International Scholars Journals

African Journal of Soil Science ISSN 2375-088X Vol. 7 (8), pp. 001-004, August, 2019. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Levels of toxic elements in soils of abandoned waste dump site

Okoronkwo[1]*, N.E., Odemelam, S.A.[2] and Ano, O.A.[3]

[1]Department of Industrial Chemistry, Abia State University, Uturu, Nigeria.
[2]Department of Chemistry, Michael Okpara University of Agriculture, Umudike Abia, State, Nigeria.
[3]Department of Soil Sciences, National Root Crop Research Institute, Umudike, Abia State, Nigeria.

Accepted 12 April, 2019

The soils of an abandoned waste dumps sites which has been presently used for crop cultivation was investigated. Three points on the location of the waste dump site were selected and three pits of 100 cm depth were dug at selected points. Soils samples were collected at an interval of 10 cm from the three pits. The physico-chemical properties and toxic heavy metal (As, Cd, Cr, Ni and Pb) levels were determined. The results of the study showed that the mean percentage of sand, silt and clay were 75.01±2.31, 12.87±0.93 and 10.45±1.47, respectively, while the mean pH was 6.89±0.01. The mean percentage organic matter content were high and was 3.47±0.41. The mean exchangeable Ca, Mg, K and Na in meq/100 g of soil were 4.20±0.42, 3.41±0.32, 0.31±0.004 and 0.47±0.006, respectively. The mean exchangeable acidity (EA) and exchangeable Al were 0.23±0.002 and 0.69±0.004, respectively. Of all the five toxic elements studied, the highest mean concentration (mg/kg) of 133.74±10.60 was recorded for Pb followed by Cr (22.27±3.03), Ni (8.14±0.33) and As (5.97±0.32) in the soils while the least mean concentration of 1.64±0.11 was recorded for Cd. The toxic elements were examined for dependency upon some soil factors through the use of correlation analysis, sand, organic matter and effective cation exchange capacity (ECEC) correlated significantly and positively with Cr and Pb indicating that these factors largely control the concentration of these elements in the soils.

Key words: Toxic elements, waste dump site, crop cultivation physico-chemical.

INTRODUCTION

The soil is a primary recipient of solid wastes (Nyles and Ray, 1999). Millions of tons of these wastes from a variety of sources: industrial, domestic and agricultural, find their way unto the soil. These wastes end up interacting with the soil system thereby changing the physical and chemical properties (Piccolo and Mbagwu, 1997). According to Anikwe (2000), waste amended soils have high content of organic matter. Soil organic matter influences the degree of aggregation and aggregate stability (Mbagwu and Piccolo, 1990) and also can reduce bulk density and increase total porosity) and hydraulic conductivity in heavy clay soils, but the magnitude of increase depends on the rate of application (Anikwe, 2000 and Mbagwu, 1989).

According to Anikwe and Nwobodo (2001), municipal wastes increase the nitrogen, pH, cation exchange capacity, percentage base saturation and organic matter. Organic waste can provide nutrients for increased plant growth, and such positive effect will likely encourage continued land application of these wastes (Anikwe and Nwobodo, 2001; Nyles and Ray 1999). However excessive waste in soil may increase heavy metal concentration in the soil and underground water. Heavy metals may have harmful effects on soils, crop and human health (Nyle and Ray 1999; Smith et al., 1996).

Many metals act as biological poisons even at parts per billion (ppb) levels. The toxic elements accumulate in organic matter in soils and sediments are taken up by

*Corresponding authors E-mail: nnennaejijeokoronkwo@yahoo.com

Table 1. Mean ± SEM values of the physico-chemical properties of the abandoned waste dump soils with respect to the profiles.

