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POTENTIAL GROUNDWATER CONTAMINATION WITH TOXIC METALS IN AND AROUND A DUMPSITE AND LIMESTONE QUARRY IN SAGAMU SOUTHWESTERN, NIGERIA.

ODUKOYA, A.M, LANIYAN, T.A AND FAWIBE,S

Abstract
This study evaluated contamination of groundwater with toxic metals in and around Oke diya dumpsite and Limestone quarry in Sagamu Southwestern Nigeria. The pH values for the Groundwater were acidic based on pH with a range of 3.3 to 6.6 and a slight increase of the values along the groundwater flow direction which is generally towards the eastern part of the study area. Values of Total Dissolved Solids and Electrical Conductivity were between 57 to 1538mg/l and 88 to 2366us/cm respectively which classify the water in the study area as fresh to slightly saline. Higher values were observed in the dumpsite area when compared with quarry site. The major and trace elements were determined using inductively coupled plasma optical emission spectrometry (ICP-OES) analytical method at Actlabs in Canada. Water samples around WAPCO and Oke diya dumpsite areas showed a relative abundance of Sr>Ba>Zn>Bi>Pb>Si>Cu>Co>Mn>U→ and→ Zn>Sr>Ba>Y>Bi>Ce>Cu>W>Pb>Ni>Si>Co>Mn>U respectively for trace elements. The concentrations of trace elements were within World Health Organisation (WHO) standard except ., Ba and Ni for leachate sample only. The concentrations of Nitrate, Iron and Aluminium were higher than WHO standards in most of the locations with value as high as 483.76mg/l, 0.36mg/l and 14.3mg/l respectively in leachate. Most of the toxic metals decreased with distance from the dumpsite especially along the groundwater flow direction and this confirmed the possibility of Natural attenuation processes in the study area.

Keyword:
Trace elements, Dumpsite, Quarry, leachate

INTRODUCTION

The disposal of wastes and mining operation generated by human activities within a municipality is generally an urban problem. The waste disposal sites and landfills that are neither properly designed nor constructed consequently, over the years become point source for pollution of the water units close to them. Apart from being a source of air, soil, sediment and water pollution, chemical and biological reaction inside a dumpsite may cause the generation of toxic liquid that will leach from the dumpsite without liners, thus polluting the surface and the groundwater. If the leachate is released into the underlying aquifer, it forms a complex contaminant plume that fundamentally alters the chemical properties of the aquifer (Baedecker and Back 1979; Nicholson et al., 1983; Lyngkilde and Christensen 1992; Bjerg et al. 1995; Jankowski 1997; Jankowski and Acworth 1997; Ludvigsen et al. 1998; Cozzarelli et al. 1999; Jankowski and Beck, 2000; Christensen et al. 2001).

There is therefore the need to deposit waste in an engineered landfill and operate mining activities with minimum environmental and health risks and at optimum cost. For a landfill to be secured there is need for the study of engineering, geological, chemical characterization and evaluation of the soil within the site. These investigations are a necessary part of the environmental impact assessment which is obligatory for a secured landfill site.

LOCATION OF THE STUDY AREA

The two study areas are in Sagamu, South Western Nigeria. The study areas fall within the West African Portland Cement Company (WAPCO)-Sagamu and Oke diya dumpsite which are situated within the Eastern part of Dahomey Embayment and lies within the Ewekoro depression with Sagamu as part of type section. They are located within Sotubo and Ebinpejo areas of Sagamu. They are located between Latitude 6°46'N – 6°50'N and Longitude 3°33'E– 3° 39' E (Fig 1). Oke-diya dumpsite is very extensive with a topographical height of about 48.3m with reference to ground level and situated to the North East of old Ikorodu road very close to West Africa Portland Cement. It covers an area of approximately 184m². It has been in operation since 1996.

