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Assessing the Effect of a Dumpsite on Groundwater Quality: A Case Study of Aduramigba Estate within Osogbo Metropolis.

Oyelami A. Charles[1*] Ojo A. Olabanji[1] Aladejana J. Abimbola[2] Agbede O. Olamide[1]

1. Osun State University, P.M.B 4494, Osogbo, Osun State.
2. Afe Babalola university, Ado Ekiti.

* E-mail: adebayo.oyelami@uniosun.edu.ng

Abstract

This research assessed the impact of an open dumpsite, on the quality of groundwater within the vicinity of Aduuramigba Estate. Twenty water samples were collected and analyzed for physic-chemical parameters, major ions and trace metal using AAS, Iron Chromatographic and titrimetric methods.

The result showed that almost all the physico chemical parameters such as pH (7.5-10.8), temperature (27.4^{o}C-31.5^{o}C,) EC (70µS/cm-364 µS/cm), TDS (49-248mg/l) fall within limits as recommended by WHO and NSDWQ. Chemical parameters has the following results: Cl^- (122-720mg/l), SO_4^{2-} (0-7.41mg/l), NO_3^-(0.64-1.64mg/l), HCO_3^- (12.20-91.5mg/l), Ca^{2+} (3.95-65.12mg/l), mg^{2+} (0.73-17.28mg/l), Fe^{2+} (0-1.36mg/l), Na^+ (3.45-27.37mg/l), k^+ (1.04-24.41mg/l) Mn^{2+} (0-0.57mg/l). All major ions revealed concentration within the acceptable limit of both standards except Chloride and Sodium in some of the wells, this is due to the addition of a disinfectant named Sodium Dichloroisocyanurate ($C_3N_3O_3CL_2Na$) commonly called water guard and weathering of feldspars which characterized the basement rocks underlying the area. Most of the trace metals tested for were below detectable limit of the AAS except Zinc, Iron and Manganese. Iron and Zinc concentrations fall well within the acceptable limit of both WHO and NSDWQ standards while Manganese concentration were above the limit in most of the surface and shallow groundwater at the down slope of the Dumpsite. This could be attributed to the impact of the leachates from the waste and because of the persistent nature of manganese within the medium, it may not be easily attenuated.

Keywords: Leachates, dumpsite, groundwater, conductivity, basement rocks.

1. Introduction

Waste disposal and management remains one of the major challenges in the developing countries. Waste if not properly disposed could lead to contamination of surface and groundwater in its immediate environment. Vodela *et al*., (1997) noted that one of the most important environmental issues today is ground water contamination and between the wide diversity of contaminants affecting water resources, heavy metals receive particular concern considering their strong toxicity even at low concentration.

The practice of landfill system as a method of waste disposal in many developing countries is usually far from standard recommendations (Mull, 2005; Adewole, 2009). Landfills are sources of groundwater and soil pollution due to the production of leachate and its migration through refuse (Chistensen & Stegmann, 1992). In recent times, the impact of leachates on groundwater and other water resources has attracted a lot of attention because of its overwhelming environmental importance. Leachates migration from wastes sites or landfills and the release of pollutants from sediments (under certain conditions) pose a high risk to groundwater resource if not adequately managed (Ikem et al. 2002). Water has unique chemical properties due to its polarity and hydrogen bonds which means it is able to dissolve, absorb, adsorb or suspend many different compounds (WHO, 2007), thus, in nature, water is not pure as it acquires contaminants from its surrounding and those arising from humans and animals as well as other biological activities (Mendie, 2005).

This research was carried out with a view of assessing the effect of leachates from a dumpsite on the groundwater, in order to achieve this aim, the hydrochemical results were compared with the World Health Organization (WHO, 2004) standard for drinking water and Nigerian Standard of Drinking Water Quality (NSDWQ, 2007) with the motive of predicting their level pollution and/or contamination as the case may be.

2. Study Area, Hydrogeological and Geological Settings

The study area is Aduramigba Estate and its environs, it falls within the Southwestern part of Nigeria. Ido osun local government area of Osun state, Nigeria. It lies between longitude 07° 46' 35" N - 07 °47' 45" N and latitude 004° 29' 14" E-004° 30' 28" E. The area is part of Osogbo Metropolis and its made accessible by the Iwo-Osogbo major roads. Osogbo being a State capital has witnessed rapid growth in population, according to 2006 census report has about 154,694 people. The dumpsite is the only and the most active dumpsite for all the inhabitants of Osogbo metropolis. The area is characterized by the tropical rain forest. The temperature ranges from 19^0C to 34^0C with an annual mean temperature of about 24^0C. The average rainfall is about 350 mm. Hydrogeologically, the drainage pattern is dendritic due to clayey weathered overburden overlying the basement complex rock. The area is characterized by many rivers flowing NW-SE and discharged into river Osun. See figure 1.

