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Quantitative analysis of physical and chemical attribute of soil around power-line dumpsite at Boji-Boji Owa, Delta State, Nigeria

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ABSTRACT

The study ascertains some physiochemical properties of soils around Power-line dumpsite at Boji-Boji Owa, Delta State, Nigeria. In order to evaluate the effects of municipal solid waste dumpsites on soils, soil samples were collected with the aid of a graduated soil auger at depths of 0 – 10 cm, 15 – 25 cm and 25 – 40 cm, representing top to sub and bottom soil sand also 500 m away from dumpsites which serves as control site (R). Samples were taken for laboratory analyses to determine the level of physiochemical properties such as: pH, grain size distribution, Electrical Conductivity (Ec), Organic Carbon (OC), Organic Matter (OM), Available Phosphorous (Av. P), Overall Nitrogen (ON), Basic Cations and Cation Exchange Capacity (CEC) in soils. Results obtained from the study, revealed that values between waste dumpsite and control site were significantly different. Findings showed that the pH value in sampled soils from studied dumpsites ranged from 6.22±0.06 and 7.97±0.04 while the mean pH value for controlled site was 39.8±0.08. The increase in the pH value of the sampled soil indicated an increase in CEC mean value of soil which ranged from 4.73±0.30 and 10.28±0.46 mEq/100 g while a low pH indicated low CEC mean value of 1.50±0.22 mEq/100 g. This is because there exists a positively significant relationship between pH, OC, OM, Av.P, ON, basic cations and CEC. As Ec varied between 692±4.50 to 918±4.03 μScm^{-1}, OC varied between 0.05±0.00 to 0.64±0.03%, OM varied between 0.10±0.06 to 0.57±0.07%, Av.P varied between 8.98±0.06 to 25.36±0.22 mg/kg and ON varied between 0.44±0.01 to 0.93±0.03% across all studied dumpsites.

***Keywords*:** Solid waste, dumpsite, Cation exchange capacity, Exchangeable cation, Boji-Boji Owa, Delta State, Nigeria

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1. INTRODUCTION

Solid waste is garbage, refuse/trash which is on the rise mostly in developing countries without adequate management [1-3]. Solid waste is grouped according to its source such as: household waste as municipal waste, industrial waste is referred to as hazardous waste while medical waste as infectious waste [4]. Increase in population growth, urban expansion, agricultural and domestic activities, industrialization and alteration in consumer habits is a major contributor to the generation of municipal solid waste [5]. However, the methods associated with handling, storing, collection and disposing of these wastes (open dumpsites) poses environmental challenges [6]. It is a common phenomenon to see open dumpsites as a major source of waste disposal in municipalities [7, 8]. These are found where there is an availability of land, and solely takes place in around municipalities without proper consideration to the safety of the citizenry and the environment [9, 10].

Municipal solid waste has become a major environmental challenge. The manner and way in which solid wastes are being disposed have generated a major concern from lack of waste reduction to illegal dumping of wastes indiscriminately to its poor management in Boji-Boji Owa south-south Nigeria. Different researchers have carried out various studies on the negative impact of solid waste on soil. For example, the leachate generated from dumpsites and landfill sites is a combination of chemical and biological components [11]. Waste that penetrate or percolate into the soil goes through various process such as degradation into smaller substances via dissolution, hydrolysis, oxidation and reduction processes [12], as the generated leachate moves downward affecting soil [40-50].

This has made soil conservation an environmental concern globally. Consequently, the composition of waste generated, its volume, temperature and soil morphology is related to the leachate gotten from municipal solid waste [12]. As soil is seen as a major source for absorption of solid waste, materials or debris are thrown away day-to-day by man. Hundreds to thousands of tons of these wastes materials generated from household, industrial and agricultural uses infiltrate into the soil and interact with soil structure, thereby causing an alteration in the physiochemical properties of soils. On the other hand, soils with waste constituents have an increase content of nitrogen, organic matter (organic matter serves as nutrient provider for plant growth which also causes generation of waste) and cation exchange capacity [13]. The presence of heavy metals concentration in soils may be caused by waste increase in soils. The contamination of soil at low concentration with heavy metals poses a negative effect on ecosystem and environmental quality. Relatively, the contaminants generated from leachate that infiltrates into the soil depends on both the leachate and the physiochemical properties of the soil around the dumpsites. Hence, in the evaluation of the soil physiochemical properties around Power line dumpsite in Boji-Boji Owa, it is pertinent to ascertain the baseline information for waste generation and its contaminants effects on soils through laboratory procedure (soil analysis).

Study Area

Power-line dumpsite is situated in Ika North East Local Government Area, South-South Nigeria between latitude 6° 15' 0" North, 6° 13' 0". The dimension of the study area occupies a land mass of about 463 km^3, with an elevation of 205 m above sea level. The climate of Boji-Boji Owa is tropical equatorial with two different seasons: wet season begins from March and ends October and a distinct dry season that extends from November and ends in April.

