British Journal of Environmental Sciences

Vol.8, No.2, pp. 57-68, July 2020

Published by ECRTD-UK

ISSN 2054-6351 (print), ISSN 2054-636X (online)

GROUNDWATER QUALITY MAPPING IN IKOT ABASI USING GEOGRAPHIC INFORMATION SYSTEM (GIS)

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ABSTRACT: *In this work, the GIS Software Quantum 1.7.0 was used to analyse and create groundwater contoured maps for Ikot Abasi. Five groundwater samples were collected and analysed for some physical parameters (pH, temperature, turbidity, conductivity, total dissolved solids) and trace metals (aluminum, zinc, manganese, chlorine, copper). The physical properties were measured directly using HQ40D multi-parameter, while the trace metals were determined using atomic emission spectroscopy. The water parameters of concern were aluminum and manganese because they had marked departure from the WHO standard. The aluminum values in the area ranged from 0.2 mg/l to 0.4 mg/l, with an average value of 0.34 mg/l which is above the WHO limit of 0.2 mg/l. The manganese values in the area ranged from 2.13 mg/l to 2.18 mg/l, with an average value of 2.16 mg/l which is above the WHO limit of 0.1 mg/l. Treatment measures should be considered to reduce the concentration of these metals.*

KEY WORDS: Trace metals, groundwater, Ikot Abasi, WHO

INTRODUCTION

Groundwater is the major source of fresh water for drinking, irrigation and industrial uses and indispensable for our day to day existence, but over time anthropogenic activities have resulted in degradation of its quality. For its sustainable use, quantity and quality issues have to be addressed together. Groundwater contamination with metals is one of the most important environmental issues in the world (Kumar *et. al*., 2012). Human health has thus become a casualty of the metal related pollution (Datta *et.al*., 2006). Most of the groundwater pockets are contaminated due to unscientific disposal of domestic and industrial effluents.

The spatial distribution of trace elements in groundwater can assist in understanding the possible sources of contamination as well as identifying the extents of contamination. The trace elements contamination is mainly controlled by the geological and geochemical heterogeneity in the groundwater aquifer. Trace metals usually occur in small amount in groundwater around industrial areas that use variety of chemicals in the manufacture of batteries, paints, pharmaceutical products, agrochemicals, etc. These industries dispose the treated waste water that do/do not meet the standards in the surface water bodies (rivers, lakes, ponds) and into the sea in coastal areas. Contamination due to heavy metals is also commonly reported around landfills (Bakis and Tuncan, 2011; Lu *et.al*., 2016).

Ikot Abasi is an area of intense anthropogenic activities like aluminum smelting plant and power generation plant, which may contribute considerable amount of trace metals like aluminum in

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groundwater. Beyond permissible limit in groundwater these trace metals can harm ecosystem, plants, animals and cause health problems to humans. This study was undertaken to access the groundwater quality and map the distribution of some quality parameters in Ikot Abasi using Geographic Information System (GIS).

LOCATION AND GEOLOGY OF THE STUDY AREA

The study area, Ikot Abasi lies between latitudes $4^0\ 30^1$ and $4^0\ 40^1$ North and between longitudes $7^0\ 30^1$ and $7^0\ 45^1$ East. The map of the study area is presented in Figure 1. Ikot Abasi is situated at a break in the mangrove swamp and rain forest of the Eastern Niger Delta. It is bordered by Oruk Anam Local Government Area, Mkpat Enin Local Government Area, Eastern Ogbolo Local Government Area and the Atlantic Ocean.

The study area, Ikot Abasi is flat and low-lying. Three major physiographic units are identified from the terrain; the alluvial plains (mangrove and flood plains), the beach ridge sands and the rolling sandy plains. It consists of the Quartering sedimentary deposits, and the tertiary coastal plain sands, generally referred to as Calabar Formation. The quaternary sediments give rise to alluvial plains as well as the beach ridge sands. The alluvial plains include mangrove mudflats, which area under the influence of tidal brackish waters along the coast and in the estuaries of rivers and creeks. The flood plains and inter-tributary areas have light grey to dark carbonaceous mud and clay. The tertiary coastal plain sand, or Calabar Formation is older and consists of beds of unconsolidated coarse textured sandstones, inter-bedded with layers of fined grained massive day (ALSCON, 1997).

