IMPACT OF LEACHATES ON THE QUALITY OF GROUNDWATER IN SHAGAMU SOUTHWESTERN, NIGERIA IN GROUNDWATER – SOME URBAN CITIES OF SOUTHWESTERN, NIGERIA

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ABSTRACT

The overwhelming environmental significance of solid waste has attracted a lot of attention because of its leaching into groundwater through waste deposit. The study determines impact of leachate from a landfill site on the quality of groundwater sources in Shagamu, Southwestern, Nigeria. Twelve groundwater samples, (hand dug wells (7) and boreholes (5)) were analyzed for their major ionic components. Groundwater qualities for cation were determined at Acme Laboratories, Canada and anion was determined at the University of Ibadan, Nigeria. Mean concentration of pH (5.89) was found to be outside the WHO 2004 and USEPA 2001 permissible limits, and was due to the effect of leachate on the groundwater. Total dissolved solid, Electrical conductivity and Alkalinity were found to be within the permissible limits. Mean concentration of cations and anions for all the samples were also found to be within the permissible limits with the exception of Mn (0.50 mg/L), Cl^- (83.33 mg/L), and NO_3^- (26.44 mg/L) respectively which could be as a result of abattoir found around the dumpsite. Leachate has had significant impact on groundwater quality. Groundwater quality improves with increase in depth and distance of the well and boreholes from the pollution source (landfill). The present study demands for proper management of waste and suggests some remedial measures to reduce future groundwater contamination via leachate percolation,

Keywords: Water quality, Ground water, Contamination, Leachate, Landfill.

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INTRODUCTION

A landfill a managed facilities for the disposal of solid waste is a carefully designed structure built into or on top of the ground, in which trash is separated from the area around it (ADS 2017). Landfills are located, designed, operated and monitored to ensure compliance with federal regulations, and are also designed to protect the environment from contaminants, which may be present in the waste stream. Landfills should not be built in environmentally-sensitive areas, and they are placed using on-site environmental monitoring systems (EPA 2016), but due to population increase and indiscriminate dumping of refuse in the environment landfills have been identified as one of the major threats to groundwater resources (Fatta *et al.,* 1999; US EPA, 1984). Waste placed in landfills or open dumps are subjected to either groundwater underflow or infiltration from precipitation caused by rain. The dumped solid wastes gradually release its initial interstitial water and some of its decomposition by-products get into water moving through the waste deposit, such liquid containing innumerable organic and inorganic compound is called 'leachate.' Leachate is one of the most common types of liquid that can seep into our water supply and contaminate it. Leachate is a liquid that drains or 'leaches' from a landfill. The moisture can come from rain, snow melts or from the waste itself. It varies widely in composition depending on the age of the landfill and the type of waste that it contains. It usually contains both dissolved and suspended materials. Leachate varies widely in composition regarding the age of the landfill and the type of waste that it contains. It usually contains both dissolved and suspended material it accumulates at the bottom of the landfill and percolates through the soil(TLE 2017; IDR 2015).When waste is placed in landfills, over time the waste decomposes and sweats. This liquid, leachate, is hazardous and must be collected for disposal (IDR, 2015), The leachate from Municipal Solid waste landfills is a highly concentrated "chemical soup", so concentrated that small amounts of leachate can pollute large amounts of groundwater, leaving it unsuitable for domestic water use, unfortunately, this hazardous liquid are left uncollected and they become environmental menace through concentration and toxicity of contaminants, permeability and type of the geologic strata and the direction of groundwater flow. Water flows through an improper disposed waste and percolates contaminating the groundwater by promoting and assisting the process of decomposition through bacteria and fungi, which is an important source of drinking water for many rural areas and small communities (Naveen *et al.,* 2016). The process thus release toxic metals into the groundwater thereby polluting the water, such metals are: lead that causes anorexia, abdominal pain, constipation, chronic nephropathy, hypertension; Mercury which causes tremors, memory loss, seizures, coma, irritability, acute kidney failure, decrease in platelets, anaemia that follows gastrointestinal bleed; Cadmium compounds that leads to anaemia, kidney damage, possible prostate and lung problems; Phenols and cresols that causes renal failure and Benzene that causes blood-related disorders(Raihan and Alam 2008).Thus, residents living close to the landfills run the risk of contracting several health problems which could be from an acute/short exposure, or long term chronic exposure to leachates from landfills, such health problems include profuse sweating, bleeding stomach disorders, to blood disorders, birth defects, even cancer, medical literature tells us. (Kannan 2016, IDR, 2015). The impact of leachate on groundwater has attracted a lot of attention because of its overwhelming environmental significance (Tijani 1994).

