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Influence of Leachate on Groundwater Quality in Sagamu Ne, Southwestern Nigeria

Amu Babatola Daniel
Student, University of Lagos, Lagos State, Nigeria
Sofade Aduragbemi Oluwatobi
Student, Uppsala University, Uppsala, Sweden
Dr. Ajibade Olumiyiwa Micheal
Senior Lecturer, Olabisi Onabanjo University, Ogun State, Nigeria

Abstract:
Leachate from landfills and waste deposit sites contain high amount of toxic elements leading to the pollution groundwater in the study area. The study examines the impact of leachate from landfill sites on the quality of groundwater. Twelve groundwater samples, consisting of seven hand-dug wells and five boreholes, were analyzed for their major ionic components. Mean concentration of pH 5.89 was found to be lower than the WHO 2006 and USEPA 1986 permissible limits. Total dissolved solid(TDS), electrical conductivity(EC) and alkalinity were found to be within the permissible limits. The mean concentrations of major cations, Na, Ca, K, Mg, Fe, anions, HCO_3, Cl^-, NO_3^-, SO_4^{2-} and heavy metals were found to be within the permissible limits with the exception of Mn. The high concentration of Mn was due to the influx of leachate in the landfill into groundwater. Furthermore, the moderately high values ofCl^- and NO_3^-could be attributed to the impact of leachate from the abattoir found around the dumpsite area. Therefore, there is need for drinking water quality assessment to determine the suitability of groundwater for domestic and industrial consumption.

Keywords: *Water quality, ground water, contamination, leachate, landfill, heavy metals*

1. Introduction

Leachate is one of the primary sources of contamination of ground and surface water. Up to 13% of the earth's water is found in groundwater, which is an important source of drinking water worldwide (Bachmat,1994). Most rural areas and small communities have groundwater as their only source of clean water (Carter,1987). Only a fraction of this water is suitable for drinking and other human use. Objectionable odour, colour and taste, as well as the presence of harmful substances, may render it unsuitable for human use (Tijani, 1994). Landfills are one of the primary threats to groundwater suitability for the above-mentioned purposes (Fattaet et al., 199; US EPA, 1984). The environmental 'disaster' this leachate constitutes has brought about global attention. It has been documented that indiscriminate waste disposal is the major source of pollution in many developing countries (e.g. Tijani et al., 2004; Ariyo et al., 2013). Nigeria presently totals an average of 0.58kg of solid waste per person daily (Adewumi et al., 2005). The chemical breakdown of organic wastes produces leachate which is high in suspended solids and of varying organic constituents, most of this leachate goes into the groundwater (Desa et al., 2009). The assessment of the state and nature of landfills show that 90% of the materials are from organic waste while the remaining 10% are plastics and other metallic waste. Groundwater contains several chemical components resulting from the interaction of the water with the geology of the area. Over 200 million people have been affected by arsenic and fluoride contamination in groundwater (Amini et al., 2009). The increase in the number of residents has also favored the accumulation of more pollutants in the study area. To what extent the underground water has been polluted and how much harm these anthropogenic and geogenic contaminants can cause in the study area is yet unknown and hence, the purpose of this paper.

1.1. Location and Geology of the Study Area

Sagamu is located within the Dahomey basin (figure 1.0). It has a land area of about 27.4 square kilometers. Sagamu is made up of a shale and clay sequence of the Akinbo formation which is underlain by the Ewekoro formation (Agagu 1985). The study area has a tropical climate with an average rainfall of about 230mm while temperature ranges from 29 ^oC during the dry season to about 40 ^oC in the wet season.

