Assessment of Potable Water Quality from Boreholes and Rainwater Reservoirs in Etsako Communities in Edo State, Nigeria.

[1]Ideriah, T. J. K., [2]Osiriamhe, G., [2]Bull, S, [2]Okafor, C. C.

[1]Institute of Pollution Studies, Rivers State University, Nkpolu Oroworukwo, Port Harcourt

[2] Department of Chemistry Rivers State University, Nkpolu Oroworukwo, Port Harcourt

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ABSTRACT

The quality of water obtained from fifteen stations consisting of boreholes and rainwater reservoirs in Etsako, Edo state, were assessed in this study. The levels of physico chemical, microbial Properties were determined using standard methods recommended by the American Society for Testing and Materials for physico chemical properties and spread plate count method for microbial content. Water Quality Indices were determined using an adopted mathematical model. The results showed that the mean pH levels ranged from (4.3±0.1 – 7.2±0.1), Turbidity (0.6±0.00 – 2.0±1.3 NTU), Conductivity (17.5±0.5 – 307.5±21.5 µS/cm), TDS (12.5±0.5 – 216.0±15.0 mg/l), Salinity (0.01±0.00 – 0.19±0.05 ‰), Total Hardness (1.2±0.5 – 64.5±3.9 mg/l), Alkalinity (6.0±2.0 – 80.0±56.0 mg/l), Chloride ion (1.0±0.00 – 10.3±5.9 mg/l), Sulphate (1.0±0.00 – 9.5±4.0 mg/l), Nitrate (0.00 – 2.46±1.15 mg/l), Phosphate (0.00 – 0.69±0.02 mg/l), Total Heterotrophic Bacteria (3.00±2.00 – $2.458\times10^4\pm2.44\times10^4$ cfu/ml), Total Coliform Bacteria (0.00 – 7.5±4.5 MPN/100ml), Faecal Coliform Bacteria (0.00 – 3.00±0.01 MPN/100ml), pH levels of water in the areas were within set limits in most stations. Water Quality Indices showed that the water in the study area ranged from poor to Unsuitable for drinking. The results from this study show that water in the study area is poor for drinking purposes and can pose health hazards to the population if consumed without proper treatment. Thus, regular monitoring, adequate treatment as well as alternative source of drinking water were recommended.

Key words: Potable, Water Quality, Boreholes, Rainwater, Reservoirs, Edo, Nigeria

INTRODUCTION

Nature is full of water, which makes up a significant portion of the earth's ecosystem and covers around 75% of the planet's surface. It is found as surface water in bodies of water including lakes, streams, rivers, ponds, shallow aquifers, oceans, seas, ice caps, and glaciers as well as groundwater (when it builds up in the ground), which is received as spring water, well water, and borehole water (Chandra *et al*., 2012). All naturally occurring water contains small amounts of atmospheric gases including N_2, O_2, and CO_2 (Borne, 1998). Water, which is composed of the two components hydrogen and oxygen, is the most widely used solvent since it can dilute many compounds. Water also has excellent heat absorbing properties and plays a major role in the physiology of both flora and fauna (plant and animals) and also in their metabolic activities (Golterman, 1998).

In many processes, particularly those involving intricate chemical compounds like amino acids, water is a key component. It is essential to manufacturing, industrial, and agricultural processes, particularly irrigation. Since life cannot survive without water and the majority of manufacturing enterprises cannot run without it, water is a crucial natural resource. The existence of trustworthy water supplies is a crucial prerequisite for the development of a stable community (Erah*et al*., 2002). Water pollution from human activities frequently renders such water unfit for usage. Water pollution is a change in water quality that makes it unstable or unsafe for recreational activities, industry, agriculture, fishing, and human and animal health. However, the level of contamination of water was modest before to the onset of industrialization. Modern activities including manufacturing processes contaminated the source of drinking water. A common illustration is the placement of chemical industries along river banks, where effluent is discharged into the river. Streams and rivers get polluted when sewage is dumped into water bodies, as is done in the Lagos lagoon (Okonkwo *et al* ., 2009).

The use of pesticides, herbicides, and fertilizers in agricultural processes results in the production of harmful compounds that are discharged into water sources as effluents, where they contaminate water bodies (Obi *et al*., 2007). Similar to this, the waste water from textile factories contains organic dyes that introduce various ions into the water and change its chemical composition (Olowe *et al*, 2005). Oil spills contaminate bodies of water and create a layer that prevents oxygen from reaching the water's surface. As a result, the water becomes anaerobic, which kills fish and other aquatic life (Edward, 1980). The introduction of specific ions or chemicals into water during oil drilling operations frequently contaminates ground water supplies, lowering the quality of the water. Poisonous ions are clearly present in contaminated surface and ground water. However, some ions that are added to bodies of water may interact with other substances to create insoluble compounds that might cause considerable injury when ingested. Despite the fact that natural water is never pure, groundwater sources are thought to be the cleanest. However, subsurface contamination from local groundwater sources into surface water sources happens (Hutton, 1981).

The largest freshwater reserve, outside of the ice caps, is provided by groundwater, which is a crucial resource from a global standpoint. The amount of freshwater being withdrawn from the ground today accounts for about 26% of the total global outflow (VanderGun, 2012). Nearly half of the world's drinking water comes from groundwater, and 43 percent of the world's consumptive consumption for irrigation (Siebert *et al*., 2010). It is crucial for industry and as a source of energy. Groundwater is the sole trustworthy source of water in arid and semiarid areas of the planet. Groundwater supports groundwater-dependent ecosystems and significantly contributes to base-flow in rivers.

