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Geophysical and Hydro-Physicochemical Analysis of Groundwater Quality at Gbede Mining Site, Ogbomoso, South West Nigeria.

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Abstract: A research on the assessment of groundwater quality was conducted around old mining site at Gbede area, Ogbomoso, Oyo State, Nigeria using electrical resistivity (vertical electrical sounding) and hydro-physicochemical approach. This study was carried out to investigate the water quality and the situation of various wells situated in the study area. A total of ten VES were carried out, campus tiger terrameter was used to carried out the geophysical survey. A total of nine samples of water were taken for hydro-physicochemical analysis at the peak of wet season. The result obtained from the interpreted VES data revealed low value of resistivity at some layers, which indicate the presence of iron mineral. The outcome of hydro-physicochemical result revealed the hazardously high value of some minerals especially Fe^{2-} to further support the findings from the VES survey.

Keywords: Geophysical, Groundwater, Hydro-physicochemical, Resistivity, Terrameter, Vertical Electrical Sounding (VES).

1. Introduction

Groundwater quality comprises the physical, chemical, and biological qualities of groundwater. Temperature, turbidity, color, taste, and odor make up the list of physical water quality parameters. Since most ground water is colorless, odorless, and without any specific taste, we typically most concerned with its chemical and biological qualities, and not only that we are also very much concerned with the aquifer parameters. Naturally ground water contains mineral ions (Tiwari et al., 2013). These ions slowly dissolve from soil particles, sediments, and rocks as the water travels along mineral surfaces in the pores or fracture of the unsaturated zone and aquifer. The groundwater used for drinking should be free from any toxic elements, living and non living organisms, and excessive amounts of minerals that may be hazardous to health. Assessment of ground-water quality requires determination of ion concentrations which decide the suitability for drinking, agricultural and industrial uses. Some heavy metals are very essential in human health, but they may cause various health problems, if present in higher concentrations (Tiwari et al., 2013). The contamination of groundwater by heavy metals and pesticides may cause problem due to their general non biodegradable nature.

2. Location and geology of the study area

The study area is located in Gbede, Oyo State, Southwestern Nigeria. It is delineated between latitude 8˚17'37.7" and 8˚17'49.8'' North and between longitude 4˚20'45.9'' and 4˚20'58.8 East. Figure 1.1 shows the location map of the study area. The geology of the study area consist of migmatite-gneiss, migmatite is a rock that is a mixture of metamorphic rock and igneous rock. The drainage type of the study area is dendritic in nature.

3. Materials and method

Vertical Electrical Sounding (VES) in Schlumberger configuration (arrangement) was employed, the total area of 100 x 80 meters were covered with ten vertical electrical soundings along five profile line. That is profile1, profile 2, profile 3, profile 4 and profile 5, along the first profile line, three vertical electrical soundings (VES 1, VES2, VES3) were taken while along second, third and fifth profile, two vertical electrical sounding that is VES 4 and 5, VES 6 and 7 and VES 9 and 10 were recorded respectively and finally only VES 8 was recorded along fourth profile. In this project, resistivity measurements were conducted using simple equipment such as Terrameter – campus tiger, GPS, tape rule, four metal stakes, hammer and four reels of undulated cable. Nine samples of water were taken from various well around the site for hydro Physicochemical analysis.

