ASSESSMENT OF THE LEVEL OF CONTAMINATION OF SOILS FROM A DUMPSITE AT ONITSHA, NIGERIA

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Abstract: The concentrations of heavy metals and other soil variables; textural classes, pH, bulk density and soil moisture in soil receptacles of a solid waste dumpsite at Onitsha, Nigeria were assessed to ascertain the level of contamination. Soils from three sampling points and depths; SP1 (0-15 cm), SP2 (16-30 cm) and SP3 (31-45 cm) soil depths were analyzed. Results revealed that the mean values of Nickel (Ni), Iron (Fe), Lead (Pb), Manganese (Mn), Zinc (Zn), Chromium (Cr) and Cadmium (Cd) varied thus: 2.04 ± 0.53, 287 ± 69.76, 16.12 ± 4.16, 90.36 ± 18.12, 91.11 ± 19.88, 16.52 ± 4.01 and 9.54 ± 1.49 mg/kg, respectively; in the order Fe > Zn > Mn > Cr > Pb > Cd > Ni. Concentrations of some metals were above the permissible limit set by EPA. There were significant differences in the concentrations of most metals across the soil profile (P>0.05). The acidic pH (5.4 to 6.0) recorded encouraged the mobility of the metals, the soil texture at all sampling points was found to be sandy (69% sand and above). The moisture content was directly proportional to the sand content while the bulk density was indirectly proportional to the sand content.

Keywords: Heavy metals, soil receptacles, dumpsite, bulk density, moisture content

Introduction

Increasing population and proliferation of basic industrial processes in major cities of the world led to increasing waste volumes. Proper wastes disposal has been a serious problem in Onitsha, the largest city in Anambra state and most other cities in Nigeria. Industrialization has led to increased concentration of heavy metals in soils (Massas *et al.*, 2009; Koulourasis *et al.*, 2009; Srinivasa *et al.*, 2010). This had led to a growing environmental pollution thus posing threat to the environment (Adewuyi and Opasina, 2010).

When metals are burnt at dumpsites, ashes with high metallic contents are produced. These would afterwards dissolve in rain water, leached into the soil and transferred into the food chain via absorbtion by plants (Dosumu, 2003; Trueby, 2003). Akaeze (2001) observed a concentration of iron range between (10,300 - 31,000) ppm at Elelenwo dump site, Rivers State. Awomeso *et al*. (2010) linked the high concentrations of heavy metals in the environment with effluents from industries, refuses and sewage while Eddy *et al*. (2004) opined that other natural sources of iron must be considered in assessing pollution of an environment by iron. Amusan *et al.* (2005) reported that crops growing in dumpsites bio-accumulated considerably higher heavy metal content than those in normal agricultural soils; with differences in the crops' ability to uptake them. Lenntech (2009) documented that an uptake of too much Nickel causes lung cancer, nose cancer, birth defects and allergic reactions.

Oriasojie and Ndiokwere (2008) reported that low pH favours availability, mobility and redistribution of metals. Ogbonna *et al.* (2009) observed that the pH of soils of waste dumpsites in Port Harcourt Municipality and Environs were slightly acidic; 5.5 for the top soil and 5.8 for 30 cm soil depth in all the dumpsites studied.

This research work is aimed at assessing the levels of some heavy metals and other edaphic factors in soil receptacles of a solid waste dumpsite in Onitsha main market, Anambra State, Nigeria.

Materials and Methods

Study area

Onitsha cited between latitude 6° 09' 8.64''N of the equator and longitude 6° 46' 17.76''E of the Green which meridian is located by the bank of River Niger (Plate 1). It is a commercial town in the South-East Nigeria and has one of the largest markets in Nigeria, which attract people from all parts of the world. It is surrounded by many industrial factories, gasoline stations, motor parks, automobile spare parts markets, automobile repair workshops, electrical parts market and hospitals. The dumpsite thus receives wastes from domestic, industrial, medical and agricultural sources which have constituted environmental nuisance in the city.

Plate 1: Map of Nigeria showing Onitsha in red

Three sampling points and depths; SP1 (0-15 cm), SP2 (16-30 cm) and SP3 (31-45 cm) respectively were taken at the dumpsite which had been used for 20 years.

Soil sample collection

Soil samples were collected from all the sampling points; four samples fromeach point along the direction of the drainage. These were afterwards packed in labeled polythene bags and transferred for laboratory analysis.

Determination of heavy metals

Concentrations of Pb, Cd, Zn, Cr, Ni, Mn and Fe were determined using Spectra AA 600 Atomic Absorption Spectrometer.

Determination of soil textural classes

This was carried out using the hydrometer method (Hamdeh, 2004).

Determination of pH

Soil pH was measuredusing Corning pH meter model 7 (Pansu and Gautheyrou, 2006).

