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(RESEARCH ARTICLE)

Assessment of soil properties in abandoned dumpsites in Aba Metropolis, Abia State, Nigeria

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Abstract

Solid waste management is an environmental challenge affecting all spheres of environment including soil. However, little is known about the status of soil under abandoned dumpsites. The present study investigated the soil properties in the abandoned dumpsites of different ages in Aba Metropolis namely Umunwankwo (25 years) and Umuigwe (3 years) dumpsites. Ten 10m x10m quadrats were delineated in each dumpsites and relatively disturbed forest (RDF) i.e. control plot. A soil sample was collected in each quadrat using soil auger at the topsoil (0-15cm depth); thus, 10 soil samples were collected from each dumpsite and RDF. Soil samples were collected into well-labelled polythene bags and brought into the laboratory. The soil samples were air-dried and carefully sieved with 2mm diameter mesh to separate the soil from stones. Thereafter, the soil samples were taken to the laboratory for analysis to determine the levels of the physical and chemical properties in the dumpsites and RDF using standard techniques. Descriptive and inferential statistics were used for data analysis. Results showed that sand content was predominantly high in the study area and silt content (3.15±0.6%), Organic C (3.33±0.6%), total N (0.33±0.1%) and K (0.50±0.2 meq/100g) were significantly highest in the abandoned dumpsite of 3 years while P was significantly higher in the abandoned dumpsite of 25 years. Heavy metals were highest in the abandoned dumpsite of 3 years except Cu which was highest in the abandoned dumpsite of 25 years (28.06±7.0 mg/kg). The physico-chemical properties of soil were higher in the dumpsite than the RDF and varied significantly among the plots at $p<0.05$. The study concluded that dumpsites have the capability of releasing heavy metals into the soil ecosystem but increase the soil nutrients. The study recommended that the solid wastes should be sorted to remove those that have potentials of releasing heavy metals.

Keywords: Abandoned dumpsites; Soil properties; Solid waste; Relatively disturbed forest

1. Introduction

Soil plays significant roles in ecosystem as it presents various kinds of interactions within minerals, air, water and biota. Recently, the soil structure has been exposed to physical, chemical and biological stress by the introduction of various metallic substances. This further degrades soil organic constituents and moreover lowers soil fertility of the upper layer caused by erosion. In addition, soil tends to react much slowly to external influences than water and air, as it is able to bind smaller substances into complexes (Hickman, 2006). The binding capability of soils is done primarily with the aid of clay minerals and humic acids. Soil properties determine its usefulness. For instance, the quality of soil intended for agricultural purpose reckons within heavy metals concentration present in such a soil. Solid wastes dumped at different sites include food wastes, chemicals such as pesticides, deposits of heavy metals, etc. Certainly, all solid wastes are occupier of soil in many developing countries, the management and disposal techniques of this waste has been a

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problem for a long time. Increase in population and development have led to a gradual change in the practice of disposal of solid wastes indiscriminately at dumpsites to sanitary landfills and incineration in developed countries. One cannot over-look the possible hazards that can be created from long term dumping of refuse in the soil.

The management of urban waste is worrisome; as a result of inadequate sorting, collection/transportation and finally disposal methods has impacted on the environment, contributing to the degradation of urban cities thereby promoting health challenges to the populace. Those whom are affected mainly, are those living within the vicinity of dumpsites owed to the fact that the waste has the attribute of polluting water, food-chain, soil and other terrestrial organisms (UN-HABITAT, 2008). the quantity of waste generated (UNDP, 2006). Waste disposal methods are not monitored resulting to open dumping of refuse which leads to contamination of the environment by heavy metals. Open dump have become a cause for concern to both developed and developing countries as they have also contributed to the damage of the ecosystem (Uwah, 2011). Due to the strategic position of the market, industries and fabricating companies in Aba has contributed to high population density and accumulation of wastes. This study examined the assessment of soil properties under abandoned dumpsites of different ages in Aba Metropolis; Osisioma Ngwa LGA, Abia State in Nigeria.

2. Materials and Methods

The study was carried out in the abandoned dumpsites of Umunwankwo and Umuigwe in Osisioma LGA, Abia State, Nigeria. The dumpsite in Umunwankwo had been abandoned for thirty years twenty-five years while that of Umuigwe had been abandoned for ten years. Umunwankwo and Umuigwe abandoned dumpsite lies between latitudes 5°7‘58.60"N, 7°18‘7.22"E and 5°10‘30.81"N, 7°18‘7.22"E respectively (Figure 1). The burrow pits were excavated during the construction of the Aba-Port-Harcourt Expressway in the 1970’s and these burrow pits has given rise to the abandoned dumpsites. These abandoned dumpsites have close proximity to residential and industries areas. It was observed that solid waste was the major type of waste at the abandoned dumpsites. Its composition included plastics, metal scraps, roofing sheets, food waste, saw dust, leather materials, agricultural waste, medical waste, wood, fabrics, and many others. Umunwankwo abandoned site was about 100 sq km while for Umuigwe was about 70 sq km.. Both the commercial and fabrication activities has resulted to huge amount of wastes that are generated and discarded on daily basis lead to the choice of Umunwankwo and Umuigwe dumpsite for this study (Figure 1 & 2).

