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Assessment of Groundwater Quality of Isiohor Community and Environs, Ovia Northeast Area, Southern Nigeria

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INFORMATION

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ABSTRACT

Seven (7) groundwater samples were randomly collected and analysed with the aim of assessing the groundwater quality in Isihor community and environs, southern Nigeria. All samples were analysed for their physico-chemical properties which include; pH ranged 6.26 to 6.84, electrical conductivity (EC) 24.3 to 82.3µS/cm, total dissolved solids (TDS) 17.0 to 57.6mg/l, sulphate (SO_4^{2-}) 0.09 to 0.18mg/l, phosphate (PO_4^{3-}) 0.16 to 0.27mg/l, nitrate (NO_3^-) 0.12 to 0.24mg/l, ammonium nitrogen (NH_4N) 0.05 to 0.18mg/l, total hardness (TH) 2.16 to 2.87mg/l, turbidity and suspended solid (Non-detected), calcium (Ca^{2+}) 0.23 to 1.06mg/l, magnesium (Mg^{2+}) 1.80 to 1.83mg/l, alkalinity 0.6 to 1.50mg/l, sodium (Na^+) 0.06 to 0.15mg/l and potassium (K^+) 0.08 to 0.49mg/l. The physico-chemical analysis reveals that the values obtained for all parameters fall below WHO and NSDWQ specification for drinking water. Findings reveal that anthropogenic activities do not have any effect on groundwater. The study however shows that the groundwater is potable and can be consumed without treatment.

1. Introduction

Groundwater resource is a natural resource of water that are potentially useful, it is a vital natural resource that plays a crucial role in supporting human activities, ecosystem, health, and overall water supply. Groundwater is a body of water that occurs within the Earth. All living things require water to grow and reproduce. Groundwater is fresh water located in the subsurface pore space of soil and rocks; it flows within the aquifer below the water table. This water can be derived for use from boreholes, wells etc. There is a growing demand for groundwater in virtually all parts of Nigeria (Adeyemi et al., 2003).

This is as a result of rapid growth in population and increasing industrial activities. The quality of groundwater is very important because it affect the social economic factor of an area; therefore, efforts are put in place to know the quality of groundwater in a country, state, or an area. Groundwater remains the preferred source of water because of its high quality with respect to potability and the minimum treatment requirement in most cases (Okoro, 2012).

Naturally, groundwater is less susceptible to contamination unlike surface water thus remediation/treatment of polluted groundwater is difficult and expensive to undertake. Generally, water pollution not only affects water quality but threatens human health, economic development, and social prosperity (Milovanovic, 2007). In Nigeria, most pollution problems are around the largest cities. The primary objective of this assessment is to evaluate the current state of groundwater quality in the study area. By analyzing various physical and chemical parameters, the aim is to identify potential risks, sources of contamination (in case of any), and the overall suitability of groundwater for human consumption.

2. Geological Setting

The study area is Isihor in Ovia North-East Local Government Area of Edo State which ranges from latitude 6^0

24' 0" N to 6^0 26' 0" N to latitude 5^0 34' 0" E to 5^0 38' 0" E (Fig. 1), it is a major unit in the Niger Delta Formation. The Niger Delta Basin is a prolific hydrocarbon province, known for its vast reserves of oil and gas. It covers a vast area of approximately 300,000 square kilometers and extends offshore into the Gulf of Guinea. The basin comprises a sequence of sedimentary rocks, including sandstones, shales, and conglomerates, which were deposited during the Cretaceous and Tertiary Periods (Whiteman, 1982). The morphology of Niger Delta changed from an early stage spanning the Paleocene to early Eocene to a later stage of delta development in Miocene time. The early coastlines were concave to the sea and the distributions of deposits were strongly influenced by basement topography (Doust and Omatsola, 1989). The Stratigraphic Column of the Three Formations of the Niger Delta is exposed in southern Nigeria and is shown in Fig. 2.

