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Spatial Distribution of Trace Metals occurrence in Groundwater around selected Areas of Ogbomoso, Southwestern Nigeria

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Abstract

The present increase in human population most especially in urban and rural areas requires an understanding of good quality of groundwater in preventing diseases and improving quality of life. This study was carried out to ascertain the extent of trace metals contamination in the study area. The area is underlain by the Nigerian Basement Complex consisting of pre-cambrian rocks. A total of twenty-four (24) water samples were collected from shallow hand dug wells in the study area. Parameters such as static water level, elevations, coordinate of each of the water sample locations were recorded. Water samples were analysed for trace metals using Atomic Absorption Spectrometer (AAS) and titration method to determine the chemical quality of the groundwater in the study area. Eight trace metals were analysed which include copper, chromium, cobalt, nickel, lead, zinc, manganese and cadmium. Spatial distribution of these trace metals were plotted. The study shows that most of the shallow groundwater in the study area are contaminated with respect to trace metals. High amount of these trace metals above the maximum recommended levels attributed to the pollution from anthropogenic sources (domestic and industrial). There should be treatment of shallow groundwater in the study area before use and continuous monitoring of the groundwater in the area should be carried out.

Keyword: Trace metals, Ground water, spatial distribution, Physicochemical Analysis, Environment pollution.

1. Introduction

Water serves as an important resource in maintaining a good life (Osunkiyesi, 2012) and needed in the day to day activities for the survival of man. Water is also an essential component to the existence of all living organism (Layade *et al*., 2018). Water sources include the atmospheric and groundwater. Groundwater considered as most common way of water supply in most urban and rural areas due to the continuous deterioration of surface water.

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Groundwater is an important source of water supply and provides a practical and affordable way of meeting basic human needs for water in both urban and rural areas where it has a wide range of uses such as drinking, cooking, irrigation and agricultural purposes (Gomo, *et al*., 2019).

It comprises of over 90% of the freshwater. But this important resource is continuously being threatened either through natural or anthropogenic inputs (Amadi *et al*., 2010; Yisa and Jimoh 2010). Groundwater pollution by trace metals has created a question within the public and scientific concern in the light of the evidence of their toxicity to human health and biological system (Anazawa *et al*., 2004). These trace metals generated much concerns especially considering their toxicity even at a lower concentration (Marcovecchio *et al*., 2007; Layade, 2018). Increasing concentration of trace metals in groundwater has generated a lot of concern in recent times. This has been attributed to human interference, proliferation of industries, and recent agricultural practices in urban areas (Zubair and Faroooq, 2008). Presence of these trace metals in human body can results to a serious health threats. The trace metals in drinking water can lead to a potential health hazard. In the strength of all these, the assessment of trace metals in groundwater around Ogbomoso metropolis becomes imperative.

Description of the study area

The study area (Ogbomoso) is a major town in Oyo State, South-western Nigeria. It is situated between latitudes 8^{o} $10^{'}$ and 8^{0} $15^{'}$ and longitudes 4^{o} $22^{'}$ E and $4^{'}$ $27^{'}$ E (Figure 1). The study area is gentle rolling lowland in the south, rising to a plateau of about 40m. The area has an equatorial climate with dry and wet seasons and relatively high humidity. The dry season starts from November and ends in March while the wet season start from April and ends in October. Average daily temperature ranges between 25^{0}C and 35^{0}C almost throughout the year. The vegetation pattern of the area is that of rain forest in the south and guinea savannah in the North. Thick forest in the South gives way to grassland interspaced with trees in the North.

Geology of the Study Area

The geology of the study area was reviewed from the work of previous workers. The rock groups in the area include quartzites and gneisses. The gneisses are the most dominant rock type. They occur as granite gneisses and banded gneisses with coarse to medium grained texture. Noticeable minerals include quartz, feldspar and biotite. Pegmatites are common as intrusive rocks occurring as joints and vein fillings. They are coarse grained and weathered easily into clay and sand-sized particles, which serve as water-bearing horizon of the regolith. Structural features exhibited by these rocks are foliations, faults, joints and microfolds which have implications on groundwater accumulation and movement.

