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Spatial Variations in Groundwater Quality Around Dumpsite in Igando

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Abstract: Water samples collected from fifteen hand dug wells in November (dry season), 2011 and July (Wet season), 2012 using random sampling technique. In situ parameters were measured for pH, electrical conductivity, total dissolved solids using portable meters. Heavy metals were analyzed for; Fe, Cu, Zn, Cd, Pb, and Cr using Atomic Absorption Spectrophotometer (AAS). The study aimed at examining the spatial variations in groundwater quality around dumpsite in Igando using paired sample T-test statistical technique. The result shows that the measured pH values were below the minimum WHO standard for drinking water quality in wet and dry seasons in about73.3% and 26.7% respectively. Also, approximately, 13.3% of EC, and 6.7% exceeded the prescribed standard limit of WHO in dry and wet seasons respectively. Concentration of Fe exceeded drinking water quality in all the sampling locations during wet season and only about 46.7% in dry season. Pb, Zn, and Cu exceeded WHO limit in about 86.7%, 80%, and 26.7% respectively in dry season. Concentration of Pb, Cd , Cu and Cr were under detection limit in all the locations except at locations G_2 for Cu in wet season. The paired samples statistics and correlation revealed that the mean values of all the parameters were higher in dry season with the exception of Fe. No significant correlations exist among the parameter for both seasons at $p<0.05$. The paired T-test show significant seasonal variations among four heavy metals including Fe, Cd, Pb and Zn.The study concluded that, samples in dry season are of low quality compared to wet. The study recommends public enlightenment on solid waste disposal, controlled anthropogenic activities, and treatment /recycling of waste to prevent heavy metal from leaching unto the sub-surface.

Keywords: Dumpsite, Heavy metal, Igando, Leachates, Groundwater, Seasonal variation, Solid waste, Water quality

Introduction

The ever-growing demands for water resources coupled with the rate at which the earth's fresh waters are being adversely degraded by human activities poses great threat to water resources quality if not appropriately managed (Charkhabi and Sakizadeh, 2006). The degradation of water quality both surface and groundwater resources has become a worldwide concern, especially the developing nation such as Nigeria. Thus the availability of potable water plays a major role in the socioeconomic development of any nation (Christiane *et al.*, 2010).

The introduction of guidelines or regulatory standards in Nigeria is part of government's environmental pollution abatement policy strategy geared toward achieving a sustainable environmental development in the country. These guidelines relates to six areas of environmental pollution control including; effluent limitations, water quality for drinking, domestic and industrial uses at point of intake and industrial emission limitations among others (FEPA,1989).

Water quality is usually affected by various natural or anthropogenic sources. Once these sources are introduced into a water source, it undergo physical, chemical, and biological transport within or across the water media thus, resulting to adverse effects (i.e., water pollution or toxicity) (Nedeau *et al.* 2003; WHO, 2006; Charkhabi and Sakizadeh, 2006; MacCausland and McTammany, 2007). Sources of anthropogenic contamination include volatile organic chemicals (VOCs), heavy metals, fertilizer, insecticides, herbicides, pesticide and pathogens into a production well. These phenomenons constitute health and environmental problems to human health.

The analysis of land use types provides a tool for investigating groundwater contamination, prediction and prevention of future contamination of groundwater resources (Levin *et al.*, 2002; argued that, underground storage tanks, industrial effluents, agricultural runoff, leachates from dumpsites, seepage from septic tanks among others constitutes sources of groundwater contamination. Heavy metals (i.e., zinc, copper, chromium, nickel, cadmium, lead and mercury) contamination of groundwater sources can arise from industrial discharges, chemical and metallurgic factories or leachates from landfills (Keshiro, 2006). In developing countries, dumpsites/landfills serve as the primary medium of Municipal Solid Waste (MSW) disposal because of its low economical costs in comparison to other disposal methods such as incineration. However, leachates from dumpsite/landfill are characterized by heavy metals, chlorinated organic and inorganic salts and complex compounds that are difficult to deal with (Renou *et al.* 2008).

In Nigeria, groundwater quality is relatively good. However, increased industrial activities have brought about huge discharge and diverse pollutants reaching water bodies (NWSSP, 2004). NWSSP (2004) reported that about 20% of the country's groundwater resource is underlain by highly corrosive water, 40%

each by moderate and non-corrosive water respectively. Hence, concern for clean and safe drinking water quality is justified because a large proportion of rural and sub-urban dwellers in Nigeria obtain domestic water, and sometimes drinking water from ponds, streams and shallow wells (Sangodoyin, 1990).