The area is underlain by basement complex. It is part of the Ilesha Schist belt. The main lithologies in the area include amphibolites, pegmatite and quartzite. Quartzites within the study area outcrop as massive ridge. The quartzite outcrops mostly in the southern part of the area (See fig.2). Only few outcrops occur as boulders. Pegmatite in the area occurs as intrusions within the ridges and some low-lying outcrops at times forming an isolated hill. They are the most widespread of the rock types in this area. The amphibolites are flat lying and occur mainly as boulders. They outcrop in two places in the study area in the south eastern part. They are greenish black in color. They are mainly fine grained and contain hornblende and epidote.

3. Sampling and Laboratory Analyses

Twenty wells were sampled away from the dumpsite at Ido osun area. Global Positioning System was used to georeference each sampling point. Physico-chemical parameters like EC, tempratue and pH were taken in-situ with the aid of multi parameter EC/pH meter. Other physical parameters tested include: depths to water level, depth to bottom of the well, total dissolved Solids, colour, odour, taste and turbidity. Two drops of Nitric Acid (HNO_3) was dropped in the cation sampling bottle to prevent metallic ions from adhering to the walls of the container and homogenize the water sample. Samples were refrigerated to prevent loss of ion and laboratory analysis was carried out within 48hours at the Agronomy Departmental water laboratory, University of Ibadan. Cations and heavy metals analyses were carried out using Atomic Absorption Spectrophotometer, while anion analysis was done using Iron Chromatographic method and titrimetric method was used for SO_4 and HCO_3. All tests were done in accordance to the prescription of APHA 2005. In all, four anion namely: Nitrate (NO_3^-), Bicarbonate (HCO_3^-), Chloride (Cl^-) and Sulphate (SO_4^-). Thirteen metals were tested these include: Calcium, Magnesium, Potassium and Sodium, together with heavy metals: Manganese, Iron, Copper, Zinc, Cobalt, Chromium, Cadmium, Lead and Nickel. All these were compared with the World Health Organization (WHO) and Nigerian Standard Drinking Water Quality.

4. RESULTS AND DISCUSSIONS

4.1. Physico-chemical parameters

Table 1 summarizes the physico-chemical parameters as compared with the World Health Organisation Standard for Drinking water and the Nigerian Standard for Drinking Water Quality (NSDWQ). pH value ranges between 7.5-10.8 with most wells within the permissible limit of WHO, the high values noticed in some of the wells, signifies the water is alkaline, this may be due to the fact that the wells were freshly dug, equally the underlying geology which has pegmatite rich in mica and feldspar affected the pH of the well. Temperature is relatively high for most well especially those that were located at the Northeastern part of the study area, which was close to the dumpsite; this indicated the influence of effluent from the dumpsite on the surrounding wells. Generally speaking, samples from Aduramigba are having higher temperature compared to those from Ido osun which serves as control for the work.

EC is a valuable indicator of the amount of materials dissolved in water. Conductivity ranges from 70 to 364µs/cm with an average value of 199.4µs/cm. The conductivity around Ido osun town gently varies compared to those around Aduramigba with steep concentration indicated by the concentration contour map in Fig 5. This indicated a certain level of pollution from the effect of leachates from the dumpsite on the wells around Aduramigba, this is due to its proximity dumpsite. Though all conductivity and TDS values with ranges of 70 to 364 average of 199.4µs/cm and 49 to 248.2 with an average of 142.2 respectively, falls within the permissible limit of drinking water as prescribed WHO, (2004) and NSDWQ standard (2007). The result implies that the water around Adduramigba estate is suspected to be polluted but not contaminated yet. This is confirmed by the trend of concentration contour map as shown in fig. 6. The result equally agrees with the findings of Akinbile 2011.

4.2 Anions

Table 2 gives the summary of the anion with their corresponding standards i.e WHO and NSDWQ while figure 2 shows their variation within wells. Following observations were made. Chloride in the wells varies from 122 to 720 with an average value of 268.87 mg/l. Some wells (4,5,7,8,15,16,18&19) exceed the maximum permissible limit by WHO (2003) and NSDWQ standard (2011) which is 250 mg/l. An excess of chloride in water is usually taken as an index of pollution and considered as tracer for groundwater contamination (Loizidou and Kapetanois, 1993). The excessive content in these wells may not necessarily indicate pollution, they maybe as a result of the

recent treatment of the wells with a compound, popularly known as waterguard. This compound contains more than 50% chlorine and about 20% sodium. To confirm this, high chloride concentration also coincides with wells of high sodium concentration.
Sulphate concentration in the wells varies from 0 mg/l to 7.413 mg/l with an average of 1.341 mg/l which is very low compared with the permissible limit of 250mg/l and 100mg/l of WHO and NSDWQ respectively. These are within the range described by Abdurafiu et.al. (2011) which according to him shows that the groundwater under review are free from possible sulphate toxicity which include gastrointestinal irritation. The low level of sulphate could be as a result of microbial action capable of reducing $SO4^{2-}$ to S^{-} leading to depletion of sulphate in study areas. (Abdurafiu et. al, 2011).