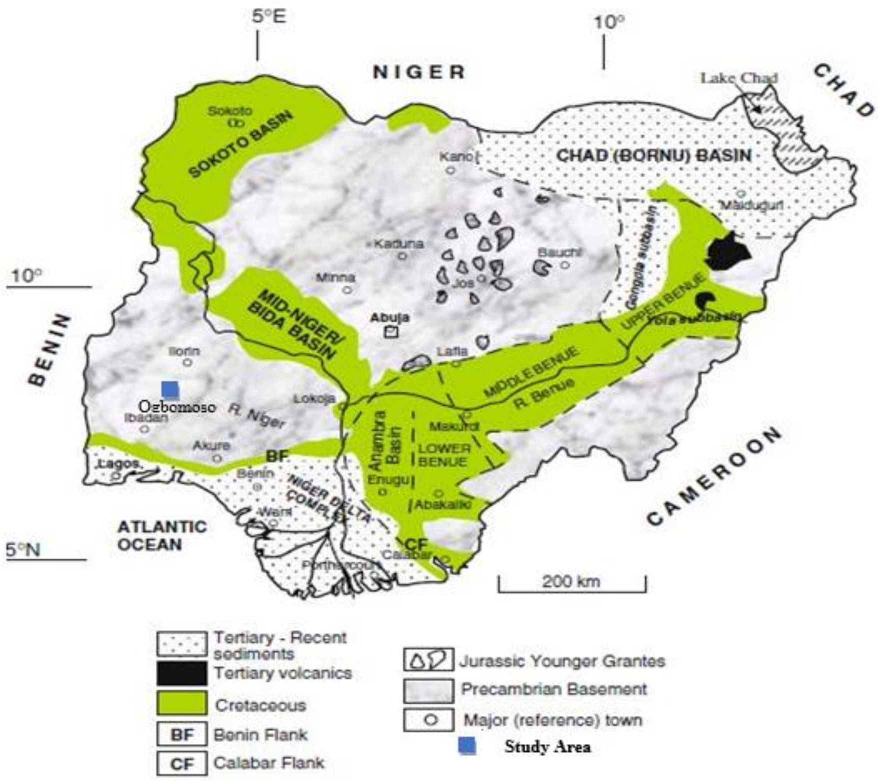


Figure1: Geological Map of Study Area (After Obaje and Abaa, 1996).

2. Materials and Methods

Random method of sampling was carried out in some selected parts of the study area as shown in Fig. 2. A total of twenty – four (24) water samples were collected from shallow hand dug wells in the study area in late year 2017. Based on the guidelines by World Health Organization (WHO, 2006) standards, the physical properties were examined on the field using a calibrated pH meter, conductivity meter and total dissolved solid meter respectively. The water samples were collected using 2 litres containers and were taken to the laboratory for chemical analyses in Kwara State Ministry of Water Resources. The longitude, latitude and elevation of each location were recorded using a global positioning system device (GPS). The static water level of each shallow hand dug well was measured using meter tape. Trace metals analysed in the laboratory include zinc, copper, chromium, lead, cadmium, manganese, cobalt and Nickel using Atomic Absorption Spectroscopy and Titration methods.

