Pollution Prevention and Environmental Sustainability of Water, Soils and Stream Sediments in Southwestern Nigeria

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Abstract

Impact of heavy metals has become a major public health concern. The study is aimed at accessing ways by which pollution can be prevented towards a resounding environmental sustainability in the Southwestern, Nigeria. Groundwater, soil and stream sediment samples were picked and analyzed using ICP-ES and ICP-MS respectively. Results obtained were compared with WHO (2006) and was observed that all metals were within the permissible standard with the exception of Pb and K. High Pb was attributed to wastes disposed at the dump site found in the study area, while high K was more or less due to dissolution of minerals through weathering processes which was confirmed by the negative and weak correlation it has with other metals except with As which indicates same geochemical origin. It can therefore be concluded that measures such as organization of enlightenment program on the impact of polluted metals on the environment; provision of adequate disposal facilities; and a good waste management policy should be made to prevent depletion by these metals and also giving the environment a future hope, thus sustaining the environment and public health of the study area.

Keywords: Environmental, Sustainability, Heavy metals, Permissible standard, Public health

Introduction

Increase in population that has invariably led to increase in diverse human activities with no stringent law on the environmental protection is becoming a major issue in the developing countries. Therefore, ways on how to reduce the emission of wastes (in industries, hospitals, and many others), and toxic materials must be looked into, to prevent soil, water, stream sediment and air pollution and to conserve and rework/reuse resources (Hawken 2007; United Nations General Assembly, 1987). Environmental sustainability which is the responsible interaction with the environment to avoid degradation of natural resources and allow for long-term environmental quality is not only on the environment (Kates *et al.* 2005; Thiel *et al.* 2015); but also about our health as a society to be sure that the public health does not suffer as a result of environmental legislation; it also ensures checking the future impact of the human activities and how it can be sustained (Sherman *et al.* 2016; World Commission on Environment and Development, 1987).

Soil, stream sediments and water (surface and ground) are crucial components of the environment that become altered due to uncontrolled release of elements known as 'heavy metals' (Chibuike, 2014; Yan Xie, *et al.*, 2016). Heavy metals occur naturally in most cases but can also get to the environment through human activities, consequently becoming toxic to the environment. Heavy metals constitute an ill-defined group of inorganic chemical hazards, and the most common problem causing cationic metals such as mercury, cadmium, lead, nickel, copper, zinc, chromium, and manganese (GWRTAC, 1997; Singh, 2011). The availability of these chemical elements in their right proportion and combination in water, soil and stream sediments is important to life (Maslin and Maier, 2000; McLaughlin, *et al.*, 2000a, b). Conversely, the presence of toxic metals in soil/water can severely inhibit the biodegradation of organic contaminants and pose risks and hazards to humans and the ecosystem (Maslin and Maier, 2000; McLaughlin, *et al.*, 2000a, b; Ling, *et al.*, 2007).

Various heavy metals are injurious to the health of human, aquatic and wildlife when they occur in the environment at some critical high concentrations (Brkovic – Popovic, 1977; Wickliff and Evans, 1980;

Godbold and Huttermann, 1985; Powlesland and George, 1986). Exposure is normally chronic over a longer period due to food chain transfer. Acute and immediate poisoning from heavy metals is rare through ingestion or dermal contact, but is possible. Examples of chronic problems associated with long-term exposures to heavy metal are mental lapse through Pb, kidney and liver diseases, with gastrointestinal tract infection from Cd, skin poisoning, kidneys and central nervous system problems caused by As.

Water/soil may become contaminated by the accumulation of heavy metals and metalloids through emissions from the rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilisers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition (Khan, *et al.*, 2008; Zhang, *et al.*, 2010). Soils are the major sink for heavy metals released into the environment by these anthropogenic activities and their total concentration may persist for a long time before being leached into the groundwater (Kirpichtchikova, *et al.*, 2006; Adriano, 2003). Howard *et al.* (1998), Elueze *et al*, (2002), Fakayode, *et al*. (2003), Tijani (2004), and Odewande and Abimbola (2008) stated that the consequence of altering the chemistry of the earth's surface and subsurface water/soil may be more severe by dumping of mining, industrial, and domestic wastes resulting in deterioration of water quality. Hence, the investigation of heavy metals in water and soil is essential since slight change in their concentration above the acceptable level can result in serious environmental and subsequent health problems (Fangueiro *et al*, 2002, Sandroni and Smith 2002, Cobelo – Garcia *et al*, 2003). This study is aimed at evaluating the impact of heavy metal contamination in the soil and water of the study area.

