THE ENVIRONMENTAL IMPACT ASSESSMENT OF WASTE DISPOSAL SITE ON GROUNDWATER IN OKE-ODO, LAGOS, SOUTH WESTERN NIGERIA.

Odukoya, A.M[1], Abimbola, A.F.[2] and Odesanya, K[1].

1. Department of Earth Science, Olabisi Onabanjo University, Ago-Iwoye, NIGERIA

[2] Department of Geology, University of Ibadan, Ibadan, NIGERIA

ABSTRACT

Physical, chemical and bacteriological analysis of surface and groundwater in Oke-Odo waste disposal site were carried out on surface and groundwater within the vicinity. A total of thirty-one samples were collected from the hand dug wells, twenty-five from boreholes and one sample from the stream around the waste disposal site.

Results of chemical analysis show that the water in the area is colourless, odourless with pH ranging from 6.0 to 7.2 that is slightly acidic to slightly alkaline and turbidity ranging from 5.3TU to 7.5TU. The concentration of bicarbonates ranges between 24.00mg/l to 120.00mg/l, concentration of chloride ranges from 20.00mg/l to 84.20mg/l, concentration of nitrate ranges from 2.17mg/l to 56.53mg/l and that of sulphate ranges from 0.00mg/l to 35.00mg/l.

For the cations, concentration of calcium ranges from 9.60mg/l to 55.50mg/l, concentration of magnesium ranges from 4.25mg/l to 58.00mg/l while that of potassium ranges from 3.24mg/l to 14.32mg/l. The results were statistically analyzed to determine the range, mean, standard deviation and correlation coefficients of the chemical constituents.

Relative abundances of anions and cations based on the overall mean follow the order HCO_3^- > Cl > NO_3^- > SO_4^{2-} and Na^+ > Ca^{2+} > Mg^{2+} > K^+ respectively Fe^{2+} Pb^{2+}, Cu^{2+} and Mn^{2+} are in trace amounts for all the water samples. The bacteriological analysis result shows coliform count ranging from 4 to 22 cfu per 100ml.

It was generally observed that hand dug wells and boreholes closer to the waste disposal site have higher concentration of coliform count, pH, Cl^-, Mg^{2+}, Na^+, Fe^{2+} and NO_3^- than those located father off. Samples from wells have higher pH, total hardness and concentrations of HCO_3^-, Cl^-, K^+, Na^+, Cu^{2+}, Mg^{2+} and SO_4^{2-} than samples collected from boreholes.

The total hardness of the water varies from moderately hard to very hard. Based on the total dissolved solids, the water is fresh and the sodium absorption ration falls within the excellent range. The characteristics of water from the piper diagram are Na^+-K^+-Ca^{2+}-Cl^--HCO_3^- and Na^+-K^+-Cl^- and from the boomerang diagram, most of the water samples are influenced by the chemical weathering of the underlying sediments.

The chemical constituents of most of the water samples fall within the WHO standard although concentration of Nitrate at few locations close to the waste disposal site and bacteriological analysis of all the water samples fall above the recommended values.

Key words: Dumpsite, groundwater, Oke-Odo, contamination, environmental impact.

Introduction

Lagos is the most densely populated city in Nigeria with population in excess of 13 million. Over 50% of Nigeria's industrial activities including 300 industries and 12 industrial estates are located in the Lagos area. The continuous increase in population and industrial growth in Lagos persistently cause large volumes of waste to be generated (about 10,000 tons per day) and there are no environmentally safe landfills to cater for them. Oke-Odo dumpsite, which is the case study of this research is superficially designed, has no facilities for hazardous waste disposal and is poorly located just like many other disposal sites in Lagos. The wastes from the case study consist mainly of household and commercial types. Inside the dumpsite, chemical and biological reaction may cause the generation of toxic liquids that will leach from the dumpsites thus polluting the surface and groundwater especially where the underlying geology is composed of uncompacted coarse sands like that of the case study.

The study area, which is Oke-Odo, falls within the northwestern part of Lagos metropolis (Fig. 1). It lies between latitudes 00 35' 00" 40'N and longitudes 30 15'-30 20'E

within the southwestern part of Nigeria. The dumpsite is situated close to the Lagos - Abeokuta expressway and between two market places (Oja-Oba and Oke-Odo markets). The population density is high and all the sample locations fall with human habitation areas.

