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Study on the Impact of Municipal Solid Wastes on Physico-Chemical Properties of Dumpsite Soils in Benin City, Nigeria

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ABSTRACT

The present study was carried out to examine some physicochemical properties of soils around selected municipal solid waste dumpsites in Benin City, Nigeria. Composite soil samples were collected around three (3) major municipal solid waste dumpsites in Benin City using a stainless steel spade at depths of 0-45cm. Samples were taken for laboratory analyses for physicochemical properties such as pH, electrical conductivity (EC), particle size distribution, total organic carbon (TOC), soil organic matter (SOM), nitrogenous content, available phosphorous (P), basic cations, cation exchange capacity (CEC) and some anions. Results showed that there were significant variations ($p \leq 0.05$) between the waste dumpsites soils and control soils as revealed by the least significant difference (LSD) t-test for mean separation in terms of pH, basic cations, CEC, EC, available phosphorous and the anions. The pH of the soil samples around the studied dumpsites varied between 6.04± 0.01 and 8.17±0.06 while the mean pH of soil samples from the adjoining area (control) was 4.78± 0.06. The high pH of the soil samples around the studied dumpsites was also reflected in the high CEC (varied from 4.24±0.67 to 16.96 ±0.83 meq/100g) in most of the analysed soil samples while the low acidic pH of the control soil samples was also reflected in the low CEC (mean levels of 1.70±0.24 meq/100g) because of the strong positive relations that exist between pH, basic cations and CEC. EC ranged from 668± 3.53 to 944±4.51µS, TOC ranged from 0.03±0.00 to 1.52± 0.05%, SOM ranged from 0.05±0.00 to 2.62± 0.08% while P component varied from 1.93± 0.80 to 25.64± 0.41% in the studied dumpsites soils.

1. INTRODUCTION

Municipal solid wastes (MSW) are usually referred to as unwanted materials which commonly may be solids, semi solids or liquids in containers discharged as a result of human domestic and commercial activities from residential houses, street, academic environment and commercial premises like market places and Artisan's workshops (Eneje and Lemoha, 2012). They are commonly called trash or garbage and include durable goods, non-durable goods and other domestic wastes. This category of wastes generally referred to as common household wastes as well as office and retail wastes exclude industrial hazardous and construction wastes (Eneje and Lemoha, 2012). Waste may be defined as any substance or object which is supposed to be disposed or intended to be disposed by the provisions of the law (Anake *et al*., 2009). Creation of waste by mankind is inevitable in that the manipulation of the chemical environment continues to produce waste. MSW varies in composition which may be influenced by many factors such as location, culture affluence and its management depends on the characteristics of the solid waste including the gross composition, moisture contents, average particle size, chemical composition and density (Allen, 2001).

In Nigeria just like the rest of the world, rapid urbanization and population growth have brought about a proportional increase in the amount of waste that is generated, with a mean rate of 0.43 kg/head/day in most urban areas in Nigeria (Anake *et al*., 2009). The inability to manage these wastes effectively in most developing and developed countries becomes an issue of great concern because apart from the destruction of aesthetics of landscape by the waste dumpsites, some of these municipal solid wastes contain both organic and inorganic toxic contaminants that threaten human health and the entire ecosystem. MSWs in Nigeria are composed of paper, food scraps, vegetable matter, plastics, metals, textiles, rubber, ceramics and glass (Uba *et al.,* 2008).

Places with accumulated solid wastes are called refuse dumps while a designed place for dumping of refuse is known as dumpsite (Civeira and Lavado, 2006). Several waste dumpsites are located at various parts of Benin City metropolis and some of these sites are indiscriminately located at stream valleys, open fields, water canals, plan land and in abandoned borrow pits (Akpoborie *et al*., 2000; Isu, 2005). Many techniques of waste disposal abound but the most favourite technique used in Nigeria municipal is the disposal on land or holes made in the earth possibly due to its low cost (Eneje and Lemoha, 2012). One critical issue in all waste management techniques is how to keep the harmful effects of wastes away from man and his environment. A major concern in waste dumping either above or below the earth surface is the safety of the ground water in the area. In areas like Benin City of shallow water table and abundant rainfall, the danger is greater, since waste contaminated water reaches the aquifer easily.

Soil is the primary recipient of solid waste and also a reservoir of nutrients and water for plants and animals. Its contamination and degradation have far reaching effects on the entire living components of the ecosystem (Nyle and Ray, 1999). Soils intensively affected by human activities might present special features such as mixed horizons, foreign materials and thin top soil (Civeira and Lavado, 2006). Millions of tons of waste materials from variety of sources (industrial, domestic and agricultural) find their way into the soil, interacting with the soil systems and changing their physical and chemical properties (Adaikpoh and Kaizer, 2012). Therefore, the objective of this study is to evaluate the impact of municipal solid wastes on some selected physicochemical properties of soils around some waste dumpsites and compare them with those of the adjoining area.

2. MATERIALS AND METHODS

2.1. Study Area

The study area is within Benin City metropolis. The city is the capital of Edo state, Nigeria and is located in the south-south geopolitical zone of Nigeria; bounded by latitudes 6^0 15'N to $6^0$30'N and longitudes 5°30'E to 5°45'E and with an area of about 500 square kilometres. The climatic condition falls within the Rain forest type and is similar to other parts of southern Nigeria with annual rainfall generally high ranging from 2000 – 2400 mm (Kogbe, 1989). The city is underlain by sedimentary formation described by Short and Stauble, (1967). The formation is made up of top reddish clayed and capping highly porous fresh water bearing, loose pebbly sands, and sand stone with local thin clays and shale interbeds which are considered to be of weathered surfaces to white in the deeper fresh surfaces. Limonitic coatings are responsible for the brown reddish-yellowish colour. The formation is covered with loose brownish sand (quaternary drift) varying in thickness and is about 800m thick; almost all of which is water bearing with water level varying from about 20 to 52 metres. It is generally believed to be highly permeable, porous and prolific in water yield (Kogbe, 1989; Adaikpoh *et al*., 2005; Adaikpoh and Kaizer, 2012).