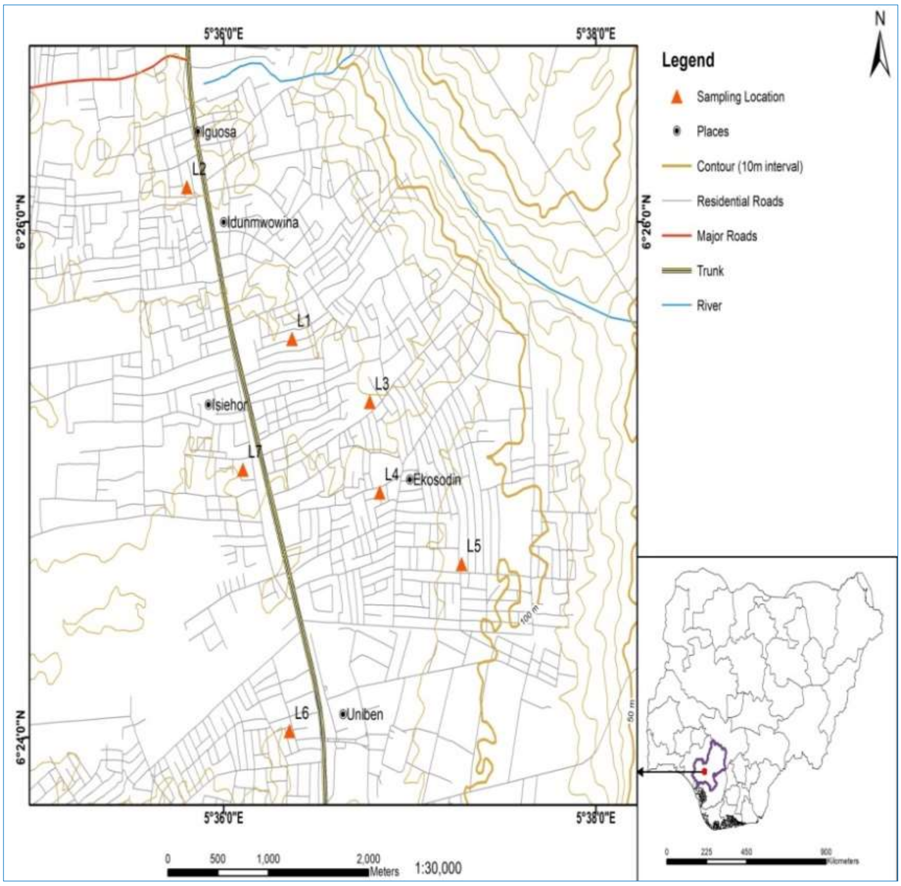

Fig. 1. Location map of Isihor Community and environs

The three major lithostratigraphic units defined in the subsurface of the Niger Delta are (Fig. 3);

a) Akata Formation
b) Agbada Formation
c) Benin Formation

3. Local Geology of Isihor Community and Environs

The study area is underlain by the Benin Formation which is a major lithostratigraphic unit in the Niger Delta Basin (Fig. 3), Nigeria. It is marked by top reddish earth, composed of ferruginized or literalized clay sand. The reddish soil covered in sands, sandy clays, and ferruginized sandstone that characterizes the paleo-coastal environment of the Paleocene-Pleistocene Age was first referred to as Benin Sand (Parkinson, 1907).

The Benin Formation (Fig. 4) is assigned to the Oligocene-Pleistocene period in the continent of Africa and to the Oligocene-Pleistocene to recent at the sub-oceanic (Whiteman et al., 1982). However, Reyment (1965) reinstated the name Benin Formation to identify the reddish-brown-yellow generally white sands often with clayey and pebbly horizons with type-locality around Benin. The Ogwashi-Asaba Formation (Lignite Series) underlain the Benin Formation (Fig. 4), it occurs extensively within the Niger Delta Basin in southern Nigeria (Reyment, 1965).

It is encountered in the uppermost strata of the Benin Formation in drill holes, stream/riverbanks, and road cut outcrops (Okezie and Onuogu, 1985). The Lignite Series consist of coarse-grained sandstones, light-coloured clays, and carbonaceous shales, within which are continental lignite seam intercalations (Reyment, 1965; Kogbe, 1976; Chene et al., 1978). The Imo Shale Formation (Palaeocene-Lower Eocene) is the oldest stratigraphic unit in Niger Delta Basin. It is a transgressive sequence of (fine grain) dark grey shale (Obiadi II et al., 2011).