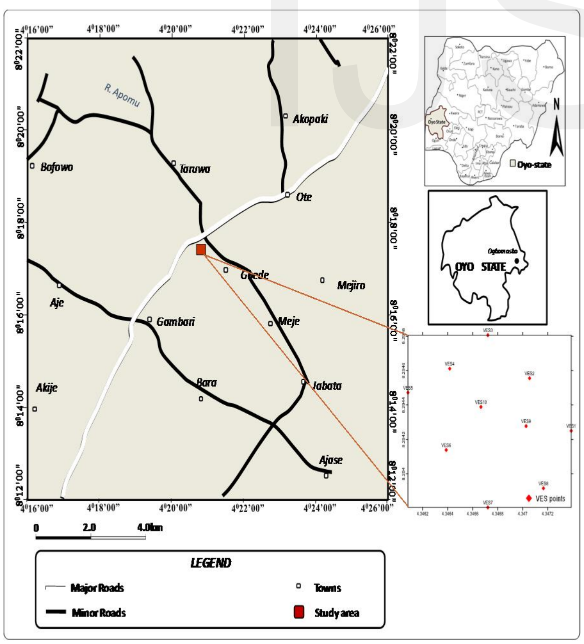

Fig. 1. Location map of the study area

4. Result and discussion

4.1 Geoelectric Parameters

The geoelectric sections in fig 2, fig 3, fig 4, fig 5 and fig 6 were generated using data presented as resist graph. The VES interpretation reveals the maximum of seven geoeletrical layers and minimum of three geo-electrical layers in the study area: The first layer for all VES in study area consists of top soil which is sandy, the second layer which is made up of compacted lateritic/lateritic soil for all VES except for VES 7 in which the second layer is pictured to be saturated clay because of a very low resistivity value in this layer and not only that third layer for VES 10 is made up of lateritic soil. The third and forth layer consist of either weathered/saturated soil/clayed soil except for VES1, 2 and 8 in which the forth layer consists of fresh/fracture basement and not only that, the third layer for VES 7 is made up of fresh basement. The last layer for all VES is either fresh or fractured basement. The geoelectric sections show subsurface variation in electrical resistivity along the profiles and attempt to correlate the geoelectric sequence across the profiles (E.R. Olafisoye et al., 2007). In the first layer, the resistivity values ranged from 188 to 834Ωm with relative thickness of 0.5 to 2.8m. The second layer has resistivity varying from 19.2 to 5536.6Ωm with relative thickness of 0.8 to 21.1m, the high values of resistivity in this layer is attributed to the lateritic nature of the layer. Also the third layer along profile1 has the resistivity values varying from 10 to 55 Ωm with relative thickness of 1.2 to 2.9m. However, the low resistivity values depicted in this layer is due to high porosity and permeability characteristics of the saturated or clayed soil. This trend is also noticed in third layer of profile2 in which resistivity value varied from 20 to 56Ωm which thickness of 11 to 16m. Also the process is noticed in third layer of VES 8 and VES9. Generally the geo-electric layer of all VES extends to thickness of an infinite depth.