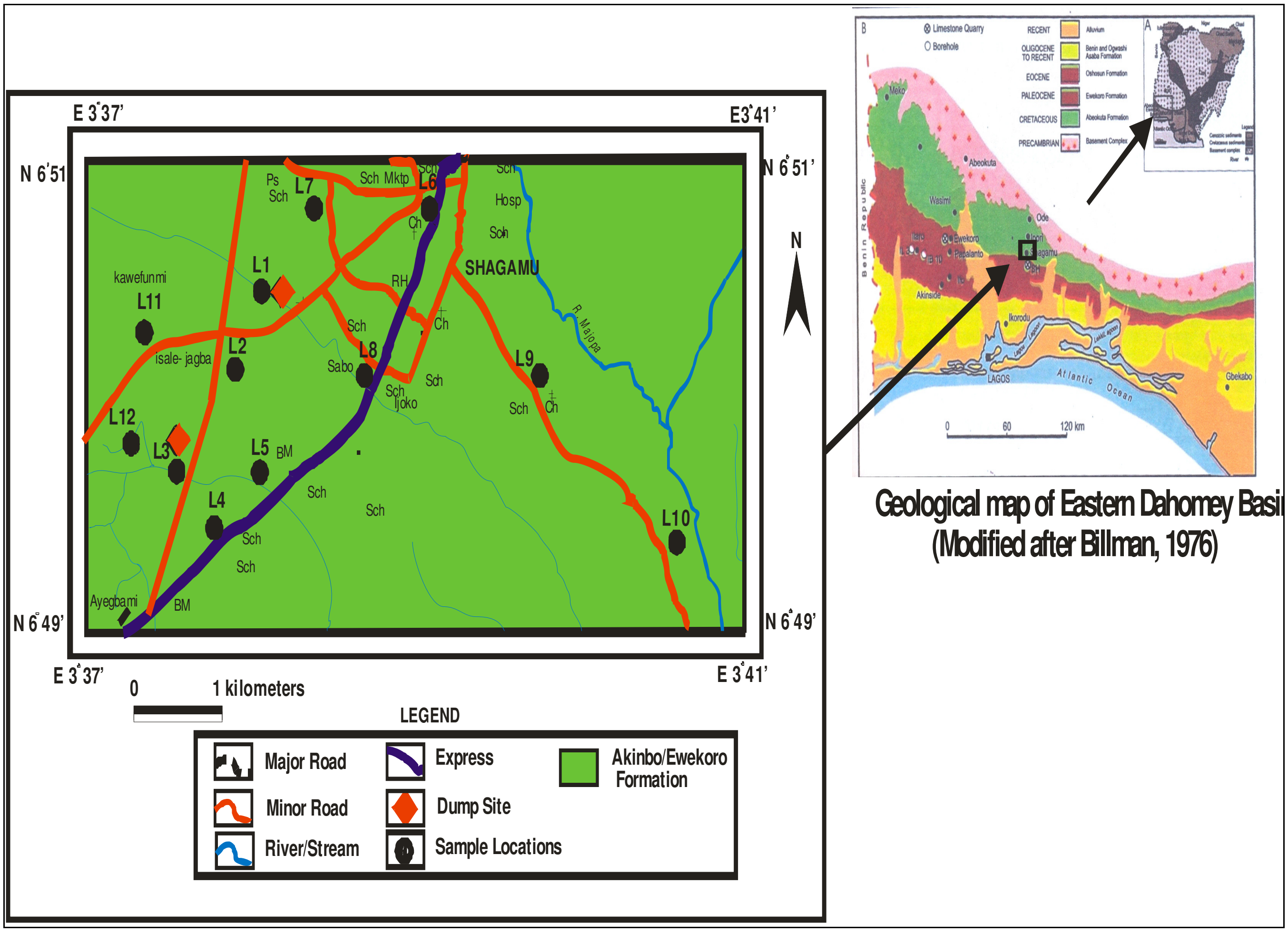

Figure 1: Geologic setting of the study area showing location points

2. Methodology

A total of twelve (12) groundwater samples (7 hand-dug wells and 5 boreholes) were analyzed for their major ionic components alongside their physio-chemical parameters. Groundwater samples were collected in clean plastic containers. After de-ionising the containers, two drops of nitric acid were added into the sample to preserve the cations. GPS readings were recorded for each sample point. Samples that were to be used for anion analysis were stored in the refrigerator at 4°C.Analysis of the samples was carried out using Inductive CouplePlasma- Mass Spectrometry and Inductive Couple Plasma-Atomic Emission Spectrometryfor cations atAcme laboratories, Canada. HCO_3 was estimated by titrimetric method, Sulphate (SO_4^{2-}) was determined by turbidimetric method; phenoldisulphonic method was used in the determination of nitrate (NO_3^-) while chloride (Cl^-) was determined using ion chromatography. All these were analyzed at the University of Ibadan, Nigeria. Physical parameters such as pH, total dissolved solids, electrical conductivity and temperature were measured in-situ in the field with appropriate standard meters such as pH meter, TDS meter and portable thermometer.

Simple summary statistics including mean, standard deviation, minimum and maximum values of hydrochemical data were also used to interpret the data. The concentration and variation of the contaminants were also mapped using surfer8 software. Trilinear diagram and water flow net were analysed using the Rockwork software to show the distribution and flow direction of these contaminants.

3. Results

Sample Location	Description	Water Source	pH	Conductivity (ms/cm)	Temperature (^{0}C)	Salinity (%)	TDS (mg/l)	SAR	Colour