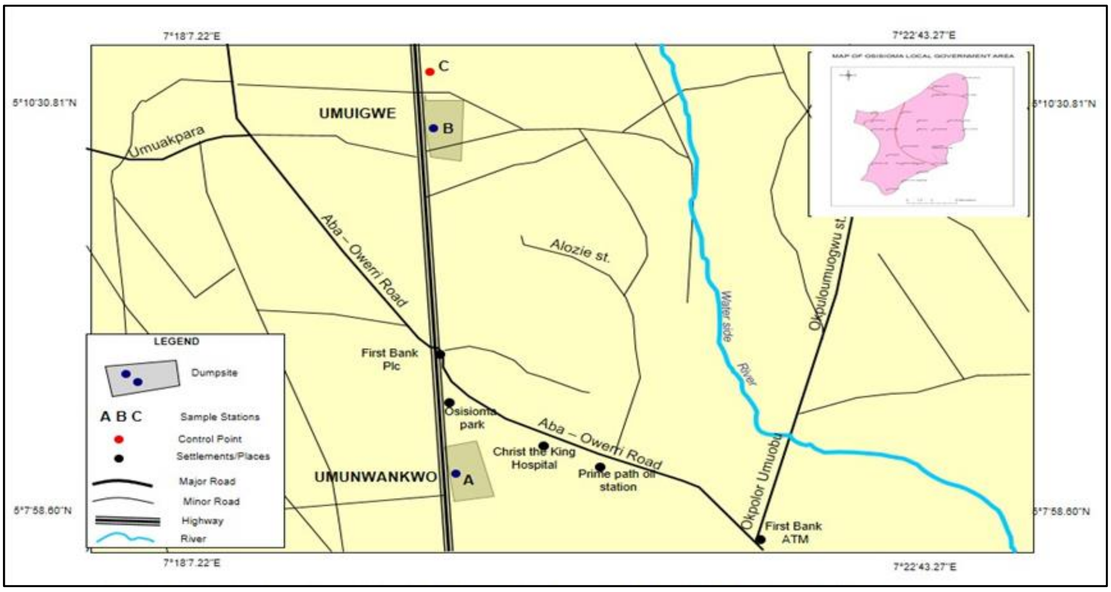

Figure 1 Umunwankwo Abandoned dumpsite of 25 years

Figure 2 Umuigwe Abandoned dumpsite of 3 years

The area of study falls within the boundaries of tropical rainforest and humid zone of South-Eastern in Nigeria. Aba falls under Am climate of Koppen's classification, with two distinguishable seasons namely, the rainy and dry seasons (Anyadike, 2002). Aba Metropolis and its environs experience intense rainfall especially in the rainy or wet teason. Rainfall is present all year with an annual total of 2000mm-2300mm, with monthly average of about 180mm. The minimum air temperature of the area is 22.8°C, whereas the maximum for this period is 32°C. The months with high temperature are January and March but the cooling influence of the harmattan winds is usually experienced in December and February. This intense rainfall is induced by excessive evapotranspiration in the urban area due to prevalent high temperature (Nwoko, 2013), though annual rainfall is greater than annual evapo-transpiration resulting in moisture surplus (Anyadike, 2002). The Aba vegetation is characterized as a rainforest vegetation belt whereby the trees are about 30 metres tall with evergreen branches interlocking to form canopies. The life-form spectrum of the vegetation of the study area indicated bush fallow type consisting of herbs, shrubs, grasses and randomly distributed oil palm trees (*Eleais guineensis*). The geology of Aba consists of the formerly coastal plain sands now known as the Benin formation of the tertiary period. The geological formation is of Cenozoic age, cross bedded, and only occasionally are pebbly sands and some beds of grey sand clay found (Umeji, 2002). The Benin formation has a maximum thickness of 1,200m and contains oil reserves, within this geologic formation are found some oil production wells of Imo River oil fields around Owaza (Ikejiani-Clark, 2007). The study area is close to the famous commercial centre with the popular Ariaria Market sited west of the Aba town (Nwoko, 2013).

2.1. Soil sampling technique, collection and laboratory analysis

The study employed an experimental research design and the abandoned dumpsites were seen as the experimental plots while the relatively disturbed forest was used as the control plot which was about 1500 meters away from the dumpsites. Ten 10m x 10m quadrats were randomly established in each of the dumpsites and the control plot minimum of 50m apart. Soil samples were collected from the the four corners of the quadrats and the center at the topsoil (0-15m) using a soil auger into a bowl for proper mixture and from this a composite soil sample from each quadrat was taken into clean polythene bags, labelled appropriately and taken to the laboratory for analyses. Thus, ten soil samples were collected in each experimental sites and the control site; therefore making a total of thirty soil samples that were used for the study. The collected soil samples were air dried remove moisture and sieved through a <2mm sieve made of stainless steel. These samples were further processed to determine the physical and chemical properties of the soil

The particle size analysis was carried out, using the Bouyoucos hydrometer method as described by Gee and Bauder (1986). Bulk density was determined by the core method as modified by Ogbuagu et al.(2013). Water holding capacity was carried out by the method of Shrivastava and Banerjee (2004). Total organic carbon was carried out by Walkley Black method (Walkey and Black, 1965; Van et al., 1999). Soil pH and electric conductivity was analysed potentiometrically in 0.01M calcium chloride solution using 1:2 soil/water solutions (Jones, 2001). Total nitrogen was determined by Kjedahl method using flask of nominal volume 50ml suitable for digestion as described by APHA (1978). Cation exchange capacity (CEC) was analysed by summation method (Chapman, 1965). Available phosphorus (P) was extracted using Bray and Kurtz solution (0.025M HCL to 0.03MN H4F) using Murphy and Riley method (Ogbonna and Okeke, 2011). Exchangeable bases such as Calcium (Ca) and Potassium (K) was determined using flame photometry. Extracts used for heavy metals analysis was obtained by leaching soil samples using 0.1N EDTA. The concentrations of extractable trace metals such as Lead (Pb), Zinc (Zn), Chromium (Cr) and Cadmium (Cd) in the solutions were determined using atomic absorption spectrophotometer (AAS) (Pansu and Gautheyrou, 2006). Descriptive statistics was used to explain the mean values of soil physical and chemical properties under abandoned dumpsites of different ages and control site. Inferential statistics such as pairwise T-test was used to determine significant variation of soil properties between the two abandoned dumpsites. All statistical analyses were performed using SPSS version 20.0 and the results were presented in tables and graphs.