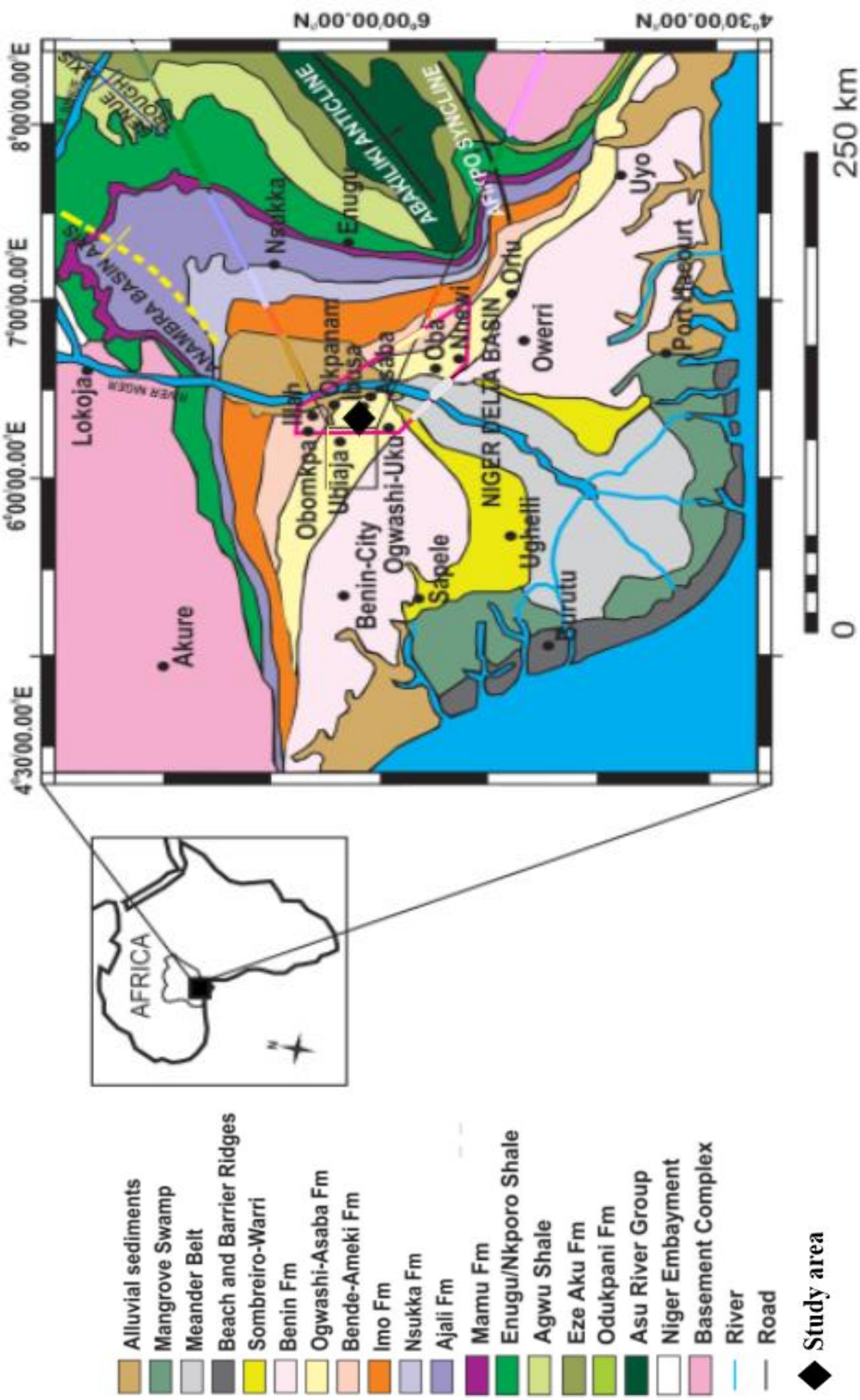

Figure 1. Geology Map of Study Area (Source: [16])

High rainfall values are recorded from July to September, with an average precipitation of 2000 mm. Humidity and atmospheric temperature is high, with mean values of 24–27 °C reported for both, day and night [14]. Most dumpsites in Boji-Boji Owa have been in existence since 1996 and were initially seen several kilometers away from residential areas, but due to increase in population growth and rapid urbanization these areas are now built-up areas. The dumpsites occupy a large expanse of land with leachate infiltrating into the soil following the terrain. The wastes found on the landfill mainly consist of household, industrial, agricultural and medical waste which are not being separated aside from waste collector that partly collects plastic materials, glass and metals for recycle or reuse. It was also observed that there are changes in the soils around the dumpsite due to the municipal solid waste as well as serious threat onto the environment.

Geological Setting

The study area is underlain by the Ogwashi-Asaba Formation (see Fig. 1). The Oligocene – Miocene Ogwashi Asaba Formation consists of interbedded successions of lignite, shale, sandstone, siltstone, and claystone facies, as shown in **Table 1**. It is the outcropping equivalent of the Agbada Formation in the subsurface of Niger Delta. Depositional environment has been interpreted to be continental [15].

Table 1. Outcropping Units of the Cenozoic Niger Delta

Age span	Lithostratigraphic unit		Charactertics
Oligocene-Present	Benin Formation		Known also as the Coastal Plains Sands; cross-bedded, coarse, pebbly continental sands, with clay lenses and lignites; has marine shale breaks with foraminifera, ostracods, and molluscs
Oligocene-Miocene	Ogwashu-Asaba Formation		Clays, silts, and sands with thin to thick lignite seams
Eocene-Early Oligocene	Ameki Group	Nsugbe Formation	mainly sands with some conglomerate bands
		Nanka Formation	Calcareous clays and silts with thin shelly limestone, rich in foraminifera
		Ameki Formation	Calcareous clays and silts with thin shelly limestone, rich in foraminifera, mainly sands, minor silt, and clay intercalations

Paleocene-Early Eocene		Blue–gray shales with sand lenses, marls, and fossiliferous limestones, sandstone members—ebenebe, Umuna, and Igbaku sandstones; shales with foraminifera and ostracods

2. MATERIALS AND METHODS

In order to evaluate the physiochemical properties of soil around Power-line dumpsite in Boji-BojiOwam, soil samples around the dumpsite were collected for analysis. The soil samples were accumulated between February 2016 to April 2016. Composite soil samples were collected from five different locations in the dry season (April- November) and wet season (March – October).

The soil samples were collected with the aid of a graduated soil auger at depths of 0 – 10 cm, 15 –25 cm and 25 – 40 cm, representing top soils, sub-soils and bottom soils, respectively. The three soil samples per points were bulked together from each of the three depths to create one composite sample. At each dumpsite, five (5) points were randomly chosen 50 meters away from each center for sample collection and were labelled MT-1, MT-2, MT-3, MT-4 and MT-5. Each soil sample was then placed in a polythene bag covered with aluminum foil and they were immediately transported to the laboratory and stored under room temperature before subjected to physiochemical analysis.

The soil samples were further air dried and were made to pass through 2-mm stainless steel sieve. The control soil samples were obtained in the same way (500 m away from dumpsites). The control site is unaffected by waste from dumpsites and served as the control site-labeled (R).

Physiochemical Analysis

The composite soil samples for the physio-chemical analysis were determined using a standard analytical method [12]. The parameters examined included: pH, grain size distribution, electrical conductivity, total organic carbon, organic matter, phosphorous (P), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), and cation exchange capacity (CEC). Grain size distribution, otherwise known as mechanical analysis, was determined using hydrometer method [18] by means of sodium hexametaphosphate as dispersant.

Organic matter was evaluated from the total organic carbon through the method given in [18], while the soil available phosphorus was determined by colorimetric method reported by [19]. Cation exchange capacity (CEC) was examined using the ammonium acetate digestion method described by [20]. The pH and electrical conductivity were measured in a soil suspension (1:2.5 w/v dilutions) by digital pH meter (Labotronics-LT-1) and conductivity meter (CO150), respectively.

