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Adsorption, desorption and mobility of cyfluthrin in three Malaysian tropical soils of different textures

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Abstract

The sorption and desorption of cyfluthrin mixture isomers were determined using batch equilibration method and mobility was studied under laboratory conditions, using packed soil column. The soil types used in the study were clayey, clay loam and sandy clay loam obtained from three tomato farms in Cameron Highlands. A low Freundlich adsorption distribution coefficient $K_{ads(f)}$ for cyfluthrin was observed for clayey, clay loam and sandy clay loam soils (95.69, 21.64 and 8.99 l/kg, respectively). Results showed that cyfluthrin had high Freundlich organic matter (OM) distribution coefficient K_{oc} values of 5799, 2278 and 1635 lkg^{-1} for clayey, clay loam and sandy clay loam soils, respectively. These values indicate that cyfluthrin is considered immobile in Malaysian soils with different textures, based on the value of K_{oc} by McCall. Adsorption of cyfluthrin was significantly (P< 0.05) affected with soil pH, fertilizer NPK, organic matter content and temperature. It was observed that approximately 95.8%, 93.8% and 91.8% of the adsorbed cyfluthrin remained sorbed after four successive rinses for clayey, clay loam and sandy clay loam soils. Soil column test showed that cyfluthrin was not detected in leachate. Cyfluthrin was detected in topsoil and its concentration decreased with depth. The downward movement of cyfluthrin in sandy clay loam soil was more than that in clay loam and clayey soils. Approximately, 80.9%, 77.8% and 67.3% cyfluthrin was observed at the depth of 0-5 cm (rainfall 350 mm) for clayey, clay loam and sandy clay loam soils respectively. Mobility of cyfluthrin showed that the percentage of cyfluthrin leached into soil was not affected by the amount of rainfall. The result clearly showed that cyfluthrin molecules were bound strongly to all the three Malaysian soil types.

Key words

Cyfluthrin mobility, Freundlich equation, Leaching, Packed soil column, Solid phase extraction.

Introduction

Synthethic pyrethroids are currently being used more commonly in agricultural production due to their selective insecticidal activity, effectiveness at low doses, non-persistence in environment, rapid biodegradation and low mammalian toxicity (Lopez *et al*., 2001; Vázquez *et al*., 2008). Cyfluthrin [(R)-cyano-[4-fluoro-3-(phenoxy)phenyl]methyl] (1R,3R)-3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropane-1-carboxylate is a non-systemic, synthetic pyrethroid, that is widely used to control various types of insects in agricultural farms. This insecticide is degraded biotically and abiotically through hydrolysis and photodegradation processes or adsorbed at soil surface depending on the physical and chemical characteristics of pesticide and soil, especially soil pH, cation-exchange capacity (CEC), type and content of clay and organic carbon content in soil (Gupta and Gajbbhiye, 2002; Saikia *et al*., 2005; Choo *et al*., 2013).

