**Original Research Article**

**EFFECTS OF LEACHATES FROM SOLID WASTE DUMPSITES ON NEARBY BOREHOLES IN RUMUEME, PORT HARCOURT, NIGERIA**

**ABSTRACT:** The investigation of solid waste around Port Harcourt, Rivers State Nigeria was carried out to acquire information on the condition of the soil and the types of waste as well as the nature of leachates produced within the environment. It aims at predicting hydrogeologic site conditions and contaminating transport potential. Samples were collected at three locations using hand auger at depths of 1 m, 2 m and 3 m and laboratory analyses conducted. Results of the soil analyses revealed medium grained sands with average permeability of 10-3mm3/s while the chemical analyses of leachates indicated high concentration of the waste derivates which have been degraded. Among the parameters measured, the average values of pH, 8.8; conductivities 1750 mS/cm and total dissolved solids (TDS)1150 mg/L of the boreholes (BHI, BH2 and BH3) are above the world health organization (WHO) standards of 8.0, 1500 mS/cm and 450 mg/L respectively. The result from this study will enable the officials of municipalities to design and construct dumpsites in appropriate locations thereby mitigating their associated leachates.

**KEYWORDS**: **Borehole, Conductivity, Dissolved Solids, Dumpsite, Hand Auger, Leachates, Permeability, Solid Waste.**

**1.0 INTRODUCTION**

Rapid urbanization and population growth in developing cities like Port Harcourt, Nigeria, have exacerbated solid waste management challenges, posing serious threats to environmental integrity, public health, and urban sustainability (Gedefaw, 2015). In Rumueme, a suburban area within Port Harcourt, uncontrolled dumpsites have led to environmental hazards, including the generation of harmful leachates, greenhouse gases (GHGs), and the spread of vector-borne diseases, particularly in low-income communities lacking proper waste disposal methods (Nwugha et al., 2021).

Open dumpsites, often located along roadsides, are common in Nigerian cities and contribute to soil and groundwater contamination, ultimately affecting human health (Adekola et al., 2021). These sites accumulate both biodegradable and non-degradable waste, releasing toxic gases and pollutants into the environment (Kebede, 2016). Poorly managed waste, especially during the wet season, is carried by rain into nearby streams and rivers, contaminating water sources. The shallow groundwater levels in the south-south and southeast regions of Nigeria increase the risk of infiltration, exposing communities to hazardous substances through borehole water consumption (Okeke et al., 2023a; Besufekad, 2020).

Given the proximity of residential areas to dumpsites, the health risks posed by soil and water contamination are significant. The mobility of groundwater can extend these risks to distant communities (Beyene and Banerjee, 2011). Leachates from waste may contain toxic substances harmful to humans, plants, and animals, necessitating an urgent evaluation of environmental impacts and waste management practices.

This study aims to assess the environmental effects of solid dumpsites in Rumueme by analyzing the physical, chemical, and biological characteristics of accumulated waste and its impact on the surrounding environment. The findings will provide essential data for developing effective waste management policies to enhance urban sustainability in Port Harcourt. Additionally, the study will examine community awareness of waste management and environmental health, identifying key areas for intervention and education (Leveson, 1980).

Ultimately, this research underscores the urgent need for improved waste management strategies and community involvement to mitigate the adverse effects of solid dumpsites, thereby enhancing living conditions in Rumueme and the broader Port Harcourt region.

**2.0 MATERIALS AND METHOD**

The study was conducted at the dumpsite within Rumueme which has been operational for quite a long time and spans an area of about 10 m2.

**2.1 Materials**

**Sampling equipment**:

Water sampling kit consisting of sterilized bottles for water sampling; Soil Sampling Tools: Hand augers and soil cores for collection of soil samples; Electrodes: For vertical electrical sounding (VES) measurements; pH Meter: For measuring pH levels in soil and water samples. Weighing balance (Scale), Cans and Oven.

Conductivity Meter: For assessing electrical conductivity of water samples.

Chemical Reagent Kits: For desired chemical analyses (e.g., sulphate, sulphide, chloride).

Field sampling: Instruments and devices used for sample collection include hand gloves, safety boots, shovel, hand auger, black cellophane bags, plastic containers to collect leachate.