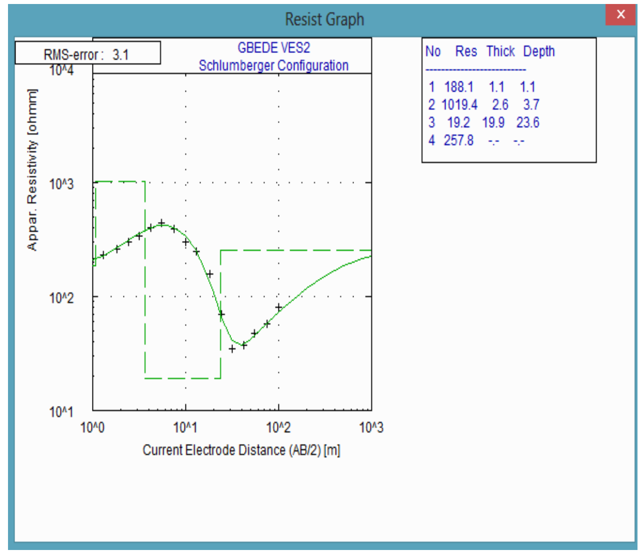

Fig. 3. Resist graph showing VES 2

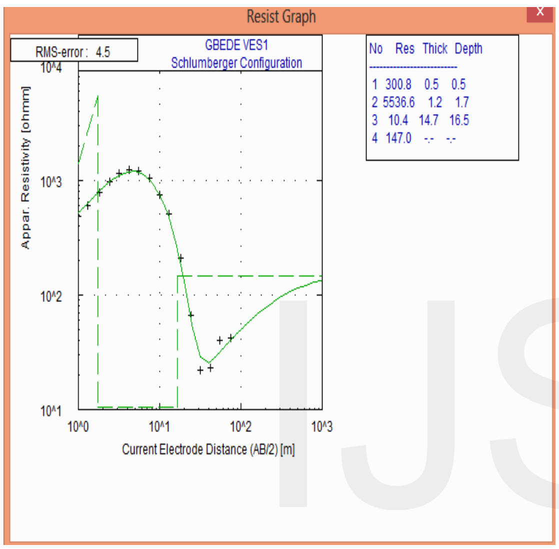

Fig. 2.Resist Graph showing VES 1

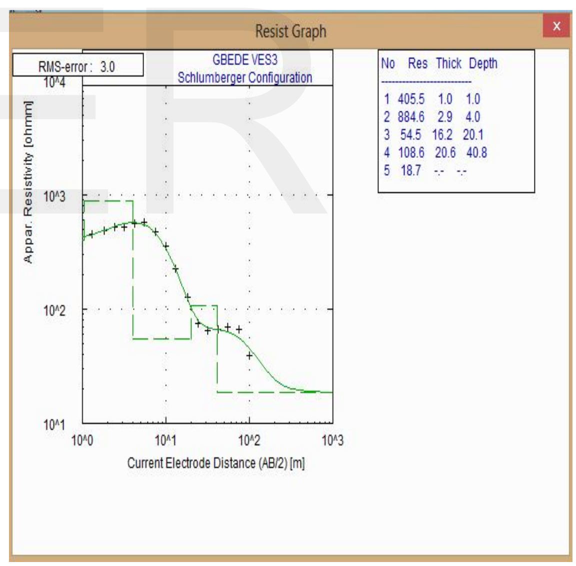

Fig. 4: Resist graph showing VES 3

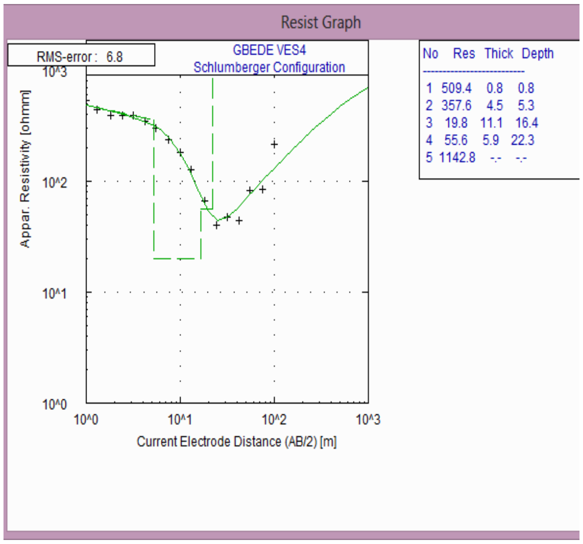

Fig. 5. Resist graph showing VES 4

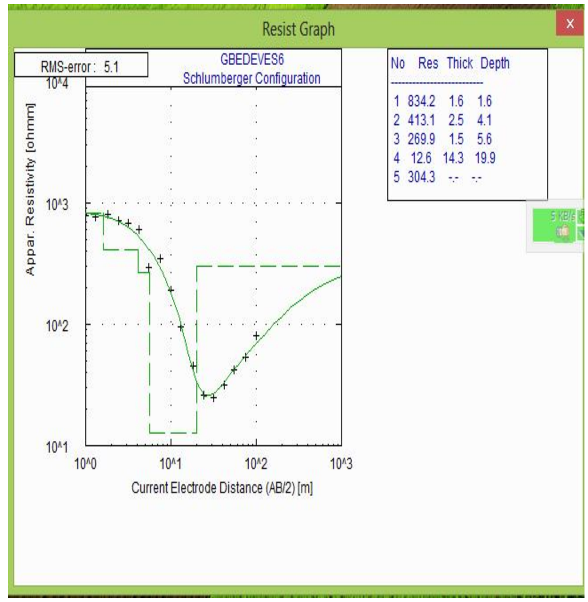

Fig. 7. Resist graph showing VES 6

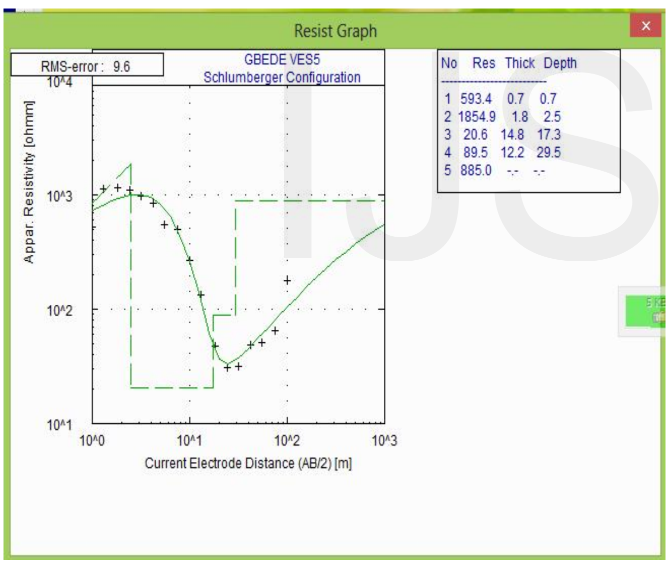

Fig. 6. Resist graph showing VES 5

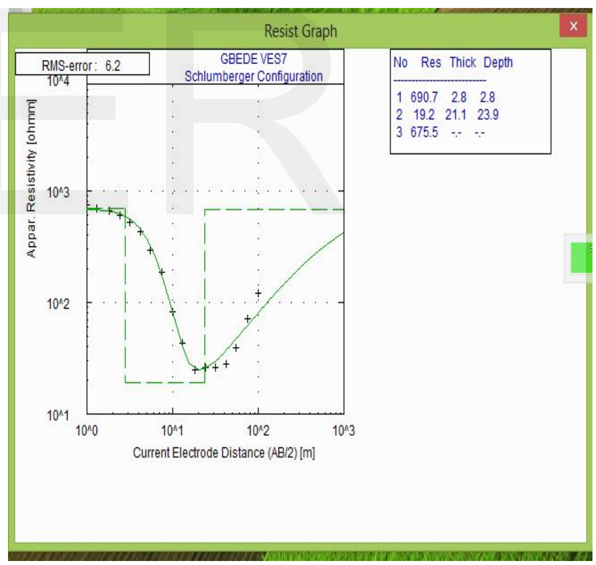

Fig. 8. Resist graph showing VES 7

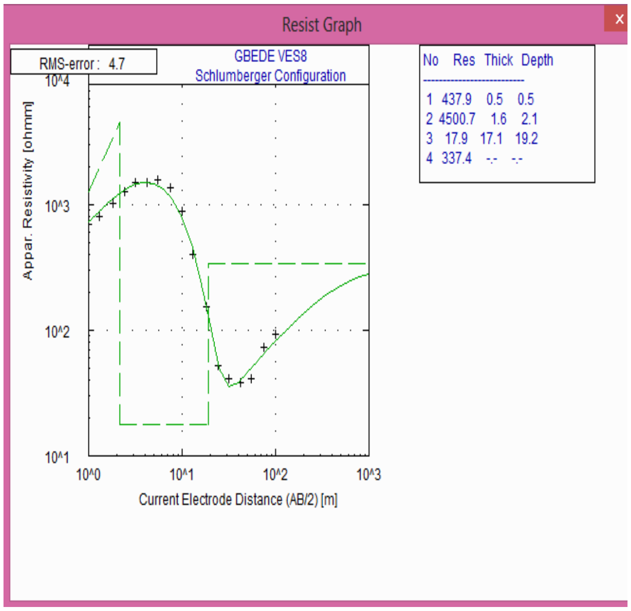

Fig. 9. Resist graph showing VES 8

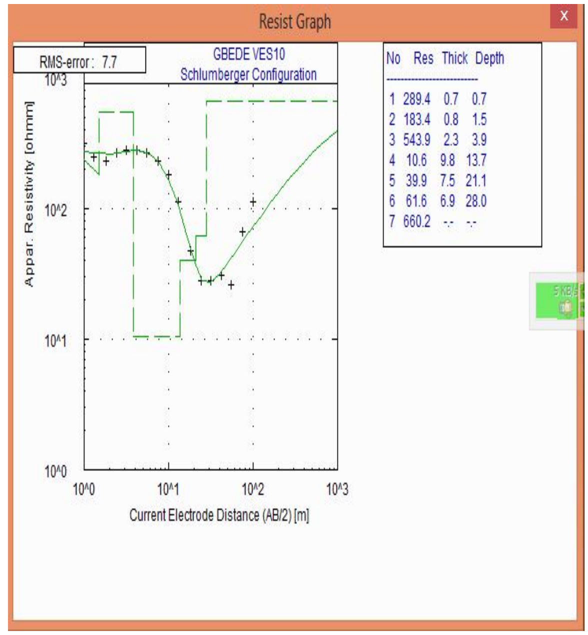

Fig. 11. Resist graph showing VES 10

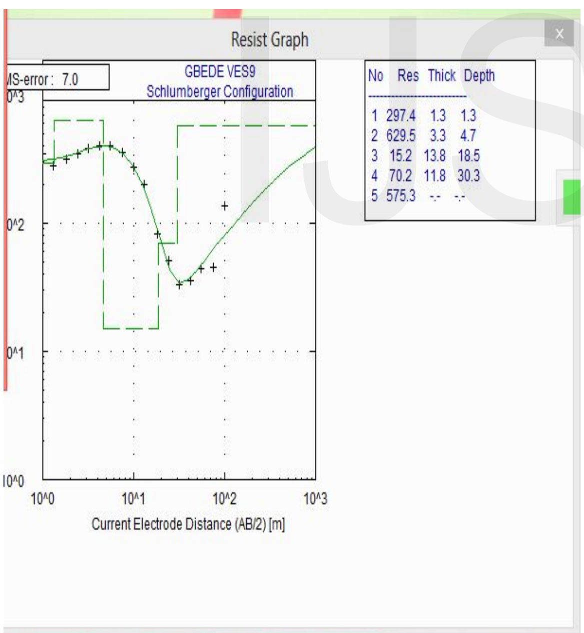

Fig. 10. Resist graph showing VES 9

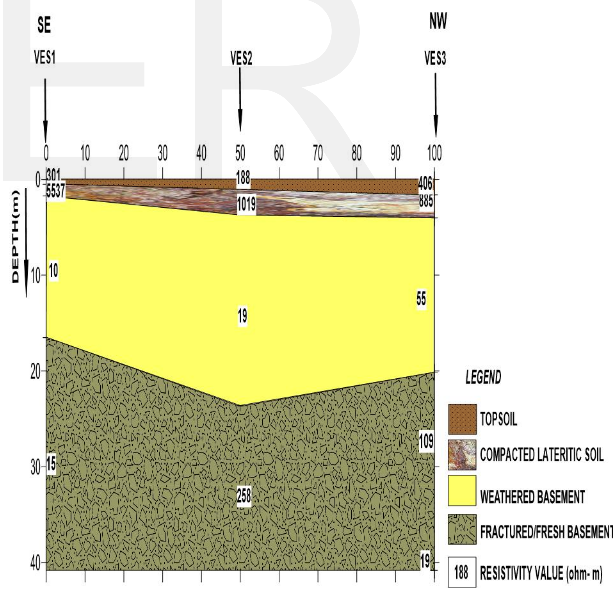