3. Results

3.1. Physical Properties of Soil in Abandoned Dumpsites of Different Ages

Table 1 explains the physical properties of soil in the abandoned dumpsites of different ages. The bulk density was 1.28 g/cm3 and 1.19 g/cm3 in the abandoned dumpsite of 25 years and that of 3 years respectively suggesting that the bulk density in the older abandoned dumpsite was higher. In comparison with the control, it is found out that the bulk density was higher than that of the abandoned dumpsites. The water holding capacity was 13.45% at the control plot while at the abandoned dumpsite of 25 years, it was 12.52% and 19.19% at the 3 years abandoned dumpsites. It is also discovered that the clay content in the control was 5.15%, and 4.93% in the abandoned dumpsite of 25 years and 6.37% in the abandoned dumpsite of 3 years. Thus, the clay content in the younger abandoned dumpsite was higher than the older one. The analysis showed that silt content was lower in the older abandoned dumpsite than that the younger abandoned dumpsite while the sand content was higher in the older abandoned dumpsite.

Table 1 Physical properties of soil in abandoned dumpsites of different ages

Soil Properties	Control	Abandoned Dumpsite 25 Years	Abandoned Dumpsite 3 Years
	Mean±SD	**Mean±SD**	**Mean±SD**
Bulk Density (g/cm^3)	1.31±0.1	1.28±0.1	1.19±0.1
Water Holding Capacity (%)	13.45±4.7	12.52±2.5	19.19±5.0
Clay (%)	5.15±1.0	4.93±0.6	6.37±0.9
Silt (%)	2.03±0.6	2.16±0.7	3.15±0.6
Sand (%)	92.82±1.4	92.91±1.2	90.48±1.3

3.2. Chemical Properties of Soil in Abandoned Dumpsites of Different Ages

The chemical properties of soil under the abandoned dumpsites and control are presented in Table 2. The pH was 6.96 in the 25 years abandoned dumpsite, 6.51 in 3 years abandoned dumpsite and 5.81 in the control plot. It is thus known that the control plot was more acidic than the abandoned dumpsites. The pH in the abandoned dumpsites was more alkaline than the control plot. The EC was highest in the 3 years abandoned dumpsite while the least was found in the control plot. The CEC Organic C, total N, Na, K, Ca, and Mg in the abandoned dumpsite for 3 years was higher than that of 25 years and the lowest was seen in the control plot. The analysis of phosphorus showed that 25 years abandoned dumpsite recorded the highest (29.29 mg/kg) while the least was observed in the control plot. The study reveals that the heavy metals (Fe, Mn, Zn, Cu, Cr, Cd, Pb) were all higher under the 3 years abandoned dumpsite except Zn which was higher under the 25 years abandoned dumpsite.

Table 2 Chemical properties of soil in abandoned dumpsites of different ages

Soil Properties	Control	Abandoned Dumpsite 25 Years	Abandoned Dumpsite 3 Years
	Mean±SD	**Mean±SD**	**Mean±SD**
pH	5.81±0.4	6.96±0.3	6.51±0.3
EC (µS/cm)	242.0±63.2	317.0±111.2	2827.0±1868.9
CEC (meq/100g)	5.61±1.2	6.00±1.8	18.12±7.4
Organic C (%)	1.32±0.2	3.21±0.9	3.33±0.6
Total N (%)	0.12±0.01	0.29±0.1	0.33±0.1
Na (meq/100g)	0.88±0.2	1.04±0.3	4.33±2.1
K (meq/100g)	0.13±0.04	0.23±0.1	0.50±0.2
Ca (meq/100g)	3.81±0.8	3.91±1.4	10.50±3.9
Mg (meq/100g)	0.80±0.2	0.93±0.4	2.82±1.4
Av. P (mg/kg)	11.68±1.8	29.29±8.2	20.26±7.4
Fe (mg/kg)	205.31±84.9	417.54±178.83	612.11 ±211.2
Mn (mg/kg)	21.20±6.3	37.63±11.3	61.15±25.0
Zn(mg/kg)	32.11±6.8	97.77±15.7	104.11±32.1
Cu (mg/kg)	3.46±1.5	28.06±7.0	22.55±7.2
Cr(mg/kg)	0.73±0.2	14.01±3.9	23.38±4.3
Cd (mg/kg)	0.60±0.2	17.02±3.5	23.34±6.9
Pb (mg/kg)	1.01±0.3	15.54±4.5	24.79±6.5

3.3. Relationship among the Soil Parameters

3.3.1. Relationship among the soil chemical parameters in the relatively disturbed forest

The relationships among the chemical property in relatively disturbed forest in soils are presented in Table 3. The analysis showed that CEC is positively correlated with EC ($r=0.70$; $p<0.05$), while N and organic C ($r=0.99$; $p<0.05$). Furthermore, Na was positively correlated with CEC ($r=0.91$; $p<0.05$); while K was equally correlated with CEC ($r=0.69$; $p<0.05$). In addition, Ca was significantly correlated with CEC ($r=0.97$; $p<0.05$), Na ($r=0.80$; $p<0.05$) and K ($r=0.76$; $p<0.05$). Mg was significantly and positively correlated with EC, CEC, Na and Ca; while available P was correlated with pH and Potassium, Ca ($r=0.56$; $p<0.05$) and Mg with equal correlated ($r=0.57$; $p<0.05$). In a related development, Fe correlated negatively with pH, Na and Mg while available P had a positive correlation with Fe ($r=0.65$; $p<0.05$). The correlation between Zn and Mn was positive ($r=0.74$; $p<0.05$) while Pb also had a positive but significant correlation with pH ($r=0.65$; $p<0.05$).

