# Physicochemical Characteristics, Particle Size Distribution and Total Hydrocarbon Content in Soil from Abandoned Landfill Site in Igbogene, Bayelsa state, Nigeria

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**ABSTRACT:** Most household and some industrial solid wastes end up in the landfill which is the commonest means of solid waste management in many parts of Baylesa state, Nigeria. This study assessed the physicochemical characteristics, particle size distribution and total hydrocarbon content in soil samples from abandoned landfill site in Igbogene, Bayelsa state, Nigeria by collecting samples from varying distances (50m, 100m and 150m) at a depth of 0-20cm and analyzed using standard methods. Results were in the range of 5.01 – 5.34 (pH), 0.73 – 0.98 meg/100g (Exchangeable Acidity), 2.45 – 3.48 meg/100g (sodium), 0.19 – 0.31 meg/100g (potassium), 3.94 – 5.33 meg/100g (calcium), 1.52 – 2.15 meg/100g (magnesium), 9.57 – 11.49 mg/kg (nitrate), 4.18 – 5.19 mg/kg (sulphate), 6.99 – 8.85 mg/kg (available phosphorus), 8.23 – 12.60 mg/kg (total hydrocarbon content), 76.48 – 100.25 mg/kg (chloride), 5.14 – 7.59 mg/kg (ammonium), 8.83 – 8.95% (clay), 2.70 – 3.10% (silt), 87.93 – 88.35% (sand), 2.62 – 3.58% (organic carbon), 4.51 – 6.16% (organic matter) and 0.22 – 0.33% (total nitrogen). Analysis of variance (ANOVA) showed no significant deviations ($p > 0.05$) across the various distances for all parameters except for organic carbon and matter, total nitrogen, potassium and ammonium. In addition, most of the nutrients showed positive significant relationship at $p < 0.05$. This suggests that at large the activities of old landfill in the study area is not influencing the soil characteristics under study. Rather the apparent decline in value away from old landfill may be due to mobility level of minerals in the soil toward the southwest direction, which the cluster analysis clearly showed.

The environmental components are basically made up of the water including the surface water and its sediment, soil or land and air. These major environmental components are mostly recipients of wastes streams including liquid, gaseous and solid that are generated from human activities in different setting i.e. industrial and household. Soil pollutants have the tendency to alter air quality of a particular location (Seiyaboh and Izah, 2019). In addition, solid wastes and / or liquid waste discharged into the surface water and or close to surface water could alter the characteristics of the receiving water (Uzoekwe and Achudume, 2011). The discharge of solid waste into surface water or close to surface water is carried out by several families in many coastal communities in the Niger Delta especially in Bayelsa state. Many human activities are being carried out in the soil of Niger Delta region. As such many wastes streams including solid and liquid from food processing sectors such as garri and palm oil production (Izah et al., 2016), effluents from refineries and crude oil production processes (Uzoekwe and Nwachokor, 2012; Uzoekwe and Achudume, 2011), are discharged into the environment with little or no treatment.

Wastes that are discharged into the land fill and or dumpsite are mainly solid including remains of scrap metals, food remains and household items, wastes emanating from agricultural and industrial activities. Wastes can be classified as organic or inorganic. Organic wastes are wastes streams that emanate from biomass and has the tendency to degrade. Microbes being ubiquitous are found everywhere and some have the tendency to degrade some substances found in our environment.

Wastes are basically toxic to our environment and as such they need to be properly managed. In many regions of the world, most solid wastes are managed through landfill system, incineration, composting and recycling through anaerobic digesters with different configurations. In Nigeria most wastes are managed using landfill system. Wastes have the tendency to alter the characteristics of the receiving soil. For instance, Izah and Aigberua (2017) reported that cassava waste water has the tendency to alter the microbial density and diversity in the receiving soil. There is also a report that the waste water could alter the physical, biological and chemical characteristics of

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receiving soil, and oil palm processing waste water could alter the characteristics of receiving soil and hinder plant growth and productivity (Izah et al., 2016). Uzoekwe and Nwachokor (2012) reported that wastes and other forms of pollution arising from crude oil production altered both the fertility status and microbial distribution of a typical ultisol. Due to the effect of wastes on the soil surface, it is necessary to study the characteristics of the soil with respect to its biological, chemical and physical characteristics. Therefore, the objective of this study is to evaluate the physicochemical characteristics, particle size distribution and total hydrocarbon content in soil samples obtained from abandoned landfill site in Igbogene, Bayelsa State, Nigeria.

