Advances in Natural and Applied Sciences, 3(2): 260-264, 2009
ISSN 1995-0772

ORIGINAL ARTICLE

Spatial Variability of Mercury in Soils Affected by Automobile Wastes at Port-harcourt, Nigeria.

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E.U. Onweremadu, M.C. Chukwuma and F.C. Ogbonna: Spatial Variability of Mercury in Soils Affected by Automobile Wastes at Port-harcourt, Nigeria: *Adv. in Nat. Appl. Sci., 3(2): 260-264, 2009*

ABSTRACT

We investigated the spatial variability of mercury in soils affected by automobile wastes at Choba, South-South Nigeria. Guided by transect sampling technique, 30 soil samples were collected from the study site at a depth of 0-20cm using soil auger. Sampled soils were air-dried, gently crushed and sieved using 2mm sieve mesh. Sieved soil samples were taken to the laboratory for analysis using standard procedures. Data obtained were subjected to statistical analysis using analysis of variance (ANOVA) involving RCBD. Mercury was correlated and regressed with selected soil properties. Soil physicochemical properties of polluted soils differed when compared with unpolluted soils. Mercury content of polluted soils was doubled in comparison to unpolluted soils. Though Hg increased in polluted soils, it was however below MAL by 57.5times indicating non-toxicity. There was no significant difference in Hg among studied soils at p=0.05. The R^2 value for Hg against pH_{water}, organic matter and ECEC showed that pH_{water}, organic matter and ECEC accounted for 74.9%, 90.4%, 57.6%, 84.5%, 95.6% and 100% variations of Hg contents in A, B, C, D, E and F respectively. pH_{water}, organic matter and ECEC accounted for 34.7% variation in Hg content in all the studied soils. *Sequel to the findings of this study, it was concluded that efforts should be geared by all concerned in order to halt the indiscriminate disposal of automobile wastes in an effort to save our environment from further contamination and subsequent deterioration.*

Key words: Tropical soils, spatial variability, automobile wastes, mercury.

Introduction

Soils are complex biogeochemical materials on which plants are grown and they have structural and biological properties that distinguish them from the rocks and sediments from which they are normally originated (Singer and Munns, 1999). Soils suffer from environmental pollution as a result of indiscriminate disposal of pollutants such as automobile wastes (Onweremadu, 2007). In Nigeria, automobile maintenance and servicing centres are spread all over major cities and towns. These automobile wastes when generated are indiscriminately discharged into the environment thereby contaminating soils. Dominguez-Rosado and Pitcher (2004) noted that automobile wastes such as waste-engine-oil, petrol and grease contain toxic elements which deteriorate soils and pollute surface and ground water.

Although soils are recipient of heavy metals (He, *et al*., 2004), they occur naturally in soils (Ojanuga *et al*., 1996). Heavy metals are toxic and unlike other pollutants are not easily biodegradable (Nurbeg, 1984). Rapid mobilization of heavy metals could result in environmental disaster, threatening human health and welfare by poisoning water and food (Stiglin and Anderberg, 1993). Javier and Rafael (2005) reported that Hg is among the eight known toxic metals in soils. Mercury is a cationic toxic substance which has no known function in plant or human biochemistry or physiology and does not occur naturally in living organisms (Brown, 2003). It has been reported that exposures of high levels of Hg can permanently damage the brain,

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kidneys and developing foetus (Barry, 1998). Mercury in soils can be adsorbed by plants, and Lag and Steinnes (1978) observed that Hg content in crop plants grown on soils was the same as that of soil. In the light of the above therefore, this study was aimed at investigating the spatial variability of Hg in soils affected by automobile wastes at Choba, Port-Harcourt, Southern Nigeria.

Materials and methods

Location:

The study was located at Choba mechanic automobile servicing centre otherwise known as "Choba Mechanic Village" in Port-Harcourt, South-South Nigeria. It lies between latitude 4^0 $30^'$ to 5^0 00' N and longitude 7^0 05' and $7^0$15' E. The area is underlain by Coastal Plain Sands which is also referred to as "Acid Sands" (Orajaka, 1975). Soil of the Coastal Plain Sands comprises old alluvial deposits over unconsolidated sedimentary parent material which was laid down during Miocene-Pleistocene period (Iwegbue *et al.*, 2006). The mean annual rainfall in the area is about 2590 mm. Annual temperature varies between 27.6 and 35^0 C. It has generally high relative humidity of 58.8-95.0%. Arable crop production, fishing and automobile servicing are major socio-economic activities in the area.

Experimental Design:

Transect intervals (A, B, C, D, E) including the control (F) served as treatments and 5 samples per distance land unit were used as replicates which was arranged in a randomized complete block design (RCBD).