The total assessment of the landfill waste of Isale-Jagba and the Abattoir in Shagamu, south western Nigeria, revealed that about 80% of the total waste is organic in nature, followed by plastic/nylon 15.72% and 1% metal (Akinbile and Yusoff 2011). Increasing waste generation and disposal would result in increase groundwater pollution. The extent of contamination of groundwater quality due to leachate percolation depends upon a number of factors like leachate composition, rainfall, depth and distance of the well from the pollution source. The extent at which water hand dug wells and boreholes in the area have been contaminated by the landfill site is unknown and hence needed to be determined.

BACKGROUND

Shagamu, a densely populated and industrialized city (Fig 1.0) with an extent of about 27.4 square kilometers is located within Dahomey Basin, and has a dendritic drainage typical of sedimentary environment with uniform resistance and fairly homogenous geology composed predominantly of a shale clayey sequence of the Akinbo Formation underlain by limestone of the Ewekoro formation. The area has a tropical climate and average rainfall of about 230 mm while temperature ranges from 29 °C during dry season to about 33°C in rainy season Relative humidity lies between 65% and 75%, while the vegetation is greatly influenced by climate.

Fig 1.0: Geologic setting of the study area showing locationpoints

MATERIALS AND METHOD

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. Samples were placed in clean plastic containers after de-ionising the containers, two drops of nitric acid were added into the sample for cation analysis, while samples that were to be used for anion analysis were stored in the refrigerator at 4^0 C. Physical parameters (pH, Total dissolved solids, Electrical conductivity, Temperature) were measured in-situ on the field with appropriate standard meters.

Geochemical analysis of the samples was carried out using inductive couple plasma- mass spectrometry and inductive couple plasma-atomic emission spectrometry for cations and trace elements at Acme laboratories, Canada; HCO_3wasdeterminedby titrimetric method, Sulphate (SO_4^{2-})was determined by turbidimetric method, phenol disulphonic method was used in the determination of nitrate(NO_3^-) while chloride (Cl^-) was determined using ion chromatography at the University of Ibadan, Nigeria.

RESULTS AND DISCUSSION

Physio-Chemical Characteristics of Leachate and Ground water

Mean values of the Electrical conductivity (370.58), temperature and Total Dissolved Solid (108.33) were found to be within the WHO (2010) USEPA (2009) and SON (2007) permissible limits with the exception of pH (5.89)with (Table 1). High pH was found in wells that are close to the dumpsite. High pH was observed in the dumpsite because of the decomposition process that takes place within the site, and the process led to increase in the temperature and complete decrease in the pH immediately.

The mean concentrations of the metals Pb (0.s0365), Zn (0.042), Mn (2.482), Fe (0.0458), K (4.693), Na (27.15) were all found to be within the WHO (2010) USEPA (2009) and SON (2007) permissible limit while the mean value and range of the anions Cl^- (83.33& 50-180), NO_3^-(26.44 & 6.98 – 22.14), revealed anthropogenic impact which could become a problem if not controlled. Cl^- showed the impact of sewage effluent on the landfill which is present in water in the form of sodium chloride and gives such water a salty detectable taste. Nitrate (NO_3^-) the most highly oxidized form of nitrogen compounds, is commonly present in surface and groundwater because it is the end product of the aerobic decomposition of organic nitrogenous matter. Unpolluted natural waters usually contain only minute quantities of nitrate. The mean value and range of HCO_3^- (93.33 & 50-270) showed that the metal is above WHO (2010) permissible limit which is also an anthropogenic impact. Geochemical maps (Figure 2) of heavy metals revealed a higher concentration of elements near the dumpsite while concentration decreases as distance increases away from the dumpsites.