Sorption is used to describe the process of pesticide partitioning between water solution and soil (Yazgan *et al*., 2005). The sorption rate affects movement and degradation processes of pesticide, e.g. volatilization to atmosphere, leaching into ground water, movement by runoff water and bioaccumulation in soil environment (Coquet, 2003; Ismail and Ooi, 2012). pH of soils can affect sorption of organic molecules by influencing ionization of organic molecules as well as by affecting accessibility of different organic functional groups (Mehdi *et al*., 2011). Pesticide sorption is an exothermic process whereby the sorption rate decreased with increasing temperature and thus, caused increase in the desorption process. Pesticide sorption is higher in soils with high organic matter or clay content as soil colloids provide a wide surface area for the binding molecules. Water solubility is an important criterion for evaluating the mobility of compounds. The solubility of cyfluthrin in water is 2.0 μgl^{-1} and it is immobile in the environment. Mobility out of the treated soil creates the potential to shorten the effective life of the product and could result in environmental contamination (Peterson, 2007). The rate and magnitude of rapid transport seem to be influenced by multiple factors, including not only the pesticide properties, but also soil properties (structure, organic matter, clay content, iron oxides, etc.), soil hydrological processes and management (e.g., time of application) (Estevez *et al*., 2008). Knowledge of the pesticide's adsorption–desorption characteristics in soil is necessary for predicting its mobility and fate in soil environments (Kumar and Philip, 2006). Several studies have shown relationship between soil properties and mobility of pesticides (Abdullah *et al*., 2001; Cespedes *et al*., 2002; Li *et al*., 2005; Peterson, 2007; Shao-nan *et al*., 2007). However, only limited studies have been conducted on adsorption, desorption and mobility of cyfluthrin in tropical soils. Therefore, the present study aimed at providing a better understanding of the sorption and movement of cyfluthrin in tropical soils. The study aimed to analyze adsorption, desorption and mobility of cyfluthrin in three Malaysian soil types of different texture, under laboratory conditions. Besides, an attempt was made to understand the effect of soil pH, fertilizer (NPK), temperature and organic matter content on adsorption of cyfluthrin and leaching potential of cyfluthrin in tropical soils.

Materials and Methods

Soil samples: Three different types of cyfluthrin free soils were collected (0-15 cm depth) from three different tomato farms located in Cameron Highlands, Pahang. Soil samples were analysed by Gas chromatography and it was found that no residue of cyfluthrin was detected. Soil samples collected were initially air-dried at room temperature and sieved through 2-mm mesh prior to analysis and classification at the Soil Testing Laboratory of the School of Environmental and Natural Resource Sciences, University Kebangsaan Malaysia (UKM).

Determination of adsorption equilibrium time: Sub soil samples of each soil type (2gm) were weighed and placed into 27 centrifuge tubes (in triplicate). An analytical grade of cyfluthrin mixture of isomers (purity 98.3%) was obtained from Sigma-Aldrich (Germany). 10 ml of cyfluthrin solution was added to each tube, followed by mixing and shaking using a reciprocate shaker (set at 150 rpm and at a constant temperature of 30 ºC) for intervals of 10, 30 mins and 1, 2, 4, 6, 10, 14 and 24 hrs. After each interval, the tubes were removed and centrifuged (@ 3000 rpm, 20 mins). Subsequently, 5 ml of supernatant from each tube was transferred into 250 ml Schott bottles and the contents were made up to 200 ml with distilled water. They were then mixed and shaken for 1 min and the samples were placed in an ultrasonic bath for 15 mins, pH was adjusted to pH 4.0 with 2M HCl. The SPE cartridges (containing 200 mg of sorbent were obtained from International Sorbent Technology (IST), MidGlamorgan UK) used were attached to the manifold that was pre-conditioned with 3 ml acetonitrile, 3 ml methanol and 5 ml distilled water. SPE tubing was immersed separately into each mixture and the aqueous sample was then passed through ENV^+ cartridge at a rate of 4 $mlmin^{-1}$. Each cartridge was then dried under vacuum for 30 mins. The absorbed cyfluthrin was eluted with 6 ml ethylacetate:acetone (1:1 v/v). Finally, the eluent was evaporated to dryness under vacuum and redissolved in 1 ml acetone prior to GC analysis.

Determination of desorption equilibrium time: Samples of cyfluthrin solution (10 ml) were poured into tubes, each containing 2 g of soil. A procedure similar to that used in the determination of adsorption equilibration time was followed. At the end of centrifugation, the remaining supernatant was discarded and replaced with 0.01 M $CaCl_2$ solution (10 ml). Tubes were shaken on a reciprocate shaker (30°C, 150 rpm) at intervals of 10, 30 mins, 1, 2, 4, 6, 10, 16 and 24 hours. The tubes (in triplicates) were taken out at completion of each interval and centrifuged. An aliquot solution (5 ml) from each tube was then subjected to solid-phase extraction as described above. All the treatments were carried out in triplicates.

