



Spatial Distribution of Adsorption Capacity and Persistence of Pesticides in Soils of Cross River Basin Development Authority, Itu, Akwa Ibom State, Nigeria

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ABSTRACT

Pesticides hold a unique position among environmental contaminants due to their high biological activity and toxicity and are capable of harming all forms of life other than the target pest. Movement of pesticide off-site, are capable of contaminating surfaces and groundwater and causing adverse impacts on aquatic ecosystems. Sorption is the crucial phenomenon determining the behaviour of pesticides in the soil environment. Hence spatial distribution of adsorption capacity and persistence of pesticides in soils of Cross River basin development authority, Itu, Akwa Ibom State, Nigeria was evaluated with the aim of assessing the degree of spatial variability of adsorption strength of the soil. A transect was cut across the entire Cross River Basin Development Authority Farm from the north to the south and soil augering was carried out. Base on textural differences, soil colour, consistence and drainage, mapping units were delineated. A total of 10 mapping units were identified in the study area and composite soil samples were collected at five representative points within each mapping unit at a depth of 0-30 cm with the aid of soil auger. A total of 50 soil samples were generated for laboratory analysis. The study revealed that soil mapping units 1, 2, 3, 4 and 5 (poorly drained soils) had high surface area, high sorption capacity and strong bonding between clay and organic compound, high pesticide adsorption coefficient (K_d), higher organic carbon –water partition coefficient (K_{oc}) due to high clay and organic matter content of mapping units than mapping units 6, 7, 8, 9 and 10. The risk of environmental pollution of off-target pesticides is more in soil mapping units 6, 7, 8, 9 and 10 (upland) than soil mapping units 1, 2, 3, 4 and 5 (floodplain).

Keywords: sorption strength, organic carbon – water partition coefficient, organomineral association

INTRODUCTION

The adsorption of pesticides in soil is markedly influenced by the type of soil to which they are applied, and particularly by soil properties such as particle size, mineral and organic content and hydrogen ion concentration (Weber *et al.*, 2004; Liu *et al.*, 2008). The smaller the particles of a soil the longer pesticides persist in it. There is a significant correlation between the persistence of pesticide in a range of soils and the available adsorptive surface area, which correspond to a decrease in size of the soil particles. The residual life of pesticides also depends upon the biological activity of the soil, since the breakdown patterns of many pesticides are mediated by enzymes (Liu *et al.*, 2000). Hence, adsorption capacity and persistence of pesticides in soil is the ability of the soil to hold a pesticide in place and not allow it to be transported (Calvet, 1989). Adsorption is the passage of a solute from an aqueous phase to the surface of a solid adsorbent. The accumulation of a pesticide on the soil particle surfaces depends on both the chemical properties of the pesticide (i.e., water solubility, polarity) and properties of the soil (i.e., organic matter and clay contents, pH, surface charge characteristics, permeability etc) (Calvet, 1989). Depending on the properties of pesticides and soil, several adsorption mechanisms such as hydrogen bonding, ion exchange, interactions with metallic cations, polar interactions, charge transfers, London-Van der Waals dispersion forces and hydrophobic effects are involved in the binding of pesticide to soil particles (Celis

et al., 1998; Calvet *et al.*, 2005). The type of adsorption mechanism involved in the binding of pesticides to soil particles determines the retention, persistence and residual life of pesticide in soil and this varies spatially even within a short distance (Coquet and Barriuso, 2002). This is due to spatial variability of soil pH, organic matter, soil structure, clay minerals, oxides of Fe and Al and water content of soil etc (Mermoud *et al.*, 2008, Vieublé-Gonod *et al.*, 2009). This gives rise to spatial variation in soil surface area and sorption strength of soil even within a short distance. This spatial variation in soil surface area and sorption strength is responsible for the movement of pesticide off-site, contaminating surfaces and groundwater and causing adverse impacts on aquatic ecosystems. Adsorption of pesticides on soils is a major factor that determines the destination of pesticides in the environment and their eventual degradation processes. To improve the understanding of the fate of pesticides in soils and predicting the potential for adsorption and persistence, it is importance to take into account the spatial variability of soil surface area and sorption strength during pesticide application. But information on the spatial distribution of sorption strength of soil is inadequate. Therefore, this study was carried out to assess the spatial distribution of adsorption capacity and persistence of pesticides in soil of Cross River Basin Development Authority, Itu, Akwa Ibom State, for effective, efficient and sustainable pesticides management.