3.3.2. Relationship among the soil chemical parameters in the abandoned dumpsite of 25 years

The relationships among the chemical parameters in soils under dumpsite of 25 years are presented in Table 4. The analysis showed that CEC has positive correlation with EC ($r=0.90$; $p<0.05$), while TN and Organic matter were significantly correlated with Organic C. Furthermore, Na was positively correlated with EC ($r=0.97$; $p<0.05$) and CEC ($r=0.94$; $p<0.05$); while K was equally correlated with Organic C, Total N and Organic matter ($r=0.91$; $p<0.05$). In addition, Ca was significantly correlated with EC ($r=0.87$; $p<0.05$), CEC ($r=0.99$; $p<0.05$) and Organic matter ($r=0.90$; $p<0.05$). Mg was significantly and positively correlated with EC, CEC, Na and Ca; while available P was correlated with Organic C and Organic matter with equal correlation coefficient ($r=0.77$; $p<0.05$). In a related development, Fe was positively correlated with EC, Na and available P while Mn had a negative correlation with Fe ($r=-0.64$; $p<0.05$). The correlation between Zn and Fe was negative ($r=-0.65$; $p<0.05$) while Pb also had a negative but significant correlation with Cu ($r=-0.81$; $p<0.05$).

3.3.3. Relationship among the soil chemical parameters in the abandoned dumpsite of 3 years

The relationships among the chemical property in soils under abandoned dumpsite of 3 years are presented in Table 5 The analysis revealed that CEC has a positive correlation with EC (r=0.86; p<0.05), while Na and EC were significantly correlated. Furthermore, Na is positively correlated with CEC (r=0.97; p<0.05); while K correlated with EC (r=0.75; p<0.05) and also, K was equally significantly correlated with CEC and Na. In addition, Ca was significantly correlated with EC (r=0.91; p<0.05), Ca (r=0.97; p<0.05). Na and K were equally significantly correlated (r=0.88; p<0.05). Mg was significantly and positively correlated with EC, CEC, Na and K, Ca; while available P was correlated with Organic Matter (r=0.80; p<0.05). In a related development, Fe was negatively correlated with P (r=-0.73; p<0.05), Mn also had a positive correlation with Ca (r=0.63; p<0.05). Zn and TN correlated were significantly (r=0.66; p<0.05). Cu and TN correlated positively (r=0.79; p<0.05) while Cr and Mn were negatively correlated (r=-0.73; p<0.05). The correlation between Cd and pH was positive (r=0.79; p<0.05), Cd and Organic matter correlated negatively (r=-0.78; p<0.05), same as Cd and Mn. while Pb also had a positive correlation with Cr and Cd (r=0.71; p<0.05).

Table 3 Correlation of Chemical Property in Relatively Disturbed Forest

	pH	**EC**	**CEC**	**Org. C**	**TN**	**Na**	**K**	**Ca**	**Mg**	**P**	**Fe**	**Mn**	**Zn**	**Cu**	**Cr**	**Cd**	**Pb**
pH	1.00	0.14	0.42	-0.23	-0.21	0.48	0.34	0.34	0.48	-0.64*	-0.65*	0.39	-0.05	-0.42	-0.46	0.30	0.65*
EC		1.00	0.70*	0.15	0.16	0.83*	0.04	0.58	0.83*	-0.07	-0.54	-0.13	-0.33	0.26	-0.13	0.02	-0.20
CEC			1.00	-0.12	-0.11	0.91*	0.69*	0.97*	0.91*	-0.60	-0.61	-0.11	-0.21	-0.05	-0.23	-0.30	0.04
OrgC				1.00	0.99*	-0.16	-0.45	-0.07	-0.16	0.43	0.32	-0.40	-0.13	0.18	-0.05	0.01	-0.03
TN					1.00	-0.15	-0.45	-0.05	-0.15	.043	0.32	-0.41	-0.11	0.14	-0.15	0.03	-0.06
Org.M						-0.16	-0.45	-.007	-0.17	0.43	0.32	-0.40	-0.13	0.17	-0.05	0.01	-0.03
Na						1.00	0.46	0.80*	1.00*	-0.57	-0.77*	-.03	-0.30	0.08	-0.31	-0.13	0.07
K							1.00	0.76*	0.46	-0.71*	-0.45	-0.15	-0.19	-0.33	-0.05	-0.61	-0.03
Ca								1.00	0.80*	-0.56	-0.46	-0.14	-0.13	-0.11	-0.17	-0.36	0.03
Mg									1.00	-0.57	-0.77*	-0.04	-0.30	0.09	-0.31	-0.13	0.06
P										1.00	0.65*	0.09	0.27	0.49	0.40	0.30	-0.43
Fe											1.00	0.13	0.63	0.19	0.26	0.21	-0.03
Mn												1.00	0.74*	0.20	0.04	0.76*	0.56
Zn													1.00	0.26	0.14	0.59	0.42
Cu														1.00	0.19	0.05	-0.25
Cr															1.00	-0.02	-0.26
Cd																1.00	0.57
Pb																	1.00

