Investigation of Physiochemical Properties of Groundwater at Estako-West, Edo-North, Nigeria

Olotu Yahaya, Ibrahim R., Eboreimen Lucky, Eriakha C. E., Gimba I.N., Yusuf I.

Abstract: *The physicochemical parameters of groundwater at Auchi and South-Ibie were investigated to determine underground water quality in this environment. Water sampled locations in Auchi were categorized as Iyekhei(Iyekhei), Auchi Poly Water(Auchi PW), Auchi Poly Hostel (Auchi PH), Double Delight Hostel (DDH); South-Ibie locations are Levis Gas Plant (LGP), Pastoral Centre (PC), Global Castle Hostel Sawmill Road (GCHS), Arsenal Hostel and, Lagos Street (AHLS). A total number of 80 water samples from eight locations were collected and analyzed using some statistical metrics to determine the relationship among measured parameters. The pH of water samples ranged from 1.4 at GCHS to 4.12 at AHLS. The result indicated that all the investigated water samples have low pH values with a high alkalinity level. Total dissolved solids (TDS) of 300mg/L, 400mg/L, and 500mg/L were obtained from the water samples at Iyekhei, Auchi PH, and DDH. These values are within the allowable World Health Organization (WHO) standard. However, the chloride level for all locations was very high except for Iyekhei, with a value of 115 mg/L, which is accepted within the WHO requirement of 250 mg/L. Conductivity values of four sampled water locations; namely, Auchi PH, DDH, PC, and GCHS, are within the allowable limit. High conductivity values of 304 sm/cm, 116.7sm/cm, and 845 sm/cm were obtained for LGP, Auchi PW, Iyekhei, respectively. All the water sampled locations' results indicated that none of the sampled water is within the WHO required standard of 20oC to 23oC. The statistical metrics showed a strong relationship between the conductivity and chloride concentration with $R^2=0.7174$; this may be related to some dissolved conductive ions in the water sampleThe research study's output is imperative to understand the relationship between different groundwater parameters to develop and good groundwater quality.*

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I. INTRODUCTION

Groundwater resources have played a critical and vital role in the growth. However, they will continue to be important in all contemporary societies' economic growth (Kumar and Kumar, 2013). In developing like Nigeria, the optimum utilization and effective management of their water resources should be the dominant economic growth strategy and development strategy. Conversely, in recent years, unscientific management and uses of these resources for various purpose almost invariably has created an undesirable problem (Patil, 2010).

Waterlogging and salinity, in the case of agricultural use and environment pollution of various limits resulting from mining industries and municipal use in some cases (Kumar and Kumar 2013). Despite the large volume of water covering our planet's surface, only about 1% is inland fresh and readily available for human use (Ramesh and Soorya 2012). The quality of groundwater resources varies naturally and widely depending on the climate, season, and geology of bedrocks and anthropogenic activities (Ramesh and Soorya 2012).

Groundwater is the ultimate, most suitable freshwater resource with a near-balance concentration of salt for human composition (Tewari *et al.,* 2010). In Nigeria, most of the population is dependent on groundwater as the only source of safe drinking water. It is believed to be comparatively much cleaner and free from pollution than surface water (Patil, 2010). Groundwater, which is usually exploited through the sinking of boreholes, is majorly used for drinking purposes by more than fifty percent of the people in Auchi and its environs. Groundwater supplies are replenished or recharged by rain and snowmelt that seeps down into the crack and crevices beneath the land's surface (Nick, 2015). In some areas of the world, people face severe water shortages because groundwater is used faster than naturally replenished. In other areas, groundwater is polluted by human activities (Wolf, 2014). Water in aquifers is brought to the surface naturally through a spring or can be discharged into lakes and streams (Mumma, 2011). Underground water can be brought to the surface by a pump. Wells, known as artesian wells, do not need a pump because of natural pressures that force the water up and out of the well.

