THE ROLE OF GEOCHEMISTRY IN LANDFILL CHARACTERIZATION. CASE STUDY: ASABA, SOUTHERN NIGERIA

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ABSTRACT

This study was designed to assess the suitability the sanitary landfill site for waste disposal by evaluating hydrogeological and geochemical properties of rocks and soils within a designated area. The results and findings of this work would throw more light on the selection of solid waste disposal site and in prescribing whether the site could be given consideration for the disposal of waste or not.

20 soil samples were collected at 0.5m intervals to a depth of 3m within an area of 44,100m^2 and analysed for mineralogical and chemical constituents which include pH, Total Organic Carbon (TOC), Cation Exchange Capacity (CEC) and the clay mineralogy (using X-Ray Diffraction method). Soil lithology from the geotechnical boreholes range from very dark brown, medium sandy silty clay to very hard mottled reddish brown and grey ferruginised sandstone. The pH values range from 4.5 to 5.9 (Acidic soil). The TOC values range from 0.233% to 0.778%. The values of the CEC ranges from 2.59 cmol/kg to 8.51cmol/kg. X-ray diffraction show Kaolinitic clays to have an average of 63% and Quartz with an average of 26%.

Results of the major and trace elements analysis indicates the presence of SiO_2, ranging from 37.00 % to 54.50 % and Al_2O_3 ranging from 23.00 % to 30.00 %.

Based on these results and existing standards, the subsurface materials at Okpanam junction, Asaba with minimal soil enhancement is suitable for the construction of a geologically designed landfill.

INTRODUCTION

As seen in other parts of the developing countries, the problem of inadequate solid-waste management is alarming as heaps of refuse are found along major roads, drainage channels, close to residential areas and in open spaces, hence the dire need of a landfill. One of the first steps in developing a waste management plan is to identify the region and scope to be covered. The role of geology can be categorized into selection of sites selection of construction materials as well as hydrogeological conditions.

Matheis and Pearson (1982) investigated some lateritic soils from Northern Nigeria and observed the absence of Montmorillonite. This was in agreement with the findings of Ogunsanwo (1988) who investigated five genetically different southwestern Nigerian soils and Adeyemi (2002) who studied the geotechnical properties of lateritic soils developed over quartz schist in Ishara area, Southwestern Nigeria. The presence of the clay mineral affords the soil sample in the study area to exhibit the two main functions of containment and attenuation expected of natural landfill soils (Allen, 2000).

The results and findings of this work would throw more light on the hydrogeological and geochemical properties for the selection of solid waste disposal site and in prescribing whether the site could be given consideration for the disposal of waste or not. This study was designed to assess the suitability the sanitary landfill site for waste disposal by evaluating hydrogeological and geochemical properties of rocks and soils within the study area (210m X 210m). The results obtained from the different laboratory tests carried out were also discussed in relation to the study and its suitability for the base of a landfill. Soil samples were analysed for mineralogical and chemical constituents. The study area is located at the outskirts of Asaba the capital city of Delta state, Nigeria. Its longitudes falls within the range of $N6^{0}12'35.4''$ - $N6^{0}12'45.8''$. The relief of Asaba is a gentle undulating type characterized by a gentle slope. The elevation in the study area has a range of 96m – 117m above sea level with an average of 106m above sea level (Akpokodje, 1986). The major river is River Niger. Asaba is characterized by the tropical climate. The study area falls precisely in the Niger Delta Basin (Southern Nigeria). The major formation at the location comprises of the Bende-Ameki Formation. It is capped by the Ogwashi-Asaba formation and underlying it is the Imo Formation (Fig. 1.).

