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# Effect of Waste Dump Site Leachate Seepage on Soil Quality in Idumwowina Community Benin City, Edo State, Southern Nigeria

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**Abstract**
The study was carried out to evaluate the environmental impact of waste dumpsite to the quality of ground water and its impact on the soil in Idumwunowina Community Edo State, Nigeria. The heavy metal such as (Cd, Fe, Cr, Pb, Ni) were determined in the topsoil from dept S (0–10 cm) and (10–20 cm) where analyzed using atomic absorption spectrometry (AAS). The determination for the soil components were the heavy metal concentration at depth 0–10 cm and 10–20 cm, with lead Pb having minimum value of 0.01 mg/kg–0.03 mg/kg, Cadmium 0.1 mg/kg–0.2 mg/kg, Fe (518 mg/kg–1070 mg/kg), Cr (0.1 mg/kg–0.8 mg/kg), Ni (0.6 mg/kg–2.4 mg/kg), Zn (2.6 mg/kg–8.6 mg/kg), Cu (0.2 mg/kg–0.8 mg/kg). The value of Pb, Cd, Fe, Ni e.t.c. shows variable value as some were below WHO standard and other above WHO standard at the different sources of collection.

**Keywords**
Soil, waste, dump site, heavy metal, Idunmwonwina

## 1. Introduction

Waste dumpsites significantly threaten groundwater quality, especially in areas where waste management is poorly regulated. As rainwater percolates through layers of waste, it generates leachate, a contaminated liquid that seeps into the underlying soil and groundwater (Akan, 2013). This leachate often contains high concentrations of organic matter, heavy metals, pathogens, and other hazardous substances (Fatta et al., 1999).The permeability of soil and the depth of the water table influence how quickly and severely groundwater is contaminated (Longe and Williams, 2006).

In unlined dumpsites, especially common in developing countries, contaminants easily migrate into aquifers, making the water unsafe for human consumption and agricultural use (Ogundiran, 2007). Studies show elevated levels of nitrate, cadmium, lead, and coliform bacteria in wells near such dumpsites (Yusof et al, 2009). Contaminated groundwater can lead to serious health issues, including gastrointestinal infections, neurological damage, and various forms of cancer when consumed over time (Jham, 2008). Furthermore, the ecological impacts are profound, affecting aquatic life and soil quality downstream (Mor et al., 2006). Mitigation strategies such as proper lining of dumpsites, waste segregation, and regular groundwater monitoring are necessary to prevent further degradation (Aluko and Monu, 2003).

In summary, uncontrolled waste dumping poses a clear and present danger to groundwater resources. Waste dumpsites are significant sources of groundwater contamination due to the migration of leachate plumes generated from decomposing waste. These plumes often contain a complex mixture of organic and inorganic pollutants, including heavy metals, nitrates, and pathogenic microorganisms, which can infiltrate and deteriorate groundwater quality (Kumar and Alappat, 2005). The uncontrolled disposal of municipal solid waste, particularly in unlined or poorly managed dumpsites, accelerates leachate percolation into aquifers (Mor et al., 2006).

Studies have shown elevated concentrations of contaminants such as lead, cadmium, and chloride in groundwater near dumpsites, surpassing WHO drinking water standards (Oyeku et al., 2010). Moreover, leachate plumes can travel considerable distances, affecting both shallow and deep aquifers depending on local hydrogeology and soil permeability (Fatta et al., 1999).

The seasonal variability in rainfall further influences the volume and migration speed of these plumes (Christensen et al., 2001). Collectively, these effects pose serious public health risks and threaten the sustainable use of groundwater resources. Effective mitigation requires improved landfill design, continuous groundwater monitoring, and implementation of remediation strategies (Jegede, 2009).