The climate of the area is that of humid tropic. Temperatures are high, lying between 26^0C and 28^0C, rainfall is heavy and the mean annual rainfall lies between 2000mm to 4000mm. The rainy season lasts from April to November and is characterized by high relative humidity, while the dry season proper begins in November and ends in March (ALSCON, 1997).

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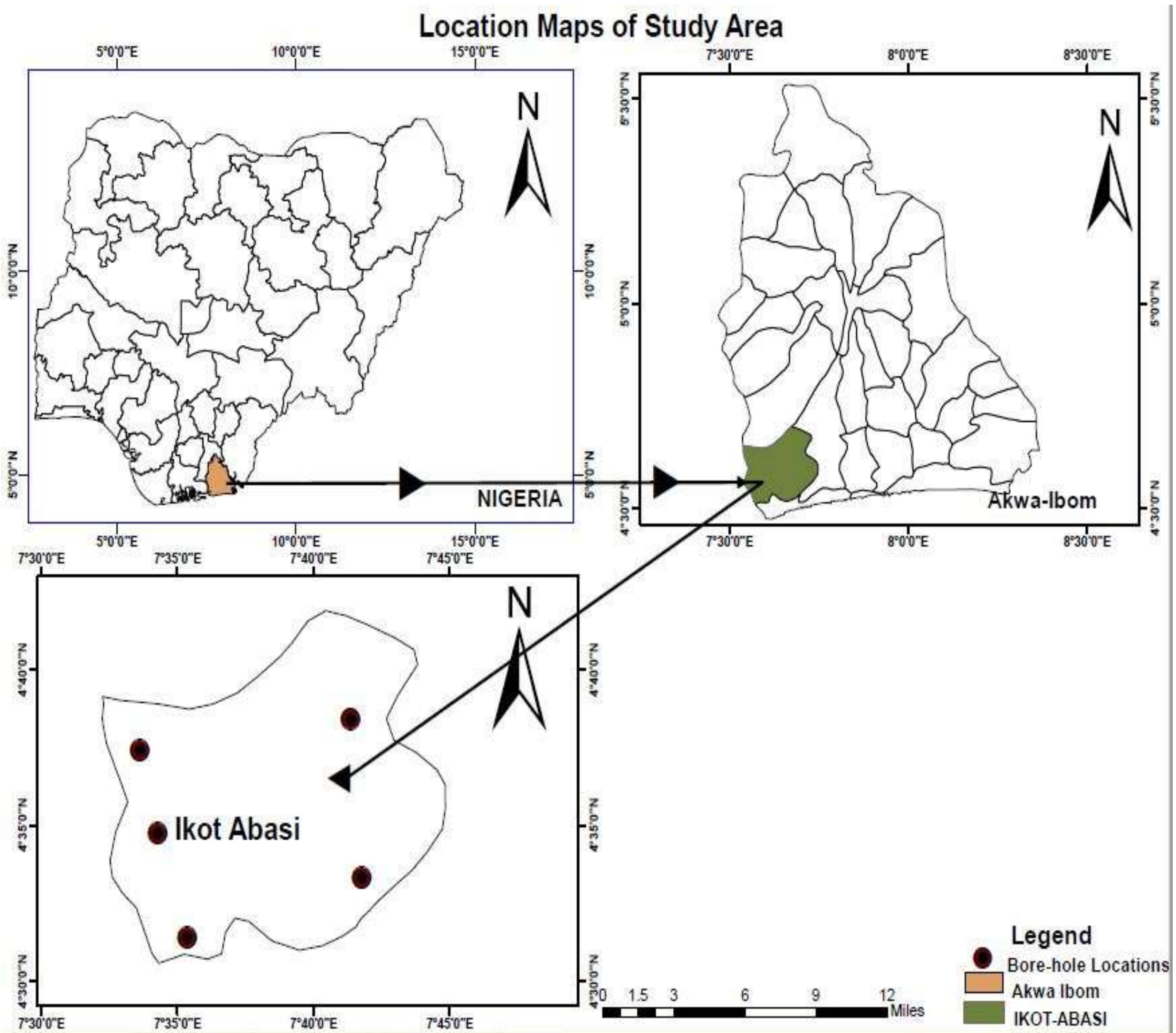