Poor water quality results to incidences of water-borne diseases like diarrhea, cholera, typhoid, malaria, hepatitis and have been linked to about 80% of illnesses in developing countries (UNU, 1983) .Sangodoyin (1990) inferred that high incidence of deaths have been traced to the use of polluted waters while, about 25,000 deaths have been linked to water-related diseases on a daily basis. Yusuf and Sonibare (2004) argued that the situation has contributed to the present shorter life expectancy in Nigeria. Recent studies in Cambodia revealed that the country is confronted with high infant mortality rate, poor drinking water coverage and increased natural (arsenic, iron, and manganese) and anthropogenic (nitrate, nitrite, and fluoride) (WHO/UNICEF, 2005). Charkhabi and Sakizadeh (2006) reported agricultural activity and urban land use as the most contributing factors to the pollution of the Anzali River in Northern Iran.

Studies abound in literature on groundwater contamination. Such work includes (Bably and Bodis, 2008).They all concluded that there is need to monitor water quality on regular basis. This is because the increase in concentration of trace metals in potable water will increase the threat to man's health and life. Hossam (2010) examined the effect of landfills on contamination of groundwater resources in Mafraq landfill, Jordan. The study showed that, the landfill does not fulfill the required international conditions hence impose a major threaten to groundwater in the area. Concentration of nitrate, total coliform count and E-coli were found to be high in the groundwater samples. Raj and Azeez (2009) examined the spatial variation in water chemistry of river Bharathapuzha, India. The study revealed that, water discharge, water quality and elemental load result from changes in land use, especially reduction in forest cover in the catchments and due to irrigation projects.

Akoteyon (2012) evaluated groundwater quality around dumpsite using contamination index in parts of Alimosho, Lagos-Nigeria The study revealed high contamination due to Cadmium, Lead and Copper .The study recommended proper maintenance ,treatment and compliance to the specification of dumpsite/landfill according to world standard. Akoteyon *et al.* (2011) investigated heavy metal contamination in groundwater around landfill in a sub-urban settlement of Alimosho, Local Government Area of Nigeria. The study revealed that about 90% of Pb and Zn exceeded the permissible limits of WHO standards for drinking water quality while Fe and Cu also exceeds the maximum permissible limits of WHO standards for drinking water quality in about 50% and 40% respectively. Also, the pattern of relative variation of the examined parameters was heterogeneous in nature. Groundwater quality assessment near a municipal landfill, Lagos, Nigeria.

Longe and Balogun (2009) assessed groundwater quality near a Municipal Landfill in Lagos, Nigeria. The study revealed that the mean concentrations of all measured parameters with the exception of NO_3, PO_4 and Cr conform to the stipulated World Health Organization and the Nigerian Standard drinking water quality. The study recommends an upgrade of the landfill to ensure adequate protection of both the surface and the groundwater resources in the area.

The study area

The study area is located approximately between latitude 6°31 0' N to 6°31 30'N and longitude 3°15 0'E to 3°15 30'E within Alimosho Local Government Area (LGA) of Lagos State, Nigeria. It occupies an area of about 25.1sq.km (Fig.1).It is bounded in the East by Ifako- Ijaiye, Agege and Ikeja LGAs of Lagos state.In the North by Ado-Odo/Ota LGA of Ogun state and in the South by Oshodi/Isolo, Amuwo-Odofin and Ojo LGAs of Lagos state and by Owo River in the West. The climate is characterized by dry and wet seasons between November and March and wet season between April and October respectively. Annual precipitation is about 2000mm and serves as the major source of groundwater recharge (Longe,2011). Temperatures ranged between 28-33°C.The soil is composed of red and sandy-clay (laterite). The relief patterns show that the land generally rises towards the northern section of the dump sites.