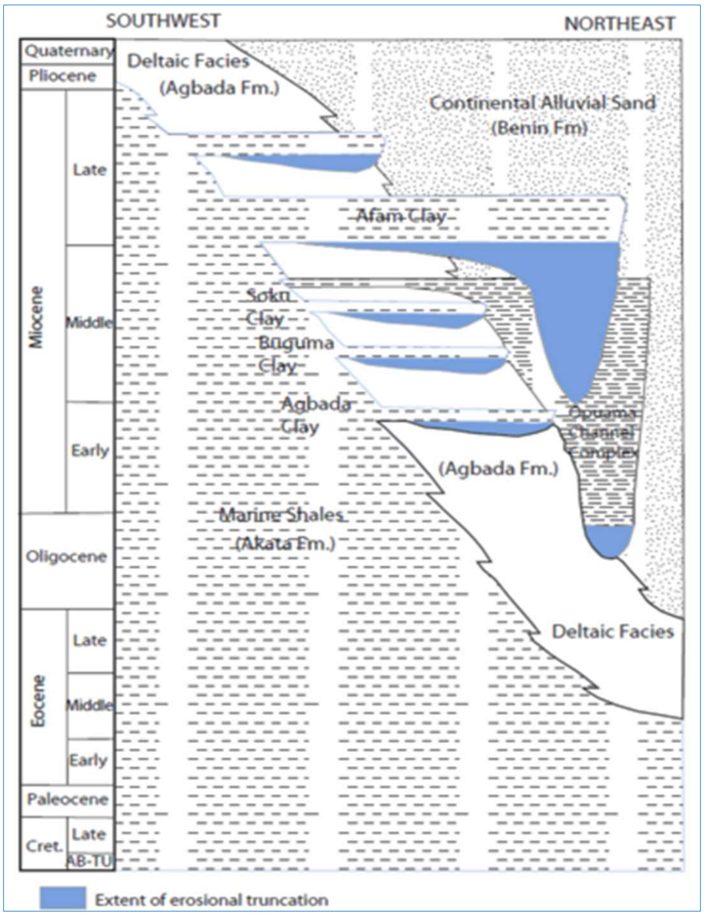

Fig. 2. Stratigraphic column showing the three formations of the Niger Delta. (Modified from Shannon and Naylor (1989) and Doust and Omatsola (1990))

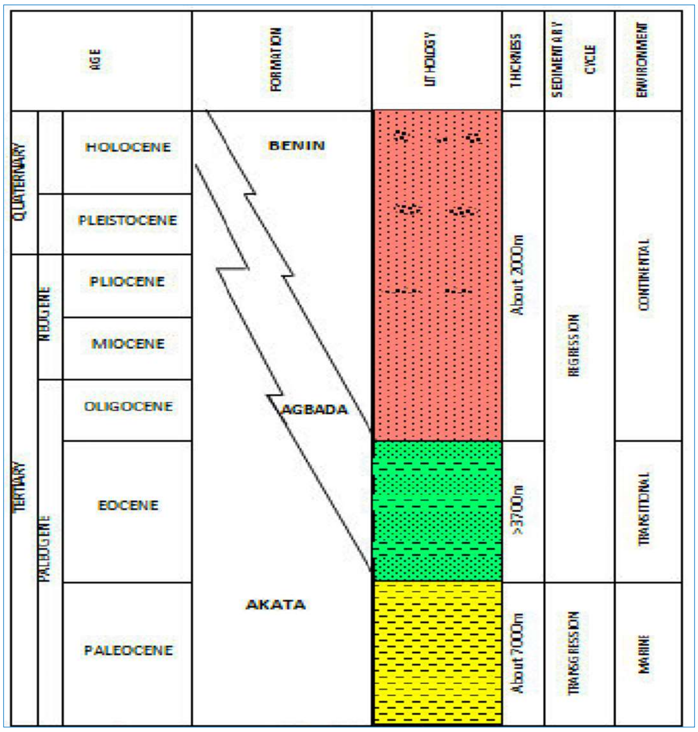

Fig. 3. Generalized lithostratigraphy of Niger Delta (Nwangwu, 1990)