Unpolluted natural waters usually contain only minute quantities of nitrate. Nitrate like chlorine is also an index of groundwater pollution. The nitrate concentration in the wells varies from 0.641 to 1.638 with an average value of 1.073 mg/l as compared with 50mg/l limit of both WHO and NSDWQ. This result corresponds with those of Adeyemo et al. who described nitrate concentration of 0.1 mg/l to 10 mg/l as being in its natural concentration in groundwater. Steep contours around Aduramigba as shown in figure 7 infers higher concentration due to possible interaction between the dumpsite and groundwater.
The bicarbonate concentration in the wells varies from 12.20 to 91.50 with an average value of 58.22 mg/l. All the well samples falls within the permissible limit of WHO (2004).

4.3 Cation

Table 3 gives the summary of major cation. Calcium concentration varies from 3.95 to 65.12 with an average of 23.42 mg/l. Magnesium concentration varies from 0.73 to 17.28 with an average of 4.39 mg/l. Calcium and magnesium varies widely in all the twenty well samples as shown in figure 3 with a relatively high concentration value, the presence of this two ions in groundwater relates to the hardness of the water. Though all values are within the permissible limit of 75mg/l and 50mg/l for calcium and magnesium respectively.

Table 1: Physico-chemical Parameters

Well No	pH	EC(µS/cm)	TDS(mg/l)	Temp(^{o}C)	DtoW(m)	DtoB(m)	Comment
1	8.1	209	146.3	27.4	4.9	7.3	Colorless, Odorless
2	8.8	126	88.2	28.7	5.9	6.0	Colorless, Odorless
3	8.6	147	102.9	28.5	3.9	4.1	Milky cl. Odorless
4	9.4	173	121	28.5	3.3	3.4	Turbid, Odorless
5	8.8	286	200.2	28.1	1.0	1.9	Colorless, Odorless
6	9.1	259	181.3	27.4	3.5	3.7	S. Turbid. Odorless
7	8.8	259	181.3	27.8	7.1	7.2	Treated, Odorless
8	10.8	262	183.4	27.8	3.4	6.1	Treated, Odorless
9	8.6	239	167.3	27.4	7.5	9.3	Colorless, Odorless
10	8.9	168	117.6	27.8	9.2	13	Colorless, Odorless
11	7.5	70	49	28.3	6.2	7.4	Colorless, Odorless
12	8.0	231	161	27.7	6.4	8.5	Colorless, Odorless
13	7.6	86	60.2	28.5	4.7	7.6	Colorless, Odorless
14	8.8	364	254.8	31.5	6.5	9.3	Colorless, Odorless
15	8.8	277	193.9	29.0	6.0	8.7	Colorless, Odorless
16	8.7	95	66.5	30.5	5.7	7.6	Treated, Colorless
17	8.0	146	102.2	30.5	4.5	6.2	Colorless, Odorless
18	8.1	215	150.5	29.0	4.7	7.3	Colorless, Odorless
19	8.6	273	191.1	28.5	5.6	8.5	Milky New well
20	8.2	103	72.1	28.0	7.2	8.3	Treated Odorless
WHO [ ]	**6.5-9.5**	**1400**	**500**				
NS [ ]	**6.5-8.5**	**1300**	**500**				

D to W: Depth to Water, D to B: Depth to Bottom, NS: Nigerian Standard for Drinking Water.

Table 2: Anion concentrations values in water samples.

Well	NO_3^-(mg/l)	HCO_3^-(mg/l)	Cl^-(mg/l)	SO_4^-(mg/l)
1	0.748	91.5	216	2.224
2	0.659	30	187.2	ND
3	0.641	45.75	136.8	2.246
4	0.936	61	360	0.743
5	1.371	61	295.2	2.717
6	1.104	61	273.6	0.619
7	0.979	61	720	ND
8	1.495	12.2	648	7.413
9	0.997	61	122	0.246
10	0.819	75.25	180	0.743
11	1.638	61	144	ND
12	1.175	61	144	0.246
13	0.712	45.75	129.6	1.235
14	1.175	61	129.6	2.654
15	0.641	61	252	0.246
16	0.926	30.5	532.8	0.246
17	1.46	30.5	129.6	ND
18	1.353	61	288	1.235
19	1.317	91.5	288	ND
20	1.317	91.5	201.6	ND
WHO [ ]	**50**	**250**	**250**	**250**
NS[ ]	**50**	**250**	**250**	**100**