**2.2 Methods**

**2.2.1 Water Sample Collection and Analysis**

1. Collection procedures: Water samples were collected from three locations around the dumpsite using clean sterilized bottles, ensuring that samples were taken at varying depths to capture vertical stratification. Each collection was labelled, and the time and location were recorded.

2. Laboratory Analyses: The samples were analyzed within 24 hours of collection. The water samples were tested for the following chemical parameters: Electrical Conductivity (EC), pH, Dissolved Oxygen (DO), Total Dissolved Solids (TDS),

Chloride, Biochemical Oxygen Demand (BOD). Heavy metals (Lead, Cadmium and Arsenic).

Analytical techniques employed included (e.g., spectrophotometry, titration, atomic absorption spectroscopy) as per standard methods outlined in (reference to specific standard method guidelines, such as APHA).

**2.2.2 Soil Sample Collection and Analysis.**

1. Sampling Techniques: Soil samples were collected using a hand auger from (number) locations with samples taken at depth intervals of 1 m, 2 m and 3 m.

2. Preparation and Testing: Collected soil samples were air-dried, sifted through a 2 mm mesh, and analyzed for: Soil pH, Electrical Conductivity (EC), Organic Matter Content, Nutrients (Nitrate and Phosphate). Trace Metals: Soil Texture (by hydrometeror sieve method)

Like water analyses, soil parameter assessments were done following (reference to standard methods).

**2.2.3 Vertical Electrical Sounding (VES)**

1. VES Methodology: Vertical electrical sounding was conducted using ABEM SAS 1000 Terrameter.

2. Electrode Arrangement: An electrode array of Schlumberger was established, with electrodes placed at intervals according to the spacing distance.

3. Data Acquisition: Measurements were recorded to determine the resistivity of subsurface materials, which aids in lithological interpretation. The process was repeated at different locations within the dumpsite.

4. Data Analysis: Resistivity data were analyzed using IPI2WIN to generate models of the subsurface lithology.

5. Data from all the measurements were analyzed by using software to analyze and describe the statistics (mean, standard deviation and correlations between soil and water quality parameters).

**2.2.4 Laboratory tests and analyses:**

Procedure: mass of empty plastic containers was determined, then the weight of the container with the samples were also recorded. The sample was dried in air for about 12 hours, then the container and the sample were removed and weighed to determine the mass of dry sample. The moisture content was computed with this formula:

(i) Mass of container + wet soil - (mass of Container + dry soil) = mass of water (Mw or Ww)

(ii) Mass of dry Soil + Container- Mass of Container=Mass of dry soil (Ms or Ws)

Water content = (Mw/Ms) x 100

**2.2.5 Wet sieving**

Wet sieving was carried out to determine the percentage of clay present in the soil sample.

The soil was put in the 200 cm mesh sieve and washed thoroughly with water to clearness and labeled.

The wet sample and Container were put in the oven to dry.

The dried sample and the container were weighed to determine the weight of the dry sample.

Clay Percentage (%) = mass passing – sieve 200 cm x 100/mass of sample after washing.

Sand Percentage (%) =mass retained on sieve 200 x 100/ Mass of sample before washing.

**2.2.6 Particle size analysis**

Procedure:

1. Empty sieves were weighed and their weights recorded.
2. The oven dry soil from the wet sieving was used, the soil was pulverized to separate into individual grain sizes.
3. The stock of sieves was arranged with the pan at the bottom.
4. The sample was poured into the topmost sieve, covered with a lid and shaken for about ten minutes into various sizes.
5. The individual sieves with their retained particles were weighed and results were recorded.

**2.2.7 The Leachate Analysis:**

The parameters analysed include Sulphate, Sulphide, pH, Conductivity, Total dissolved solid (TDS), Chloride and Biochemical oxygen demand.

Using a hand auger, soil samples were taken from each of the three locations within the dumpsite at intervals of one meter down to a depth of three meters. For use in laboratory experiments using black cellophanes, they were appropriately stored. At every borehole on the dumpsite, the leachates were gathered in bottles and transported to the lab within twenty-four hours. A weighing scale, an oven, and mesh sieves of different sizes are the fundamental tools used for the analysis.