One benefit of using groundwater for drinking water supplies is that it is naturally shielded from many toxins. For instance, unique soil, climate, aquifer structure, and groundwater flow characteristics may favor de-nitrification, which would naturally attenuate high concentrations of nitrates and other pollutants with anthropogenic origins. People in water-scarce areas will depend more on groundwater during droughts and as a result of climate change due to its ability as a buffer and resilience to sudden shocks. However, climate change may have an impact on both the amount and quality of groundwater, thus it is important to include this when conducting groundwater evaluations.

Because of the pressure that human activities and climate change place on groundwater resources, an assessment of its quality is necessary. However, because groundwater is an invisible resource, most people don't think about it. For the sake of maintaining food supply, preserving ecosystems, and safeguarding human health, our groundwater resources must be protected. Since modern water treatment is not viable from an economic standpoint, many regions and nations rely on naturally pure groundwater. Therefore, it's crucial to understand the hazards to this resource and where to find clean groundwater.

1.2 Justification of Study

Etsako is located in the northern part of Edo State, and the inhabitants depend solely on groundwater (boreholes) and rainwater (collected in reservoirs) as their only sources of water for drinking and other purposes. Increased population over the years has led to an increase in anthropogenic activities such as farming, indiscriminate waste disposal, dumpsites, and human waste, which has led to the pollution of the groundwater in the study area. Most common disease cases in the study area include diarrhea, hepatitis A, cholera, typhoid, dysentery, and skin diseases, which are traceable to the quality of groundwater as these

diseases are waterborne.

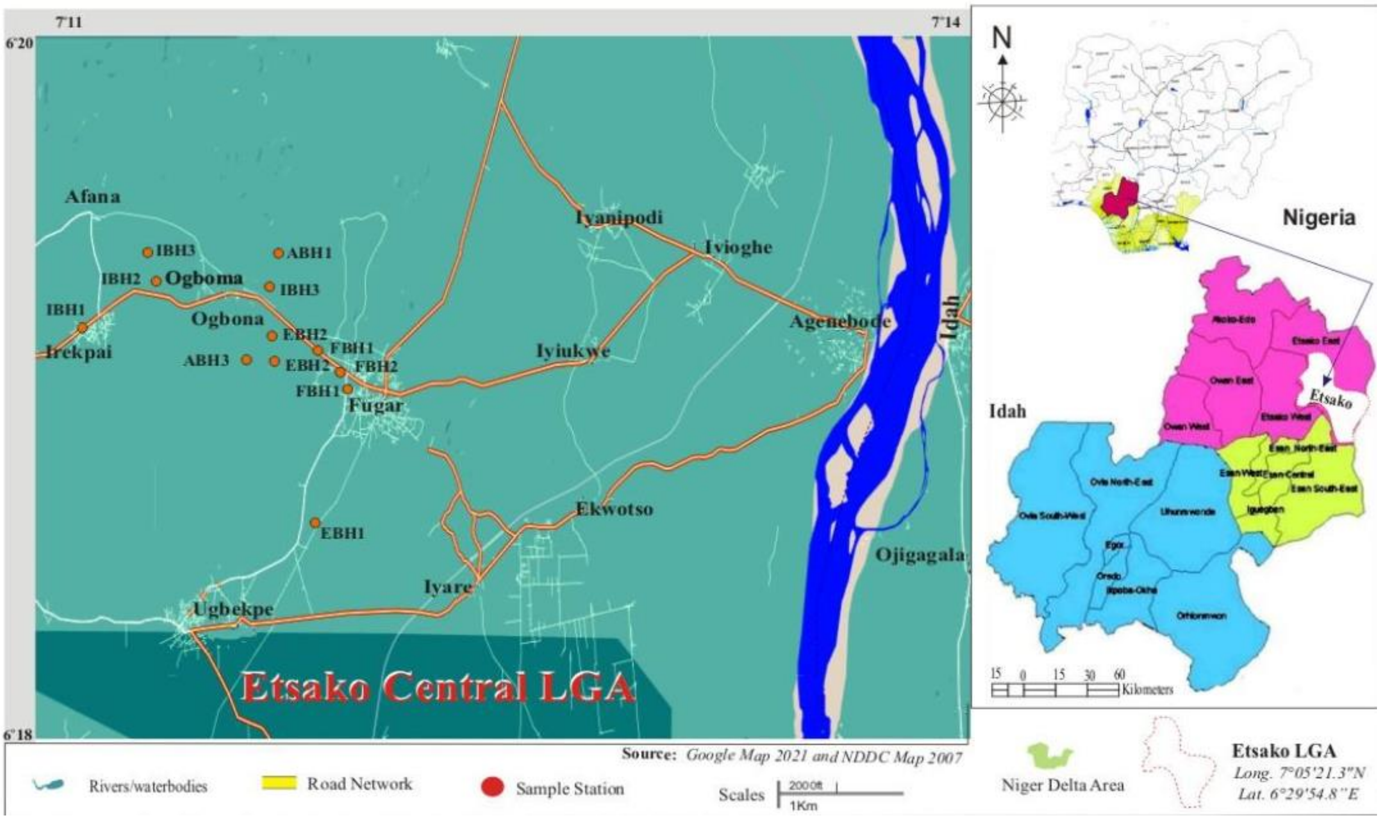
Therefore, in an attempt to protect the health and well-being of the people in the study area, it is important to evaluate the quality of the water to reduce the rate of morbidity and mortality in the study area.