Presence of Iron and Manganese can lead to change in coloration of groundwater (Rowe et al., 1995). Iron concentration varies from 0 to 1.36 with an average of 0.23mg/l while sodium has 3.45 to 27.37 with 11.75mg/l average. Sodium concentration in the wells are generally low excluding some wells such as wells (5, 7, 8, 15,18&19) with fairly high concentration. The high concentration is in the wells as earlier discussed, is as a result of the wells being recently treated with water guard ($C_3N_3O_3CL_2Na$). Potassium concentration varies from 1.04 to 24.41 with an average value of 5.66mg/l. Two wells (8&19) exceed the maximum permissible limit by WHO (2004) and NSDWQ standard (2007). This is due to the underlying geology of the area as confirmed by the soil around the well gotten from the recent digging of these wells. The soil appear to be weathering products of k-feldspar present in pegmatite which happens to be the underlying rock in the area. The well being a new well which has not been used or treated, preserved the effect of this mineralogy. Manganese concentration varies from 0 to 0.57 and has an average value of 0.11 mg/l. About half of the well sampled are above the recommended limit. In deep wells manganese may reach concentrations as high as 2 to 3 milligram per liter, this is because, solid waste when dissolved usually contains abundant manganese (Hughes 2004). Wells with a fairly high amount of manganese in the study area corresponds with increasing depth. This indicates a level of pollution in these wells due to the effect of dissolved solid waste from the dumpsite. Manganese can be kept in solution by adding a small amount of sodium hexameta-phosphate to the water (Wilham, et al., 2005).

4.4 Other Trace Metals

Most of the trace metals tested for were below detectable limit of the AAS except Zinc, Iron and Manganese (See figure 4). Zinc concentration varies from 0 mg/l to 0.041 mg/l with an average value of 0.015 mg/l. It shows probably pollution from either anthropogenic sources or due to toxic wastes, zinc may not be easily attenuated and also the dumpsite is bounded in both east and west by wetlands, this can aid the movement of leachates as some of the wells are being recharged by the surface water close to them. This result is in agreement with those of Tijani (2009) where he reported that the dominant total trace metals in urban stream water observed from Osogbo metropolis include: Manganese, Lead, Zinc, Cadmium and Nickel.

5. Conclusion

This study had assessed the impact of waste dumpsite on the shallow groundwater and surface water quality around an active dumpsite in Ido Osun area of Oshogbo metropolis. The low contamination observed may be attributed to high compaction level observed in most of the weathered overburden of the soil underlying this area which could act as protective layer. Although there seems to be a little pollution in the area as typified by presence of some trace metals (e.g. Mn, Zn) in high concentration and in the trend of the selected contour maps (fig. 5-8). On-going assessment/monitoring of water quality from time to time, especially around Aduramigba estate, together with the bacteriological assessment is encouraged to complement this study. Improved waste disposal management system is advised, with padded clay layers to serve as absorbent and attenuation for leachates should be introduced to the dumpsite, since the wetlands in the vicinity of this dumpsite could promote leachate migration especially during the raining season if this trend of improper waste disposal habit is not properly controlled, this could as well lead to severe contamination of the groundwater resources of the area. A constant monitoring of the groundwater quality is highly recommended especially at the Northeastern part of the study area where concentrations were fairly on the high side.