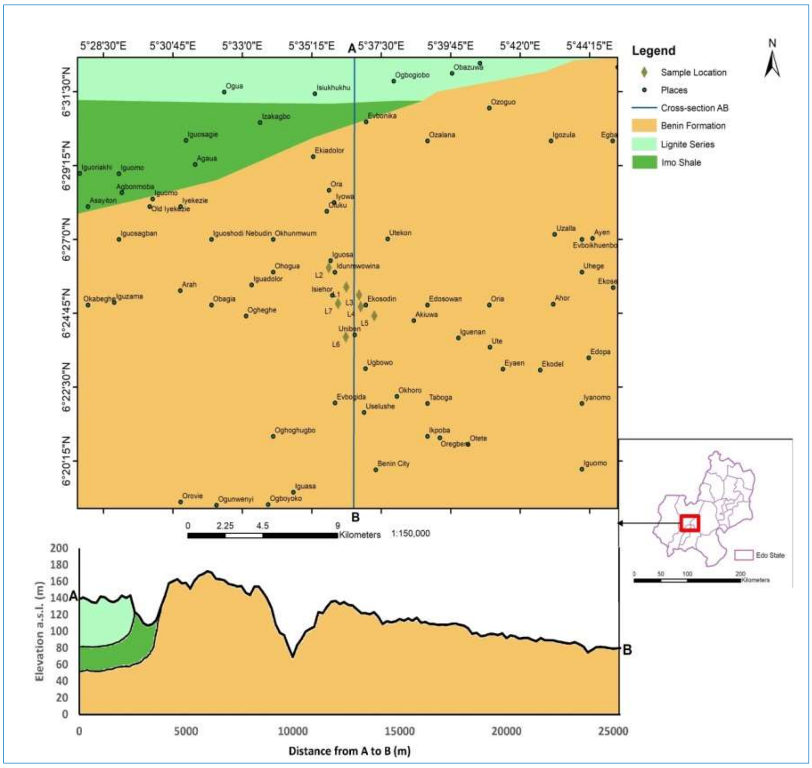

Fig. 4. Geological map of Isihor Community and environs

4. Materials and Methods

Seven (7) water samples were collected directly from random borehole using a clean plastic polyethylene bottle for physicochemical analysis. Analysis was carried out at Benin Owena River Basin Laboratory in Benin City. Samples were collected in the month of June during the rainy season. Global Positioning System (GPS) is used to determine the longitude and latitude of all sample locations. Calibrated Hanna pH Meter is used to determine or measure the acidity or alkalinity of water samples. Hanna instrument (3-in-1) is used to measure the electrical conductivity of water samples, providing an indication of salinity or total dissolved solids (TDS). Atomic Absorption Spectrophotometry (AAS) is used for quantitative analysis of specific parameters in water sample. Turbidity of the water sample is obtained using HACH colorimeter.

5. Presentation and Discussion of Results

The physicochemical analysis of the groundwater samples and World Health Organisation (WHO, 2011) standard as well as Nigeria Standard for Drinking Water Quality (NSDWQ, 2015) are presented in Table 1.

Table 1. Results of physicochemical analysis of borehole water with WHO and NSDWQ standard

Samples	ISH1	ISH2	ISH3	ISH4	ISH5	ISH6	ISH7	WHO, 2011	NSDWQ, 2015
pH	6.84	6.52	6.33	6.93	6.26	6.54	6.28	6.5-8.5	6.5-8.5
EC (µS/cm)	82.30	24.60	41.60	65.50	24.30	37.60	35.20	1000	1000
TDS (mg/l)	57.60	17.20	24.10	45.80	17.00	26.30	24.60	1000	500
S.S (mg/l)	0	0	0	0	0	0	0	500	-
Turbidity (NTU)	0	0	0	0	0	0	0	5	5
Sulphate	0.18	0.16	0.15	0.14	0.09	0.12	0.14	250	100
Phosphate	0.27	0.22	0.25	0.21	0.17	0.19	0.16	5	-
Nitrate	0.24	0.13	0.19	0.17	0.14	0.21	0.12	50	10
Ammonium- Nitrogen	0.18	0.09	0.14	0.11	0.08	0.13	0.05	0.5-1	0.5
Total Hardness	2.16	2.29	2.16	2.53	2.46	2.42	2.87	200	200
Calcium	0.23	0.48	0.34	0.71	0.64	0.62	1.06	75	150
Magnesium	1.83	1.81	1.82	1.82	1.82	1.80	1.81	50	100
Alkalinity	1.50	0.70	0.80	1.20	0.60	0.80	0.70	100	-
Sodium	0.13	0.06	0.13	0.14	0.10	0.14	0.15	200	200
Potassium	0.39	0.08	0.49	0.47	0.15	0.22	0.37	1-2	1.0