Herewith, the exchangeable bases: calcium (Ca) and magnesium (Mg) were determined by EDTA titration while potassium (K) and sodium (Na) were determined by bulk scientific standard solutions, used to calibrate the Atomic Absorption Spectrometer (Bulk Scientific VGP 210 model).

Statistical Analysis

Data obtained from the mean physicochemical parameters of sampled soils from Power-line dumpsite were subjected to descriptive statistical analysis (mean and ± S.D. value). Correlation coefficient was analyzed using Statistical Package for Social Sciences (SPSS), while bivariate plots were used in determination of relationship between the studied dumpsite and controlled site (R).

3. RESULTS AND DISCUSSION

The physicochemical properties of soil samples in dumpsite and controlled site (R) in Boji-Boji Owa, Delta state, is presented in **Table 1**. The physicochemical analysis of soil samples results shown in **Table 2** indicated that the presence of solid waste in dumpsite significantly affects soil properties such as: pH, grain size distribution, electrical conductivity (Ec), organic carbon (OC), organic matter (OM), available phosphorous, overall nitrogen, basic cation and cation exchange capacity (CEC) in contrast to the soil in controlled site (R), as shown from the results obtained. It was revealed in Table 1 that there was an increase in the physicochemical properties of soils component in soil from dumpsite than controlled site (R).

The results obtained in the study were in accordance with the results of [16] and [21] which stated that solid wastes in dumpsites had a significant increase in most of the analyzed soil properties. This increase in concentration might be as a result of the decayed and mineral content of decomposable solid waste in dumpsite.

Table 2. The Physiochemical Properties of Sampled Soil Aggregates (Mean) close to Power-line Dumpsite Boji-BojiOwa, Delta State.

Area close to dumpsites						
Parameters	MT-1	MT-2	MT-3	MT-4	MT-5	R
pH	6.22 ±0.06	7.60 ±0.10	7.05 ±0.08	7.64 ± 0.05	7.97 ±0.04	3.98 ±0.08
Sand (%)	86.43 ±0.03	82.20 ± 0.07	90.40 ± 0.12	85.60± 0.14	90.05 ± 0.10	84.32 ± 0.13
Silt (%)	1.82 ± 0.00	0.79 ± 0.03	2.35 ± 0.12	1.97 ± 0.08	1.56 ± 0.04	1.24 ± 0.10
Clay (%)	9.30 ± 0.05	8.15 ± 0.10	14.50 ± 0.03	8.35 ± 0.12	17.42 ± 0.14	11.50 ± 0.05
EC (μScm^{-1})	768 ±2.43	692 ±4.50	890 ±3.87	918 ±4.03	790 ±5.44	420 ±20.76
OC (%)	0.05 ± 0.00	0.34 ± 0.03	0.15 ± 0.00	0.64 ± 0.03	0.45 ± 0.05	0.20 ± 0.03
OM (%)	0.10 ± 0.06	0.25 ± 0.05	0.34 ± 0.00	0.57 ± 0.07	0.38 ± 0.03	0.34 ± 0.05

Av. P (mg/kg)	10.60 ± 0.32	24.38 ± 0.10	8.98 ± 0.06	11.64 ± 0.34	25.36 ± 0.22	4.98 ± 0.35
ON (%)	0.44 ±0.01	0.48 ±0.02	0.86 ±0.06	0.39 ±0.01	0.93 ±0.03	0.06 ±0.01
Ca (mEq/ 100 g)	5.40 ± 0.08	2.76 ± 0.49	5.34 ± 0.22	4.96 ± 0.50	4.76 ± 0.00	1.29 ± 0.10
Na (mEq/ 100 g)	0.30 ± 0.00	1.28 ± 0.00	0.58 ± 0.01	0.89 ± 0.00	1.35 ± 0.01	0.03 ± 0.00
Mg (mEq/ 100 g)	0.10 ±0.00	0.12 ±0.02	0.36 ±0.08	2.10 ±0.10	0.69 ±0.09	0.30 ±0.09
K (mEq/ 100 g)	0.98 ± 0.03	0.67 ± 0.00	0.12 ± 0.01	0.85 ± 0.03	0.79 ± 0.00	0.02 ± 0.01
CEC (mEq/ 100 g)	5.65 ± 0.06	4.87 ± 0.30	4.73 ± 0.03	6.30 ± 0.03	10.28 ± 0.46	1.50 ± 0.22

where: mean ± S.D., Ec = Electrical Conductivity, OC = Organic Carbon, OM = Organic Matter, CEC = Cation Exchange Capacity.

pH Measurement

The physicochemical properties of sampled soils revealed that the mean values for soil pH around dumpsite varied between 6.22±0.06 to 7.97±0.05 and ranged between slightly acidic to slightly alkaline as against the pH value of the controlled site (R) at 3.98±0.08 (Table 1) which is strongly acidic. This was due to the settling down of waste at the dumpsite. It was revealed that there were no significant differences in pH of soil in MT-2 and MT-4 dumpsite. Nevertheless, there was a significant difference in soil pH values of MT-1, MT-3 and MT5 dumpsites. The values obtained are similar with values described by [22], which have a slight increase in comparison with the values described by [23]. The slight alkalinity pH value of soils around the dumpsite are due to decrease in anaerobic soils present in the environment, [24] and [25]. The attributes of soil pH also have a great impact on concentration of element and soil infiltration. The highest pH value was gotten from sampled soil DS5 at 7.97±0.04 while the lowest was MT-1 at 6.22±0.06. The pH value range obtained by [26] between 6.90 to 7.79 according was also obtained around hazardous waste dumpsite in India. Other pH values have also been identified in different domestic waste dumpsites in various parts of the country; these include report obtained by [27] on dumpsite environment in Ondo State, Nigeria, with the mean pH value of between 7.40±0.04 [28], also reported on physicochemical properties of municipal waste dumpsites at Kubwa, Abuja, Nigeria with mean pH value equaling about 7.30±0.05 [16], on municipal solid wastes with physicochemical properties of dumpsite soils in Benin City, Nigeria, with mean pH value of 7.79±0.05. Furthermore, the slight acidity in soil pH in (CS) was due to the presence of basic cations caused by erosion and leaching. This is because basic cations increase as pH and CEC increase, and vice versa.