MATERIALS AND METHODS

The Study Area

The study was conducted in Cross River Basin Development Authority farm located in Itu Local Government Area of Akwa Ibom State, Nigeria. It lies within latitudes 4° 30' and 5° 30' N and longitudes 7° 30' and 8° 20' E. The climate is humid tropical, annual rainfall ranges from more than 3000 mm along the coast to about 2250 mm at the extreme north, with 1 – 3 dry months in the year. Mean annual temperature varies between 26 and 28 °C, while mean relative humidity is 80%. The original natural vegetation which comprised lowland rainforest, mangrove forest and coastal vegetation, has given way to a mosaic farmland/ oil palm forest, riparian forest and oil palm forest (Petters *et al.*, 1989).

Field work

A transect was cut across the entire Cross River Basin Development Authority Farm from the north to the south and soil augering was carried out. Based on textural differences, soil colour, consistence and drainage, mapping units were created. A total of 10 mapping units were identified in the study area and composite soil samples were collected at five representative points within each mapping unit at a depth of 0-30 cm with the aid of soil auger. A total of 50 soil samples were generated for laboratory analysis.

Laboratory Analysis

The following analyses were carried out: **Particle size analysis** was carried out using the bouyoucos hydrometer method as described by Udo *et al.*; (2009). **Bulk density** was determined by the method described by Udo *et al.*,(2009). **Saturated hydraulic conductivity** was determined using the constant head permeameter method. Soil pH was determined in water using a 1:2.5 soil to water suspension and the soil pH was read using a glass electrode. **Organic carbon** was determined by the dichromate wet-oxidation method as described by Nelson and Sommers (1996). The value was multiplied by 1.732 to obtain organic matter content. **Available phosphorus** was determined using the bray P1 extractant. The phosphorus in extract was measured by the blue method of Murphy and Riley (1962). **Total nitrogen** was determined by kjeldahl digestion and distillation method as described by Udo *et al.*; (2009). **Exchangeable bases**: Ca, Mg, Na, K. were extracted using normal ammonium acetate (Thomas, 1982). The exchangeable K and Na were determined by flame photometer while Ca and Mg were determined using atomic absorption spectrometer. **Effective cation exchange capacity (ECEC)** was determined by summing up exchangeable cations and exchangeable acidity. **Percentage base saturation** was calculated using the formula:

$$\% \text{ base saturation} = \frac{\text{Summation of exchangeable bases} \times 100}{\text{CEC}}$$

Pesticides Adsorption Strength and Persistence Analysis

1. Organo-mineral association and sorption capacity of soils of the study area: Regression analysis that expresses the relationship between clay size fraction (soil texture) and soil organic carbon was carried out for all the mapping units as:

$Y = a + b X$ where

Y = Soil organic carbon, a = Intercept of regression line representing soil organic carbon associated with clay fraction at zero clay fraction (no clay fraction), b = slope of regression line representing soil organic carbon associated with clay size fraction, X = Clay size fraction in the soil.

2. Organic carbon –water partition (distribution) coefficient (Koc)

Soil sorption is characterized by a distribution coefficient that describes the partitioning of pesticide between solid and liquid phases. Large number of pesticides (organic chemical pollutants) is hydrophobic, literally 'afraid of water'. These chemical have limited solubility in water but do tend to dissolve easily in oil, fats, non-polar organic solvent and organic carbon in the soil. Sorption strength in different soils is often estimated using the K_{oc} value, expressed as:

$K_{oc} = \frac{\text{Chemical concentration of sorbed to organic carbon (mg/g)}}{\text{Chemical concentration in water (mg/g)}}$ (Wauchope *et al.*, 2002).