Sampling and Analytical Procedure
A total of 5 ground water samples were collected from five different boreholes for physical and chemical analysis within the study area. The sampling locations were recorded using Global Positioning System (GPS). The longitude and latitude of each sampling locations were recorded in the field. All pumps were allowed to run for 5-10 mins before the actual samples were taken. Table 1 shows the locations of the 5 sampling sites. The physical parameters (pH, conductivity, turbidity and total dissolved solids) were measured on site using HQ4OD multi-parameter. Temperature was measured using thermometer. The concentrations of the 5 elements (aluminum, zinc, copper Manganese, chlorine) were determined by atomic emission spectroscopy (Model ICP – Ats-9000). The metals were estimated in the samples by aspirating the sample solution directly

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into the plasma of the instruments. Calibration curves were obtained for every ion using standard solution and the results obtained were plotted and contoured using quantum GIS (1.7.0) and surfer 3.2 software.

RESULTS AND DISCUSSION

The results of the 5 groundwater samples were analysed for physical properties and trace metals. The results of the physical parameters analysis are presented in table 2 while the results of the trace metals analysis are presented in table 3.

Table 2: Some Physical properties of the Groundwater samples

S/No	Location	Physical Parameters				
		pH	**Temperature (^{0}C)**	**Conductivity (µs/cm)**	**Turbidity (NTU)**	**TDS (mg/l)**
1	Ibekwe	7.5	28	36.0	3.0	15.0
2	Church Road	7.2	26	27.0	0.0	13,40
3	Ring Road 1	8.1	29	26.0	0.0	24.0
4	Ring Road 2	8.3	27	30.0	4.0	20.0
5	Alscon Road	7.4	30	30.0	0.0	19.0
Range		7.4 – 8.3	26 – 30	26.0 – 36.0	0.0 – 4.0	13.4 – 24.0
WHO Limit		6.5 – 8.5	30	500	5.0	500

Table 3: Some Chemical Properties of the Groundwater Samples

S/No	Location	Trace Metals				
		Aluminum (mg/l)	**Copper (mg/l)**	**Zinc (mg/l)**	**Manganese (mg/l)**	**Chlorine (mg/l)**
1	Ibekwe	0.4	0.2	0.5	2.16	0.72
2	Church Road	0.2	0.1	0.3	2.18	0.00
3	Ring Road 1	0.3	0.3	0.1	2.13	0.55
4	Ring Road 2	0.4	0.3	0.4	2.16	0.00
5	Alscon Road	0.4	0.2	0.5	2.17	0.43
Range		0.2 – 0.4	0.1 – 0.3	0.1 – 0.5	2.13 – 2.18	0.00 – 0.72
WHO Limit		0.2	2	5.0	0.1	10

The construction of contour maps is one of the standard procedures used in water resources assessment in order to evaluate and predict natural variability and assess the risk regarding groundwater contamination in waste disposal industries and other sites (Singh and Lawrence 2007; Pius *et. al.*, 2012; Fekri *et. al.*, 2012). The contour maps are presented in Figures 2 to11 which indicates that, the hot spot, their zone of concentration beyond the critical limits, are highly variable

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spatially. The pH values of the samples varied from 7.4 – 8.3 (Table 2). All the values were within the WHO permissible limit. Khan *et. al*. (2010) reported that pH value below 6.5 can cause corrosion of metal pipes resulting in the release of toxic metals such as Zn, Cu, Pb etc. Also, groundwater with low pH can cause gastro intestinal disorder such as hyperacidity, ulcers, and burning sensation. The total dissolved solid (TDS) concentration varied between 13.40 mg/l – 24.0 mg/l. The TDS values fall within the WHO permissible limit. Chatterjee *et. al.* (2010) observed that TDS signifies the organic contamination of waste which may be due to the gradual deposition of salts over the years. Shanker *et.al.* (2008) have also reported TDS values as high as 4,100 mg/l in groundwater of an industrial area of Bongalore which indicated a very high load of salinity in water. Edmunds et*. al*. (2003) stated that water with high TDS may induce an unfavourable physiological reaction and cause gastrointestinal problem.

