to the root system, the rhizosphere, was mixed with the composite soil samples before all the cabbages were mixed. Cabbage samples were placed in properly labelled re-sealable plastic bags and temporarily stored in a cooler with ice before transporting it to the laboratory.

Several five-inch deep holes, about one meter distance from each hole, were dug in each sampling site. Soil samples taken from different holes of a common

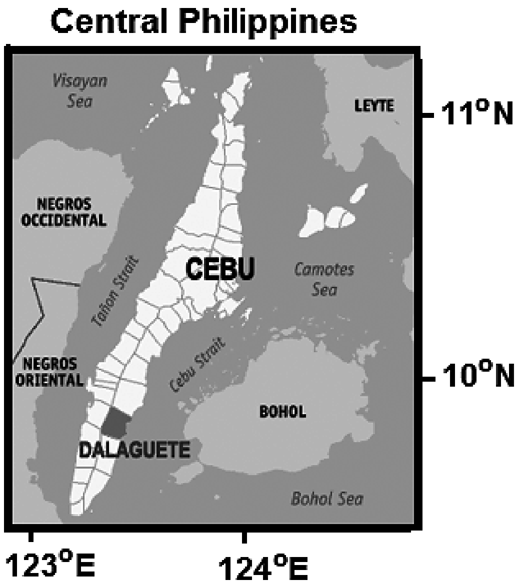

Fig. 1. Location map of Dalaguete, Cebu, Philippines.

Table 1. GPS coordinates of the sampling sites.

Sample Collected	Area Assignment	GPS Coordinates	Elevation
Cabbage and Soil	Top	N 09°52'16.9" E 123°29'01.1"	595 m
Cabbage and Soil	Mid	N 09°52'16.4" E 123°29'01.6"	592 m
Cabbage and Soil	Bottom	N 09°52"16.9" E 123°29'02.4"	578 m
Water	Water Effluent	N 09°52'28.3" E 123°28'30.3"	554 m

site were combined to represent the composite soil sample for analysis. Soil samples were placed in properly labelled re-sealable plastic bags and temporarily stored in a cooler with ice before transporting it to the laboratory.

Water samples were collected from the water catchment located downhill about 20 meters from the farm. One liter of water effluent was collected and placed in acid-washed polypropylene bottles and stored in a cooler with ice.

Pesticide analysis

The cabbage, soil and water samples were analyzed for pesticide residue of deltamethrin and lamda-cyhalothrin. Lambda-cyhalothrin ($C_{23}H_{19}ClF_3NO_3$) with an IUPAC name of (R)-cyano-(3-phenoxyphenyl)-methyl-(1S,3S)-rel-3-[(1Z)-2-chloro-3,3,3-trifluoro-1-propenyl]-2,2-dimethylcyclopropanecarboxylate, and deltamethrin ($C_{22}H_{19}Br_2NO_3$) with IUPAC name of (S)-α-cyano-3-phenoxybenzyl (1R,3R)-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropane carboxylate; both belong to the synthetic cyano-containing type II pyrethroid pesticide (EPA 2011). Due to poor water solubility of pyrethroids, gas chromatography is the instrumental technique generally used for routine pyrethroid analysis.

1. Sample preparation

Water. Liquid—liquid extraction with a 1:2 sample to acetone ratio was performed on a filtered water sample. The filtered acetone layer was concentrated to near dryness in a rotary evaporator at a water bath temperature of 40°C.

Soil. A 15 g of homogenized, screened and air dried samples and spiked soil samples were obtained and added with 80 mL acetone. Approximately 10 g of anhydrous Na_2SO_4 was added and the mixture was shaken for 1 hour. The mixture was filtered and the residue further washed with 20 mL of acetone. The combined filtrate was concentrated to near dryness in a rotary evaporator at a water bath temperature of 40°C.

Cabbage. A 15 g of homogenized samples were obtained, added with 15 mL acetonitrile and shaken for 1 minute. Approximately 6.2 g of anhydrous $MgSO_4$

was added and the mixture was vigorously shaken for 1 minute. The mixture was centrifuged and about 6 mL of the clear liquid solution was allowed to pass through a C18 column and eluted with 20 mL dichloromethane. The eluent was concentrated to near dryness in a rotary evaporator at a water bath temperature of 40°C.