Soil	% Sand	% Silt	% clay	PH (H_20)	OC (%)	OM (%)	meq/100 g of soil				TEB	EA	ECEC	BA (%)	Al	P
							Ca	Mg	K	Na						
P1	66.80± 2.60[b]	17.90± 1.26[a]	15.30± 1.46[a]	7.13± 0.01[a]	1.02± 0.29[c]	1.76± 0.50[b]	2.60± 0.60[b]	2.02± 0.15[c]	0.39± 0.102[a]	0.46± 0.006[a]	5.47± 0.65[c]	0.17± 0.004[a]	5.64± 0.59[c]	97.22± 0.38[a]	0.57± 0.004[a]	3.23± 0.59[c]
P2	78.62± 2.48[a]	10..33± 1.41[a]	11.33± 3.52[ab]	6.91± 0.14[a]	1.97± 0.38[b]	3.19± 0.69[b]	3.96± 0.52[b]	3.34± 0.57[b]	0.26± 0.04	0.34± 0.002[a]	7.91± 0.65[c]	0.25± 0.003[a]	8.15± 0.76[b]	96.65± 0.57[a]	0.76± 0.007[a]	7.62± 0.71[b]
P3	79.62± 5.24[a]	10.39± 0.76[b]	4.99± 0.79[b]	6.61± 0.01[b]	3.39± 0.24[a]	5.46± 0.37[a]	6.04 ± 0.67[a]	4.86± 0.45[a]	0.29± 0.006[a]	0.61± 0.96[a]	11.80± 0.97[a]	0.26± 0.002[a]	12.07± 0.97[a]	97.77± 0.30[a]	0.75± 0.11[a]	10.81 ± 0.51[a]
Mean	75.01± 2.31	12.87± 0.93	10.45± 1.477	6.89± 0.01	2.13± 0.25	3.47± 0.41	4.20± 0.42	3.41± 0.32	0.31± 0.004	0.47± 0.00	8.39± 0.66	0.23± 0.002	8.62± 0.67	97.21± 0.26	0.69± 0.004	7.22± 0.67

Values are mean ± SEM (mg/kg).
OC: Percentage Organic Carbon
OM: Percentage Organic Matter
TEB: Total Exchangeable Bases
EA: Exchangeable Acidity
BA: Base saturation
ECEC: Effective Cation Exchange Capacity
SEM: Standard Error of Mean
Simple Size of each soil (pit) = 10
Similar letters in a column indicates not statistically significant using Duncan Multiple Range test.

growing plants (Dara, 1993). The metals are not toxic as the condensed free elements but are dangerous in the form of cation and when bonded to short chains of carbon atoms (Bairds, 1995). Most metals with important commercial uses are toxic and hence undesirable for indiscriminate release into the environment. Such metal include copper, chromium and nickel, which are used in electroplating as well as vanadium, nickel and mercury are often the active ingredients in catalysts (Bunce, 1990) It is the aim of this work, therefore to investigate the physico-chemical properties and levels of some highly toxic elements in the waste dump soils currently used for cultivation of crops.

MATERIALS AND METHODS

The study was carried out on an abandoned waste dump site in urban Umuahia, capital of Abia State in Southern Nigeria presently used for cultivation of crops. Three points on the location of the waste dump site were selected and three pits of 100 cm depth were dug at selected points. Soils samples were collected at an interval of 10 cm from each pit which were placed in labeled plastic bags.

The soil samples were air -dried and passed through 2 mm sieve. Thereafter, 10 g of the 2 mm sieve soil samples were further homogenized. Then 1 g of the homogenized soil sample was weighed into a beaker (100 ml) and 10 ml nitric acid was added. This was heated until dryness. Then 10 ml concentrated HNO_3 and 3 ml concentrated $HClO_4$ were added and the solution was heated until fuming. The sample solution was obtained by processing the residue with 4 ml of hot 6 M HCl which was then filtered and diluted with water to 50 ml (MAFF, 1981). The toxic elements (As, Cd, Cr, Ni and Pb) in these solutions were determined by Atomic Absorption Spectrophotometer (AAS), UNICAM 919 model.

The physico- chemical properties of the soils were determine by using standard methods: particle size distribution was determined by the hydrometer method as described by Bauyocos (1951); soil pH and organic matter were determined by methods described by Ano (1994) and Walkley and Black (1934). Total exchangeable bases (TEB) and exchange acidity (EA) in the soil were determined by method described by Jackson (1958). And the effective cation exchange capacity (ECEC) was then calculated as ECEC = TEB + EA. The available phosphorus was determined by the method described by Udo and Ogunwale (1978).

RESULTS AND DISCUSSION

The physico- chemical properties of the soils are shown in Table 1. The sand is poorly sorted and the sand fraction was generally high in all three soils profiled; pits P_1, P_2 and P_3. The poorly sorted nature of the various particle size indicate that these soils were not formed from the natural process of weathering of the underlying parent material but rather from deposited wastes. The clay fraction was low. According to Nyles and Ray (1999), soils separate with high sand and low clay content have high pollutant leaching potentials. It could therefore be deduced that the underground water in this dump site could suffer from pollution.