The map of Benin showing soil sample collection points and a table showing sampling sites description with their geographical position coordinates are presented in Figure 1 and Table 1 respectively.

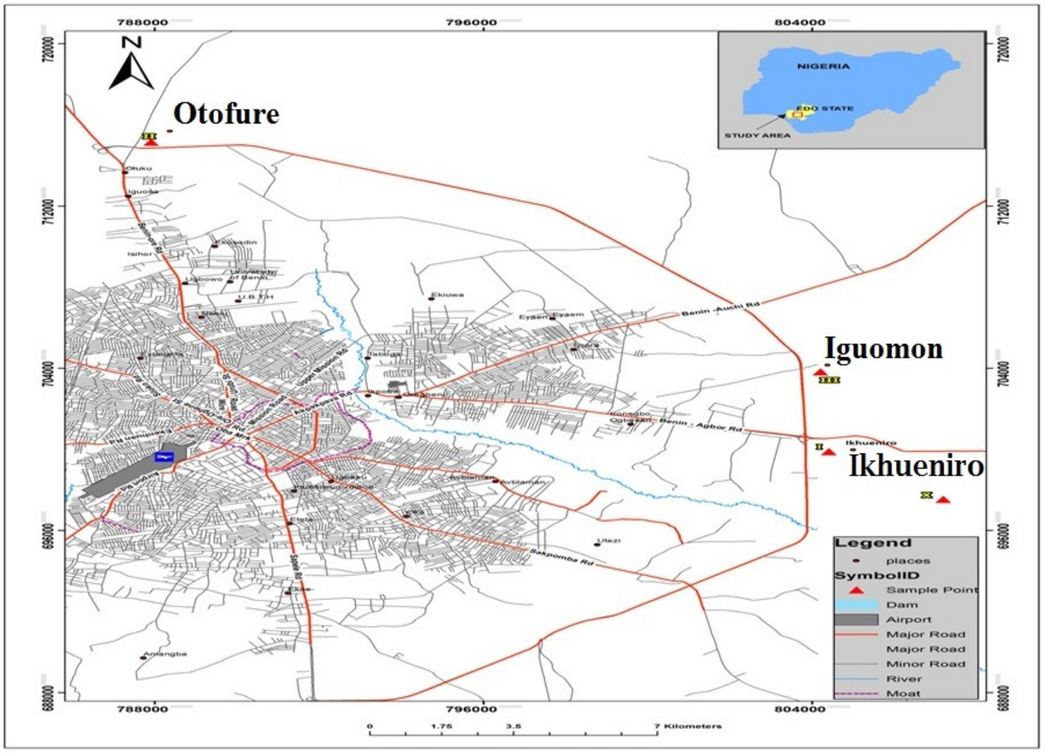

Figure 1: Map of Benin showing the sampled locations

Table 1: Sampled sites description and coordinates

Sampled sites	Location of dumpsite	Type of waste	Age of dumpsite	Size of dumpsite	Coordinates
Dumpsite (I)	Ikhueniro dumpsite; Ikhueniro community, Benin Agbor road (Bye pass) Benin City.	Domestic	15yrs	52,000 m^2	6^{0}19’28.261” N5^{0}45’04.158”E
Dumpsite (II)	Otofure dumpsite; Otofure community, Oluku Bye pass, Benin City.	Domestic	Above 17yrs	37,500 m^2	6^{0}27’47.599” N5^{0}36’10.397”E
Dumpsite (III)	Iguomon dumpsite; Iguomon community, Benin Lagos express way (Bye pass), Benin city.	Domestic	15yrs	58,560 m^2	6^{0}21’36.360” N5^{0}44’58.085”E
Control site (X)	Farm land at Ikhueniro community, Benin Agbor road, Benin City	–	–	–	6^{0}18’11.394” N5^{0}46’34.226”E

2.2. Sample Collection and Preparation

Composite soil samples were collected around three (3) Government approved municipal solid waste dumpsites in Benin City, using a stainless steel spade at depths of 0 – 15, 15 – 30 and 30 - 45cm, representing top soils, sub soils and bottom soils respectively. Three soil samples per points from the three depths were bulked together to form one composite sample. At each studied dumpsite, six (6) different points were randomly chosen (50 metres away from the centre of each studied dumpsite) for sampling. The composite soil samples from the six different points in each studied dumpsite were labelled A, B, C, D, E and F for dumpsite (I); G, H, I, J, K and L for dumpsite (II); and M, N, O, P, Q and R for dumpsite (III), to give a total of eighteen (18) composite soil samples from the three studied dumpsites. The gradient (high and low gradient) and the direction of flow of erosion were also considered for each sampling point (spot). Control soil samples were also obtained in similar manner from a farm land in the adjoining area of the solid wastes dumpsite (500 metres away from the studied wastes dumpsites) to serve as control and was labelled sample 'X'. The control site was unaffected by dumping of waste materials. The geographical position coordinates of the sampled sites were identified and mapped using global position system (GPS). Soil samples collected were transferred into a black polythene bag, labelled properly and transported to the laboratory for analysis. Soil samples were air-dried for a period of two weeks in a well-ventilated space. Samples were homogenized by grinding in porcelain mortal and sieved through a 2mm (10 meshes) stainless sieve. The air-dried < 2mm soil samples were oven-dried at 105 ± 0.5^oC to a constant mass, cooled and stored in labelled air-tight plastic Cans prior to analysis (Allen *et al.*, 1974; Okuo *et al.*, 2016a).