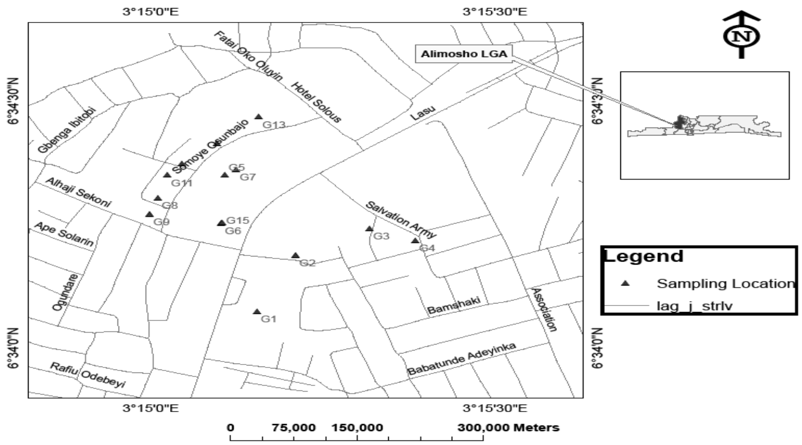

Fig. 1: The study area

The vegetation is composed of swamp forest and coastal plants. The sub-surface geology is characterized by semi-permeable to impermeable materials. The basal sand layers constitute the confined aquifer. The first aquifer horizon is underlain by clayey sand of intermediate thickness. The hydrology is dominated by River Owo and its tributaries (River Abesan, River Oponu and River Illo).They drain into the Ologe Lagoon. The population is about 1,277,714 people with a density of about 6,899 people per km^2(Odumosu,1999).The sources of water supply in the area include pipe borne water through the Lagos Water Corporation (LWC), boreholes and hand dug wells by private individual. Due to erratic power supply and the unwillingness of the people to pay and because the people believed water supply should be free of charge. Hence majority of the inhabitants has resorted to digging boreholes/hand dug wells as sources of water supply for drinking and other domestic uses.

Major land uses in the area includes, residential, industrial, commercial, agricultural and landfill. As a result of increasing rise in population and high rate of waste generation in the state, the Lagos Waste Management Authority (LAWMA) constructed 3 landfills between 1996 and 2009. The dump sites were designed with the capacity of about 469,202.50 tonnes of waste from the entire state with lifespan of about 5-6 years (Longe *et al.*2010). Currently, the dump site has undergone rehabilitation and the level of maintenance has improved considerably compared with past years. Though the location of the dumpsites at Igando is geared towards effective waste management in the state, its activities has greatly impacted on the groundwater quality of the area. Most of the wells formerly used for drinking and other uses are no longer useable due to infiltration from the dumpsites into the wells. This situation poses great threat to the health of majority of the people who depend on groundwater for their daily water supply needs.

Materials and methods

Fifteen samples from hand dug well were collected during November, 2011 (dry season) and July, 2012 (wet season) using random sampling technique around dumpsites in Igando. Samples were stored in clean 150mL polyethylene bottles and preserved in ice chests for onward delivery to chemistry department, University of Lagos, Akoka for analyses using standard methods (APHA, 1998). In-situ parameters were measured for pH, electrical conductivity (EC), and total dissolved solids (TDS) using portable hand held TM digital meter. Heavy metals, iron,copper,cadmium, lead,zinc and chromium were analyzed using Atomic Absorption Spectrophotometer (AAS) and the concentration of each metal read directly at their specific wave length. Co-ordinates of the sampling locations were recorded using Global Positioning System (GPS) and were plotted using ArcMap 9.3 software to generate map of the sampling locations (Fig.1).

Results and Discussion

Seasonal variations of groundwater parameters across sampling locations

The seasonal variation of the measured pH versus WHO (2006) minimum standard (6.5) for drinking water quality across the sampling locations is presented in Fig.2. About 73.3% and 26.7% of the measured pH values were below the minimum requirement in wet and dry seasons respectively. The measured EC and TDS exceeded the prescribed standard limits of (1,000$uScm^{-1}$; 500mg/L^{-1}) set by WHO(2006) in about 13.3% and 6.7% each in dry and wet seasons respectively (Figs.3 and 4).