Effect of concentration on adsorption*:* A series of cyfluthrin solution at 0.05, 0.1, 0.5 and 1.0 μgml^{-1} concentration was prepared in triplicates. Ten ml of the standard solution of different concentrations were added to centrifuge tubes containing 2 g of dry clayey, clay loam and sandy clay loam soils, respectively. Tubes were shaken on a reciprocating shaker at equilibrium time (as determined by the time obtained in a previous study for the three different soil types). Temperature and velocity were set at 30°C and 240 rpm, respectively. The next process was centrifugation at 3000 rpm for 20 mins. Five ml of the supernatant from each of the centrifuge tubes was then subjected to solid-phase extraction.

The sorption isotherms were determined using Freundlich equation. The sorption coefficients ($K_{ads(f)}$ values) were obtained using Freundlich equation from the ratio of adsorbed concentration to the equilibrium concentration of the solution. Difference in the amount of cyfluthrin from initial concentration versus the amount in the supernatant of the samples was considered to be the amount adsorbed. The pesticide sorption isotherm was calculated using Freundlich equation (Ismail *et al.*, 2013).

Effect of pH on adsorption: Ten ml of the standard solution (1.0 µg/ml) was added into each of the centrifuge tubes containing 2 g of dry soil. The pH of solution was adjusted to pH 3, 7 and 10 with HCl and NaOH to determine the effect of pH on adsorption. Then, the samples containing cyfluthrin were shaken at 30 °C and 150 rpm, followed by solid-phase extraction (three replicates per treatment).

Effect of temperature on adsorption: The effect of temperature on adsorption was carried out using 1.0 μgml^{-1} of cyfluthrin and incubation temperature level of 25°C, 30°C and 35°C. Each treatment was done in triplicates. An aliquot solution (5 ml) was then subjected to solid-phase extraction.

Effect of compound fertilizer (NPK) on adsorption: The effect of compound fertilizer NPK on the adsorption of cyfluthrin was determined by adding 10 ml of cyfluthrin solution of concentration 1.0 μgml^{-1} (in triplicates) into centrifuge tubes containing 2 g of dry soil and the compound fertilizer NPK (1:2:1). An aliquot solution (5 ml) was extracted using solid-phase extraction.

Desorption study: A known volume of the supernatant used in the adsorption study was discarded and replaced with 10 ml of calcium chloride solution (0.01 M). Centrifuge tube was shaken and centrifuged. Then, 5 ml of the supernatant was subjected to the extraction process as described above, prior to GC analysis. This process was repeated three times.

Mobility study: Polyvinyl chloride tubes, 8.5 cm in diameter, were cut into several pieces of 5 cm length and then reassembled into one column of 20 cm length. The bottom ring of the column was covered with a plastic mesh. Each column was packed with untreated clayey, clay loam and sandy clay loam soils to a depth of 20 cm and supported vertically by a custom-made wooden rack. The soil surface in each column was covered with a single sheet of Whatman No. 3 filter paper. The top of the columns were covered with aluminium foil to minimize evaporative losses. Conical flasks (250 ml) fitted with glass funnels were placed at the bottom of each column to collect the leachate. The columns were saturated with distilled water to settle the soil and minimize compaction and then left to drain for 48 hrs. Once the soil columns had settled, a 1 cm thick layer of the soil treated with 1.0 lha^{-1} of cyfluthrin (recommended dosage for the field) was placed on top of each soil column. The soil column was watered with 150 ml, 250 ml and 350 ml water (simulating 140.3, 233.8 and 348.7 mm of minimum, medium and maximum rainfall respectively, recorded in the Cameron Highlands, according to the year 2010 rainfall records of the Malaysian Meteorological Department). After 48 hrs, each column was separated into 5 cm segments (0-5cm, 5-10cm, 10-15cm and 15-20 cm) and then the leachate was collected. Distribution of cyfluthrin in each of the 5 cm soil segments was analysed. Experiment was replicated thrice.