MATERIALS AND METHODS

Description of the Study Area

The investigation was conducted in some communities in Northern part of Edo State. It has a land area of 2800 km^2 and a population 589,000 people (NPC, 2006). It is located on latitude 7′.0057″N and longitudes E 06′.4503″ (see Fig.3.1). The research area has two different seasons: the rainy season (February to November) and the dry season (December to January). The geography of the study area is primarily undulating, and it is located at an altitude of 704 meters above sea level. It has a double rainfall maxima region and a wet semi-equatorial climate, with the main rainy season falling between March and July. The period from September through November is known as the 'small rainy season'. A typical monthly temperature of roughly 21 °C characterizes the year-round high temperatures. During the rainy season, humidity is high. An average of 84.16 percent humidity is present. The cultivation of crops like mangoes, oranges, plantains, vegetables, cassava, yams, etc. is ideal for this climatic environment. However, it must be emphasized that due to climate change, existing trends in the district's climatic conditions are growing unpredictable. However, this has had an impact on agricultural activity. The majority of the research area's vegetation is of the semi-deciduous rain forest variety. As a result, the land is rich in fertility and is appropriate for agricultural ventures. Cassava, rice, maize, cocoa, citrus, oil palm and other food and cash crops are commonly planted there. Secondary forests have rapidly supplanted primary forests as a result of unsustainable practices like shifting cultivation, the slash-and-burn technique of farming, illicit mining, and

Fig 3.1: Map of Study Area



Sample collection

At various locations in the study area, samples were collected from residential reservoir wells and boreholes.

All water sample containers where reviewed for the right kind, volume, integrity, temperature, preservation, and holding period.

One- to two-liter plastic bottles were used to collect samples. The bottles were properly cleaned and rinsed with diluted distilled water, and a little amount of the water that would be evaluated before samples were taken. All samples taken were immediately and meticulously labeled with the name and code of the location and transported to the laboratory. The water samples were filtered using Whatman filter paper, acidified with strong HNO_3 to keep the pH at 2, and then stored in a dark area. Heavy metals and microbiological content samples were brought to the laboratory in an icebox and kept there in a refrigerator at 4°C.

Estimation of Water Quality Parameters

An approach suggested by the American Public Health Association (APHA) in 1995 was used in the investigation. A multimeter was used to take measurements in the field of pH, specific conductivity, water level, turbidity, and temperature

Determination of Total Dissolved Solids (TDS)

To determine the total dissolved solids, present in the water samples, electrical conductivity was tested using a probe and a meter that apply a voltage between two electrodes. After placing the electrodes in water, the conductivity was determined by measuring the voltage drop. The voltage drop was due to resistance brought on by charged ions in the water.

Determination of chloride (Cl^-) ion

This was determined by placing 100ml of the water sample in a 250ml beaker. The pH was adjusted to the range of 7-10 by gradually adding H_2SO_4, 1ml of K_2CrO_4 was added as indicator and the solution was titrated with 0.14M silver nitrate to give a pinkish yellow end point.

Determination of nitrate (NO_3^-)

Water sample (10ml) was transferred into 25ml volumetric flask. Then 2ml of Brucine reagent (dimethoxystrychnine-$C_{23}H_{26}O_4N_2.2H_2O$) was added, followed by the addition of 10ml of concentrated H_2SO_4. The content was mixed for about 30 seconds and allowed to stand for 30 minutes. The flask was air cooled for 15 minutes, made up to the mark, and the absorbance was measured by portable datalogying spectrophotometer model DR/2023 at the wavelength of 470nm. Standard nitrate solution was prepared by dissolving 0.8g of KNO_3 in 500cm^3 of distilled water. 0.5cm^3 of chloroform was added in order to preserve it. Aliquots having concentrations range of 0.01-2.0M of (NO_3^-) were prepared from stock solution and used to obtain a calibration curve. The absorbance obtained for each sample was compared to the calibration curve and the concentration of nitrate in each sample was obtained.

Determination of sulphate (SO_4^{2-})

The water sample (15ml) was measured into 50ml volumetric flask and 5ml of distilled water was added. 1ml of gelatinous reagent (Gum acacia) was added and made up to the mark with distilled water that formed barium sulphate turbidity. The content was thoroughly mixed and allowed to stand for 30 minutes. The optical density (OD) corresponding to the absorbance of the barium sulphate was measured using a HACH

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DR/2010 portable datalogying spectrophotometer at a wavelength of 420nm. Reading was taken at intervals of 30 seconds over a period of 4 minutes and the maximum reading resolved. A calibration curve was prepared using analytical grade anhydrous potassium sulphate (K2SO4) that covered the range of 0.01-1.6mg/l SO_4^{2-}. From the calibration plot, the level of sulphate ion equivalent to the observed optical densities (absorbance of the test and blank solution) were read off and the level of sulphate (SO_4^{2-}) ion in the sample obtained**.**

The Brucine method was used to estimate the concentration of nitrate ions, the turbi dimetric method was used to determine the level of sulphate, the Stannous chloride method was used to estimate the level of phosphate, the Argentometric method was used to determine the level of chloride, and the calcium ions were calculated using ethylenediaminetetraacetic acid (EDTA).

Determination of total alkalinity

Total alkalinity of water, usually due to the bicarbonate, carbonate and hydroxide components, was determined by titrating aliquots of the water sample against 0.020 M HCl using a mixed indicator-bro mocresol and green methyl indictor

Determination of Heavy Metals Concentrations

The research samples were gathered, and an atomic absorption spectrophotometer (AAS) was used to analyze samples for heavy metals. The sample was aspirated into a flame where it atomized to count the amount of heavy metals. A monochromator and detector were used to quantify the amount of light energy that was absorbed after the light beam was directed through the flame. A certain lamp's ability to create a certain amount of light and have that light then be absorbed by a flame directly relates to how much of that element is present in the sample.

Microbial Content Analysis

The pour-plate method, sometimes referred to as a conventional plate count, was used in this work to conduct a heterotrophic plate count (HPC). The technique was employed to calculate the concentration of culturable, live heterotrophic bacteria in water. An aliquot (0.1) must be aseptically transferred onto a sterile petri dish or glass as part of the operation. Then, sterile, nutritious agar was added once it had cooled. The mixture was after that given time to settle and harden before being incubated for 48 hours at 37°C. On the plate, the formed bacterial colonies were counted and multiplied by the appropriate dilution's reciprocal.