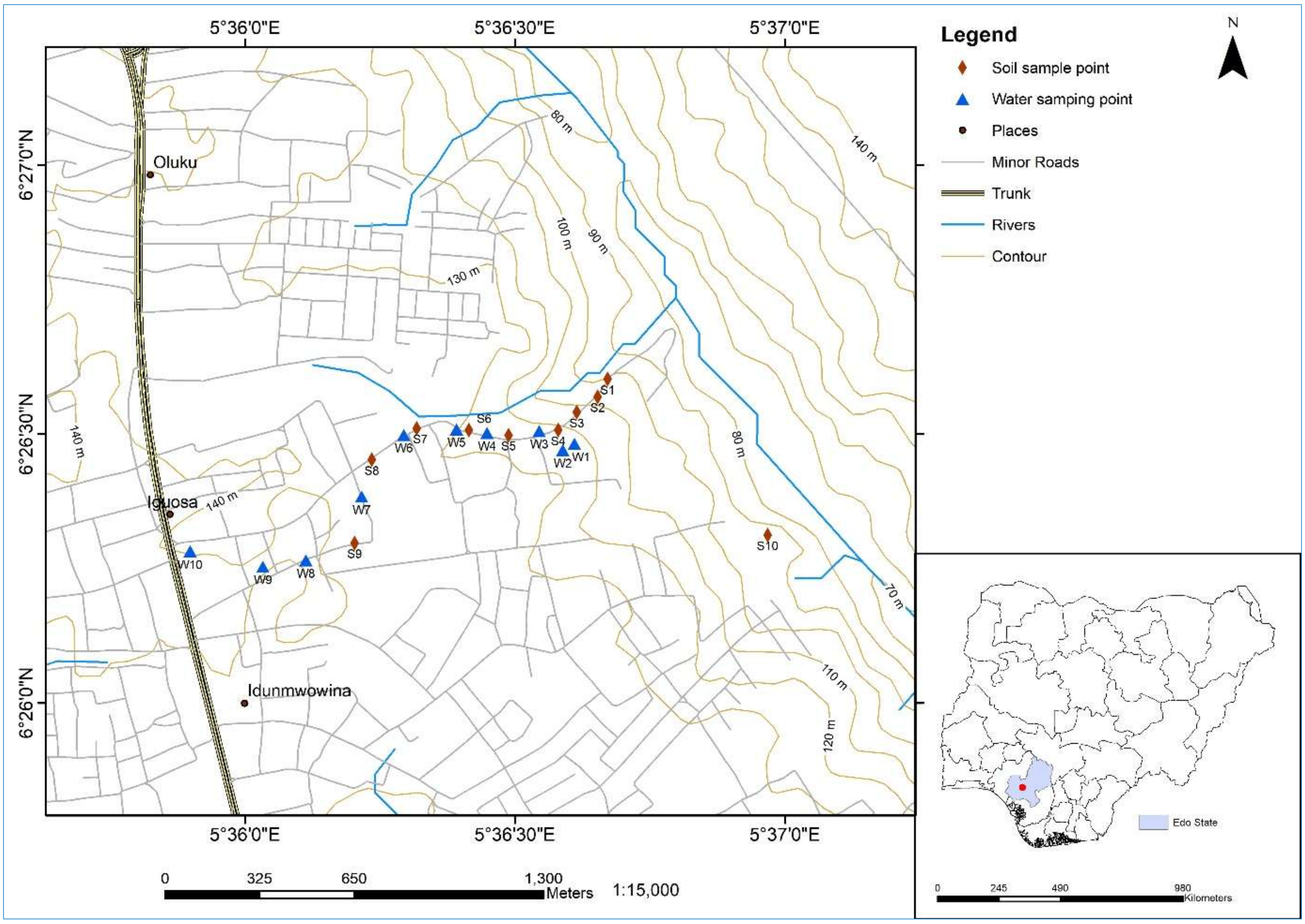


Fig. 1. Map showing point of collection of samples

## 2. Geological Setting

The Niger Delta Basin was formed by a failed rift junction during the separation of the South American plate and the African plate, as the South Atlantic began to open. Rifting in this basin started in the late Jurassic and ended in the mid Cretaceous. As rifting continued, several faults formed many Geologic maps of the Niger Delta Basin and the Benue trough, and the oil fields in the region. Basin formation of them thrust faults. Also, at this time syn-rift sands and then shales were deposited in the late Cretaceous. This indicates that the shoreline regressed during this time (Burke and White, 1973).