Soil Sampling:

Guided by transect sampling technique, soil sampling was carried out before the rains in February, 2009. Samples were collected from the plough layer (0-20cm) at intervals of 50m away from polluted site. Soil samples were collected from the following points: A (0-50m), B (50-100 m), C (100-150 m), D (150-200 m), E (200-250 m) and control, F (2 km away from polluted area). Five samples were collected from each sampling point making it a total of 30 samples. Soil samples were thereafter air-dried, gently crushed and made to pass through 2 mm mesh sieve preparatory to laboratory analysis.

Laboratory Studies:

Particle size distribution was determined by hydrometer method (Gee and Or, 2002), while soil pH (water and 1N KCl) was obtained by the use of pH meter (Hendershot, *et al.*, 1993). Soil organic carbon was estimated using wet digestion (Nelson and Sommers, 1982) and organic matter values were obtained by multiplying organic carbon by 1.724 (Van Bemmelen's correlation factor). Exchangeable bases and exchangeable acidity were determined by the procedure of McLean (1982), available phosphorus was according to the method of Olson and Sommers (1990) and total nitrogen was measured by MicroKjeldahl digestion technique (Bremner, 1996). Soil samples were digested with a mixture of concentrated $HClO_4$ and HNO_3 at a ratio of 2:1 and Hg was extracted using 0.5M HCl (Lacatusu, 2000). Mercury concentration in the supernatant was determined using Atomic Adsorption Spectrophotometer (Alpha 4 Model).

Data Analysis:

Soil generated data were subjected to statistical analysis using analysis of variance (ANOVA). Mercury was correlated and regressed with selected soil chemical properties in a multiple correlation and regression analysis in which their coefficient determinants were obtained. This was carried out using SPSS Software, Version 15.0 (SPSS, 2006).

Results and discussion

In Table 1, the physicochemical properties of studied soils are represented. Sand had the highest value of 936 gkg^{-1} in F (Control) and least value of 896 gkg-1 in E (200-250m away from polluted site), while silt and clay contents were highest in E with values of 49 and 53 gkg^{-1} respectively and least in A (33 gkg^{-1}) and F (19 gkg^{-1}) respectively. Soils were generally sandy. Silt-clay ratio ranged between 0.47 and 1.09 with highest value in E and least in F. Akamigbo (1984) reported that climatic factors such as high precipitation and temperature which are characteristics of the region are responsible for the low silt and clay content. Similarly, Eshett *et al.*(1990) noted that such climatic factors accounts for high lessivage in the area leading to low clay status at the soils' epipedal layers. According to Unamba-Oparah (1982) silt-clay ratio below 2.0 indicates that such soils are highly weathered. Thus, soils of the study area are highly weathered.

Table 1: Selected physicochemical properties of studied soils.

Property	A	B	C	D	E	F
Sand (gkg^{-1})	940	933	942	918	898	940
Silt (gkg^{-1})	27	31	22	36	53	19
Clay (gkg^{-1})	33	36	36	46	49	41
SCR -	0.82	0.87	0.61	0.78	1.09	0.47
TC -	Sand	Sand	Sand	Sand	Sand	Sand
pH$_{kcl}$ -	4.38	4.38	4.66	4.50	4.09	4.27
water-	5.51	5.19	5.63	5.80	5.13	5.21
OC (g/kg)	24.7	29.6	28.7	32.5	12.9	25.6
OM (g/kg)	42.6	51.0	49.5	56.1	22.3	38.9
TEA (mgkg^{-1})	0.16	0.22	0.30	0.33	0.17	0.25
TEB (mgkg^{-1})	1.53	1.42	1.84	1.78	1.57	1.13
ECEC(mgkg^{-1})	1.7	1.64	2.13	2.11	1.80	1.38
BS (%)	90.31	86.41	86.21	84.56	86.24	81.64
TN (g/kg)	0.64	0.28	0.25	0.23	0.13	0.33
AP (mg/kg)	2.61	4.49	5.72	8.77	6.67	11.47
Alsat. (%)	1.44	6.83	6.84	5.63	4.13	4.46

SCR=Silt-clay ratio; TC=Textural class; OC=Organic carbon; OM=Organic matter; TEA=total exchangeable acidity; TEB=Total exchangeable bases; ECEC=Effective cation exchange capacity; TN=Total nitrogen; AP=Available phosphorus; BS=Base saturation; Alsat.=Aluminium saturation

Table 2: Variability of selected heavy metals in studied soils

Land Units	pH$_{KCl}$	OM	C/N	N	P	ECEC	Alsat.Hg
A	4.48	4.26	8	0.24	2.61	1.71	1.44
B	4.3	5.1	10	0.28	4.49	1.64	60.83
C	4.16	4.99	10	0.26	5.72	2.13	60.84
D	4.15	5.81	10	0.33	8.77	2.11	50.00
E	4.09	3.48	10	0.13	6.67	1.8	40.18
F	4.87	3.89	3.8	0.63	11.54	2.58	4.46
LSD$_{(0.05)}$	4.88*	22.53*	66.0*	7.45*	15.30*	21.01*	9.81*

OM=Organic matter; C/N=Carbon-nitrogen ratio; N=nitrogen; P=phosphorus; ECEC=Effective cation exchange capacity; Alsat.=Aluminium saturation; Hg=Mercury; *=Significant at p=0.05

Table 3: Prediction equation for concentrations of Hg in studied soils.

