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Trending of Pesticide Residues and Consumer's Health Risk

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Abstract

This study aims to assess trending of insecticide residues in crop commodities and soil samples in Benguet, Philippines. This is a comparative secondary analysis of two sampling periods (2008 and 2010). Samples were analyzed for multi-pesticide residue analysis using gas chromatography. In 2008, the insecticide residues detected in the soil and crop samples were chlorpyrifos, chlorothalonil, endosulfan sulfate, and profenofos. Of these residues, endosulfan sulfate yielded the highest concentration at 0.095ppm. In 2010, the residues found in the crop and soil samples were chlorpyrifos, cypermethrin, cyhalothrin, deltamethrin, and fipronil. Of these residues, chlorpyrifos registered the highest concentration at 1.41ppm. The residues that exceeded the maximum residue limit for soil samples were endosulfan and chlorpyrifos. Meanwhile, chlorpyrifos and cypermethrin were the most frequently detected insecticide residues in the crop samples. The results of the study provide information on the insecticide contamination in soil and crops in Benguet.

Keywords

Pesticide Residues, Agricultural Crops, Soil and Crop Samples, Consumer Health Risk, Environmental Health

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1. Introduction

Pesticides are used to control various kinds of pests and boost agricultural production in order to cope with the demands of the market. However, when pesticides are used indiscriminately, they pose danger and risk to human health (Fenik et. al., 2011).

The study was conducted in Benguet which is the largest vegetable producer in northern Philippines. The province produces major agricultural crops such as leafy vegetables, stems and flowers, tubers, roots and bulbs. It has a land area of about 2,599.4 km^2 with an estimated 27.5 thousand farms and 30 thousand hectares of agricultural land. (BAS, 2013). This is the first documented study on trending of pesticide residue in the local area.

2. Methods and Materials

This study is a comparative analysis of two sampling periods (2008 and 2010) of residues in agricultural soil and crops in Benguet, Philippines.

Table 1. Average Distance of Sampling Per Municipality.

Communities	Average distance (meter)
Community A- Atok	1,600.71 (s.d. 2590.49)
Community B- Bugias	3,642.33 (s.d.1970.10)
Community C- Itogon	7,915.55 (s.d.3344.56)
Community D- La Trinidad	2,464.91 (s.d. 3270.62)
Community E- Bokod	8,192.28 (s.d.9764.169)
Community F- Sablan	8,099.73 (s.d.13864.1)
Community G- Kabayan	18,869.29 (s.d.21169.81)
Community H- Tuba	2,020.822(s.d.3249.01)

Samples of soil and crops were collected using cluster sampling technique in eight communities of Benguet which are engaged in commercial agriculture. Fifty one samples

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were collected in 2008, and 52 samples in 2010. Table 1 shows the average distance of sampling per community. The samples collected were submitted for multi-pesticide residue analysis using gas chromatography.

