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IMPACT OF WASTE BATTERIES DUMPSITES ON THE WATER QUALITY OF PARTS OF IBADAN NORTHEAST (SHEET 261), SOUTHWESTERN NIGERIA

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ABSTRACT

Industrial waste disposal commands a relatively large share of attention, because many industrial wastes are toxic and hazardous. Open dump methods used by Exide Batteries Manufacturing Company are unsatisfactory means of solid waste disposal because certain elements such as Lead (Pb), Zinc (Zn) and Copper (Cu) used in the Production of these batteries are toxic and require special handling in disposal. The disposal of waste batteries and accumulators at Olodo, Arubiewe and Ikumapayi villages led to the need for the determination of the Heavy Metals, Cations and Anions concentrations of surface and ground waters of these areas. A study of twenty-one water samples which were randomly collected from streams, hand-dug wells and borehole at Olodo, Arubiewe, Ikumapayi was carried out, samples from the Polytechnic Ibadan North Campus which served as a control point. Field parameters such as geographical co-ordinates, elevation, water level, colour, odour, taste and pH were determined. The following hydrochemical parameters were determined Anions (Cl, -SO_4^{2-} NO_3- and HCO_3-), Cations (Mg^{2+}, Na^+ K^+ and total Fe) and Heavy metals (Pb, Zn, Cu, and Cd). These were determined using the Atomic Absorption spectrophotometer bulk 200 models.

Results of the geochemical analyses for both surface and ground water samples were assessed and compared to World Health Organization (WHO) standard and also to the control sample (Polytechnic Ibadan). The concentrations of Anions (Cl, SO42-, HCO3- NO32-) were found to be adequate and below the acceptable permissive level so also were the concentrations of the Cations (Mg, Na and K). However, the concentrations of Pb, Cu and Cd exceeded the maximum permissible level at Olodo, Ikumapayi and Arubiewe, while that of Zn was below the minimum permissible level.

The Leachate from the waste batteries and accumulators' dumpsites that came in contact with surface and shallow groundwater was considered to be responsible for the high values of Pb, Cu and Cd. This is further corroborated by the values of these trace elements at the control points. The continual usage of these waters constitutes a great health hazard to plants, animals and man.

KEY WORDS: waste, dumpsites, batteries, hydrochemical and hazard.

INTRODUCTION

Waste dumping is a common practice over the World. Wastes resulting from domestic and industrial processes are disposed off in several ways. These include discharge into drains, canals, water ways or areas of land that are inhabited or erosion stricken. As a result of population pressure an increasing development, Nigeria has witnessed accelerated growth in the industrial sectors during the 1970s and early 1980s. However, various ecological and human disasters such as cholera outbrake, increase infant mortality and poliomyelitis have continually occurred in different parts of the country due to this industrialization.

West African Batteries Nigeria Limited is a company located at Iya-Church area of Ibadan, some 8km to the centre of the city along Iwo Road. The company manufactures batteries and accumulators commonly used by motor vehicles since the 80s. The factory started operations in 1982. It basically carries out secondary lead smelting involving the carbon reduction of lead compounds to raw Pb. The exact chemical composition of batteries varies from type to type, but most contain heavy metals such as Pd, Zn, Ni, Cu, and Cd which are the main causes of environmental concern. When disposed improperly, the heavy metals leach into the ground when the battery casing corrodes resulting in soil and water pollution which eventually cause harm to all forms of existing life around it. The contamination of the environment with heavy toxic metallic ions has become not only a local phenomenon but a global one as well, (Nnagu,1990).

Indiscriminate dumping of used batteries and accumulators was casually done by Exide Batteries Nigeria Limited at different sites within Olodo, Arubiewe and Ikumapayi areas of Ibadan, SouthWestern Nigeria. This was done at a time when the areas were thickly forested and uninhabited. However, over time, plots of land were sold to individuals who have now developed the area. An area which used to serve as sites for the dumping of toxic materials is now being habited by several thousands of people. (Elueze et al,2001), worked on the effect of the effluent generated by the industry. The concentration of Pb was found to decrease away from the factory site. It also decreases with depth from the top soil, but not above the permissible level recommended by WHO.

LOCATION AND HYDROGEOLOGIC SETTING

Location of the study area.

The study area Olodo, Arubiewe and Ikumapayi villages (Fig 1) form part of Ibadan NE sheet 261 (scale 1:50,000) of SouthWestern

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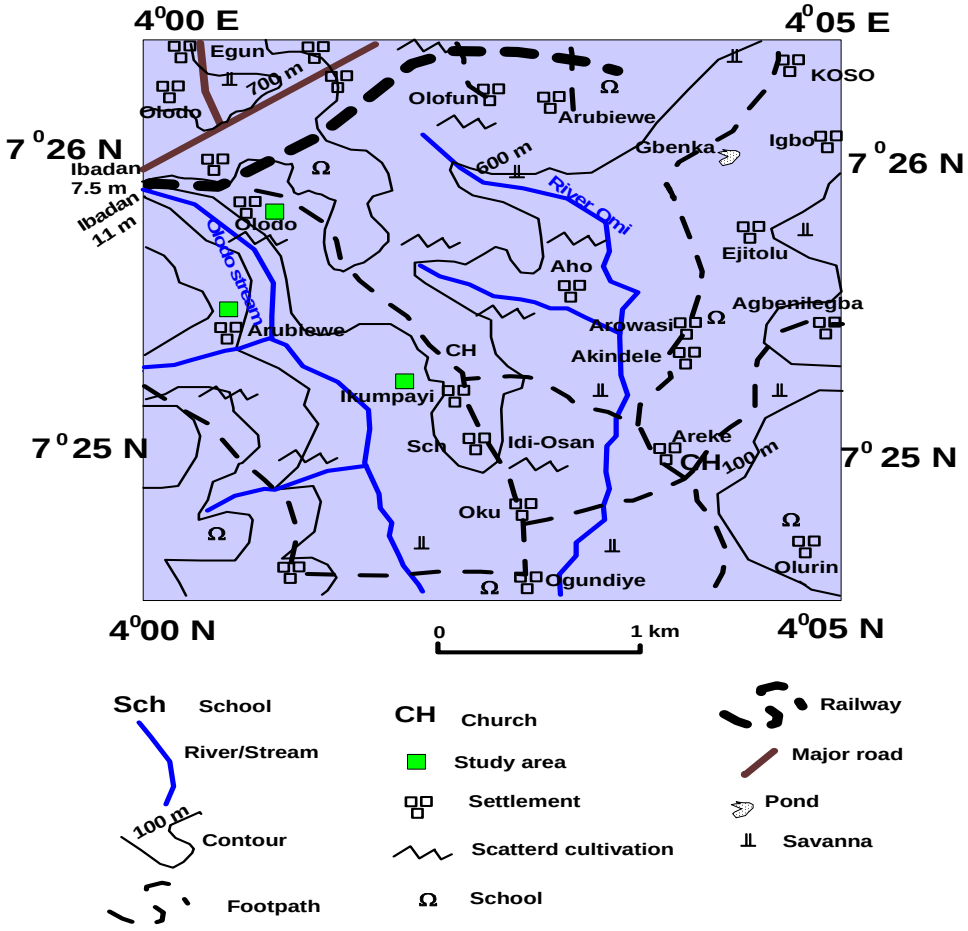


Figure 1: The location map of the study area (Ibadan NE Sheet 261)

Nigeria. It lies within Longitude $4^0$00 and $4^0$05E and Latitude $7^0$25 and $7^0$26N (Fig1). The area is densely populated and highly accessible, served with an express road that terminates at Olodo junction and great numbers of tarred and unstarred roads and foot paths which link up to form a good road network.

The area lies within the basement complex of Southwestern Nigeria. (Fig 2) The basement rocks are generally considered to be poor aquifers because of their crystalline nature which leads to low porosity and permeability. However appreciable porosity and permeability have developed through fracturing and weathering of the rocks, (Davis and Deweist,1966).This makes the weathered rock to function as a groundwater aquifer. The availability of ground water also depends on the extent of weathered overburden and the presence of joints in the underlying rocks (Acworth,1987). The ground water occurrence in Ibadan is essentially semi-confined to unconfined, occurring under water table conditions and highly influenced by infiltration and percolation of precipitations,(Abimbola et al, 2002). This is also applicable to Olodo, Arubiewe and Ikumapayi areas.

