EVALUATION OF SELECTED HEAVY METAL CONCENTRATIONS IN SOILS AFFECTED BY AUTOMOBILE WASTE IN OWERRI AREA, SOUTHEASTERN NIGERIA

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Abstract
The study was conducted to evaluate the concentration of selected heavy metals Lead (Pb) and Cadmium (Cd) in Soils of Nekede Mechanic Village, Owerri, Imo State, Nigeria. Eight (8) composite soil samples were collected from 0-15 cm and 15-30 cm soil depths in four (4) different locations designated as Nekede phase I, Nekede Phase II, Nekede phase III and a continuously farmed land as control site (CONT). Data obtained were statistically analyzed using coefficient of variation (CV), standard deviation (SD) and mean (X). Results showed that the values of lead were 12.36 mg/kg (0-15 cm), 7.15mg/kg (15-30 cm) at NKF1, 15.54mg/kg (0-15 cm), 9-12mg/kg (15-30cm) at NKF2, 10.61mg/kg (15-30 cm) at the control (CONT) site respectively, cadmium, 1.65mg/kg(0-15 cm), 2.40mg/kg (15-30 cm) in NKF1, 1.85mg/kg (0-15 cm), 1.21mg/kg (15-30 cm) in NKF 2, 2.30mg/kg (0-15 cm), 1.15mg/kg (15-30 cm) in NKF 3 and 0.85mg/kg(0-15 cm) and 0.74mg/kg (15-30 cm) at the control. Contents of lead and cadmium at the study sites were above the permissible limit of 0.50mg/kg for Pb and 0.010mg/kg for Cd. Soil texture was sandy loam to sandy clay loam in all the studied sites, while the BD ranged between 1.70-2.00g/cm. Soils were generally acidic (4.5-6.14) with low soil organic matter, soil organic carbon, total nitrogen etc. Medium cation exchange capacity and high base saturation (>77%). It was recommended that to reduce emission of fumes from cars and deposition of oil on soils be made in Nekede mechanic village and immediate remediation measures be adopted on the soils to avoid pollution of soils and environment.
Keywords, Heavy metals, concentration, soils, Automobile wastes.

Introduction

Soil includes aggregate of decayed organic matter, living organisms and weathered materials (Bellamy, 2005), also do suffer from environmental pollution as a result of indiscriminate disposal of pollutants such as auto mobile wastes (Onweremadu, 2007).

Soil forms a sink for the potentially toxic elements often referred to as heavy metals, including, Zn, Cd, Pd, Cr, As, and Hg. They are termed heavy metals due to their high relative atomic mass which persist in nature and can cause damage or death in animals, humans and plants even at very low concentration (Duffus, 2002). Heavy metal concentration in soil is a major concern because of their toxicity and threat to human life and environment (Chaudri and Griller, 1995). Also, heavy metal in soils considered as pollutants are harmful due to the adsorption and immobilization of nutrients in the soil (Isirimah *et al*., 2003).

In Nigeria, auto-mechanic businesses designated in cities contribute to the anthropogenic release that induces increase in heavy metal concentration in soils (Duffus, 2002). Auto-vehicle servicing activities is one of the significant anthropogenic sources of heavy metals in the environment (Ankley, 1994). An automobile service station popularly called mechanic village is an area of open land allocated to automobile repair workers in the vicinity of an urban centre (Nwachukwu *et al*., 2010). These vehicle servicing centres may constitute sources of soil contamination; and fossils fuel products will accumulate various forms of heavy metals which deteriorates nearby vegetation causing non-point source pollution (Aiyesanmi, 2008). Therefore, this study was carried out to evaluate the concentration of selected heavy metals cadmium (Cd) and lead (Pb), and some physico-chemical properties in soils of Nekede mechanic village, Owerri, Imo State, Nigeria.

Materials and method

Study area: The study was conducted in Nekede Mechanic Village, Owerri which lies between latitudes 5^0 20'N[1] and 6^0 55'E and longitudes 6^0 35'E and $7^0$08'E. It's bounded in the east by Abia State, bounded in the west and north by Anambra State and south by Rivers State (FDALR, 1985). Soils of the study area are mainly derived from coastal plain sand (Orajaka, 1975), underlain by coastal plain sand (FDALR, 1985) while the topography is relatively flat and gently sloped towards the Otamiri river side that borders it in the west. The study area lies within the tropical rainforest zone of Nigeria having annual rainfall of 1950-2200mm (Enwezor *et al., 1989).* The rainfall pattern is bimodal with peaks in the month of July and September and a short dry spell in the month of August (August break).