2.3. Determination of Physico-chemical Properties of Soil

Physico-chemical analysis of the composite soil samples were conducted using standard analytical methods (Ilori *et al.*, 2012). The soil pH and electrical conductivity (EC) were determined using soil / water mixture as described by Ilori *et al.* (2012). The hydrometer methods described by Asagba *et al.* (2007) were used in evaluating the soil particle size. Dichromate wet oxidation method described by Anegbe *et al.* (2014) was used to determine the total organic carbon content, while the organic matter content was estimated from the total organic carbon by the method described by Asagba *et al.* (2007). Basic cations and cation exchange capacity (CEC) was analysed using the ammonium acetate digestion method described by Elfaki *et al.* (2015). The nitrogen content and soil nitrate–N were analysed using micro-kjeldahl method described by Vogel and Mendham (2000) while the soil available phosphorus was determined by colorimetric method described by Okuo *et al.* (2016b). The level of soil sulphate was also analysed by the colorimetric method described by Oviasogie *et al.* (2006), while the turbidimetric method was used to evaluate the soil sulphate-sulphur (Yahaya *et al.,* 2009). Titration method described by Radojevic and Bashkin (1999), was used to determine the soil chloride content. All glassware used were soaked and washed with chromic acid and rinsed with distilled water. Bulk scientific standard solutions were used to calibrate the Atomic Absorption Spectrometer (Bulk Scientific VGP 210 model) which was used for the determination of exchangeable calcium and magnesium. Procedural blank samples were subjected to similar extraction method using the same amount of analytical reagents.

2.4. Statistical Analysis of Data

The analytical results of the mean physicochemical properties of soil samples from the studied sites were subjected to analysis of variance (ANOVA) using Genstat 8.1 Edition. Their significantly differing means treatments were found significant at $p \leq 0.05$ using the least significant difference (LSD) *t*-test. Soil properties variability was estimated using mean and co-efficient of variation (CV %). Properties with larger CV values are more variable than those with smaller CV values. Ranking of variability was done using the Wilding's (1985) classification scheme described by Ezeaku *et al.* (2015). Little variation (CV= 0 - 15%), moderate variation (CV = 16 - 35%), high variation (CV > 36%). Simple correlation analysis was executed to reveal the magnitudes and directions of relationships between analysed soil parameters.

3. RESULTS AND DISCUSSION

Results of the physico-chemical analysis are show in Tables 2 - 4. The results show that the solid wastes in the studied dumpsites had a significant influence in most of the analysed soil properties like, pH, EC, basic cations, CEC, available phosphorus and the anions when compared with the soils from the adjoining area (control) as revealed by the ANOVA. The coefficient of variation amongst the analysed soil properties ranged from little variation to high variation.

3.1. Hydrogen Ion Concentration (pH)

The soil physico-chemical analysis shows that the pH of the soils around the studied dumpsites varied from 6.04±0.01 to 8.17±0.06 and was ranked from slightly acidic to slightly alkaline, while the mean pH of the control soils was 4.78 ± 0.06 (Tables 2-4), which was ranked strongly acidic. Most metals in the pH ranges of 6.0 – 9.0 are not always in their free form (Porteus, 1985). The pH of the soil samples around the studied dumpsites fell within these ranges. This would eventually influence lower release of heavy metals into sub-soil and ground water. pH is known to be a very unstable soil property that is easily influenced by other properties. Higher release of heavy metals down the horizons could occur when condition like pH and other factors becomes favourable. The major effects of soil acidification on plants include the reduction in nutrient supply, increased concentration of metal ions in solution, especially of Al, Cu and Mn, which may be toxic while Nitrogen fixation by legumes may be reduced unless the rhizobium strain is acid tolerant (Dorraji *et al.,* 2010).

Table 2: Mean value of physico-chemical properties of aggregate soil samples around dumpsite (I) in Benin City (dry weight)

	Located spots around the dumpsite						
Parameters	A	B	C	D	E	F	Control X
pH	7.50±0.01	7.60±0.01	7.40±0.17	7.90±0.01	8.17±0.06	8.10±0.01	4.78±0.06
EC (µS)	668±1.53	868±1.53	721±2.52	922±4.04	888±5.51	827±5.57	390±22.12
Clay (%)	9.23±0.06	16.20±0.00	8.17±0.06	8.33±0.12	8.20±0.00	17.53±0.15	12.07±0.06
Silt (%)	1.67±0.06	0.67±0.06	1.23±0.06	2.70±0.00	2.17±0.06	1.33±0.15	1.37±0.12
Sand (%)	89.10±0.00	83.13±0.06	90.60±0.00	88.97±0.12	89.63±0.06	81.13±0.15	86.57±0.15
TOC (%)	0.03±0.00	0.03±0.00	0.13±0.03	0.04±0.02	0.34±0.02	0.39±0.04	0.22±0.05
SOM (%)	0.05±0.00	0.05±0.00	0.23±0.04	0.06±0.04	0.59±0.03	0.67±0.06	0.38±0.08
N (%)	0.39±0.02	0.36±0.03	0.97±0.06	0.43±0.02	0.66±0.00	0.84±0.03	0.08±0.01
P (ppm)	11.39±0.03	7.63±0.00	21.94±0.16	25.64±0.41	24.26±0.47	11.84±0.08	5.53±0.39
Ca (meq/100g)	2.96±0.06	2.67±0.05	5.37±0.04	5.48±0.16	5.52±0.09	4.43±0.51	1.30±0.17
Mg (meq/100g)	0.08±0.00	0.15±0.01	2.12±0.11	0.23±0.07	0.49±0.06	0.19±0.03	0.32±0.10
Na (meq/100g)	0.72±0.00	0.85±0.00	1.39±0.01	0.75±0.00	0.67±0.02	0.50±0.00	0.05±0.01
K (meq/100g)	0.64±0.03	0.69±0.00	1.49±0.00	0.34±0.00	0.14±0.00	0.36±0.02	0.03±0.01
CEC (meq/100g)	4.40±0.07	4.35±0.06	10.38±0.14	6.79±0.22	6.82±0.03	5.48±0.56	1.70±0.24
SO_4^{2-} (mg/kg)	6.02±0.04	3.57±0.13	3.06±0.04	3.75±0.02	4.59±0.09	6.07±0.08	2.21±0.09
NO_3^- (mg/kg)	2.49±0.03	2.82±0.03	2.38±0.05	1.36±0.02	3.09±0.07	4.37±0.07	1.01±0.06
Cl^- (mg/kg)	2.98±0.03	2.37±0.09	1.97±0.05	0.99±0.03	1.48±0.05	4.68±0.09	0.98±0.03
PO_4^{3-} (mg/kg)	4.29±0.12	3.20±0.06	1.58±0.04	1.76±0.05	1.40±0.02	3.73±0.07	1.54±0.29