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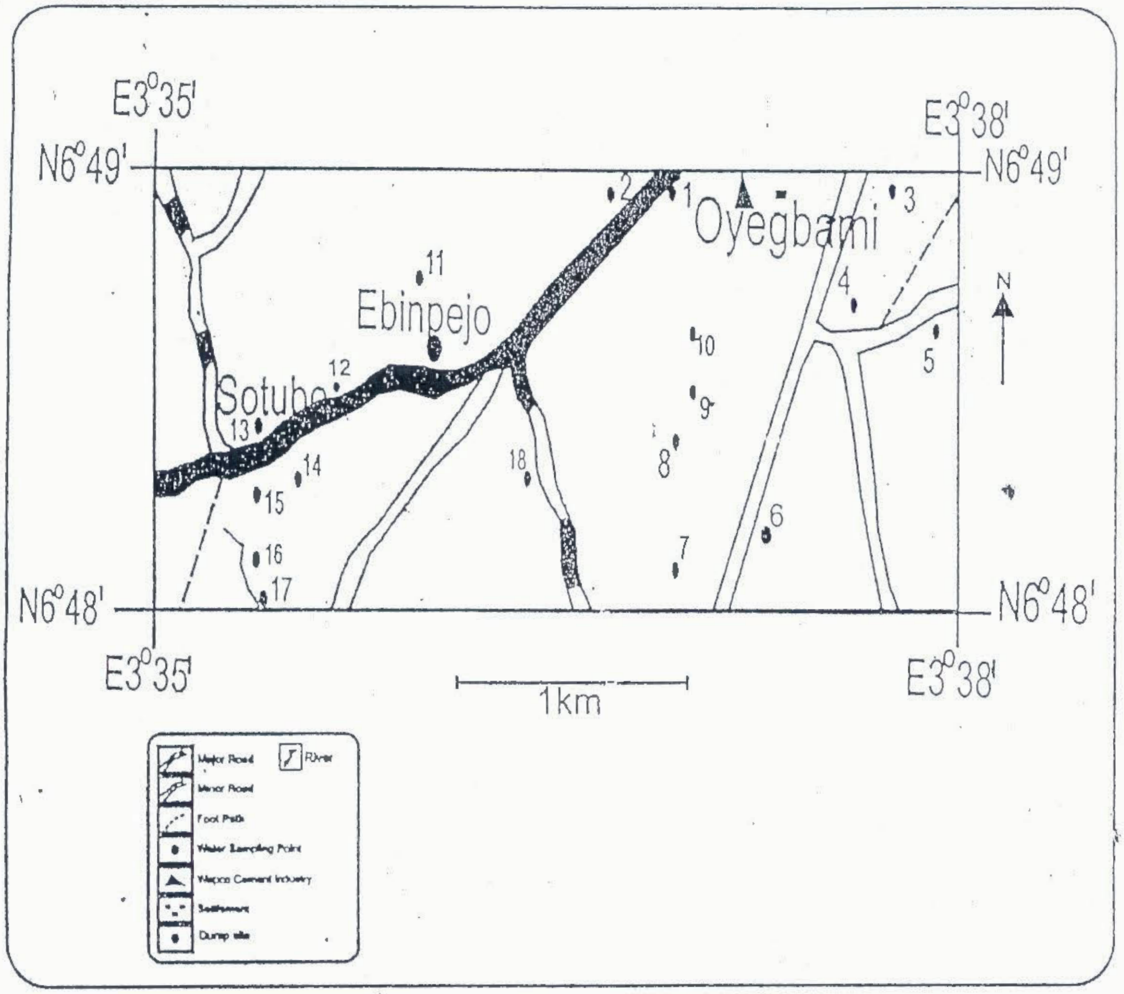

Fig 1: Map of the Study Area

Geology of the Study Area

The study areas are underlain by the Ewekoro formation in the Eastern Dahomey Basin which is predominantly highly rich in fossiliferous limestones (Adegoke, 1969; Adegoke and Omatsola 1981) The Formation consists of marl and its arenaceous content increases towards the base and grades into the underlying predominantly sandy Abeokuta .Group. The formation is extensive and traceable over a distance of about 32km continuously from Ghana eastwards, towards the eastern margin of Dahomey Basin. The thickness of the Formation is about 30m at Ewekoro quarry. The lithology exposed at Sagamu quarry consists of limestone, shale and ferrugenised sandstone as topsoil. The borehole drilled revealed two principal formations, namely the shale, and the underlying limestone present throughout the area (Fig 2). The shale which represents the bulk of the overburden overlies the limestone with a slight unconformity indicating that it was deposited on an eroded limestone surface such that it rested on a progressively younger and thicker limestone succession.

The exposed layer at the dumpsite showed fine to coarse, reddish brown to grey sand grains of thickness 1.3m at the topmost layer. It is subsequently followed by pinkish white to yellow clay and ferruginised sandy clay of about 0.8m and 5.2m respectively while grey shale is of varying thickness (Fig 3).

