Research article

Risk Assessment of Pesticide Residues in Organic Waste in Northeast Thailand

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Abstract The objective of this study aims to monitor pesticide residues in organic waste in Northeast Thailand. Pesticides are widely used in agriculture and trade of agricultural products to increase agricultural yield and to protect plants from diseases, weeds and insect damage. The increasing use of pesticides has significantly increased crop contamination and human health hazard. On the Thai markets, fruit and vegetables have high risk for pesticide contamination. Uneatable and unusable parts of these goods transform to a fraction of organic waste. The quantity of waste in terms of solid waste from Northeast Thailand was 11,820 tons/day and over 50% was organic waste. Composting (such as compost, biological fermentation fertilizer) and animal feed are conventional methods to manage waste from vegetables and fruit in Northeast Thailand. However, the risk assessment of pesticide residue in organic waste should be studied and taken into consideration for environmental safety and human health. A total of 22 pesticides from different chemical groups (organochlorine, organophosphate and pyrethroid) in the different organic wastes collected from the markets in Khon Kaen provinces, in the Northeast of Thailand, were monitored in the rainy and winter season in the year 2010 by gas chromatography with electron capture detector (ECD) and flame photometric detector (FPD). Pesticide residues were found in organic waste. The most frequently found pesticides were cypermethrin followed by chlorpyrifos deltametrhrin and lambda-cyhalothrin, respectively ranging from 0.044 to 2.608 mg kg^{-1}. Pesticide residue in organic waste was found to be higher in the winter season than in the rainy season. Pesticide residue was found higher in cabbages followed by kale, lettuce and corn peel, respectively. Therefore, a monitoring program for pesticide residues and a risk assessment study in organic waste are needed for protection of human's health and the environment.

Keywords organic waste, biological waste, pesticide, pesticide residues, Northeast Thailand

INTRODUCTION

Thailand is an agricultural country where agriculture is a very important part of the economy. Thailand expanded exports of agricultural products and also imports fertilizers and pesticides intensively. Pesticides are used widely in agriculture and trade of agricultural products to increase agricultural yield and to protect plant from diseases, weeds and insect damage (Department of Agricultural, 2010). The result from increasing pesticides uses has resulted in significant increased crop contamination and human health hazard (Office of Epidemiological, 2009). The risk of pesticide contamination in fruits and vegetables in Thai market often occurs. Pesticide residues in agricultural products such as vegetables and fruit were studied in Northeast Thailand (Table 1) (Office of Agricultural Research and Development Region 3, 2010; Office of Agricultural Research and Development Region 4, 2010). Uneatable and unusable parts of agricultural products transform to a fraction of organic waste. The quantity of waste in term of solid waste from

Northeast Thailand was 11,820 tons/day and over 50% was organic waste. Solid waste in Khon Kaen province occurred about 800 tons/day (Pollution Control Department, 2010).

As agricultural production is vast worldwide, the increasing of waste and its adverse effects on the environment are of great concern. Waste management takes an important role for maintaining a sustainable environment. The organic waste management has been done in three main ways: 1) organic waste can be used for soil improvement, 2) animal feeding, and 3) alternative source of energy (biogas) (Lardinois and Klundert, 1993; Pollution Control Department, 2009). Composting (such as compost, biological fermentation fertilizer) and animal feed are the conventional methods to manage waste from organic waste in Northeast Thailand.

Composting is an important waste management strategy in Europe. The end product, compost, can be used as soil conditioner and fertilizer, thereby recycling nutrients back to agriculture and horticulture. However, compost may contain a wide range of organic pollutants (Kupper et al., 2008).

Therefore, using compost may be a case a hidden input of pesticides into the environment. Once incorporated into the soil the fate of pesticides is not fully clear (Taube, et al., 2002; Hart and Pluimers, 1996). The concern about the pollutants in the organic waste in Thailand has been increasing. However, most studies have dealt with the heavy metals contamination in the waste but less research has been done on pesticides. Therefore, the risk assessment of pesticide residues in organic waste were studied by monitoring pesticide residues in organic waste from the markets in Khon Kaen province in two seasons (rainy and winter season).