L1(lchA)	Isale-Jagba	Well	5.6	725	27.2	0.01	0114	8.99	Clear
L2	Ladesuwa	Well	6.1	523	25.2	0.00	0013	2.4	Clear
L3(lchB)	Abattoir	Well	6.2	956	27.0	0.03	0251	12.4	Clear
L4	Lafarge-Wapco Road	Borehole	8.62	576	25.7	0.2	0204	0.6	Not clear
L5	Owoyemi	Well	5.1	445	27.2	0.02	0198	40.8	Clear
L6	Isale –Oko	Well	5.2	132	26.4	0.01	0120	8.7	Clear
L7	Ijoku	Borehole	5.55	205	28.2	0.02	0206	18.9	Clear
L8	Sabo	Well	5.61	423	28.7	0.02	0171	11.2	Clear
L9	Shagamu LocalGov. Area	Borehole	5.62	183	27.3	0.00	0000	3.5	Clear
L10	Market	Well	5.6	273	27.6	0.00	0008	4.3	Clear
L11	Kawefunmi	Borehole	5.75	183	27.6	0.00	0000	2.2	Clear
L12	Ayegbami	Borehole	5.8	423	28.6	0.00	0015	4.8	Clear

Table 1: Physicochemical characteristics of leachate and groundwater samples

TDS = Total Dissolved Solids, mg/l,
SAR = Sodium Absorption Ratio
EC = Electrical Conductivity,(ms/cm)
lch A = Leachate A lch B = LeachateB

Element	Mean (mg/l)	W.H.O 2006	U.S.E.P.A 1986	S.O.N 2001
pH	**5.89**	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5
Alkalinity	27.5	N/A	N/A	N/A
TDS	108.33	< 1000	N/A	500
Conductivity	370.58	< 2000	650	1000
Ca^{2+}	17.64	< 50	200	N/A
Mg^{2+}	2.482	<50	50	0.2
Na^{+}	27.15	< 200	175	200
K^{+}	4.693	< 5	12	N/A
Fe^{2+}	0.045	<0.30	0.3	0.3
HCO_3^-	93.33	< 250	#	N/A
Cl^-	83.33	<5	600	N/A
SO_4^{2-}	15.42	<250	250	100
NO_3^-	26.44	<50	25	50
Ba	0.1062	0.700	2.0	0.70
Fe	0.0458	N/A	0.3	N/A
Mn	**0.468**	0.40	0.050	0.20
Pb	0.00365	0.01	0.015	0.01
Zn	0.042	N/A	5	3

Table 2: Comparing Parameters with Standards (WHO 2006, EPA 1986 and SON 2001)

TDS = Total Dissolved Solids, (mg/l)
WHO - World Health Organization
SON – Standard Organisation of Nigeria
EC = Electrical Conductivity, (ms/cm)
USEPA – United States Environmental Protection Authority