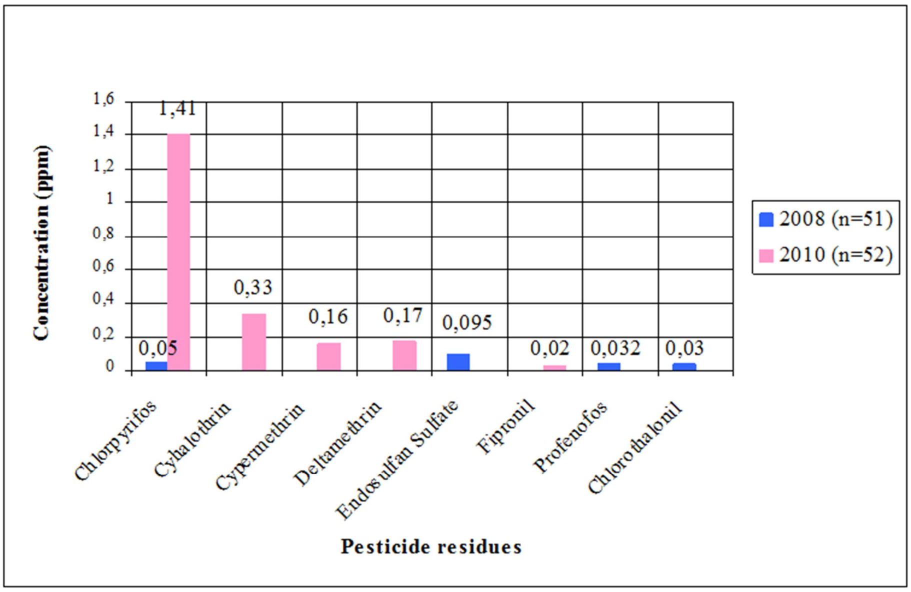

Figure 1. Pesticide Residues Found in Soil 2008 (n=51) and 2010 (n=52).

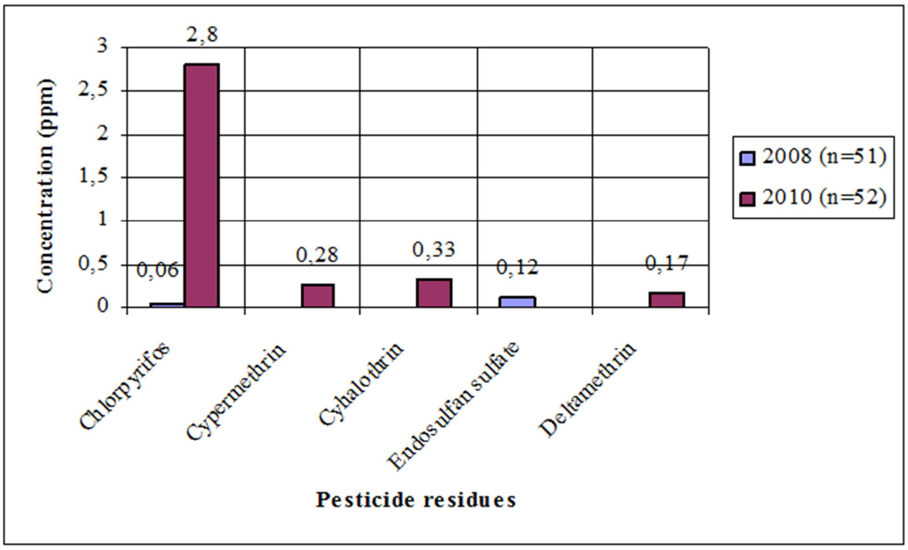

Figure 2. Exceeded Concentrations of Pesticide Residues Found in Soil in 2008 (n=51) and 2010 (n=52).

3. Discussion of Results

3.1. Pesticide Residues in Agricultural Soil

In 2008, four types of insecticide residues were detected in soil samples. These residues were chlorpyrifos, chlorothalonil, endosulfan sulfate, and profenofos. Of these residues, endosulfan sulfate yielded the highest concentration at 0.095ppm. In 2010, five types of residues were found, namely, chlorpyrifos, cypermethrin, cyhalothrin, deltamethrin, and fipronil. Of these residues, chlorpyrifos registered the highest concentration reading at 1.41ppm.

Only chlorpyrifos was the residue detected in both years (Figure 1). This is similar to the study of Zhang et al. (2012) wherein endosulfan residues were detected in agricultural soils in China.

Of all the exceeded residues in 2008, endosulfan sulfate recorded 18% prevalence followed by chlorpyrifos at 12%. In 2010, 4% of samples had residues of chlorpyrifos, cypermethrin, cyhalothrin, and deltamethrin. In 2008, only two residues were found exceeding the maximum concentration level. These were endosulfan sulfate at an average concentration of 0.12ppm, and chlorpyrifos at an average concentration of 0.06ppm. Chlorpyrifos recorded the highest residue concentration at 2.8ppm in 2010. This was followed by cyhalothrin at 0.33ppm and cypermethrin at 0.28ppm. See Figure 2.