## MATERIALS AND METHODS

*Study Area:* The study area is an old dumpsite in Igbogene community which witnessed excavation during construction of Mbiama- Yenagoa Road. Igbogene community is located at the entrance of Yenagoa metropolis, Bayelsa state capital. Water body (known as Epie creek) passes through the community like many other adjourning communities that make up the Yenagoa metropolis. The creek is a major receipt of solid wastes from families close to the creek. Two major climatic conditions observed in the study are; wet season which starts from April and ends in October and dry season which starts from November and ends in March.

*Sampling Techniques:* The soil samples were collected from the four cardinal points (east, west, north and south) at varying distances (50m, 100, 150m) within the vicinity of old dumpsite in Igbogene. The samples were collected using soil auger at a depth of 0-20cm. The samples were packaged and labeled and transported to the laboratory for analyses.

*Sample Preparations and Analysis:* The soil hydrogen ion concentration (pH) was determined using bench pH meter with combined glass electrode at 1:2.5 (soil:water) ratio as described by Carter (1993). The percentage organic carbon content of the soil samples was determined in accordance with Walkley and Black (1934).

The total nitrogen content in the soil was determined by using the Kjeldahl procedure as modified by Allison (1965) and it was converted to organic matter content using OMC= 1.720C. The total nitrogen (N) content in the soil was determined by using the Kjeldhal procedure which involves three successive processes- digestion, distillation and quantitative analysis (Jackson, 1956) and modified by Udoh and Ogunwale (1986).

The exchangeable acidity in the soil which represents the total titratable acidity due to exchangeable hydronium and aluminum ions was achieved using ammonium acetate method as described by Peech (1965). Exchangeable bases (Ca, Mg, K and Na) in the soil were extracted with ammonium acetate solution (1N $NH_4OAC$ at pH 7.0); Ca and Mg were estimated with help of atomic absorption spectrometer (AAS model: Pye Unicam 969) while K and Na were measured using flame photometer (model (Van Reeuwijik, 2002). The available P was determined by the Mehlich method (Mehlich, 1984) and ammonium by APHA (1998). Anions present (chloride, sulphate and nitrate) were determined titrimetrically according to AOAC (1984) method.

Finally, the particle size distribution was determined by the hydrometer method described by Van Reeuwijik, (2002). The total hydrocarbon content was determined using spectrophotometer (model: Genesis 10UV) according to modified EPA 8015 technique (USEPA, 2002b).

*Statistical Analysis:* SPSS version 20 was used to carry out the statistical analysis. The data was expressed as mean± standard deviation. One way analysis of variance was used to show significance variation at $P<0.05$, and Duncan statistics was used to discern the source of the observed variations. Relationship between each of the parameters were determined using Spearman rho correlation matrix. Hierarchical cluster analysis carried out at Euclidean Distance was used to show relationship between the various sampling points across the three distances (50m, 100m and 150m).

## RESULTS AND DISCUSSION

Soil is a complex matter and comprises of organic matter, water and air. Soil physicochemical properties have great influence on the soil quality and thus the importance of the investigation. The general characteristics, particle size distribution and total hydrocarbon content in the old landfill in Igbogene community, Bayelsa State Nigeria is presented in the Table 1 below. The pH range from 6.0 to 6.5 and this enables most plant nutrients to be available. Between pH 6.5 and 7.5, most microorganism proliferates (Balkhair and Ashraf, 2016).The pH and exchangeable acidity values ranged from 5.01±0.05-5.34±0.39 and 0.73±0.26-0.98±0.22 meg/100g respectively. They were found to differ significantly (p<0.05) across the various distances. The pH remains the most significant property of the soil. This is because low or high pH of soil effects other parameters. The pH were generally found to be acidic. This study area also recorded relatively higher values of organic content and thus

lower pH. According to Aigberua (2019), lower levels of soil acidity (low pH and exchangeable acidity) and organic matter tends to create weak retention of metals in the soil and thus influence soil pH and organic content. In addition, it increases availability of metals to the living organisms. Furthermore, increase in organic matter of the soil helps to minimize absorption of heavy metals by the plants (Aigberua, 2019). The values recorded in this study is comparable to values

reported by Atiku and Noma (2011). The results of pH and organic matter content however suggest influence by anthropogenic activities including land used as a dump site. Electrical conductivity (EC) of soil solution is a measure of ions present (Smita-Tale and Ingole, 2015). The electrical conductivity of a solution increases with the increased concentration of the solution. The electrical conductivity measured range between 315.81±1.77.48-385.00±179.91 µs/cm.