Methodology

Water Samples from 10 production wells penetrating shallow aquifers were collected around West African Portland Cement Company Sagamu plant and another 10 samples which include one leachate were collected around Oke-Diya dumpsite (Fig 4). Two set of water samples were collected at each location; one set for analyses of anions while acidified water samples were used for the determination of cations. They were collected into appropriate plastic containers for storage prior to analyses. Total Dissolved solids (TDS) and pH were determined in-situ (in the field) using portable WTW-Conductivity meter (model LF/95) and WTW-pH meter (model pH/91). The analysis of trace elements and cations were carried out using Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) while unacidified water samples were analyzed for anions concentrations using the DIONEX DX-120 Ion Chromatography techniques. The analyses were carried out in Actlabs laboratory, Ontario, Canada.

Discussion of Results

The summary of the concentrations of dissolved elements in water samples around both WAPCO and Oke diya dumpsites in Sagamu, South western Nigeria were given together with international standards (WHO (2006) and EPA (2004)) in Tables 1and 2 , .pH values range from 3.3-6.6 with most of the samples acidic to slightly acidic (Ezeigbo, 1989) and were above recommended standards except one sample. Concentrations of Total dissolved solids (TDS) were low generally and fresh with mean values of 232.1 and 221 for dumpsite and WAPCO respectively and fall within recommended standard except for leachate sample which was slightly saline (Todd, 1990).

Concentrations of major elements in the water system show the following trends Na>Ca>Mg>Al>K>S>Fe>P and Ca>Na>Mg>S>K>Fe>Al>P for dumpsite and WAPCO respectively (Table 2). The higher concentration of Ca^{2+} in water samples around WAPCO is due to the presence of limestone which is the main rock type in the area while the higher concentration of Na^{2+} in dumpsite area may be from the decomposition of wastes. Major elements concentrations were within the limits of WHO (2004) and EPA (2006) standards for drinking water with the exception of Al, Fe, N and NO_3 for samples close to the dumpsites respectively (Table 1).

The metals showed the following trends Sr>Ba>Zn>Pb>Bi>Cu>Si>Co>Mn>U and Zn>Sr> Ba> Y> Bi>Ce>Cu>W>Pb>Ni>Si>Co>Mn>U for samples taken around WAPCO and dumpsite respectively (Table1). The mean concentrations of trace elements for samples taken around WAPCO and dumpsite were 43.4 and 158.8ppm for Ba, 0.094 and 0.15ppm for Mn, 3.58 and 4.64 for Si, 1.76and 4.24 for Co, 10.8 and 15.2ppm for Bi, 3.4and 11.8ppm for Cu, 7.4 and 8.4ppm for Pb, 70 and 166ppm for Sr, 15.6 and 229.4 for Zn and 0.047 and 0.076 for U respectively (Table 1, Fig 4). Y, Ni and Ce were only detected in samples taken within the dumpsite with mean values as high as 28ppm, 6.76ppm and 14ppm respectively. Water samples from the dumpsite area show higher concentrations for all the elements when compared with those from WAPCO area except Ca^{2+} (Figs 5 and 6). The variability of concentrations of these metals within the groundwater suggests local anthropogenic input through domestic, municipal and industrial wastes within the study area.

Compared to WHO, (2004) and EPA, (2006) standards, Al, Fe, N, NO_3, Pb, Ba and Ni concentrations were found to be in excess for samples within the dumpsite especially leachate sample with mean values as high as 14.3, 0.36 109.2, 483.76, 70, 158.8 and 22 respectively. Concentrations of Al, Fe, K, P, Ni, Y, Ce, W and S were below detection limits in most of the samples around WAPCO but showed high concentration in samples within the dumpsite (Tables 1 and 2). The total concentrations of the elements and TDS were compared at several sampling sites and there was a slight overall trend of decrease in the concentration of trace elements along the groundwater flow for dumpsite samples and this may be due to the natural attenuation processes while those around WAPCO did not follow any pattern (Figs 7, 8, 9 and 10).