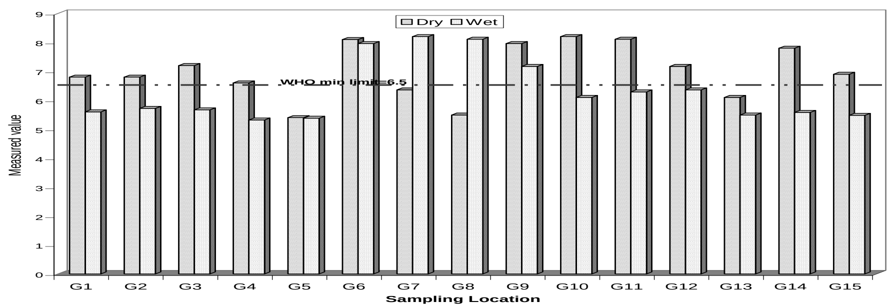

Fig.2: Seasonal variations in measured pH vs. WHO standard

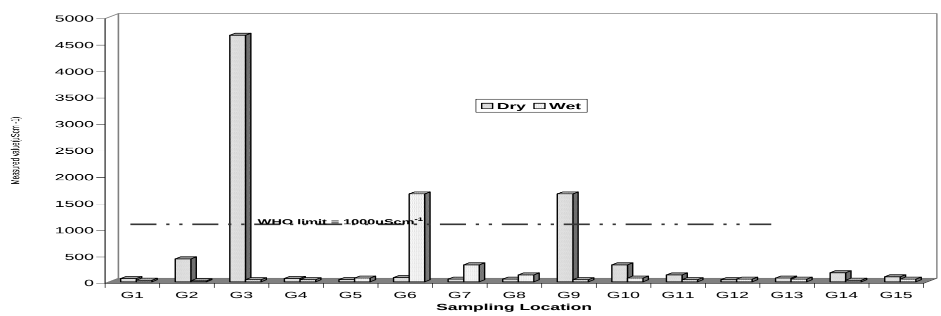

Fig.3: Seasonal variations in measured EC vs. WHO standard

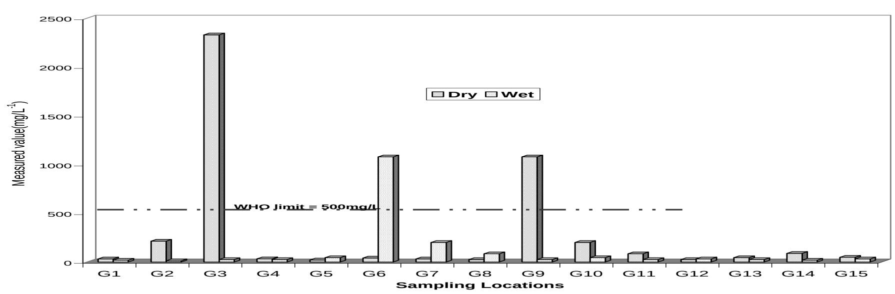

Fig.4: Seasonal variations in measured TDS vs. WHO standard

Results of the seasonal variations in the concentration of Fe versus WHO(2006) standard for drinking water quality across the sampling locations revealed that, Fe exceeded the standard limit (0.3) for drinking water quality in all the locations for wet season and about 46.7% in dry season (Fig.5). Cu exceeded the WHO(2006) standard limit (2.0) only in dry season in about 26.7% (Fig.6). The concentrations of Pb and Zn exceed the WHO(2006) standard limits of (0.01, 5.0) only for dry season in about 86.7% and 80% respectively (Figs.7 and 8). Unlike Cd and Cr all the sampling points were within the WHO standard limits of (0.003, 0.05) in dry season whereas, in wet season, Cd and Cr were not detected in the study area.