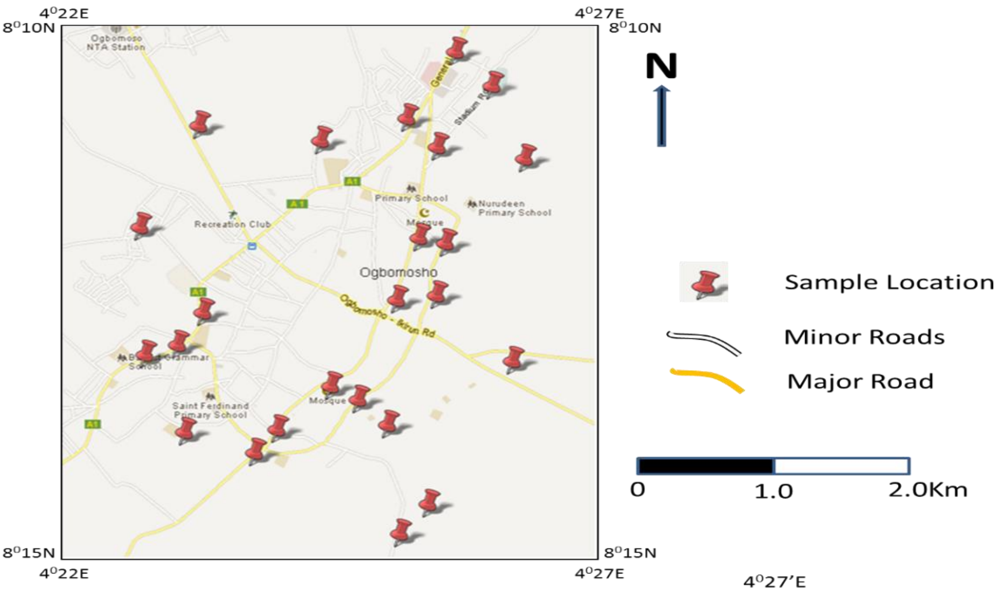


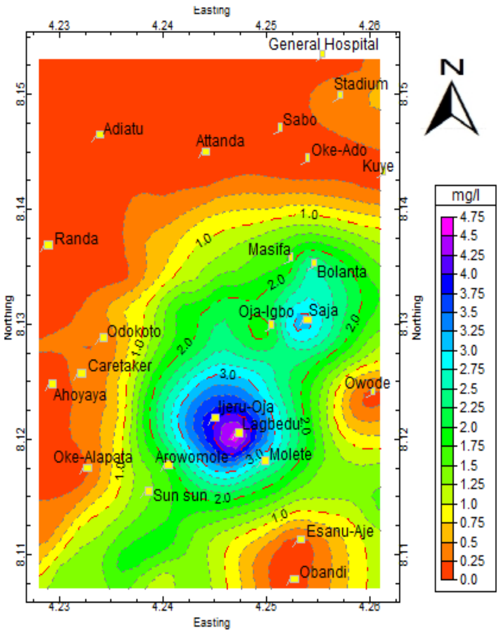
Figure 2: Location map of study area showing sampling locations.

3. Result and Discussion

The pH of the water in the study area varied from 6.9 to 8.1 According to Stumn Morgan (1981), pH value of natural water ranged from 6.0 to 9.0, hence the pH values falls within the World Health Organization (WHO, 2006) standards for drinking water. The Electrical Conductivity values of water samples falls within the acceptable standards for drinking and domestic purposes except in locations 11, 12, and 15. The high EC values at these locations could be due to incorporation of dissolved components of overburden and anthropogenic influences arising from contamination. Total Dissolved Solid (TDS) concentration of water samples varied from 48-840mg/l with a mean value of 346mg/l. The TDS concentration falls within the acceptable standards for drinking and domestic water. According to Fetter (1994) the water samples belong to fresh water type (TDS <1000mg/l).