Two gram of dry soil from each segment were weighed and inserted into a centrifuge tube. Then, 20 ml acetone: water (1:9 v/v) solution was added into the tube and shaken at 150 rpm and at a constant temperature of 30ºC for 60 min. Tubes (in triplicates) were taken out of the reciprocating shaker and centrifuged at 3000 rpm for 20 min. Subsequently, supernatant from samples was transferred into 250 ml Schott bottles. Distilled water was added to make up the contents to 200 ml, mixed and shaken for 1 min. pH was adjusted to 4.0 with 2M HCl and the bottles were placed on an ultrasonic bath for 5 min. Then, the samples were subjected to solid-phase extraction as described above.

Analysis of cyfluthrin: The extracted residues of cyfluthrin were analyzed using the Hewlett-Packard model 6890 Series II Gas Chromatograph, fitted with a micro electron-capture detector (-ECD), manual injector for HP-5 Crosslinked 5% Phenyl Methyl Siloxane column (30.0 m 0.25 mm I.D 0.25 m film thickness) (Hewlett-Packard, Waldbronn, Germany). The operating temperatures were: detector 310ºC, injector port 250ºC, with the oven programmed initially at 100ºC isotherm for 1.5 mins followed by the temperature being increased to 290ºC at the rate of 20ºCmin^{-1}, maintained for 4 min. The flow rate of the carrier gas (N_2, 99%) was set at 1 mlmin^{-1}. The volume of injection was 1 μl in the splitless mode. There were three replicates and each solution was injected twice. The calibration curve of cyfluthrin was obtained using standard cyfluthrin concentrations ranging from 0.01μgml^{-1} to 5.0 μgml^{-1}.

Results and Discussion

Preliminary studies showed that cyfluthrin achieved equilibrium in 6 hrs for clay loam and sandy clay loam soils and 16 hrs for clayey soil. This result was used in the investigation on adsorption characteristics. For many pesticides, adsorption in soil reached equilibrium within 24 hrs (Uchimiya *et al.*, 2012).

Table 1: Freundlich parameters for cyfluthrin sorption in the studied soils

Parameter(Lkg^{-1})^{a}	**Clayey**	**Clay loam**	**Sandy clay loam**
$K_{ads(f)}$	95.69	21.64	8.99
1/n	1.98	1.62	1.39
K_{oc}	5799.39	2277.89	1634.55
r^2	0.9627	0.9925	0.9874
K_{des1}	33.74	21.83	16.83
K_{des2}	41.71	35.28	32.87
K_{des3}	NA	156.02	69.32
K_{des4}	NA	NA	NA

[a] Except for 1/n; *NA-Not available as desorption did not occur.

^{a}Except for 1/n; *NA-Not available as desorption did not occur.

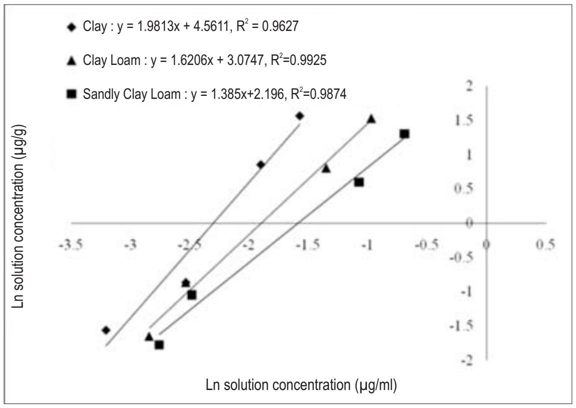

Fig. 1: Freundlich adsorption isotherm of cyfluthrin in clayey, clay loam and sandy clay loam soil