Fig. 12. Geoelectric section beneath VES 1, 2 and 3 along profile 1

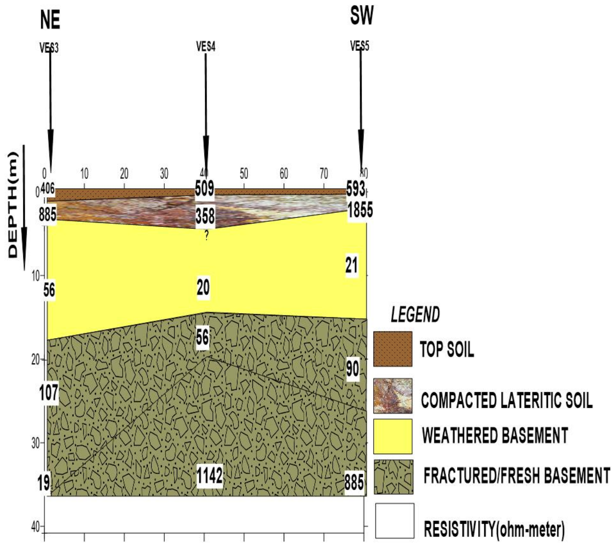

Fig. 13. Geoelectric section beneath VES 3, 4 and 5 along profile 2

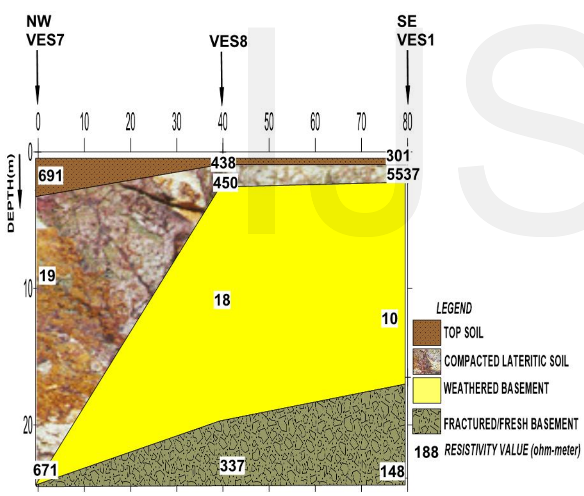

Fig. 14. Geoelectric section beneath VES 7, 8 and 1 along profile 4

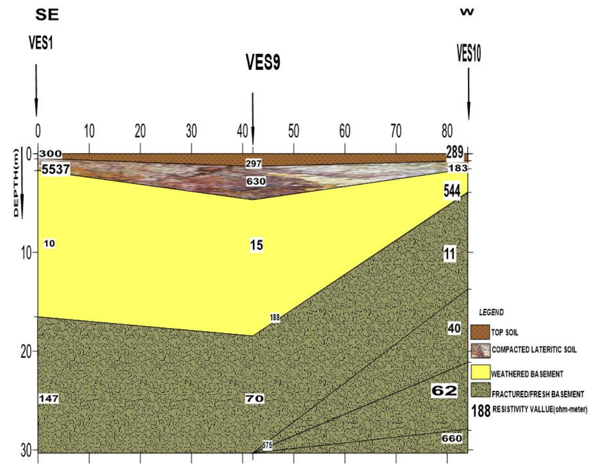

Fig. 15. Geoelectric section beneath VES 1, 9 and 10 along profile

4.2 Hydro-Physicochemical result

Results of the hydro-physicochemical analysis of the collected water samples were presented in Table 1. Water samples were collected mainly from shallow wells (SW-1, SW-2, SW-3, SW-4, SW-5, SW-6, SW-7 and SW-8) and a borehole (BH) which is the only deep well around the site. Table 4.2 also shows the descriptive statistics of hydro-physicochemical parameters along with World Health Organization