Grain Size Distribution

Soil sampled result from dumpsite revealed that sand had a high percentage composition. The mean values for sand fractions ranges between from 82.20±0.07 to 90.40±0.12. with clay value ranging between 8.15±17.42% and silt composition which has the lowest value ranging from 0.79 to 1.9. There is also a high mean soil value for controlled site (R). The sand fraction also had the highest mean value at 84.32±0.13%, clay at 11.50±0.05%, and silt at 1.24±0.10, respectively, as shown in Table 1. The higher increase in sand content in the studied dumpsite was due to the low contents of organic carbon (OC), organic matter (OM), cation exchange capacity (CEC) and nitrogenous component in soils around dumpsite. Additionally, an increase in sand fraction in the dumpsite causes leaching of high pollutant, because clay contents and organic matter in colloids are accountable for retaining metallic ions in soils [29]. This is because soils with excessive sand content with more than 75% have not too strong soil accumulation at the surface and thus liable to porosity, air circulation leaching and easily transportable [30,31].

Electrical Conductivity (Ec)

Electrical conductivity (Ec) is the evaluation of salinity, soil texture and cation exchange capacity (CEC) in soil [31]. The EC mean value range of soil around dumpsite in the study area varied between 692±4.50 to 918±4.03 (μScm^{-1}). Here (CS) had a value range of 20.76±420 (μScm^{-1}), as shown in Table 2. The result revealed that the effect of high Ec in the study dumpsite was due to the presence of ions in soil and in wet filled pore soil which improves soil Ec. In other words, it shows that the circulation of charged particles in soils around dumpsite is higher than the values in controlled site, as reported by [32].

Organic Carbon (OC) and Organic Matter (OM)

The availability of organic carbon (OC) in soils has resulted in rise in the cation exchange capacity (CEC) which helps in the accumulation of nutrients taken in by plants. OC is the preserved carbon in organic matter (OM). Table 2 showed that the percentage of OC in soil around dumpsite ranged from 0.05±0.00 to 0.64±0.03% while controlled site has a value of 0.20±0.03%. The presence of low organic carbon in the studied dumpsite was attributed to high amount of sand fraction obtained from particle size distribution due to the non-degradation of compostable or solid waste found around dumpsites, as observed by [33]. This was the same with the observation of [33] and [16] on municipal solid wastes dumpsite soils in Benin and municipal solid waste dumpsites in Kano and Kaduna, all in Nigeria. Organic matter (OM) improves the importance of soils for agricultural use. The OM value of soil sample in the study dumpsite varied from 0.25±0.05 to 0.10±0.06%, while controlled site has a value range of 0.34±0.05%, as shown in Table 2. This result was in accordance with [34] result, which stated that the pH system and OM is higher in dumpsite in comparison to controlled site, same with the study carried out by [35] on municipal open waste dumpsite in Yenagoa, Nigeria and [16] on municipal solid waste dump in Benin, Nigeria. An increase in OM (>2.0%) in soils is favorable for heavy metal chelation formation [36].

Cation Exchange Capacity (CEC)

The number of exchangeable cations per unit mass of dry soil which perform a major function in soil fertility is known as cation exchange capacity (CEC). It means the total number of exchangeable basic cations, such as: Calcium (Ca), Sodium (Na), Magnesium (Mg) and Potassium (K) ions were in sampled soils; they rely on the competence of absorption of heavy metals. It depends on the summation of properties of soil and a particular properties of soil elements like pH, clay and organic matter (OM) contents of soil [37]. It was revealed in Table

2, that the result of CEC in the studied dumpsite ranged from 4.73±0.03 mEq/100 g to 10.28±0.46 mEq/100 g as compared to the controlled site with value ranging between 1.50±0.22 mEq/100 g. Moreover, since the clay content for the dumpsite and controlled site were low, it is viable that greater part of the exchangeable bases at the dumpsite have been occurring in absorbent form instead of an exchangeable form adsorbed at cation exchange locations. In addition, the low CEC content in sampled soil from dumpsite and controlled site was as a result of increase in sand fractions. The soil with low CEC content may certainly yield insufficient Ca, Na, Mg, K and low organic matter [31].