Spatial Distribution of Trace Metals

Results of the water analysis revealed that all the water samples analysed except location 4 have values of chromium above the World Health Organization (WHO, 2006) and Nigeria Standard for Drinking Water Quality (NSDWQ, 2007) health based guideline value of 0.05mg/l. The source of high concentration of chromium in the study area could be from metal fittings in wells and electronic wastes. The mean value of Zinc is 0.34mg/l and all the water samples analysed have values within the recommended range of 3.0mg/l. Nickel with a mean value of 0.08mg/l. The recommended value for nickel is 0.02mg/l. All the locations except locations 19, 20, 22 and 24 have their values above the recommended limits. Copper has a mean value of 310.5mg/l. Every location in the study area have value above recommended limit of 0.03mg/l. Concentration of Manganese in water samples analysed ranges between 0.30mg/l to 91.0mg/l. All the locations have their values above health based guideline value of 0.20mg/l. Manganese is present in groundwater as the divalent ion (Mn^{2+}) due to lack of surface oxygen. Cadmium concentrations in the water samples analysed ranges between 0.01mg/l and 3.01mg/l. All the locations have their values above recommended limits of 0.003mg/l value for drinking water. Possible sources of cadmium contamination in this area could be from domestic waste water, sewage and through deterioration of galvanized plumbing. The water analysis result shows that the mean concentration of lead in the water samples is 0.50mg/l. All the locations except location 2 have their values above the recommended value for drinking water which is 0.01mg/l. Cobalt concentration ranges between 0.10mg/l and 32.0mg/l with a mean concentration of 9.15mg/l in the study area.



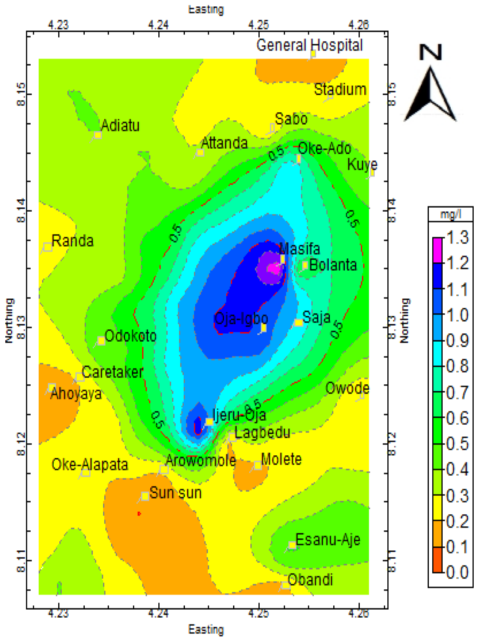
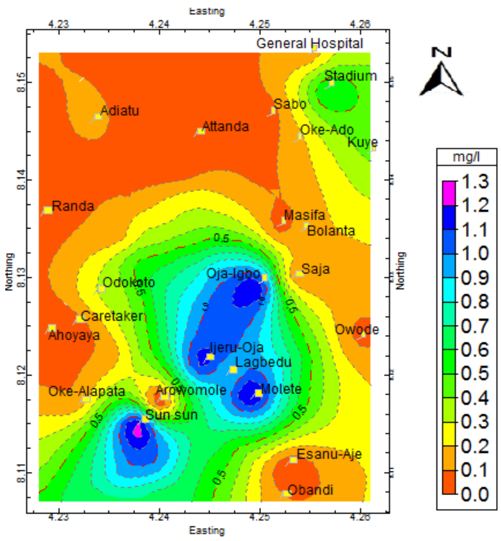


Figure 3.1: Spatial Distribution of Chromium. **Figure. 3.2:** Spatial Distribution of Zinc.



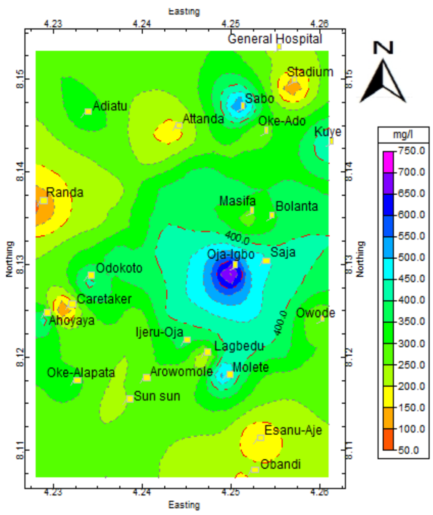


Figure 3.3: Spatial Distribution of Nickel. **Figure 3.4:** Spatial Distribution of Copper.