**Table 1:** General characteristics, particle size distribution and total hydrocarbon content in old landfill in Igbogene, Bayelsa state, Nigeria

| Parameters | Distances, meter | | |
|---|---|---|---|
| | 50 | 100 | 150 |
| pH | 5.18±0.46a | 5.01±0.27a | 5.34±0.39a |
| Electrical conductivity, µS/cm | 385.00±179.91a | 342.50±166.81a | 315.00±177.48a |
| Organic carbon, % | 3.58±0.72b | 3.06±0.47ab | 2.62±0.44a |
| Organic Matter, % | 6.16±1.24b | 5.26±0.81ab | 4.51±0.75a |
| Total nitrogen, % | 0.33±0.06b | 0.28±0.04ab | 0.22±0.03a |
| Exchangeable Acidity, meg/100g | 0.98±0.22a | 0.90±0.27a | 0.73±0.26a |
| Sodium, meg/100g | 3.48±0.59a | 2.85±0.62a | 2.45±0.65a |
| Potassium, meg/100g | 0.31±0.09b | 0.24±0.06ab | 0.19±0.05a |
| Calcium, meg/100g | 5.33±0.78a | 4.79±0.82a | 3.94±1.22a |
| Magnesium, meg/100g | 2.15±0.68a | 1.80±0.52a | 1.52±0.35a |
| Chloride, mg/kg | 100.25±33.10a | 85.53±25.31a | 76.48±28.83a |
| Available Phosphorus, mg/kg | 8.85±1.32a | 7.60±1.46a | 6.99±1.53a |
| $NH_4N$, mg/kg | 7.59±1.02b | 6.47±1.22ab | 5.14±0.71a |
| Nitrate, mg/kg | 11.49±1.72a | 9.68±1.78a | 9.57±1.91a |
| Sulphate, mg/kg | 5.19±1.21a | 4.62±1.36a | 4.18±1.40a |
| Total hydrocarbon content, mg/kg | 12.60±7.41a | 10.90±6.05a | 8.23±3.67a |
| Clay, % | 8.83±0.54a | 8.88±0.43a | 8.95±0.53a |
| Silt, % | 3.00±0.37a | 3.10±0.56a | 2.70±0.58a |
| Sand, % | 87.93±0.67a | 88.03±0.64a | 88.35±0.54a |

This levels were found to be lower than values reported by Igbinosa and Aisien (2018) for soil matrix collected from solid waste collection site, but lower than values reported by Atiku and Noma (2011). The relatively higher values recorded in this study may be as a result of inputs of various salts and minerals by municipal solid waste (MSW) and organic matter decomposition that occurs in the waste (Oberlin, 2013). Though their values decreases steadily from the landfill, there was no significant variations (P>0.05) between the various distances (50m, 100m and 150m). For the soil organic matter, carbon and nitrogen content, the results ranges from 4.51± 0.75 – 6.16±1.24, 2.62±0.44 – 3.58±0.72 and 0.22±0.03 – 0.33±0.06 respectively. Analysis of variance showed that there is significant variation (P<0.05) across the distances. However, Duncan multiple test statistic revealed that the observed significant variation was between 50m and 150m distance. Soil organic matter is the greatest store of soil nitrogen and most of this nitrogen is available to the plant in various form-nitrate, ammonia, ammonium and amino acids. Nitrogen in the form of nitrate is the nutrient that the plant needed in the largest quantity. The results obtained from this investigation were similar to that of Oluyemi et al., (2008), who found high organic matter content in Nigerian landfill soil. The results of the

soluble cation content: Na (2.45±0.65 – 3.48±0.59), K (0.19±0.05 – 0.31±0.09), Ca (3.94±1.22 – 5.33±0.78) and Mg (1.52±0.35 – 2.15±0.68) showed a gradual decrease in concentration with distance. This is likely due to the deposition of the cation containing waste to the investigated landfill site. This distribution pattern is similar to that of pH which has the strongest effect on the cations availability. Similarly, Söderberg et al., (2019) recorded higher concentration of some cations within the immediate vicinity of landfill used for glass waste deposit. The concentration of Ca+ ion is much higher than others. This may be due to the aggregating and bridging potential of the cation (Klitzke and Lang, 2009). Nutrients such as nitrate, sulphate and available phosphorus ranged from 9.57±1.91-11.49±1.72mg/kg, 4.18±1.40-5.19±1.21mg/kg and 6.99±1.53-8.85±1.32mg/kg respectively, being significant but across various distances. Based on Table 2, the high significant relationship between most nutrients suggests that similar factors are influencing the concentrations of most of the parameters. Previous studies observed that levels of certain parameters originating from similar sources tend to have significant relationships (Jiang et al., 2014). The authors further opined that positive significant relationship is an indication of common sources, mutual dependence and identical behavior, while