Water Quality Index (WQI)

The weighted numerical water quality index was used to assess the suitability for drinking purpose. In the method, water quality rating scale, relative weight and overall water quality index was calculated using the equation.

$$q_i = \frac{C_i}{S_i} X\, 100 \qquad (3.1)$$

Where; q_i represents the quality rating scale, C_i indicates the concentration of the i parameter and standard value of i -parameter respectively

Therefore, the relative weight was computed as

$$w_i = \frac{1}{S_i} \qquad (3.2)$$

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Such that the standard value of the ***ith*** parameter is inversely proportional to the relative weight The overall water quality index (WQI) was determined using the equation below;

$$WQI = \frac{\sum_{i=1}^{n} q_i w_i}{\sum_{i=1}^{n} w_i} \qquad (3.3)$$

Where; q_i = quality rating of i^{th} water quality parameter, w_i = unit weight of i^{th} water quality parameter =1

In this study, the National Sanitation Foundation water quality approach (NSF-WQI) of United State was adopted. The National Sanitation Foundation water quality NSF-WQI includes the following nine parameters of quality; total of dissolved solid (TDS), turbidity, pH, Nitrate, Phosphates, Coliforms, Dissolved Oxygen, BOD and temperature.

WQI- NSF is a positive integer ranging between 0-100; where, indicates the weighing factor for each parameter, is the sun-index of the quality parameter which can be obtained from the conversion curve. Curves that convert parameters determine by values ranging between 0-100 (Ichwena et al, 2016).

RESULTS

Physicochemical properties

The results of physicochemical properties in groundwater samples from the study are shown in Figs. 1 – 8.

Mean pH levels ranged from 4.3±0.1 – 7.2±0.1; Temperature levels were between 29.2±0.7 and 29.5±1.0 °C; Turbidity levels ranged from 0.60±0.00 – 2.0±1.3 NTU; Conductivity levels ranged from 17.5±0.5 – 307.5±21.5 µS/cm; Salinity levels ranged between 0.01±0.0 and 0.19±0.05 ‰; Total Dissolved Solids (TDS) levels were between 12.5±0.5 and 216.0±15.0 mg/L; Total Hardness levels ranged from 1.2±0.5 – 64.5±3.9 mg/L; Alkalinity levels were between 6.0±2.0 and 80.0±56.0 mg/L; Chloride levels ranged from 1.0±0.0 and 10.3±5.9 mg/L; Sulphate levels were between 1.0±0.0 and 9.5±4.0 mg/L; Nitrate levels ranged from 0.000±0.000 to 2.460±1.150 mg/L; Phosphate levels were between 0.000±0.000 and 0.690±0.020 mg/L; Calcium levels ranged from 0.375±0.235 to 18.070±10.650 mg/L; Magnesium levels ranged between 0.053±0.013 and 6.735±0.245 mg/L; Sodium levels were from 0.644±0.289 to 10.59±2.015 mg/L; Potassium levels ranged from 0.289±0.134 to 15.655±2.540 mg/L; Bicarbonate levels were between 6.0±2.0 and 80.0±56.0 mg/L and Carbonate levels ranged from 0.000±0.000 to 2.218±0.776 mg/L.

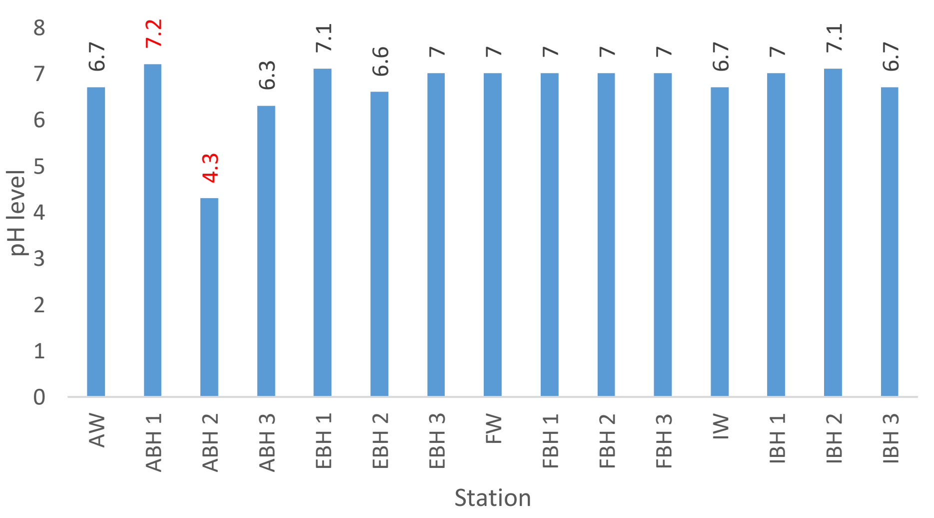

Fig 1: Mean pH level

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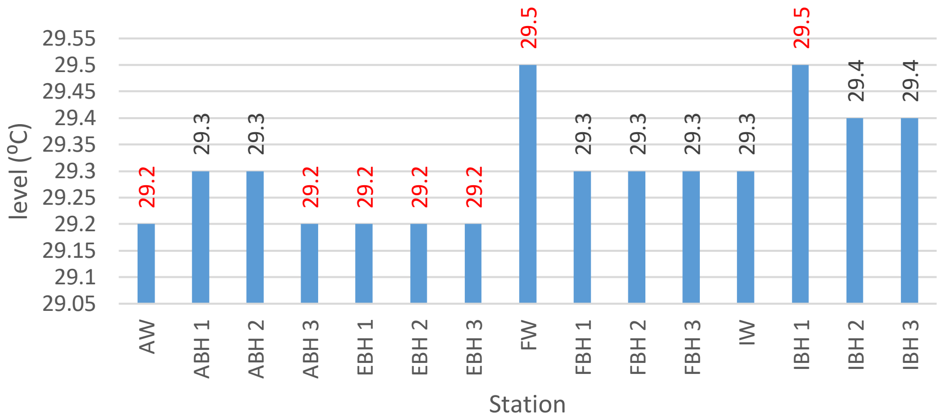