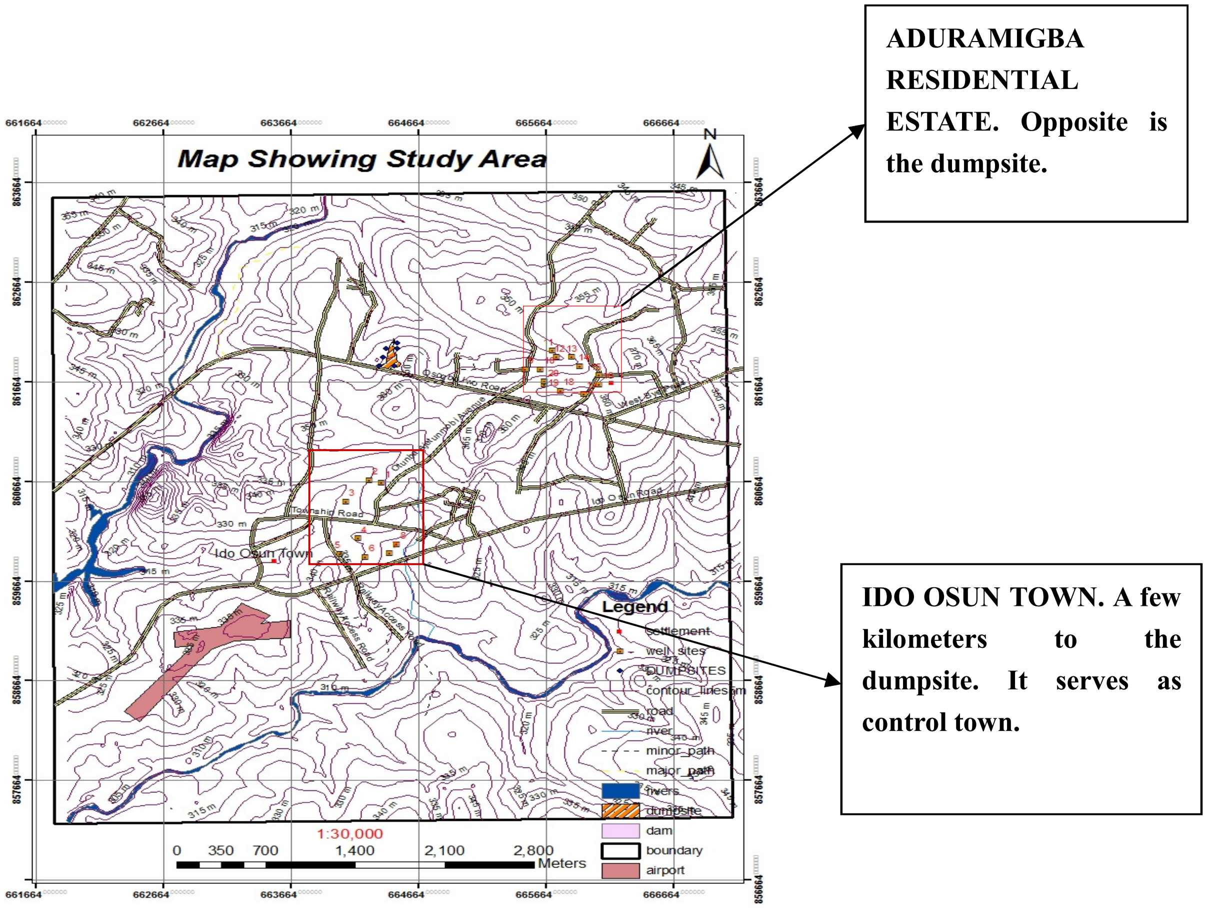

Figure 1: Location map showing the study area.