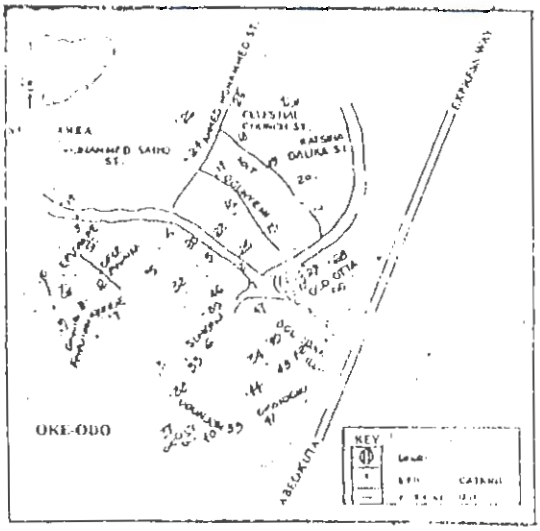

Fig. 1: Location map of Oke-Odo Area, Abule - Egba, Lagos

The relief is relatively low with the topography ranging between 50-150m above sea level. The climate condition is typical of the sub-equatorial belt of southwestern Nigeria.

Geology and hydrogeology

The study area is located within the Dahomey Basin, which is one of the sedimentary basins on the continental margin of the Gulf of Guinea extending from southeastern Ghana in the West to the Western flank of the Niger Delta, (Jones and Hockey, 1964). Various authors like Jones and Hockey (1964), Fayose (1970) and Omatsola and Adegoke (1981) have studied the stratigraphy of the Dahomey Basin.

The sedimentary formations of the study area are classified into three: the Quaternary sediments, the Tertiary sediments and the Cretaceous sediments. Quaternary sediments are alluvial deposits with loose sands, silt and clay at various depths. The Tertiary sediments consist of clays, which are laminated or calcareous. The sediments are fine-grained with the presence of coarse sands while the Cretaceous sediments are the oldest unit with medium to coarse sand.

A study of the groundwater wells located all over Lagos area revealed that four aquifer horizons have been identified in the state. The three upper aquifers are generally associated with coastal plain sands of varying thickness. The first two aquifers are generally encountered near the zero elevation and extend to a depth of about 80-150m below ground level while the third aquifers are at the depth of about 150-250m and the thickness of the permeable layers rarely exceeding 25m. The fourth aquifer horizon is generally deeper than 450m and is associated with the Ilaro/Abeokuta Formation. In the study are, the upper aquifer constitutes the hydrogeological characteristics.

Methodology

Sampling was carried out in the month of February. Fifty-seven water samples were collected, 31 from hand dug wells, 25 from boreholes and 1 from the stream around the dumpsite.

The water samples were collected into sterilized polyethylene bottles. The water samples were transferred to the laboratory for physical, chemical and bacteriological analyses. The pH meter was used to determine the pH values while the Atomic Absorption Spectrophotometer and titration methods were used to determine the concentration of calcium, magnesium, potassium, sodium, iron, manganese, lead, copper, nitrate, sulphate, bicarbonate and chloride.

The bacteriological analysis was performed using standard plate count and multiple tube technique. The chemical data were treated to statistical and correlation coefficient analyses.

Results and discussion

The water samples collected were analysed to for the possible effects of the waste disposal site on the water quality by determining their physical, chemical and bacteriological characteristics.

The result of the physical and chemical analyses are presented in Tables 1 and 2, summary of the water chemistry is presented in Table 3.

The pH of water ranges between 6.0 and 7.2 with a mean of 6.6 while turbidity ranges from 5.37U to 7.51U. Colour ranges between 5-15 Hazen. Total hardness ranges from 60mg/l to 120mg/l. Concentration of chloride ranges from 20mg/l to 84mg/l while that of nitrate and sulphate ranges from 2.17mg/l to 56.3mg/l and 0mg/l to 35mg/l respectively.

Values of potassium ranges from 3.24mg/l to 14.56mg/l, sodium, 7.10mg/l to 58mg/l, calcium, 9.6mg/l to 35.5mg/l and magnesium 4.25mg/l to 21.6mg/l.

Concentration of copper, iron and manganese are very low with values of 0.05mg/l to 0.2mg/l, 0.01mg/l to 0.03mg/l and 0mg/l to 0.05mg/l, in that order. There is no trace of lead in all the water samples while Total Dissolved Solids range between 89.39 mg/l to 550mg/l.

Physical parameters

Based on the classification of pH by Ezeigbo (1989) the water samples vary between slightly acidic to slightly alkaline and fall within the World Health Organisation Standard. In addition, colour and odour of most of the water samples fall within WHO standard for drinking water (Tables 1 and 2). The turbidity of all the samples show higher values as against 5.0TU recommended by WHO.