2. Extraction and GC-ECD injection

The remaining extracts collected during water sample preparation was redissolved with 5 mL of n-hexane: acetone mixture (70:30) and sonicated for complete dissolution. A florisil solid phase extraction cartridge was conditioned and washed with 5 mL of of n-hexane followed by 5 mL of n-hexane-acetone mixture (70:30). Samples were then loaded to the prepared cartridge and eluted with 10 mL n-hexane: acetone mixture (70:30). The eluate was collected, evaporated to near dryness, redissolved with 2 mL and injected into the GC instrument.

The above step was also done for extracts collected during soil sample preparation. Similar step as stated above was performed for the extract collected during cabbage sample preparation. However, instead of using hexane-acetone mixture, acetonitrile was used in the washing the florisil solid phase cartridge and in the GC elution process.

3. Gas Chromatography—Electron Capture Detection (GC-ECD) Analysis

The extracts were analyzed for the presence of lambda-cyhalothrin and deltamethrin using GC-ECD at retention time of 9.78 minutes and 12.32 minutes, respectively. The working condition for the GC-ECD analysis is summarized in Table 2.

4. Quality Assurance

External calibration method and standard spiking was done for the determination of lambda-cyhalothrin and deltamethrin in the samples analyzed. Recovery tests were also performed through solid and liquid matrices. Fortification of control samples and recovery percentages from spiked samples were done. The averaged % recovery is shown in Table 3.

Table 2. GC-ECD working conditions.

Injector temperature	250 ˚C
Detector Temperature	300 ˚C
Oven Temperature Program	120 ˚C hold for 1 minute, 9 ˚C/min to 285 ˚C
Carrier Gas	Nitrogen (GC grade)
Make-up Gas	Hydrogen (GC grade)
Column Flow Rate	3.0 mL/min
Column	2.7 m x 4 mm i.d. glass on 5% OV-210 on 80–100 mesh Cromosorb W-HP
Amount Injected	2 microliters
Data System	HP Chem Station

Table 3. Retention time and % recovery of tested insecticide after extraction and clean-up using GC/ECD.

Insecticide	Retention time (R_t), minutes	Solid Matrix	Liquid Matrix
		Mean % Recovery	Mean % Recovery
Lambda-cyhalothrin	9.78	90.46	90.17
Deltamethrin	12.32	83.39	94.45

Other analyses on soil and water samples

The various parameters: organic matter in soil (Walkey-Black method); chemical oxygen demand (COD) in water (dichromate open reflux method); cation exchange capacity of soil (ammonium acetate method); and pH (electrode method) in soil and water were determined using recommended procedures (RADOJEVIC *et al*. 1999).

Rainfall and ambient temperature

Rainfall and temperature data were obtained from one of the monitoring stations of PAG-ASA (2013).

Local Practices in Pesticide Application

During the cabbage, soil and water sampling, the farmers were interviewed to obtain information regarding their knowledge and practices on pesticide management. Farmers were asked about their training on the safe and effective use of pesticide, knowledge of withholding period and source of recommendations regarding time, application rate and method of application and the subsequent harvest and sale of treated crops and also the contacts they make with pesticide dealers, researchers, extension workers for making decisions regarding the use of pesticides. They were asked whether they use protective clothing while they handle and spray the field, and whether they suffer of any discomfort during pesticides application.

Results

Pyrethroids in Cabbage, Soil and Water

Deltamethrin and lamda-cyhalothrin were used to represent the pyrethroid group of pesticides. Deltamethrin and lamda-cyhalothrin were detected and observed to be higher in concentration in cabbage heads than in soil samples and least in water samples (Table 4). Lamda-cyhalothrin was detected only in cabbage while values of below the method detection limit for soil and water samples.

At the moment, no existing norms for pesticides in the Philippines and such, other international guidelines are used for comparison (Table 4). The deltamethrin and lamba-cyhalothrin levels in cabbage, in soil and in water are way below the environmental guideline values.