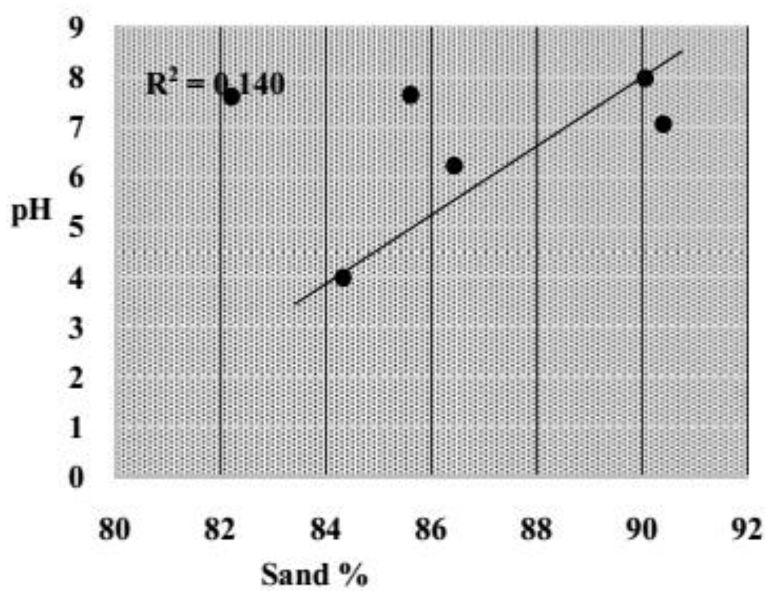

Fig. 3a: Plot of pH against sand

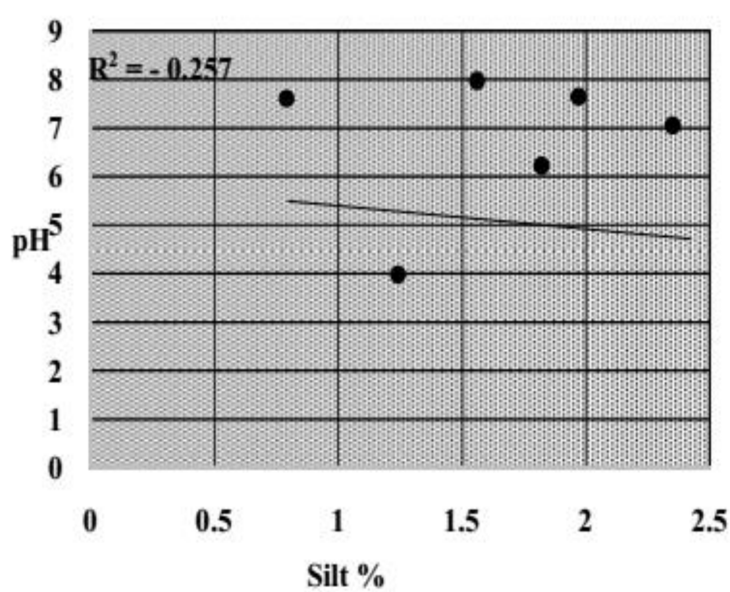

Fig. 3b: Plot of pH against Silt

The increased organic matter in CEC soils needed time to take effect, whereas soils high in CEC are less liable to leaching of cations. It appears, low CEC soils are subjected to high rate of leaching [31].

This increase in CEC found in some sampled soils in dumpsite location were due to the increased value of exchangeable calcium (Ca) seen in sampled soil. Because CEC decreased with the increase in sand content, there is smaller exchange location that impact the retention of metals in sand when compared to OM and clay content in soil [29].