N=10; *Correlation is significant at p<0.05

Table 4 Correlation of Chemical Property in Abandoned Dumpsite of 30 Years

	pH	**EC**	**CEC**	**Org.C**	**TN**	**Org.M**	**Na**	**K**	**Ca**	**Mg**	**P**	**Fe**	**Mn**	**Zn**	**Cu**	**Cr**	**Cd**	**Pb**
pH	1.00	-0.03	0.02	-0.14	-0.13	-0.14	-0.08	0.12	0.01	-0.19	-0.12	-0.07	-0.22	-0.08	-0.46	0.50	-0.06	0.01
EC		1.00	0.90*	0.15	0.13	0.15	0.97*	0.38	0.87*	0.94*	0.04	0.73*	-0.41	-0.30	-0.42	0.37	-0.25	0.43
CEC			1.00	-0.04	-0.06	-0.04	0.94*	0.19	0.99*	0.84*	-0.01	0.38	-0.05	0.04	-0.27	0.32	-0.51	0.29
Org.C				1.00	1.00*	1.00*	0.18	0.91*	-0.13	0.33	0.77*	0.57	0.04	-0.54	-0.03	0.26	0.32	0.06

TN					1.00	1.00*	0.16	0.91*	-0.15	0.31	0.76*	0.56	0.03	-0.54	-0.03	0.24	0.32	0.05
Org,M						1.00	0.18	0.91*	-0.13	0.33	0.77*	0.57	0.04	-0.54	-0.03	0.26	0.31	0.06
Na							1.00	0.37	0.90*	0.95*	0.11	0.64*	-0.26	-0.18	-0.38	0.36	-0.24	0.40
K								1.00	0.10	0.47	0.58	0.70*	-0.13	-0.60	-0.21	0.33	0.12	0.09
Ca									1.00	0.79*	-0.10	0.30	-0.02	0.10	-0.22	0.26	-0.56	0.25
Mg										1.00	0.31	0.77*	-0.26	-0.21	-0.37	0.42	-0.19	0.44
P											1.00	0.33	0.27	-0.23	-0.09	0.42	0.20	0.25
Fe												1.00	-0.64*	-0.65*	-0.46	0.38	0.22	0.41
Mn													1.00	0.59	0.57	-0.19	-0.50	-0.39
Zn														1.00	0.14	-0.12	-0.42	-0.108
Cu															1.00	-0.57	-0.21	-0.81*
Cr																1.00	0.08	0.38
Cd																	1.00	0.15
Pb																		1.00

N=10; *Correlation is significant at p<0.05

Table 5 Correlation of Chemical Property in Abandoned Dumpsite of 10 Years

	pH	**EC**	**CEC**	**Org.C**	**TN**	**Org.M**	**Na**	**K**	**Ca**	**Mg**	**P**	**Fe**	**Mn**	**Zn**	**Cu**	**Cr**	**Cd**	**Pb**
pH	1.00	-0.38	-0.48	0.18	-0.02	-0.50	-0.48	-0.48	-0.45	-0.48	-0.10	0.05	-0.56	-0.32	0.30	0.36	0.79*	0.58
EC		1.00	0.86*	-0.26	0.20	0.08	0.76*	0.75*	0.91*	0.76*	0.12	-0.12	0.45	0.48	-0.09	-0.35	-0.38	-0.26
CEC			1.00	-0.18	0.28	0.25	0.97*	0.97*	0.97*	0.97*	0.28	-0.45	0.63	0.43	0.15	-0.38	-0.57	-0.43
Org.C				1.00	0.58	0.44	-0.19	-0.19	-0.16	-0.19	0.46	-0.35	0.22	0.32	0.39	-.10	0.00	0.03
TN					1.00	0.47	0.21	0.21	0.33	0.21	0.33	-0.48	0.30	0.66*	0.79*	-.11	-0.38	-0.07
Org.M						1.00	0.19	0.19	0.29	0.19	0.80*	-0.48	0.66*	0.41	0.29	-0.59	-0.78*	-0.38
Na							1.00	1.00*	0.88*	1.00*	0.20	-0.43	0.59	0.28	0.13	-0.31	-0.53	-0.53
K								1.00	0.88*	1.00*	0.20	-0.44	0.59	0.27	0.13	-0.31	-0.54	-0.53
Ca									1.00	0.88*	0.34	-0.44	0.63*	0.56	0.15	-0.41	-0.56	-0.32
Mg										1.00	0.20	-0.43	0.59	0.28	0.13	-0.31	-0.54	-0.53
P											1.00	-0.73*	0.49	0.22	0.32	-0.51	-0.44	-0.12
Fe												1.00	-0.37	-0.16	-0.53	0.32	0.41	0.23
Mn													1.00	0.57	0.16	-0.73*	-0.77*	-0.53
Zn														1.00	0.41	-0.13	-0.41	0.13
Cu															1.00	0.09	-0.16	0.17
Cr																1.00	0.69*	0.70*
Cd																	1.00	0.71*
Pb																		1.00

N=10; *Correlation is significant at p<0.05

4. Discussion of findings

Amongst the abandoned dumpsites in Aba metropolis, Umunwanwko dumpsite is the oldest and Umuigwe is among the newest closed dumpsites. It had received large volume and varieties of waste on daily basis due to its location. Umunwankwo and Umuigwe abandoned dumpsites has a close proximity to the famous Ariaria international market, mechanic workshops, factories, residential houses, plastic dealers and so on. The composition of waste in the dumpsite ranges from glass, plastics, tins, metal scraps, compostable (food, wood, agricultural waste), aluminium scraps, water sachets, cellophane bags to clinical waste etc. These wastes poses threat to their immediate surroundings, both the surface and groundwater through percolation and infiltration of dissolved wastes inform of leachates.