negative significant relationship suggested mutual independence of the parameters. The particle size distribution in this study is comparable to the values of 80.50% (sand), 4.55% (clay), and 14.95(silt) observed in Imiringi community, Bayelsa State by Uzoekwe (2019). Similar trend have been made in previous reports for study areas in Niger Delta (Aigberua, 2015). Finally, total hydrocarbon content ranged between 8.23±3.67 – 12.60±7.41mg/kg, distribution found to be similar to other parameters discussed above. The observed trend tends to support the anthropogenic source especially waste deposit. The Spearman's rho correlation matrix of general characteristics, particle size distribution and total hydrocarbon content in old landfill in Igbogene, Bayelsa state, Nigeria is presented in table 2. The pH showed positive significant relationship with magnesium at p<0.05, and negatively correlate with exchangeable acidity and % silt at p<0.01. Electrical conductivity revealed positive significant relationship with organic carbon, organic matter, sodium, potassium, calcium, magnesium, chloride, available phosphorus, nitrate, sulphate and total hydrocarbon content at p<0.01 and total nitrogen at p<0.05. Organic carbon revealed positive significant relationship with organic matter, total nitrogen, sodium, potassium, magnesium, chloride, available phosphorus, ammonium, nitrate, sulphate and total hydrocarbon content at p<0.01 and negatively correlate with clay at p<0.05. Organic matter showed positive significant relationship with total nitrogen, sodium, potassium, magnesium, chloride, available phosphorus, ammonium, nitrate, sulphate and total hydrocarbon content at p<0.01 and negatively correlate with clay at p<0.05. Total nitrogen showed positive significant relationship with exchangeable acidity, sodium, magnesium, chloride and sulphate at p<0.05, and potassium, available phosphorus, ammonium, nitrate, and total hydrocarbon content at p<0.01. Exchangeable acidity showed positive significant relationship with silt at p<0.01. Sodium showed positive significant relationship with potassium, calcium, magnesium, chloride, sulphate, available phosphorus, nitrate and total hydrocarbon content at p<0.01, and ammonium at p<0.05. Potassium showed positive significant relationship with magnesium, chloride, sulphate, available phosphorus, ammonium, nitrate and total hydrocarbon content at p<0.01, and negatively correlated with clay at p<0.05. Calcium showed positive significant relationship with magnesium at p<0.05, and chloride and sulphate at p<0.01. Magnesium showed positive significant relationship with chloride, nitrate, sulphate at p<0.01,
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and chloride and available phosphorus and total hydrocarbon content at p<0.05. Chloride showed positive significant relationship with available phosphorus, nitrate, sulphate and total hydrocarbon content at p<0.01. Available phosphorus showed positive significant relationship with ammonium, nitrate, sulphate and total hydrocarbon content at p<0.01, and negatively correlate with clay. Ammonium showed positive significant relationship with nitrate at p<0.05 and total hydrocarbon content at p<0.01. Nitrate showed positive significant relationship with sulphate and total hydrocarbon content at p<0.01, and negatively correlated with clay at p<0.05. Sulphate showed positive significant relationship with total hydrocarbon content at p<0.01, and negatively correlated with clay at p<0.05. Clay showed negative significant relationship with sand and total hydrocarbon content at p<0.05. Figure 1 shows the hierarchical cluster analysis of the parameters studied from old landfill in Igbogene, Bayelsa state, Nigeria based on distances. Two major clusters were formed. Cluster one has 50m SE, 100m SE and 150m SE, 50m NW, 100m NW and 150m NW, 50m NE, 100m NE and 150m NE, while cluster two has 50m SW, 100m SW and 150m SW. Within the cluster, two sub clusters were formed with the distances between 100m SW and 150m SW being equal. Cluster one has sub-clusters as well with 50m NW and 50m SE, having an equal distances and while 100m SE and 150m SE, 100m NW and 150m NW, 50m NE, 100m NE and 150m NE have equal distances as well.
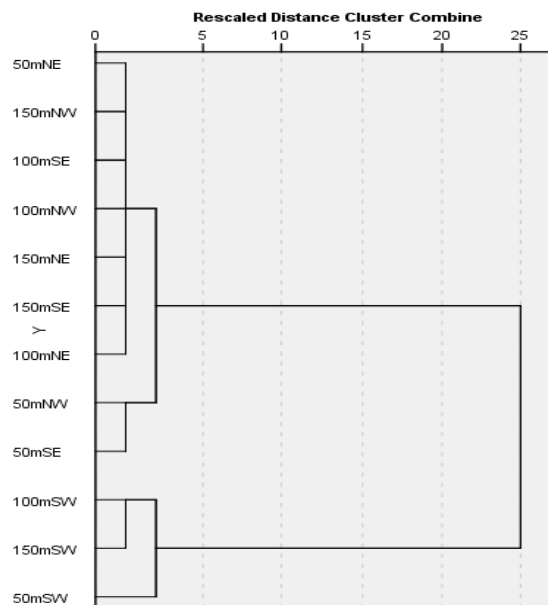