The values are mean ± S.D, EC = electrical conductivity, TOC= total organic carbon, SOM= Soil organic matter, CEC= cation exchange capacity.

Table 3: Mean value of physico-chemical properties of aggregate soil samples around dumpsite (II) in Benin City (dry weight)

	Located spots around the dumpsite						
Parameters	G	H	I	J	K	L	Control X
pH	6.21 ± 0.01	6.42 ± 0.01	6.04 ± 0.02	6.53 ± 0.02	6.35 ± 0.02	6.29 ± 0.01	4.78±0.06
EC (µS)	690 ±2.03	944±4.51	674±3.09	750±14.01	825±8.14	869±8.50	390±22.12
Clay (%)	8.60 ± 0.02	11.27±0.15	11.63±0.25	4.97±0.12	4.73±0.15	13.36±0.21	12.07±0.06
Silt (%)	2.30±0.04	2.17±0.06	2.37±0.06	2.33±0.06	2.50±0.20	2.93±0.12	1.37±0.12
Sand (%)	89.10±0.13	86.57±0.12	86.00±0.26	92.70±0.10	93.23±0.15	83.7±0.10	86.57±0.15
TOC (%)	0.26±0.04	0.21±0.06	0.23±0.04	0.23±0.03	0.81±0.04	1.52±0.05	0.22±0.05
SOM (%)	0.46±0.06	0.37±0.11	0.40±0.07	0.39±0.06	1.41±0.07	2.62±0.08	0.38±0.08
N (%)	0.14±0.02	0.12±0.03	0.05±0.03	0.08±0.01	0.29±0.01	0.10±0.03	0.08±0.01
P (ppm)	9.62±0.29	8.96±0.06	5.59±0.13	18.41±0.43	24.80±0.22	6.94±1.18	5.53±0.39
Ca (meq/100g)	3.90±0.18	3.20±0.08	3.78±0.83	3.67±0.45	2.92±0.34	2.58±0.73	1.30±0.17
Mg (meq/100g)	0.52±0.05	2.61±0.28	1.40±0.62	1.39±0.53	1.04±0.05	1.22±0.09	0.32±0.10
Na (meq/100g)	0.05±0.01	0.10±0.00	0.05±0.01	0.25±0.04	1.25±0.04	0.16±0.04	0.05±0.01
K (meq/100g)	0.43±0.04	0.77±0.01	0.46±0.13	0.85±0.02	2.17±0.01	0.28±0.02	0.03±0.01
CEC (meq/100g)	4.91±0.16	6.68±1.22	5.69±2.38	6.16±1.15	7.38±0.38	4.24±0.67	1.70±0.24
SO_4^{2-} (mg/kg)	8.46±0.04	12.04±0.79	9.25±0.38	5.45±0.29	7.93±0.44	3.79±0.48	2.21±0.09
NO_3^- (mg/kg)	7.85±0.18	10.25±0.34	8.46±0.28	6.10±0.15	4.57±0.32	2.23±0.40	1.01±0.06
Cl^- (mg/kg)	5.08±0.02	6.25±0.23	3.77±0.51	3.99±0.10	3.14±0.18	2.15±0.17	0.98±0.03
PO_4^{3-} (mg/kg)	14.73±0.22	9.51±0.36	4.88±0.13	5.33±0.34	4.96±0.23	2.99±0.67	1.54±0.29

The values are mean ± S.D, EC=electrical conductivity, TOC= total organic carbon, SOM= Soil organic matter, CEC= cation exchange capacity

Table 4: Mean value of physico-chemical properties of aggregate soil samples around dumpsite (III) in Benin City (dry weight)