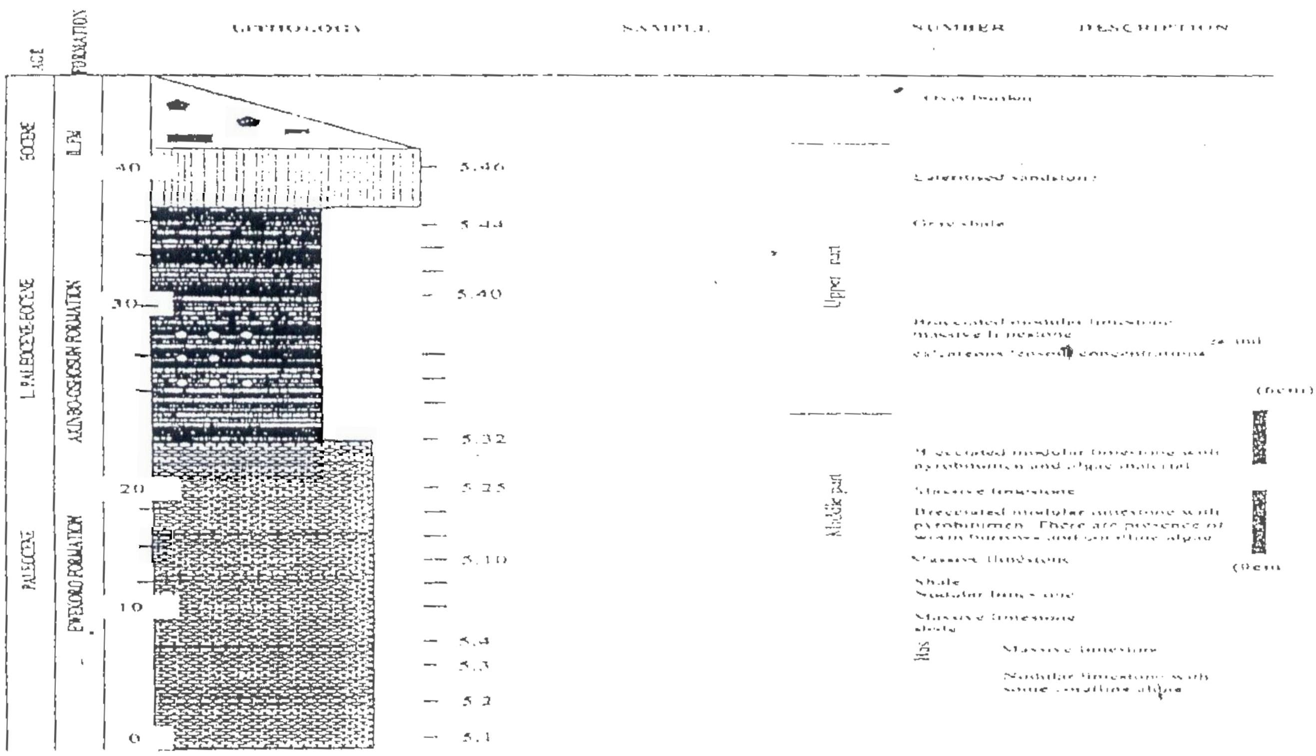

Fig.2: Lithostatigraphic section of the Sagamu quarry After Adekeye O.A and Akande S.O (2006)

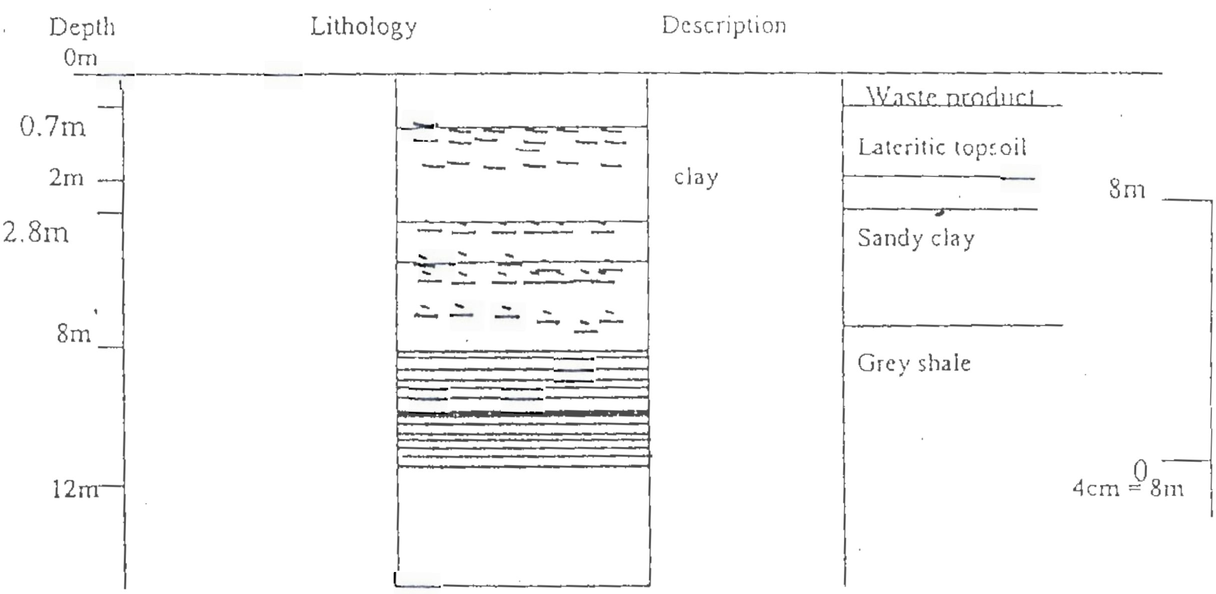

Fig 3: Lithostratigraphic section of Sagamu (Oke Diya dumpsite) .