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In areas where material above the aquifer is permeable, pollutants can readily sink into groundwater and pollute the underground water system.

It can also be polluted by landfills and seepage from septic tanks. The research study focuses on investigating the physico-chemical properties of selected boreholes (Groundwater) in Auchi and its environs to determine the water quality and develop strategic measures of addressing improving the water quality

II. METHODOLOGY

A. Study area

Auchi community is made up of Akpekpe, Igbe, Utsogun, Aibotse, and Iyekhei. It is the administrative headquarters of Etsako West Local Government Area of Edo State. Auchi is located at the lat. of 7.06770N and long 6.27480E of the equator. South Ibie is made up of Sabo, Iyakpi, Iyereku, and Igieda; Sabo is the administrative headquarter of South Ibie. The study area is Auchi and South Ibie regions and was divided into six zones, namely Auchi-South (Auchi Poly Water), Auchi- North (Auchi Poly Hostel), Auchi-West (Double Delight Hostel), Auchi-East (Iyekhei), Sabo-North (Levis Gas), and Sabo-South (Global Castle Hostel). A total of 80 samples (10 samples per zone) were collected from the borehole. Water samples were collected for a total number of 80 boreholes. This study's physico-chemical parameters are temperature, pH, dissolved oxygen, turbidity electrical, electrical conductivity, total dissolved solids, salinity, sulphate, total hardness, and chloride contents. Complex metric titration methods estimated total hardness and alkalinity of water samples were measured volumetrically by the titrimetric method. Standard methods estimated all other parameters. Plate 1 shows the map of Edo-State indicating the study area.
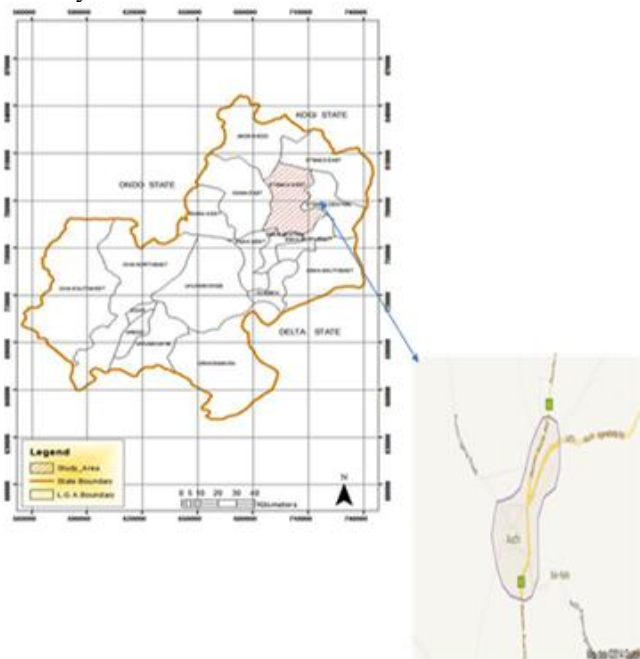
Map of Edo State showing Etasko-West (Auchi)
Source: Author's Arcmap 10.1 Production

III. RESULT AND DISCUSSION

A. Physio-chemical parameters

The properties of the water samples, collected from the six categorized zones of Auchi (Iyekhei, Auchi Poly Water, Auchi Poly Hostel, Double Delight Hostel, Igbe Road) and South-Ibie (Levis Gas Plant, Pastoral Centre, Global Castle Hostel, Arsenal Hostel, Lagos Street) were analyzed, and the investigated variables obtained are shown in Table 1 and 2. The pH of water samples ranged from 1.4 at Global Castle Hostel Sawmills Road (GCHS) to 4.12 at Arsenal Hostel Lagos Street (AHLS). The pH values obtained are generally very low compared to the prescribed WHO standard that ranges between 6.5-8.5(Table 2; Fig.1).