	Located spots around the dumpsite						
Parameters	M	N	O	P	Q	R	Control X
pH	7.67±0.02	6.30±0.01	7.12±0.02	6.6±0.01	7.01±0.01	7.12±0.01	4.78±0.06
EC (µS)	703±26.10	791±18.03	974±16.09	672±23.58	810±16.29	829±19.97	390±22.12
Clays (%)	10.60±0.06	13.47±0.12	8.47±0.12	15.10±0.00	12.07±0.06	12.53±0.12	12.07±0.06
Silt (%)	2.33±0.06	2.33±0.06	1.77±0.06	1.23±0.12	1.80±0.00	1.90±0.10	1.37±0.12
Sand (%)	87.10±0.10	84.20±0.10	89.77±0.15	83.67±0.12	86.13±0.06	85.57±0.15	86.57±0.15
TOC (%)	0.98±0.12	0.44±0.06	1.20±0.20	0.27±0.05	0.47±0.03	0.41±0.05	0.22±0.05
SOM (%)	1.70±0.21	0.76±0.10	2.08±0.35	0.47±0.08	0.82±0.05	0.70±0.08	0.38±0.08
N (%)	0.12±0.03	0.10±0.02	0.16±0.04	0.11±0.05	0.13±0.02	0.15±0.06	0.08±0.01
P(ppm)	2.22±0.24	5.82±1.48	4.47±0.59	1.93±0.80	3.81±0.13	5.61±0.25	5.53±0.39
Ca (meq/ 100g)	6.80±1.05	4.31±0.93	8.49±0.74	4.13±0.31	5.80±0.69	13.37±0.45	1.30±0.17
Mg (meq/100g)	0.32±0.03	0.88±0.16	7.88±0.11	3.59±0.12	1.17±0.17	0.93±0.06	0.32±0.10
N (meq /100g)	1.44±0.02	0.50±0.30	0.45±0.04	0.20±0.03	0.14±0.04	0.04±0.02	0.05±0.01
K (meq/ 100g)	0.24±0.04	0.13±0.03	0.14±0.04	0.27±0.01	1.16±0.02	0.53±0.07	0.03±0.01
CEC (meq/100)	8.80±1.13	5.83±0.38	16.96±0.83	8.20±0.14	8.27±0.89	14.87±0.74	1.70±0.24
SO_4^{2-} (mg/kg)	6.70±0.34	12.35±0.29	15.24±0.43	3.70±0.22	8.54±0.34	7.71±0.15	2.21±0.09
NO_3^-(mg/kg)	2.68±0.31	3.78±0.29	4.59±0.31	1.68±0.28	3.18±0.21	2.92±0.13	1.01±0.06
Cl^-(mg/kg)	2.30±0.17	4.04±0.18	3.97±0.13	1.37±0.55	3.15±0.29	2.03±0.07	0.98±0.03
PO_4^{3-}(mg/kg)	4.45±0.40	2.61±0.25	4.82±0.22	2.11±0.19	3.18±0.15	1.19±0.14	1.54±0.29

The values are mean ± S.D, EC=electrical conductivity, TOC= total organic carbon, SOM= Soil organic matter, CEC= cation exchange capacity

However, the mean pH levels recorded in the studied dumpsites indicates the suitability as landfill for wastes rich in heavy metals since their mobility would not be supported by this pH range, as most of them will be in insoluble form and hence they are unavailable to the environment for plant uptake. These pH range (6.04 ± 0.01 – 8.17 ±0.06) for the studied dumpsites is alright for the growth of a wide variety of plants as only pH values below 4.2 that the H^+ ions in the soil can stop or even reverse cation uptake by roots (Anegbe and Okuo, 2013). It has also been reported by Oviasogie and Ndiokwere, (2008) that lower pH (acidic) would favours availability, mobility and redistribution of heavy metals due to increased solubility of metal ions in acidic environment. The mean levels of pH recorded in this studies (dumpsites) were similar to the pH values reported in other domestic waste dumpsites in different parts of the country; such as the report of Amos–Tautua *et al.* (2014) on municipal open waste dumpsite in Yenagoa, Nigeria with mean pH of 7.60±0.02. Badmus *et al.* (2014) on dumpsite environment in south Western Nigeria with pH ranging from 5.45 to 6.45. Anake *et al.* (2009) also reported on the physicochemical properties of municipal solid waste dumpsites in Kano and Kaduna States, Nigeria with pH values ranging from 6.2 to 8.2. The low acidic soil pH from the farmland in the studied dumpsites adjoining area (control) could be attributed to the depletion of basic cations due to leaching of the soil nutrient and other factors like erosion which could have resulted from the continuous crop cultivation on the control farmland because as basic cations increases, pH and CEC also increases vice versa. The acidic property of soils from the control site is also typical of the Niger Delta soils (Odu *et al.,* 1985). The pH coefficient of variation (CV) was 8% and was ranked little variation (Table 5). The correlation of the mean pH showed that the pH was positively and significantly correlated with EC (r = 0.398), % Sand (r = 0.127), Na (r = 0.613). But the mean pH was positively and not significantly correlated with % Silt, Mg, K, CEC, $SO4^{2-}$, NO_3^-, Cl^-, PO_4^{3-} content of the soils. However, the mean pH was also negatively and not significantly correlated with % Clay (r = -0.161), negatively and significantly correlated with TOC (r = -0.607), SOM (r = -0.605) (Table 6).

Table 5: The ANOVA comparison of the mean physicochemical parameters of soil samples in the studied site using the LSD test at 5% for mean separation