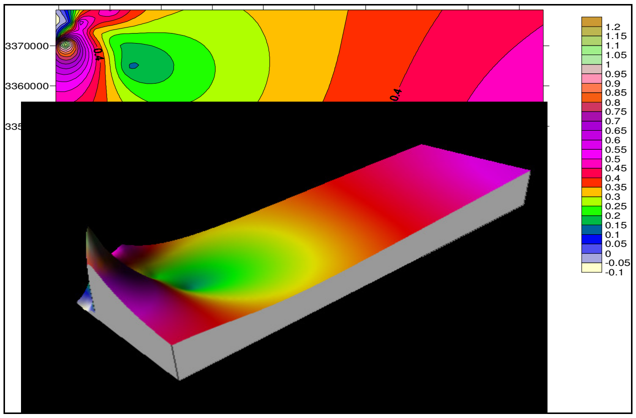

Figure 2a: 2D and 3D representation of the geochemical map of the Mn in the area

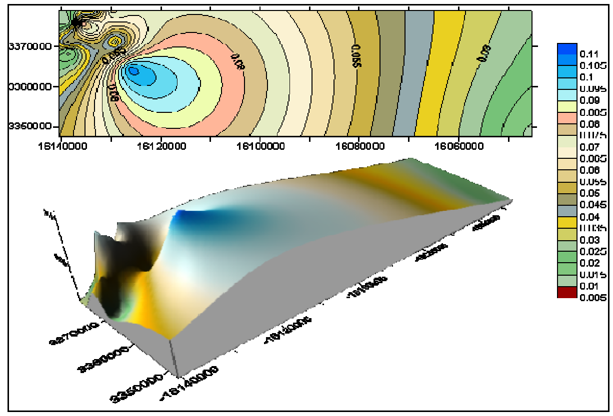

Figure 2b:2D and 3D representation of the geochemical map of the Fe in the area

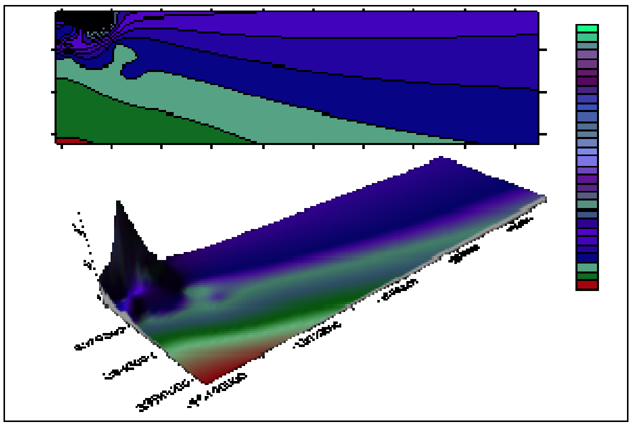

Figure 2c: 2D and 3D representation of the geochemicalmap of the Ba in the area

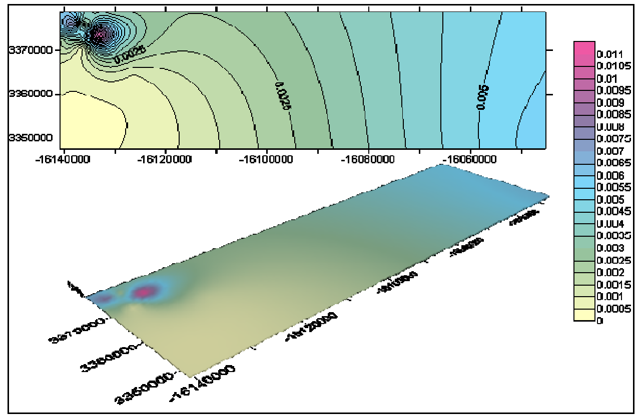

Figure 2d: 2D and 3D representation of the geochemical map of the Pb in the area.