Field study

At each side within the study area (mechanic village), an area of 50x20m land area was mapped out as a phase site for the study and composite soil samples collected randomly from soil depths of 0-15 cm and 15-30 cm respectively. A total of eight (8) composite samples were collected from the study area.

Soil characterization: The collected composite soil samples were air-dried, and sieved with 2mm. The particle size was determined by modified hydrometer method (Gee and Or, 2000) and textual class of soils obtained by using textural triangle. Soil p^H was determined in both distilled water and O.IN KCL solution, Mclean, (1982). The soil organic carbon was determined by micro-kjeldahl method. Available phosphorus was extracted using Bray II solution (Olsen and Sommers, 1982). Exchange cation (Ca^{2+}, Mg^{2+}, K^+, Na^+) was extracted using ammonium acetate and Ca^{2+}, Mg^{2+} were determined with Atomic absorption spectrometer (AAS) while Na^+ and K^+ were determined in flare photometer. The soils heavy metals were also determined using A (UNICAM, 919 model).

Data Analysis

The data collected was subjected to statistical analysis using the following descriptive statistics-coefficient of variation (CV), standard deviation (SD) and mean (X).

Results and Discussion

Soil physical properties

The particle size distribution and soil bulk density of the soils of the study area are shown in Table. 1. All the study sites had predominantly high sand content ranging between 70.80-85.80%, making the texture of the studied soils sandy loam to sandy clay loam. The high content of the sand fraction compared to the silt and clay fraction is typical of soils of South-eastern Nigeria, formed largely from coastal plain sand and this positively influences the leaching rate in the soils. Also, this conforms to the findings of Onweremadu *et al*., 2007 who observed that the sandiness of soils allows for easy leaching of heavy metals and nutrients through the pedosphere to ground water.

Table 1: Soil physical properties of study sites

Location	Depth (cm)	%sand	% silt	%clay	TC	BD(gcm^{-3})
NKF1	0-15	73.80	6.00	20.20	SL	1.94
	15-30	70.80	6.00	23.20	SCL	1.98
	SD	2.12	0.00	2.12		0.03
	MEAN	72.30	6.00	21.70		1.96
	CV(%)	2.93	0.00	9.78		1.53
NKF2	0-15	79.80	4.00	16.20	SL	1.97
	15-30	74.80	4.00	21.20	SCL	2.00
	SD	3.54	0.00	3.54		0.02
	MEAN	77.30	4.00	18.70		1.99
	CV(%)	4.57	0.00	18.91		1.07
NKF3	0-15	85.80	6.00	8.20	SL	1.87
	15-30	73.80	8.00	18.20	SCL	1.96
	SD	8.49	1.40	7.07		0.06
	MEAN	79.80	7.00	13.20		1.92
	CV(%)	10.63	20.20	53.57		3.32
Control	0-15	72.80	8.00	19.20	SL	1.74
	15-30	70.80	6.00	23.20	SCL	1.76
	SD	1.41	1.41	2.83		0.014
	MEAN	71.80	7.00	21.20		1.75
	CV(%)	1.97	20.20	13.34		0.80

NKF 1= Nekede phase 1 site, NKF2 = Nekede pahse 2 site, NKF3= Nekede phase 3 site, SL sandy. Loam, SCL= sandy clay loam, LS= loamy sand, SD= Standard Deviation, TC= textural Class, BD= Bulk Density, CV= Coefficient of variation.

Bulk density (BD)

At the NKF1 site, Bulk density (BD) decreased with increased in soil depth with values of 1.94gcm^{-3}(0-15cm) and 1.98gcm^{-3} (15-30 cm), respectively. Similar trend of BD decrease with increasing depth was recorded at the control site with 1.74gcm^{-3} (0-15 cm) to 1.76gcm^{-3} (15-30 cm). But, at NKF2 and NKF3 sites the trend was different as BD increased with increasing depth. Thus, at NKF2, BD was 1.97gcm^{-3} (0-15 cm), 2.00gcm^{-3} (15-30 cm) while; at NKF3, BD was 1.87gcm^{-3}(01-5 cm) and 1.96gcm^{-3}(15-30 cm). The high BD as recorded at NKF1, NKF2 and NKF3 can be attributed to the compaction resulting from anthropogenic activities, especially; vehicular activities and trampling by humans rather than rainfall which may have been responsible for the result obtained at the control site. Generally, the bulk densities of the studied soils were high (>1.5g cm^{-3}) throughout the study area, which is undesirable. This is supported by Hunt and Gilkes, (1992), in their affirmation that it is generally desirable to have a soil with low bulk density (<1.5g cm^{-3}), for optimum movement of air and water through the soil.