Some Factors Affecting Pesticide Persistence and Transfer

The organic matter, CEC and pH values showed significant correlation with adsorption of deltamethrin in soil while inversely proportional to rainfall (Table 5). Deltamethrin residue in cabbage showed inverse relationship with deltamethrin residue in soil; and rainfall data supports to this observation. Residue in water does not show any correlation to any other parameters as its concentration is beyond detection limit.

The amount of precipitation during sampling also correlates to the lambda-cyhalothrin residue level detected in cabbage. Lambda-cyhalothrin residue in water and in soil did not show any correlation to any other parameters as it was below the method limit of detection (Table 5).

The rainy/moisture condition maximizes the pesticide (deltamethrin and lambda-

Table 4. Pesticide residue on cabbage, soil and water samples together with guideline values.

Month	Deltamethrin (ppm)			Lambda-cyhalothrin (ppm)		
	Cabbage	Soil	Water	Cabbage	Soil	Water
Oct-13	0.029	0.007	<0.0005	0.007	<0.001	<0.0005
Nov-13	<0.001	0.008	<0.0005	0.006	<0.001	<0.0005
Guideline limit (ppm)	0.5[a]	1290[b]	0.0025[c]	0.3[d]	68.5–229[e]	$5.2x10^{-5}$[f]

[a] ASEAN 2002: maximum residual limit (MRL) for leafy vegetables like cabbage.

[b] EC 2002: acute toxicity for earthworms: LC_{50} (14 days) for *Eisenia fetida* > 1290 mg/kg soil.

[c] Kegley *et al*. 2014: Canadian water standard for agricultural use / livestock water guidelines.

[d] FAO/WHO Codex 1993: MRL for leafy vegetables like cabbage.

[e] Garcia *et al*. 2011: acute toxicity for earthworm, Eisenia fetida: soil at tropical region: LC50 (14 days) = 68.5–229 mg applied insecticide/kg dry weight soil; EC50 = 54.2–60.2 mg applied insecticide/kg dry weight soil (soil at temperate region: LC50 = 99.8–140 mg a.i./kg soil; ED50 = 37.4–44.5 mg applied insecticide/kg soil).

[f] EPA 1998: maximum concentration detected in simulated water pond = 0.52 ppb.

Table 5. Some physical properties of soil and water samples, together with the weather condition during sampling.

Parameter	Cabbage		Soil		Water	
	Oct-13	Nov-13	Oct-13	Nov-13	Oct-13	Nov-13
	Mean	Mean	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Deltamethrin (ppm)	0.029	<0.001	0.007	0.008	<0.0005	<0.0005
Lambda-cyhalothrin (ppm)	0.007	0.006	<0.001	<0.001	<0.0005	<0.0005
Organic Matter (ppm)	–	–	51,942.2 ± 3,832.1	54,639.1 ± 1,818.6	2.011.2 ± 6.13	1,304.0 ± 4.0
Cation Exchange Capacity (meq/100g)	–	–	30.5 ± 0.8	36.0 ± 0.6	–	–
pH	–	–	6.97 ± 2.03	7.01 ± 0.03	6.50 ± 0.01	6.80 ± 0.0
Moisture (%)	–	–	2.92 ± 0.01	8.14 ± 0.12	–	–
Weather condition	Oct-13	Nov-13				
Rainfall (mm)	154.6	240.8				
Temperature (°C)	18.7–23	17.6–23				

cyhalothrin) transfer and leaching from cabbage to sediment to water media. High day temperature also facilitated pyrethroid degradation and volatilization.

Local Practices in Pesticide Application

Cabbage cultivation takes 2.5–3 months and within this cultivation period, pesticide application is primarily directed to cabbage heads. After the fifteen day of cultivation, pesticide spraying is done twice a month on normal harvest cycles and sprayed one last time before harvest to ensure that the inner portion of cabbage head is protected from pest attack, or as often as needed to prevent pest attack using the recommended dosage of the pesticides. On the event of a big infestation, the dose of the pesticide is increased based on farmers' personal assessment and experience. Cocktailing is a common practice in pesticide application. A dose of one pesticide is mixed with a dose of another in the same dilution volume which makes the resulting solution very potent. Sometimes, the pesticide is applied too close to the crop's harvest. In unforeseen events arising like unseasonal weather, high market demands and farmers' urgent need for a daily source of income from sale of cabbages, the withholding period of the pesticide is not properly taken into account in the harvest and sale of cabbage products by the local farmers. Buyers or consumers are not also informed by the farmers that the withholding period of the pesticide has not expired. Most of the farmers are unaware about the recommended doses, spray intervals and no training on the safe use of pesticides and application techniques. They only consulted pesticide dealers for recommendation of pesticide use but only a few were found spraying on the recommendations of agriculture experts.