Concurrently, the basin had been undergoing extension resulting in high angle normal faults and fault block rotation.at beginning of the Paleocene there was a significant shoreline transgression. During the Paleocene, the Akata Formation was deposited, followed by the Agbada Formation during the Eocene. This loading caused the underlying shale Akata Formation to be squeezed into shale diapirs. Then in the Oligocene the Benin formation was deposited, which is still being deposited today (Burk and Dewey 1974).The overall basin is divided into a few different zones due to its tectonic structure. There is an extensional zone, which lies on the continental shelf, caused by the thickened crust. Moving basinward is a transition zone, and a contraction zone, which lies in the deep-sea part of the basin.

### *2.1. Benin Formation*

The Benin Formation is Oligocene and younger in age. It is composed of continental flood plain sands and alluvial deposits. It is estimated to be up to 2,000 meters thick. It is made up of massive, highly porous, fresh water bearing sandstone with local thin shale inter-beds which are thought to be of braided stream origin. The shale inter-beds where present usually contain some plant remains and dispersed lignite. It is thicker in the central onshore part where it is about 1970 m (1.97 km) and thin towards the delta margins.

The Benin formantion describe by Parkinson (1907) describe with the name subsequently applied by Reyment (1965) to Pliocene-Pleistocene sandstones exposed at Benin, Onitsha and Owerri Province. The Benin Formation consists predominantly of massive highly porous freshwater-bearing sandstones, with local thin shale inter beds which are considered to be of raided stream origin.