Study Location

The study area lies within latitude $7^{0}20^{1}$ to $7^{0}23^{1}$N and longitude $3^{0}53^{1}$ to $3^{0}56^{1}$E in southwestern Nigeria (Figure 1). The study area is part of Ibadan, the largest indigenous city in sub-Sahara with an estimated population of two million five hundred and fifty thousand five hundred and ninety-three (NPC 2006). The growth of the city has nothing to do with industrialisation (with only few industries). Rather, it is related to the age long role of the city as regional administrative capital since the colonial era. The city is thus characterised by lack of proper sewage and waste disposal systems. The implication of these problems is that many households especially within the congested central part of the city lack toilet and waste disposal facilities (Tijani, and Ayodeji, 2002; Tijani, *et al.*, 2004, 200; Tijani and Agakwu, 2007). The household, therefore, defecate and pour their waste directly into the water thereby reducing the quality of water found in the area. Groundwater, soil, and stream sediments of the study area, which is densely populated lacks adequate drainage and waste disposal system (Figure 2).

Materials and method

Twelve 10ml plastic bottles were prepared for the collection of water sample around the study area; the bottles were rinsed with the water that was to be taken to avoid/reduce any form of contamination. Concentrated hydrochloric acid was pipetted into a syringe and two drops of the acid was used to acidify the water samples. This helps in the metals to maintain their normal state prior the laboratory analysis. A rubber bucket expected to introduce the least contamination was used to draw water samples from all the wells because the water being sampled is at a considerable depth below the ground surface. Conductivity meter was used to measure pH, Total dissolved solids (TDS), conductivity, salinity, and temperature of water samples at the point of collection. Nine soil samples and four stream sediment were collected randomly at depths not exceeding 5cm in the various locations (Fig. 1). In the stream, samples were not taken from the bank of the stream to avoid contaminated samples. The samples were decanted and bagged into polythene bags using nonmetallic plastic shovel. The samples were appropriately labelled on the spot to avoid mixing them up. The trowel was rinsed immediately after each collection to avoid contamination of the samples. Heavy metals analysis was done using inductively coupled plasma – mass spectrometer at the Acme Analytical Laboratories, Canada. The results from the analysis were subjected to the statistical analysis such as the calculation of anthropogenic factor, contamination factor, risk and geo-accumulation index. The indices are expressed as follows and their classification schemes shown in Tables 1 - 4.

*Anthropogenic Factor (A.F) also known as Igeo is $Igeo = \log_2(C_n/1.5B_n)$

Where C_n is the concentration of element in study area, B_n is the normal or average concentration of element in standard medium and 1.5 is the correction for matrix factor.

*Contamination factor Cf is C_n/B_n

Where C_n is the concentration of element in study area and B_n is the normal or average concentration of element in standard medium

*Index of Geoaccumulation (I_{geo}) used to evaluate the degree of metal contaminated in terrestrial, aquatic as well as marine environment is expressed as:-

$Igeo = \log_2 Cn / 1.5 \times Bn$

Where Cn is the concentration of element in the sample, Bn is the geochemical background value (i.e. average Crustal abundance) of the element and 1.5 is the matrix factor for possible variation in the background concentration due to lithologic differences. The geochemical index proposed by Muller (1969) is shown in Table 3.

* Risk index. (K_o) Risk index K_o, calculated by: $K_o = C/MPL$

Where, C=content of particular element in the soil (mg/kg) MPC-maximum permissible concentration of the same element (mg/kg)

Result and Interpretation

Physico-chemical Analysis of Water Samples

Physico-chemical parameters were compared with WHO (2006) permissible limits and the results were observed to be within the permissible limits (Table 5) with the exception of a location (Odinjo) found high for the TDS. This was due to the high level of organic matter and indiscriminate disposal of dumps found in the area.

Geochemical evaluation of the major elements

Statistical analysis for major elements (Table 6), indicates the range from K (7.43-148.70), Ca (8.8-139.9), Mg (2.95-46.29) and Fe (0.01-0.56) with an increasing downward form of K> Ca > Mg > Fe and mean of 53.69, 51.79, 16.99 and 0.07 respectively. While the range for trace elements revealed Zn (0.00-0.64), Pb (0.00-0.05), Cu (0.00-0.03), As (0.00-0.00) and Cd (0.00-0.00) with an increasing downward order of Zn > Cu > Pb > As > Cd with mean 0.1131, 0.0065, 0.0045, 0.0010 and 0.00002 respectively. The metals were compared with WHO 2006 permissible standard (Table 6), Pb and K was observed to be higher than the WHO (2006) permissible limits with mean values 0.05ppm and 148.70ppm respectively. High concentration of Pb found was from human activities which were confirmed by its strong correlation with some elements Pb - Fe with 'r' = 0.900, while the other elements though negatively correlated showed they are not from the same anthropogenic source. There is no contamination of lead except for the sample taken from Owode (W14) which has a high contamination level. Possible sources of such anomalous concentration of Pb in Owode could be human activities, such as fuel combustion, industrial processes and solid waste combustion. Lead is a particularly dangerous chemical, causing several unwanted effects, such as: Anemia, Kidney damage and Brain damage. K was observed to be above the permissible standards, inter-elemental analysis (Table 7) revealed a positive but weak correlation in the groundwater while a negative correlation was also observed, all of which is pointing to the fact that K comes more from geogenic source than from anthropogenic source. High rate of Potassium could be associated with the weathering of bedrock, which gets into the groundwater through leaching. Excessive influx of K into the environment causes malfunctioning of the kidney, which could lead to disturbing heartbeats, irritation of the eyes, nose, throat, lungs with sneezing, coughing and sore throat.