The turbidity values ranged from 0.0 NTU – 4.0 NTU. The turbidity values in all the samples fall within the WHO permissible limits. The conductivity values in the study area varies from 26.0 µs/cm – 36.0 µs/cm and which falls within the WHO permissible limit. The concentration of manganese varied from 2.13 mg/l – 2.18 mg/l. 100% of the groundwater samples had values higher than the WHO prescribed permissible limits of 0.1mg/l. According to Haloi and Sharma (2012), Mn can promote iron bacteria in groundwater. Also prolonged inhalation of high levels of manganese negatively affects the central nervous system, visual reaction time, hand steadiness and eye-hand coordination. The concentration of zinc in groundwater samples from the boreholes varied from 0.1mg/l to 0.5mg/l which was lower than the WHO permissible limits of 5.0mg/l. Copper varies from 0.1 mg/l - 0.3 mg/l and chlorine varies from 0.0mg/l – 0.72mg/l respectively, which falls within the WHO permissible limits. Aluminum concentration ranged from 0.2 mg/l – 0.4 mg/l, indicating that only location B2 (Church Road) had a value within the WHO limit of 0.2 mg/l. The values in other locations (B1, B3, B4, B5) were above the WHO permissible limit. High concentration of Al can lead to serious health effects (Momodu and Anyakora, 2010).

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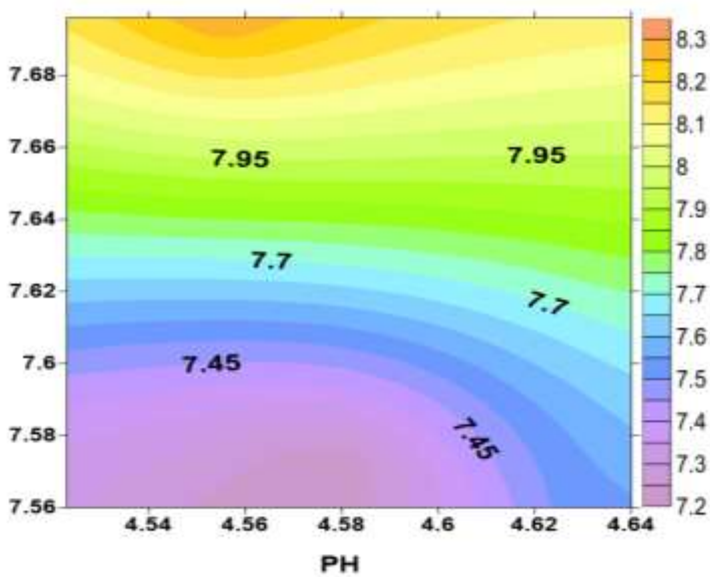