Accordingly, K_{oc} , the organic carbon –water partition coefficient can be used to estimate the extent of sorption. The partitioning of hydrophobic organic compound between water and bulk soil can be estimated by the equation: $K_d = f_{oc} \times K_{oc}$ where f_{oc} is the fraction of the soil that is organic carbon (m/m), K_d = sorption coefficient measuring that amount of pesticides adsorbed into the soil per unit amount of water without consideration of the organic carbon content of the soil (Walker and Jurado-Exposito, 1998).

RESULTS AND DISCUSSION

1.0: Soil properties of the soil mapping Units

The soil properties of the mapping units are presented in Table 1.

Soil texture

The soil mapping units 1, 2, 3, 4, and 5 are located in the floodplain with sandy clay loam texture and are poorly drained during the wet season of the year. The mean sand fraction of soil mapping units 1, 2, 3, 4 and 5 were 610.0, 510.0, 548.6, 622.7, and 546.3 gkg^{-1} respectively. The silt fractions were 147.5, 185.0, 178.6, 96.8 and 111.5 gkg^{-1} respectively. The mean clay fractions were 242.5, 305.0, 272.8, 280.5 and 342.2 gkg^{-1} respectively. The soil mapping units 6, 7, 8, 9 and 10 are located in the upland with loamy sand to sandy loam texture and are well drained. The sand fractions were 838.4, 826.7, 715.0 and 775.6 gkg^{-1} . The silt fractions were 49.0, 42.0, 54.7, 49.0 and 49.0 gkg^{-1} respectively. The clay fractions were 112.6, 131.3, 123.2, 236.0 and 175.4 gkg^{-1} respectively. This showed that the soil texture of soil mapping units 1, 2, 3, 4, 5 and 9 were sandy clay loam in the surface soil while soil mapping units 6, 7, 8, 9 and 10 varied from loamy sand to sandy loam. The soil mapping unit 6, 7 and 8 were loamy sand while soil mapping unit 10 was sandy loam in the soil surface. The differences in soil texture among mapping units could be attributed to differences in parent material and rate of weathering of the parent rocks. Alluvium parent material in soil mapping units 1, 2, 3, 4 and 5 while sandstone parent material in mapping units 6,7,8,9 and 10 (Petters *et al.*, 1989).

Bulk density

The mean bulk density of soil mapping units 1, 2, 3, 4, and 5 were 1.3, 1.2, 1.2, 1.2 and 1.1 gcm^{-3} respectively. The mean bulk density of soil mapping units 6, 7, 8, 9, and 10 were 1.5, 1.6, 1.5 and 1.5 gcm^{-3} . The mean bulk density of soil mapping units 1, 2, 3, 4, and 5 were less than 1.4 gcm^{-3} while that of soil mapping units 6, 7, 8, 9, and 10 were greater than 1.4 gcm^{-3} . The mean bulk density value of soil mapping units 1, 2, 3, 4, and 5 were within the level that may not limit roots growth, gas exchange and availability of less mobile essential plant nutrients (P and K) but that of soil mapping units 6, 7, 8, 9, and 10 may affect root growth. The high bulk density in soil mapping units 6, 7, 8, 9, and 10 could be

attributed to tillage practices in the mapping units. This is because tillage practices resulted in increase in bulk density in surface soil (Celik, 2005).

Saturated hydraulic conductivity

The mean saturated hydraulic conductivity of soil mapping units 1, 2, 3, 4, and 5 were 0.3, 0.1, 0.06 and 0.04 cmhr⁻¹ while that of soil mapping units 6, 7, 8, 9, and 10 were 1.6, 3.2, 2.8, 3.1 and 0.7 cmhr⁻¹ respectively. The rate of water flow was very slow in soil mapping units 1, 2, 3, 4, 5 and varied from slow to moderate in soil mapping units 6, 7, 8, 9, and 10. This could be attributed to moderately fine texture of soil mapping units 1, 2, 3, 4, 5 and coarse to moderately coarse texture of soil mapping units 6, 7, 8, 9, and 10 (Celik, 2005).