Table 1 Pesticide residues in vegetables and fruit in Northeast Thailand in 2009

Region	samples	Pesticide residues found		Pesticides found
		Number of Samples	Over MRL	
Upper Northeast Thailand	1,422	394(27.7%)	31(2.18%)	chlorpyrifos,cypermethrin, ethoprophos,deltamethrin, diazinon,cyfluthrin, lambda-cyhalothrin, methidathion
Lower Northeast Thailand	1,689	605(35.8%)	111(6.6%)	cypermethrin, chlorpyrifos, profenofos, lambda-cyhalothrin, fenvalerate

MRL = Maximum residue limit
Source: Office of Agricultural Research and Development Region 3, (2010)
Office of Agricultural Research and Development Region 4, (2010)

MATERIALS AND METHODS

Chemicals

Hexane, ethyl acetate and acetonitrile (PR grade), sodium chloride (analytical grade), magnesium sulfate anhydrous, primary secondary amine (PSA) and 1% acetic acid in acetonitrile were used for the pesticide extraction process.

Sample collection

The selection of the samples was based on the typical composition of organic waste. The samples chosen for analysis should match the fractions presenting a high percentage of the total organic waste. The samples were collected from three main markets in Khon Kaen province, Northeast Thailand in the rainy and winter season in 2010. Altogether, 3 samples of organic waste from each market and 4 samples of organic waste based on the typical composition of organic waste (cabbages, lettuce, kale and peel corn) were analyzed in three replicates by using the QuEChERS method (Anastassiades, et al., 2003).

Extraction and clean up

To prepare the samples, 15 g of a previously homogenized food material sample was transferred into a suitable vessel and filled with fifteen milliliters of acetonitrile. The vessels were capped before mixing on a Vortex mixer for 1 min at optimum speed. Once the initial sample mixing was completed, 1 g NaCl and 4 g anhydrous $MgSO_4$ were added and immediately mixed on a Vortex mixer for 1 min. To separate the phases, the samples were centrifuged for 5 min at 4000 rpm. Using an adjustable repeating pipette, 6.0 ml aliquot of upper acetonitrile layer was transferred into a 15 ml centrifuge tube containing 900 mg anhydrous $MgSO_4$ and 150 mg PSA sorbent. The centrifuge tube was tightly capped and shaken on a Vortex mixer for 1 min before the extracts (or the batch of extracts) were centrifuged for 5 min at 4000 rpm to separate the solids from the solution. The solution was then transferred into a vial for Gas Chromatograph (GC) analysis.

Pesticide residues analysis

The samples were analyzed for 22 pesticides from different chemical groups (organochlorine, organophosphate and pyrethroid) using GC multi-methods with ECD and FPD detection. Organophosphorus group were chlorpyrifos, diazinon, dicrotophos, dimethoate, ethoprophos, fenitrothion, malathion, methamidophos, methidathion, mevinphos, monocrotophos, parathion-methyl, pirimiphos-methyl, prothiophos, triazophos. For organochlorine group were ∝-endosulfan, β-endosulfan, endosulfan sulfate and pyrethroid group are lambda-cyhalothrin, cypermethrin, deltamethrin, fenvalerate, permethrin, cyfluthrin. GC-ECD used capillary column HP-5 5% Phenyl Methyl Siloxane (30m x 0.25mm ID, 0.25 μm flim thickness) with helium (2.0 ml min^{-1}) carrier gas, splitless injection and used electron capture detector (ECD) for organochlorine group and Pyrethroid group. GC-FPD used capillary column DB1701 (30m x 0.32mm ID, 0.25 μm flim thickness) helium (1.9 ml min^{-1}) carrier gas, splitless injection and used flame photometric detector (FPD) for organophosphorus group.