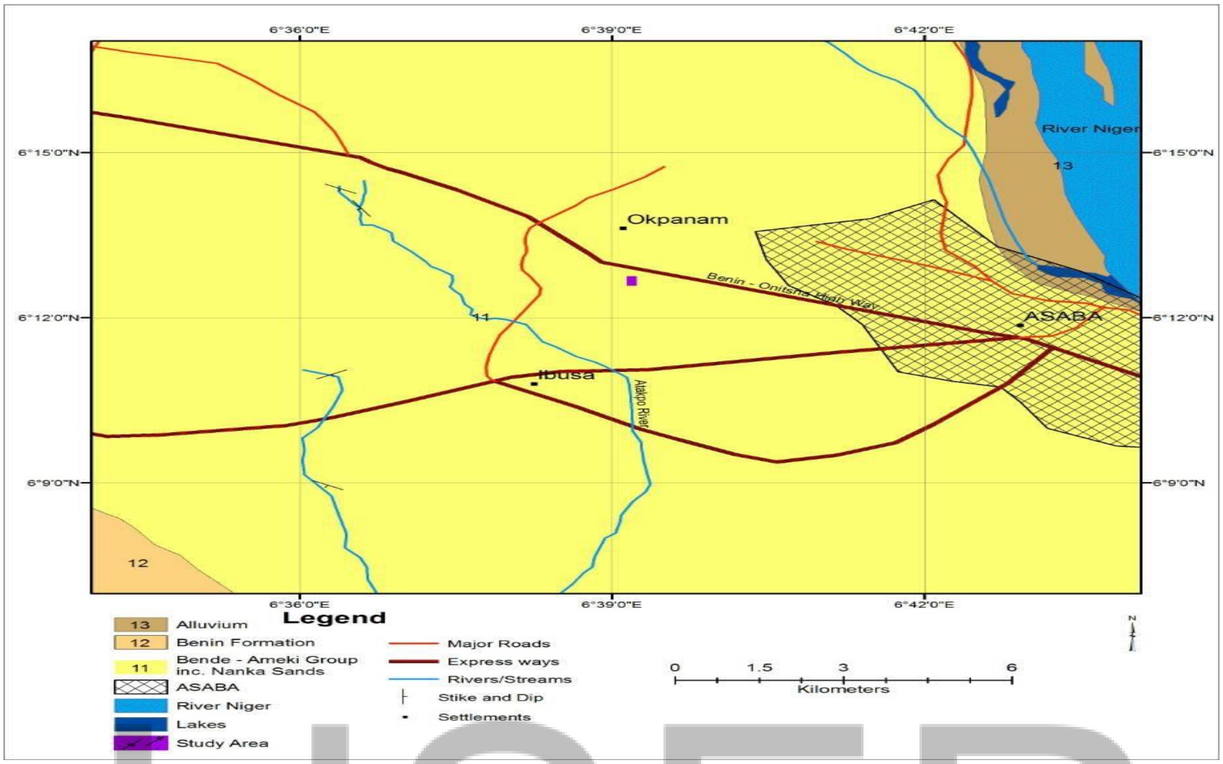

Fig 1: The geological map of the study area (NGSA, 2006)

RESEARCH METHODOLOGY

After desk study, Field work/ Data Acquisition, Hydrogeological/Geochemical sampling and laboratory work were carried out. Soil samples were collected at 0.5m intervals to a depth of 3m and from 2 geotechnical boreholes to 17.25m and 20m depth. Other Physico-Chemical parameters relevant for landfill siting and operation which include pH, Total Organic Carbon (TOC) and Cation Exchange Capacity (CEC) were determined. The clay mineralogy of the samples was also determined using X-Ray Diffraction method.

RESULTS AND DISCUSSIONS

Soil lithology from the geotechnical boreholes range from very dark brown, medium sandy silty clay (topsoil) to very hard mottled reddish brown and grey ferruginised sandstone. The pH values range from 4.5 to 5.9. This indicates that the soil is dominantly *Acidic*. The pH range of the soil indicates that the soil will not be suitable for waste that is rich in heavy metals because of their solubility. The TOC values range from 0.233% - 0.778%. TOC in the soil in this study is low. Organic matter content in lateritic soils is generally low, usually below 2% of the top soil, and can be as low as 0.2 -0.6% in typical lateritic soil profile. The values of the CEC in this study range from 2.59 - 8.51cmol/kg with a mean of 4.55cmol/kg. CEC normally ranges from 1.0-100mmol./kg, the least for sandy soils and most for clayey soil.

X-ray diffraction shows that Kaolinitic clays are the dominant clay type with an average value of 63%, and Quartz has an average value of 26%. For the borehole samples, the average value of quartz is 58.59% by weight and that of Kaolinite is 1.30% by weight. Figure 2 below shows some results from the XRD analysis. Other clay minerals (Montmorillonite, Vermiculite, and Illite) are notably absent in the soil samples. This is quite different from Oyediran (2012), where the other clay minerals are observed in small amounts. Iron is present as hematite (table 1)

Results of the major and trace elements analysis indicates the presence of of SiO_2, ranging from 37.00 % (at a depth of 2.0m) to 54.50 % (at a depth of 3.0m). Al_2O_3 ranges from 23.00 % to 30.00 %. Also, Fe_2O_3 and TiO_2 range from 5.38% to 7.70%, and 1.87% to 2.27% respectively. All other elements range from 0.01% to 0.26%. Cr is the most abundant trace metal in the samples, with values ranging from 0.04% to 0.17%. Zr, P, V, S, Ni and K have values ranging from 0.01% to 0.15%, while Cu, Ba and Zn ranges from <0.01% to0.01%, indicating a high detrital quartz and clay mineral constituents. Based on classification of soils using silica sesquioxide molar ratio of iron and aluminum ($SiO_2/Al_2O_3+Fe_2O_3$), the soil samples are 'true laterite to lateritic soils' (average molar ratio is 1.40).