Correlation coefficient

The correlation matrix (Table 7) showed very strong and positive correlation in the following Zn – Cd; Pb – Fe; Ca-As; K-As; Mg-As; with 'r' values of 0.983; 0.900; 0.797;0.683 and 0.761 respectively indicating that the elements are governed by the same geochemical factors and are from the same source. While Mg-Ca ('r'=0.607) though indicates same geochemical environment is the essential element necessary for growth of both plants and animals in the study area

Geo-accumulation index

The Igeo (Table 8) is less than zero across all the trace elements. This indicates that the water samples are practically uncontaminated with any of the trace metals.

Contamination factor

The results (Table 9) which give the level of contamination of metals in the water samples reveal that there is a general low contamination of these major elements across every location except for the samples which were taken from Molete, Muslim, Odingo and Ayeye which have a moderate contamination of Ca.The results reveal a low contamination factor across all trace elements except for the sample taken at Owode which has a considerable contamination factor. There is also a low degree of contamination across the elements ie. Cdeg>8. There is also a low degree of contamination across all major elements

Factor analysis

For the analyzed (Table 10) water samples, Factor 1 has an eigen values of 1.65 summing up to 40.85% of the variance. There exists a high loading value for As and Cd, while Cu and Pb have negative loading values indicating that they are from different sources (anthropogenic). For the factor 2, the Eigenvalues is 1.026 summing up to 25.66% of variance. There exist a high loading value for Cu, a moderate loading value for As and Cd, and a low loading value for Pb indicating that this is also from different sources. The result correlates with that of the correlation matrix (Table 7) which suggests elements coming from the same geochemical zone.

Hydro-geologic interpretation

The piezometric map (Figure 3) shows the direction of flow of water in the study area. The map reveals that the direction of flow of water is to the southwest of the map. The flow point also depicts the area where there is the highest concentration of the heavy metals since the water is flowing from a high point to a lower point.

Soil Chemistry

Major Oxides: Concentrations of the major oxides Table 11 for soil and sediments in the study area showed that Fe_2O_3 ranges from 3.30- 7.15% with mean of 5.23 in the sediment; 2.17-6.06% with mean of 4.04 in the soil; CaO ranges from 0.74-0.99% with mean of 0.84 in the sediment; 0.31-2.97% with mean of 1.48 in the soil; MgO ranges from 0.22-0.98% with mean of 0.41 in the sediment; 0.08-0.48% with mean of 0.27 in the soil; Na_2O ranges from 0.01-0.02% with mean of 0.02 in the sediment; 0.01-0.07% with mean of 0.03 in the soil; K_2O ranges from 0.17-0.36% with mean of 0.22 in the sediment; 0.10-0.41% with mean of 0.22 in the soil. The dominance of Fe_2O_3 in the sediments when compared to the soil confirmed poor sanitary and waste/sewage disposal facilities in the study area where their stream channel is used mainly as the waste disposal tank. Dominance of other oxides (CaO, MgO, Na_2O, K_2O) was found in all the areas. This showed the oxides had been majorly contributed from the weathering of aluminosilicates, evidence of Ferromagnesian and aplite rich minerals from weathering of rocks on the soil which reveals the impact of each oxide on the environment (Figs 4.0). A significant correlation also confirms the above revelation Table 12. Factor analysis, Table 13 of the soil and stream used to explain the underlying controlling variables (Dowdy and Feth, 1967, Tijani, 2005) showed that the variables in factor 1 consists of all the major oxides which shows that they are those controlling the chemical character of the soil and stream sediments, and they account for 57% of the total variance of the variables with Eigen value of 2.8; furthermore the relatively high positive correlation is a reflection of the influence of community on the soil and stream sediment chemistry which affirms the indiscriminate dumping of industrial and market sewage waste in the soils and sediments of the study area. Factor 2 consists of all the oxides except Fe_2O_3, K_2O which suggests a natural environment for the oxides, but it still shows the influence of CaO on the chemistry. Factor 3, also affirms the same controlling environment for the oxides with the exception of CaO and Fe_2O_3. This can be concluded that the chemical character of the soil and sediment is mostly the major oxides analysed but it is dominated by CaO and Fe_2O_3.