Soil solution in water with pH too acidic results in nutrients deficiency especially iron micronutrient (Sureh, 2008). The mean pH obtained from the soil in water ranged from 5.81μS/cm for Relatively Disturbed Forest, 6.69μS/cm for abandoned dumpsite for 25years and 6.51μS/cm for abandoned dumpsite for 3years respectively. The highest concentrations of pH were observed in abandoned dumpsite for 25years and abandoned dumpsite for 3years. DPR permissible limit for pH in soil is 6-9μS/cm (DPR, 2002). The concentrations of pH observed in soils collected from a relatively disturbed forest, abandoned dumpsite for 25years and abandoned dumpsite for 3years respectively were within the DPR limit. The result is in accordance with the work of Fowles, (2007) which has been shown that there is change in neutral pH in acidic soils. Also such results were reported for dumpsites by other researcher Isirimah, Igwe and Iwegbue, (2003) reveals that high pH (alkaline in reaction) is attributed to the organic accumulated on the soils. Most plants and soil microbes thrive best in pH of 6 and 7.5.

The results of electric conductivity (EC) in soils of the study reveals the mean of 242.0μS/cm, 317.0μS/cm and 2,827μS/cm for relatively disturbed forest, abandoned dumpsite of 25years and abandoned dumpsite of 3years respectively as shown in Table 1. The EC is high and salt-related, such results has been reported for some dumpsites at Zaira (Uba, Uzairu, Harrison, Balarabe, & Okunola, 2008). It may be attributed to the leachate infiltration in the in-situ soil by accumulation of salinity content causing increase in soil content in the abandoned dumpsite (Bhattacharya and Michael, 2003). The highest mean was obtained in abandoned dumpsite of 3years (32.70meq/100g) with relatively disturbed forest having the lowest value as 7.02meq/100g. This implies that the fertility status of abandoned dumpsite of 3years may be better than that of abandoned dumpsite of 25years and relatively disturbed forest. Cation Exchange Capacity (CEC) is the sum total of the acidic and basic cation present in the soil solution. The CEC in the soil samples of the studied reveals the mean of 7.02meq/100g, 9.29meq/100g, and 32.70meq/100 g for Relatively Disturbed Forest, and Abandoned Dumpsite of 3years respectively as shown in Table 1. All dumpsite soils had low cation exchange capacity (Lancrop Laboratori, 2013). Abandoned Dumpsite of 25years had the highest CEC 32.70meq/100g while relatively Disturbed Forest had the least CEC value of 9.29meq/100g. This suggests a low capability of the studied soils to hold cations from being leached or washed away. Cation Exchange Capacity (CEC) usually gives soil a buffering capacity that causes a slowdown in leaching of nutrient (Yoo and James, 2002).

The Organic carbon reflects the decomposition of carbon in a material. The Organic C content of the soils ranged from 1.33%, 3.22% and 3.33% for Relatively Disturbed Forest, Abandoned Dumpsite of 25years and Abandoned Dumpsite of 3years respectively. The results of Organic carbon reveals a moderation based on classification of organic carbon prescribed by Kparmwang *et al.* (2000). However, the abandoned dumpsite of 25years and 3years soils revealed a higher Total organic carbon content than the relatively disturbed secondary forest. This is achieved by the decomposition of organic material present in the waste by microorganism that increases the level of organic carbon to the dumpsite soil. Whereas organic carbon is one of the requirement for plant growth, the levels of organic matter present also influence chemical and physical processes in soil. Organic carbon is an important indicator of rooting system in soil (Okalebo *et al.,* 1993).

The total nitrogen, in the soil samples of the studied reveals the mean of 0.12%, 0.29% and 0.33% for relatively disturbed forest, abandoned dumpsite of 25years and abandoned dumpsite of 3years respectively as shown in (Table 1). Generally, the results of the total nitrogen is very low. Hence, relatively disturbed forest has lowest values of 0.12% for total nitrogen than abandoned dumpsite of 25years (0.29%) and abandoned dumpsite of 3years (0.33%). Total nitrogen is revealed to be the least nutrient present in the soil studied and these findings is in accordance with that of Obasi *et al.* (2012).

The organic matter composition in soil of the study area were 1.30%, 3.10% and 3.40% for relatively disturbed forest, abandoned dumpsite of 25years and abandoned dumpsite of 3years respectively. It is high based on the classification of soil organic matter given by Enwezor *et al.* (1998). Moreso, pH and Organic matter of dumpsites revealed to be higher at the abandoned dumpsite of 25years with the following values; pH (5.81μS/cm, 6.96 μS/cm and 6.51μS/cm) and Organic matter (1.30%, 3.10% and 3.40%), respectively. The values of Organic matter content of dumpsites when compared to relatively disturbed forest are higher and this is responsible for the high pH values obtained for the abandoned dumpsite of 25years and 3years. This finding is similar to the study conducted by Ogwuegbu and Muhanga, (2005).

The exchangeable Na values was 0.88±0.24meq/100g, 1.04±0.46meq/100g and 4.33±2.10meq/100g for relatively disturbed forest, abandoned dumpsite of 25years and abandoned dumpsite of 3years respectively as shown in (Table 1). Comparatively, the mean Na content in abandoned dumpsite of 3years was greater than Abandoned Dumpsite of 25years and Relatively Disturbed Forest. The high Na content for abandoned dumpsite of 3years also revealed high organic matter of abandoned dumpsite of 3years, compared to abandoned dumpsite of 25years and relatively disturbed forest. It can be inferred that accumulation of solid waste increase the concentration of the exchangeable bases in the soil. The mean values of exchangeable Potassium (K) reveals that 0.13meq/100g, 0.23meq/100g and 0.50meq/100g for Relatively Disturbed Forest, Abandoned Dumpsite of 25years and abandoned dumpsite of 3years respectively were observed as shown in Table 1. Potassium had a very high value of 0.5 at abandoned dumpsite of 3years, moderately high value of 0.23 at abandoned dumpsite of 25years and a very low value of 0.13 at the relatively disturbed forest, abandoned dumpsite of 3years and abandoned dumpsite of 25years were highly homogenous in both sites; there is homogeneity of K and Total Organic Carbon, as such shows that they are spatially distributed in respect their component at different locations within the abandoned dumpsites.