Fig. 2: Mean Temperature level

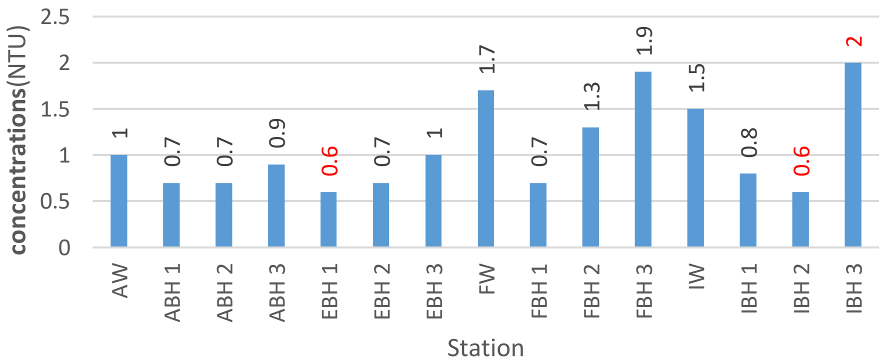

Fig. 3: Mean Turbidity level

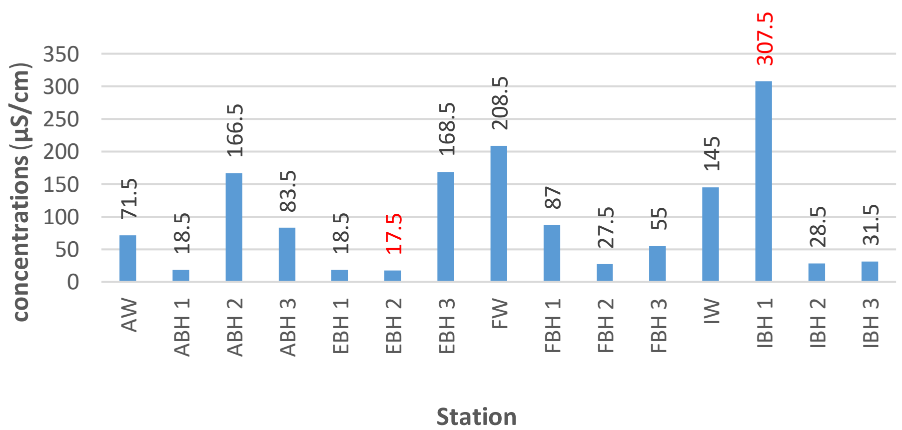

Fig. 4: Mean Conductivity level

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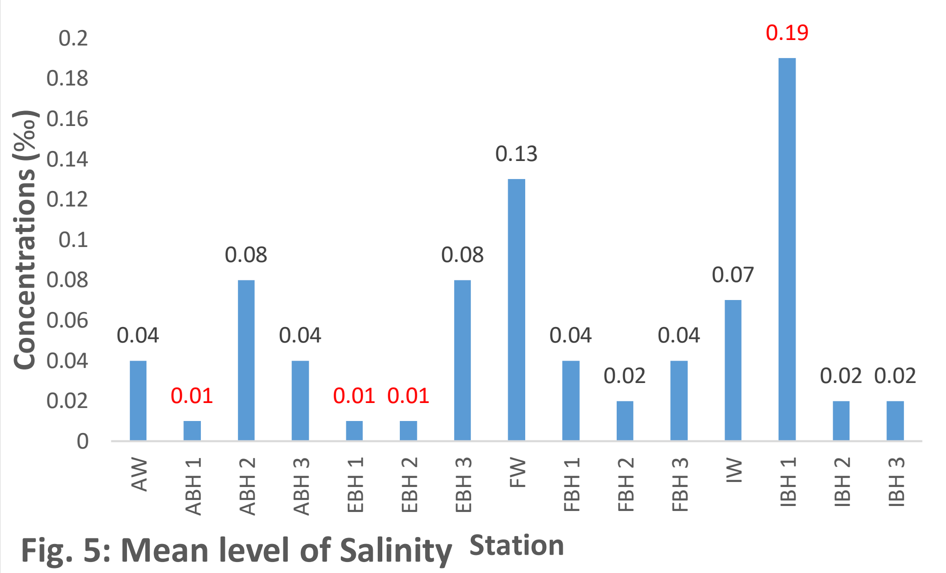