Trace Elements: mean concentrations Table 14 for all the elements in both soil and stream sediment showed an increasing order of Zn>Pb>Cu>As>Cd, but the concentration of trace elements in soil samples is quite higher than that of stream sediments in the areas. The highest concentrations were found in Elere River (LC13), Eyin Grammar (LC1) and Surulere (LC5) due to sewage sludge, steel and iron works and refuse incineration activities found within the area. These metals when compared with their respective crustal average according to Taylor, 1964 and were observed to be higher than the recommended average with the exception of Ba. Since the samples taken were from areas that were densely populated. It therefore, revealed all the metals to be from human activities due to the fact that different mini-industries such as soap making, plastic factory, battery making, steel and iron work industries exist in the study area, Figs 5 and 6 revealed the comparison of each elements with the crustal average. A strong and positive correlation (Table 15) was observed amongst the metals Cu-Pb (0.643), Cu-Ba (0.604), As-Zn (0.707), Cd-As (0.612), Zn-Cd (0.724); these results thus confirmed anthropogenic source of the metals which indicates all the elements to be of the same source due to the strong and positive correlation it showed.

Data evaluation for soil and stream sediment

For the assessment and quantification of the level of contamination in the various media study, some quantitative contamination indices were used to describe the concentration trends, and they also allow for ease comparison between the determined parameters. The indices used include;

- Anthropogenic Factor (A.F)
- index of geoaccumulation (I_{geo}) and
- risk index.(K_o)

- **Index of Geo-accumulation**

Geo-accumulation classification index (I_{geo}) Table 16 Hakanson, 1980 for soil and stream sediment revealed all metals to be practically uncontaminated with the exception of Zn, Cd and Pb in soil with vales 2.8; 3.1 and 7.2 respectively, which is between moderately contaminated to highly, to very highly contaminated. Possible sources found are leaded gasoline and tyre wears, automobile emissions, batteries and municipal waste effluents/sewage sludge. Therefore, the order of degree of anthropogenic factor contamination or enrichment in both soil and stream sediments is Pb>Zn>Cd>Cu>As>Ba

Risk index

Risk index in soil and sediments Table 17 showed Zn (6.7 for stream sediment and 27.7 for soil), Cd (2.5 for stream sediment and 13 for soil) and Pb (9.1 for stream sediment and 186.6 for soil) to be between dangerous to extremely dangerous.

Pollution prevention and Environmental sustainability

Pollution forestalling is a key issue to environmental sustainability. To forestall the continual pollution of metals in groundwater and soils of the study area, the following must be done: a drastic measure must be taken to evacuate the dump site around it; another way is to close the groundwater around the dump site and another dug at a safe area; plants that are good in adsorbing and absorbing metals must be cultivated on the affected soils; a cultural change, that encourages more anticipation and internalizing of real environmental costs by those who may generate pollution must be instilled on the people in the environment; since it is everyone's responsibility to utilise his/her knowledge to take actions that are protective of human health and the environment; finally a comprehensive pollution prevention programme should be arranged thus forestalling further Pollution of these metals.

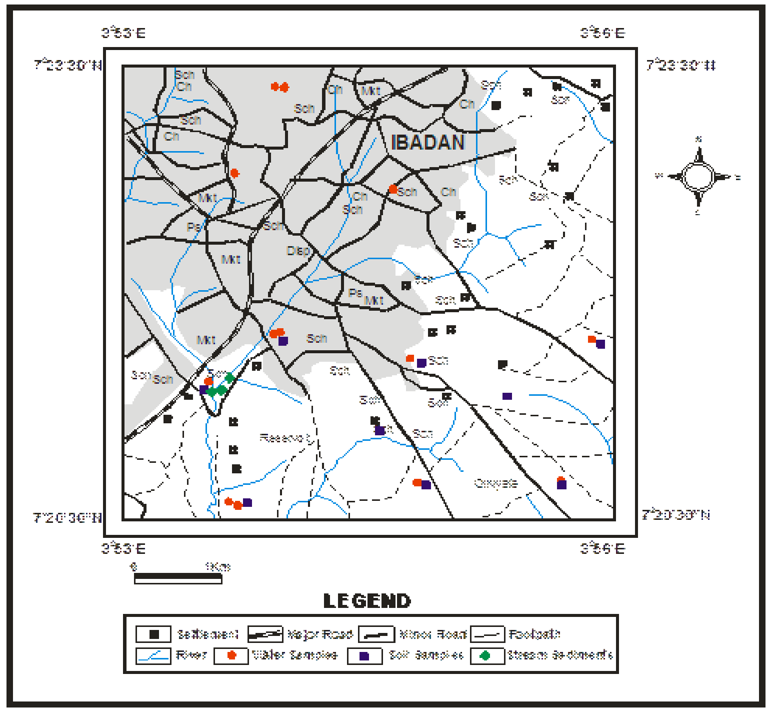

Figure 1.0: The sample location points.