Land Units	Prediction equation (n=30)	R^2	Level of significance
A	Hg=0.151-0.023pHwater-0.01OM+0.022ECEC	0.749	NS
B	Hg=-0.063+0.003pHwater+0.009OM+0.012ECEC	0.904	NS
C	Hg=0.163-0.032pHwater+0.019OM-0.029ECEC	0.576	NS
D	Hg=-0.096-0.001pHwater+0.01OM+0.033ECEC	0.845	NS
E	Hg=-1.354+0.262pHwater-0.086OM+0.120ECEC	0.956	NS
F	Hg=0.00+1.0pHwater+0.0Om+0.0ECEC	1	S
All	Hg=0.054-0.012pHwater+0.002Om+0.012ECEC	0.347	S

Hg=Mercury; ECEC=Effective cation exchange capacity; OM=Organic matter; NS=Not significant; S=Significant at p=0.05

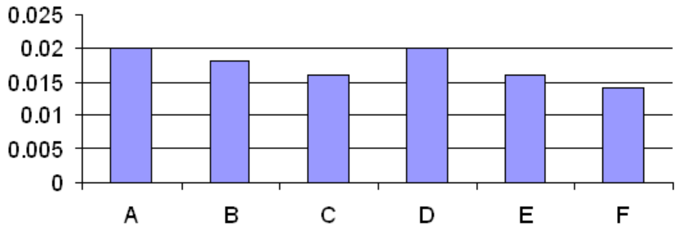

Fig. 1: Mercury concentrations in mg/kg in studied soils.

Soil pH ranged from 5.13 (water) in E and 4.09 (KCl) also in E to 5.8 (water) in D and 4.66 (KCl) in C. Results showed that soils' acidity varied from strongly to moderately acidic conditions. Though soil pH was generally higher in polluted soil than in unpolluted soil; Atuanya (1987) however observed reduced acidity in waste-oil polluted soil when compared to unpolluted soil. Soil organic matter values decreased away from polluted site with values higher than Control except in E which had lower value than F (Control). Higher organic matter content of polluted soils could be attributable to the presence of oil (hydrocarbon) which contributed to the high values of organic carbon, and organic carbon is a factor of organic matter. Soil total nitrogen followed the same trend as organic matter. Unamba-Oparah (1982) observed a positive correlation between organic matter and total nitrogen.

Available phosphorus increased with distance away from polluted site. Thus, lowest value of 2.61 mgkg^{-1} was obtained in A (0-50m away from polluted site) and highest value of 11.47 mgkg^{-1} in Control. This corroborates the report of Atuanya (1987) who noted that in waste-oil polluted soils, phosphorus is limiting. Total exchangeable basic cations (TEB) were highest in locations with high pH values. Singer and Munns (1999) hinted that at pH range of 5.5-8.5, basic cations of Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} are readily available. The carbon-nitrogen ratio values are higher in polluted soils when compared to control. Amadi and Bari (1992) reported that oil pollution of soils widens C-N ratio due to the presence of hydrocarbons.

Mean value of Hg content in polluted soils was highest in A and D with a value of 0.02 mgkg^{-1} as against 0.014 mgkg^{-1} in unpolluted soil which was the least value (Fig. 1). This implies that there was an increment in Hg content of polluted soils due to automobile wastes. Though, the Hg content of contaminated soils was about double that of unpolluted, it was far below maximum allowable limits (MAL) by 57.5times. Wild (1996) gave the MAL of Hg in soils as 1.15 mgkg^{-1}. Hence, Hg was found to be non-toxic on the polluted soils. Mercury showed no significant difference among studied soils at p=0.05. In table 3, the R^2 value for Hg against pH_{water}, organic matter and ECEC showed that pH_{water}, organic matter and ECEC accounted for 74.9%, 90.4%, 57.6%, 84.5%, 95.6% and 100% variations in A, B, C, D, E and F respectively, while on the whole, they accounted for 34.7% variation in Hg with a significant difference at p=0.05.

Conclusion:

This study showed that there was higher concentrations of Hg in automobile waste contaminated soils, though below MAL and therefore non-toxic. In addition, the soils' physicochemical properties were equally affected with increase in pH, organic matter, total nitrogen and decrease in available phosphorus. It can be surmised therefore that indiscriminate disposal of automobile wastes is inimical to our environment. Therefore, stringent regulation should be evolved and enforced strictly in a bid to ameliorate its harmful effects on our environment and living biota.

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