The amount of cyfluthrin at different concentration levels, adsorbed to the sandy clay loam, clay loam and clayey soils are shown in Table 2. The amount of cyfluthrin adsorbed onto the clayey soil were 0.21, 0.42, 2.35 and concentrations 4.79 µgg^{-1} for 0.05, 0.1, 0.5 and 1 µgml^{-1} concentrations respectively. The amount of cyfluthrin adsorbed onto the clay loam and sandy clay loam were 0.19, 0.42, 2.24, 4.62 µgg^{-1} and 0.19, 0.40, 2.16 and 4.50 µgg^{-1} for the above respective concentrations. The soil sorption coefficient (K_f) was used to describe the binding strength of cyfluthrin to soil. Adsorption of cyfluthrin to sandy clay loam (r^2=0.99), clay loam (r^2=0.99) and clayey (r^2=0.96) soils was found to follow the Freundlich adsorption isotherm (Fig. 1). Table 1 shows Freundlich constants, $K_{ads(f)}$ and the slope, 1/n. The $K_{ads(f)}$ values decreased in the same order as soil OM content: clayey > clay loam > sandy clay loam. The 1/n values, which are the values for the slope of the line, were more than unity (<1.0) for the three Malaysian soil types. This suggests increased adsorption of the chemicals with increasing solution concentration. Sorption equilibrium has also been found to be influenced by sorbent concentration (Zhang *et al*., 2011). The statistical analysis of variance (ANOVA) confirmed that the amount of cyfluthrin adsorbed onto the sandy clay loam, clay loam and clayey soil was significantly (P< 0.05) affected by different concentrations of cyfluthrin solution in all the three soil types tested. K_{oc} is defined as distribution coefficient (K_d) for a particular soil/pesticide combination divided by the organic carbon content of soil. The K_{oc} value indicates that soil organic matter content affected cyfluthrin sorption. High K_{oc} value observed for the three soil types suggested high adsorption of cyfluthrin to soil particles. The results showed that adsorption onto the clayey soil was stronger (K_{oc} 5799 l/kg) than that onto the clay loam and sandy clay loam soils, probably due to higher organic matter content (1.65 %). Cyfluthrin was classified as having low mobility capabilities (K_{oc} 500-5000) with the values of 1635, 2278 and 5799 lkg^{-1} for sandy clay loam, clay loam and clayey soils, respectively, according to the classification of pesticide mobility in soil based on the value of K_{oc} by Donia *et al*. (2011). In most cases, OM and CEC of the soil played a dominant role in sorption and desorption. Similar studies undertaken revealed that the K_{oc} values for cyfluthrin ranged from 56,000 to 300,000 lkg^{-1} for American soils (Koskinen *et al*., 2006). Difference in the results of the current study and that of Koskinen *et al*. (2006) is probably due to the differences in soil properties and climatic conditions.

The study on the effect of temperature on the adsorption of cyfluthrin to sandy clay loam, clay loam and clayey soils was carried out at temperature levels of 25°C, 30°C and 35°C. Results showed that adsorption of cyfluthrin to soil decreased by 11.27%, 9.46% and 5.12 % for clay, clay loam and sandy clay loam soils respectively as temperature was increased from 25°C to 35°C. The reason for this behaviour is that elevated temperatures can enhance cyfluthrin solubility and sorption process is an exothermic reaction, mainly of physical type (Uchimiya *et al*., 2011). The results showed that the total amount of cyfluthrin adsorbed onto the sandy clay loam, clay loam and clayey soils was affected significantly (P < 0.05) by temperature. These observations are similar to other findings (Lifeng *et al*., 2010) where there was apparent effect of temperature on adsorption of pesticides onto soil particles.

Table 2: The amount of adsorption (µg g^{-1}) and the percentage adsorption of cyfluthrin in clayey, clay loam and sandy clay loam soils

Initial amount (µgml^{-1})	Amount adsorbed					
	Clayey		Clay loam		Sandy clay loam	
		(%)		(%)		(%)
0.05	0.21^{a} (±0.013)	83.80	0.19^{a} (±0.004)	76.66	0.19^{a} (±0.009)	74.66
0.10	0.42^{b} (±0.007)	84.11	0.42^{b} (±0.020)	83.12	0.40^{b} (±0.010)	79.48
0.50	2.35^{c} (±0.043)	94.02	2.24^{c} (±0.030)	89.66	2.16^{c} (±0.023)	86.36
1.00	4.79^{d} (±0.035)	95.85	4.62^{d} (±0.151)	92.44	4.50^{d} (±0.054)	89.99

^{a*} Means in the same column with same letter are not significantly different using Tukey'sstudentized range (HSD) test (0.05 probability level).