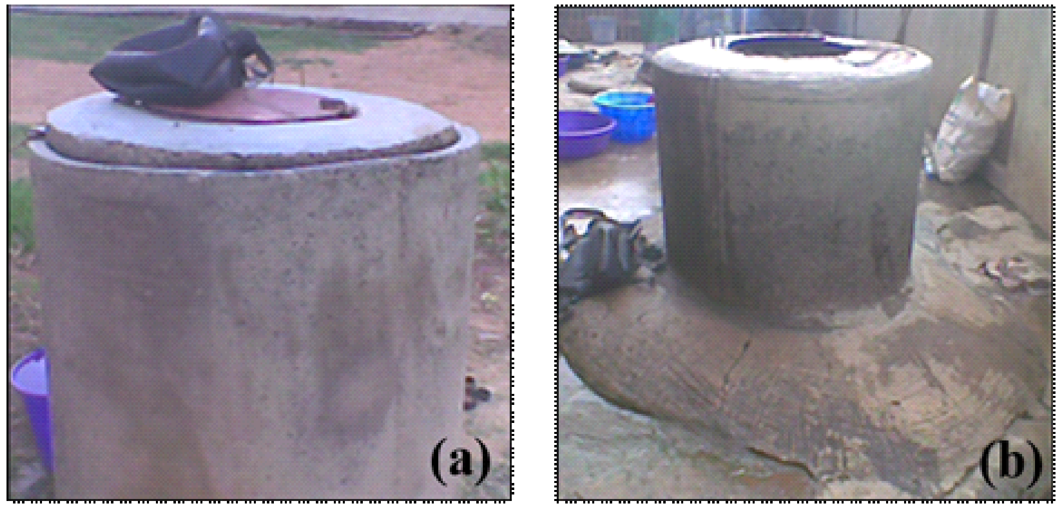

Figure 2: Hand-dug wells Sampled (a,c,e cased; b,d,f uncased)

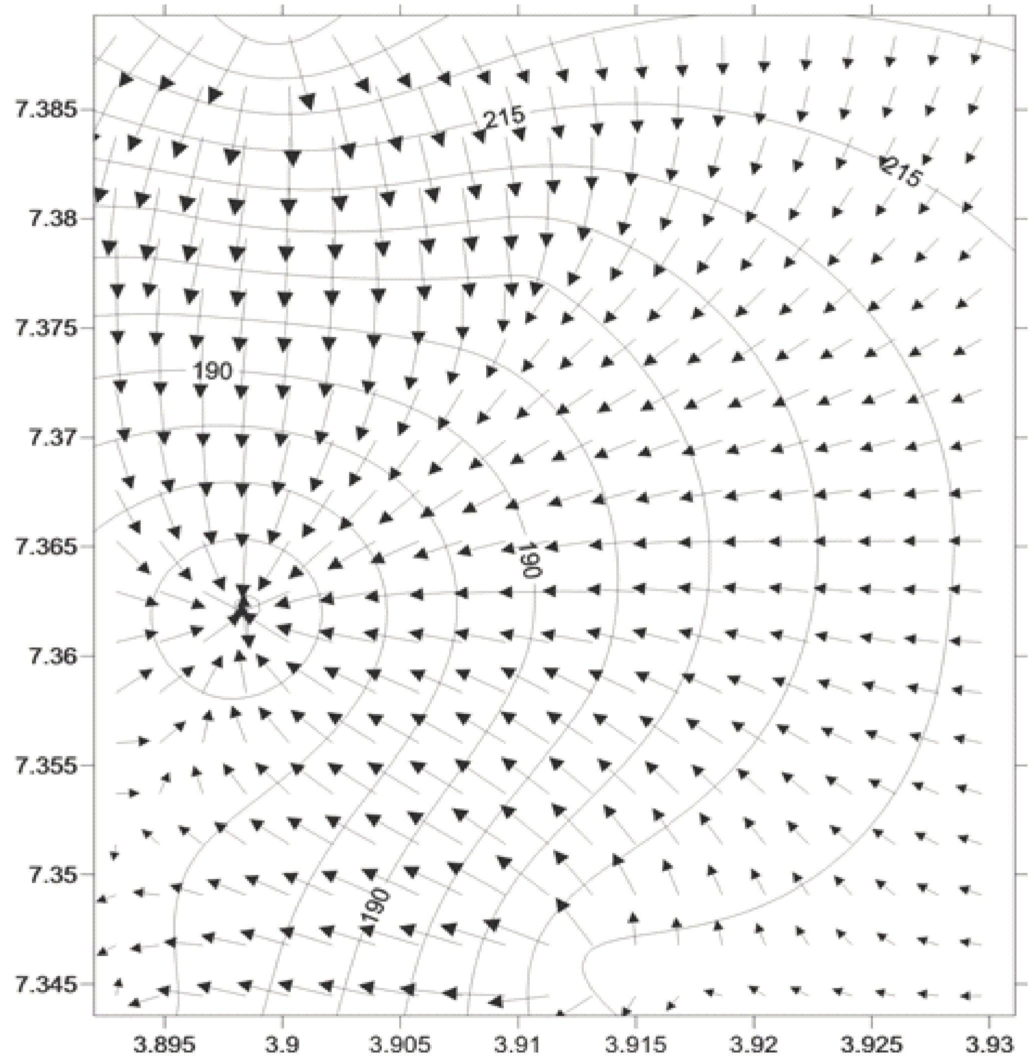

Figure 3.0: Piezometric map of study area.