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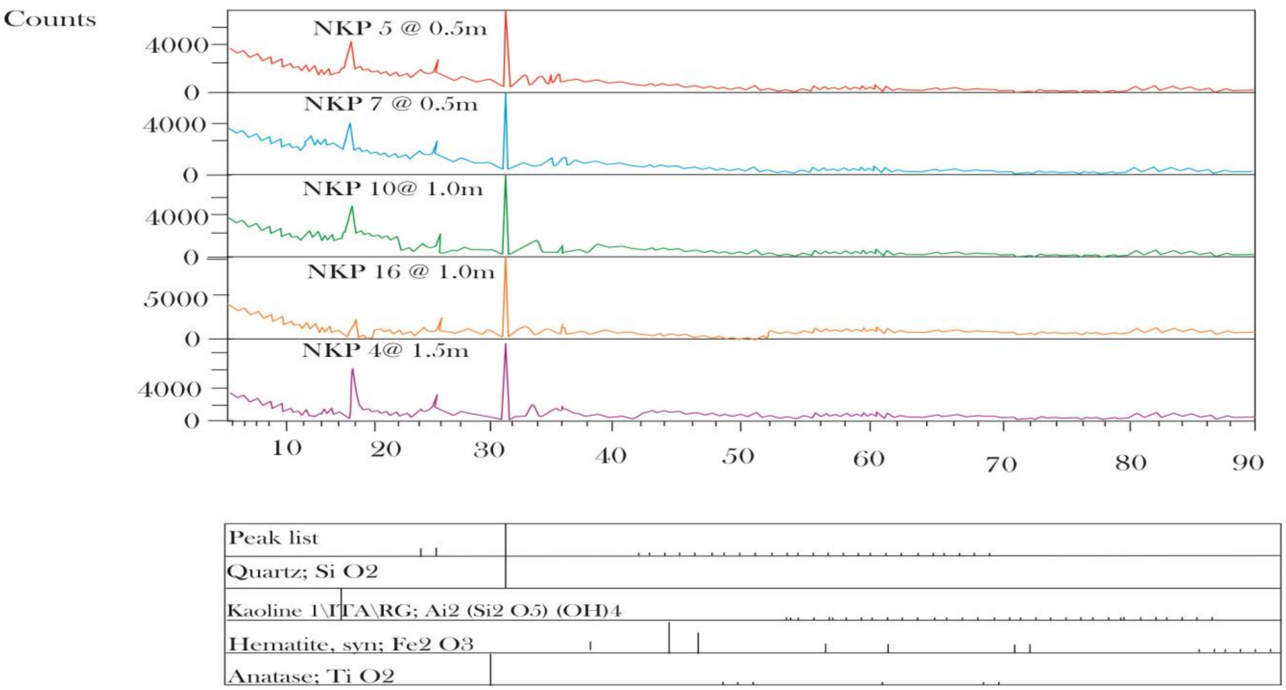

Fig.2: Results from XRD Analysis of some soil samples

Table 1: Average values of minerals

Depth(m)	**Average Weight %**			
	Anatase	**Haematite**	**Kaolinite**	**Quartz**
0.5m	5.18	5.56	65.80	23.70
1.0m	5.17	5.98	64.97	23.88
1.5m	4.41	5.54	59.2	30.76
2.0m	5.29	5.77	65.09	23.85
2.5m	5.43	5.33	63.64	25.60
3m	4.96	5.70	61.45	27.89

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the pH can be increased with lime or high bicarbonate irrigation water as well or it can be decreased with nitrogen fertilizers or elemental sulfur based on the need. TOC shows an expected decrease with depth because organic matter is mostly concentrated within the top layer of soil. The TOC and CEC of the soil in the present study need to be enhanced for its suitability as landfill. Biodegradable waste high in organics could be suitable in the landfill as the waste will improve the TOC of the soil. XRD analysis reveals the geology to be dominantly sandstone. Kaolinite is associated with a well-drained environment. Hence the soils could be used as materials for the base of landfills.

The effect of the geology on the sites should be investigated as several geologically distinct profiles can be experienced within a location. This conclusion has important implications for future research and training in the area of hydrogeology and surface biogeochemistry especially in sedimentary terrains where integrated approach will be emphasized. Also, more integrated approaches are advised to be carried out in as many sedimentary terrains as possible.

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