The moisture content of the soil samples was determined using oven and weighing balance. The sample was kept in the oven for 24 hours heated to dryness to remove any water that may be in the sample and thereby determine the water or moisture content of the samples.

Wet sieving was done to determine the percentage of clay in the sample using 200 cm mesh sieves, weighing balance and water.

The fraction of clay content or mass passing through 200 cm sieve determines the sand content. The clay percentage is the amount of mass passing through sieve 200 cm multiplied by 100 of the total mass of samples. The sand percentage is the mass retained.

**3.0 RESULTS AND DISCUSSION**

**3.1 Moisture content**

In many environmental studies, such as those pertaining to waste management, groundwater recharge, and agricultural production, an understanding of the moisture content of soil is essential. This analysis will assess the moisture contents of soil samples taken from three different boreholes across three distinct locations. The measured moisture contents are expressed in percentage, reflecting the proportion of water present in the soil relative to its dry weight.

This is the amount of moisture in the soils at the dumpsite. The results are presented in Table 1.

**Table 1: Moisture content of samples at depths of 1 m, 2 m and 3 m.**

|  |  |  |
| --- | --- | --- |
| BH NO. | DEPTH (m) | MOISTURE CONTENT (%) |
| 1 | 1 | 9.46 |
| 2 | 27.6 |
| 3 | 28.6 |
| 2 | 1 | 13.9 |
| 2 | 21.6 |
| 3 | 35.9 |
| 3 | 1 | 42.2 |
| 2 | 105.5 |
| 3 | 150.3 |

It was observed that the moisture content increases at depth as shown in Figures 1, 2, and 3. Additionally, the maximum water content was found in borehole 3 (BH3).



**Figure 1: The moisture contents of Boreholes 1, 2, and 3 at the depth of 1 m of the dumpsite.**



**Figure 2: The moisture contents of Boreholes 1, 2, and 3 at the depth of 2 m of the dumpsite.**



**Figure 3: The moisture contents of Boreholes 1, 2, and 3 at the depth of 3 m of the dumpsite.**

**Analysis**

General Trends:

Across the three locations, moisture content varies significantly. The third location displays notably higher moisture levels compared to the first two locations.

**Location 1**:

The moisture contents are relatively low, with values ranging from 9.46 % in Borehole 1 to 28.6 % in Borehole 3. This variance suggests a possible drainage issue or low water retention in this area. The relatively higher content in Borehole 3 compared to Borehole 1 indicates variations in soil characteristics, such as texture or compaction, which may influence water retention capacity.

**Location 2**:

Moisture content increases overall, with values ranging from 13.9 % to 35.9 %. This increase may indicate better soil fertility or organic matter presence in Location 2 compared to Location 1. As the moisture content rises, one can infer enhanced water availability, potentially leading to improved agricultural productivity if this land was cultivated.

**Location 3**:

The moisture contents are exceedingly high, particularly in Boreholes 2 and 3, with values of 105.5 % and 150.3 %, respectively. These values exceed 100 %, which indicates a measurement anomaly, suggesting either saturation of the soil or the presence of waterlogged conditions. This might reflect an inability of the soil to drain efficiently or a high-water table in the area. The presence of such high moisture content could severely impact any construction or agricultural activities and suggest the need for proper drainage solutions.

**3.2 The Particle size analysis Results**

The particle size analyses are given in the PSD curve. The results of the parameters are presented in Table 2.

**Table 2: The Results of sieve analyses of soils and derived parameters**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| BH | SAMPLE DEPTH(m) | 2mm | 1mm | 0.425 | 0.150 | 0.075 | D10 | D30 | D60 | CU | MnK/Sec |
| 1 | 1 | 92.4 | 88.0 | 68.1 | 31.5 | 28.7 | - | 0.14 | 0.38 | - | - |
| 2 | 97.8 | 91.1 | 59.4 | 14.2 | 7.4 | 0.10 | 0.28 | 0.42 | 4.2 | 1 |
| 3 | 99.4 | 92.8 | 62.3 | 14.6 | 4.0 | 0.12 | 0.38 | 0.44 | 3.66 | 1.44 |
| 2 | 1 | 93.0 | 85.2 | 55.8 | 18.0 | 13.9 | - | 0.27 | 0.45 |  | - |
| 2 | 98.2 | 93.8 | 74.0 | 38.9 | 32.4 | - | 0.26 | 0.44 |  | - |
| 3 | 93.0 | 84.7 | 54.5 | 19.3 | 15.5 | - | 0.19 | 0.35 |  | - |
| 3 | 1 | 94.8 | 89.7 | 66.1 | 34.8 | 31.4 | - | - | 0.37 |  | - |
| 2 | 94.0 | 90.2 | 68.9 | 24.1 | 16.0 | - | 0.19 | 0.35 |  | - |
| 3 | 89.8 | 83.4 | 59.5 | 56.1 | 51.8 | - | - | 0.42 |  | - |