Table 1: Geo-accumulation index classes

CLASSES	RANGES	INDICATION/WATER QUALITY
0	Igeo<0	Practically uncontaminated
1	0<Igeo<1	Uncontaminated to moderately contaminated
2	1<Igeo<2	Moderately contaminated
3	2<Igeo<3	Moderately to heavily contaminated
4	3<Igeo<4	Heavily contaminated
5	4<Igeo<5	Heavily to extremely contaminated
6	5<Igeo<	Extremely

Table 2: Descriptive classes of contamination factor (Hakanson, 1980)

CLASSES	INDICATION
CiF<1	Low contamination factor
1<CiF<6	moderate contamination factor
3<CiF<6	Considerable contamination factor
6<CiF	Very high contamination factor

Table 3: Geo Accumulation Index Classes Proposed By Muller (1969)

Classes	Ranges	Indication
1	$I_{geo}<0$	Practically uncontaminated
2	$0<_{geo}<1$	Uncontaminated to moderately contaminated
3	$1<l_{geo}<2$	Moderately contaminated
4	$2<l_{geo}<3$	Moderately to heavily contaminated
5	$3<l_{geo}<4$	Heavily contaminated
6	$4\ l_{geo}<5$	Heavily to extremely contaminated
7	$5<l_{geo}$	Extremely contaminated

Table 4: Class indication for Risk index Ko

`Contamination Level	Ko Value	Required Actions
Permissible	Ko_<1	Detailed soil investigation and monitoring is recommended
Medium dangerous	1<Ko_<3	Reducing of impact from pollution sources. Quality control of surface and ground water
Dangerous	3<Ko <_10	Obligatory is soil remediation (liming, adding with clean soil) up to permissible level in residential and recreation areas. agriculture areas must be used for technical crops or afforestation
Extremely dangerous	Ko>10	Polluted soil layer must be removed to landfill of hazardous substances or remediated insitu up to superior level of contamination.

Table 5: Physico-chemical Parameters of Water Samples

Location	pH	Conductivity	TDS
Molete	7.73	576	205.9
Eyin Grammar	7.23	183	119
Kudeti	7.58	423	275
Oke Aremu	6.81	158	103
Owode	7.36	109	71
Muslim	6.33	132	86
Odinjo	7.83	956	624.35
Olorunsogo	6.72	205	133.3
Oja Oba	8.05	523	340
Ayeye	7.54	538	350
WHO	6.5-9.2	1400	500

Table 6: Descriptive Statistics of the Heavy Metals

Location	As (mg/l)	Cd (mg/l)	Cu (mg/l)	Pb (mg/l)	Zn mg/l)	K (mg/l)	Mg(mg/l)	Ca(mg/l)	Fe(mg/l)
Molete	0.00165	0.000105	0.0065	0.00045	0.62125	63.36	24.525	136.9	0.01
Eyin Grammar	0.00055	0.00005	0.00335	0.00125	0.0618	14.77	13.925	27.5	0.0555
Kudeti	0.0009	0.00005	0.00645	0.00135	0.0209	57.935	10.88	62.945	0.0395
Oke Aremu	0.0005	0.00005	0.00205	0.00195	0.0467	26.945	6.06	24.3	0.0245
Owode	0.0005	0.00005	0.0217	0.0275	0.06575	22.255	5.41	11.88	0.285
Muslim	0.00125	0.00005	0.0069	0.0048	0.0981	76.005	15.19	56.55	0.038
Odingo	0.00175	0.00005	0.00295	0.00055	0.01505	91.15	33.44	51.46	0.127
Olorunsogo	0.0005	0.00005	0.0023	0.0001	0.032	7.43	18.58	16.98	0.01
Oja Oba	0.0011	0.00005	0.0061	0.0001	0.0042	102.7	12.58	42.61	0.01
Ayeye	0.0012	0.00005	0.0031	0.0007	0.0271	97.68	38.89	77.03	0.01
WHO (2006)	0.01	0.003	2	0.01	3	13.48	100	200	0.5

Table 7: Correlation coefficient of heavy metals in the study area

	As	Ca	Cd	Cu	Fe	K	Mg	Pb	Zn
As	1								
Ca	0.797	1							
Cd	0.440	0.747	1						
Cu	-0.219	-0.180	0.004	1					
Fe	-0.040	-0.148	-0.161	0.050	1				
K	0.683	0.407	0.081	-0.117	-0.267	1			
Mg	0.761	0.607	0.239	-0.387	0.044	0.343	1		
Pb	-0.263	-0.281	-0.115	0.134	0.900	-0.276	-0.238	1	
Zn	0.396	0.723	0.983	0.000	-0.071	0.021	0.200	-0.011	1