Table 3: Desorption of cyfluthrin onto clayey, clay loam and sandy clay loam soils

Desorption stage	Clayey		Clay loam		Sandy clay loam	
	Desorbed (μg g^{-1})	Amount desorbed (%)	Desorbed (μg g^{-1})	Amount desorbed (%)	Desorbed (μg g^{-1})	Amount desorbed (%)
1	0.12	2.5	0.18	3.9	0.24	5.3
2	0.08	1.7	0.09	1.9	0.09	2.0
3	0.00	0.0	0.02	0.4	0.04	0.9
4	0.00	0.0	0.00	0.0	0.00	0.0
Total desorbed	0.20	4.2	0.29	6.2	0.37	8.2

Table 4: Mobility of cyfluthrin in clay, clay loam and sandy clay loam soil

Soil Type	Simulated rain fall(mm)	Residue concentration (%)				
		Depth of column(cm)				
		0-5	5-10	10-15	15-20	Leachate
Clay	150	82.89	5.17	ND	ND	ND
	250	85.07	9.88	ND	ND	ND
	350	86.00	16.04	ND	ND	ND
Clay loam	150	87.06	5.30	ND	ND	ND
	250	85.12	12.93	ND	ND	ND
	350	83.11	24.17	ND	ND	ND
Sandy clay loam	150	80.00	9.98	ND	ND	ND
	250	78.19	18.78	ND	ND	ND
	350	73.98	28.90	ND	ND	ND

*ND=Not Detected

The effect of pH on adsorption of cyfluthrin on to sandy clay loam, clay loam and clayey soil was investigated at three pH values of 3, 7 and 10. It was observed that adsorption of cyfluthrin was higher at low pH for the three soil types. At pH 3, the amount of cyfluthrin adsorbed onto the clayey, clay loam and sandy clay loam soils was 4.82, 4.51 and 4.25 μgg^{-1} respectively. The results showed that the total amount of cyfluthrin adsorbed onto the sandy clay loam, clay loam and clayey soils were affected significantly ($P < 0.05$) by pH. Numerous laboratory studies have established that the effect of soil pH on the sorption of weakly acidic pesticides (Boivin *et al.*, 2005; Lifeng *et al.*, 2010). Sorption of the ionized form would be stronger than the neutral form due to repulsion between electro-negative charges of the soil constituents and those of the ionized molecules (Boivin *et al.*, 2005).

The results showed that with addition of fertilizer (NPK), the adsorption of cyfluthrin onto the clayey, clay loam and sandy clay loam soils decreased due to the competition caused by additional generation of ions associated with fertilizer treatment. The adsorption of cyfluthrin decreased to 78.0%, 70.3% and 63.5 % for clayey, clay loam and sandy clay loam soils, respectively. The results showed that the total amount of cyfluthrin adsorbed onto the three soil types was affected significantly ($P < 0.05$) by addition of compound fertilizer (NPK).