Table 1: Results Summary of Trace Elements in water samples for both sites

Elements	Range	Mean Dumpsite	Mean WAPCO	Standard Dev.	EPA, 2006	WHO, 2004
Ba	7-730	158.8	43.4	38.12	300	300
Mn	0.04-0.65	0.15	0.094	0.076	500	500
Si	1.8-5.1	4.64	3.58	1.17		
Co	0.8-16	4.24	1.76	0.97		
Bi	7-40	15.2	10.8	4.22		
Cu	2-31	11.8	3.4	1.64	2000	2000
Pb	3-20	8.4	7.4	5.42	10	10
Sr	10-730	160	70	24.35		
Zn	5-530	229.4	15.6	13.35	3000	3000
U	0.015-0.16	0.076	0.047	0.055	2	2
Ni	BDL-22	6.76	0	8.6		20
Y	BDL-140	28	0	62.61		
Ce	BDL-70	14	0	31.3		
W	BDL-30	10.6	0	11.15		

Table 2: Results Summary of Major Elements in water samples for both sites

Elements	Range Dumpsite	Range WAPCO	Mean Dumpsite	Mean WAPCO	Standard Dev.	WHO/EPA Standards
Al	0-14.3	BDL-0.1	1.81	0.1	4.39	0.2
Ca	4.2-88.3	6.6-67.3	14.21	37.1	26.08	200
Fe	0.02-0.36	BDL-0.57	0.106	0.15	0.103	0.3
K	0-1.7	BDL-1.4	0.98	1.3	0.48	
Mg	1.8-52.1	1.8-14.3	8.51	5.93	15.75	
Na	4.8-112	6.6-26.1	56.16	15.18	34.2	200
P	0.02-0.1	BDL-0.06	0.058	0.07	0.036	
S	0-3	BDL-10	0.8	4.83	1.033	
TDS	57-1538	102-445	232.1	229	459.08	1000
pH	3.3-6.6	4.3-6.6	4.59	5.23	0.645	6.5-8.5

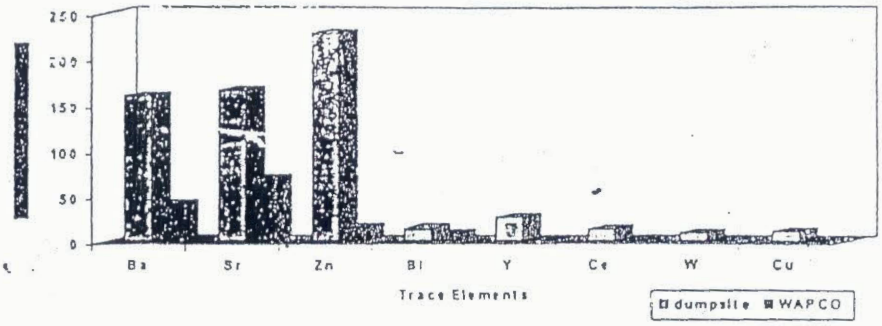

Fig 4: Average concentration of metals in water samples from both dumpsite and WAPCO