Table 8: Geo-accumulation Index for trace element in water samples

	Locations	As	Cd	Cu	Pb	Zn
W1	Molete	0.047	0.037	-0.081	-0.534	0.256
W2	Eyin Grammar	-0.073	-0.053	-0.162	-0.534	-0.1120
W3	Kudeti	-0.020	-0.053	-0.112	-0.534	-0.317
W4	Oke-Aremo	-0.097	-0.053	-0.262	-0.534	-0.110
W5	Owode	-0.097	-0.053	0.160	-0.534	-0.182
W6	Muslim	-0.097	-0.053	-0.012	0.036	0.029
W7	Odingo	0.047	-0.053	-0.129	-0.534	-0.536
W8	Olorunsogo	-0.097	-0.053	-0.187	-0.534	-0.127
W9	Oja Oba	0.006	-0.053	-0.060	-0.534	-0.392
W10	Molete	0.070	0.050	-0.028	-0.262	0.265
W11	Eyin Grammar	-0.097	-0.053	-0.118	-0.118	0.008
W12	Kudeti	-0.020	-0.053	-0.012	-0.108	-0.118

W13	Oke Aremo	-0.097	-0.053	-0.162	-0.058	-0.052
W14	Owode	-0.097	-0.053	0.009	0.291	0.035
W15	Muslim	0.084	-0.053	-0.086	-0.156	0.009
W16	Odingo	0.084	-0.053	-0.187	-0.232	-0.141
W17	Ayeye	0.017	-0.053	-0.149	-0.279	-0.149

Table 9: Contamination factor with contamination degree for major elements

	Factor 1	Factor 2	Communalities
As	0.839	0.109	0.715
Cd	0.679	0.575	0.791
Cu	-0.403	0.766	0.749
Pb	-0.555	0.312	0.406
Eigenvalues	1.635	1.026	
% of Variance	40.865	25.656	
Cumulative %	40.865	66.521	

Table 10: Factor matrix for trace elements.

Locations	Ca(ppm)	Fe(ppm)	Mg(ppm)	As(ppm)	Cd(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)
Molete	1.825	0.01	0.24515	0.165	0.0348	0.00325	0.045	0.2066
Eyin Grammar	0.365	0.0555	0.13925	0.055	0.0166	0.001675	0.125	0.02045
Kudeti	0.839	0.0395	0.1088	0.09	0.0166	0.003225	0.135	0.00695
Oke Aremo	0.3225	0.0245	0.0606	0.05	0.0166	0.001025	0.195	0.01545
Owode	0.158	0.033	0.0541	0.05	0.0166	0.01085	2.75	0.0219
Muslim	0.7535	0.038	0.1519	0.125	0.0166	0.00345	0.48	0.0327
Odingo	0.684	0.127	0.3344	0.175	0.0166	0.001475	0.055	0.005013
Olorunsogo	0.226	0.01	0.1858	0.05	0.0166	0.00115	0.01	0.01066
Ayeye	1.027	0.01	0.3889	0.12	0.0166	0.00155	0.07	0.009
Oja Oba	0.568	0.01	0.1258	0.11	0.0166	0.00305	0.01	0.0014
WHO (2006)	75	1	100	0.01	0.003	2	0.01	3
CD	11.715	0.685	2.88	1.7	0.282	0.055	7.66	0.639

Table 11: Descriptive statistics of major oxides for the soil (s) and stream sediment (ss)

ELEMENT	N	range%	minimum	maximum	mean
Fe_2O_3	s	2.17-6.06	2.17	6.06	4.04
	ss	3.30-7.15	3.3	7.15	5.23
CaO	s	0.31-2.97	0.31	2.97	1.48
	ss	0.74-0.99	0.74	0.99	0.84
MgO	s	0.08-0.48	0.08	0.48	0.27
	ss	0.22-0.98	0.22	0.98	0.41
Na_2O	s	0.01-0.07	0.01	0.07	0.03
	ss	0.01-0.03	0.01	0.03	0.02
K_2O	s	0.10-0.41	0.1	0.41	0.22
	ss	0.17-0.36	0.17	0.36	0.22

Table 12: Correlation Coefficient of major oxides for the soil and stream sediment

	Na_2O	K_2O	Fe_2O_3	CaO	MgO
Na_2O	1				
K_2O	.623*	1			
Fe_2O_3	.453	.454	1		
CaO	.521	.221	.159	1	
MgO	.479	.786**	.628*	.165	1

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 13: Factor Analysis of major oxides for the soil and stream sediment

	Component		
	1	2	3
Na_2O	.810	.353	-
K_2O	.860	-	-.411
Fe_2O_3	.730	-	.609
CaO	.464	.825	-
MgO	.854	-.356	-
Eigen vales	2.872	1.048	0.567
Percentage of variance	57.448	20.964	11.345
Cummulative percentage	57.448	78.412	89.757