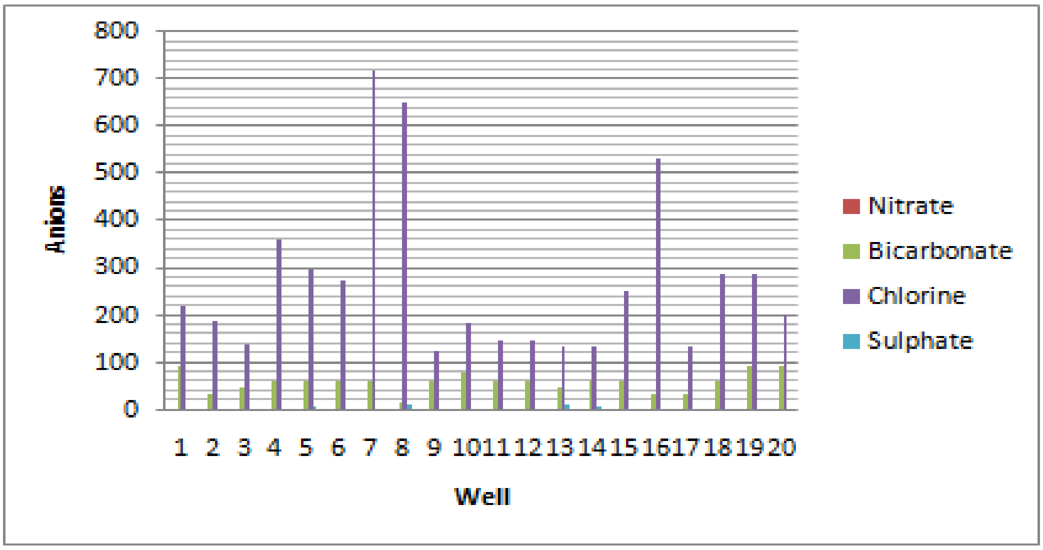

Figure 2: Bar chart showing the anion variation within the study area

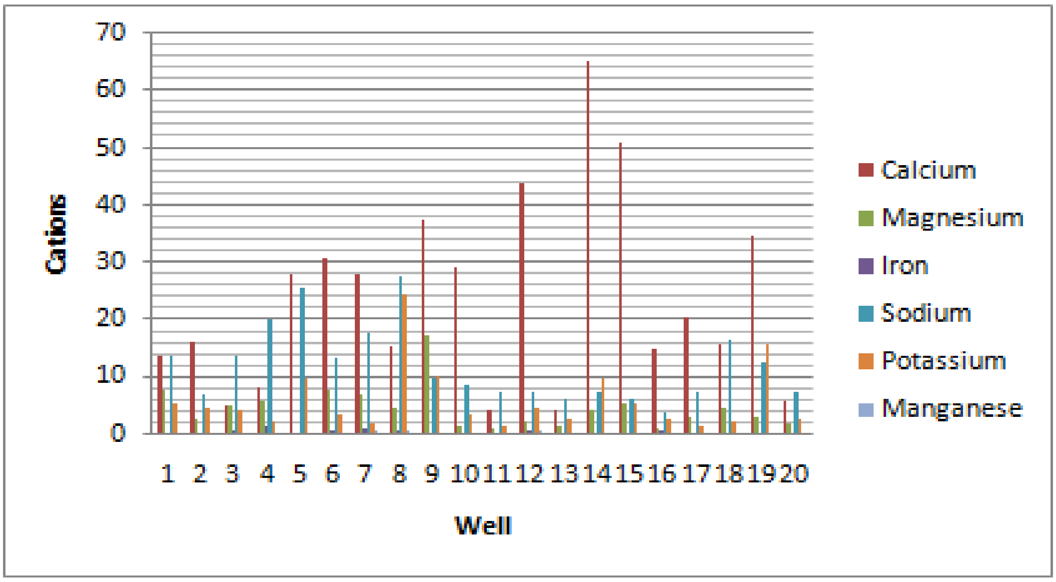

Figure 3: Cation distribution within wells.

Figure 4: Other trace metal distribution within wells.

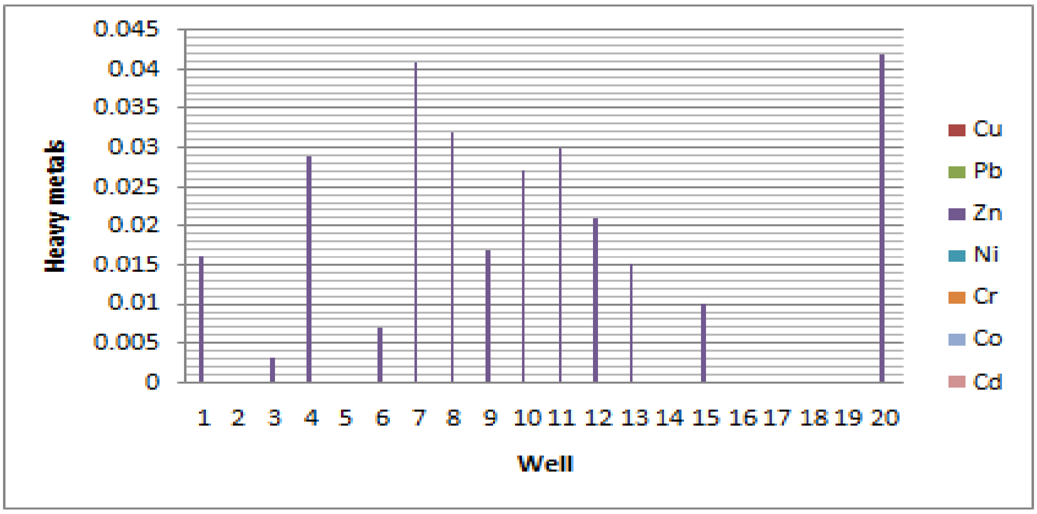

Table 3: Cation concentration values compared with WHO and NSDWQ.

Well	Ca(mg/l)	Mg(mg/l)	K(mg/l)	Na(mg/l)	Mn(mg/l)	Fe(mg/l)	Cu(mg/l)	Zn(mg/l)	Co(mg/l)	Cr(mg/l)	Cd(mg/l)	Pb(mg/l)	Ni(mg/l)
1	13.45	7.59	5.2	13.45	0.01	0.19	0	0.016	0	0	0	0	0
2	15.78	2.39	4.57	6.85	0.05	0.12	0	0	0	0	0	0	0
3	4.61	4.91	3.79	13.68	0.02	0.59	0	0.033	0	0	0	0	0
4	8	5.44	1.85	19.84	0.1	1.36	0	0.029	0	0	0	0	0
5	27.84	5.39	9.5	25.64	0	0.15	0	0	0	0	0	0	0
6	30.82	7.67	3.27	13.12	0.18	0.25	0	0.007	0	0	0	0	0
7	27.72	6.85	1.49	17.46	0.57	0.68	0	0.041	0	0	0	0	0
8	15.11	4.55	24.41	27.31	0.34	0.29	0	0.032	0	0	0	0	0
9	37.38	17.28	9.84	9.56	0.08	0	0	0.017	0	0	0	0	0
10	28.84	1.01	3.15	8.3	0.09	0.16	0	0.027	0	0	0	0	0
11	3.95	0.73	1.04	7.12	0.01	0.04	0	0.03	0	0	0	0	0
12	43.75	1.84	4.39	7.11	0.39	0.29	0	0.021	0	0	0	0	0
13	4.13	1.09	2.48	6.11	0	0.05	0	0.015	0	0	0	0	0
14	65.12	3.78	9.47	7.23	0	0	0	0	0	0	0	0	0
15	50.82	5.08	5.01	5.85	0.1	0	0	0.01	0	0	0	0	0
16	14.72	0.81	2.41	3.45	0.04	0.21	0	0	0	0	0	0	0
17	20.41	2.64	1.39	7.11	0	0.01	0	0	0	0	0	0	0
18	15.59	4.44	1.99	16.25	0.04	0.17		0	0	0	0	0	0
19	34.56	2.84	15.32	12.45	0.07	0.09	0	0	0	0	0	0	0
20	5.7	1.55	2.55	7.01	0.02	0	0	0.042	0	0	0	0	0
WHO[]	**75**	**50**	**10**	**50**	**0.3**	**300**	**1**	**5**	**Nil**	**0.01**	**0.01**	**0.3**	**0.02**
NS[]	**75**	**50**	**10**	**50**	**0.2**	**300**	**1**	**3**	**0.01**	**0.05**	**0.03**	**0.01**	**0.02**