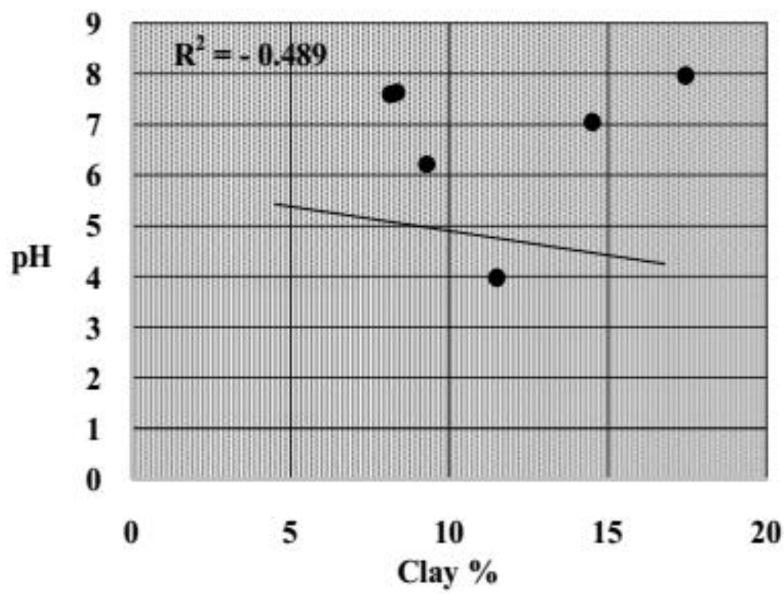

Fig. 3c: Plot of pH

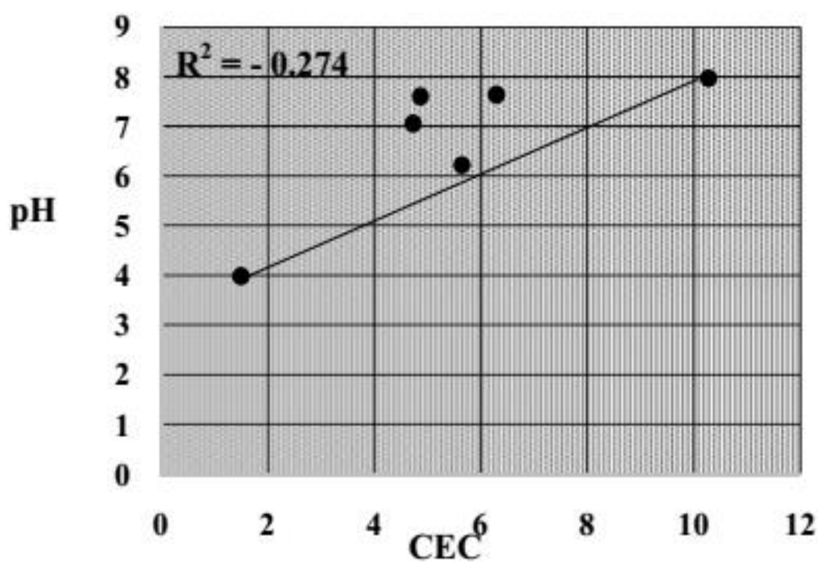

Fig. 3d: Plot of pH against CEC

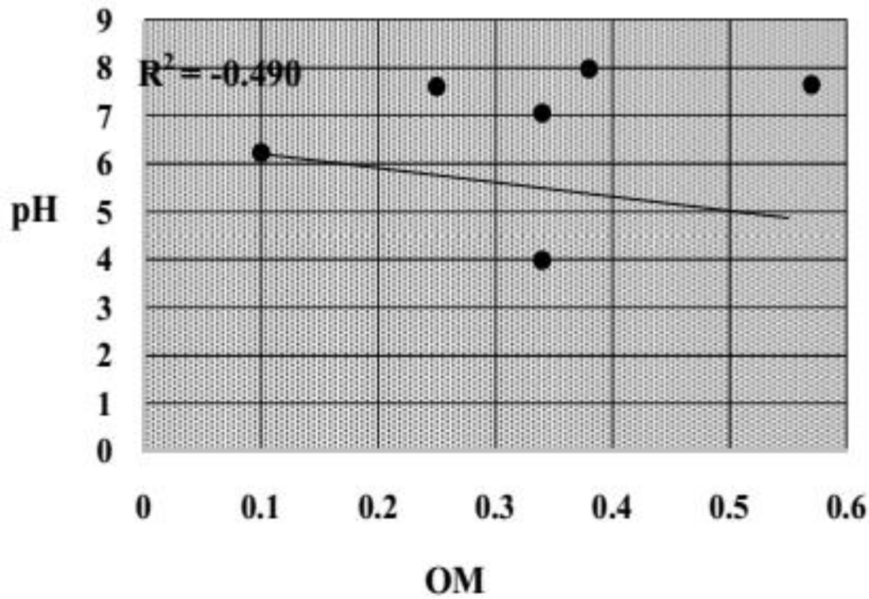

Fig 3e: Plot of pH against OM

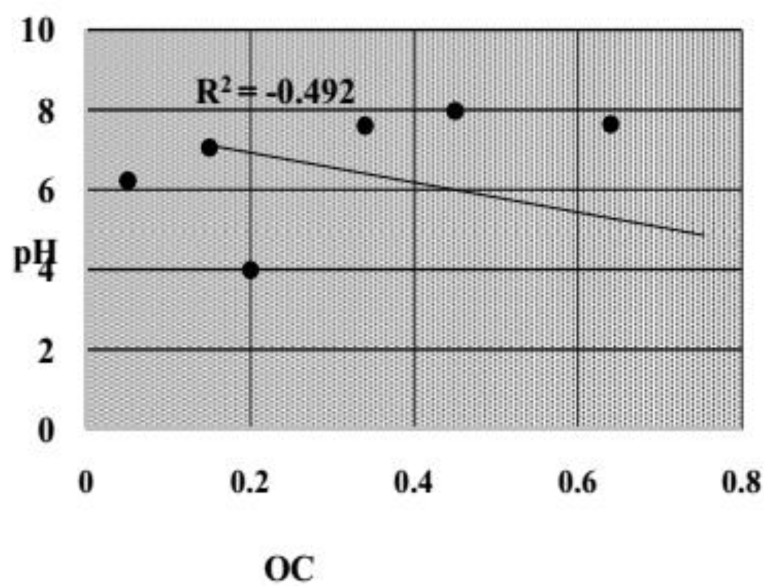

Fig 3f: Plot of pH against OC

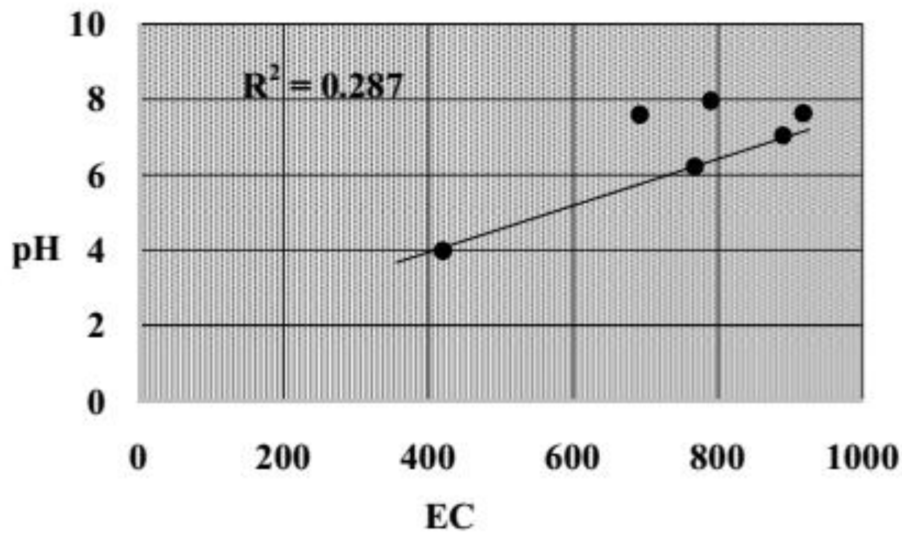

Fig. 3g: Plot of pH against EC

Figure 3 (a – g). Comparison of the mean Physicochemical Parameters of Soil Samples in the studied Dumpsite and Controlled site using Plots.

Overall Nitrogen (N) Content

The overall Nitrogen content (N) of soils around the studied dumpsite varied between 0.39±0.01 to 0.93±0.03%, while the value for controlled site varied in the range 0.06±0.01% (Table 1). The low value and low degradation of OM content in the studied dumpsite was due to decreased value of ON content to a crucial stage of 1.0 to 2.0 g/kg. This result was in accordance with [38], as well as [16] and [21]. Thus, since the value for studied dumpsite is greater than that of the controlled site, the waste dump is a major contributor to the low levels of these soil properties.

Available Phosphorous (P)

The mean value of P in dumpsite ranged from 8.98±0.06 mg/kg to 25.36±0.22 mg/kg, while the controlled site ranged from 4.98±0.35 mg/kg (Table 2). The values of P value in the studied dumpsite and controlled site were lower. This low presence of P value in some of the sampled soil around the dumpsite was due to higher content of non-biodegradable waste caused by microorganisms, low level of organic matter (OM) and degradation of agricultural materials in both dumpsite and the controlled site [39, 40]. All sampled soils have P value greater than 10 mg/kg [41]. Conclusively, it was observed that the P value in all studied dumpsites were low when related to 12.11±0.01 to 44.13±0.03 mg/kg values, as reported by [27] in sub-surfaces soils: 68.22±0.89 to 84.20±1.02 mg/kg obtained by [35] in surface soils, and 14.35±7.00 to 33.16±20.68 mg/kg, reported by [42] in surface and sub-surface soils. Therefore, the low P value was also attributed to other soil parameters such as: low percentage of clay and sand fractions and low pH which reduces the binding sites of metals and also high leaching rate from sandy soils [33, 43].

The correlation coefficient of the mean pH value revealed that pH was significantly correlated and positive with electrical conductivity (Ec), where: μScm^{-1} EC (r = 0.274), mEq/100 g Na (r = 0.554), and % sand (r = 0.466), respectively. The mean pH was also positive and not significantly correlated with parameters, such as: % silt, Mg, and K soils component. Nevertheless, the mean pH was negative and not significantly correlated with % clay (0.231), but negative and significantly correlated with mEq/100 g OC (r = −0.512) and mEq/100 g OM (−0.506), as shown above in Table 2 and Figure 3 (a − g).

4. CONCLUSION

The study revealed that the physical and chemical attributes of soils from the studied dumpsites were higher than those obtained from the controlled site (R). The study showed that waste from studied dumpsite could have effect on the grain size distribution or soils found below them and also significantly contributed to increased values of pH, EC, OC, OM, Av. P, ON, basic cations and CEC. The relative increase in the pollution leaching potentials of municipal solid waste in soils within the studied site shows that the soil has an increased percentage of sand fraction and a low clay fraction. The overall conclusion from the study reveals that the underwater near the dumpsites may be exposed to poisonous pollutants derived from solid waste due to increased percentage of sand fraction and low clay fraction present in soils in the environment close to dumpsite. With this, it can be deduced that with the level of pollution or contamination of the soils by solid waste, the results obtained from the study have permitted the evaluation of soil physicochemical properties around the Power Line dumpsite.