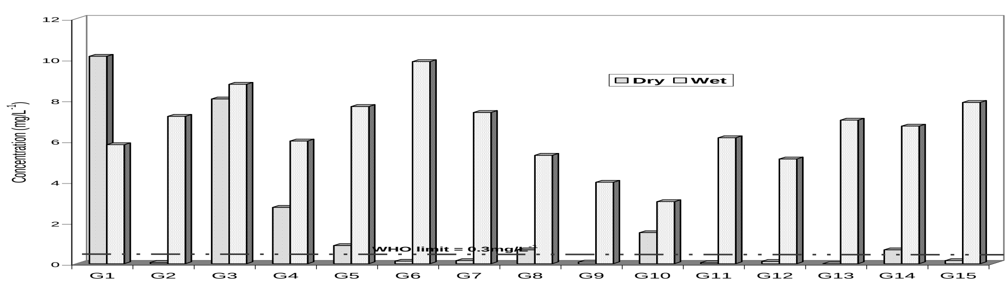

Fig.5: Seasonal variations in Fe vs. WHO standard

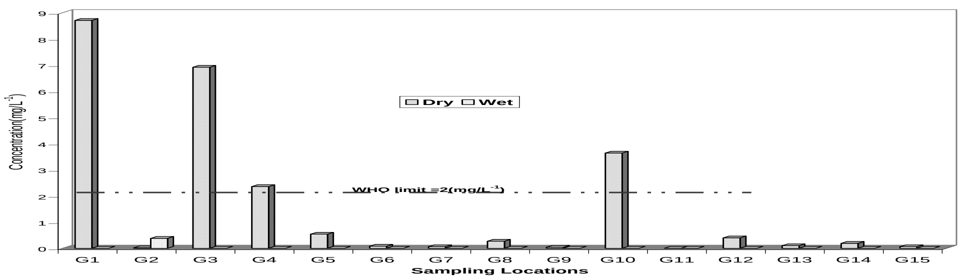

Fig.6: Seasonal variations in Cu vs. WHO standard

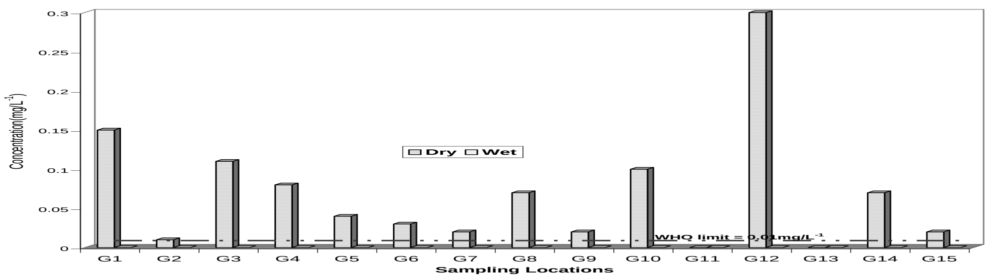

Fig.7: Seasonal variations in Pb vs. WHO standard

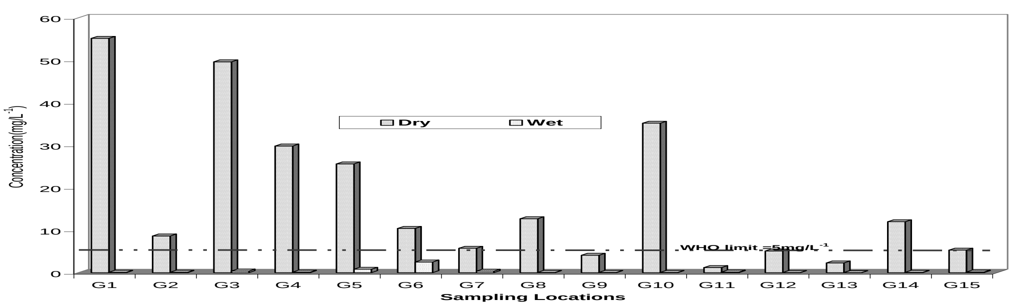

Fig.8: Seasonal variations in Zn vs. WHO standard

Seasonal variations of groundwater parameters

The paired samples statistics and correlation of the examined parameters is presented in (Table 1).The result show that the mean and SD of pH, EC, TDS, Fe, Cu, Cd, Pb, Zn, and Cr for dry and wet seasons are in the order of (6.99,6.295 ± 0.919,1.046;528.467,176 ± 1,214.1,417.147; 287,113.533 ± 625.084,271.135; 1.699,6.545 ± 3.126,1.778; 1.559,0.025 ± 2.761,0.098; 0.072,0.000 ± 0.072,0.000; 0.068,0.000 ± 0.078,0.000; 17.530,0.331 ± 17.491,0.637; 0.004,0.000 ± 0.009,0.000 respectively. With the exception of Fe, the mean values of all the parameters were higher in dry season compared to wet season in the study area (Table 1).The degree of relationship between these parameters shows that there are no significant correlations between the examined parameters for both dry and wet seasons (Table 1).