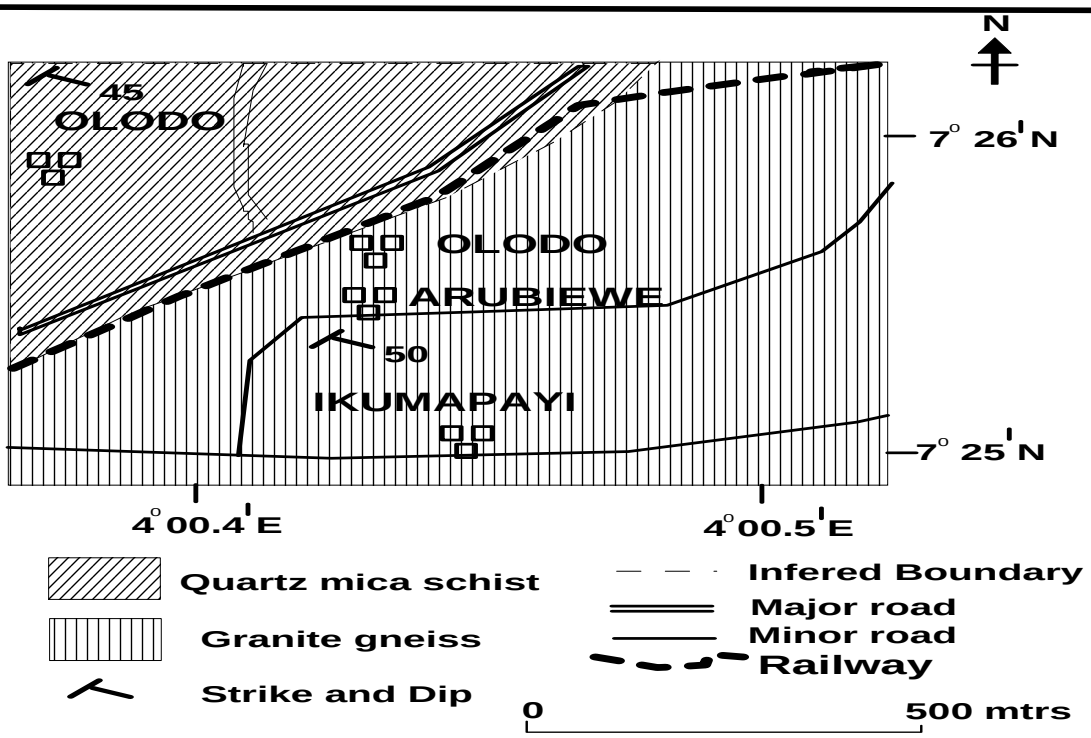


Figure 2: The geology map of the study area

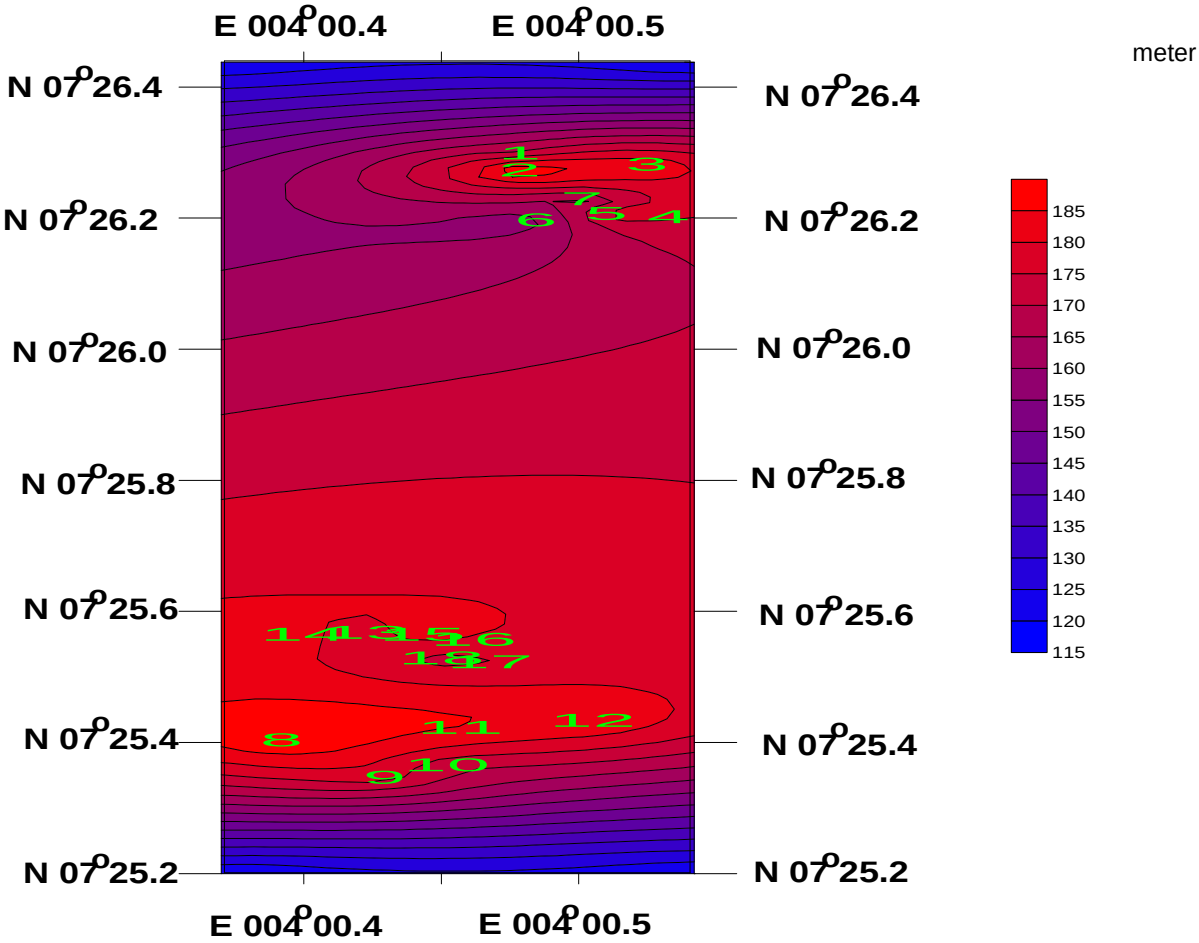


Figure 3: Topographic Map of the Study Area

GEOLOGIC SETTING

Geologically, the study area lies within the Precambrian Basement Complex of Southwestern Nigeria. Nigeria is part of the Pan African Mobile Belt lying east of the West African Craton, (Jone and Hockey, 1964),(Rahaman,1989). The major rock unit in the study area is granite gneiss, which occur at the eastern, southern and part of the northern parts, quartz mica schist occurs at the north western part of the area, (Fig 2). In addition to these, there are several occurrences of minor pegmatite vains, which are intrusions to the crystalline rocks. The bedrocks are covered by the weathered regolith, composed mainly of clay and sandy materials.

MATERIAL AND METHODS

A total of three batteries and accumulators waste disposal sites were identify for this study (Fig 3). Six water samples were collected from streams, two from Olodo, three from Arubiewe and one from the Polytechnic Ibadan (control). One sample was collected from a pond at Ikumapayi. Twelve samples were collected from hand-dug wells; five from Olodo, three each from Ikumapayi and Arubiewe and one from The Polytechnic Ibadan (control).

Table 1: Results of Field Parameters.