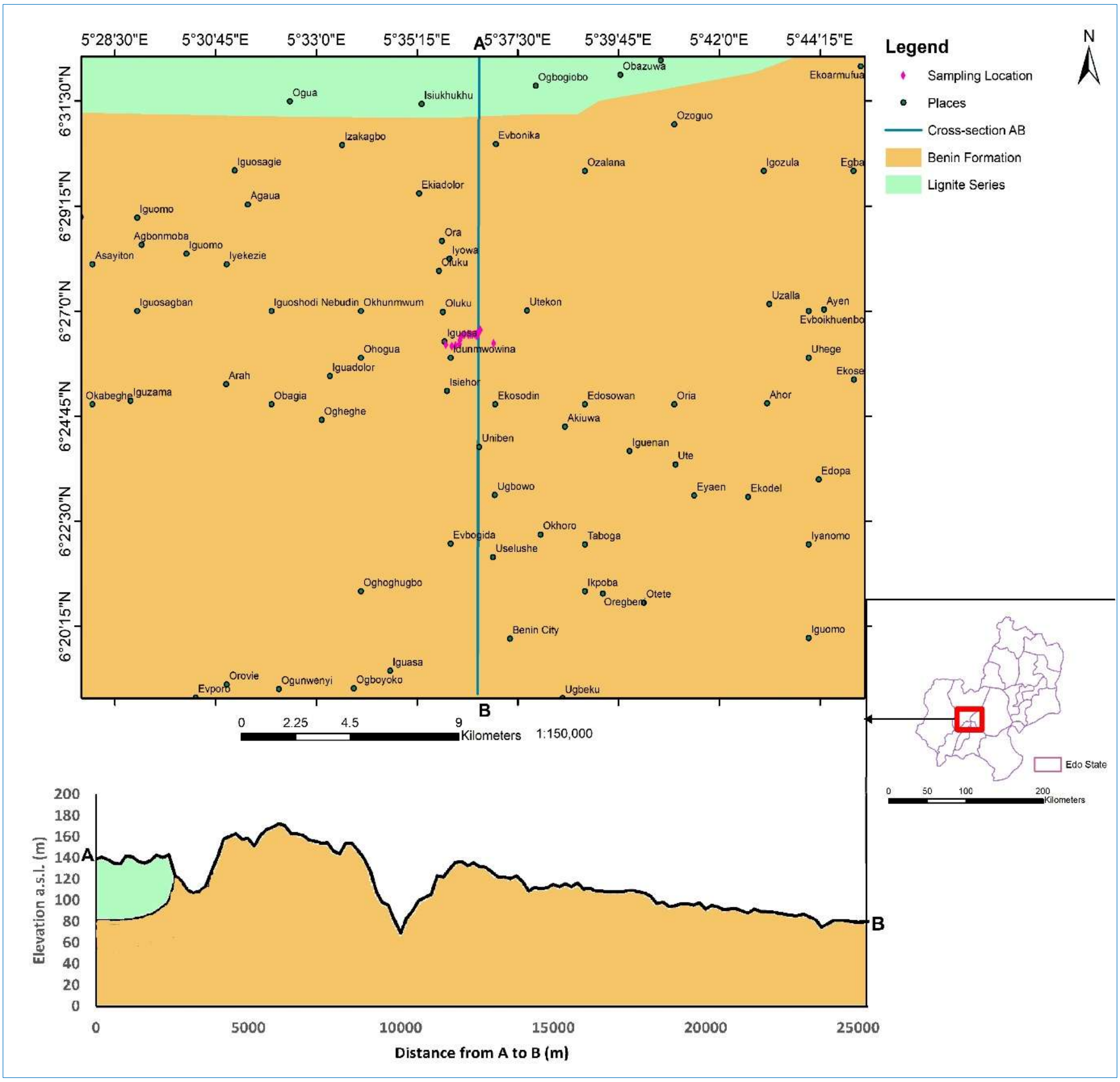


Fig. 2. Geological map of study area (Idunmwowina Community)

**Lateral Extent of Benin Formation**: It occurs across the whole of Niger Delta, Benin-Onitsha area in the north to beyond the present coastline.

### *2.3. Lithology*

The subsequence is predominantly sandy with a few shale intercalations which become more abundant toward the base. The sand and sandstone are coarse-grained, commonly very granular and pebbly to very grained. In general, they appear to be very poorly sorted. The grains are too well-rounded. The sand and sandstone are white or, because if limonite coating, are yellowish brown.

Lignite occurs; hematite grains and feldspar are common, the shale is grayish brown, sandy to silty, and contain some plant remains and dispersed lignite. Composition upper deltaic plain environment.

**Age**: Age span is Miocene to Recent (Short and Stauble, 1967).

### *2.3. Local Geology of Study Area*

The study area is located along Benin Lagos Road precisely Idunmwowina in Ovia North-East Local Government Area of Edo State, between latitude 6°26'N–7°14'N and between longitude 5°35–5°36'E (Fig. 1). It shares boundary with Oluku and Evbomore Community. The location is made up of highly erosive lateritic topsoil. The erosive nature of the location is as a result of the stipe slope which drains to the close borrow pit where sand is piled out for construction and building purposes. The temperature of the area is between $27^0$–$29^0$ depending on the average sunshine. The vegetation of the area is of a typical rainforest with trees at different canopy levels with dense underlay of scrubs.

The geological setting of Idunmwowina Community confines to Benin formation which is a major geological unit primarily found in southern Nigeria including the Benin region and part of Niger Delta geological basin. The Benin formation is characterized by the following characteristics. It mainly consists of coarse finding grain sandstone often poorly sorted and unconsolidated to consolidated Abam et al. (2016). The formation includes reddish brown to yellowish brown, sandy clay and occasional shale lenses. The sediments are mostly fluviatile river deposits with cross beddings and poorly bedded layers.

Stratigraphically, the Benin Formation is Oligocene to Pleistocene in age. It is the uppermost stratigraphic unit in the Niger Delta sequence and overlays the Agbada and Akata Formations. It covers approximately 95% of the Benin region and extends widely across southern Nigeria and offshore basins.

## 3. Materials and Methods

### *3.1. Soil Sampling*

A total of twenty (20) soil samples were collected randomly at depths of 0-10 cm and 10-20 cm. Each sampling point was spaced 25 meters apart to provide representative coverage across the study area Samples were dried at room temperature and sieved through a 2 mm mesh. The sampling depths were selected to represent the topsoil and subsoil layers and understand the vertical distribution of contaminants. The samples were collected using a well-calibrated hand auger and placed in new, clean sample bags. After collecting, the samples were dried at room temperature, disaggregated, and sieved through a 2 mm mesh to remove debris and larger particles. The resulting fine fractions were homogenized and stored in airtight containers until analysis (Iwegbue et al., 2019).