**Fig 1**: Hierarchical cluster analysis of the parameters studied from oil landfill in Igbogene, Bayelsa state, Nigeria based on locations

**Table 2:** Spearman's rho correlation matrix of general characteristics, particle size distribution and total hydrocarbon content in old landfill in Igbogene, Bayelsa state, Nigeria

| Parameters | pH | EC | OC | OM | TN | EA | NA | K | Ca | Mg | Cl | AvP | NH4N | NO3 | SO4 | Clay | Silt | Sand | THC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 1.000 | | | | | | | | | | | | | | | | | | |
| EC | .404 | 1.000 | | | | | | | | | | | | | | | | | |
| OC | .032 | .809** | 1.000 | | | | | | | | | | | | | | | | |
| OM | .032 | .809** | 1.000** | 1.000 | | | | | | | | | | | | | | | |
| TN | -.156 | .642* | .914** | .914** | 1.000 | | | | | | | | | | | | | | |
| EA | -.759** | -.021 | .371 | .371 | .586* | 1.000 | | | | | | | | | | | | | |
| NA | .189 | .935** | .839** | .839** | .694* | .102 | 1.000 | | | | | | | | | | | | |
| K | .151 | .882** | .953** | .953** | .898** | .303 | .883** | 1.000 | | | | | | | | | | | |
| Ca | .490 | .757** | .490 | .490 | .420 | -.155 | .734** | .567 | 1.000 | | | | | | | | | | |
| Mg | .592* | .932** | .741** | .741** | .616* | -.117 | .804** | .823** | .832** | 1.000 | | | | | | | | | |
| Cl | .214 | .960** | .839** | .839** | .662* | .071 | .986** | .879** | .699* | .818** | 1.000 | | | | | | | | |
| AvP | -.046 | .813** | .895** | .895** | .820** | .410 | .881** | .935** | .413 | .643* | .874** | 1.000 | | | | | | | |
| NH4N | -.182 | .511 | .783** | .783** | .928** | .555 | .629* | .809** | .392 | .483 | .566 | .748** | 1.000 | | | | | | |
| NO3 | .224 | .844** | .888** | .888** | .718** | .145 | .895** | .907** | .510 | .727** | .888** | .923** | .671* | 1.000 | | | | | |
| SO4 | .385 | .960** | .846** | .846** | .673* | .032 | .888** | .921** | .594* | .881** | .923** | .867** | .559 | .909** | 1.000 | | | | |
| Clay | .175 | -.470 | -.631* | -.631* | -.507 | -.178 | -.519 | -.615* | .123 | -.250 | -.568 | -.716** | -.402 | -.621* | -.582* | 1.000 | | | |
| Silt | -.742** | -.159 | .095 | .095 | .274 | .736** | -.035 | .087 | -.424 | -.368 | -.057 | .322 | .304 | .071 | -.081 | -.291 | 1.000 | | |
| Sand | .386 | .288 | .242 | .242 | -.025 | -.456 | .267 | .218 | -.036 | .221 | .310 | .242 | -.121 | .357 | .339 | -.613* | -.387 | 1.000 | |
| THC | .032 | .739** | .881** | .881** | .806** | .399 | .720** | .911** | .266 | .636* | .748** | .902** | .720** | .867** | .874** | -.677* | .247 | .175 | 1.000 |

*\*\*. Correlation is significant at the 0.01 level (2-tailed). \*. Correlation is significant at the 0.05 level (2-tailed). N=12, n=4*

*Conclusion:* The study showed that most of the physicochemical parameters measured decreased as the distances from the old landfill increased, though not significantly. The study also revealed that most of the nutrients showed positive significant relationship, which is an indication of the similar influence of anthropogenic activities. Furthermore, the study showed that parameters measured were at higher concentration in samples collected from SW direction.

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