Table 14: Descriptive statistics of trace elements of soils (s)and sediments (ss)of the study area

N/S	Description	Cu	Pb	Zn	As	Cd	Ba
S1	Eyin Grammar	137	2333	992	3	2.6	240
S2	Eyin Grammar	34.5	79	211	2	0.5	102
S3	Owode Academy	16	36	198	2.5	0.5	70
S4	Owode	21.5	41.5	197	2	0.5	67
S5	Surulere	57	170.5	906	2.5	0.8	101
S6	Laoye Muslim	45.5	74.5	912	2	2.1	107
S7	Kudeti	37	90.5	312	3	0.7	147
S8	Odinjo	83.5	127	2716	3.5	2.2	145
S9	Olorunsogo	20.5	53	493	2	0.5	72
	mean	50.28	333.89	770.78	2.50	1.16	116.78
	Stan dev	38.74	750.88	800.73	0.56	0.87	54.92
	Range	16-137	36-2333	197-2716	2-3.5	0.5-2.6	67-240
SS10	Ogunpa River	46	78	267	2	0.5	77
SS11	Ogunpa River	75	82	657	2	0.5	217
SS12	Elere River	77	99	285	2	0.5	81
SS13	Elere River	121	114	307	2	0.5	88
	mean	79.75	93.25	379.00	2.00	0.50	115.75
	starndev	30.93	16.56	186.05	0.00	0.00	67.65
	Range	46-121	78-114	267-657	02-Feb	0.5-0.5	77-217
	Crustal Average	50	12.5	97.9	1.8	0.2	500

Table 15: Correlation Coefficient of trace elements for the soil and stream sediment

	Cu	Pb	Zn	As	Cd	Ba
Cu	1					
Pb	**.643(*)**	1				
Zn	.355	.177	1			
As	.292	.401	**.707(**)**	1		
Cd	.497	**.645(*)**	**.724(**)**	**.612(*)**	1	
Ba	**.604(*)**	**.672(*)**	.388	.477	**.559(*)**	1

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 16: Geo-accumulation index (I_{geo}) of the trace elements in soi (s)l and stream sediment (ss)

ELEMENTS	**Cu**	**Pb**	**As**	**Cd**	**Ba**	**Zn**
S_1	0.8	7.2	0.2	3.1	-1.6	2.8
S_2	-1.1	2.1	-0.4	0.7	-2.9	0.5
S_3	-2.3	0.9	-0.1	0.7	-3.4	0.4
S_4	-1.8	1.2	-0.4	0.7	-3.5	0.4
S_5	-0.3	3.2	-0.1	1.4	-2.9	2.6
S_6	-0.6	1.9	-0.4	2.8	-2.8	2.6
S_7	-1.0	2.3	0.2	0.3	0.3	1.1

{$_8$	0.2	2.8	0.4	2.9	2.9	4.2
S_9	-1.9	1.5	-0.4	0.7	0.7	1.7
SS10	-0.7	2.1	-0.4	0.7	-3.3	0.9
SS11	0	2.1	-0.4	0.7	-1.8	2.2
SS12	0.1	2.4	-0.4	0.7	-3.2	1.0
SS13	0.7	2.6	-0.4	0.7	-3.1	1.1

Table 17: Risk index (K_o) for trace elements in soil (s) and stream sediment (ss)

ELEMENTS	**Cu**	**Pb**	**As**	**Cd**	**Ba**	**Zn**
S_1	2.8	186.6	1.7	13	0.5	10.1
S_2	0.7	6.3	1.1	2.5	0.2	2.2
S_3	0.3	2.9	1.4	2.5	0.1	2.0
S_4	0.4	3.3	1.1	2.5	0.1	2.0
S_5	1.1	13.6	1.4	4.0	0.2	9.3
S_6	0.9	6.0	1.1	10.3	0.2	9.3
S_7	0.7	7.2	1.7	3.3	0.3	3.2
S_8	1.7	10.2	1.9	1.1	0.3	27.7
S_9	0.4	4.2	1.1	2.5	0.1	5.0
SS10	0.9	6.2	1.1	2.5	0.2	2.7
SS11	1.5	6.6	1.1	2.5	0.4	6.7
SS12	1.5	7.9	1.1	2.5	0.2	2.9
SS13	2.4	9.1	1.1	2.5	0.2	3.2

Conclusion

In conclusion, heavy metal results in ground water revealed all to be within the permissible limits with the exception of Ca and Pb which are attributed to wastes disposed at the dump site found in the study area, while Cd, Zn and Pb were observed to be above the standard in the soil and stream sediment. Therefore, measures such as organization of enlightenment program on the impact of polluted metals on the environment; remediation of the affected media, to prevent depletion by these metals and also giving the environment a future hope, thus sustaining the environment and public health of the study area should be taken.

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