Soil pH

The mean soil pH in water of soil mapping units 1, 2, 3, 4, and 5 were 6.3, 6.1, 5.9, 5.9 and 5.9 respectively. The means soil pH of soil mapping units 6, 7, 8, 9, and 10 were 5.2, 5.6, 5.3, 5.6 and 5.1 respectively. Mean soil pH was slightly acid in soil mapping units 1 and 2, and moderately acid in mapping unit 3, 4, 5, 7 and 9 while soil mapping units 6, 8 and 10 were strongly acid. The strongly acid of soil mapping units 6, 8 and 10 could be attributed to intense cultivation and leaching of exchangeable bases due to the topographic location (upland) of the mapping units. Generally, the variation in soil pH among the mapping units could be due principally to the topographic location of the mapping unit (Onasanya, 1992).

Organic carbon and organic matter

The mean organic carbon of soil mapping units 1, 2, 3, 4, and 5 were 22.8, 21.8, 21.6, 23.8 and 22.5 g/kg respectively. The mean organic carbon of soil mapping units 6, 7, 8, 9, and 10 were 0.5, 0.5, 0.5, 0.4 and 0.4 g/kg respectively. Mean organic carbon was high in soil mapping units 1, 2, 3, 4, 5 and low in soil mapping units 6, 7, 8, 9, and 10. The high organic carbon content of soil mapping units 1, 2, 3, 4 and 5 could be attributed to their topographic location (floodplain). Soils in the floodplain or lower topography or river channels receive considerable quantities of sediments and organic debris transported from upslope or upstream which enhance their organic matter accumulation and nutrient status. In addition, they are also saturated with moisture for a much longer period than upper slope soils. This usually slows down the rate of microbial degradation and mineralization of organic matter in lower slope position (Gao *et al.*, 2009).

Total N

The mean total N of soil mapping units 1, 2, 3, 4, and 5 were 1.0, 0.9, 0.9, 1.0 and 1.0 g/kg respectively. The mean total N of soil mapping units 6, 7, 8, 9, and 10 were 0.8, 0.8, 0.8, 0.7 and 0.7 g/kg respectively. Mean total N was low in soil mapping units 1, 2, 3, 4, 5 and very low in soil mapping units 6, 7, 8, 9, and 10. The low total N content of soil mapping units 1, 2, 3, 4 and 5 could be attributed to the slow rate of microbial degradation and mineralization of organic matter in lower slope position (Gao *et al.*, 2009).

Available P

The mean available P of soil mapping units 1, 2, 3, 4, and 5 were 4.2, 12.3, 8.2, 4.7 and 19.8 mg/kg respectively. The mean available P of soil mapping units 6, 7, 8, 9, and 10 were 29.5, 29.8, 31.7, 24.1 and 32.6 mg/kg respectively. Available P was low in soil mapping units 1 and 4; moderate in soil mapping units 2, 3 and 5 and high in soil mapping units 6, 7, 8, 9, and 10. The low available P of soil mapping units 1 and 4 despite high organic matter could be attributed to period of submerged soil which resulted in slow organic matter mineralization to P (Kristensen and Holmer, 2001).

Exchangeable bases

The mean exchangeable Ca was moderate in soil mapping units 1 (7.6 cmol/kg), 2 (9.0 cmol/kg), 3 (8.0 cmol/kg), 4 (8.2 cmol/kg), and 5 (6.5 cmol/kg) and low in soil mapping units 6 (4.6 cmol/kg), 7 (4.3 cmol/kg), 8 (4.1 cmol/kg), 9 (3.9 cmol/kg), and 10 (3.2 cmol/kg). Mean exchangeable Mg was moderate in all the mapping units except mapping unit 2 with exchangeable Mg value of 4.4 cmol/kg, indicating high. Mean exchangeable Na was very low in all the mapping units except mapping unit 2 with exchangeable Na value of 0.1 cmol/kg, indicating low. Mean exchangeable K was very low in all the mapping units in the study area with mean values ranging between 0.05 to 0.2 cmol/kg. The moderate

exchangeable Ca and Mg in soil mapping units 1, 2, 3, 4, and 5 could be attributed to the mineral matter present in the soil and the deposited sediments from the river (Nayman and DeLaune, 1991).