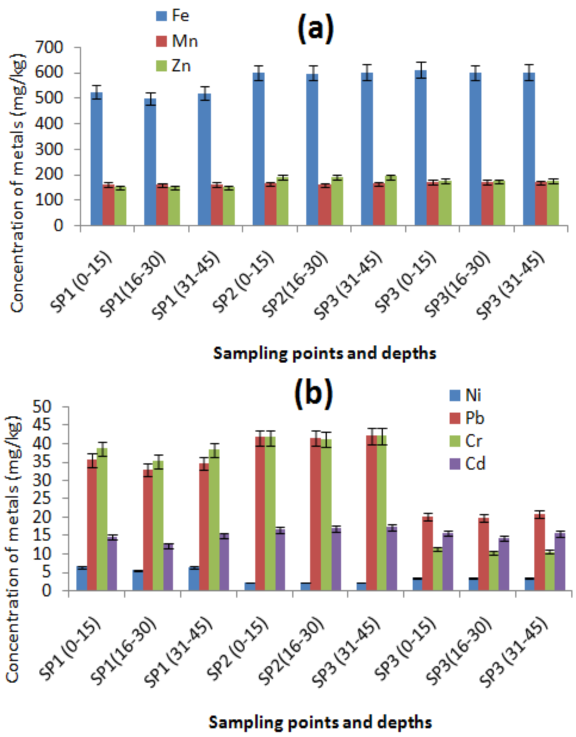
Determination of bulk density
Bulk density was determined according to Pansu and Gautheyrou (2006).

Determination of moisture content
The moisture content was determined using an oven dry method in which samples were dried to constant weights (Pansu and Gautheyrou, 2006).

Data analysis
Data were analyzed with descriptive statistics, one way analysis of variance and Pearson's correlation coefficient at 5% level of significance.

Results and Discussion

Concentration of heavy metals
The results of the mean concentration of the heavy metals investigated are shown in Figs 1a, 1b and Table 1. Concentration of iron in the soil samples ranged from498.7 to 610.4 mg/kg. The concentration of Iron was found to be above the permissible limit set by EPA (26,000 mg/kg) at all sampling points (Table 1). The highest concentration of iron in soil samples (610.4 mg/kg) was from 31-45 cm soil depth and the least (498.7 mg/kg) from the top soil (0-15 cm) (Fig. 1a).



Figs. 1a&b: Variations in concentrations of heavy metals (mg/kg) in the soil samples (Values shown are Mean ± Standard Error (SE))

Concentration of manganese in the soil samples ranged between 158.8 to 171.1 mg/kg. The concentration of manganese recorded for all the soil samples was below the permissible limit specified by EPA (550 mg/kg; Table 1). The highest concentration of manganese in soil samples (171.1 mg/kg) was from 31-45 cm soil depth and the least (149.8 mg/kg) from the top soil (0-15 cm) (Fig. 1a).

Concentration of zinc in the soil samples ranged between 149.8 to 192.3 mg/kg. The concentration of zinc was found to be above the permissible limit specified by EPA (60 mg/kg) at all sampling points (Table 1). The highest concentration of zinc in soil samples (192.3 mg/kg) was from 16-30 cm soil depth and the least (149.8 mg/kg) from the top soil (0-15 cm) (Fig. 1a).

Concentration of nickel in soil samples ranged between 2.19 to 6.45 mg/kg which is below the permissible limit (19 mg/kg) set by EPA (Table 1). The concentration of nickel was highest at the top soil and lowest at 16-30 cm soil depth (Fig. 1b). There are significant differences between the concentration of nickel at the top soil and those at the other soil depths ($P>0.05$).

The concentration of lead was found to be above the permissible limit recommended by EPA (20 mg/kg) at almost all the sampling points (Table 1).The highest concentration of lead in soil samples (41.6 mg/kg) was from 16-30 cm soil depth and the least (20.1 mg/kg) from 31-45 cm soil depth (Fig. 1b).

The concentration of Chromium in the soil samples was highest (42.0 mg/kg) at 16-30 cm soil depth and lowest (10.2 mg/kg) at 31-45 cm soil depth (Fig. 1b). The concentration of Chromium at all sampling points is far below the permissible limit set by EPA (Table 1). There are significant differences between the concentration of Chromium at the 31-45 cm soil depth and those at the other soil depths.

The concentration of cadmium recorded in the soils from all the sampling points was above the permissible limit recommended by EPA (1.00 mg/kg; Table 1). The 16-30 cm soil depth recorded the highest concentration of Cadmium (17.2 mg/kg) and the lowest (12.3 mg/kg) at the top soil (Fig. 1b).

The concentration of heavy metals in the soil receptacles was high (Figs. 1a and b). This could be attributed to industrial growth as well as a prolong decomposition of solid wastes in the waste dumpsite.

Iron, zinc and manganese were most responsible for the observed spatial variation, thus making these metals major pollutants of special interest. High concentration of zinc was probably as a result of zinc related depositions, while the high influx of manganese might be as a result of available steel making and aluminum industries.