References

[1] Cointreau, S.J., Mundial, B. Environmental management of urban solid wastes in developing countries: a project guide. *The World Bank*, vol. 5, 1982.

[2] Doan, P.L. Institutionalizing household waste collection: the urban environmental management project in Cote d'Ivoire. *Habitat International*. 1998. 22, 27-39

[3] Singh, R.P., Arouja, A.S.F., Ibrahim, M.H., Sulaiman, O. Management of urban solid waste: vermin composting a sustainable option. *Resource Conservation Recycle*, 2011. 55, 719-729

[4] Abul, S. Environmental and Health Impact of Solid Waste disposal at Mangwane Dumpsite in Manzini Swaziland. *Journal of Sustainable Developmentin Africa*, vol. 12, no. 7, 64-78, 2010

[5] Akoteyon, I.S. Mbata, U.A., Olalude, G.A. Investigation of heavy metal contamination in groundwater around landfill site in a typical sub-urban settlement in Alimosho Lagos-Nigeria. *Applied Science of Environment and Sanitation*, 2011. 6, 155-163

[6] Otabor, K.E., Oviawe, A.P. Ilori, E.G. (2018). Study on the Impact of Municipal Solid Wastes on Physico-Chemical Properties of Dumpsite Soils in Benin City, Nigeria. *Nigerian Research Journal of Engineering and Environmental Sciences*, 3(2), 529-541

[7] Jhamnaniand, S., Singh, B. Groundwater contamination due to Bhalaswa landfill site in New Delhi. *International Journal of Environmental Science and Engineering*, vol. 1, 121–125, 2009

[8] Longe, E., Balogun, M. Groundwater quality assessment near a municipal landfill, Lagos, Nigeria. R*esource Journal of applied Science and Engineering Technology*, 2010. 2, 39-44

[9] Sabohi, E.A., Abdul, R.S. Leachate composition and groundwater pollution at municipal solid waste landfill of Ibb city, Yemen. *Sains Malaysiana*, 2009. 38, 295–304

[10] Adefemiand, S.O., Awokunmi, E.E. Determination of Physicochemical parameters and heavy metals in water samples from Itaogbolu area of Ondo State, Nigeria. *African Journal of Environment Science and Technology,* 2010. 4, 145-148

[11] Piccolo, A., Mbagwu, J.S.C. Exogenous humic substances as conditions for the rehabilitation of degraded soils, Agro-Foods Industry Hi-Tech. March/April. 1997.

[12] Badmus, B.S., Ozebo, V.C., Idowu, O.A., Ganiyu, S.A., Olurin, O.T. Physicochemical Properties of Soil samples and Dumpsite of Environmental Impact on Ground Water Quality in South-western Nigeria. *The Africa Reviewer of Physics,* 2014, 9(15), 103-113

[13] Anikwe MA, Nwobodo KC. Long term effect of municipal waste disposal on soil properties and productivity of sites used for urban agriculture in Abakaliki, Nigeria. *Bioresource Technology* 2002 Jul; 83(3):241-250. DOI: 10.1016/s0960-8524(01)00154-7

[14] Illeoje, S.I. General Geography of Nigeria. Heinemann Books Ibadan. 2003.

[15] Kogbe, C.A. Paleogeographic history of Nigeria from Albian times. In: Kogbe, C.A. (Ed.) Elizabethan Publishers, Lagos, 1976. pp. 237–252.

[16] Ogala, J.E., Kalaitzidis, S., Rizos, A.M., Christanis, K., Omo-irabor, O.O., Adaikpoh, E.O., Ejeh, O.I., Papaefthymiou, H. Petrographic and mineralogical study of extended out crops of lignite layers in Agbor area, southern Nigeria, *Journal of African Earth Sciences*, (2019), doi:https://doi.org/10.1016/j.jafrearsci.2019.103659

[17] Ilori, E.G., Aisueni, N.O., Sulaiman-Ilobu, B.B., Ekhator, F., Eneje, R.C., Efetie-Osie, A. Immobilization effect of Cow Dung on Lead and Chromium in Soil Cultivated with Oil Palm. *Bulletin Environmental and Pharmacological Life Sciences,* 2012, 1(9), 74-80

[18] Asagba, E.U., Okiemen, F.E., Osokpor, J. Screening and speciation of heavy metal contaminated soil from an automobile Spare Parts Market. *Chemical Speciation and Bioavailability,* 2007. 19(1), 9-15

[19] Okuo, J.M., Anegbe, B., Atenaga, M.A., Ighodaro, A., Emina, N.A. Oladejo. Distribution and Speciation of Heavy Metals in Soils around some Selected Auto Repair Workshops in Oghara, Delta State Nigeria. *International Journal of Environmental, Agriculture and Biotechnology,* 2016, 3(2), 575-584

[20] Elfaki, J., Gafer, M., Suliemanand, M., Ali, M. Comparison and evaluation of two analytical Methods for cation exchange capacity and exchangeable sodium percentage of five soil types in Central Sudan. *Journal of Soil Science,* 2015, 5, 311-318

[21] Wunzani, D.K., Dauda, M.S., Wyasu, G., D.A.A. David. "Assessments of Physicochemical Properties and Heavy Metals Content in Soils from Selected Solid Waste Dumpsites in Kaduna Metropolis, Kaduna State, Nigeria. *Science World Journal*, 2020, 15(1), 76-79

[22] Akpoveta, O.V., Osakwe, S.A., Okoh, B.E., Otuya, B.O. Physicochemical Characteristics and Levels of Some Heavy Metals in Soils around Metal Scrap Dumps in Some Parts of Delta State, Nigeria. *Journal of Applied Sciences and Environmental* Management, vol. 14(4), 57 – 60, 2011.