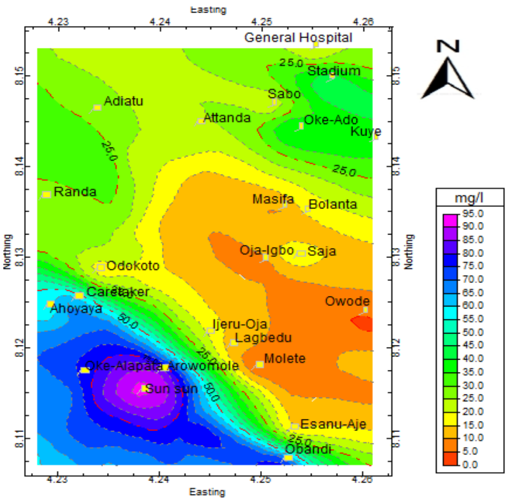


Figure 3.5: **Figure 3.5:** Spatial Distribution of Manganese.

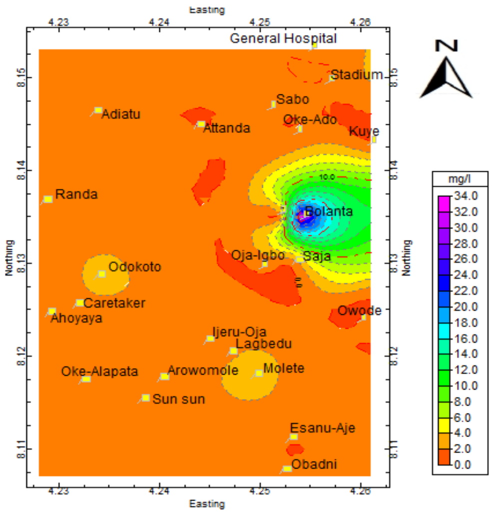


Figure 3.6: Spatial Distribution of Cadmium.

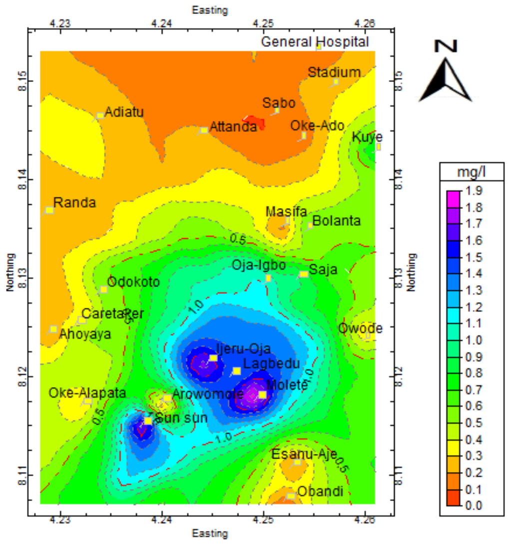


Figure 3.7: Spatial Distribution of Lead.

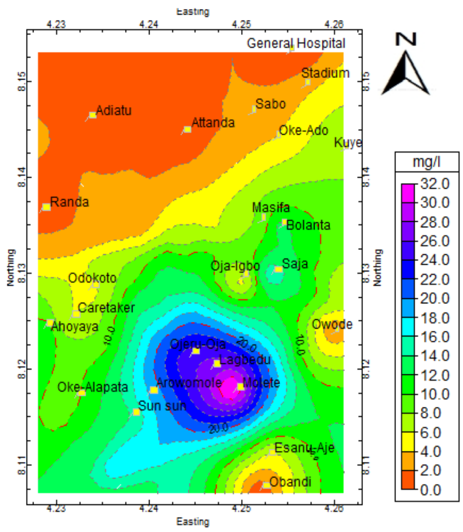


Figure 3.8: Spatial Distribution of Cobalt.