Effective cation exchange capacity (ECEC)

The mean ECEC was moderate in soil mapping units 1 (12.3 cmol/kg), 2 (14.0 cmol/kg) and 3 (13.6 cmol/kg) and low in all other soil mapping units (4, 5, 6, 7, 8, 9 and 10) with values ranging between 8.1 to 11.9 cmol/kg. The moderate ECEC of soil mapping units 1, 2 and 3 could be attributed to high organic matter and clay contents of the mapping units. According to Menzies and Gillman (1997), soils with very low ECECs, the adsorption capacity of these soils are humus-dependent. Onasanya (1992), observed that organic matter had a more controlling effect on ECEC than clay minerals, especially in tropical soils.

Exchangeable Al and Acidity

The mean exchangeable Al of soil mapping units 1, 2, 3, 4, and 5 were 3.2, 3.0, 3.2, 3.2 and 3.4 cmol/kg respectively. The mean exchangeable Al of soil mapping units 6, 7, 8, 9, and 10 were 0.9, 0.9, 1.0, 1.6 and 0.8 cmol/g respectively. This shows that soil mapping units 1, 2, 3, 4, and 5 had more potential acidity while soil mapping units 5, 6, 7, 8, 9, and 10 had more active acidity (Menzies and Gillman, 1997)

Base saturation

The mean base saturation was very high in soil mapping units 1 (82.5 %), 2 (87.0 %) and 3 (84.2 %) and high in all other soil mapping units (4, 5, 6, 7, 8, 9 and 10) with values ranging between 61.0 to 79.5 %. The high base saturation in acidic soils could be attributed to the low cation exchange capacity of the soils, with low buffering capacity. Hence, slight changes in soil base cations resulted in high base saturation (Menzies and Gillman, 1997)

2: Organo- mineral association and sorption capacity of the soil of the study area

The regression analysis that expresses the relationship between clay fraction and organic carbon content in the study area is presented in Table 2. The results showed that about 3.8 % of clay fraction was associated with organic matter in soil mapping units 1, 2, 3, 4 and 5 while about 0.98 % of clay fraction was associated with organic matter in mapping units 6, 7, 8, 9 and 10. The high association of clay fraction with organic matter in mapping units 1, 2, 3, 4, 5 compared to others could be attributed to the high clay and organic matter content of the soil. This accounts for high sorption capacity, high surface area and strong bonding between clay and organic compound. The high reactivity of the soil resulted in high adsorption strength (Akpan and Ukut, 2015)

3. Adsorption coefficient (K_d) of pesticides in the study area

The adsorption coefficient (K_d) of pesticides in the study area is presented in Table 3. The adsorption coefficient of soil mapping units 1, 2, 3, 4 and 5 were 962.6, 767.4, 1060.6, 1530.3 and 1332.0 while that of soil mapping units 6,7,8,9 and 10 were 0.55, 0.69, 0.61, 0.38 and 0.38 respectively. Soil mapping unit 1, 2, 3, 4 and 5 had higher pesticide adsorption coefficient than mapping unit 6, 7, 8, 9 and 10. The high pesticide adsorption coefficient of mapping units 1, 2, 3, 4 and 5 compared to others could be attributed to the high water content of the soil that dissolved the pesticides (Roy *et al.*, 2000). The soil water content defines the specific exchange surface between solid and liquid phases. The adsorption of pesticides increases with water content as it facilitates pesticide diffusion to sorption sites. As water content increases, the organic matter also becomes more hydrophilic with greater sorption potential for hydrophilic pesticides (Roy *et al.*, 2000). But most pesticides are non-polar and hydrophobic. Hence, adsorption coefficient (K_d) is not the best measure of pesticides adsorption and persistence in soil for non-polar pesticides since it measures the amount of pesticides adsorbed onto soil per amount of water without considering the organic matter content of the soil.