NO	DESCRIPTION	WATER SOURCE	LONGITUDE	LATITUDE	ELEVATION (meter)	WATER LEVEL(m)	TASTE	ODOUR
1	OLODO 1	Well	E004^{0}00.479	N07^{0}26.298	171	-11.8	Tasteless	Odourless
2	OLODO 2	Well	E004^{0}00.479	N07^{0}26.272	191	-13.5	Tasteless	Odourless
3	OLODO 3	Well	E004^{0}00.526	N07^{0}26.281	184	-10.5	Tasteless	Odourless
4	OLODO 4	Stream	E004^{0}00.534	N07^{0}26.201	175	0	Tasty	Odour
5	OLODO 5	Stream	E004^{0}00.511	N07^{0}26.206	179	0	Tasty	Odour
6	OLODO 6	Well	E004^{0}00.485	N07^{0}26.196	157	0	Tasty	Odour
7	OLODO 7	Well	E004^{0}00.502	N07^{0}26.228	163	-0.5	Tasteless	Odourless
8	IKUMAPAYI 1	Well	E004^{0}00.391	N07^{0}25.403	190	-8.8	Tasteless	Odourless
9	IKUMAPAYI 2	Pond	E004^{0}00.429	N07^{0}25.346	178	-0.5	Tasty	Odour
10	IKUMAPAYI 3	Well	E004^{0}00.452	N07^{0}25.365	171	-1.1	Tasteless	Odourless
11	IKUMAPAYI 4	unprotected well	E004^{0}00.457	N07^{0}25.422	185	-1	Tasteless	Odourless
12	IKUMAPAYI 5	Well	E004^{0}00.506	N07^{0}25.433	185	-1.2	Tasteless	Odourless
13	ARUBIEWE 1	Stream	E004^{0}00.422	N07^{0}25.567	177	0	Tasteless	Odourless
14	ARUBIEWE 2	Well	E004^{0}00.399	N07^{0}25.564	182	-6.5	Tasteless	Odourless
15	ARUBIEWE 3	Well	E004^{0}00.443	N07^{0}25.564	183	-4.5	Tasteless	Odourless
16	ARUBIEWE 4	Well	E004^{0}00.462	N07^{0}25.556	179	-4.5	Tasteless	Odourless
17	ARUBIEWE 5	Stream	E004^{0}00.468	N07^{0}25.522	175	0	Tasty	Odour
18	ARUBIEWE 6	Stream	E004^{0}00.45	N07^{0}25.528	173	0	Tasty	Odour
19	POLY 1	Stream	003^{0}52.554	N07^{0}26.247	189	0	Tasty	Odour
20	POLY 2	Well	003^{0}52.555	N07^{0}26.285	190	-3.6	Tasteless	Odourless
21	POLY 3	Borehole	003^{0}52.539	N07^{0}26.297	190	60	Tasteless	Odourless

One sample was collected from an unprotected well at Ikumapayi and the only borehole sample was collected at The Polytechnic Ibadan.

In all, twenty one samples were collected. All the samples were analyzed with atomic absorption spectrometry (AAS) at International Institute for Tropical Agriculture **(IITA) Ibadan.**

Some field parameters like pH, elevation, water level, taste and Odour were taken at the site because they serve as quick control checks for subsequent laboratory results Table 1. (Llyod and Heathcote, 1985). pH was measured with a WTW-pH meter model pH/91. Taste and Odour of the water samples were orally observed and Garmin e-Trex Global positioning system (GPS) was used to determine the Longitudes and Latitudes, Elevation and depth to water level using measuring tape in all the locations.

RESULTS AND DISCUSSION

Results from the hydrochemical analysis and other physical parameters for ground and surface water samples are given below.

The pH values (Table 2) range from 4.66 to 4.96; and mean value is 4.85, which is very low (acidic) when compared with the WHO stipulated standards (Table 2). Such low pH value of far less than 8 is said to be an indication of the presence of free $C0_2$ and that

Table 2 :Results of pH and Anions Concentration.

NO	DESCRIPTION	pH	Cl^-(mg/L)	So_4^{2-} (mg/L)	HCO^{3-} (mg/L)	No_3^- (mg/L)	
	WHO STANDARD	**6.5**	**200**	**200**	**500**	**25**	
1	OLODO 1	4.78	10.8	0.001	42.7	6	
2	OLODO 2	4.79	10.8	6.47	97.6	9.1	
3	OLODO 3	4.89	10.8	0.001	97.6	6.5	
4	OLODO 4	4.66	28.8	74	97.6	12	
5	OLODO 5	4.74	25.2	2.31	134.2	12	
6	OLODO 6	4.82	18	74.07	128.2	11	
7	OLODO 7	4.75	10.8	27.3	97.6	13	
8	IKUMAPAYI 1	4.86	14.4	1.23	67.1	12	
9	IKUMAPAYI 2	4.9	28.8	0.001	79.3	10	
10	IKUMAPAYI 3	4.95	10.8	9.71	79.3	9.5	
11	IKUMAPAYI 4	4.93	21.6	6.47	73.2	10.5	
12	IKUMAPAYI 5	4.92	10.8	9.71	79.3	10.5	
13	ARUBIEWE 1	4.86	25.2	0.001	85.4	9.5	
14	ARUBIEWE 2	4.93	18	0.926	39.04	10	
15	ARUBIEWE 3	4.91	18	0.001	79.3	11.5	
16	ARUBIEWE 4	4.96	72.2	0.001	109.8	12	
17	ARUBIEWE 5	4.84	21.6	74	85.4	6.5	
18	ARUBIEWE 6	4.86	21.6	6.47	73.2	7.5	
19	POLY 1	4.74	21.6	7.86	42.7	10.5	
20	POLY 2	4.73	10.5	0.001	61	10	
21	POLY 3	4.78	14.4	0.001	54.1	6.6	

Table 3:Results of Cation Concentration.

NO	DESCRIPTION	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	
	WHO STANDARD	**50**	**200**	**10**	**0.3**	
1	OLODO 1	6.84	1.82	4.6	0.001	
2	OLODO 2	6.93	2.56	5.52	0.001	
3	OLODO 3	5.03	0.77	3.28	0.001	
4	OLODO 4	3.16	0.64	18.9	0.001	
5	OLODO 5	4.11	0.11	0.92	0.14	
6	OLODO 6	3.28	0.09	1.04	0.18	
7	OLODO 7	3.41	0.75	2.76	0.11	

8	IKUMAPAYI 1	5.14	3.59	7.36	0.001	
9	IKUMAPAYI 2	3.11	1.69	4.5	0.001	
10	IKUMAPAYI 3	5.34	1.33	3.74	0.12	
11	IKUMAPAYI 4	5.23	0.68	1.84	0.001	
12	IKUMAPAYI 5	4.34	1.31	3.74	0.001	
13	ARUBIEWE 1	6.11	0.97	2.76	0.1	
14	ARUBIEWE 2	9.24	2.11	5.12	0.001	
15	ARUBIEWE 3	7.55	2.87	4.64	0.001	
16	ARUBIEWE 4	8.91	1.95	4.87	0.001	
17	ARUBIEWE 5	6.24	4.83	6.44	0.001	
18	ARUBIEWE 6	5.23	0.68	1.84	0.001	
19	POLY 1	14.68	7.49	13.8	0.08	
20	POLY 2	8.75	3.86	8.28	0.01	
21	POLY 3	2.11	0.57	2.76	0.05	

dissolved carbonate exist almost entirely in $HC0^3$ ions form, (Freeze and Cherry,1979).

For the anions; chlorine concentration ranges from 10.8- 72.2 mg/l, with an average value of 21.01mg/l. $S0_4^{2-}$ ranges from 0.001 – 74.07 mg/l with the average value of 14.79mg/l. The average values for $HC0_3$- and $N0_3$- are, 85.88mg/l and 9.95mg/l respectively (Table 5). The average concentration of cations are; mg =5.51mg/l, Na = 1.60mg/l, K = 4.66mg/l and Fe = 0.04 mg/l.

The ground and surface water of Olodo, Arubiewe and Ikumapayi recorded low anions concentration, except for slightly higher Cl^- concentration at Location 16 and $S0_4^{2-}$ at Location 4,6 and 17, (Figs 4 and 5) respectively. Also, the level of the anions in both ground and surface water samples are generally lower than the prescribed threshold level recommended by the WHO. The cations concentrations are also far below the recommended values by WHO. The anions and cations concentrations are presented in Tables 2 and 3 respectively.