Soil chemical properties

The soil chemical properties of the study sites are shown in Table 2

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Soils pH, Organic Carbon & Total Nitrogen

The mean pH values obtained from the study sites were 4.44, 4.89, 4.86, 5.81 at NKF1, NKF2, NKF3 and control sites, respectively. The p^H of the study sites were extremely acidic to moderately acidic (4.31-6.14) but, the NKF1, NKF2 and NKF3 were more acidic compared to the control site. The higher acidic state of NKF1, NKF2, and NKF3 is expected because of the industrial wastes (Brookes *et al., 1992)* and the overall acid state found in the study area can be attributed to the tropical rainfall zone that is characterized by high weathering and leaching of soil nutrients (Ano 1994; Onweremadu, 2007).

Table 2: Soil chemical properties of study sites

Location	Soil depth (cm)	pH (H_20)	OC (%)	OM (%)	CEC	BS (%)	TN	Avail. P. $Mgkg^{-1}$)	TEA
NKF 1	0-15	4.31	1.36	2.35	7.20	83.30	0.10	3.76	1.20
	15-30	4.57	0.74	1.27	5.12	82.40	0.05	2.84	0.90
	SD	0.18	0.44	0.76	1.47	0.64	0.04	0.65	0.21
	MEAN	4.44	1.05	1.81	6.16	82.85	0.08	3.30	1.05
	CV(%)	4.14	41.75	42.19	23.88	0.77	49.14	19.71	20.20
NKF2	0-15	4.86	1.96	3.38	9.07	86.30	0.12	6.12	1.10
	15-30	4.91	0.79	1.37	6.67	89.50	0.06	3.00	0.70
	SD	0.04	0.83	1.42	0.99	2.26	0.04	2.21	0.28
	MEAN	4.89	1.38	2.38	7.37	87.90	0.09	4.57	1.90
	CV(%)	0.72	60.17	59.84	13.43	2.57	47.14	48.38	31.45
NKF3	0-15	5.24	1.93	1.62	5.17	84.50	0.08	12.07	0.80
	15-30	4.47	0.59	1.03	4.28	78.90	0.06	9.12	0.90
	SD	0.44	0.24	0.42	0.63	3.96	0.01	2.09	0.07
	MEAN	4.86	1.57	1.33	4.73	81.70	0.07	10.59	0.85
	CV(%)	11.21	31.63	31.49	13.32	4.85	20.20	19.69	8.32
Control	0-15	6.14	1.84	1.45	5.47	74.40	0.07	7.55	1.40
	15-30	5.47	0.79	1.37	5.06	80.20	0.06	4.75	1.00
	SD	0.47	0.04	0.06	0.29	4.10	0.01	1.98	0.28
	MEAN	5.81	0.82	1.41	5.27	77.30	0.07	6.15	1.20
	CV(%)	8.56	4.34	4.01	5.51	5.31	10.88	32.19	23.57

OC= Organic carbon, OM= organic matter, CEC= cation exchange capacity
BS= Base saturation, TN= Total nitrogen, AP= available phosphorus

The range of SOC with depths over the study sites were 1.36% (0-15cm) to 0.74% (15-30 cm) at NKF1 site; 1.96% (0-15 cm) to 0.79% (15-30 cm) at NKF2 site; 093% (0-15 cm) to 0.59 % (15-30 cm) and 0.84 (0-15 cm) to 0.79% (15-30 cm). While, the mean SOC values were 1.05, 1.38, 0.76 and 0.82% for NKF1, NKF2, NKF3 and control respectively. Higher accumulation of SOC in the surface is possible and similar result and it have been attributed through the accumulation of plants and animals on the surface.

Across the depths and locations studied, total nitrogen ranged from 0.12% (0-15 cm) and 0.06% (15-30 cm). The mean total nitrogen values obtained were 0.08% (8.0 gkg^{-1}), 0.09% (9.0 gkg^{-1}), 0.07% (7.0 gkg^{-1}), 0.07% (7.0 gkg^{-1}) for NKF1, NKF2, NKF3, and control, respectively. These range of values were rated as been low when compared with the medium range of 1.00-4.50gkg^{-1} (Enwezor *et al.*, 1989*)*. This could be attributed to the coarse nature of the soils which encourages leaching with respect to heavy rainfall characteristics of the study area. This agreed with the report of Opukiri *et al.*, 1991 that heavy rainfall in the humid tropics causes serious leaching of soil nutrients especially, nitrogen.

Caton exchange capacity, base saturation & available phosphorus

The mean CEC values obtained over the study area ranged from 4.73 to 7.37 $Cmolkg^{-1}$. Higher CEC value of 6.16 $Cmolkg^{-1}$ and 7.37 $Cmolkg^{-1}$ obtained at NKF 1 and NKF 2, respectively may be due to their high organic matter content which is CEC dependent. Generally, CEC values were low and may be attributed to high weathering and leaching of soils over the studied area (Ufot, 2012).