5.1. pH of The Samples

The pH value or hydrogen ion concentration is a measurement of the acidity or alkalinity (basicity) of water (Twort et al., 1985). The pH range of the water sample is 6.26-6.93 which falls within the allowable limit of WHO (2011) and NSDWQ (2015) drinking water standard. This indicates that the water sample in the study area is slightly acidic. Acidity in the groundwater may be attributed partly to gas flaring from industries such as Agen Aluminium Company, Seven-up Bottling Company, Mouka Foam Industry and vehicles; found within the area. This industrial activity releases carbon dioxide which reacts with atmospheric precipitation to for carbonic acid. This acid infiltrate into groundwater body thereby increasing acidity. Acidic water may occur naturally as a result of alteration of groundwater (Umar, 2003; Absar, 2003), and may result in serious health complications such as irritation in the eyes, skin and mucous membrane (Karunakaran, 2008). The pH observed in this study is within the limits of WHO (2011) standard and NSDWQ (2015) compared to the pH level observed by Rawlings and Ikediashi (2020) in Impact of Urbanizing Ovia-North East Local Government Area, Edo State, Southern Nigeria; it was observed that pH did not meet up with WHO (2011) standard and Ogbeifun et al. (2019), in physiochemical analysis of the water samples where the observation shows that the pH falls below WHO (2011) standard.

5.2. Electrical Conductivity (µS/cm)

This is measurement of the ability of a solution to conduct electric current and is a function of temperature; types and concentration of ions present (Karunakaran, 2008). Electrical conductivity gives an indication of the amount of total dissolved solids in water (Yilmaz, 2014 and Koc, 2014). The electrical conductivity of the water sample ranges from 24.60 – 83.20 µS/cm. The values were below the WHO (2011) recommended limit 1000 µS/cm. At high levels of EC, drinking water may have an unpleasant taste or odor, or may cause gastrointestinal distress in humans. In comparison with previous work carried out by Ogbeifun et al. (2019), physiochemical analysis of the water samples; it was observed that TDS did not exceed WHO permissible limit as well as work carried out by Rawlings and Ikediashi (2020).

5.3. Total Dissolved Solids (TDS)

TDS values recorded in this study are below WHO (2011) limit, its range is 17.00 mg/l – 57.60 mg/l: hence suitable for use as drinking water and other domestic purpose. High TDS value limits the suitability of water to be used for domestic purpose (Davis, 1996; De Weist, 1966). WHO (2011) has set 1000 mg/l as standard allowable limit for drinking water because water with high TDS is of poor quality and may induce physiological reaction to consumers; high TDS has been shown to be responsible for hardness, odour, colour, alkalinity and taste (ASTM, 2004).

5.4. Sulphate (SO_4^{2-})

Sulphate in water is due to industrial effluent where sulphate or sulphuric acid have been used in processes such as tanning and pulp paper manufacturing or naturally from dissolution of gypsum and other minerals deposits containing sulphate and also from sea water intrusion. The values for all sample ranges from 0.09 mg/l – 0.18 mg/l, it does not exceed the WHO (2011) standard and NSDWQ (2015) specification which is 400 mg/l and 100 mg/l respectively.

5.5. Phosphate (PO_4^{3-})

The range of phosphate for the groundwater sample is between 0.16 mg/l – 0.27 mg/l; all phosphate value recorded in the study is below the WHO (2011) limit and thus the water is suitable for consumption. Phosphate mainly originates from sewage effluents which contain phosphate-based synthetic detergents, or from industrial effluents including run-off from organic fertilizer or from industrial effluent.

5.6. Nitrate (NO_3^-)

According to WHO, the acceptable limit for nitrates is 50 mg/l. Result indicates the range of nitrate from 0.12 mg/l to 0.24 mg/l; hence, all the nitrate values recorded in all location were less than the WHO (2011) standard and NSDWQ (2015).Major source of nitrate is due to human activities and high nitrate content in drinking water may cause methemoglobinemia in small children (National Academy of Science, 1972).

5.7. Ammonium Nitrogen (NH_4N)

The range of ammonium nitrogen for the groundwater sample is between 0.05 mg/l – 0.18 mg/l. The value does not exceed WHO (2011) standard and thus it is suitable for consumption. Ammonium nitrogen is the presence of ammonium ions in the water which emanates from underground sources such as aquifers or wells. Elevated levels of ammonium nitrogen in groundwater can have adverse effects on water quality, leading to issues such as eutrophication, contamination of drinking water source, and harmful algal blooms (Duan et al., 2019).

5.8. Total Hardness (TH)

The range of hardness for the groundwater sample is between 2.16 mg/l – 2.87 mg/l; it conforms to WHO (2011) standard and NSDWQ (2015) specification. The primary sources of hardness in groundwater are the dissolution of minerals such as calcium carbonate (calcite) and magnesium carbonate (magnesite) present in geological formations through which groundwater flows (Hem, 1985). Other minerals like gypsum (calcium sulfate) and dolomite (calcium magnesium carbonate) can also contribute to groundwater hardness (Sawyer et al., 2003).