[23] Osakwe, S.A., Okolie, L.P. Physicochemical Characteristics and Heavy Metals Contents in Soils and Cassava Plants from Farmlands along A Major Highway in Delta State, Nigeria. *Journal of Applied Science and Environmental Management*, 2015, 19(4), 695-704

[24] Odu, C.T.I., Esurosu, O.F., Nwaboshi, I.C., Ogunwale, J.A. Environmental study Soil and Vegetation) of Nigeria Agip Oil Company Operation Area. A report submitted to Nigeria Agip Oil Company Limited, Lagos, Nigeria. 1985. pp. 102-107

[25] Isirimah, N.O. An inventory of some chemical properties of selected surface soils of River state of Nigeria. In *Proceeding of the 15th Annual Conference of Soil Science Association of Nigeria, Kaduna.* 1987, 217-233

[26] Daniel Omeodisemi Omokpariola, John Kanayochukwu Nduka, Patrick Leonard Omokpariola, Elshalom Chioma Onomeda Omokpariola, Ionic composition of rainwater from different sampling surfaces across selected locations in Rivers State, Nigeria. *World Scientific News* 150 (2020) 132-147

[27] Akinyinka, A., Jacob, O.A. Physicochemical Characteristics and Heavy Metals Concentration in Sub-Surface Soil at Different Dumpsites in Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria. *Journal of Environmental and Agricultural Sciences*, 2016. 8, 21-28

[28] Useh, M.U., Etuk-Udo, G.A., Dauda, M.S. Evaluating the Physico-chemical Properties and Heavy Metals in Soils of Municipal Waste Dumpsites at Kubwa, Abuja, Nigeria. *Journal of Chemistry and Chemical Sciences*, 2015, 5(11), 654-662

[29] Nyleand, B., Ray, R.N. The nature and properties of soils.12th Edition United States of America, 1999. 734-785

[30] Gbadegesin, A.S., Abua, M.A. Variation of Soil Properties on Cassava Production in the Coastal Area of Southern Cross River State, Nigeria. *Journal of Geography and Geology*, 2011, 3(1), 94-103

[31] Eyankware, M.O., Eyankware, O.E., Ulakpa, R.O.E. Assessment of Impact of Leachate on Soil Physicochemical Parameters in the Vicinity of Eliozu Dumpsite, Port Harcourt, Nigeria. *Basic Resource Journal of Soil and Environment and Science, Benin, Nigeria*, 4(2), 15-25, 2016

[32] Obasi, N.A., Akubugwo, E.I., Ugboguand, O.C. Otuchristian, G. Assessment of physicochemical properties and heavy metals availability in dumpsites along Enugu-

Port-Harcourt expressways, South-East, Nigeria. *Asian Journal of Applied Sciences*, 2013, 5, 342-356

[33] Anake, W.U., Adie GU, Osibanjo, O. Heavy Metals pollution at Municipal Solid Waste Dumpsites in Kano and Kaduna States in Nigeria". *Bulletin of the Chemical Society of Ethiopia*, 2009, 23(2), 281-289

[34] Oyedele, D.J., Gasu, M.B., Awotoye, O.O. Changes in Soil Properties and Plant Uptake of Heavy Metals on Selected Municipal Solid Waste Dump Sites in Ile-Ife, Nigeria. *African Journal of Environmental Science and Technology*, 2008, 3(5), 107-115

[35] Amos–Tautua, B.M.W., Onigbindea, A.O., Ere, D. Assessment of some heavy metals and physicochemical properties in surface soils of Municipal Open Waste Dumpsite in Yenagoa, Nigeria. *African Journal of Environmental Science and Technology*, 2014, 8(1), 41-47

[36] Ayolaghaand, G.A., Onwugbata, G.C. Suitability comparison of waste disposal site. 27th proceedings of the Annual Conference of the Soil Science of Nigeria, University of Calabar, Nigeria. 2001. November, 5-9.

[37] Brady, N.C. The nature and properties of soil. 11th Ed.; McMillan: New York. 1996. 621 pages.

[38] Eyankware, O.R., Eyankware, M.O., Effam, C. Soil Erodibility Assessment in Selected Part of Ekwusigo Local Government Area Anambra State South-Eastern Nigeria. *International Journal of Innovation and Scientific Research*, 2015, 13(1), 50-62

[39] Sobulo, R.A., Osiname, O.A. Soils and fertilizer use in Western Nigeria. *Research Bulletin*, 1981, No. 1, I.A.R.T. University of Ife.

[40] Ideriah, T.K.J., Omuaruand, V.O.T., Adiukwu, P.A. Soil quality around a waste dumpsite in Port-Harcourt, Nigeria". *African Journal Ecology*, 44, 388-394, 2006.

[41] Ukpong, E.C., Antigha, R.E., Moses, E.O. Assessment of Heavy Metals Content in Soils and Plants around Waste Dumpsites in Uyo Metropolis, Awka-Ibom State, Nigeria. *The International Journal of Engineering Sciences*, 2(7), 75-86, 2013.

[42] FAO, A framework for land Evaluation. *FAO Bulletin* 32, FAO/UNESCO, 1976. France.

[43] Sandeep, G. Influence of prolonged disposal of municipal solid waste on soil productivity factors. *Journal of Applied and Natural Science*, 2019, 11(4), 816-822

[44] Bamidele, A.T., Onigbinde, M.W., Adebayo, O., Preye, E. Assessment of Heavy metals content and Physico-chemical properties in surface soil of municipal open waste dumpsites in Yenagoa, Nigeria. *African Journal of Environmental Science and Technology*, 2014, 8(1), 41-47

[45] E. C. O. Omokpariola, D. O. Omokpariola, Weathering Profile of Schistose Rock from Geotechnical and Geochemical Parameters at Okpe, Igarra Schist Belt in Edo State, Nigeria. *World Scientific News* 154 (2021) 89-100

[46] Dawit Yihunie, Afera Halefom, Investigation of groundwater potential zone using Geospatial Technology in Bahir Dar Zuria District, Amhara, Ethiopia. *World Scientific News* 146 (2020) 274-289

[47] Francis Chizoruo Ibe, Benjamin Ekene Ibeachu, Metallic contaminant levels of borehole water sources within metal scrap dumpsites in Aboh Mbaise, Imo State, Nigeria. *World Scientific News* 144 (2020) 226-242

[48] Mevayerore Daniel Igbini, Natural – Resource Curse, Niger Delta Crisis and Oil Exploration in Nigeria: A Theoretical Analysis. *World Scientific News* 141 (2020) 1-11

[49] Harrison Charles Ekoh, Spatial Variation of Air Quality in Mpape Area of Abuja, Nigeria. *World Scientific News* 140 (2020) 79-112

[50] K. G. Ugbena, A. C. Tse, Enuvie G. Akpokodje, Modeling Soluble Contaminant Migration by Advection Process in Subsurface Water in the Eastern Niger Delta, Nigeria. *World Scientific News* 139(2) (2020) 102-114