3.2. Pesticide Residues in Agricultural Crops

Of all the crops sampled in 2008, cabbage had the highest concentration of pesticide residues (Figure 3). This was followed by celery. For cabbage, the pesticide residue detected was profenofos. For celery, the residues detected were chlorpyrifos, t-endosulfan, deltamethrin, and cyhalothrin. This was found to be similar in the study of Chen et. al. (2011) in China where pesticide residues were most frequently detected in cabbage, legumes, and leaf mustard. In the study of Osman et. al. (2011), pesticide residues found in vegetable samples in Saudi Arabia exceeded the maximum residue level (MRL) in cabbage, squash, green pepper, carrots, cucumber, lettuce, eggplant and tomato. The vegetable with the highest contamination rates were cabbage followed by carrot, cucumber, green pepper, squash, lettuce, tomato and eggplant.

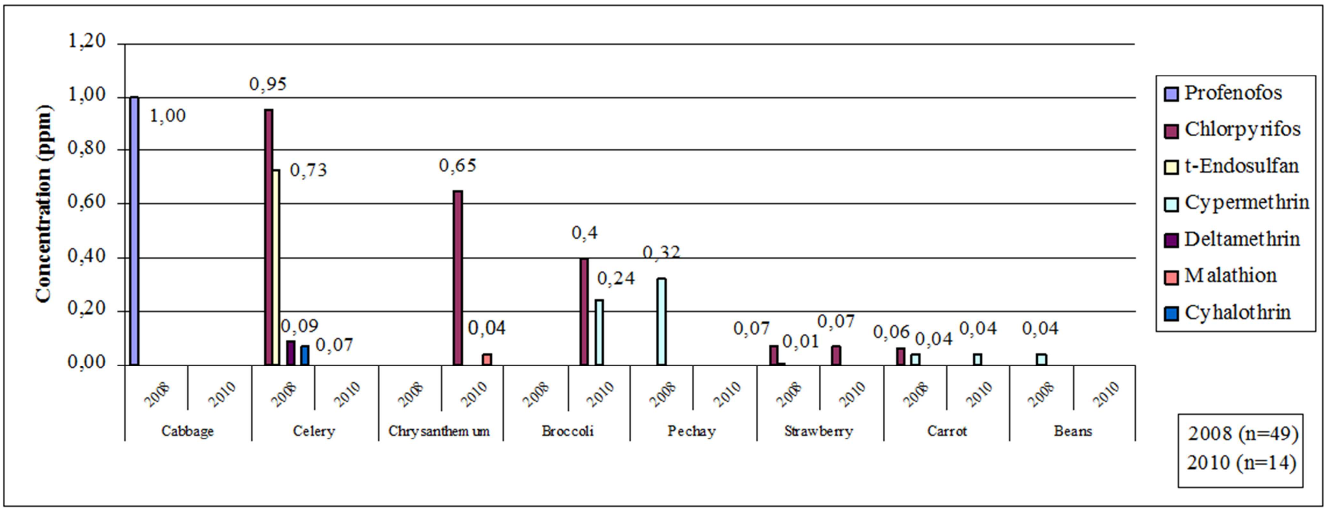

Figure 3. Pesticide Residues found in Crops in 2008 (n=49) and 2010 (n=14).