Figure 2: Geochemical maps of some heavy metals in the study area

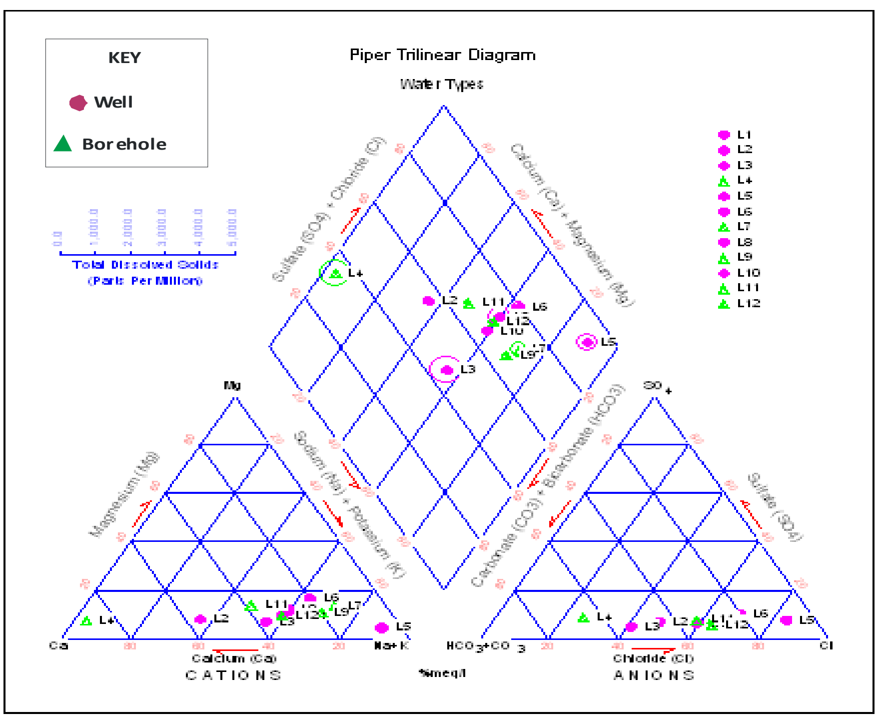

Figure 3: Piper – Trilinear diagram of the study area

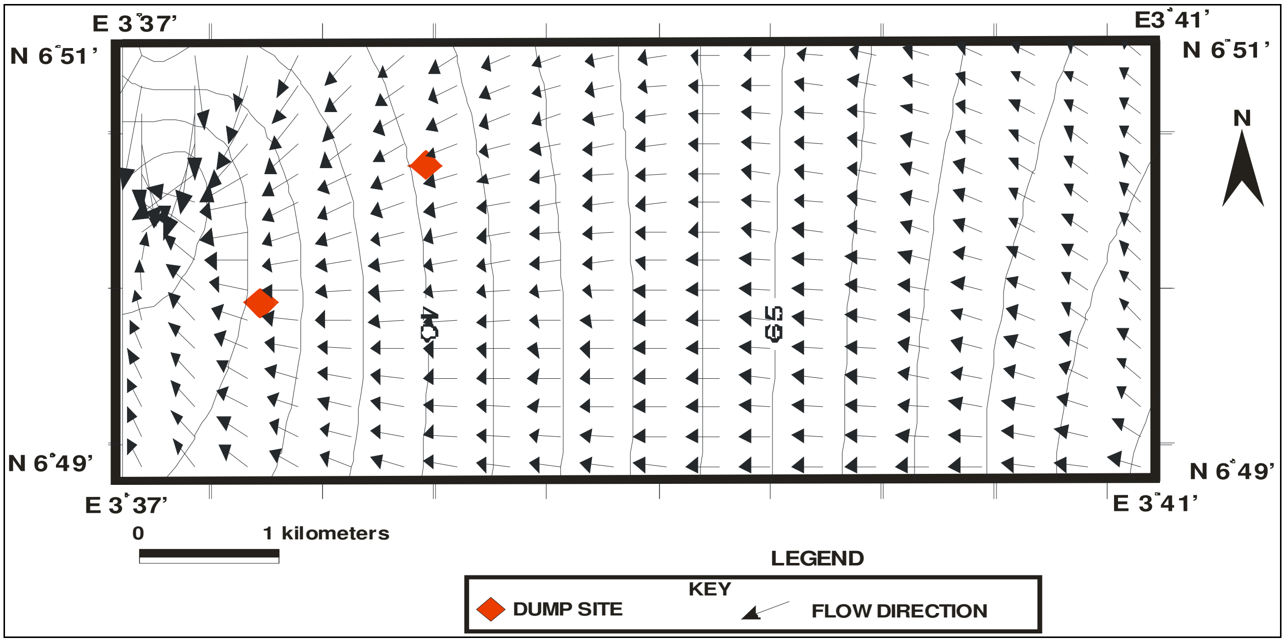

Figure 4: Groundwater flow net of the study area

4. Discussions

4.1. Physico-Chemical Characteristics of Leachate and Ground water

The measured field physico-chemical parameters are presented in Table 1. The summary of the hydrochemical data as compared with various standards are presented in Table 2. The analyses show that pH ranges from 5.1 to 8.62; temperature varies between 25.2 to 28.7 ^{0}C, while electrical conductivity (Ec) values (123 to 956ms/cm) recorded at the study area were found to be high around the dumpsite (Table 1). These high conductivity values obtained for groundwater near the landfill is an indication of the effect of leachate on the water quality. The high concentration of Mn was due to influx of manganese from the leachate of the landfills into groundwater. The moderately high values of chloride (105mg/l) and nitrate (36.44mg/l) near the landfill shows a high degree of pollution and are considered as tracers for groundwater contamination.

4.2. Geochemical Maps

The 2D and 3D geochemical maps (figure 2) show a high concentration of Manganese, Iron, Barium and Lead in the area close to the landfill and this is due to the high concentration of leachate infiltration in the groundwater in those areas. The high concentrations of these toxic elements are associated with the different materials that are contained in the landfills such as automobile parts, human waste, decayed animals, contraband drugs and other wastes. Water samples collected in these areas have been found to be anomalously high in Manganese and Lead which can affect human lives in the area.

4.3. Piper Trilinear Diagram

Piper (1944) trilinear diagram (Fig 3), based on Furtak and Langguth (1967) classification, showed that about 67% of the water falls within the normal alkaline chloride water field, while 17% of the water is of alkaline carbonate water type with high alkaline proportion, 8% was of calcium carbonate chloride water type, and 8% falls in the calcium carbonate water field (Figure 3). Based on Piper 1944 classification, the water samples analysed in the study area showed a similar trend that can be deduced to contain a high degree of hardness and this can be explained from the diamond symbol in figure 3 which shows a slightly high concentration of alkaline carbonates typical of a limestone environment.