Standard for drinking water quality. Drinking water standard are generally based on two main criteria (Davis and DeWiest, 1966): (1) Presence of objectionable taste, odour and colour and (2) Presence of substances with adverse physiological (health effects) characteristics.

4.2.1 Major elements

The pH of groundwater samples ranges from 6.9 to 8.4 indicating weakly acidic to slightly alkaline conditions. Total hardness of groundwater of the study area varies from 65.5 to 99.0 mg/L, all the samples in the study area is categorized as soft to moderately hard water. The cation composition of the groundwater shows an order of Na > Mg > K. The sodium in the groundwater varies from 14.40 to 56.74 mg/L, the sodium composition of the samples in the study area are all within the permissible limit WHO 1993 (Table 2). The anion composition of the groundwater is characterized by $NO_3^- > HCO_3^- > Cl^- > SO_4^{2-}$. The concentration of the nitrate, bicarbonate, chloride and sulphate of the samples the study area ranges from 7.00 to 65.5 mg/L, 19.40 to 61.10 mg/L, 8.90 to 60.0 mg/L and 2.27 to 16.90 mg/L respectively. All these parameters are below World Health Organization (WHO 1993) standard for drinking purpose.

4.2.2 Trace elements

The trace elements analyzed in the study area are lead, iron and copper as presented in Table 1. All the tested trace elements (lead and copper) are within maximum permissible limit of WHO standard for drinking purpose except iron. In about 77% of the samples, the maximum permissible limit of iron in water is exceeded; the elevated iron in this case is as a result of iron ore deposit in the area.