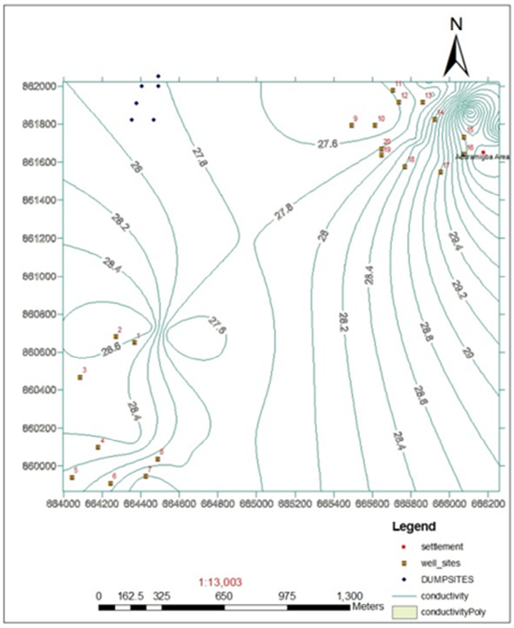

Figure 5: Conductivity Conc. Contour map

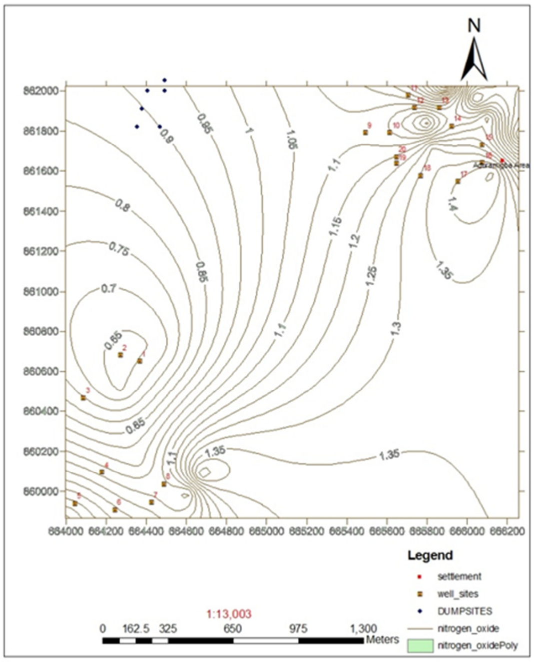

Figure 7: Nitrate Concentration Contour Map

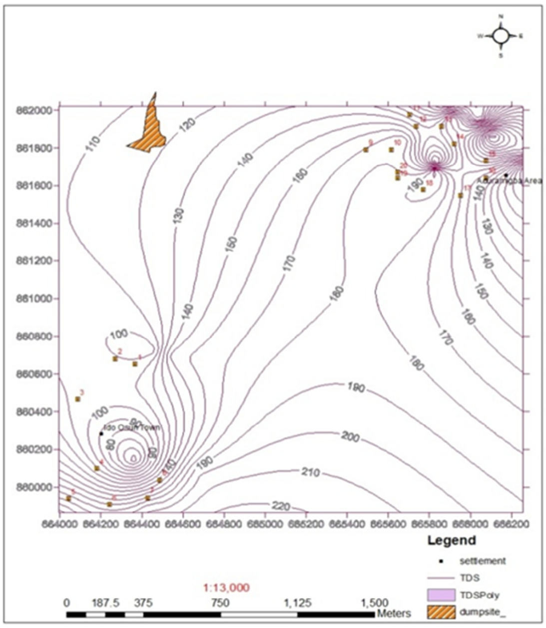

Figure 6: TDS Concentration Contour map.