This indicated that all the investigated water samples have low pH values. The results revealed that only three of the water samples from Iyekhei, Auchi Poly Hostel, and Double Delight Hostel, Igbei Road, are with TDS of 300mg/L, 400mg/L, and 500mg/L. These values are within the desirable criteria compared with the WHO standard (they fall within the minimum and maximum permitted TDS value (Table 2; Fig.1). Again, only the water sample from Iyekhei met the WHO standard with a chloride level of 115mg/L, which is within the WHO standard of 250mg/L. All other samples produced values above the recommended standard. Five samples, namely, Auchi PH, DDH, PC, GCHS, and AHLS, are within the prescribed limit.

Table 1: The physicochemical parameters of groundwater samples in Auchi and South Ibie

Sample Name	Conductivity MS/CM	Mg2x present (Mg/L)	Sulphate	Colour range	Hardness mg/L	Taste
Iyekhei	845	1.8	Opacity (opaque) =Sulphate present	0 – 01	260	Tastes Salty
Auchi Poly Water	116.7	1.2	Not opaque (no sulphate)	0.3 – 0.5	305	Tastes Salty
Auchi Poly Hostel	28.7	1.7	Not opaque (no sulphate)	0.3 – 0.5	355	Tastes Salty
Double Delight Hostel, Igbe Road	70.2	1.9	Opacity (opaque) =sulphate present	0 – 01	300	Tasteless
Levis Gas Plant	304	1.6	Not opaque (no sulphate)	0 – 01	305	Tasteless
Pastoral Centre	37.5	1.3	Not opaque (no sulphate)	Nil	300	Taste salty
Global Castle Hostel Sawmill Road	29.5	1.8	Not opaque (no sulphate)	Nil	280	Tasteless
Arsenal Hostel, Lagos Street	90.1	2.0	Not opaque (no sulphate)	Nil	100	Tasteless

Source : Field data, 2016

Table 2: The physicochemical parameters of groundwater samples in Auchi and South Ibie

Sample Name	Chloride Mg/1	Result (pH)	TDS(mg/L)	Odour	Turbidity	Temperature (^{0}C)
Iyekhei	115	3.57	95.43	5	Non-turbid	29.9
Auchi Poly Water	265	3.14	95.5	15	265ml	29
Auchi Poly Hostel	305	2.61	95.44	10	Non-turbid	29.5
Double Delight Hostel, Igbe Road	325	4.21	95.45	5	Non-turbid	28.2
Levis Gas Plant	348	1.39	95.46	5	Non-turbid	28.7
Pastoral Centre	308	3.1	95.47	5	Non-turbid	28.7
Global Castle Hostel Sawmill Road	370	1.4	95.48	5	Non-turbid	28.7
Arsenal Hostel, Lagos Street	355	4.12	95.49	5	Non-turbid	28.8

Source : Field data, 2016

In comparison, three samples with conductivity values of 304 sm/cm(LGP), 116.7 sm/cm (Auchi PW), and 845 sm/cm (Iyekhei) have high conductivity values that exceeded the WHO maximum permitted conductivity level of 100 ms/cm. This revealed that the conductive ions come from dissolved salts. Inorganic materials such as alkalis, chlorides, sulfides, and carbonate compounds are very high. Magnesium is a beneficial metal but toxic at high concentrations, cause hardness, and exerts a cathartic and diuretic action (APHA, 1985).

The concentration of magnesium ranges from 1.2 - 2.0 mg/L for all the tested water samples. These values lie within the maximum permissible limit of 75 mg/L. The sulfate test result showed that all the samples were free from the concentration and conformity with the WHO standard. Correlation studies are critical in water quality assessment because it determines one element's effect on the other (Umadevi *et al.,* 2010). There is a strong relationship between the conductivity and chloride concentration with R^2=0.7174. This may be related to some dissolved conductive ions in the water sample. The R^2 values of 0.0061 and 0.3798 (Fig. 2) indicate no significant conductivity relationship with the water hardness and temperature.