The pH of the soil in water were 7.13± 0.01, 6.91± 0.14 and 6.61± 0.01 for P_1, P_2, and p_3 respectively. According to Isirimah et al. (2003), most plant and soil microorganisms thrive best in soils of pH between 6 and 7.5. The total mean percentage of organic matter of 3.47± 0.25% in soils could therefore be said to be high based on the classification soil organic matter given by Enwezor et al. (1988). The overall mean exchangeable bases in meq/100 g of soils were record as to be 4.20± 0.42, 3.41± 0.42, 0.31± 0.004 and 0.47± 00 for Ca, Mg, K and Na, respectively. This followed the pattern reported by Isirimah et al. (2003) for productive agricultural soil. The high base saturation of the dump soils may be as a result of increase release of Na, K, Ca and Mg by decomposing waste. High percentage base saturation in the soils is an indication of good yield. The exchangeable acidity (EA) was generally low. This may be attributed to the low acidity to neutral pH in water of the soils. The overall mean concentration of 7.22± 0.67 mg/kg was recorded for phosphorus in the soil. This contributed to good growth of plants as was observed.

The distribution of mean concentration elements present in the soils is shown in Table 2. Lead (Pb) had the highest concentration with a mean concentration (mg/kg) of 133.74±10.60 mg/kg. Cadmium (Cd) had the least mean concentration of 2.08± 0.12 mg/kg. The mean concentrations of 22.27± 3.03 mg/kg was recorded for Cr. This was followed by Ni which had the mean concentration of 8.14±0.33 mg/kg. The mean value recorded for As is 5.97± 0.32 mg/kg.

However, when the levels of these toxic elements obtained in this study were compared with values reported in literature, (Pb) levels found to be within a concentration range of 30-300 mg/kg reported by Kabata-Pendias and Pendias (1984) and well above the permissible level for soils recommended by USEPA (1986). Nickel (Ni.), chromium (Cr), Cadmium (Cd) and arsenic (As) were found to be below the critical permissible concentration of 50, 400 (provisional), 3.0 and 50 mg/kg, respectively, as given by MAFF (1992) and EC (1986). Even though these heavy metal concentrations fell below the critical permissible concentration level, it seems that their persistence in the soils of the dump site may lead to increase uptake of these heavy metal by plants. Klock et al. (1984) reported that plants can also accumulate relatively large amounts of these elements by foliar absorption.

The significant difference (at P=0.05) were examined for the three profile pits to ascertain the difference in the levels of toxic elements in each pits. This relationship was also shown in Table 2. The toxic elements in these souls were also examined for dependency upon some soil factors through the use of correlation analysis (Table 3). Sand organic matter and effective cation exchange capacity (ECEC) correlated significantly and positively with lead (Pb) and chromium (Cr) indicating that these factors largely control the concentration of these elements in the soils.

Table 2. Concentration of heavy metal in the soils of abandoned waste dump site.

Soil	Pb	Ni	Cr	Cd	As
P1	96.45±8.05[b]	8.25±0.41[ab]	14.85±1.44[b]	2.09±0.20[ab]	5.71±0.45[a]
P2	147.70±22.85[a]	7.23±0.35[b]	17.95±0.11[b]	1.64±0.11[b]	5.61±0.61[a]
P3	157.09±16.19[a]	8.93±0.76[a]	34.00±7.62[a]	2.50±0.23[s]	6.58±0.61[a]
Mean	133.74±10.60	8.14±0.33	22.27±3.03	2.08±0.12	5.97±0.32

Values are mean ± SEM (mg/kg).

Table 3. Correlation coefficient (r value) between heavy metals in soils and some soil factor.

Factor	Pb	Ni	Cr	Cd	As	Cu	Zn
Clay	-0.6988**	-0.205[ns]	0.707**	-0.350[ns]	-0.373**	-0.912**	-0.895**
Sand	0.578**	0.168[ns]	0.516**	0.358[ns]	0.2182[ns]	0.733**	0.561**
Silt	-0.244[ns]	0.130[ns]	-0.122[ns]	-0.148[ns]	0.075[ns]	-0.360[ns]	-0.104[ns]
PH	-0.523**	-0.136[ns]	-0.431*	-0.107[ns]	-0.132[ns]	-0.682**	-0.562**
OM	0.461*	0.280[ns]	0.525**	0.296[ns]	0.273[ns]	0.689**	0.474**
ECEC	0.525**	0.204[ns]	0.557**	0.357[ns]	0.315[ns]	0.737**	0.441**

**Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level.
Ns: Correlation is not significant at the 0.05 level.
OM: Organic matter (%).
ECEC: Effective cation exchange capacity.