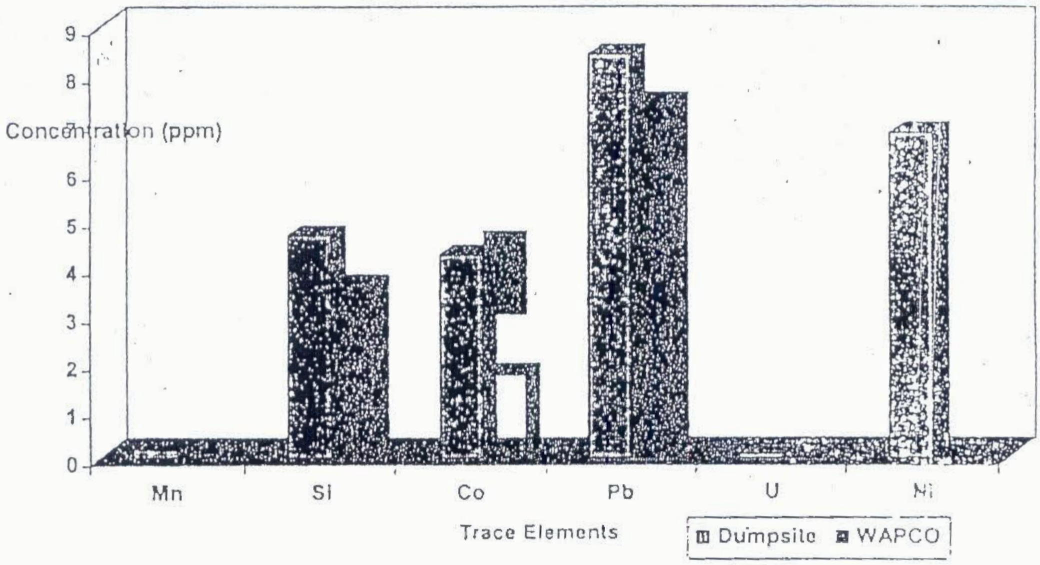

Fig 5: Average concentration of metals in water samples from both dumpsite and WAPCO

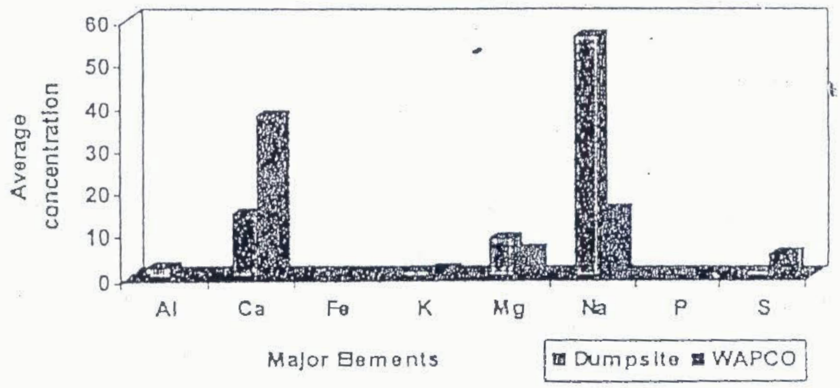

Fig 6: Average concentration of Major elements in water samples for both dumpsite and WAPCO

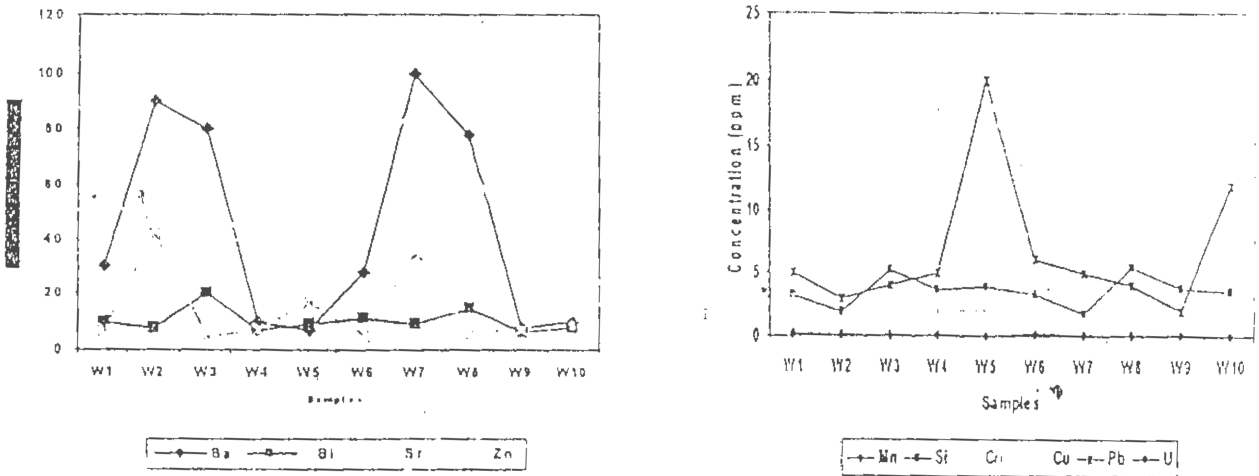

Fig 7: Plots of Trace elements against sample locations along groundwater flow at WAPCO