The concentrations of Heavy metals Pb, Zn, Cu and Cd, are presented in Table 4.

Table **4: Results of Heavy Metals Concentration**

NO	DESCRIPTION	Pb (mg/L)	Zn (mg/L)	Cu (mg/L)	Cd (mg/L)	
WHO STANDARD	**-**	**0.05- 0.05**	**1.0 - 1.0**	**1.0-1.0**	**0.005-0.005**	
1	OLODO 1	0.23	0.12	1.58	0.07	
2	OLODO 2	0.15	0.1	1.55	0.06	
3	OLODO 3	0.19	0.07	1.52	0.09	
4	OLODO 4	0.35	0.05	1.94	0.11	
5	OLODO 5	0.37	0.1	1.92	0.12	
6	OLODO 6	0.36	0.06	1.86	0.14	
7	OLODO 7	0.31	0.08	1.9	0.04	
8	IKUMAPAYI 1	0.11	0.11	1.57	0.02	
9	IKUMAPAYI 2	0.21	0.1	1.61	0.14	
10	IKUMAPAYI 3	0.16	0.1	1.43	0.05	
11	IKUMAPAYI 4	0.27	0.08	1.53	0.09	
12	IKUMAPAYI 5	0.09	0.11	1.67	0.06	
13	ARUBIEWE 1	0.15	0.06	1.4	0.12	
14	ARUBIEWE 2	0.22	0.12	1.57	0.01	
15	ARUBIEWE 3	0.14	0.11	1.63	0.02	
16	ARUBIEWE 4	0.19	0.11	1.52	0.04	
17	ARUBIEWE 5	0.25	0.12	1.54	0.12	
18	ARUBIEWE 6	0.17	0.04	1.36	0.12	
19	POLY 1	0.02	0.12	0.2	0.13	
20	POLY 2	0.001	0.03	0.001	0.01	
21	POLY 3	0.001	0.02	0.001	0.001	

Table: 5 Summary of the Results of Hydrochemical Anaylses

Parameters	Surface	Groundwater	WHO standard		CP
	Range	Mean	RL	MPL	Mean
pH	4.66-4.96	4.85	6.5	9.5	4.75
Cl-mg/l	10.8-72.2	21.01	250	600	15.5
$S0_4^{2}$-mg/l	0.001-74.07	14.79	250	400	2.62
$HC0_3^{-}$ mg/l	39.04-134.2	85.88	Variable	Variable	52.6
$N0_3^{-}$ mg/l	6.0-11.5	9.95	25	50	9.03
Mg (mg/l)	3.11-9.24	5.51	50	150	8.51
Ng (mg/l)	0.09-4.83	1.60	150	200	3.97
K (mg/l)	0.92-18.9	4.66	10	15	8.28
Fe (mg/l)	0.001-0.18	0.04	0.3	1.0	0.05
Pb (mg/l)	0.09-0.37	0.22	0.05	0.05	0.01
Zn (mg/l)	0.04-0.12	0.09	1.0	-	0.06
Cu (mg/l)	1.36-1.94	1.62	1.0	1.5	0.07
Cd (mg/l)	0.01.0,14	0.08	0.005	0.005	0.05

- RL = Recommended Level
- MPL = Maximum permissible Level
- CP = Control Point Mean.

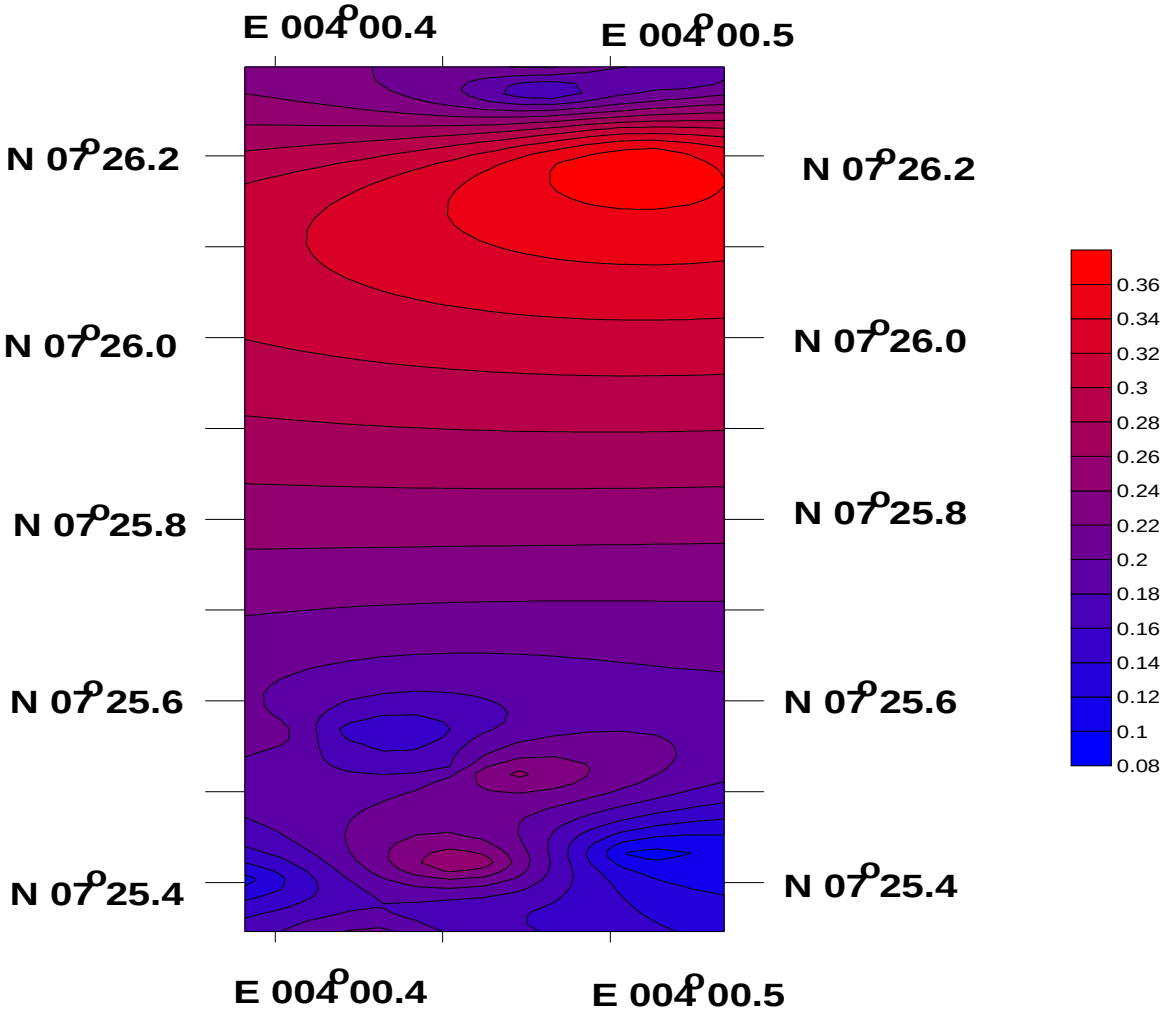
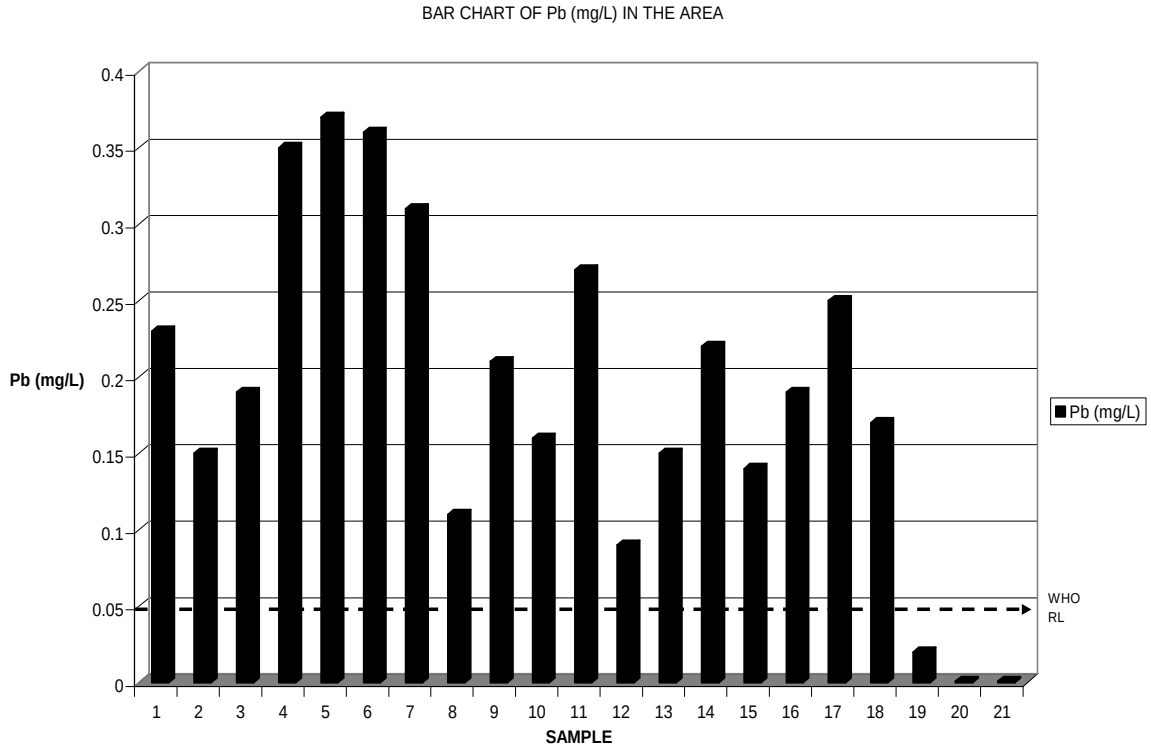