Fig. 5: Mean level of Salinity

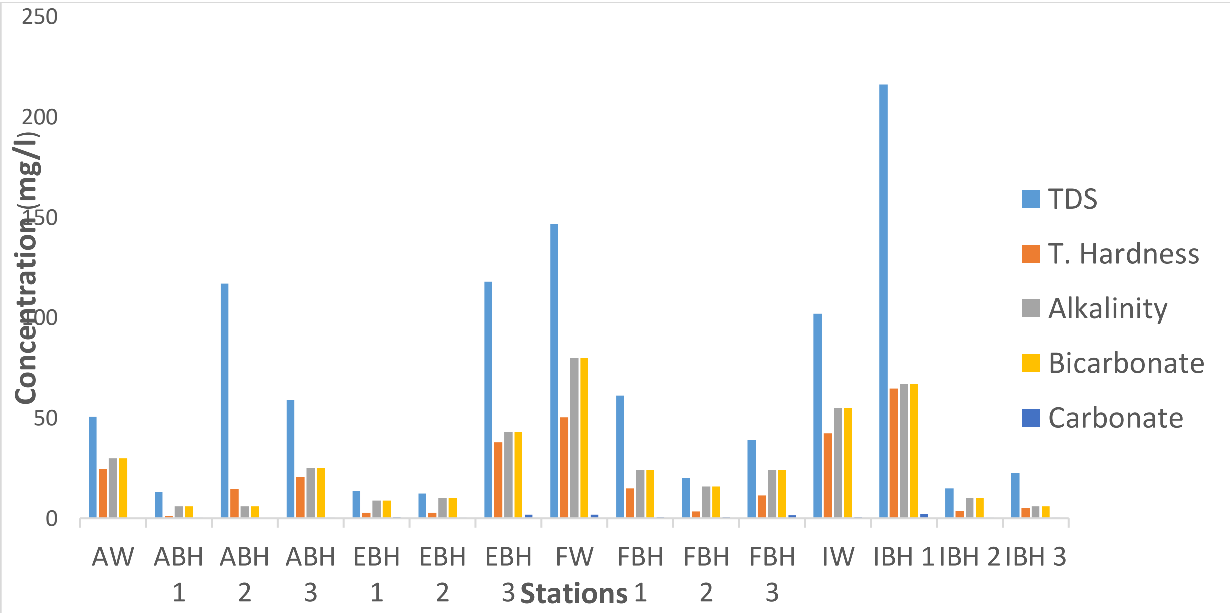

Fig. 6: Variations in Levels of some Physicochemical Parameters

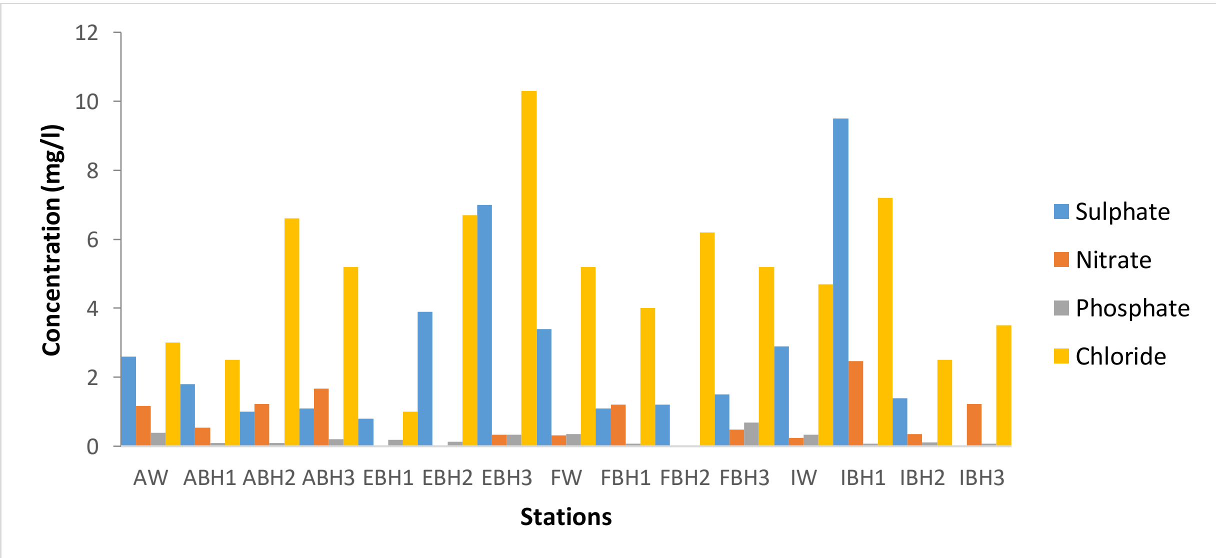

Fig. 7: Variations in Levels of some Physicochemical Parameters

Microbial Analysis

Results of microbial analysis of the water samples are shown in Table 1.

Mean Feacal Coliform Bacteria (FCB) count was between 0.00±0.00 and 3.00±0.00 MPN/100mL; Total Coliform Bacteria (TCB) count ranged from 0.00±0.00 to 7.50±4.50 cfu/mL while Total Heterotrophic Bacteria (THB) count ranged between 3.00±2.00 and $2.705\times10^4 \pm 2.695\times10^4$cfu/mL

Table 1: Mean Levels of Microbial Parameters

Stations	FCB MPN/100ml	TCB cfu/ml	THB cfu/ml
AW	0.00	2.00±0.13	$1.58\times10^2 \pm 1.10\times10^2$
ABH1	0.00	4.00±0.18	$3.5\times10^2 \pm 1.5\times10^2$
ABH2	0.00	0.00	$1.69\times10^2 \pm 1.01\times10^2$
ABH3	0.00	0.5±0.03	$5.67\times10^2 \pm 5.32\times10^2$
EBH1	0.00	0.00	0.3×10±0.2×10
EBH2	0.00	3.50±0.11	$1.95\times10^2 \pm 0.00$
EBH3	0.00	0.00	$1.12\times10^2 \pm 1.07\times10^2$
FW	0.00	7.50±4.5	$2.458\times10^4 \pm 2.44\times10^4$
FBH1	0.00	0.00	$4.35\times10^1 \pm 4.0\times10^1$
FBH2	0.00	0.00	$2.90\times10^3 \pm 2.89\times10^3$
FBH3	3.00±0.01	6.00±0.22	$3.47\times10^2 \pm 3.42\times10^2$
IW	0.00	2.50±0.24	$2.705\times10^4 \pm 2.695\times10$ 4
IBH1	0.00	0.00	$1.8\times10^1 \pm 1.6\times10^1$
IBH2	0.00	0.00	0.8×10±0.00
IBH3	0.00	0.00	$2.5\times10^2 \pm 9.0\times10^1$

Water Quality Index

Water quality index (WQI) levels in the study area are shown in Fig. 8. Results showed that WQI levels fell between 187.27 and 530.92 across all the sample stations.