4.4. Ground Water Flow Net

Ground water flow net revealed water from wells situated close to the landfill are more contaminated than those farther away due to the topographical influence. With increase in time and space the viscous fluid penetrates deeper and spreads all over a longer distance (figure 4). Toxic elements tend to accumulate from the north-western region while the concentration of this pollutants decrease as we move eastward from the dumpsite. Flow net showed that the dominant fluid direction is moving westward, which is where we have high concentration of pollutants (Figure 4).

The overall trends of the data and other analysis showed that the presence of these toxic elements in the area is due to the high human activities in the study area, most of which were caused as a result of anthropogenic influence on the environment. The leachate composes of decayed toxic materials which have undergone strong bacterial activity over a long period of time leading up to its high interaction with the ground water. The topographical regime from the geochemical maps also showed that the fluids are constantly moving in the direction of this leachate.

5. Conclusion

Based on this study, it could be ascertained that leachate had significant impact on the groundwater quality, because of the importance of groundwater as a source of drinking water to many communities and individuals, the most reasonable way to guarantee a clean water supply is to minimize pollution. Government should enforce strict sanitary rules and also educate the people on the need for a proper refuse disposal. Proper safety measures should be taken by individuals by not situating their well along the flow path of potential pollution sources such as dumpsite, septic tanks and abattoir.

Figure 5: The Abattoir landfill the (Isale-jagba) landfill (Photo by Author and research team during field investigation, 22/07/2015.)

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