Figure 4: Map showing spatial distribution of Pb (mg/L)



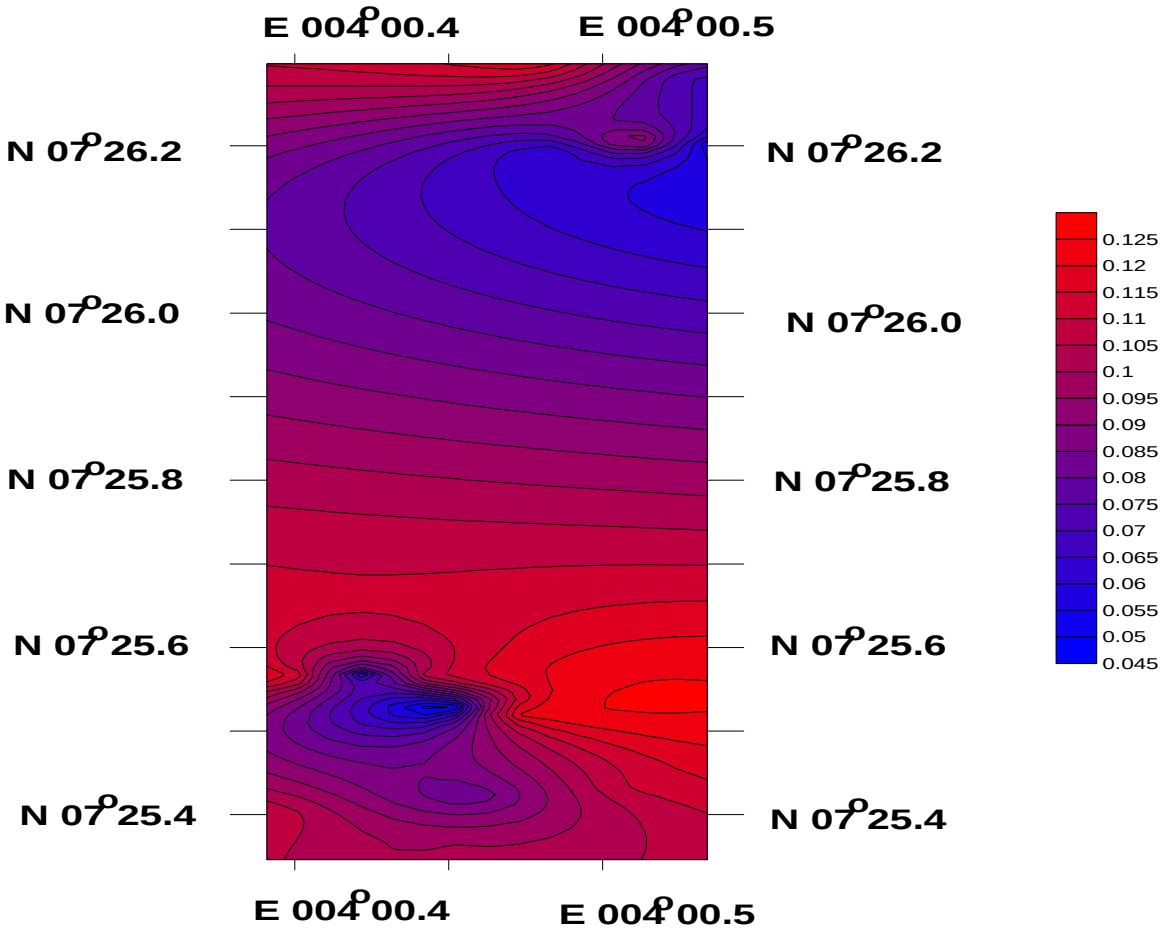
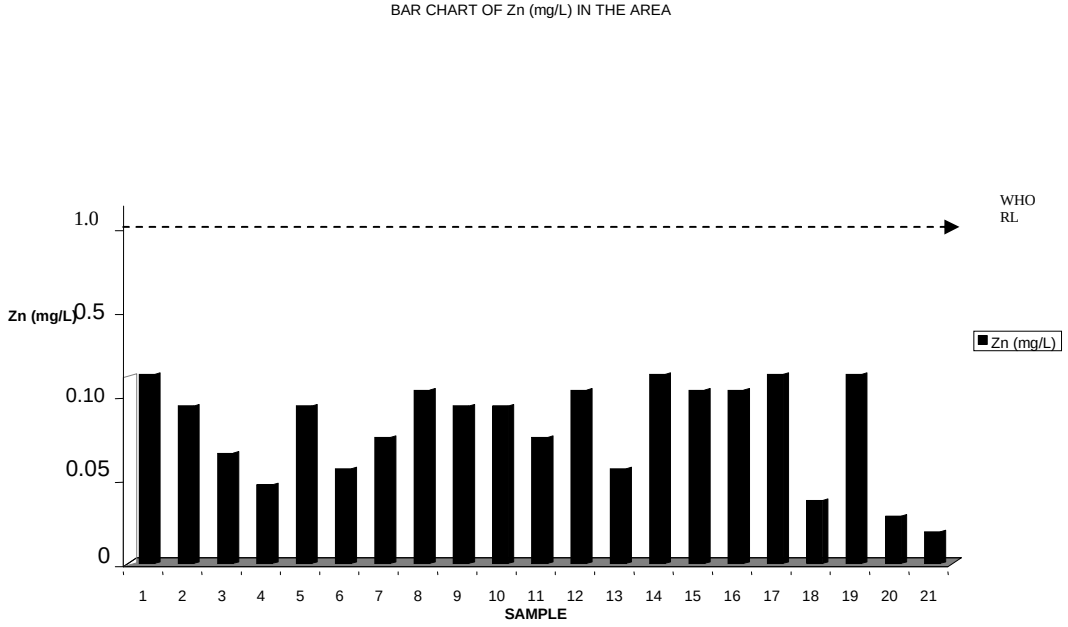


Figure 5: Map showing spatial distribution of Zn (mg/L)



The average concentration of Pb, Zn, Cu, and Cd were found to be high in Olodo, Arubiewe and Ikumapayi . The average values are Pb (0.22 mg/l), Zn (0.09mg/l),Cu (1.62 mg/l) and Cd (0.08mg/l). Pb concentration is presented in figure 4, which indicated high concentration of Pb as a result of the input from the waste of the Exide batteries and accumulators dumps. Pb concentrations in surface waters were found to be higher than that of the subsurface. (Well water e.g. samples 4 and 5 concentration are greater than samples 1, 2 and 3), (figure 4). The Pb concentration from unprotected well (11) is higher than that of the protected wells around it. Pb concentrations in samples from the polytechnic (control points) were found to be very low, except that of the pond near the road (sample 19) where there is high traffic density. The high concentration of sample is from the exhust of the vehicles traffic around the area.