Statistical Parameter

Inter-Elemental

Inter-elemental analysis (Table 2) of metals revealed a strong and positive correlation for Pb-Cu, Zn-Cu, Cd-Ba with 'r' values of 0.72, 0.58 and 0.69respectively which indicates the metals to be governed by the same geochemical factors and are from the same anthropogenic source. A strong and negative correlation was observed between Cu-Ba ('r'= - 0.69) and Zn-Mn ('r'= -0.59)this indicates that the metals are from different geochemical source. Therefore, Ba and Mn come from the weathering of rocks (geogenic) while Cu, Pb and Zn are positively related and are introduced from leachates.

Piper Trilinear Diagram

The result of Piper Trilinear diagramis presented in (Fig 3)(Furtak and Langguth (1967) 67% of the water can be classified as normal alkaline chloride water, 8% as alkaline carbonate water type with high alkaline proportion, 8% as calcium carbonate chloride water type and 8% falls in the calcium carbonate water field.

Ground Water Flow

Ground water flow as shown in (Figure 4) revealed that water from wells situated close to the landfill are more liable to be contaminated than those farther away due to the gravitational movement of the viscous fluid, With increasing time the viscous fluid penetrates deeper and spread all over a longer distance. Elements tend to accumulate from the north-western while concentration decreases, moving eastward from the dumpsite. Flow net revealed the flow of ground waters from beneath the dump site to be in the north-western and western directions.

Table 1: *Physio-chemical characteristics of Leachate and groundwater (mg/l)*

Element	Mean	Range	W.H.O 2010	E.P.A 2009	S.O.N 2007
pH	5.89	5.1 – 8.62	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5
Alkalinity	27.5	0 – 140	-	-	-
TDS	108.33	0-206	500	500	500
Conductivity	370.58	109-956	1400	1400	1000
Pb	0.00365	0.0004- 0.0119	0.01	0.015	0.01
Zn	0.042	0.0123- 0.082	3	5	3
Fe	0.0458	0.010- 0.109	0.5-50	0.3	0.3
Ca	17.64	0.68-108.71	200	75	75
Cd	0.0002	0.00009-0.0005	0.003	0.005	-
Cu	0.0131	0.0008- 0.0406	2.0	1.300	1.0
As	0.0005	0.0001-0.0005	0.01	0.05	0.01
Mn^+	2.482	0.22-5.59	50	50	0.2
Na^+	27.15	2.34- 69.90	200	200	200
K^+	4.693	0.51-15.21	13.48	12	
HCO_3^-	93.33	50- 270	250	-	-
Cl^-	83.33	50 -180	250	600	250
SO_4^{2-}	15.42	6.98 – 22.14	250	250	100
NO_3^-	26.44	16.11 – 44.2	50	25	50

TDS = Total Dissolved Solids, mg/l, EC = Electrical Conductivity (µs/cm)
J Ģî - World Health Organization, USEPA – United States Environmental Protection Authority

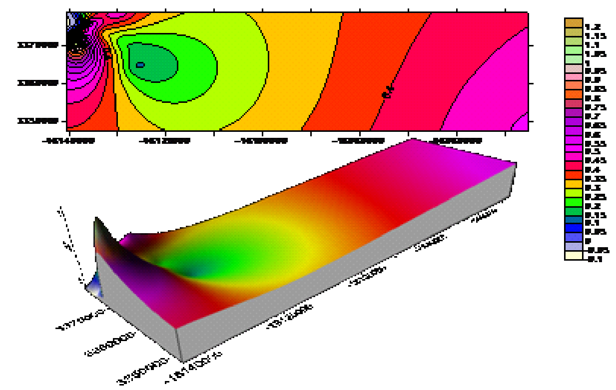


Fig 2a: 2D and 3D representation of the geochemical map of the Mn in the area.

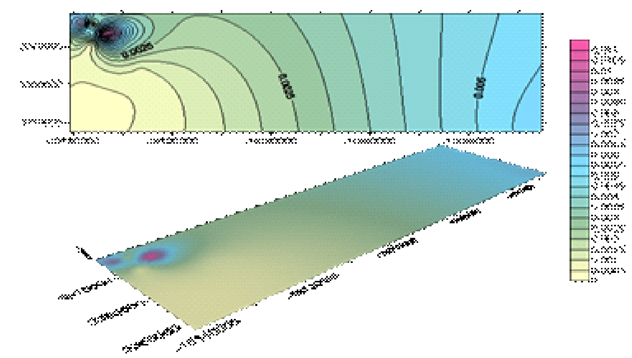


Fig. 2b: 2D and 3D representation of the geochemical map of the Fe in the area.