Table1: Major physical parameters, coordinates, elevations and static water levels.

Location Number	Locations	Coordinates	Elevation	Depth to water level (m)	Water level elevation (m)	pH	EC (Ms/cm)	TDS (mg/L)
1	Stadium	08° 08′ 57.7″ 04° 15′ 23.4″	362m	3.05	358.95	7.3	277	180
2	General Area	08° 09′10.5″ 04^0 15′ 17.4″	335m	3.66	331.34	6.9	74	48
3	Sabo	08° 08′47.6″ 04° 15′ 02.7″	354m	3.96	350.04	7.0	192	124
4	Oke-Ado	08° 08′.38.1″ 04° 15′ 12.1″	355m	3.76	351.24	7.1	360	235
5	Kuye	08° 08′.34.0″ 04^0 15′ 38.6″	339m	4.20	334.80	7.5	361	202
6	Bolanta	08° 08′.05.1″ 04° 15′ 14.4″	325m	4.53	320.47	7.4	810	526
7	Masifa	08° 08′.07.0″ 04° 15′ 06.4″	334m	3.78	330.22	7.1	527	342
8	Oja-Igbo	08° 07′.45.9″ 04° 14′ 59.5″	335m	3.05	331.95	7.6	208	395
9	Owode	08° 07^1′25.1″ 04° 15′ 34.9″	340m	3.66	336.34	7.2	123	82
10	Saja	08° 07′ 47.4″ 04° 15′ 11.6″	326m	7.01	318.99	7.1	842	550
11	Ijeru-Oja	08° 07′.16.7″ 04° 14′ 39.6″	330m	3.05	326.95	6.9	1078	700
12	Lagbedu	08° 07′.12.0″ 04° 14′47.9″	313m	1.68	311.32	7.5	1115	728
13	Esanu Aje	08° 06′.38.6″ 04° 15′ 09.3″	345m	2.01	342.99	7.0	253	168
14	Obandi	08° 06′26.3″ 04° 15′ 00.7″	341m	1.68	339.32	8.1	108	72
15	Molete	08° 07′.03.3″ 04° 14′ 56.9″	315m	1.83	313.17	7.3	1285	840
16	Arowomole	08° 07′.02.0″ 04° 14′ 23.1″	325m	3.20	321.80	7.2	795	520
17	Sunsun	08° 06′.53.8″ 04° 14′ 16.3″	316m	1.37	314.63	7.4	848	560
18	Oke Alapata	08° 07′.01.1″ 04° 13′ 55.0″	333m	2.59	330.41	7.1	752	491
19	Ahoyaya	08° 07′.27.3″ 04° 13′ 42.9″	356m	3.51	350.49	7.2	470	310
20	Caretaker	08° 07′.30.6″ 04° 13′ 53.0″	335m	4.42	330.58	7.1	264	175
21	Odokoto	08° 07′.41.7″ 04° 14′00.6″	358m	3.20	354.80	1.3	628	420

22	Randa	08º 08′.10.7″ 04º 13′ 41.4″	348m	3.20	344.80	7.0	293	198
23	Adiatu	08º 08′.45.3″ 04º 13′ 59.3″	344m	3.66	340.34	7.1	430	290
24	Atenda	08º 08′ .40′′ 04º 14′ 36.3″	347m	2.74	344.26	6.9	255	148