The exchangeable Calcium (Ca) mean recorded was 3.81meq/100g, 3.91meq/100g and 10.50meq/100g for relatively disturbed forest, abandoned dumpsite of 25years and abandoned dumpsite of 3years respectively as shown in (Table 1). Calcium which is higher in abandoned dumpsite of 3years at 10.50 than relatively disturbed forest and abandoned dumpsite of 25years, with values at 3.81 – 3.91. The high value of Ca in abandoned dumpsite of 3years revealed high organic matter in the soil. However, the values varied slightly across abandoned dumpsite of 25years (3.91) and moderately in relatively disturbed forest (3.81).

The exchangeable Magnesium (Mg) varied from 0.79meq/100g, 2.82meq/100g and 0.82meq/100g for relatively disturbed forest, abandoned dumpsite of 25years and abandoned dumpsite of 3years respectively as shown in (Table 1). The comparatively high mean of Magnesium in abandoned dumpsite of 3years revealed high organic matter content in the soil at abandoned dumpsite of 3years more than the status at abandoned dumpsite of 25years and relatively disturbed forest. The saturation of exchangeable base present at the dumpsite soils are correlated to the increase in release of Na, K, Ca and Mn by decomposing waste. High percentage base saturation in the soils is an indication of good soil property suitable for crop production.

Phosphorus is one of the essential nutrient needed for plant growth, thus soil with high phosphorus content is not regarded as significant environmental challenge. The values of the available phosphorus (Av.P) varied from 11.68mg/kg, 29.29mg/kg and 20.26mg/kg for relatively disturbed forest, abandoned dumpsite of 25years and abandoned dumpsite of 3years respectively as shown in (Table 1). The abandoned dumpsite of 25years has the highest value of phosphorus at 29.29mg/kg and the lowest value was observed for Control at 11.68mg/kg. The available phosphorus decreased with increase in distance from abandoned dumpsite of 25year, abandoned dumpsite of 3years and relatively disturbed forest. The soil sampled had higher available Phosphorus values greater than 10mg/kg, which is considered suitable for crop production as prescribed by (FAO, 1976). The concentration of available phosphorus enhanced the growth rate of plants as observed in Abandoned Dumpsite of 25years.

Solid wastes in abandoned dumpsites altered the physico-chemical properties of the soil as well as increasing the concentration of heavy metals such as Iron (Fe), Manganese (Mn), Zinc (Zn), Cadmium (Cd) and Lead (Pb). It also determined the type of plants growing in these environments (depending on their susceptibility and tolerance). The concentration level of heavy metals in soil sampled is an indication that there is appreciable contamination of the soil by leachate migration from an open dumping site (Kanmani and Gandhimathi, 2013).

Iron (Fe) not a hazardous element and by its mass is the commonest element of the earth. Much of its formation is from Earth's inner and outer core and considered as a main factor determining the adsorption capacity (Wright and Welbourn 2002). The mean concentration of 205.31mg/kg for relatively disturbed forest, 612.11mg/kg for Abandoned Dumpsite of 3years and 417.54mg/kg for Abandoned Dumpsite of 25years respectively as shown in (Table 1) exceeded the limit 20mg/kg (DPR 2002). The Abandoned dumpsite of 3years soil had the highest concentration of Fe. This is similar to the works of Magaji (2012) in a study of effects of waste dumpsites on the quality of plants cultivated around Mpape dumpsite of FCT Abuja, Nigeria reported that the quantity of Zn, Fe and Cd were higher at the dumpsite than at the control site.

The concentration of Manganese was within the permissible level. Abbasi *et al.* (1998) gave an accepted value of 1000mg/kg for manganese in an uncontaminated soil. The value obtained relatively disturbed forest, abandoned dumpsite for 25years and abandoned dumpsite for 3years indicates non-contamination as shown in Table 1. Manganese are not found in Free State in nature; they are mostly in combination with iron. Compounds of manganese are used as livestock feeding supplements, in the production of fertilizers and fungicides. Its adsorption into soil is dependent on organic content, pH, grain-size and Cation exchange capacity (Aboud and Nandini, 2009).

The mean Zinc 32.11mg/kg, 97.77mg/kg and 104.11mg/kg for relatively disturbed forest, abandoned dumpsite for 25years and abandoned dumpsite for 3years as shown in (Table 1). The highest concentrations of Zn were observed in abandoned dumpsite for 25years and abandoned dumpsite for 3years. Department of Petroleum Resources of Nigeria permissible limit for Zn in soil is 140mg/kg (DPR, 2002). The concentrations of Zn observed in soils sampled from a Relatively Disturbed forest, abandoned dumpsite for 25years and abandoned dumpsite for 3years respectively were below DPR limit. Similar Zn concentrations have been reported by Yahaya *et al.* (2009) in their study in Markudi metropolis. This result could have been influenced by the materials dumped at each site and the hyper accumulation potentials of the species present at the site. The mean concentrations of Copper (Cu) in the soil profiles varied at 3.46mg/kg, 28.06mg/kg and 22.55mg/kg for relatively disturbed forest, abandoned dumpsite for 25years and abandoned dumpsite for 3years as shown in (Table 1). The lowest concentrations of copper were observed in the relatively disturbed forest compared to the concentrations of Cu observed in the abandoned dumpsite for 25years and abandoned dumpsite for 3years respectively. The concentrations of Cu found in these sites were lower than the DPR (2002) permissible limit of 36mg/kg Cu in soil. The solubility of Cu and Zn is influenced by pH and redox conditions. pH range of 5.4 - 6.5, Cu and Zn are distinctly more soluble under oxidising conditions than reducing conditions (Bhattacharya *et al.*, 2002). In this study, only the relatively disturbed forest and abandoned dumpsite for 3years had pH value in this range, there is no solubility of Cu and Zn in the sites. Copper is used in the production of fungicides, algicides and insecticides. Copper is also used in wood preservation, electroplating, dye making, engraving, electrical wiring, roofing, various alloys, cooking utensils, and piping in the chemical industries (Aboud and Nandini, 2009). The Cu concentration is within the non-contaminated level. However, the high concentration for copper and zinc observed are as a result of degradation from some electrical materials, roofing sheets, cooking utensils, alloys, electroplating and chemical effluents (Odero *et al.*, 2000).