Constituents of the sample from BH1 at 2 m and 3 m have D10 values, other samples from other BH do not have values meaning that fine to coarse sands are more abundant within this location. The coefficient of uniformity (CU) for BH1 is 4.2 to 3.66 and they are moderately permeable in the range of 1 to 1.44.

The leachate is believed to contain substances that are dangerous and are likely to migrate downward to pollute the groundwater as the aquifer system is unconfined.

**3.3 HYDROGEOLOGICAL DATA**

The depth of water table within this study location is 35ft (10.67 m) (Etu-Efeotor, 1997). The lithologic log of the Auger hole to the depth of 3 m is shown in Figure 4. It consists of clayey sand and the clayey nature suggests that the vertical permeability will be low.



**Figure 4: The lithological log of the Borehole at Rumueme Dumpsite**

**Table 3: Result of chemical analysis of water from BHs around Rumueme dumpsite.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter/Unit | BH1 | BH2 | BH3 | WHO std. |
| pH (25˚C) | 9.2 | 8.8 | 8.4 | 8.0 |
| Conductivity, µS/cm (µmho/cm) | 1750 | 1760 | 1740 | 1500 |
| TDS (mg/L) | 1200 | 1245 | 1020 | 450.0 |
| Chloride (mg/L) | 74.0 | 77.5 | 76.5 | 200 |
| iSulphate (mg/L) | 17.0 | 17.2 | 15.9 | 195 |
| Sulphide (mg/L) | 240 | 200 | 208 | 200 |
| Biochemical Oxygen Demand BOD | 11 | 9.0 | 10 | 9.5 |

**3.4 CHEMICAL ANALYSIS DATA**

Comparing the standard and the results from the boreholes, the average pH of the leachates is 8.8 while the control is 8.0. They are alkaline, showing the absence of carbon dioxide in the dumpsite as the alkalinity is increasing. The average conductivity of the samples is 1750 µS/cm indicating the presence of objectionable taste. The total dissolved solids in the samples are high. High TDS average value of 1150 mg/L compared to the standard showed that the water is not fresh. The average chloride and sulphate concentrations of 76.0 mg/L and 16.7 mg/L respectively are quite low compared to the universal standard of 200 mg/L and 195 mg/L respectively. This means that the presence of salt in the leachate is low. The results are shown in figure 5.



**Figure 5: Chemical Analysis of water from boreholes within rumueme dumpsite.**

**4.0 Conclusion**

The analysis of moisture content across three borehole locations revealed significant variability, suggesting differences in soil characteristics that may influence land use. However, the unexpectedly high moisture content at Location 3 raises concerns about soil conditions or methodology.

Solid waste mismanagement has severe environmental and health consequences. Soil contamination occurs as toxic substances from waste leach into the ground, affecting soil health and crops. Water pollution arises from landfill leachates, which carry hazardous chemicals into groundwater and surface water, threatening drinking water sources and ecosystems. Air pollution results from decomposing waste, emitting methane and carbon dioxide, which contribute to climate change. Additionally, improper waste disposal leads to biodiversity loss and health risks such as respiratory diseases among nearby communities.

Addressing these issues requires effective waste management strategies to protect environmental quality, public health, and urban sustainability.

**Recommendations**

Proper disposal of solid waste should take place in geologically appropriate locations. To stop it from contaminating groundwater, such sites should have impermeable subsurface materials like shale and clay.

Further investigations into soil composition, texture, and existing hydrological conditions are recommended to fully understand the implications of these moisture levels and guide appropriate land management and agricultural practices

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