Figure 2: Contour Maps of pH Concentration in the Area

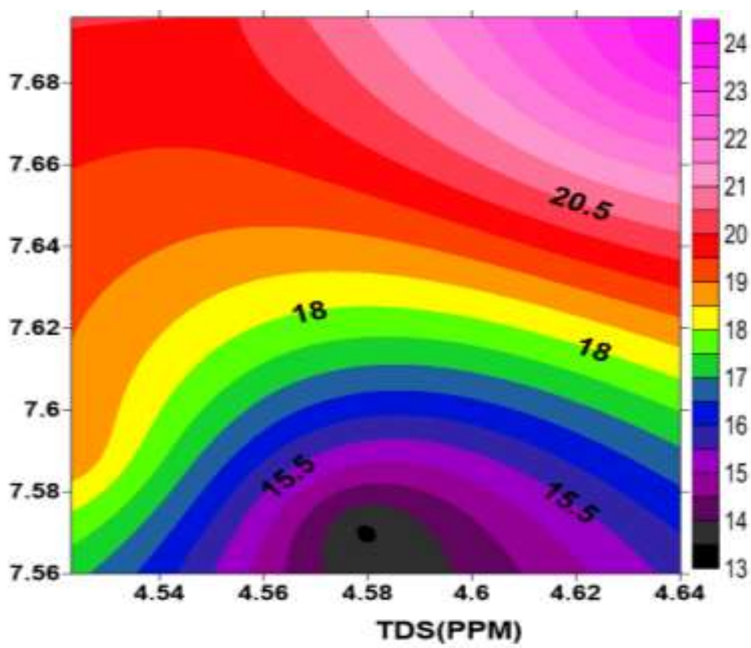

Figure 3: Contour

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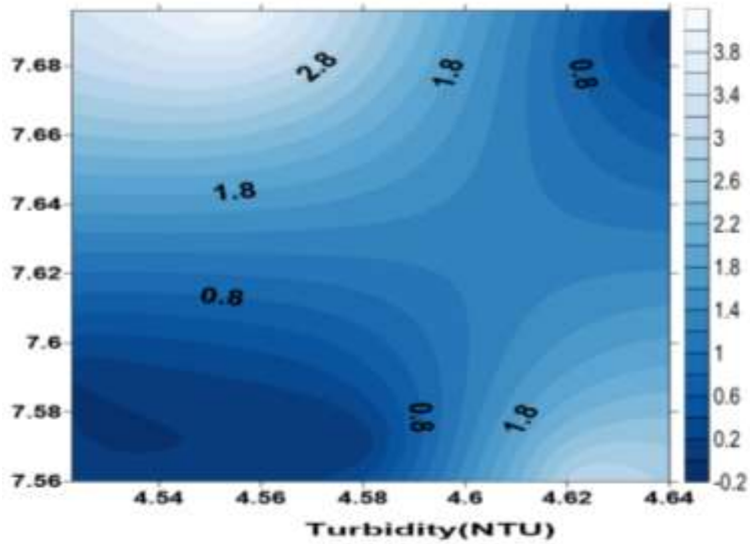

Figure 4: Contour Maps of Turbidity (NTU) in the Area

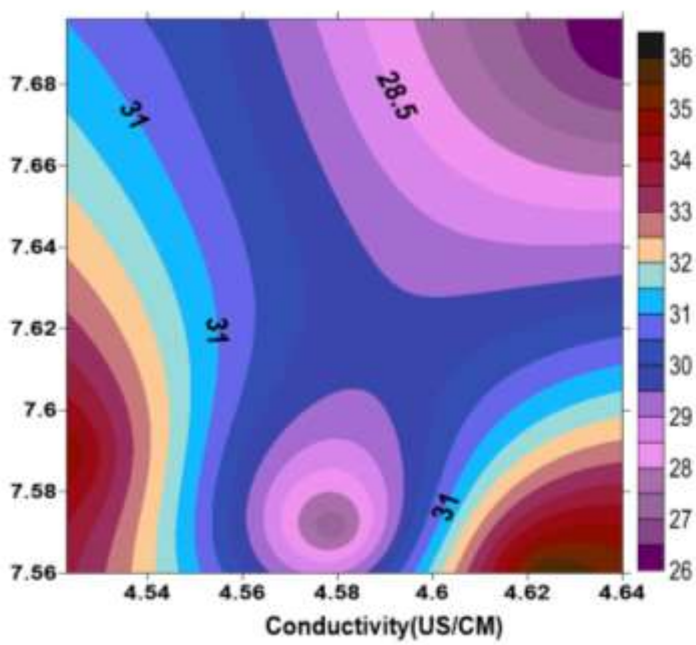

Figure 5: Contour

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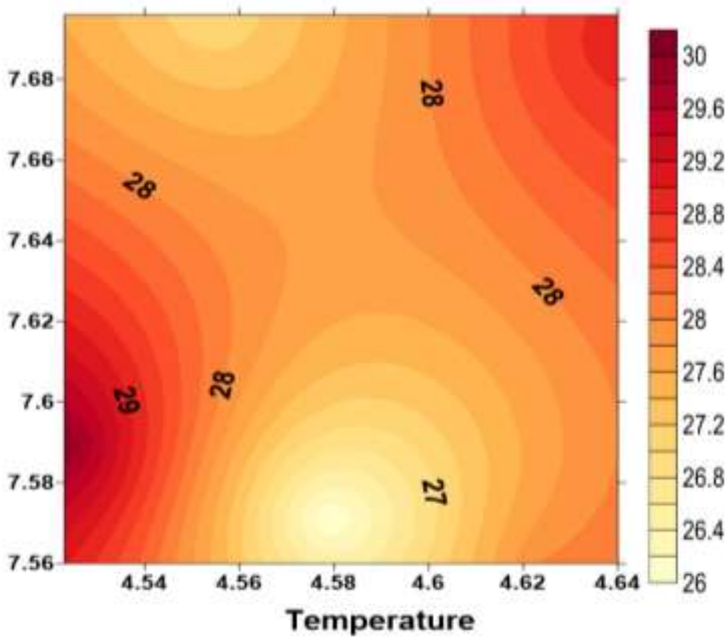