The Pb concentration in Olodo, Arubiewe and Ikumapayi were found to be higher than the recommended permissible level by WHO. (Table 4,and figure 4.)

Zn concentration is on a high side, but the average value is below the permissible level recommended by WHO. (Table 4, figure 5.)

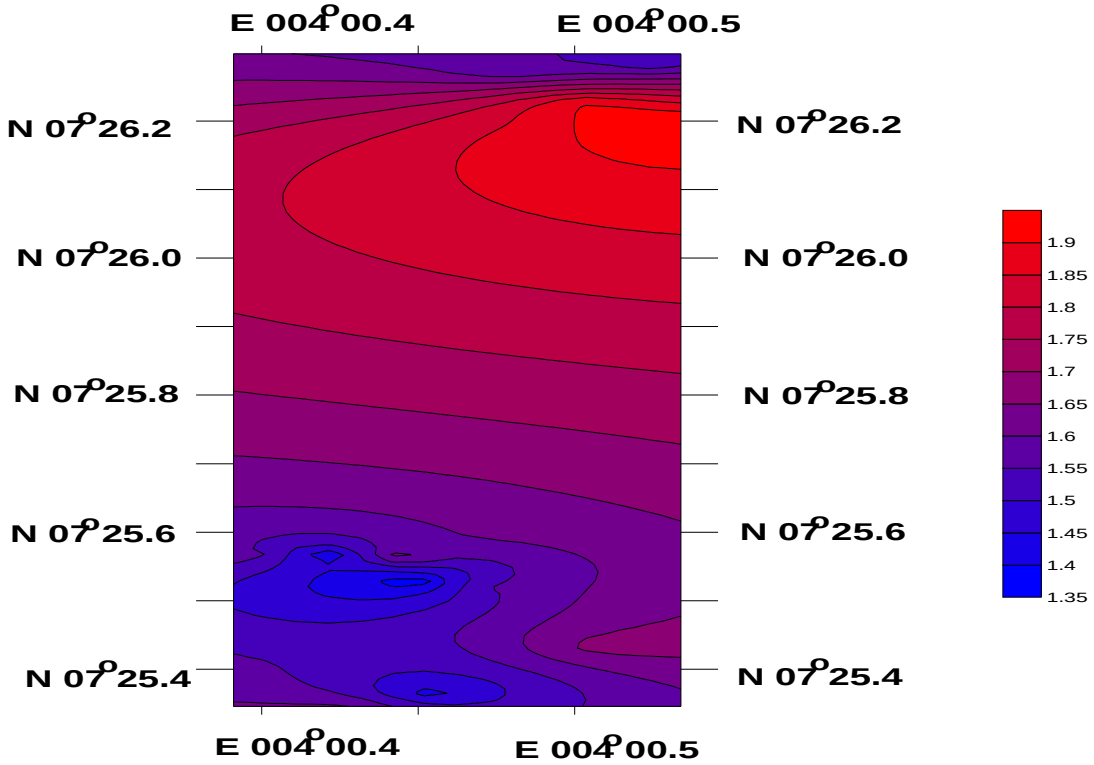
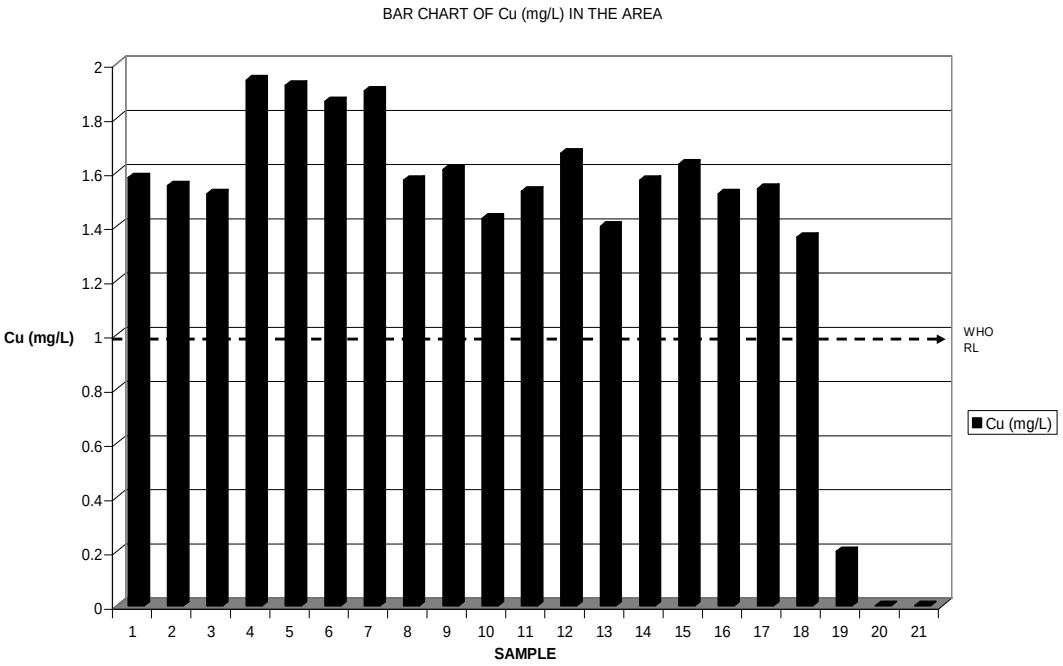


Figure 6: Map showing spatial distribution of Cu (mg/L)