4. Organic carbon –water partition coefficient (K_{oc}) of pesticides in the study area

The organic carbon –water partition coefficient (K_{oc}) of pesticides in the study area is presented in Table 3. The organic carbon –water partition coefficient (K_{oc}) of soil mapping units 1, 2, 3, 4 and 5 were 42.2, 35.2, 49.1, 64.3 and 59.2 while that of soil mapping units 6,7,8,9 and 10 were 1.1, 1.38, 1.22, 0.95 and 0.95 respectively. The organic carbon –water partition coefficient (K_{oc}) of pesticides of mapping units 1, 2, 3, 4 and 5 was higher than those of mapping units 5, 6, 7, 8, 9 and 10. The high organic carbon –water partition coefficient (K_{oc}) of pesticides of these mapping units could be attributed to organic matter content of these mapping units compared to others. Organic matter has a very high heterogeneous

composition and contains both hydrophilic and hydrophobic groups (Calvet et al., 2005). Organic matter is a major sorbent of pesticides in soil (Calvet, 1989). This is due to its high chemical reactivity towards both mineral surfaces and organic molecules, allowing various types of interaction with pesticides. The sorption capacities of organic matter are not only controlled by their chemical composition, but also by their size, due to a greater number of sorptive sites related to a greater surface area with decreasing particle-size (Benoit *et al.*, 2008). In general, the adsorption of pesticides increases with organic matter, except for ionic molecules.

CONCLUSION

The study revealed that soil mapping units 1, 2, 3, 4 and 5 (poorly drained soils) had high surface area, high sorption capacity and strong bonding between clay and organic compound compared to soil mapping units 6, 7, 8, 9 and 10 (well drained soils). Soil mapping units 1, 2, 3, 4 and 5 had high pesticide adsorption coefficient (K_d) compared to soil mapping units 6, 7, 8, 9 and 10 due to high water content of the soil that dissolved the pesticides. Also, the soil mapping units 1, 2, 3, 4 and 5 had higher organic carbon –water partition coefficient (K_{oc}) due to high organic matter content of mapping units compared to others. Organic matter has a very high heterogeneous composition and contains both hydrophilic and hydrophobic groups. Therefore, soil mapping units 1, 2, 3, 4 and 5 had high adsorption capacity and pesticide persistence than soil mapping units 6, 7, 8, 9 and 10. The movement of pesticide off-site, contaminating surfaces and groundwater is more in soil mapping units 6, 7, 8, 9 and 10 (upland) than soil mapping units 1, 2, 3, 4 and 5 (floodplain).

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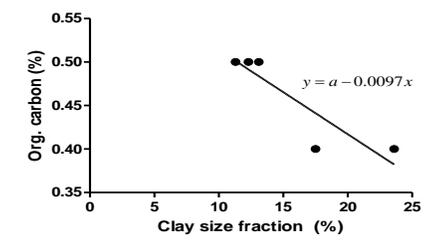
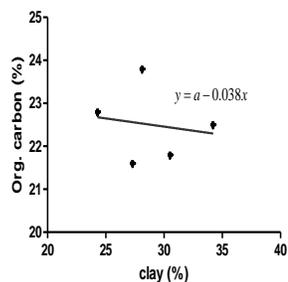
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Table 1: Physical and Chemical Properties of the soil mapping units of the Study Area