The mean values of Chromium (Cr) in the soil sampled showed that 0.73mg/kg, 14.00mg/kg and 23.38mg/kg were for relatively disturbed forest, abandoned dumpsite of 25years and abandoned dumpsite of 3years respectively as shown in (Table 1). The highest concentrations of Cr was observed in abandoned dumpsite of 25years and abandoned dumpsite of 3years compared to the relatively disturbed forest. The DPR (2002) maximum allowable level of Cr in soil is 100mg/kg. The concentrations of Cr in the relatively disturbed forest, abandoned dumpsite of 25years and abandoned dumpsite of 3years respectively samples collected were below the maximum allowable levels of Cr in soil, while abandoned dumpsite of 3years had higher concentration of Cr at 23.38mg/kg. This correlate with the studies of Yahaya *et al.* (2009) who reported the presence of Chromium in dumpsites soil in Nigeria is attributed to waste on the sites which infiltrate into the underlying soil layer. Chromium is used manufacturing industries. It is carcinogenic to living organisms and there route of entry is by inhalation (Aboud and Nandini, 2009).

The mean distribution of lead (Pb) observed in the soils varied at 1.01mg/kg, 15.54mg/kg and 24.79mg/kg for relatively disturbed forest, abandoned dumpsite of 25years and abandoned dumpsite of 3years respectively. The highest concentration of Pb was revealed at 24.79mg/kg for abandoned dumpsite of 3years. The Nigerian maximum permissible limit of Pb in soil is 85mg/kg (DPR, 2002). The concentrations of Pb found in these soil profiles were below the permissible limit. This indicates that the solid waste deposited at the site had no high amount of substances containing Pb. This is in line with the study of Adelekan and Alawode (2011) who reported that the levels of Pb at dumpsites were higher than that of control sites. Higher concentration of Pb causes water imbalance, inhibition of enzyme activities in living organisms, alterations in membrane permeability and distort the distribution of mineral nutrition of the affected organism (Sharma and Dubey, 2005).

The values of Cadmium (Cd) reveals that the mean of 0.60mg/kg, 17.02mg/kg and 23.34mg/kg were for the relatively disturbed forest, abandoned dumpsite for 25years and abandoned dumpsite for 3years respectively as shown in (Table 1). The maximum allowable concentration of Cd in soil is 0.8mg/kg (DPR, 2002). The concentrations of Cd observed in the soils of abandoned dumpsite for 25years and abandoned dumpsite for 3years were above the maximum allowable concentration while the relatively disturbed forest is below the maximum allowable concentration of 0.60mg/kg.

However, lead and Cadmium normally do not accumulate in the topsoil but, anthropogenic activities such as dumping of wastes can increase their concentration in the soil (Al-Turki et al.,2004). Anthropogenic contribution to cadmium and lead contamination of the environment can therefore be significantly more than natural input (Bakırdere *et al.*, 2013).

Cadmium is not considered an essential element for humans but its toxic effects together with lead are recognized (Dessuy *et al.*, 2011). Cadmium accumulates in vital organs (liver, lungs and kidneys) because their half-life in human is usually between 1-4 decades (Rezende *et al.*, 2011).

Bulk density can reduce the roots length and limits the roots penetrating into the soil (Rai *et al.,* 2010). The relatively disturbed forest has the highest value of 13.12g/cm3 and the lowest value was recorded for abandoned dumpsite of 3years 11.89g/cm3 for bulk densities in the soil. Water holding capacity (WHC) is controlled primarily by soil texture and soil organic matter. It decreased with increase in distance from abandoned dumpsite of 25years and 3years to relatively disturbed forest. Soil texture plays a very important role in plant species establishment, development and it also influences physical parameters. The soil texture class was examined for the study area. The results are represented in Table 2, revealed that soil from the dumpsite had low Clay content of 51.5%, 49.3% and 63.7% for relatively disturbed forest, abandoned dumpsite of 25years and abandoned dumpsite of 3years respectively while sand content 928.2%, 929.1% and 904.8%.

5. Conclusion and Recommendations

It can be concluded that the soil nutrients (N, P, K, Organic C, Organic matter) continued to improve in the dumpsite abandoned for 25 years while the heavy metal (Fe, Pb, Cr, Cd, Mn) concentrations were higher in the dumpsite of 3 years. The study therefore recommended that due to heavy metals toxicity, the use of these abandoned waste dumpsites for agricultural purposes should be discouraged. In addition, solid waste management should be provided in the yearly budget with a separate head for the purpose of adequate revenue allocation, implementation and monitoring; and indiscriminate dumping of waste should be banned/discouraged and proper monitoring/management and remediation plan is needed to reduce the chances of ground water pollution by leaching of these dumpsites.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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