Fig. 2. A farmer spraying a cocktail pesticide to cabbage plants with improper protective clothing.

Farmers wore inappropriate protective clothing during spraying —no gloves, no goggles or old clothing used as mask during pesticide application (Fig. 2). They just leave the pesticide containers at farm borders. Local farmers experienced various health effects like dizziness, vomiting, headache, sneezing, nausea, skin and eye irritations and chest discomfort, after pesticide application.

The farmers did not experience any pesticide residue monitoring with their environmental samples, except from this study. While, the researchers experienced that pesticide residue analysis was costly and can only be done by few analytical laboratories in Luzon area (North Philippines).

Discussion

Pyrethroids in Cabbage, Soil and Water

Cabbage sampling was done seven days after pesticide application to the matured and ready to be harvested cabbages. Thus, presence of pesticide in cabbage is expected as pesticide application by local farmers is directed to cabbage heads prior to harvest. Pyrethriods are highly lipophilic, too and easily adsorbed into the waxy layer of plants (SPIOC 1986). The presence of deltamethrin in the soil indicated a movement of the pesticide away from the target host. Pesticide transfer in soil and water may be due to volatilization, run-off, leaching and crop removal (FISHEL 1991).

The allowed daily intake without causing harm to humans is 0.01 mg/kg/day as an acceptable daily intake (ADI) for deltamethrin (WHO 2002) and 0.005 mg/kg/day as reference daily dosage (RfD) for lambda-cyhalothrin (EPA 1998). Ingestion of cabbage, soil or water might not be an important pathway of exposure for farmers and rural people considering the low concentration of deltamethrin and lambda-cyhalothrin in cabbages, in Dalaguete agricultural soils and in water, of this study. Pyrethroids have strong affinity to soil environment but the variability in toxicity on different soils is not clear. The available information on the acute toxicity to earthworms by deltamethrin of LC_{50} > 1290 mg/kg soil (EC 2002) and for lambda-cyahalothrin is LC_{50} = 229 mg/kg soil (GARCIA *et al.* 2011); and pyrethroids in general have acute toxicity (LC_{50} > 1000 mg applied insecticide/kg dry weight soil) to worms (INGLESFIELD 1989) is used as reference. Comparing this reported LC_{50} values to the pesticide values in soil obtained in the study, indicates that Dalaguete soil is still a good environment for earthworms.

The presence of pesticides detected in the cabbage samples may be due to great amount of pesticide applied and/or an early harvest of cabbage which did not allow most of the deltamethrin and lambda-cyhalothrin to be decomposed or degraded by the cabbage plant. Such contamination of cabbage with pesticide residue may be expected to happen often in later scenarios in relation to the information obtained from the interview of farmers with respect to excessive use of pesticides and the disregard of withholding periods.

Some Factors Affecting Pesticide Persistence and Transfer

Once applied, many pesticides are mobile in the environment due to several factors influencing the fate of the pesticide like properties of the pesticides and various conditions at the application site. The soil characteristic of the farm with high CEC value (Table 5) indicating a clay and clay loam category (DONAHUE *et al.* 1977), in addition to the neutral pH and high organic content, are considered to be reasonable conditions for the persistence of pyrethroids (repesented by deltamethrin) in soil. In soil, deltamethrin degradation occurs within 1–2 weeks (RSC 1983). Deltamethrin and fenvalerate are the most persistent pyrethroids in commercial use, especially in soil with high organic matter (SPIOC 1986). The nearly neutral pH condition (pH≃7) of the soil prevents chemical degradation of deltamethrin. Many insecticides are susceptible to rapid pesticide breakdown under alkaline medium (FISHEL 1991). However, the warm average temperature of 29 °C, low vegetation cover of the farm and the adequate soil moisture of > 5%; might justify the disappearance of pyrethroids (represented by lambda-cyhalothrin) (NABIL *et al.* 1996). Heavy rains causing wind-soil and water erosion, leaching, volatilization, photochemical and microbial degradation processes, and desorption may have enhanced the decreased or absence of pyrethroids in soil.