Chemical parameters

The relative abundance of the anions are in the order $HCO_3^- > Cl^- > NO_3^- > SO_4^{2-}$ while that of cations are in the order of $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ (Tables 1 and 2). A plot of the chemical parameters using the relative concentration of the major cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+) and anions (Cl^-, SO_4^{2-} and HCO_3^-) was carried out using the trilinear diagram proposed by Piper (1944) (Fig. 2). From the results, the characteristics of the water samples are classified as Na^+-K^+-Ca^{2+}-HCO_3^- and Na^+-K^+-Ca^{2+}-Cl^- rich.

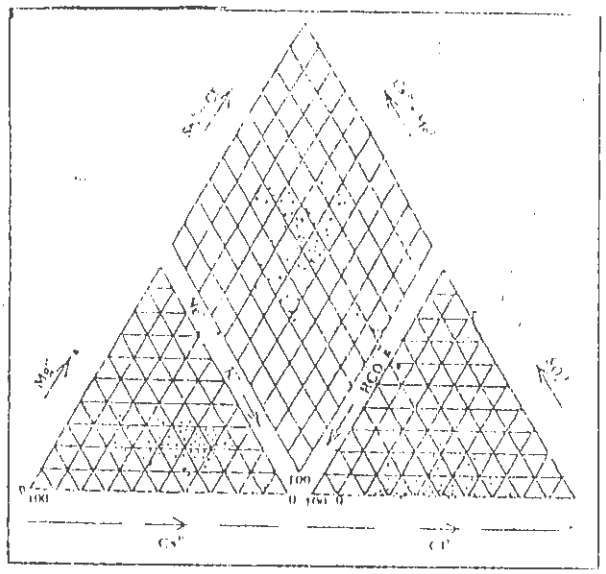

Fig. 2: Water Characterization after Piper (1944)

Classification of water according to Gibbs (1970) diagram shows that the geology, particularly the rock type and their weathered products has contributed greatly to the chemistry of the sampled water. This is confirmed almost all the water samples plotting in the center of the boomerang (Fig. 3).

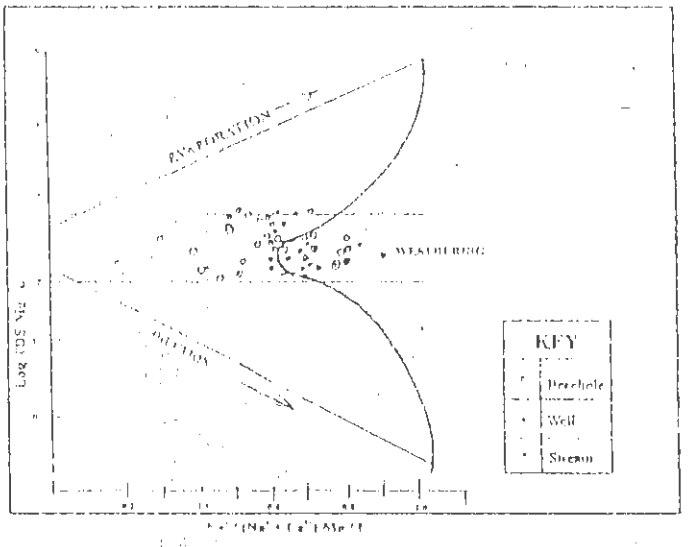

FIG 3: classification of water according to GIBBS (1970) boomerang diagram

Water quality

Standards for drinking water as classified by Davis and Dewiest (1986), are based on the presence of objectionable tastes, odours, colours as well as dangerous/harmful substances in such water. Waste disposal site contain mainly domestic and commercial wastes since it falls within the residential area which generally is devoid of industries. The physical analysis results indicate that the water in the study area is physically suitable for domestic purposes except for the stream whose turbidity is higher than the WHO recommended value.

The various ionic concentration and parameters of water in the study area are within the maximum acceptable limits as specified by the WHO (1998) standard. Nitrate, coliform counts and iron are generally higher in locality around dumpsite (Fig. 4). In addition, the positive correlation between nitrate and chloride indicate contamination in the area (Table 4). Consequently, the contamination is mainly bacteriological in origin as shown by the presence of high coliform bacteria and nitrate in all samples close to the dumpsite. Generally, the water of the study area can be classified as fresh, moderately hard to hard, slightly acidic to slightly alkaline and excellent for irrigation purposes.