Parameters	D_1	D_2	D_3	X_S	*GM*	V(±)	P-value (≤0.05)	LSDM (0.05)	SEM (±)	SEDM (±)	V (%)
pH	7.78	6.31	6.64	4.78	6.38	0.28	0.001**	0.65	0.22	0.30	8
EC	816	792	826	390	706	323.1	0.32	584.00	193.70	274.00	54
Clay	11.23	9.09	12.04	12.07	11.12	7.53	0.24	3.38	1.12	1.58	24
Silt	1.63	2.43	1.89	1.37	1.83	0.23	0.01*	0.59	0.20	0.28	26
Sand	87.09	88.55	86.07	86.57	87.07	6.85	0.42	3.22	1.07	1.51	3
TOC	0.16	0.54	0.63	1.22	0.64	0.11	0.01*	0.41	0.14	0.19	52
SOM	0.28	0.94	1.09	2.10	1.10	0.34	0.01*	0.71	0.24	0.34	53
N	0.61	0.13	0.28	0.08	0.24	0.02	0.01*	0.17	0.05	0.08	57
P	17.12	12.39	3.98	5.53	9.80	25.71	0.01*	6.24	2.07	2.93	52
Ca	4.41	3.34	7.15	1.30	4.05	7.29	0.01*	10.54	3.50	4.94	69
Mg	0.54	1.36	2.46	0.32	1.17	1.99	0.07	1.74	0.58	0.81	120
Na	0.81	0.31	0.46	0.05	0.41	0.16	0.03*	0.49	0.17	0.23	99
K	0.61	0.83	0.41	0.03	0.47	0.23	0.06	0.59	0.19	0.27	101
CEC	6.37	5.84	10.49	1.70	6.10	7.98	0.01*	10.87	3.61	5.10	61
SO_4^-	4.51	7.82	9.04	2.21	5.90	6.26	0.01*	3.08	1.02	1.44	42
NO_3^-	2.75	6.58	3.14	1.01	3.37	2.59	0.001**	1.98	0.66	0.93	48
Cl^-	2.41	4.06	2.81	0.98	2.57	1.26	0.002*	1.38	0.46	0.65	44
PO_4^-	2.66	7.07	3.06	1.54	3.58	4.56	0.002*	2.63	0.87	1.23	60

There is significant difference at P ≤ 0.05 between control and the dumpsites. Significant; ** = p << 0.05, * = p < 0.05, where D_1 = dumpsite (I) mean, D_2 = dumpsite (II) mean, D_3 = dumpsite (III) mean, Xs = control mean, *GM* = Grand or total mean, V = variance with 15 degree of freedom, LSDM = Least significant difference of means (5% level), SEM (±) = Std. Errors of Means, SEDM (±) = Std. Errors of difference of means, CV% = Coefficient of variability

3.2. Electrical Conductivity (EC)

Electrical conductivity is the measure of soluble salts (salinity) in the soil. The mean levels of electrical conductivity of soils around the studied dumpsites varied from 668 ± 3.53 to 944 ± 4.51µS. The control site had a mean value of 390 ± 22.12µS (Tables 2-4). This indicates that the movement of charge particles in soils around the studied dumpsites are higher than those of the adjoining area (control site), which is a good indicator for the high rate of plant growth around the studied dumpsites compared to the control site in wet season most especially. High EC affects nutrient uptake by soils (Agronomic Spotlight, 2015). The soil electrical conductivity depends on factors such as soil salinity, soil texture and cation exchange capacity. Soils with higher percentage organic matter (OM) retain much higher positively charged ions. The presence of these ions in the moisture filled soil pores will enhance soil electrical conductivity (Triantafilis *et al.*, 2002). The EC showed significant difference (P = 0.52) between the soils around the studied dumpsites and the control site, as shown by the ANOVA with a high coefficient of variation (54%) (Table 5). The correlation matrix showed that EC was positively and not significantly correlated with % Clay, % Silt, N, P, Na, K, NO_3^- and Cl^-, but EC was positively and significantly correlated with PO_4^{3-} ions (r = 0.414). However, EC was negatively and not significantly correlated with % Sand, TOC, OM, Ca, Mg, CEC, and SO_4^{2-} ions (Table 6).

Table 6: Significant Correlation between mean physicochemical parameters of soils around the studied dumpsites

	pH	EC	Clay	Silt	Sand	TOC	OM
pH	1.000						
EC	0.398	1.000					
Clay	-0.161	0.116	1.000				
Silt	0.226	0.046	-0.490	1.000			
Sand	0.127	-0.134	-0.985	0.334	1.000		
TOC	-0.607	-0.264	0.107	-0.063	-0.098	1.000	
SOM	-0.605	-0.264	0.105	-0.061	-0.096	0.980	1.000
N	0.666	0.248	-0.053	-0.177	0.092	-0.460	-0.460
P	0.482	0.096	-0.637	0.329	0.627	-0.426	-0.427
Ca	0.148	-0.199	-0.119	0.487	0.032	-0.029	-0.024
Mg	0.100	-0.319	-0.164	0.024	0.170	0.053	0.056
Na	0.613	0.056	-0.332	0.099	0.348	-0.299	-0.296
K	0.364	0.194	-0.463	0.171	0.481	-0.412	-0.409
CEC	0.181	-0.211	-0.156	0.461	0.078	-0.045	-0.040
SO_4^{2-}	0.287	-0.022	-0.176	0.424	0.108	-0.251	-0.247
NO_3^-	0.241	0.251	-0.236	0.430	0.170	-0.457	-0.454
Cl^-	0.326	0.328	-0.105	0.348	0.046	-0.435	-0.432
PO_4^{3-}	0.141	0.414	-0.272	0.359	0.223	-0.301	-0.297

	N	P	Ca	Mg	Na	K	CEC
N	1.000						
P	0.643	1.000					
Ca	-0.247	-0.235	1.000				
Mg	-0.073	-0.145	0.604	1.000			
Na	0.600	0.521	-0.037	-0.006	1.000		
K	0.344	0.528	0.069	0.057	0.521	1.000	
CEC	-0.205	-0.198	0.994	0.675	0.015	0.123	1.000
SO_4^{2-}	-0.127	-0.099	0.893	0.588	0.060	0.210	0.901
NO_3^-	-0.054	0.102	0.579	0.275	-0.069	0.328	0.575
Cl^-	0.048	0.032	0.627	0.307	0.021	0.336	0.627
PO_4^{3-}	-0.136	0.018	0.485	0.151	-0.057	0.226	0.471