A representative 1g portion of each soil sample was digested using a mixture of concentrated nitric acid ($HNO_3$), hydrochloric acid (HCl), and to ensure complete dissolution of heavy metals. Heavy metal concentrations (e.g., Pb, Cd, Zn, Cr, Ni) were determined using an Atomic Absorption Spectrophotometer (AAS) Model 210VGP. Calibration standards and blanks were used for quality control. Flame photometry (Model 410) was employed for measuring alkaline metals (e.g., Na, K).

## 4. Result and Discussion

All twenty samples of soil collected from idunmwowina were analyzed for heavy metal concentration, alkali and alkaline earth metals.

These whole practices were carried out in the laboratory using standard laboratory equipments such as spectrophotometer (AAS) Model 210 VGP, flame photometry (Model 410) was employed for measuring alkaline metals e.g. (Na, K). Results of heavy metals and alkaline metals in soil samples obtained within the study area as shown in Table 1.

Table 1. Result of heavy metals analysis on soil from depth 0-10 cm (mg/kg)

| S/N | Sample (mg/kg) | Pb | Cd | Fe | Cr | Ni | Zn | Cu |
|---|---|---|---|---|---|---|---|---|
| 1 | Ptw 1(0 – 10) | 20 | 10 | 52700 | 30 | 60 | 7200 | 40 |
| 2 | Ptw 2(0 – 10) | 10 | - | 54300 | 60 | 60 | 260 | 20 |
| 3 | Ptw 3(0 – 10) | 20 | - | 49800 | 10 | 110 | 390 | 20 |
| 4 | Ptw 4(0 – 10) | 20 | 10 | 43300 | 10 | 120 | 260 | - |
| 5 | Ptw 5(0 – 10) | 20 | - | 42900 | 40 | 80 | 300 | 10 |
| 6 | Ptw 6(0 – 10) | 20 | - | 47800 | 40 | 110 | 170 | 10 |
| 7 | Ptw 7(0 – 10) | 20 | - | 45000 | 40 | 30 | 37 | 10 |
| 8 | Ptw 8(0 – 10) | 20 | 10 | 37500 | 200 | 50 | 270 | - |
| 9 | Ptw 9(0 – 10) | 10 | - | 41400 | 100 | 60 | 147 | 10 |
| 10 | Ptw 10(0 – 10) | 20 | - | 21600 | 20 | 40 | 360 | 10 |
| WHO Standard(Min-Max limits) | | 300 | | 50,000 | 200-300 | 50-100 | 200-400 | 50-200 |
| **Below detectable limit (BDL) = -** | | | | | | | | |

Table 2. Result of heavy metal from depth 10-20 cm (mg/kg)

| S/N | Sample | Pb | Cd | Fe | Cr | Ni | Zn | Cu |
|---|---|---|---|---|---|---|---|---|
| 1 | Ptw 1 (10 – 20) | 10 | - | 50000 | 80 | 80 | 1250 | 30 |
| 2 | Ptw 2 (10 – 20) | 10 | 10 | 51800 | 20 | 80 | 184 | 30 |
| 3 | Ptw 3 (10 – 20) | - | - | 53500 | 20 | 120 | 163 | 20 |
| 4 | Ptw 4 (10 – 20) | 30 | - | 43700 | 20 | 118 | 136 | 20 |
| 5 | Ptw 5 (10 – 20) | 20 | 20 | 46700 | 10 | 60 | 310 | 20 |
| 6 | Ptw 6 (10 – 20) | - | 10 | 42700 | 10 | 120 | 143 | 10 |
| 7 | Ptw 7 (10 – 20) | 10 | - | 37900 | 20 | 30 | 30 | 10 |
| 8 | Ptw 8 (10 – 20) | 30 | - | 34900 | 40 | 60 | 127 | 10 |
| 9 | Ptw 9 (10 – 20) | 20 | - | 21600 | 20 | 40 | 180 | - |
| 10 | Ptw 10 (10 – 20) | 10 | - | 30600 | 20 | 20 | 130 | 10 |
| WHO Standard | | 300 | | 50,000 | | 50-100 | 200-400 | 50-2000 |