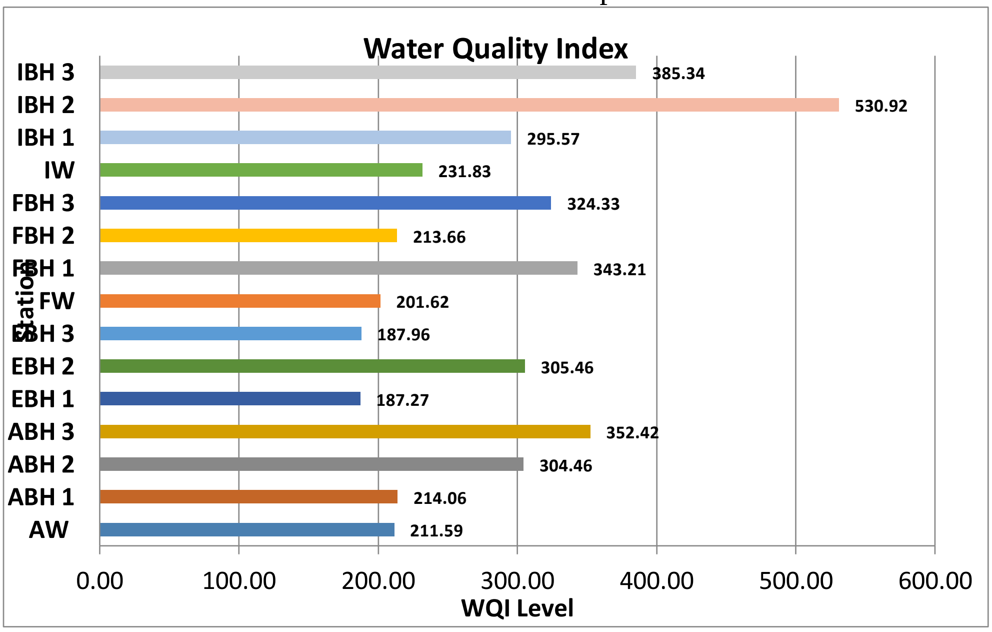

Fig. 8: Water Quality Index

STATION	WQI
EBH 1	187.27
EBH 3	187.96
FW	201.62
AW	211.59
FBH 2	213.66
ABH 1	214.06
IW	231.83
IBH 1	295.57
ABH 2	304.46
EBH 2	305.46
FBH 3	324.33
FBH 1	343.21
ABH 3	352.42
IBH 3	385.34
IBH 2	530.92

DISCUSSION

Physicochemical Properties

Water samples physicochemical property levels were compared to acceptable limits established by the US EPA (2004), NSDWQ (2015), and WHO (1996).

With the exception of samples from stations ABH2 (4.3) and ABH3 (6.3), the mean pH levels of the water samples were all within the permissible range of 6.5 to 8.5 set by the WHO and USEPA. The lower pH value obtained in some stations is in agreement with those obtained for similar study in Kenya by Wanyioke *et al.,* (2021); the study recorded pH as low as 4.78 both in dry and rainy season. The low pH is attributed to geological underground properties supported by very low levels of plant supporting parameters associated with agricultural fertilizers such as chloride, nitrate, sulphate and total phosphate. Also it could be attributed to the presence of decomposition of waste materials from dumpsites around the communities with emission of landfill gases (Adoki, 2012).

The water sample temperatures were within the permitted ranges set by the NSDWQ. Temperature affects the reduction in solubility of gases in water, how strong taste and colors are, and how quickly chemical reactions occur (Olajire and Imeppeoria, 2001). In general, cool water is safer to drink than warm water since heat encourages the growth of microbes, which can lead to problems with flavor, odor, color, and corrosion (WHO, 2011).

The water turbidity levels were all less than the WHO-acceptable limit of 5.0 NTU. The result is similar with those obtained by Ayuba*et al*., (2016) when they conducted similar study. Turbidity is a significant parameter in the examination of drinking water and is associated with the population of pathogenic microorganisms in the water that may originate from soil runoff (WHO, 2011).

Electrical conductivity levels in all water samples evaluated in the research region were less than the NSDWQ permissible limit of 1000 µS/cm. this was also in agreement with electrical conductivity recordedat Gboloko area by Ayuba*et al.*, (2016). Electrical conductivity measures the degree of ions present inwater, which greatly affects taste and may have a significant impact on user's acceptance of the water.

The USEPA and NSDWQ have established a 500 mg/L TDS standard that is acceptable in drinking water. TDS levels at every location were below the permitted threshold, according to the analysis. TDS affects taste of drinking water if present at levels above the standard limits. According to Otobo (1995), "the concentration and relative abundance of ions in waters is variable and highly depends on the nature of the bedrock, precipitation, evaporation and crystallization processes"

The greatest salinity reading was 0.190‰ at Station IBH1, and neither the WHO nor the US EPA nor the NSDWQ have established salinity standards. Salinity and electrical conductivity levels as well as TDS typically work together (Amangabara*et al.*, 2012). High salinity levels in water and soil may lead to corrosion of equipment and infrastructure like fences, roads, and bridges, poor health or death of native vegetation, a decline in biodiversity due to the predominance of salt-resistant species, the potential alteration of ecosystem structures, and a decrease in crop yields due to the poor growth and health of salt-sensitive crops (Water Quality Australia, 2018).

The NSDWQ has established 150 mg/L as the permissible level for total hardness in drinking water. The total hardness levels in each water sample were below the permissible range. Ayuba*et al.*, (2016) also obtained similar result in a study carried out at Gboloko area, central Nigeria. Although hard water does not represent a health risk, it can be an inconvenience when used for various household tasks like washing and cleaning. Hardness is a crucial factor in minimizing the negative effects of toxic substances in water (Bhatt *et al.*, 1999); also, regular consumption of soft water has been associated to cardiovascular disorders (Miroslav and Vladimir, 1999).