TABLE 1

RESULT OF THE HYDRO-PHYSICOCHEMICAL ANALYSIS OF BOREHOLE AND WELL SAMPLES CARRIED OUT DURING THE RAINING SEASON

s/no	Water Sample	PH	Pb^{2+} (mg/L)	Fe^{2+} (mg/L)	Cu^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	NO_3^- (mg/L)	HCO_3^- (mg/L)	SO_4^{2-} (mg/L)	TDS	TH
1	BH	7.0	0.001	0.56	0.014	16.00	14.40	11.70	8.90	7.00	20.00	3.67	510	69.00
2	Well1	6.9	0.013	1.00	0.010	9.47	35.90	9.00	14.98	14.70	60.60	3.90	778	93.20
3	Well2	7.3	0.040	1.70	0.012	28.40	56.74	14.50	44.90	19.50	32.40	2.27	829	75.50
4	Well3	7.1	0.005	2.40	0.200	19.50	27.80	12.50	60.00	29.90	29.90	11.50	1230	89.00
5	Well4	7.5	0.050	1.90	0.040	14.60	33.40	8.00	55.00	44.45	19.40	12.70	734	75.50
6	Well5	8.0	0.030	3.10	0.140	17.45	45.90	13.40	24.90	39.50	35.90	16.90	1115	99.00
7	Well6	7.2	0.060	1.50	0.069	24.78	39.50	18.90	36.00	40.40	45.90	12.90	690	65.50
8	Well7	8.4	0.090	2.00	0.070	29.60	53.89	15.00	29.50	65.50	40.90	15.11	1290	72.20
9	Well8	6.9	0.070	2.90	0.340	25.70	49.45	11.50	18.20	55.50	61.10	10.12	960	85.50

TABLE 2

COMPARISON OF THE PHYSICOCHEMICAL PARAMETERS OF GROUNDWATER OF THE STUDY AREA WITH WHO STANDARD FOR DRINKING PURPOSE

S. No	Water quality parameter	WHO(1993) Maximum desirable	WHO(1993) Maximum permissible	Concentration in Study area
1	PH	7.0	8.5	6.9 – 8.4
2	Pb^{2+} (mg/L)	-	0.05	0.001 – 0.090
3	Fe^{2+} (mg/L)	0.3	1.0	0.56 – 3.10
4	Cu^{2+} (mg/L)	0.05	1.0	0.01 – 0.34
5	Mg^{2+}(mg/L)	30	150	9.47 – 29.6
6	Na^{+} (mg/L)	-	200	14.40 – 56.74
7	K^{+} (mg/L)	-	12	8.00 – 18.9
8	Cl^{-} (mg/L)	200	600	8.90 – 60.0
9	NO_3^{-} (mg/L)	-	50	7.00 – 65.5
10	HCO_3^{-}(mg/L)	-	-	19.40 – 61.10
11	SO_4^{2-} (mg/L)	200	400	2.27 – 16.90
12	TDS	500	1500	510.00 – 1290.0
13	TH	300	500	65.50 – 99.00

5.0 CONCLUSION

The electrical resistivity (VES) along hydro-physicochemical method was used to investigate water quality in the study area. The analysis of vertical electrical sounding's survey revealed that there is a presence of considerable amount of iron minerals at some geo-electric layers of VES because of their general low value of electrical resistivity, this extend to a maximum depth of 23.6m in the subsurface. The continuous intake of iron may cause toxic effects to the human health (Tiwari et al., 201). At greater depth, with reducing conditions, solubility of iron-bearing minerals in water increases leading to an enrichment of dissolve iron in groundwater (Applin and Zhao, 1989; While et al., 1991). To further strengthen VES analysis, the hydro-physicochemical result conducted on various well especially well-2, well-3, well-4, well-5, well-6, well-7 and well-8 showed the concentrations of iron minerals exceeding World Health Organization's maximum permissible limit. However the results obtained from the only borehole (BH) depicted low concentrations of the tested compound in the water sample. The good condition of this borehole is attributed to the fact that it's depth of penetration is greater than 23.6

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