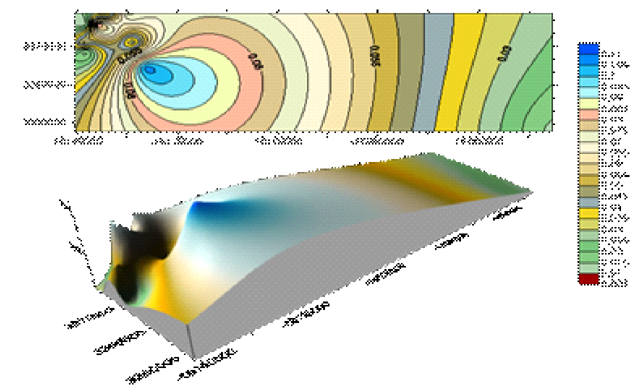


Fig 2c: 2D and 3D representation of the geochemical map of the Pb in the area

Fig 2: Geochemical maps of some heavy metals In the study area

Table 2: Correlation of Heavy Metals

	Ba	Cd	Cu	Fe	Mn	Pb	Zn
Ba	1						
Cd	0.69	1					
Cu	-0.78	-0.06	1				
Fe	0.49	0.44	-0.22	1			
Mn	0.43	0.03	-0.37	0.23	1		
Pb	0.14	0.289	0.72	0.07	-0.33	1	
Zn	-0.23	-0.09	0.58	-0.44	-0.59	0.47	1