Table 2. Result of heavy metal from depth 10-20 cm (mg/kg)

| S/N | Sample | Pb | Cd | Fe | Cr | Ni | Zn | Cu |
|---|---|---|---|---|---|---|---|---|
| 11 | Ptw 1(10 – 20) | 10 | - | 50000 | 80 | 80 | 1250 | 30 |
| 12 | Ptw 2(10 – 20) | 10 | 10 | 51800 | 20 | 80 | 184 | 30 |
| 13 | Ptw 3(10 – 20) | - | - | 53500 | 20 | 120 | 163 | 20 |
| 14 | Ptw 4(10 – 20) | 30 | - | 43700 | 20 | 118 | 136 | 20 |
| 15 | Ptw 5(10 – 20) | 20 | 20 | 46700 | 10 | 60 | 310 | 20 |
| 16 | Ptw 6(10 – 20) | - | 10 | 42700 | 10 | 120 | 143 | 10 |
| 17 | Ptw 7(10 – 20) | 10 | - | 37900 | 20 | 30 | 30 | 10 |
| 18 | Ptw 8(10 – 20) | 30 | - | 34900 | 40 | 60 | 127 | 10 |
| 19 | Ptw 9(10 – 20) | 20 | - | 21600 | 20 | 40 | 180 | - |
| 20 | Ptw 10(10 – 20) | 10 | - | 30600 | 20 | 20 | 130 | 10 |
| WHO Standard | | 300 | | 50,000 | | 50-100 | 200-400 | 50-2000 |

### *4.1. Cadmium (Cd)*

Cd was sparely present in most soil collected for analysis with AAS as cadmium was present at PW1, PW2, PW4, PW5, PW8, which according to fig 4.3, concentration was significant at $p < 0.05$ compared to WHO. The high value of cadmium at this point is likely due related to the weathering parent rock, fertilizers usage by farmers along the point of soil collection or the impart of 7up Bottling Company close to the water dump.

### *4.2. Iron (Fe)*

The value for Iron (Fe) as analyzed from the sample ranging from (PW1) to (PW10) indicates the value of Iron obtained. The point (PTW1) to (PTW3) which are then close to dumpsites shows high value reaching threshold of WHO standard. This could be as a result of dumpsites being used as a point for scrap metal disposal. The point PTW5,6,7 also shows high value of Ion in soil slightly below WHO standard. The continuous increase in the value of Iron from soil obtained from this point could be the continuous use of these points as a lace for scrap metal storage.

### *4.3. Chromium (Cr)*

The chromium value mostly falls below the WHO/FAO recommended value, showing that chromium activity in the soil from PW1 to PW10 is relatively low. PTW 8 and PTW 9 show relatively high chromium content, likely due to waste containing electroplating materials and asbestos being dumped at the site, as well as cement dust resulting from the high rate of building activities. PTW 8 has a value of 200 mg/kg, while PTW 10 sits at 100 mg/kg.

### *4.5. Zinc (Zn)*

The zinc concentration of most of the samples analyzed shows value above the maximum WHO standard. PTW 7 indicated low value of zinc valued at 30 mg/kg.

### *4.6. Copper (Cu)*

The sample collected at all twenty points shows low copper value below the recommended value. The samples were zinc tolerant with a minimum value of 10 mg/kg – 40 mg/kg. The permissible value for copper is 73.3 mg/kg.

## 5. Conclusion

The analysis of soil around Idunmwowina community dumpsite reveals significant heavy metal contamination, particularly for lead, cadmium and chromium. The concentration of these metals increases to nearness to dumpsites. Contamination is primarily due to the nearby dumpsite and waste management practices. The study confirms that soil quality in the Idunmwowina Community is significantly affected by the nearby dumpsite, which is a major source of contamination. Elevated levels of heavy metals can lead to denature of soil microbes. This elevated levels of heavy metals can accumulate in plant tissues posing severe health risk when the soil is used for planting.

## References


Abam, T.K., Ofoegbu, C.O., Osadebe, C.C., Gobo, A.E., 2016. Impact of anthropogenic activities on groundwater quality in the Niger Delta, Nigeria. Environmental Earth Sciences 75 (4), 1-12.

Akan, J.C., Kolo, B.G., Yikala, B.S., Ogugbuaja, V.O., 2013. Determination of some Heavy Metals in Vegetable. Samples from Biu Local Government Area, Borno State, Northeastern Nigeria. International Journal of Environmental Monitoring and Analysis 1, 40-60.