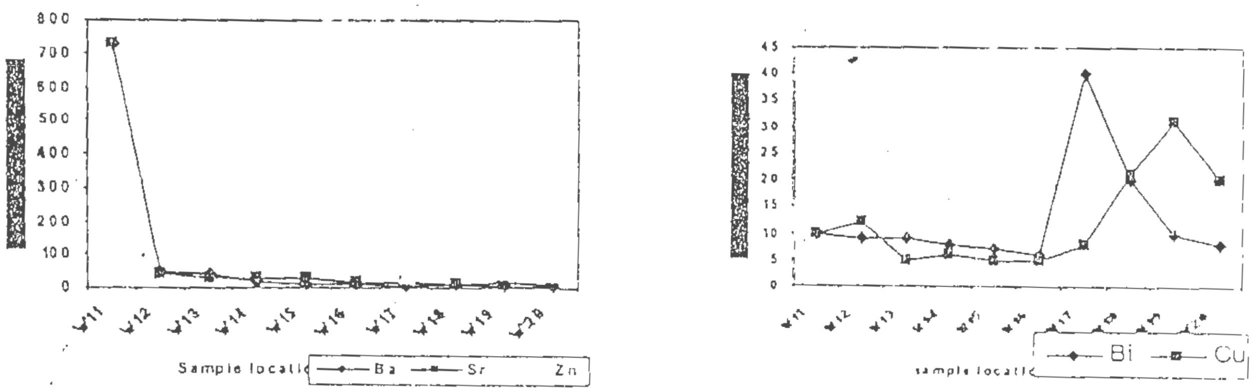

Fig 8: Plots of Trace elements against sample locations along groundwater flow at the dumpsite

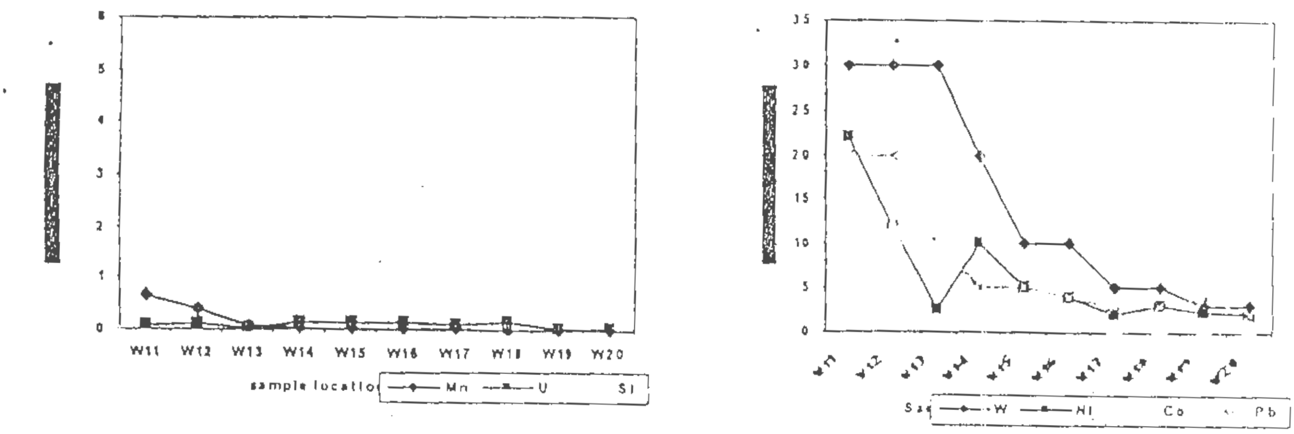

Fig 9: Plots of Trace elements against sample locations along groundwater flow at the dumpsite