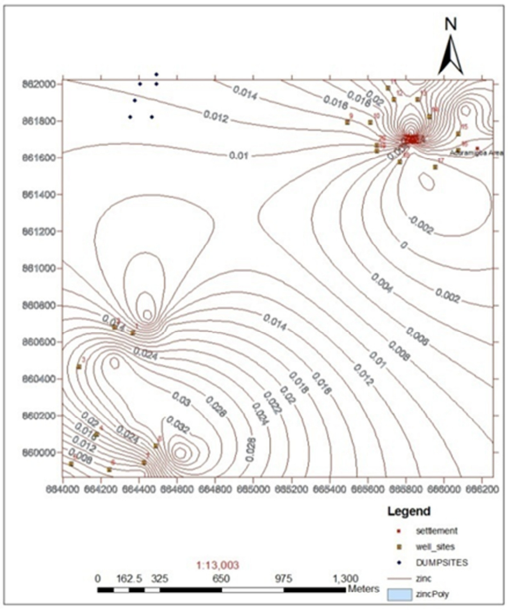

Figure 8: Zinc Concentration Contour Map

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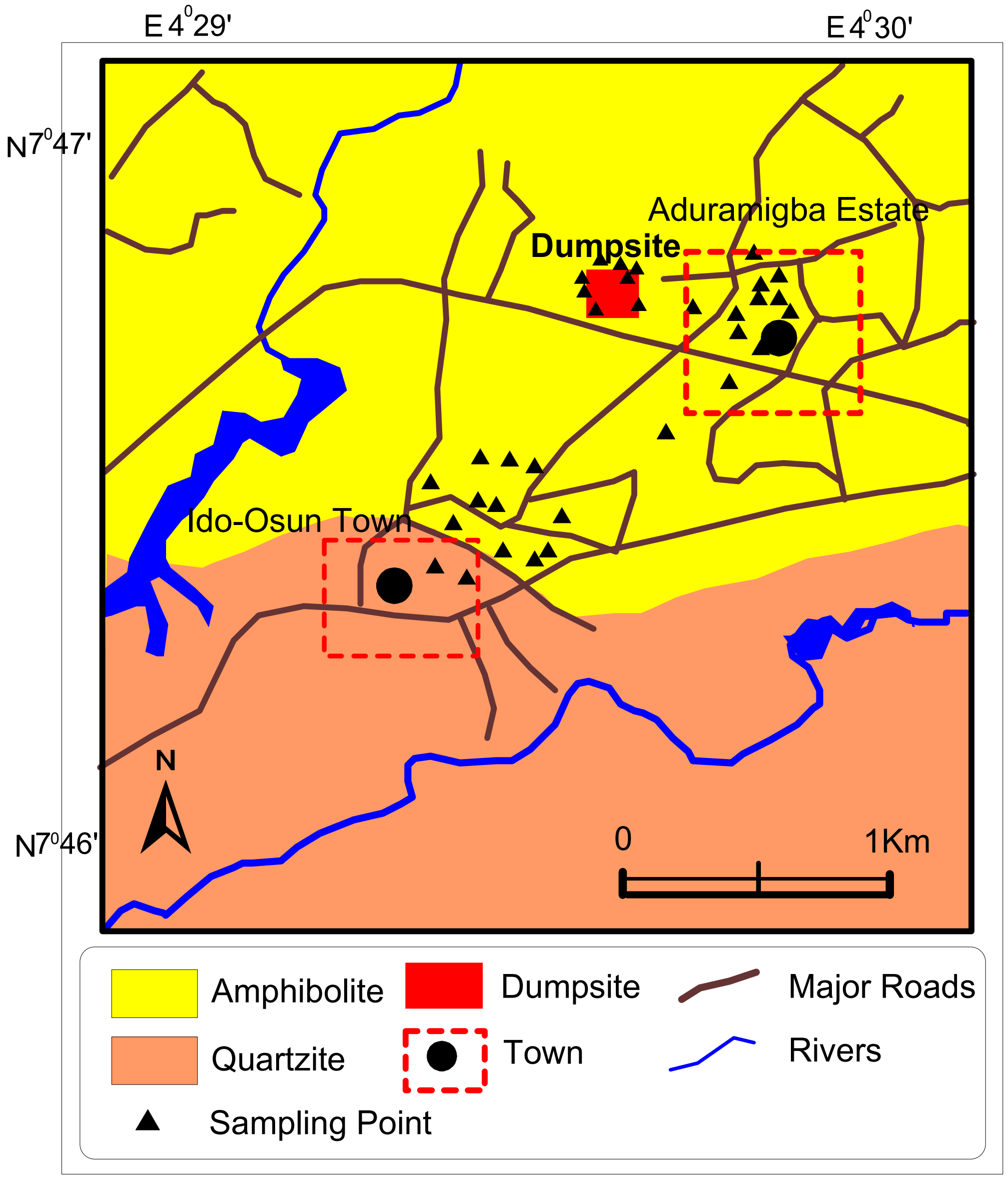

Figure 2: Geological Map of the Study Area.