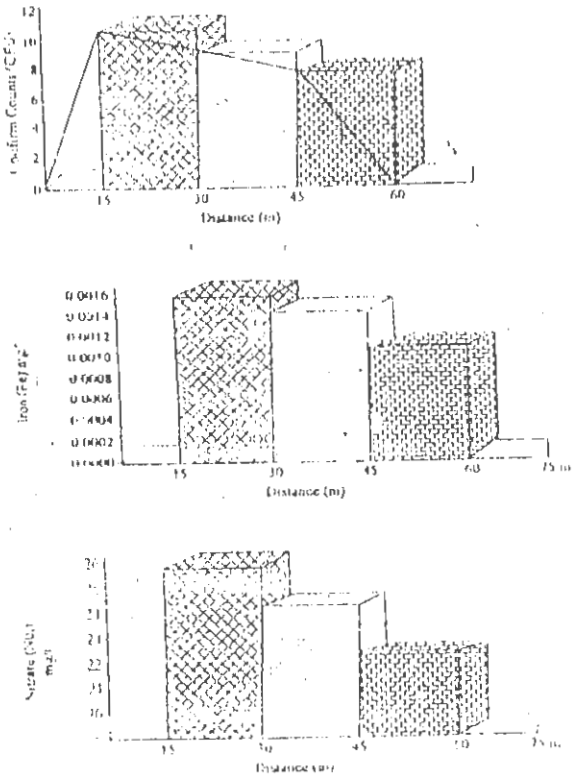

Fig. 4: Histogram showing relationship between distance from Dump site and certain parameters

Summary and conclusions

Oke-Odo waste disposal site consists mainly of domestic and commercial wastes. The result of the physical and chemical analyses show that all the parameters analysed for fall within the World Health Organisation standards for drinking water (1998), except for the turbidity of the stream which is higher than 5.0TU and nitrate concentrations above 45mg/l at few locations close to the dumpsite. The mean concentrations for all the ions shows that bicarbonate and sodium have the highest concentrations for anions and cations respectively. Concentrations of chloride, iron and nitrate and the values of coliform count are higher at locations closer to the waste disposal site. This is due to the leachates from the domestic and commercial wastes of the disposal site.

Most of the water samples are said to be moderately hard to very hard. All the water samples collected in the area are said to be slightly acidic to slightly alkaline, fresh and excellent for irrigation purposes. They can also be characterized as Na^+-K^+-Ca^{2+}-HCO_3^- and Na^+-K^+-Ca^{2+}-Cl^- water type. The water is influenced by chemical weathering of the underlying sediments in the study area.

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Table 3: Summary of the water chemistry of the study area.

	Minimum	Maximum	Mean	Standard Deviation
PH	6.00	7.20	6.29	0.37
Colour	5.00	16.00	7.11	3.13
Turbidity	5.30	7.50	6.19	0.53
Total hardness	60.00	210.00	120.88	41.24
HCO_3^-	24.00	120.00	59.63	25.49
Cl^-	20.00	84.20	33.94	16.47
Ca^{2+}	9.60	55.50	26.05	11.11
Mg^{2+}	4.25	21.50	11.36	3.14
K^+	3.24	14.32	9.29	2.85
Na^+	7.79	58.00	41.83	10.64
Fe^{2+}	0.01	0.03	0.01	0.04
Mn^{2+}	0.00	0.05	0.02	0.02
NO_3^-	2.17	56.53	22.49	13.74
Pb^{2+}	0.00	0.00	0.00	0.00
Cu^{2+}	0.05	0.30	0.12	0.04
TDS	89.39	550.02	251.10	126.35
$SO4^{2-}$	0.00	35.00	4.08	7.71

Table 4: Correlation Coefficient for the water chemistry.

	Ca^{2+}	Mg^{2+}	Na^+	K^+	NO_3^-	Cl^-	HCO_3^-	SO_4^{2-}	pH	TDS
Ca^{2+}	1.000									
Mg^{2+}	0.316	1.000								
Na^+	-0.274	0.161	1.000							
K^+	0.354	-0.086	-0.220	1.000						
NO_3^-	0.290	-0.043	0.042	0.288	1.000					
Cl^-	-0.172	0.022	0.115	-0.166	0.273	1.000				
HCO_3^-	-0.177	-0.034	-0.131	-0.017	-0.266	0.258	1.000			
SO_4^{2-}	-0.026	0.024	0.120	0.096	-0.055	0.360	0.214	1.000		
pH	-0.164	0.049	0.074	-0.135	-0.237	0.626	0.350	0.377	1.000	
TDS	0.016	0.228	0.011	-0.123	-0.307	0.264	0.248	-0.053	0.144	1.000