Fig. 1: Locations of water sampling areas
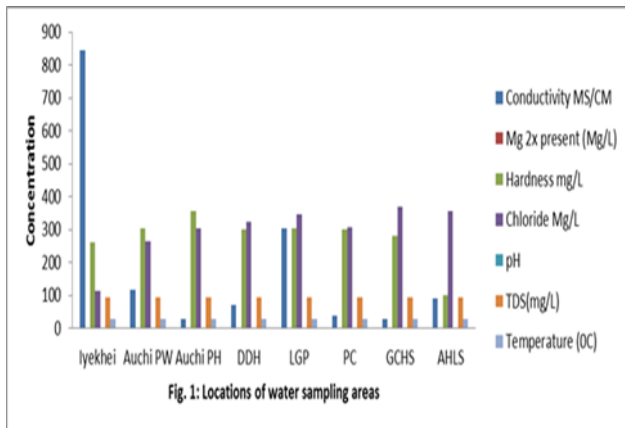
Hint:

Location Name	Abbrev.
Iyekhei	Iyekhei
Auchi Poly Water	Auchi PW
Auchi Poly Hostel	Auchi PH
Double Delight Hostel, Igbe Road	DDH
Levis Gas Plant	LGP
Pastoral Centre	PC
Global Castle Hostel Sawmill Road	GCHS
Arsenal Hostel, Lagos Street	AHLS

Fig. 2: Calibration of Hardness-Chloride-Temperature and Conductivity
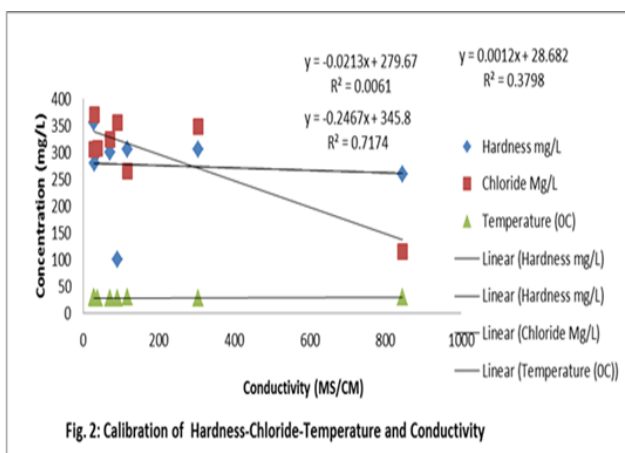
IV. CONCLUSION

The outputs of physio-chemical investigation carried out with 80 water samples from eight locations in Auchi and South Ibie showed that all the sites' pH values are very low and not within the prescribed WHO pH requirement, indicating a high presence of alkalinity. A low concentration of magnesium in all the sampled water revealed that the study area's underground water contains beneficial metal. TDS from all the sampled locations were relatively low and are within the WHO required limit. In contrast, the chloride level for all the sites was very high except Iyekhei, with the value of 115 mg/L, which is considered within the WHO requirement of 250 mg/L. Few water samples showed values above the desirable limits, whereas the concentrations of parameters in most of the samples are below and within the acceptable limit of WHO standard. Conductivity values of four sampled water locations; namely, Auchi PH, DDH, PC, and GCHS, are within the allowable limit. High conductivity values of 304 sm/cm, 116.7sm/cm, and 845 sm/cm were obtained for LGP, Auchi PW, Iyekhei, respectively. All the water sampled locations' results indicated that none of the sampled water is within the WHO required standard of 20°C to 23°C. Auchi Poly Water and Iyekhei were found not within the acceptable odour limit, while the remaining sampled locations were within the allowable limit. Water conductivity showed a strong correlation with the chloride level and normal relationship with water temperature and no significant association with the water hardness. The statistical analysis is imperative to understanding the relationship within different groundwater parameters to develop good groundwater quality.

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