Table 2: Results of Trace Metals

	Location	Chromium mg/L	Copper mg/l	Manganese mg/l	Cadmium mg/l	Lead mg/l	Cobalt mg/l	Nickel mg/l	Zinc mg/l
1	Stadium Area	0.40	123	40	0.03	0.19	3.70	0.60	0.14
2	General Hosp.	0.13	246	15	0.01	0.01	0.10	0.14	0.05
3	Sabo Area	0.10	540	17	0.06	0.03	2.40	0.06	0.13
4	Oke-Ado area	0.04	270	35	0.08	0.02	3.90	0.13	0.74
5	Kuye area	0.12	446	33	0.10	0.67	7.90	0.42	0.31
6	Bolanta Area	2.5	335	10	033	0.46	12.30	0.15	0.53
7	Masifa Area	1.80	274	5	0.13	0.08	8.40	0.07	1.26
8	Oja-Igbo Area	1.95	705	3.0	0.05	1.03	5.6	1.16	0.98
9	Owode Area	0.2	254	0.30	0.02	0.26	3.1	0.08	0.12
10	Saja Area	3.10	473	12	0.23	0.84	15.0	0.20	0.81
11	Ijeru-Oja Area	3.80	353	19	1.61	1.63	25.0	1.11	1.05
12	Lagbedu Area	4.60	210	8	1.84	1.30	27.0	0.90	0.09
13	Esanu-aje area	0.14	150	12	0.07	0.10	5.80	0.04	0.41
14	Obandi Area	0.12	200	72	0.14	0.04	0.70	0.12	0.03
15	Molete Area	2.80	510	2.5	3.01	1.84	32.0	1.20	0.08
16	Arowomole	1.65	296	86	0.18	0.15	18.0	0.04	0.06
17	Sun - sun Area	1.41	242	91	0.20	1.62	14.0	1.21	0.01
18	Oke-Alapata	0.16	310	70	0.31	0.23	9.70	0.16	0.19
19	Ahoyaya Area	0.11	415	52	0.21	0.11	11.10	0.01	0.04
20	Caretaker Area	0.25	100	60	0.72	0.30	6.20	0.02	0.07
21	Odokoto Area	0.29	410	15	2.50	0.41	5.6	0.30	0.35
22	Randa Area	0.17	93	23	0.40	0.16	0.80	0.02	0.17

23	Adiatu Area	0.13	317	24	0.74	0.21	0.90	0.11	0.29
24	Attenda Area	0.07	180	17	0.34	0.14	0.50	0.02	0.21

Table 3: Statistical Summary of Physical and Chemical Analysis of Study Area.

Parameters	Minimum	Maximum	Mean
pH	6.9	8.1	7.2
Conductivity (µs/con)	74	1285	529.29
Total dissolved solid (mg/l)	48	840	346.0
Chromium (mg/l)	0.04	46	1.09
Copper (mg/l)	93	705	310.5
Manganese (mg/l)	0.30	91.0	30.1
Cadmium (mg/l)	0.01	3.01	0.55
Lead (mg/l)	0.01	1.84	0.05
Cobalt (mg/l)	0.10	32.0	9.15
Nickel (mg/l)	0.01	1.21	0.34
Zinc (mg/l)	0.01	1.24	0.34

4. Conclusion and Recommendations

The uncontrollable disposal of domestic and industrial wastes as well as the use of chemical substances in agriculture (fertilizers, herbicides and pesticides) results in the contamination and pollution of shallow groundwater. The chemical analysis of shallow groundwater carried out in study area shows that the water contains some high amount of trace metals that is above the maximum recommended limits of World Health Organization (WHO, 2006) and Nigeria Standards for Drinking Water Quality (NSDWQ, 2007).

This calls for serious concern, as the level of contamination and pollution needs remediation. To remediate the contamination, the authorities concern should designate a properly engineering landfill in the area, putting into consideration the groundwater and its flow directions. There is need to establish a technical mechanism in the study area with sanitation inspector recruited with enactment of sanitary byelaws. More importantly, continuous monitoring of the chemical composition of groundwater in the study area should be carried out.

This research becomes important since the inhabitant in the area depend on groundwater for drinking and other domestic purposes. Mass awareness should be introduced about the effect of polluted and contaminated water on human health.

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