Table 1: Mean concentration of heavy metal in sampling points/depths and EPA guidelines for heavy metals in the soil

Heavy metal	Concentration of heavy metals (mg/kg) in the soils from the sampling points and depths									EPA guidelines for heavy metals in soils (mg/kg) (permissible limit)
	0-15 cm			16-30 cm			31-45 cm			
	SP1	SP2	SP3	SP1	SP2	SP3	SP1	SP2	SP3	
Ni	6.45	5.54	6.22	2.18	2.19	2.20	3.42	3.4	3.35	19
Fe	525.6	498.7	518.5	600.5	600.2	601.4	610.4	600.8	602.8	26,000
Pb	35.4	32.8	34.5	41.6	41.5	42.0	20.1	19.8	20.7	20
Mn	160.8	158.8	161.5	164.5	160.2	165.0	171.1	170.2	169.4	550
Zn	150.5	149.8	151.2	189.6	191.0	192.3	175.4	173.3	176.0	60
Cr	38.5	35.1	38.2	41.6	41.0	42.0	11.3	10.2	10.5	150
Cd	14.6	12.3	15.0	16.6	17.0	17.2	15.6	14.3	15.5	1

Soil variables

Variations in other soil variables are shown in Figs. 2 and 3. There were slight variations insoil texturalclasses at different sampling points. The soil composition at the dumpsite was dominated by sand with mean value of 69% at soil depth of 31-45 cm to 70 and 70.33% for 16-30 cm and 0-15 cm soil depths, respectively (Fig. 2). There were low silt (10-13%) and clay (18 – 20%) contents in all the soil samples. The soil particles areporous and permeable which implies that plume from the wastes could easily migrate to contaminate the soil and ground water. There were significant differences between the samples' sand content and those of silt and clay.

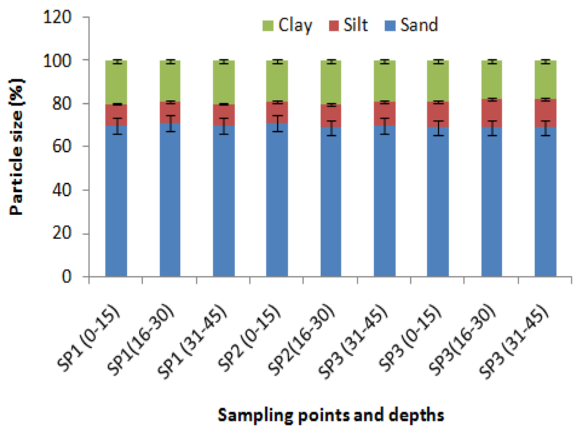


Fig. 2: Variations in soil textural classes at various sampling points. Values shown are Mean ±S.E.

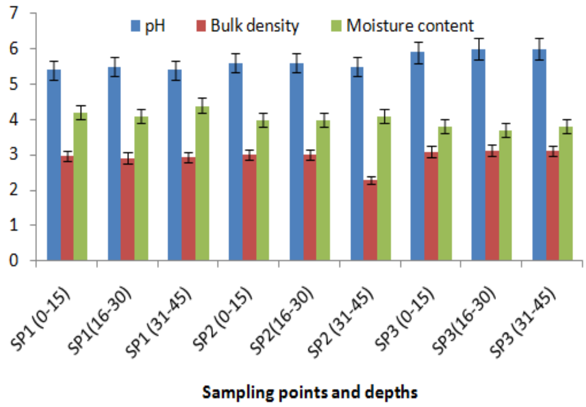


Fig. 3: Mean pH, bulk density and moisture content of soil samples

Figure 3 shows the mean pH, bulk densityand moisture content of the soil samples. The pH of the soil samples ranged from 5.4 to 6.0; slightly acidic (Fig. 3). This was probably due to the geology of the rocks. This is in line with the observations of Ogbonna *et al.* (2009) that the pH of soils of waste dumpsites in Port Harcourt Municipality and Environs were slightly acidic.The degree of acidity decreased with increasing depth which may be a contributory factor to the high concentration of heavy metals in the soils. This is in agreement with the findings of Oriasojie and Ndiokwere (2008) that low pH favours availability and mobility of metals.

The bulk density of the soil samples ranged from 2.91 to 3.13. The highest bulk density was recorded at 31-45 cm soil depth and the least at the top soil (Fig. 3). The bulk density increased with depth probably due to the compaction of the soil.Similar observation was made by Pravin *et al.* (2013) on Coimbatore Soil. The bulk density was inversely proportional to the sand content of the soil samples. There was a negative correlation between the bulk density and the sand content.

Results of the moisture content of the sampled soils are shown in Fig. 3. Moisture content ranged from 3.7 to 4.2% which was very low. The top soil (0-15 cm) recorded the highest moisture content and 31-45 cm soil depth the least (3.7%); a gradual increase with increasing soil depth. This was probably due to the high sand content which reduced the permeability of the soils. There was a positive correlation between the moisture content and the sand content.

Conclusion

The concentrations of most heavy metals were high in the soil receptacles of the waste dumpsite which poses health risk to humans and other organisms. Industrialization and migration contributed to the high concentration of heavy metals in the soil samples. Low pH encouraged the accumulation of heavy metals in the soils, and high composition of sand accounted for the high bulk density and low moisture content. Waste should be segregated and treated before disposal, while the entire waste management should be planned in the basic concept of reduction, reuse, recycle and recovery.

Conflict of Interest

Authors declare that there is no conflict of interest reported on this work.

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