The cabbages in October 2013 were sprayed twice, while the cabbages in November 2013 were of the second harvest and sprayed only once prior to sample collection. In such wet situation (like in November 2013), the dispersion of pesticide residue maybe easier to other areas. The lower pesticide residue in November maybe caused by the washing out of the adsorbed pesticides on the cabbage leaves. The high amount of precipitation during the wet months of October and November also permitted the leaching of pesticide from the vegetable to the soil. This result is consistent with the results of ZHANG *et al.* (2008) which showed the close relationship of amount of pesticide residues with dosage of application, and with weather conditions after spraying. Pesticide run-off is usually greatest when a heavy or sustained rain follows soon after an application (FISHEL 1991).

Deltamethrin and lambda-cyhalothrin were not detected in the water samples (Table 5), because these pesticides have low solubility in water at 0.002–0.0002 mg/L and 0.005 mg/L at 20 °C respectively. By pesticide movement, pesticide can possibly enter and contaminate water sources through spray-drift, leaching, pesticide persistence, soil and topography, and weather (CAST 1994).

The low level of deltamethrin and lamba-cyhalothrin in cabbage, in soil and in water are below the environmental guideline values and also suggesting efficient use and degradation of the pesticide in the area.

Local Practices in Pesticide Application

The improper practices of the farmers due to the lack of awareness on pesticide use and application can be linked to the pesticide contamination in the cabbage samples. The contaminated cabbage samples may pose health hazards to the consumers. Their practices indicating lack of awareness on the hazardous effect of these hazardous chemicals on human health and lack of knowledge on pesticide disposal may enhance the presence of pesticide contamination on the environment (soil, water, air and biota), in addition to excessive use of pesticide and not considering withholding period of pesticides.

In other studies, pyrethroids and organophosphates residues in cabbage samples exceeded the maximum residue limits for cabbage due to wrong application method techniques (ARMAH 2011) and higher doses with shorter interval of deltamethrin applications (FAO/WHO 1984). As a good agricultural practice, the application of deltamethrin and lambda-cyhalothrin on cabbage is limited to two applications only during the growing season and with a seven-day harvest interval for these two pesticides (RHS 2015). At about 10 days after use, deltamethrin have undergone chemical breakdown in the vegetation and no deltamethrin residues are observed on plants, as well, no phytotoxicity to crops. (RSC 1983, THOMSON 1989). The unintended movement of pesticides from target site to non-target site often causes toxicity symptoms on a non-sprayed site or serious hazards to non-target organisms. Deltamethrin and lambda-cyahalothrin have been found to be highly toxic to birds, fish and bees (BRADBURY *et al.* 1989). Acute exposure to pyrethroid formulations had demonstrated to cause a range of potentially hazardous health effects in humans (HE et *al*. 1988, (WHO 1990).

In this study, the local farmers used deltamethrin (trade name: Deltacide 2.5 EC and Astro 2.5 EC) and lambda-cyhalothrin (trade name: Karate 2.5 EC and Blast 2.5 EC), among a variety of other pyrethroids products available in the local market (DFA-FPA 2007). Most of these applied pesticides are in emulsified concentrate (EC) form, and some points of the farm may be considered the mixing and loading sites of these pesticides and thus, can also contribute to the presence of pesticides in the biota. The use and effect of these pesticide products needs monitoring, too.

Within the study area, the inadequate facilities for pesticide analysis (like difficulty to acquire expensive and new analytical equipment, inadequate stock of spare parts, relatively expensive chemicals, or few technicians who can handle equipment repair) can be one of the reasons for the limited pesticide studies in Cebu.

The use of pesticides still provides the main treatment against pests in agricultural activities in Cebu. Consequently, problems concerning their use may emerge in the near future that might pose serious threat to the health of the farming families, the consumers in urban areas and the environment in general; if necessary controls and measure are not in place. There is a need to promote more effort for an integrated pest management in Cebu towards minimizing pesticide hazards.

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