REFERENCES

Anikwe MAN, Nwobodo KCA (2001). Long Term Effect of Municipal Waste Disposal on Soil Properties and productivity of Sites used for Urban Agriculture in Abakaliki, Nigeria. Bioresources Technol. 83: 241-251.

Anikwe MAN (2000). Amelioration of a Heavy Clayloam Soil with Rice Husk Dust Properties and Maize Yield. Bioresource Technol. 74: 169-173.

Anikwe MAN (2000). Amelioration of a Heavy Clayloam Soil with Rice Husk Dust and its Effect on Soil Physical Properties in Abakaliki Agroecological Zone S. E. Nigeria. Environ. Edu. Infor. 18: 79-89.

Ano AO (1994). Trace Metal Studies on Soils of the Nigeria Coastal Plain Sands I: Status of Cu, ZN, Pb, Fe and Mn. J. Soils Crops. 4(1): 1-5.

Bairds C (1995). Environmental Chemistry Printed in USA pp. 384-387.

Bougoucos GH (1951). Determination of Partide Sizes in Soil Agron. J. 43: 434-438.

Bunce NJ (1990). Environmental Chemistry Winers Publishing Ltd. Winnipeg Canada. pp. 206-247.

Dara SS (1993). A Textbook of Environmental Chemistry and Pollution Control. Printed at Rjendra Ravindra Printers (PVT) Ltd. Ram Niger, New Delhi 10055, 167-206.

EC (council of the European Communities) (1986). Directive 86278 EEC on the Protection of the Environment and in Particular of the Soil when Sewage Sludge is used EEC. Brussels.

Enwezor WO, Ohiri AC, Opubaribo EE, Udoh EJ (Eds.) (1988). A Review of Soil Fertility Investigators in South Eastern Nigeria, Vol. HFDA Lagos Nigeria.

Isirimah NO, Igwe C, Iwegbue CMA (2003). Important Ions in Soils Environment In: Introductory Soil Chemistry and Biology for Agric and Biotech. Osia In'l Pub. Lt. PH. pp. 34-97.

Jackson ML (1959). Soil Chemical Analysis Prentice Hall Inc. Engle wood Clifts. New Jersey. USA.

Kabata-Pendias A and Pendias H (1984). Trace Elements in Soils and Plants CRC Press Boca Raton Fla. 85: 107-129.

Klocke A, Squerbeck DR, Vetter H (1984). Changing Metal Cycles and Human Health. Nnagu JO (ed.) Springier. Verling Bertin.

Maff (Ministry of Agriculture, Fisheries and Food)(1981). Academic S. L. Leon. p. 221.

Maff and Welch Office Agriculture Department (1992). Code of Good Agricultural Practice for the protection of Soil. Draft consultation Document, MAFF London.

Mbagwu JSC (1989). Influence of Cattle Feed lot Manure on Aggregate Stability, Plastic Limit and Water Central Italy – Biological Wastes. 28: 257-269.

Mbagwu JSC, Piccolo A (1990). Some Physical Properties of Structural Aggregator Separated from Organic Waste-amended Soil. Biological Waste. 23: 107-121.

Nyle CB, Ray RN (1999). The Nature and Properties of Soils. 12th Ed. United States of America pp. 743-785.

Piccolo A, Mbagwu JSC (1997). Exogenous Humic Substances as Conditions for the Rehabilitation of Degraded Soils. Agro-Foods Industry Hi-Tech. March/April.

Smith CJ, Hopmans P, Cook FJ (1996). Accumulation of Cr, Pb, Cu, Ni, Zn and Cd in Soil following Irrigation with Untreated Urban Efflients in Australia. Environmental Pollution 94(3): 317-323.

U. S. Environmental Protection Agency (1986). Test Methods of Evaluation for Solid Waste (USEPA S/W 846 UEPA Washington DC).

Udo EJ, Ogunwale JA (1978). Laboratory Manual for the Analysis of Soils, Plants and water Samples. Dept. of Agronomy University of Ibadan. p. 45.

Walkley A, Black, IA (1934). An Examination of the Detjare Method for Determining Soil Organic Matter and a proposed modification of the Chronic Acid Titratio. Soil Science. 37: 29-36.