Figure 6: Contour Maps of temperature Concentration in the Area

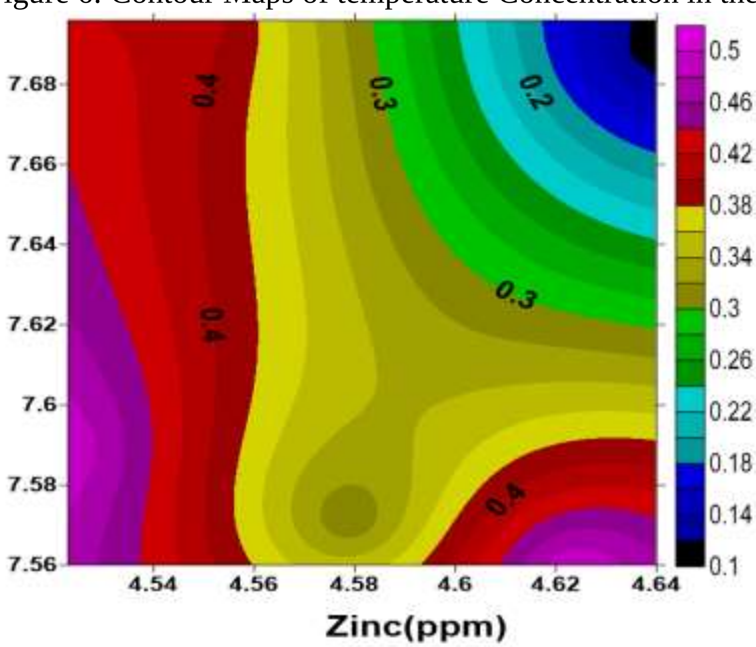

Figure 7: Contour Maps of Zinc(ppm) Concentration in the Area

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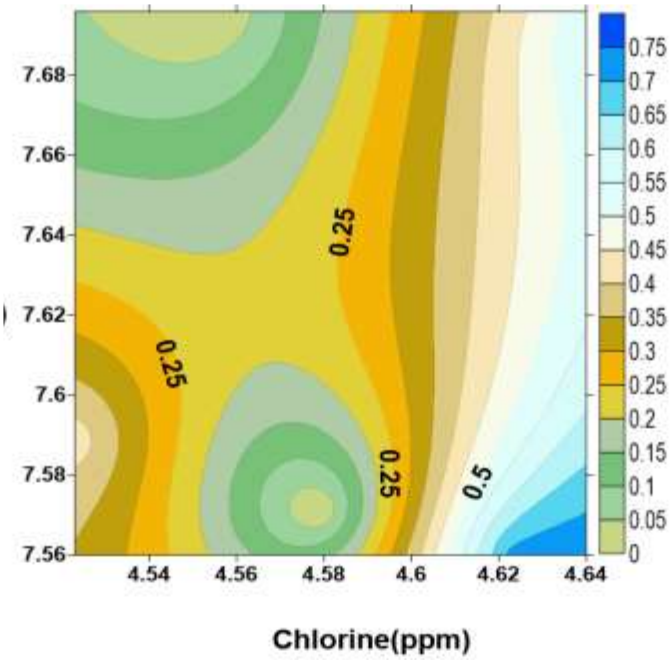