Table 1: Seasonal Paired Samples Statistics of groundwater parameters

Parameters		Mean	N	SD	Std. Error Mean	Correlation (r)	Sig.
Pair 1	pH	6.999	15	0.919	0.237	0.052	0.854
	pH*	6.295	15	1.046	0.270		
Pair 2	EC	528.467	15	1214.101	313.479	-0.131	0.643
	EC*	176.000	15	417.147	107.707		
Pair 3	TDS	287.000	15	625.084	161.396	-0.0137	0.626
	TDS*	113.533	15	271.135	70.007		
Pair 4	Fe	1.699	15	3.126	0.807	0.061	0.828
	Fe*	6.545	15	1.777	0.459		
Pair 5	Cu	1.559	15	2.761	0.713	-0.154	0.583
	Cu*	0.025	15	0.098	0.025		
Pair 6	Cd	0.072	15	0.072	0.019	-	-
	Cd*	0.000	15	0.000	0.000		
Pair 7	Pb	0.068	15	0.0780	0.020	-	-
	Pb*	0.000	15	0.000	0.000		
Pair 8	Zn	17.530	15	17.491	4.516	-0.027	0.925
	Zn*	0.331	15	0.637	0.164		
Pair 9	Cr	0.004	15	0.009	0.0024	-	-
	Cr*	0.000	15	0.000	0.000		

NB: Wet season parameters are in asterisk

The seasonal paired samples T-test of the examined parameters (Table 2) show that pH, EC, TDS, Fe, Cu, Cd, Pb, Zn, and Cr for dry and wet seasons ranged between -0.047 and 1.455, -386.453 and 1,091.387, -222.282 and 569.215,-6.784 and -2.908,-0.004 and 3.072,0.032 and 0.112, 0.025 and 0.111, 7.497 and 26.901, -0.001 and 0.009 respectively. It was concluded that there are significant seasonal variations between four heavy metals (Fe, Cd, Pb and Zn) in the study area (Table 2).

Table 2: Seasonal paired sample T-test of examined parameters

Parameters		Paired Differences							
					95% Confidence Interval of the Difference		t	df	Sig.(2-tailed)
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	pH–pH*	0.704	1.356	0.350	-0.047	1.4549	2.011	14	0.064
Pair 2	EC–EC*	352.467	1334.317	344.519	-386.453	1091.387	1.023	14	0.032
Pair 3	TDS-TDS*	173.467	714.629	184.516	-222.282	569.215	0.940	14	0.363
Pair 4	Fe – Fe*	-4.846	3.499	0.904	-6.784	-2.908	-5.363	14	0.000
Pair 5	Cu–Cu*	1.534	2.777	0.717	-0.004	3.072	2.139	14	0.051
Pair 6	Cd–Cd*	0.072	0.072	0.019	0.032	0.112	3.871	14	0.002
Pair 7	Pb – Pb*	0.068	0.078	0.020	0.025	0.111	3.375	14	0.005
Pair 8	Zn-Zn*	17.199	17.519	4.524	7.497	26.901	3.802	14	0.002
Pair 9	Cr – Cr*	0.004	0.009	0.002	-0.001	0.009	1.702	14	0.111

NB: Wet season parameters are in asterisk

Conclusion

The study revealed that about 73.3% and 26.7% of the measured pH values were found to be below the WHO minimum standard for drinking water quality in wet and dry seasons respectively. Also, approximately, 13.3% of EC, and 6.7% exceeded the prescribed standard limit of WHO for drinking water quality in dry and wet seasons respectively. Concentration of Fe exceeded drinking water quality in all the sampling locations during wet season and only about 46.7% in dry season .The concentration of Pb, Zn, and Cu exceeded WHO standard limit in about 86.7%, 80%, and 26.7% respectively in dry season. Concentration of Pb, Cd , Cu and Cr were under detection limit in all the locations except at locations G_2 for Cu in wet season.

The paired samples statistics and correlation of the examined parameters revealed that with the exception of Fe, the mean values of all the groundwater parameters were higher in dry season compared to wet season. Similarly, the degree of relationship among the parameters shows that no significant correlations exist among the examined parameters in both seasons. The seasonal paired samples T-test of the examined parameters show significant seasonal variations among four heavy metals including Fe, Cd, Pb and Zn in the study area. The study concluded that, water quality in dry season is of low quality compared to wet season because of high mean concentration of heavy metals. Thus, the study recommends , public enlightenment on sorting of solid waste at household level , controlled anthropogenic activities , treatment and recycling of complex inorganic and heavy metals to prevent them from been leached unto the sub-surface in the study area.

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