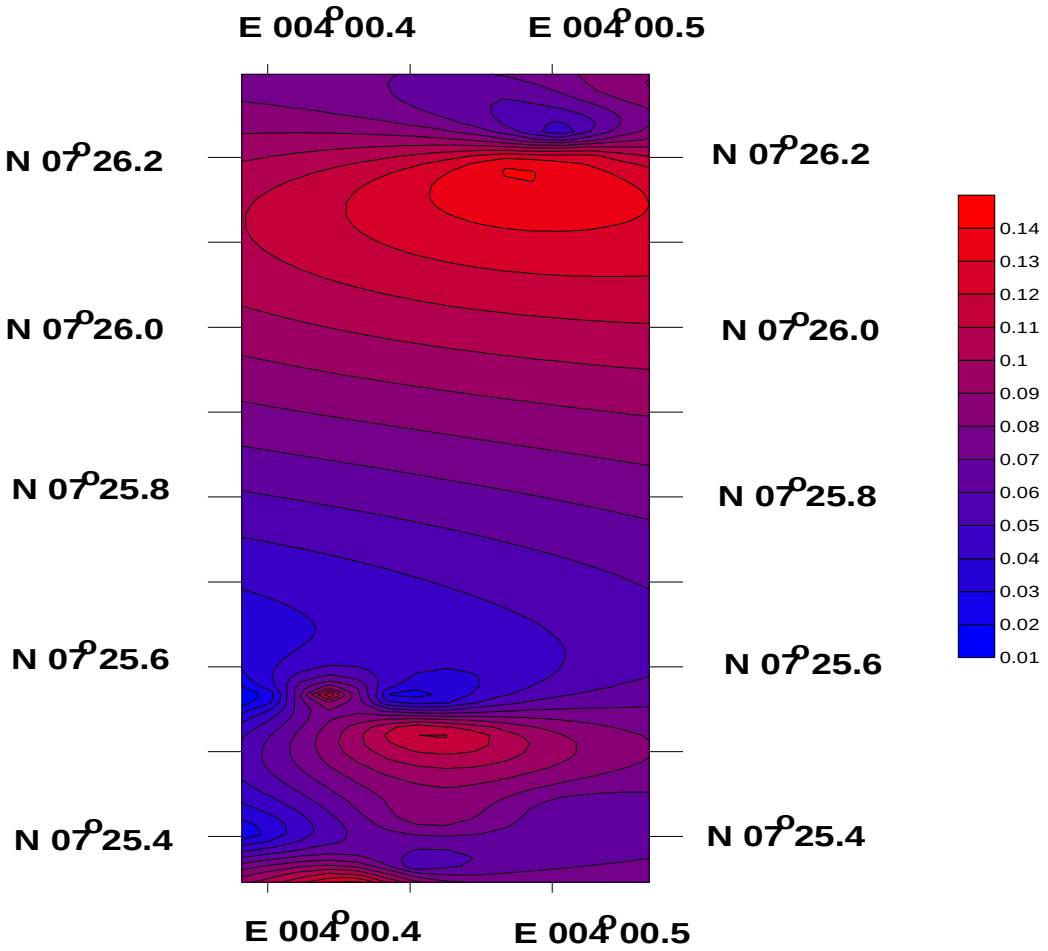
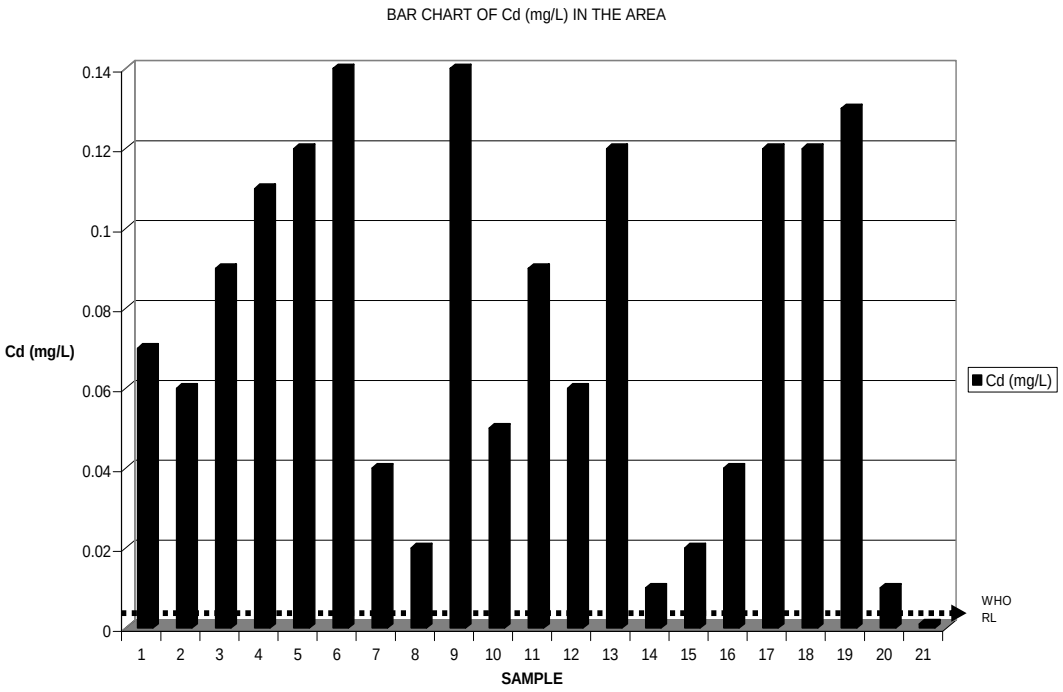


Figure 7: Map showing spatial distribution of Cd (mg/L)



WHO= W H O STANDARD

Cu concentration in both surface and ground waters of Olodo, Arubiewe and Ikumapayi were also found to be high. (Table 4, 5; and Figure 6.) The concentrations were higher than the permissible level recommended by WHO. The values for the control samples (19,20 and 21) from the Polytechnic Ibadan were found to be very low but recognizable value of (0.2 mg/l) was recorded for the pond.

Cd concentration in both surface and ground waters of Olodo, Arubiewe and Ikumapayi were found to be very high. The same range values were also recorded at the control points (sample 19,20 and 21) All the values were less than the permissible level recommended by WHO.((Table 4,5and Figure 7.)

Chemical Character and Water Quality:

The chemistry of water (surface and sub-surface) worldwide, is said to depend mostly on precipitation, mineral weathering and evaporation – crystallization processes (Gibbs, 1970). However, the effects of these controlling processes on different chemical species vary. Hudson et al (1997) pointed out that sulphate and chloride are controlled by precipitation and evapotranspiration, Sodium, magnesium, calcium and silica are controlled by mineral weathering, while Nitrate and potassium are controlled by plant uptake. The drinking water standards are generally based on two main criteria which are the colour and the presence of substances with adverse physiological effects (Davids and De weist, 1966). The results of the hydrochemical analysis were compared with those obtained through the same process from the control points (The Polytechnic Ibadan) and the World Health Organization Standard (WHO, 1996). A summary of these results and the standard are presented in Table 5.

All the pH values fall below the acceptable limits of the WHO (1996) standard. The concentration of $Cl^{-1,}$ $S0_4^{-2,}$ $HC0_3^{-}$ and $N0^{3-}$ fall within the acceptable limits. The concentrations of Mg, Na,K and Fe fall within the acceptable limits. The concentrations of Pb, Cu, and Cd fall well above the acceptable limits, while the concentration of Zn is below the acceptable limit. In terms of usage the high concentration of Pb, Cu and Cd make the water dangerous for plant, animals and man.

CONCLUSION AND SUGGESTION

From the hydrochemical analysis, it is concluded that there is a high concentration of Pb, Cu and Cd in both surface and ground waters of the areas. The concentration of Pb, Cu and Cd is above the acceptable limit recommended by WHO (1996). It is clear that the surface and groundwater within the area of batteries and accumulators waste dumpsites investigated in Ibadan (Olodo, Arubiewe and Ikumapayi) have been negatively influenced, since these are the main sources of water for domestic and agricultural purposes, these high concentration of Pb,Cu and Cd render the water unsafe for these purposes.

It is suggested that the Federal, State and Local Governments should drill deep wells in the study area for the abstraction of potable water. Treatment of water from the current sources is recommended for striping the water of the high concentrations of these heavy metals.

Government should also educate the people living in these areas on the impacts of the dumpsites on the water source in the area. Evacuation of wastes from the area to safe and well-engineered dumpsites is also recommended. More research work on the consequences of Pb, Cu and Cd concentrations on ecosystem should be encouraged to unravel and education of the public should be encouraged.

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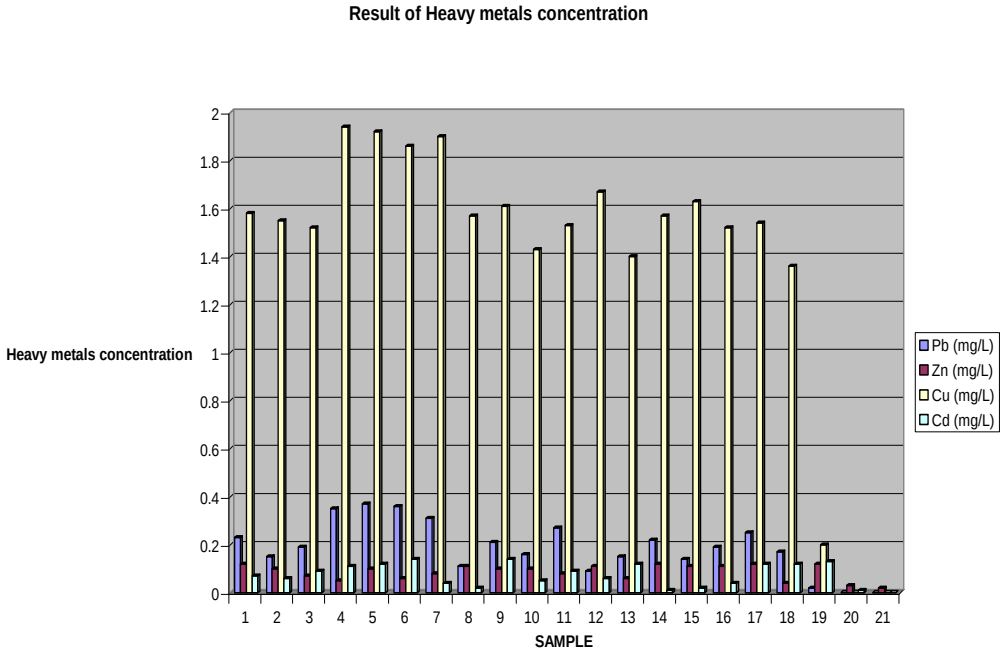


Figure 8: Variation bar chart of anions concentrations.