RESULTS

The analyses revealed that most of the samples contained pesticide. Residues were found in 100% of the samples from mixed organic waste (Table 2) in three markets. Pesticide residues (mg kg^{-1}) were found in the different kinds of organic waste collected in Khon Kaen province (Table 3). Pesticide residue in organic waste was found to be higher in the winter season than in the rainy season. The most frequently found pesticides were cypermethrin followed by chlorpyrifos, deltametrhrin and lambda-cyhalothrin, respectively ranging from 0.044 to 2.608 mg kg^{-1}. Most pesticides were recovered in the range of 70% – 110% with relative standard deviation (RSD) usually less than 10%.

Table 2 Pesticide residues (mg kg^{-1}) found in organic waste collected in Khon Kaen province

Markets	Rainy				Winter			
	Pesticide (mg kg^{-1})	$\bar{x}$	SD	%RSD	Pesticide (mg kg^{-1})	$\bar{x}$	SD	%RSD
Banglumphu	cypermethrin	0.044	0.003	7.329	cypermethrin	0.086	0.003	3.076
	lambda - cyhalothrin	0.054	0.004	7.955	chlorpyrifos	0.077	0.003	4.193
					deltamethrin	0.281	0.020	7.183
O-Jira	cypermethrin	0.050	0.004	8.075	cypermethrin	2.608	0.018	0.678
					chlorpyrifos	1.066	0.069	6.507
					deltamethrin	0.736	0.028	3.832
Srimuangthong	cypermethrin	0.072	0.007	9.130	cypermethrin	1.667	0.045	2.716
					chlorpyrifos	0.742	0.042	5.629
					deltamethrin	0.761	0.060	7.898

$\bar{x}$ = Average, SD = Standard deviation, %RSD = Repeatability

Table 3 Pesticide residues (mg kg^{-1}) found in the different kinds of organic waste collected in Khon Kaen province

Organic waste	Rainy				Winter			
	Pesticide (mg kg^{-1})	$\bar{x}$	SD	%RSD	Pesticide (mg kg^{-1})	$\bar{x}$	SD	%RSD
cabbages	cypermethrin	0.059	0.005	7.685	cypermethrin	0.586	0.022	3.762
					chlorpyrifos	1.926	0.036	1.872
					deltamethrin	0.460	0.020	4.367
kale	cypermethrin	0.050	0.002	4.323	cypermethrin	1.415	0.035	2.498
	lambda - cyhalothrin	0.079	0.006	7.804	chlorpyrifos	0.129	0.002	1.187
					deltamethrin	1.297	0.082	6.329
lettuce	ND				cypermethrin	0.096	0.008	7.791
					deltamethrin	0.269	0.019	6.895
peel corn	ND				cypermethrin	0.075	0.004	4.807
					chlorpyrifos	0.102	0.004	3.922
					deltamethrin	0.148	0.006	3.833

ND = Less than limit of detection, $\bar{x}$ *= Average, SD = Standard deviation, %RSD = Repeatability*

Table 4 The maximum residue limits (MRL) of pyrethroids and organophosphorous pesticides in vegetables

Pesticides	Vegetables	MRL (mg kg^{-1})
cypermethrin	cabbages	1.00*
	corn	0.05*
	leafy vegetables	0.70*
lambda -cyhalothrin	cabbages	0.30**
deltamethrin	cabbages	0.10*
	corn	1.00*
	lettuce, kale	0.50*
	leafy vegetables	2.00**
chlorpyrifos	cabbages	1.00**
	sweet Corn	0.01**

**ACFS, Ministry of Agriculture and Cooperatives (2008)*
*** FAO/WHO (2010)*

CONCLUSION

The results from this study give information about the pesticide residues of the organic waste. Biological waste contains a variety of pesticides and some of them were higher than the MRL. In the composting process of organic waste, pesticides might be degraded or mineralized. However, they might also be persistent to biological degradation and still occur in the process. Although pesticide residues analyses in organic wastes are not legally required, a hidden and uncontrolled input of pesticides to the soil environment might take place. Generally, organic waste products are considered environmental friendly as they are one of the waste management solutions. However, persistent pesticides introduced into this agricultural system might appear in the product and affect human health. Therefore, a monitoring program for pesticide residues and a risk assessment study in organic waste are needed for protection of human's health and the environment.

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