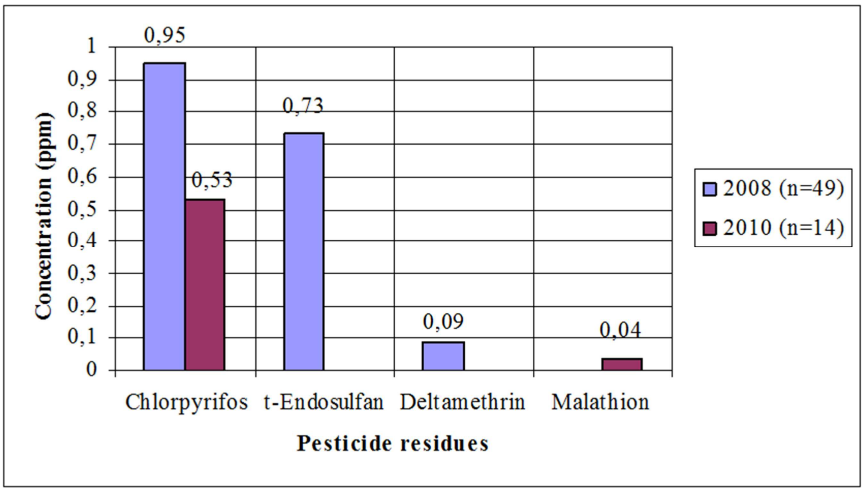

Figure 4. Distribution of Average Exceeded Pesticide Residues Found in Crops in 2008 (n=49) and 2010 (n=14).

In the pesticide residue analysis in Benguet, pesticides were detected in chrysanthemum and broccoli in 2010 sampling period. Chlorpyrifos and cypermethrin were detected in broccoli. Cypermethrin was detected in beans and pechay in 2008. Chlorpyrifos was found in strawberries in both 2008 and 2010 sampling periods. T-endosulfan residue was also detected in strawberry (2008). Cypermethrin was detected in carrots in 2008 and 2010 sampling periods. In addition, chlorpyrifos in carrots was also found in 2008. In both sampling periods, chlorpyrifos and cypermethrin were the most prevalent residues. See Figure 3. Cypermethrin and chlorpyrofos were also found to be the most common pesticide residues in the study of Chen et. al. (2011) in fruits and vegetables, as well as in the study of Lozowicka et. al. (2012) in broccoli, cauliflower, head, cabbage and other vegetables.

Figure 4 shows the distribution of exceeded pesticide residues in crops. Chlorpyrifos yielded the highest average exceeded concentration in both 2008 and 2010. The average concentration of exceeded chlorpyrifos residue detected in 2008 was higher than that in 2010. The other residues that exceeded the MRL were t-endosulfan and deltamethrin in 2008, and malathion in 2010. Pesticide residues were also exceeded in the study of Latif et. al. (2011) in cauliflower, green chilli, eggplant, tomato, peas, bitter gourd, spinach, and apple gourd in Pakistan. In Brazil, carbendazim and chlorpyrifos residues in apple, papaya, sweet pepper, and strawberry (Jardim and Caldas, 2012) were found. In Northern Greece, chlorpyrifos was the most frequently detected insecticide in peaches (Caldas et al., 2011).

In regard the type and the amount of pesticides detected, this can be linked to the change of targets among commodity producers based on the increase in the demand for these products.

Table 2. Comparison of Consumer's Pesticide Exposure to the Allowable Daily Intake of Each Pesticide Residues in 2009.

Commodity	Pesticide Residue Reading (mg/kg)	MRL		Evaluation	Exposure* (mg/kg bw/day)	ADI ** (mg/kg bw/day)	Hazard Risk
		CODEX	EU				
strawberry	Chlorpyrifos 0.07	0.3ppm	-	Within MRL	1.00	0.01	No
	T-endosulfan 0.01	-	0.01ppm	Within MRL	0.14	0.006	No
pechay	Cypermethrin 0.32	-	1.0ppm	Within MRL	4.59	0.05	No
beans	Cypermethrin 0.04	0.7 ppm	0.7ppm	Within MRL	0.57	0.05	No
cabbage	Profenofos 1.00	-	0.01ppm	Exceeded MRL	14.34	0.03	Yes
celery	Chlorpyrifos 0.95	-	0.01ppm	Exceeded MRL	13.62	0.01	Yes
	Deltamethrin 0.09	-	0.05ppm	Exceeded MRL	1.29	0.01	Yes
	Cyhalothrin 0.07	-	0.3ppm	Within MRL	1.00	0.005	No
	T-endosulfan 0.73	-	0.05ppm	ExceededMRL	10.47	0.006	Yes
carrot	Chlorpyrifos 0.06	0.1 ppm	0.1ppm	Within MRL	0.86	0.01	No