	SO_4^{2-}	NO_3^-	Cl^-	PO_4^{3-}
SO_4^{2-}	1.000			
NO_3^-	0.703	1.000		
Cl^-	0.793	0.901	1.000	
PO_4^{3-}	0.522	0.800	0.783	1.000

Significant at P = 0.05; EC = Electrical Conductivity, TOC = Total Organic Carbon, SOM = Soil Organic Matter, CEC = Cation Exchange Capacity

3.3. Particles Size Distribution

The results of the soil samples from the studied sites showed that the textural class was loamy sand as revealed by the soil texture triangular diagram, with a very high percentage sand composition which predominate in the studied sites, with mean values of percentage sand fractions ranging from 81.13 ± 0.15 to 93.23 ± 0.15%, clay composition ranging from 4.73 ± 0.15 to 17.53 ± 0.16% and silt the lowest amongst the three particle sizes ranging from 0.67 ± 0.06 to 2.93 ± 0.12% in the studied dumpsites. The control soil samples also had high mean value of sand fraction of 86.57±0.15%, 12.07 ± 0.06% clay and 1.37 ± 0.12% silt (Tables 2-4). The high percentage sand composition in the studied sites was reflected in the low soil organic matter (SOM), total organic carbon (TOC) and the nitrogenous content in most of the soil samples in the studied sites and low cation exchange capacity (CEC) in some of the soil samples also from the studied sites. Soils with high sand content exceeding 70 % have weak surface aggregation and such soils are porous and have high rate of water infiltration and air circulation (Gbadegesin and Abua, 2011). This high sand percentage composition in the studied sites favours high pollutant leaching potentials because colloids which is responsible for the retention of metal ions in soils is more associated with the clay particles and SOM (Nyle and Ray, 1999).

3.4. Total Organic Carbon (TOC) and Soil Organic Matter (SOM)

Total organic carbon (TOC) is the carbon (C) stored in soil organic matter (SOM). Organic carbon (OC) enters the soil through the decomposition of plant and animal residues, root exudates, living and dead microorganisms, and soil biota. Soil organic matter (SOM) enhances the usefulness of soils for agricultural purposes (Brady, 1996). The presence of organic carbon in soils increases the CEC of the soil which retains nutrients assimilated by plants. The total organic carbon (TOC) from the soil samples around the studied dumpsites varied from 0.03 ± 0.00 to 1.52 ± 0.05% while the control has a mean value of 0.22 ± 0.05% (Tables 2-4). The low level of organic carbon in soil samples around the studied dumpsites could be due to the utilization of the elements by microorganisms as source of nutrients for mineralization process which could account for the depletion in the soil. This low organic carbon exhibited by soils in the studied dumpsites could also be attributed to high proportion of sand from the soil particle size distribution and this could be due to high percentage net non-biodegradable solid waste present in the solid waste dumpsites as reported by Anake *et al.* (2009). The result was similar to the report made by Anake *et al.* (2009) municipal solid waste dumpsites in Kano and Kaduna States. The reason could also be that a high percentage of organic matter is lost through leaching in sand. The mean levels of soil organic matter (SOM) in soil samples from the studied dumpsites ranged between 0.05±0.00 to 2.62 ± 0.08%, while that of the control site has a mean value of 0.38 ± 0.08% (Tables 2- 4). This observation was supported by Oyedele *et al.* (2008), who reported that municipal solid waste dumpsites in Ile-Ife had significantly higher pH regime and soil organic matter as compared to the control soil. Ayolagha and Onwugbuta, (2001) also demonstrated that high SOM (>2.0%) in soils is conducive for heavy metal chelation formation. Generally, the SOM in both the dumpsites and the control site were deficient when compared to the critical level of 20 – 30 g/kg reported by Enwezor *et al.* (1989). The levels of TOC and SOM in this study were also in agreement with the results obtained from similar study reported by Amos-Tautua *et al.* (2014) municipal open waste dumpsite in Yenagoa, Nigeria.

3.5. Cation Exchange Capacity (CEC)

Cation exchange capacity is the amount of exchangeable cations per unit weight of dry soil which plays an important role in soil fertility. It is usually the summation of exchangeable basic cations like Ca, Mg, K and Na ions in a given soil sample. Nigerian soils with cation content of 2 meq/100g soils are considered for Ca and Mg while 0.2 meq/100g soils and above are adequate for K and Na ions (Odu *et al.,* 1985). CEC is directly related to the capacity of absorbing heavy metals since the absorption behaviour depends on combination of the soil properties and the specific characteristics of element also depends especially on the pH, clay and on the soil organic matter content (Barry *et al.,* 1995).The results of CEC from this study were ranked from moderately low to high, varying from 4.24 ± 0.67 to 16.96 ± 0.83 meq/100g in soils around the studied dumpsites while the mean value for the control site was 1.70 ± 0.24 meq/100g (Tables 2 - 4), which was low compared to that of the studied dumpsites. Although the clay content of both the studied dumpsites and the control site was low, it is possible that large part of the exchangeable bases at the studied dumpsites which recorded high value of CEC must have been existing as water-soluble form rather than an exchangeable form adsorbed at cation exchange sites. The low CEC that was exhibited by some soil samples from the studied dumpsites and the control site in this study could also be due to high proportion of sand fractions. Soils with low CEC are more likely to develop deficiencies in potassium (K^+), magnesium (Mg^{2+}) and other cations, while high CEC soils are less susceptible to leaching of these cations (Anegbe *et al.*, 2017). The addition of organic matter will increase the CEC of a soil, but will require time to take effect. CEC is known to decrease proportionally with increase in sand fractions in most soils because there is always lesser exchange sites that affect retention of metals in sand compared to clay and organic matter (Nyle and Ray, 1999). The high CEC that was exhibited by some soil samples from the studied dumpsites were attributed to the high value of the exchangeable Ca present in the soil samples.