The mean % BS obtained were 82.85, 87.90, 81.70 and 77.30% for NKF 1, NKF 2, NKF 3 and control. The % BS was generally high, with NKF2 having the highest and the control the least % BS. The coefficients of variation in all the study sites were low. The mean avail, P. values recorded were 3.30, 4,56, 10.59 and 6.15 $mgkg^{-1}$ for NKF 1, NKF 2, NKF 3, and the control, respectively. Generally, the variation from the mean ranges from low to moderate over the study sites.

Concentration of selected heavy metals in the studied site

The lead (Pb) and cadmium contents (Cd) of the studied area (Nekede mechanic village) are shown in Table. 3. The value of Pb obtained from the studied soils were 12.36 $mgkg^{-1}$ (0-15 cm) and 7.15 $mgkg^{-1}$, at NKF 1 site, 15.54 $mgkg^{-1}$(0-15 cm) and 9.12 $mgkg^{-1}$(15-30cm) at NKF2, 10.61 $mgkg^{-1}$(0-15 cm) and 7.26 $mgkg^{-1}$(15-30 cm) at NKF 3, 4.11 $mgkg^{-1}$(0-15 cm) and 3.15 $mgkg^{-1}$(15-30 cm) at the control site. The Pb content of NKF 1, NKF 2, and NKF 3 were significantly higher than the control and they have exceeded permissible value of 0.050 $mgkg^{-1}$ in soils according to WHO, (2006). It was observed that Pb concentration reduced with increase in depth and the coefficient of variation over the studied sites ranges from low to moderate. The very high Pb concentration observed in NKF1, NKF2, and NKF 3, may be due to land use and low P^H. high concentrations of Pb could be associated with lead acid batteries and which are among the constituents of the wastes applied at this mechanic village.

The Cd obtained from the studied soils were 1.65 $mgkg^{-1}$ (0-15 cm), 2.40 $mgkg^{-1}$(15-30 cm) at NKF1, 1.85 $mgkg^{-1}$ (0-15 cm), 1.21 $mgkg^{-1}$ (15-30 cm) at NKF 2, 2.30 $mgkg^{-1}$ (0-15 cm), 1.15 $mgkg^{-1}$(15-30 cm) at NKF 3 and 0.85 $mgkg^{-1}$ (0-15 cm), 0.74 $mgkg^{-1}$ (15-30 cm) at the control site. Also, cadmium concentration decreases with increasing depth except for NKF 1 where it increases with increasing depth.

The Cd content over the studied area exceeded the permissible limit (0.10 $mgkg^{-1}$) in soil according to WHO, (2006). The coefficient of variation ranged from low to moderate. The highest Cd content (2.40 $mgkg^{-1}$) in the 15-30 cm soil depth occurred at NKF1 site while the least Cd (0.74 $mgkg^{-1}$) was obtained at the control site. Such result may be due to the deposits at the mechanic village. Soils of mechanic village do receive waste water, crude spills and anthropogenic waste from industrial and domestic activities that contributes to heavy metal accumulation in the soils.

Conclusion and Recommendation

This study was carried out to evaluate the concentration of selected heavy metal (lead and cadmium) in Nekede mechanic village, Owerri, Imo State. Results from this study revealed that NKF 2 had the highest Pb content (15.54 $mgkg^{-1}$) in the 0-15 cm depth while the control had the lowest Pb content (3.15 $mgkg^{-1}$) in the 15-30cm. Similarly, the highest Cd content (2.40 $mgkg\text{-}^{1}$) in the 15-30 cm occurred at NKF 1 site, while the control site had the lowest Cd content (0.74 $mgkg^{-1}$) in the 15-30 cm depth. Pb recorded its highest mean value (12.33 $mgkg^{-1}$) at NKF 2 while Cd recorded its highest mean value of 2.03 $mgkg^{-1}$ at NKF 1. The concentration of the selected heavy metals [lead and cadmium] were above the permissible limit given by WHO (2006) and hence toxic to the environment. Considering land use and capability studies, its recommended that mechanic village should not be sited in lands that are suitable for agricultural purposes to avoid risk of introducing undesirable heavy metals into the soil and also the food chain. Governments should assist to put up sanctions or laws that will be geared towards reducing the amount of fume emission of vehicles by car manufactures and indiscriminate deposition of vehicular wastes/oil spills. While routine monitoring of soils, surface and underground waters in mechanic villages should be conducted frequently in order to avoid contamination/pollution of our environment as well as arable lands for agriculture.

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