A general default MRL of 0.01 mg/kg applies where a pesticide is not specifically mentioned.
http://ec.europa.eu/food/plant/pesticides/max_residue_levels/eu_rules_en.htm
Source: http://www.codexalimentarius.net/pestres/data/index.html?lang=en
http://ec.europa.eu/sanco_pesticides/public/?event=substance.selection&ch=1
*Exposure (mg/kg b.w./day)=Consumption (mg/kg b.w./day)×Residue (mg/kg)
Food Consumption= 239g/day
Average body weight=60kg
**Acceptable Daily Intake (ADI) was based on EU Pesticides Database

Table 3. Comparison of Consumer's Pesticide Exposure to the Allowable Daily Intake of Each Pesticide Residues in 2010.

Commodity	Pesticide Residue Reading (mg/kg)	MRL		Evaluation	Exposure* (mg/kg bw/day)	ADI ** mg/kg bw/day)	Hazard Risk
		CODEX	EU				
Broccoli	Chlorpyrifos (0.40)	2 ppm	0.05ppm	Exceeded (EU)	5.74	0.01	YES
	Cypermethrin (0.24)	-	1.0ppm	Within MRL	3.44	0.05	YES
Chrysanthemum	Chlorpyrifos (0.65)	-	0.01ppm	Exceeded	9.32	0.01	YES
	Malathion (0.04)	-	0.01ppm	Exceeded	0.57	0.03	YES
Strawberry	Chlorpyrifos (0.07)	0.3ppm	-	Within MRL	1.00	0.01	YES

A general default MRL of 0.01 mg/kg applies where a pesticide is not specifically mentioned.
http://ec.europa.eu/food/plant/pesticides/max_residue_levels/eu_rules_en.htm
Source: http://www.codexalimentarius.net/pestres/data/index.html?lang=en
http://ec.europa.eu/sanco_pesticides/public/?event=substance.selection&ch=1
*Exposure (mg/kg b.w./day)=Consumption (mg/kg b.w./day)×Residue (mg/kg)
Food Consumption= 239g/day
Average body weight=60kg
**Acceptable Daily Intake (ADI) was based on EU Pesticides Database

3.3. Measuring Consumer's Health Risk

Tables 2 and 3 compare the exposure of the consumers to the allowable daily intake (ADI) of each detected pesticide residue. As shown below, all the residues posed risk to consumer's health in both 2008 and 2010 sampling periods.

One significant aspect in the process of analyzing the impact of pesticide residue to human health is to estimate the risk associated with dietary intakes of pesticide residues by the consumer. The detected residues are compared to the maximum residue level. If residues are found to exceed the maximum residue level, it is necessary to compare this level to the acceptable daily intake and the theoretical maximum daily intakes to assess the consumer's risk (Nasreddine and Parent-Massin, 2002).

As shown in the data in Tables 2 and 3, the residues detected posed risk to consumer's health. In the study of Bhanti and Taneja (2007) on health risk analysis associated with pesticide residues, it was found that methyl parathion posed risk to human health while chlorpyrifos and malathion did not. In another study, the fruit diet of infants and children were found to exceed the allowable concentration for carbaryl, diazinon, and methidathion in apple, strawberry, and orange (Gebara et al., 2011). In China, the pesticide residues that exceeded the MRL in market vegetables were omethoate, phorate, chlorpyrifos, methidathion, and ethoprophos (Wang et al., 2013). In Colombia, acephate was found in tomatoes and it exceeded the recommended MRL (Bojaca et al., 2011).

4. Conclusion

The study showed that pesticide residues were found in the agricultural soils and vegetable crops in Benguet, Philippines in both 2008 and 2010 sampling periods. Certain residues exceeded the maximum residue level and this signifies that there is risk to the environment and the human health. The study also analyzed the link between pesticide residues in vegetable crops and the acceptable daily intake of consumers. It is recommended that pesticide residue monitoring will be carried out continuously in this province, It is significant to conduct educational programs for farmers on the control and safer use of pesticides. Regulatory policies on pesticides should also be done to protect farmers' and consumers' health.

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