Physical Characteristics										
Soil Parameters	Mu1	Mu2	Mu3	Mu4	Mu5	Mu6	Mu7	Mu8	Mu9	Mu10
Sand (g/kg)	610.0	510.0	548.6	622.7	546.3	838.4	826.7	822.1	715.0	775.6
Silt (g/kg)	147.5	185.0	178.6	96.8	111.5	49.0	42.0	54.7	49.0	49.0
Clay (g/kg)	242.5	305.0	272.8	280.5	342.2	112.6	131.3	123.2	236.0	175.4
Texture	SCL	SCL	SCL	SCL	SCL	LS	LS	LS	SCL	SL
Bulk Density (gcm ⁻³)	1.3	1.2	1.24	1.2	1.14	1.52	1.52	1.59	1.51	1.54
Hydraulic conductivity (c/hr)	0.34	0.11	0.06	0.14	0.04	1.58	3.20	2.81	3.12	0.74
Chemical characteristics										
pH (H ₂ O)	6.3	6.1	5.9	5.9	5.9	5.2	5.6	5.3	5.6	5.1
pH (kcl)	6.2	6.1	5.9	5.9	5.9	4.7	4.9	4.8	4.5	4.6
Electrical conductivity (ds/m)	0.03	0.03	0.11	0.01	0.01	0.12	0.1	0.22	0.06	0.03
Organic C (g/kg)	22.8	21.8	21.6	23.8	22.5	0.5	0.5	0.5	0.4	0.4
Organic matter (g/kg)	39.5	37.8	36.2	41.2	39.5	32.6	32.2	32.7	29.0	25.3
Total N (g/kg)	0.97	0.91	0.93	1.03	1.02	0.82	0.79	0.84	0.69	0.65
Available P (mg/kg)	4.2	12.3	8.2	4.7	19.75	29.5	29.8	31.7	24.1	32.6
Exch. Ca (cmol/kg)	7.6	9	8	8.2	6.45	4.6	4.3	4.1	3.9	3.2
Exch. Mg (cmol/kg)	2.9	4.4	2.6	2.7	2.5	1.6	1.6	1.6	1.4	1.2
Exch. Na (cmol/kg)	0.07	0.10	0.09	0.09	0.09	0.06	0.07	0.07	0.06	0.06
Exch. K (cmol/kg)	0.05	0.09	0.06	0.06	0.1	0.16	0.13	0.14	0.12	0.11
Exch. Acidity (cmol/kg)	2.02	1.79	1.88	2.01	2.12	2.0	2.5	2.6	3.2	1.9
Exch. Al (cmol/kg)	3.24	2.95	3.24	3.15	3.39	0.9	0.9	1.0	1.6	0.8
ECEC (cmol/kg)	12.3	14.0	13.6	11.9	11.7	8.4	8.4	8.7	8.5	8.1
Base saturation (%)	82.47	86.99	84.21	82.67	79.46	73.3	69.3	68.2	61.0	63.4

Table 2: Regression analysis expressing the relationship between clay size fraction and soil organic carbon ($y = a + bx$)

Mapping units	$Y = a + b x$	b (%)	R^2
1, 2, 3, 4, 5	$y = a - 0.038 x$	3.8	0.026
6,7, 8, 9, 10	$Y = a - 0.0097 x$	0.97	0.80



(a) Poorly drained (mapping units 1,2,3,4,5)

(b) well drained (mapping units 6, 7, 8, 9, 10)

Table 3 : Organic carbon –water partition coefficient (K_{oc}) and adsorption coefficient (K_d) of pesticides in the study area (mg/g)

	Mu1	Mu2	Mu3	Mu4	Mu5	Mu6	Mu7	Mu8	Mu9	Mu10
foc	22.8	21.8	21.6	23.8	22.5	0.5	0.5	0.5	0.4	0.4
θ	0.54	0.62	0.44	0.37	0.38	0.44	0.36	0.41	0.42	0.42
K_{oc} (mg/g)	42.2	35.2	49.1	64.3	59.2	1.1	1.38	1.22	0.95	0.95
pb	1.3	1.2	1.24	1.2	1.14	1.52	1.52	1.59	1.51	1.54
K_d (mg/g)	962.2	767.4	1060.6	1530.3	1332	0.55	0.69	0.61	0.38	0.38