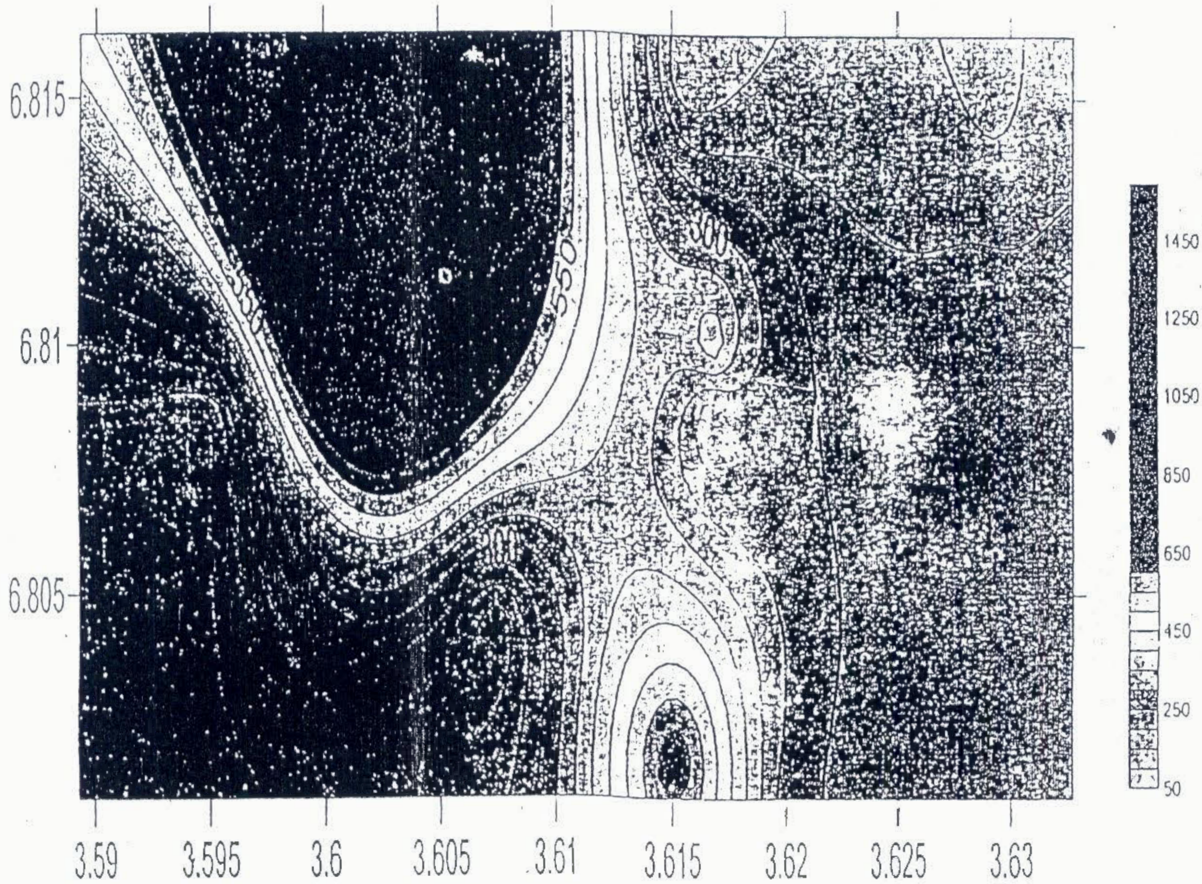

Fig 10: Spatial distribution of TDS in surface and ground water of the study area.

Environmental Quality/Pollution Assessment

Quality status and level of trace metal contaminations for water samples in terms of Geoaccumulation index (Igeo), contamination factor and contamination degree as explained by (Mueller, (1979), Sahu and Bhosale, (1991). Singh et al (1997), Sutherland (2000), Manjunatha et al (2001) and Odukoya, (2007) using WHO (2006) standard as background values showed that with the exception of Pb and Fe for few samples from WAPCO and Pb, Ba, Fe and Ni in the case of dumpsite samples which showed low contamination in the water system, all other metals showed practically no contamination while the contamination degree were 0.89 and 1.42 for water around WAPCO and dumpsite respectively which fall within low degree of contamination for the two sites.

The source of these metals may be attributed to anthropogenic activities from the various wastes at the dumpsites and dumping of wastes/rubbish on the stream channels. The adsorbed portion of these metals will pollute the water which serves as source of drinking water for some people.

Conclusions

Quality evaluation of groundwater from Sagamu, Southwestern Nigeria, was discussed as a case study of anthropogenic influence of dumpsite and limestone quarry in a typical urban environment of a developing country. From this study, it is clearly evident that lack of well constructed environmental friendly landfills and indiscriminate dumping of wastes to stream channels as well as mining activities have considerable influences on the heavy metal contaminations of groundwater in the study area. The study revealed some degree of contamination for Al, Fe, N, NO_3, Pb, Ba and Ni in the water samples around Oke diya dumpsite compared to the WHO, 2004 and EPA, 2006 standards. Among the major elements, NO_3 is the most critical in the water system as well as N and their presence is related to anthropogenic sources mostly from different wastes at the dumpsites which are domestic/municipal and slightly industrial in origin. Metals like Ni, W, Y and Ce were detected only from samples within the dumpsite and their concentrations were below detection limit in WAPCO samples. Generally, water samples around the dumpsite showed higher concentrations of dissolved elements than those around WAPCO.