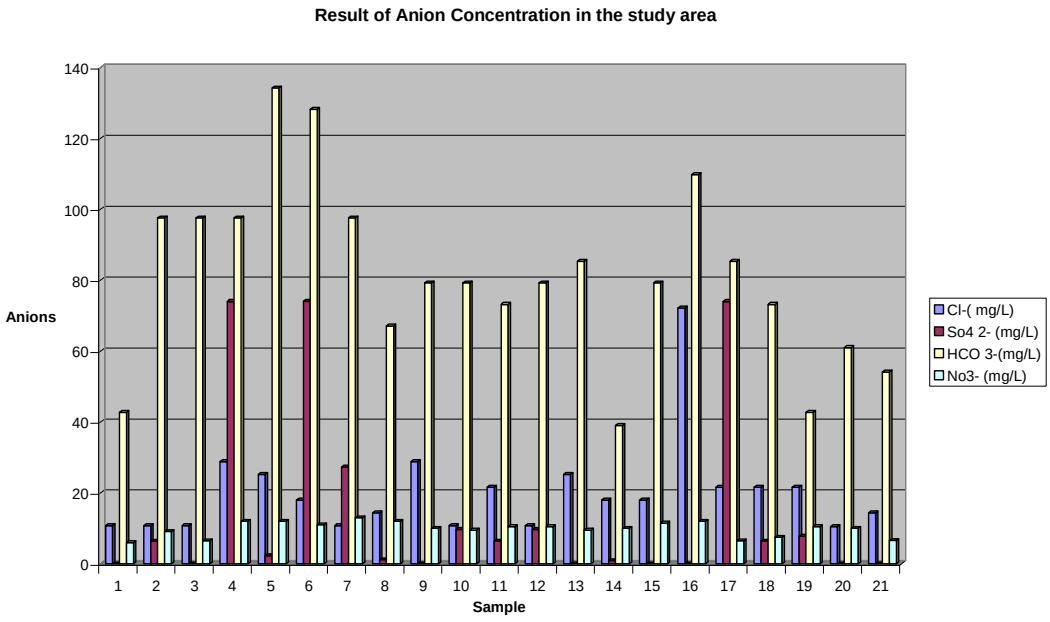
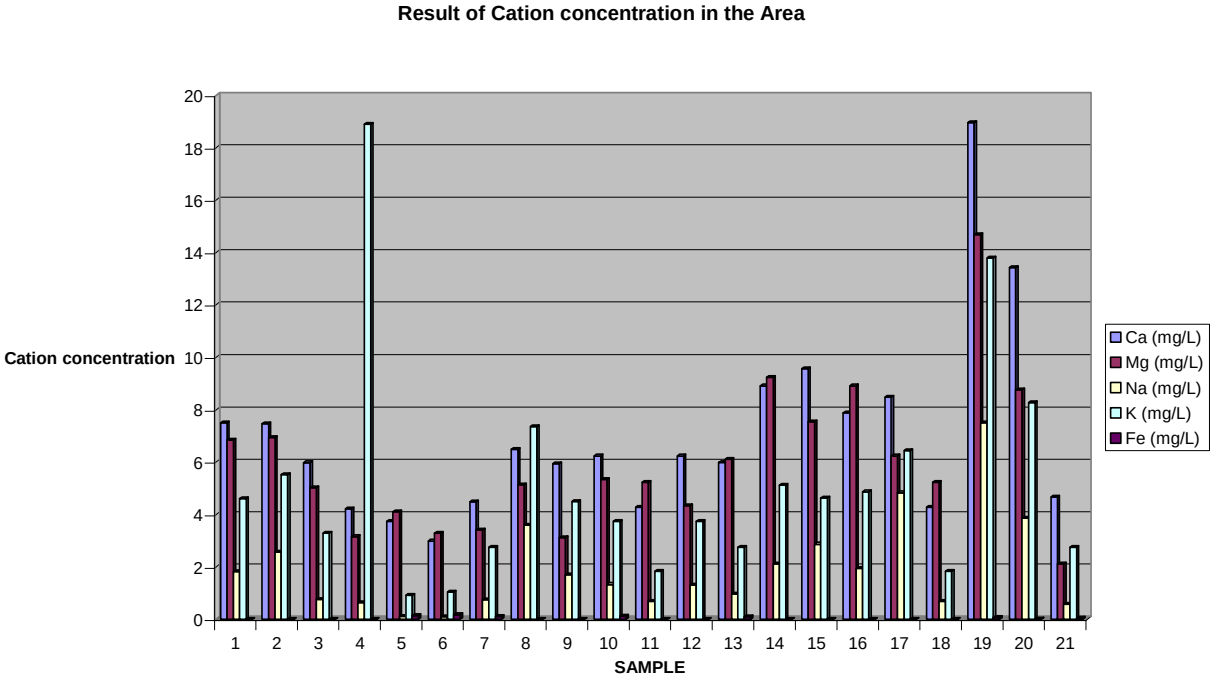


Figure 9: Variation bar chart of cations concentrations.



Sample No:1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

Zinc 0.12 0.1 0.07 0.05 0.1 0.06 0.08 0.11 0.1 0.1 0.08 0.11 0.06 0.12 0.11 0.11 0.12 0.04 0.12 0.03 0.02 1.0

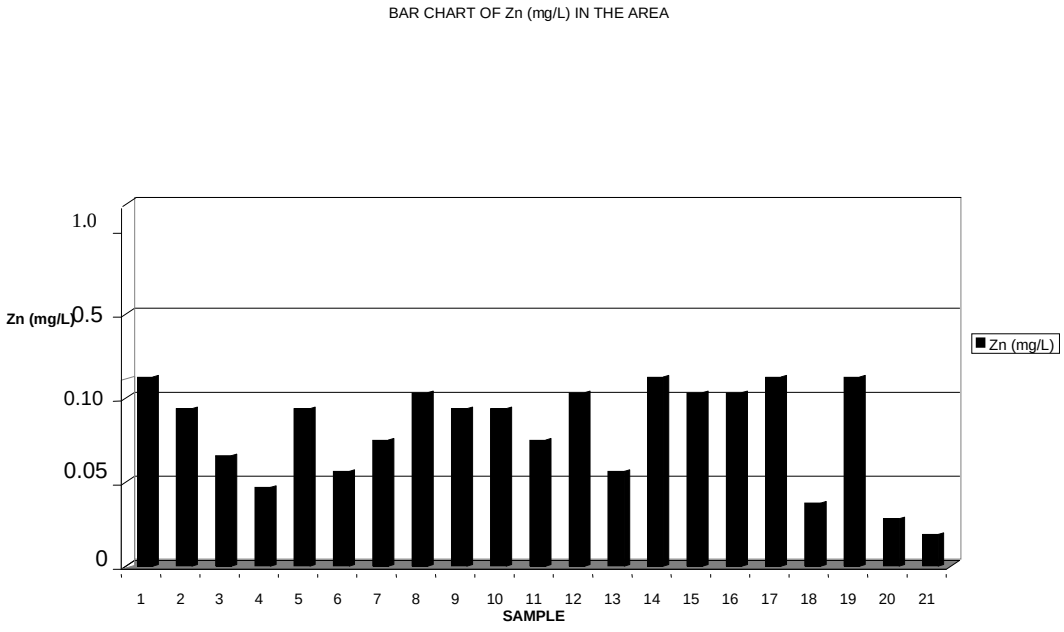


Figure 10: Variation bar chart of heavy metals concentrations.