All of the water samples had alkalinity levels below the WHO-acceptable guideline of 120 mg/L for drinking water. The levels of alkalinity in this study are similar to result obtained by Ayuba*et al.*, (2016). Alkalinity is a measurement of the presence of weak acids and their salts in water or of a body of water's ability to neutralize acids.

Chloride levels in every water sample examined in the research region were within the 250 mg/l permissible limit set by the NSDWQ and USEPA. Ayuba*et al.*, (2016) recorded similar result their study at Gboloko area in central Nigeria. Chloride is mostly created when hydrochloric acid salts, including table salt (NaCl) and $NaCO_2$, dissolve, and is then added to other substances like sewage, seawater, and industrial waste. It is crucial for the human body's metabolism function as well as other critical physiological processes. A high chloride concentration hurts developing plants and metallic pipelines and structures (Meride and Ayenew, 2016).

The NSDWQ and WHO permissible limits for sulphate in water samples are 100 mg/l and 250 mg/l, respectively. The maximum sulphate level was 9.5 mg/l at Station IBH1. This indicates that all samples analyzed had sulphate within acceptable limit set by WHO and NSDWQ. The low Sulphate concentrations recorded could be due to the absence of anthropogenic activities that influences its concentration in water bodies. Sulphates naturally occur in groundwater via sulphides dissolution by percolating water, passing through the interstratified materials, such as pyrite, producing sulphate ions (Olobaniyi and Owoyemi, 2006).

Nitrate levels recorded in the water samples were below the standard limits of 10 mg/l set by USEPA and 50 mg/l set by NSDWQ and WHO. The highest level of 2.46 mg/l was recorded at station IBH1. Ayuba*el al.*, (2016) recorded high nitrate levels in a similar study carried out in Gboloko area in central Nigeria which is not in agreement with the result of this study. Prolonged exposure to nitrite and nitrate at levels above the maximum acceptable concentration could cause such problems as diuresis, increased starch deposits and hemorrhaging of the spleen (Reimann*et al*., 2003).

Calcium levels in the water samples fell below the acceptable limit of 50 mg/l by WHO for drinking water, with the highest level of 15.993 mg/l recorded at station IW. The acceptable limits for magnesium are 50 mg/l and 20 mg/l as set by WHO and NSDWQ respectively. All samples fell below these set limits. The highest level of 6.735 mg/l was recorded at station at IBH1. Ayozie (2020) reported similar results with low calcium and magnesium levels below the respective permissible limits when he carried out a similar study in Rumuola, Rumuigbo and Rumuokwuta communities. Leoni *et al.*, (1985), in studies carried out in Abruzzo, Italy, reported an inverse relationship between the hardness (Calcium and Magnesium ions content) of drinking water and cardiovascular diseases. It has also been reported that calcium and magnesium in drinking water may help protect against gastric, colon, rectal cancer, and pancreatic cancer, and magnesium may help protect against esophageal and ovarian cancer (Pallav, 2013).

The recorded potassium levels in the water samples were all below the acceptable limit of 200 mg/l set by NSDWQ. The highest and lowest potassium levels of 15.655 mg/l and 0.289mg/l were recorded at station IBH1 and ABH1 respectively.

The highest bicarbonate levels of 80.0 mg/l was recorded at FW and the lowest level of 6.0 mg/l were recorded at ABH1, ABH2 and IBH3 respectively, while the lowest and highest carbonate levels of 0.00 mg/l and 2.21 mg/l were recorded at stations ABH2 and IBH1 respectively. Edet*et al* (2011) reported a HCO_3^- level of 71.50 mg/l within the Niger Delta area. There is no set limit for bicarbonate and carbonate by WHO and NSDWQ. According to Davis and Dewiest (1966), bicarbonate rarely exceeds 40 – 400 mg/l in water. Bicarbonate helps to buffer lactic acid generated during exercise and also reduces the acidity of dietary components (Mason, 2001).

Microbiological content

Except for station FBH3, which had an FCB value of 3.0 MPN/100ml above the NSDWQ permissible limit of 0.00 MPN/100ml, all water samples examined indicated no presence of Faecal Coliform Bacteria, indicating no danger of faecal contamination. Total Coliform Bacteria were detected in the water at stations AW (2.0 cfu/ml), ABH1 (4.0 cfu/ml), ABH3 (0.5 cfu/ml), EBH2 (3.5 cfu/l), FW (7.5 cfu/ml), FBH3 (6.0 cfu/ml), and IW (2.5 cfu/ml) which were above the safety limit of 0.00 MPN/100ml. Except for stations EBH1 and IBH2, which had THB counts of 3 and 8 cfu/ml, which are below the safety limit of 10 cfu/ml, all water samples showed Total Heterotrophic Bacterial (THB) counts over the NSDWQ safety level.

Water Quality Index

The Water Quality Index values obtained for the water samples in the study area showed that stations EBH1 (187.27) and EBH3 (187.96) had their water quality rated as POOR for drinking; FW (201.62), AW (211.59), FBH2 (213.66), ABH1 (214.06), IW (231.83) and IBH1 (295.57) had their water quality rated as VERY POOR for drinking; ABH2 (304.46), EBH2 (305.46), FBH3 (324.33), FBH1 (343.21), ABH3 (352.42), IBH3 (385.34) and IBH2 (530.92), had their water quality rated as UNSUITABLE for drinking.

CONCLUSION

The results from this study found pH levels were within set limits except for stations ABH2 and ABH3. Levels of TDS, Turbidity, salinity and Conductivity were all within standard limits. Most of the stations had Feacal Coliform Bacteria (FCB) count within standard limits. Some stations recorded high levels of lead, chromium and manganese while nickel and iron levels were all below permissible limits. The Water Quality

Index classified water in the area as ranging from Poor to Unsuitable for drinking purposes.

This study recommends that in addition to monitoring the communities should seek for an alternative source of drinking water or properly treat their sources.

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