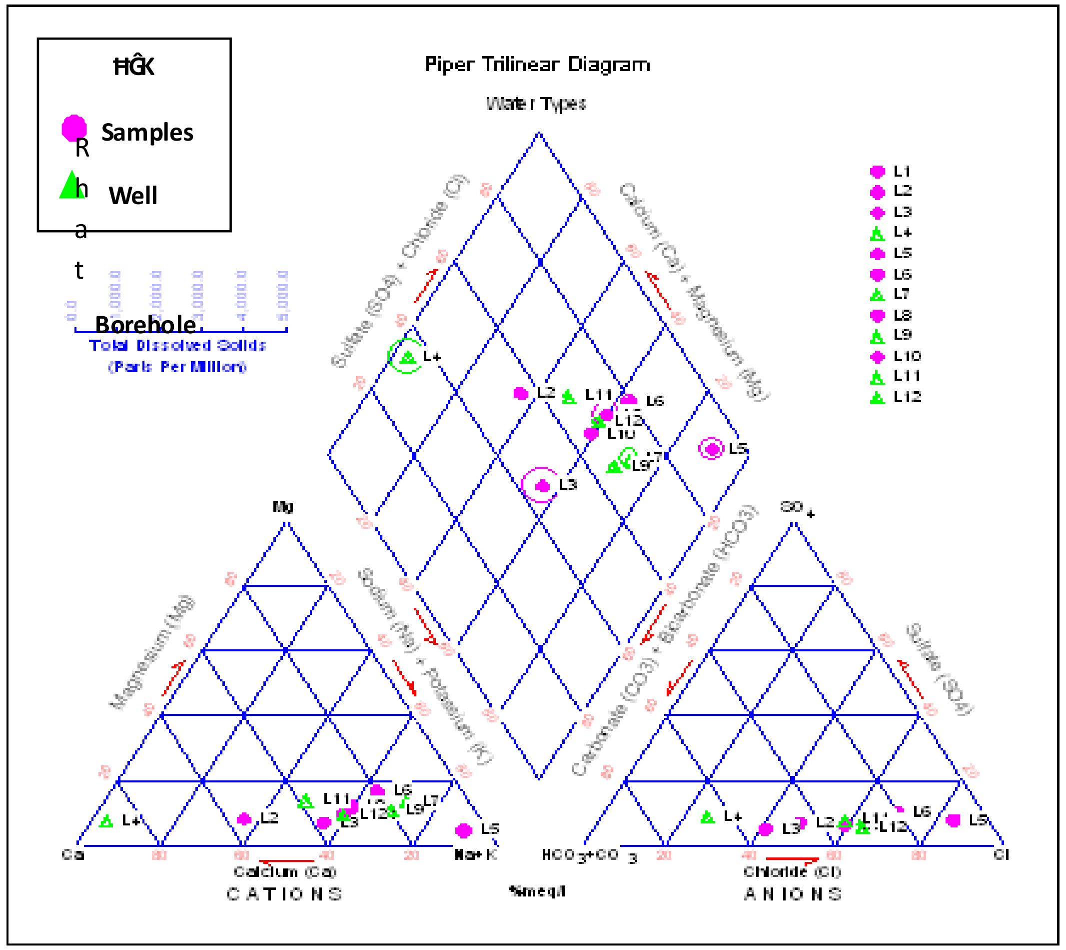


Fig 3:Piper – Trilinear diagram of the study area

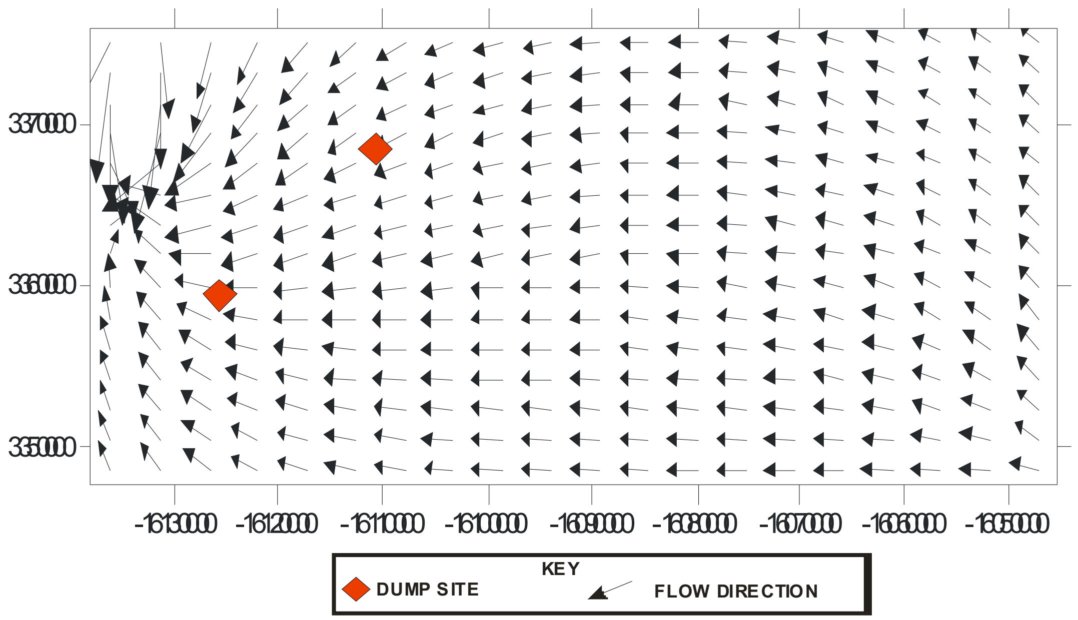
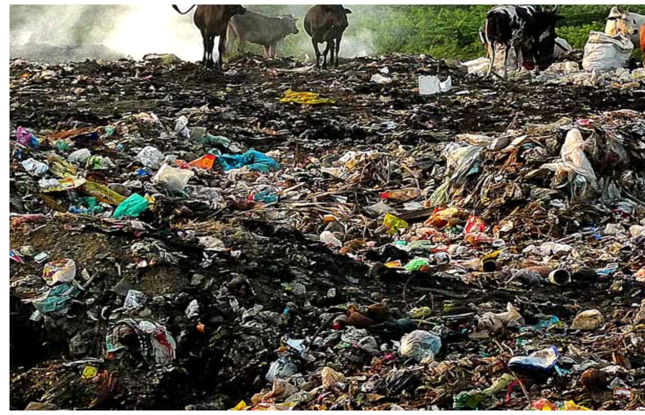


Fig 4: Ground water flow of the study area

CONCLUSION

Leachate had significant impact on the groundwater quality; it was also revealed that groundwater quality improves as the distance to dumpsite landfill increases. A proper management of waste such as provision of impermeable clay covers to limit the infiltration of water through the landfill, thus, reducing the amount of leachate reaching the landfill base; recycling of the extracted leachate collected at the base to reduce its influx into the aquifer should be put in place.



The landfill

The abattoir landfill

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