Mobility of a compound in soil can be assessed from desorption studies. Table 3 shows desorption of the adsorbed cyfluthrin from clayey, clay loam and sandy clay loam soils after four successive desorption processes. Desorption of cyfluthrin from three Malaysian soil types of different textures was found to follow Freundlich desorption isotherm (r^2=0.96-0.99). The 1/n of the Freundlich desorption equilibrium for three soil types was more than unity (>1.0), which indicated that the desorption percentage was positively correlated with the total cyfluthrin adsorbed. The percentage of cyfluthrin desorbed decreased with increase of desorption steps for all the three tested soil types. Desorption of cyfluthrin from clayey, clay loam and sandy clay loam was not significant, approximately 4.2%, 6.2% and 8.2% respectively were desorbed after four successive rinses. This suggested that there was preferential affinity by cyfluthrin for three soil types of different textures and binding was strong. The percentage of cyfluthrin desorbed from the sandy clay loam soil was higher than that of the clay soil indicating that the binding of cyfluthrin in clay soil was slightly stronger than that in the sandy clay loam soil. K_{des} value was highest in clay soil (33.74 lkg^{-1}) and lowest in the sandy clay loam soil (16.83 lkg^{-1}). Similarly, the K_{oc} value was highest in clay soil (1.65 %), and lowest in sandy clay loam soil (0.55 %). K_{des} values of 33.74, 21.83 and 16.83 lkg^{-1} were obtained after four successive desorption processes from clayey, clay loam and sandy clay loam soils respectively. Therefore, cyfluthrin had low mobility because of its hydrophobic characteristic and low water solubility (2 μgml^{-1}).

Leaching of cyfluthrin in clayey, clay loam and sandy clay loam soils in laboratory was carried out using packed soil column.

It was observed that the total amount of cyfluthrin present in clayey soil (0-5 cm) was 83.3, 82.8 and 80.9% with 150, 250 and 350 mm of simulated rainfall, respectively (Table 4). The total residue of cyfluthrin in clay loam and sandy clay loam soil (0-5 cm) was 83.6%, 81.4%, 77.8% and 79.9%, 75.1%, 67.3% for 150 mm, 250 mm and 350 mm of simulated rainfall respectively (Table 4). The results showed that cyfluthrin was immobile in three Malaysian soil types studied. Cyfluthrin was detected in the topsoil layer, no residue was observed below the depth of 10 cm and none in the leachate. The results of soil column study showed that the downward movement of cyfluthrin in sandy clay loam soil was slightly greater than that in the clay loam and clayey soils and this could be explained with respect to the organic matter content and clay content of soil. Pesticides leach from topsoil deeper into the soil profile, especially in soils with low organic matter content. The downward mobility of the residue in a column might have been enhanced by the looser structure of the repacked soil as compared to the natural state of soils in the field (Ismail and Quirinus, 2000; Ismail and Maznah, 2006). The leaching rate of cyfluthrin in column increased slightly with increasing rate of simulated rain. However, cyfluthrin did not appear in the leachate from the column even under the most arduous conditions of simulated rainfall.

The mobility of pesticides in soil depends on the mechanisms and kinetics of their sorption to and desorption from soil particles (Estevez *et al*., 2008). Low mobility of cyfluthrin in silt soil is correlated to high K_f and K_{oc} values for cyfluthrin. Koskinen *et al*. (2006) showed that the K_{oc} values for cyfluthrin ranged from 56,000 to 300,000 lkg^{-1}. Cyfluthrin is classified as possessing low mobility according to the classification of pesticide mobility in soil based on the value of K_{oc} by Donia *et al*. (2011). Moreover, mobility of a compound in soil can be assessed from desorption studies. The leaching potential of pesticides is greatly influenced by the physico-chemical properties of the compounds, soil components and environmental factors, such as the amount of rainfall (Ismail *et al*., 2004). Analysis of variance confirmed that the amount of cyfluthrin was significantly affected ($P < 0.05$) by K_f and K_{oc} values of three Malaysian soil types tested.

The study showed that sorption of cyfluthrin in soil was significantly influenced by organic matter content, pH, temperature and applied fertilizer (NPK). Adsorption of cyfluthrin was higher at lower pH and temperature levels. Cyfluthrin was found to be more mobile in sandy clay loam soil than in clay loam and clayey soils. Cyfluthrin has low probability of leaching downward or contaminating ground water. However, other factors such as soil characteristics, environmental factors, amount and frequency of rainfall and pesticide application methods are important considerations.

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