Aluko, R.E., Monu, E., 2003. Functional and Bioactive properties of quinoa seed protein hydrolysate. Journal of Food Science 68, 1254-1258.

Burke, K.C., Dewey, J.F., 1974. Plume-Generated Triple. Junctions: Key indicators in applying plate tectonics to old rocks. Journal of Geology 82 (4), 406-433.

Burke, W.T., White, W.M., 1973. Geological and geochemistry of the northern Leeward Islands , Lesser Antilles. Journal of the Geological Society of London 129 (3) 263-278.

Christensen, J.K., Paternain, A.V., Selek, S., Ahring, P.K., Lerma, J., 2021. A mosaic on functional kainite receptors in hippocampal interneurous. Journal of Neuroscience 21 (23) 926-933. https://doi.org/10.1523/JNEUROSCI.2156-04.2004.

Fatta, A., Papadopolus, Loizidou, M., 1999. A study of landfill leachate and its impacts on groundwater quality or the greater area. Journal of Environmental and Health 21, 175-190. https://doi.org/10.1023/A:1006613530137.

Iwegbue, C.M.A., Nwajei, G.E., Egboh, S.H., 2019. Assessment of Heavy Metal Pollution in soil and groundwater around an abandoned mine site. Environmental Monitoring and Assessment 191 (10), 1-13. https://doi.org/10.1007/S10661-019-7855-4.

Iwegbues, C.M.A., Nwaje, G.E., Egboh, S.H., 2019. Assessment of heavy metals pollution in soil and ground water around an abandoned mine site” Environmental Monitory Assessment 191 (10), 1-13

Jegede, A.O., 2009. Environmental Laws in Nigeria: Negligence and Compliance in the Building of Houses on Erosion and Flood Prone Areas in the South-South Region of Nigeria. Journal of Environmental and Health Science 1 (3), 1-9.

http://dx.doi.org/10.24018/ejgeo.2020.1.3.23.

Kumar, D., Alappat, B.J., 2005. Analysis of leachate pollution index and formulation of sub-leachate pollution indices. Journal of waste Management and Research 23 (3), 230-239. https://doi.org/10.1177/0734242X05054875.

Longe, E.O., Williams, A., 2006. A preliminary study of medical waste management in Lagos Metropolis Nigeria. Iran Journal of Environmental Health Science and Engineering 3, 133-139.

Mor, S., Ravindra, K., Dahiya, R.P., Chardn, A., 2006. Leachate characterization and assessment of ground water pollution near solid waste landfill site. Environmental Monitoring and Assessment 118, 435-456. https://doi.org/10.1007/s10661-006-1505-7.

Mull, J.E., 2005. Approach towards sustainable Urban Solid Waste Management. Journal of Environmental Science.

Ogundiran. O.O., Afolabi, T.A., 2008. Accessment of physiochemical parameters and heavy metal toxicity of leachate form municipal solid waste dumpsite. International Journal of Environmental Science and Technology 15, 243-250. https://doi.org/10.1007/BF03326018.

Oyeku, O.T., Eludoyi, A.O., Awomeso, A.J., 2010. Accessment of ground water quality in coaster rular community of Nigeria. Environmental Research Journal 4 (2), 171-179.

Parkinson, J., 1907. The cretaceous deposite of sourthern Nigeria. Quarterly Journal of the Geological Society of London 63, 274-307.

Reyment, R.A., 1976. Stratigraphy of the Continental Cretaceous Deposits in the Nigerian Sector of the Iullemmeden Basin (West Africa). 1 (2), 101-123.

Short, K.L., Stauble, A.J., 1967. Putline of the geology of Niger Delta. America Association of Petroleum Geologist Bulletin 51, 761-779.

UNEP, 2015. Negative impact on human health and the environment.

Yusof, N.A., Haraguchi, M.A., Hassan, M.R., Oth,an, W., Wakisaka, M., Shira, Y., 2009. Measuring organic carbon nutrient and heavy metals in rivers receiving leachate from controlled and uncontrolled waste landfills. Waste Management 29 (10), 2666-2680. https://doi.org/10.1016/j.wasman.2009.05.022.

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