5.9. Calcium, Magnesium, Potassium and Sodium (Ca^2, Mg^{2+}, K^+ and Na^+)

Calcium results from metallic ions dissolved in water. It presence in water makes the water hard and waste shampoo and soap by forming scum. The range of calcium for the groundwater sample is between 0.23 mg/l to 1.06 mg/l; it falls below WHO (2011) standard and NSDWQ (2015) standard. Calcium is a naturally occurring element in the Earth's crust and is often found in groundwater due to the dissolution of calcium-bearing minerals in rocks and soils (Machel, 2001). Groundwater can contain varying concentrations of calcium ions, influenced by the geological composition and mineral content of the aquifer through which it flows (Plummer et al., 2004). The value of magnesium ranges from 1.80 mg/l to 1.83 mg/l; it does not exceed WHO (2011) standard and NSDWQ (2015). Magnesium is a naturally occurring element that can be found in groundwater due to the dissolution of magnesium-bearing minerals present in rocks and sediments (Krauskopf, 1957). The concentration of magnesium in groundwater varies depending on geological and hydrological factors, as well as local geology (Appelo and Postma, 2005) Magnesium concentration in water is normally low. It occurs in amphiboles, olivines, pyroxene and clay minerals. It is the second element responsible for hardness of water. The range of potassium is from 0.08 mg/l to 0.49 mg/l; and it conforms to WHO (2011) and NSDWQ (2015) specifications. Potassium are the products of weathering of orthoclase, microcline, feldspathoids, some mica, clay minerals, dissolution of nitre and sylvite due to percolation of water through evaporite deposits. Result reveals that sodium range from 0.06 mg/l to 0.15 mg/l; it falls below the WHO (2011) limit. Sodium is released during the weathering of plagioclase feldspars, evaporites like halite (NaCl), exchange reaction between calcium ions and sodium ions. Concentration of these parameters in the study was observed that it conforms to WHO standard compared to previous work by Andre-Obayanju et al. (2023) in which calcium and magnesium does not conform to WHO standard and this is as a result of the presence of dumpsite in the area. Also, Akujieze (2004) observed the water quality in Benin City and found that the concentration of Ca, K, Mg and Na are low; making the water is soft and fit for drinking.

5.10. Turbidity and Suspended Solid

The analysis reveals that neither turbidity nor suspended solid were detected in the groundwater, thus; it is considered good for consumption because it does not exceed WHO (2011) standard.

5.11. Alkalinity

Alkalinity of the sample ranges from 0.6 mg/l to 1.50 mg/l; it does not exceed WHO (2011) standard as well as NSDWQ (2015). It is the capacity of water for neutralizing any acid solution. The bicarbonate and carbonates ion are mainly responsible for alkalinity. They form scales when their concentration becomes high. Alkalinity in groundwater is primarily derived from the dissolution of carbonate and bicarbonate minerals, such as calcite (calcium carbonate) and dolomite (calcium magnesium carbonate), present in geological formations (Appelo and Postma, 2005). Other contributors to alkalinity may include natural and anthropogenic sources like industrial effluents, agricultural runoff, and sewage discharges (Stumm and Morgan, 2012). The body needs these vital elements for proper nourishment, but not in excess since having too much of them might have negative health effects. It is important to note that during the research study, all nutrient levels were below the WHO drinking water standards. Thus, the water samples from all seven (7) locations are safe for drinking as the nutrient level do not exceed the WHO (2011) and NSDWQ (2015) recommended values.

6. Conclusion

Isihor community and environs is located in Ovia Northeast Local Government Area of Edo State. It houses urban settlements; the population is on the increase, industries (such as Agen Aluminium Company, Seven-up Bottling Company, etc.) are built, residential houses, agricultural activities are on-going, and marketplaces as well as slaughterhouses are located there. All these can lead to the negative impacts on the groundwater, but it was observed from the study that it has not affected the groundwater negatively. The results analyzed from the study area also reveals that physicochemical parameters where below limit of WHO (2011) and NSDWQ (2015) standards, therefore, the water is fit for drinking.

7. Recommendations

1. Government should maintain monitoring programs to provide long term records on the state of ground water.
2. Legal sanctions should be implemented against illegal dumping of waste and discharge of wastes into the environment to protect groundwater.
3. Regular annual analysis should be carried by residence to determine the state of borehole water.

Appropriate local standards should be updated regularly and made available to the general public.

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