Figure 8: Contour Maps of Chlorine(ppm) Concentration in the Area

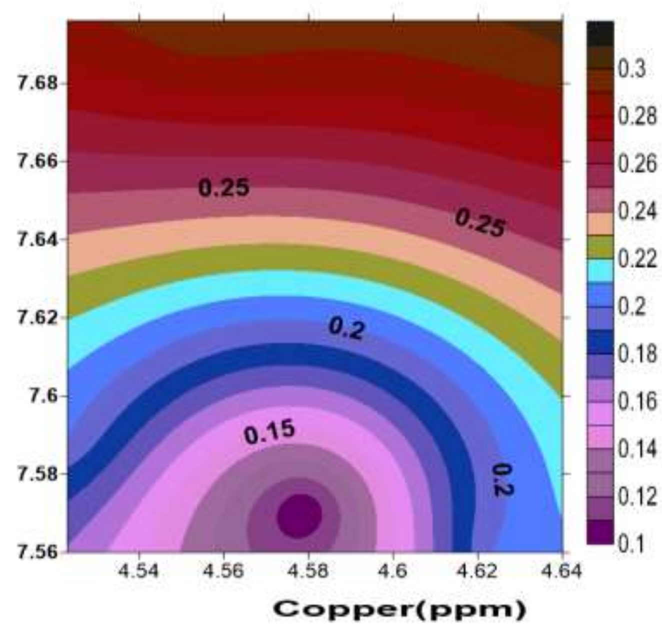

Figure 9: Contour Maps of Copper (ppm) Concentration in the Area

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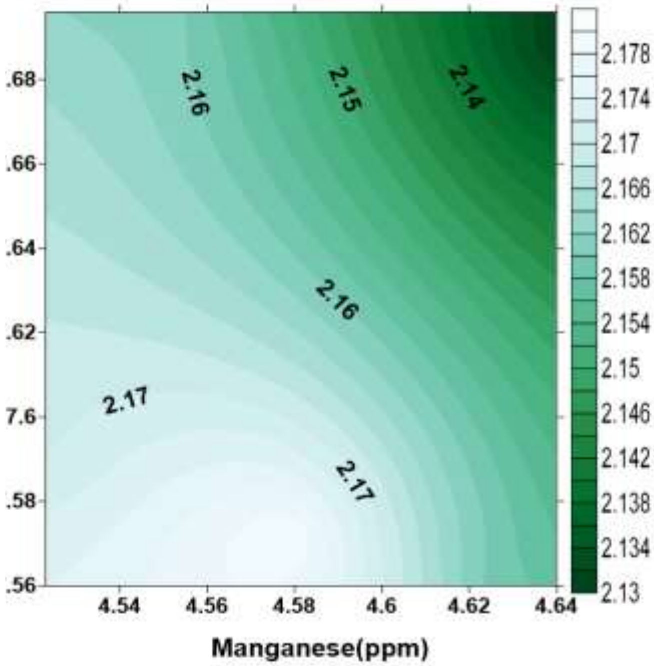

Figure 10: Contour Maps of Maganese (ppm) concentration in the Area

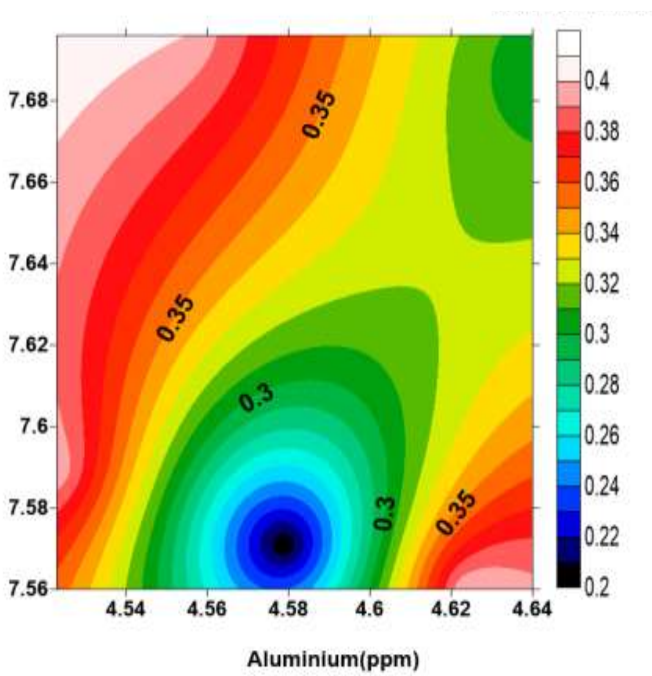

Figure 11: Contour Maps of Aluminum (ppm) Concentration in the Area

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CONCLUSION

Results of the study shows that the groundwater source around an aluminum smelting company in Ikot Abasi local Government area is contaminated with Manganese and Aluminum. This can cause a serious health hazard and remedial measures should be taken to prevent further degradation and to establish database for planning further water resources management policies Groundwater is getting contaminated due to rapid industrialization and becoming unfit for drinking. The improper disposal of effluents and the presence of radioactive elements along with other contaminants is a matter of serious concern. To meet the basic requirement and ensure portable groundwater quality and reduce contamination, groundwater should be recharged through rainwater harvesting and improper disposal of industrial/domestic effluents must be stopped or reduced. An effective monitoring and regulatory mechanism need to be put in place.

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