3.6. Total Nitrogen (N) Content and Available Phosphorus (P)

The mean levels of nitrogen content of the soils around the studied dumpsites ranged from 0.05 ± 0.03 to 0.97 ± 0.06%, while the mean value of the control soil samples was 0.08 ±0.01% (Tables 2-4). The nitrogen content in the studied sites fall below the critical level of 1.5 – 2.0 g/kg as reported by Sobulo and Osiname, (1981), for crop production. This could be attributed to low decomposition of organic matter, which was reflected in low values of SOM in the studied sites. The mean levels of P component varied from 1.93 ± 0.80 to 25.64 ± 0.41%. The control soil samples had 5.53 ± 0.39% mean value of P component (Tables 2- 4). The minimum range of P content in the dumpsites soil samples and the mean value of control soils were lower than the critical deficiency levels of 10 – 16 mg/kg for crop production as reported by Adeoye and Agboola, (1985). But the maximum range of the P mean levels in the studied dumpsites was far above the critical deficiency levels and the 10 mg/kg considered suitable for crop production (FAO, 1976). The low level of P in some of the soil samples around the studied dumpsites could also be attributed to the presence of low SOM and vegetative materials decomposition in the dumpsites and the control site. According to Ideriah *et al.* (2006), high levels of P in soils are usually attributed to the presence of high amount of soil organic matter and the decomposition of vegetative materials. Anake *et al.* (2009) reported that most waste dumpsites in the country are low in terms of organic matter content and having high percentage sand composition due to high net percentage of non-biodegradable solid wastes present in most dumpsites. Generally, we could conclude that the P components obtained from all sites in this present study were low when compared to the values of 418.70 to 763.10 mg/kg obtained by Adegbenro *et al.* (2011) in Mica Schist soil; 217 to 638 mg/kg reported by Uzu *et al.* (1975) in basement complex soil; and 191 to 243 mg/kg reported by Laganthan and Sutton, (1987) in sedimentary soil. It has been reported that low level of total P in soils may also be attributed to the presence of hydrous metal oxides of iron and aluminium and clay and the pH status of the soils (Indiati *et al.,* 1998).

3.7. Soil Anions

The mean levels of anions in soil samples from the studied dumpsites showed that sulphate varied from 3.06 ± 0.04 to 15.24 ± 0.43 mg/kg, nitrate ranged between 1.36 ± 0.02 to 10.25 ± 0.34 mg/kg, chloride ions ranged from 0.99 ± 0.03 to 6.25 ± 0.23 mg/kg while Phosphate ranged between 1.19 ± 0.14 and 14.73 ± 0.22 mg/kg (Tables 2 - 4). The concentration of phosphate in the studied sites was low when compared to 17.90±1.48 - 38.96±3.03 mg/kg reported by Anegbe and Okuo, (2013) in soils around quarry factory in Edo State. For the control soil samples, the mean value of sulphate was 2.21 ± 0.09 mg/kg, nitrate was 1.01 ± 0.06mg/kg, chloride had 0.98 ± 0.03 mg/kg while phosphate had a mean value of 1.54 ± 0.29 mg/kg (Tables 2-4). Common soluble salts present in the environment include chlorides and sulphates of calcium, magnesium, sodium and potassium. Salt contamination is not normally a hazard to human health; however, it can cause adverse and long-lasting environmental impacts to soil and ground water resources because chloride is highly soluble, it does not adsorb onto soil particles nor degrade, and generally, it inhibits biological processes. Releases of salt into the soil can damage soils by destroying the soil structure and permeability. The presence of high concentrations of soluble salts can inhibit seed germination and plants ability to uptake water. Salt-contaminated soil in the near surface can lose its ability to support agricultural crops, native grasses, or other vegetation if salt levels are high enough and potentially contributing to surface erosion (BER, 2004). The presence of high concentrations of chlorides, nitrates and sulphates may also increase heavy metals solubility, raising both aqueous mobility and uptake by plants (Moore, 1991).

Soil properties with larger co-efficient of variation (CV) values are more variable than those with smaller CV values (Ezeaku *et al.*, 2015). The positive correlations amongst soil physicochemical properties tend to suggest same sources and identical behaviour during transport while negative and insignificant (not significant) positive correlations between soil properties indicate that the appearance of local high concentration for these properties is by possible contamination (Rodrigueze *et al.*, 2008). The correlation studies computed for the analysed soil physicochemical properties in this study to check their relationship generally did not show any regular pattern (Tables 6). This could be due to the influence from the complex nature of wastes found in most open waste dumpsites across Cities in Nigeria. The statistical results from this present study agree with the report from other contaminated similar waste dumpsites by Anake *et al.*, 2009 and USEPA (Botskin and Keller, 1995).

4. CONCLUSION

The study has revealed the levels of contamination of soils around some municipal solid waste dumpsites in Benin City and explored the relationship between ranges of quantitative variables. The solid wastes from the studied dumpsites have increase the values of some soil properties like pH, EC, basic cations, CEC, SOM and available phosphorus. The study also showed that the dumpsites could also impart some influence on the particle size distribution on soils beneath them. Soils with high sand and low percentage clay content have high pollutant leaching potentials. It could therefore be deduced that the underground water close to these dumpsites could be threatened by toxic pollutants from the solid wastes because of the high percent sand composition and low clay content in soils of the studied dumpsites environment. The results from this study have allowed the analysis of the levels of soil properties around municipal solid waste dumpsites.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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