International Journal of
Science and Engineering Investigations vol. 6, issue 71, December 2017
ISSN: 2251-8843

Evaluation of Urban Drinking Water Quality in South East Nigeria

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Abstract- The study evaluated the quality of urban drinking water in South Eastern Nigeria covering the states of Abia, Anambra, Ebonyi, Enugu and Imo. Fifteen drinking water samples were collected from identified sources of water supply including Borehole, streams and reservoirs in the states. All samples collected were subjected to physical, chemical and bacteriological analysis using standard laboratory techniques. Some of the measurements like temperature, ph and conductivity were carried out in-situ while other tests were carried out in the Laboratory. The values of the physical, chemical and bacteriological parameters were assessed based on World Health Organization (WHO) specifications for safe drinking water. Results indicate variations in values of the quality parameters across the states. Turbidity values exceeded 5.0NTU specified by WHO. Also magnesium hardness and iron concentrations exceeded acceptable limits as well as phosphates. However, the bacteriological qualities are generally acceptable as no growth was recorded at 35oC after 24hrs and there was absence of E-coli. The fluctuations in quality of drinking water should be a major source of concern to government agencies involved in water delivery. There is need for improved water quality control to be supported by coordinated policy and adequate legal and institutional framework which are essential tools for sustainable development.

Keywords- *Water, Water Quality, Drinking Water, Groundwater, South East Nigeria*

I. INTRODUCTION

The term "water quality" includes the water column and the physical channel required to sustain aquatic life (Contractors, 1999). The quality of water is an indication of the natural and artificial conditions and processes occurring upstream of the part that is sampled for quality determination (Ayodele & Ajayi, n.d.) [1]. The quality of water, whether used for drinking, domestic purposes, food production or recreational purposes has an important impact on health. Water of poor quality can cause disease outbreaks and it can contribute to background rates of disease manifesting themselves on different time scales. Initiatives to manage the safety of water do not only support public health, but often promote socioeconomic development and well-being as well (Wang, 2014) [2]. Water as one of the natural resources required for the survival of man, animals and plants is unevenly distributed on the earth's surface and below the earth's surface. The water we drink is essential ingredient for our wellbeing and a healthy life, but unfortunately, polluted water and air are common throughout the world. Water is one of the most essential elements of life on Earth. In its purest form, it's odorless, colorless and tasteless, but due to human and animal activities, it is usually contaminated with solid and human waste, effluents from chemical industries and dissolved gases (Musa & Ahanonu, n.d.). [3]

Large river systems provide water for drinking (Tasi & Mallam, 2016) [4]. Humans need water for drinking (Oluyemi, 2013) [5]. Water is the essence of life and safe drinking water is a basic human right essential to all (Firmal, 2009). [6] Most human activities involve the use of water in one way or other. It may be noted that man's early habitation and civilization sprang up along the banks of rivers. Although the surface of our planet is nearly 71% water, only 3% of it is fresh. Of these 3% about 75% is tied up in glaciers and polar icebergs, 24% in groundwater and 1% is available in the form of fresh water in rivers, lakes and ponds suitable for human consumption (Contractors, 1999) [7]. Water is the resource that sustains all life on earth and is a key element of sustainable development. Water is an infinite resource, worldwide there is an imbalance between water utilization and water resources management. The availability and access to fresh water is an important issue all over the world (Tasi et al., 2016) [8]). Groundwater constitutes the only reliable water supply for drinking (Okoro et al, 2010) [9]. Good quality water will ensure the sustainability of socio-economic development, as the government priority is shifted to other sectors of the economy, rather than channeling the resources towards combating outbreaks of water borne diseases due to consumption of contaminated groundwater. Natural water is never entirely 100% pure as it carries traces of other substances which bestow to it physical, chemical and bacteriological properties. The nature and amount of these substances called impurities vary with sources of the water including rainfall, glaciers, surface water, and groundwater. Fresh water is a fundamental resource, integral to all environmental and societal processes. However, fresh water is only a small component of the total water

resources. Lakes, rivers, reservoirs, and groundwater aquifers account for less than one-third of all fresh water, with the rest locked in glaciers and permanent snow covers. Although most of the water on earth is not accessible, the surface water, which is accessible, represents only about 0.02% of the total. This slight fraction of the world water would be enough for man's needs if it were well distributed and kept clean. Since either of them is not done, water quality therefore becomes one of the primary concerns of man. Water is indispensable for life. However, it is estimated that about 1.2 billon individuals worldwide do not have access to potable water (Nchedo, 2012) [11]. Water is perhaps the most important inorganic compound in the biosphere, for it has conditioned the ecology and evolution of terrestrial organisms to an extent far greater than any other compound (Adejo et al, 2013) [12]. The need for clean water for drinking, cooking, bathing and other household needs had long been recognized. Water is needed in all facet of human life: Agriculture, Industry, Education, to mention a few. No wonder our Water Boards use the phrase 'Water is Life' as their motto (Ibiam et al 2015) [13]. In Nigeria, only 58% of inhabitants of the urban and semi-urban areas and 39% of the rural areas have access to potable water supply; the rest of the population depend on ground (well and borehole) and surface water (stream and river) for their domestic water supply (Uduosoro) [14]

Safe water includes treated surface water, as well as untreated but uncontaminated water from source such as natural springs and sanitary wells and protected boreholes. On average, a person needs about 20 liters of safe water each day to meet his or her daily metabolic, hygiene and domestic needs. (Okoro & Ezeabasili, 2015) [15]. Nonetheless, groundwater remains the preferred source of water because of its high quality with respect to potability and the minimum treatment requirement in most cases (Olatunji et al 2015) [16]. The ocean is considered the sources of all water on earth (Martins, 2001) [17]. The quality of water, whether used for drinking, domestic purposes, food production or recreational purposes has an important impact on health. Water of poor quality can cause disease outbreaks and it can contribute to background rates of disease manifesting themselves on different time scales.

Initiatives to manage the safety of water do not only support public health, but often promote socioeconomic development and well-being as well ("Water Quality and Health Strategy," 2013) [18]. Good quality water will ensure the sustainability of socio-economic development, as the government priority is shifted to other sectors of the economy, rather than channeling the resources towards combating outbreaks of water borne diseases due to consumption of contaminated groundwater (Ishaku, 2011) [19]. The importance of good quality water to life cannot, washing or be overemphasized. This is because of the many roles water play in human survival on earth (Ibiam et al., 2015) [20] Unsatisfactory water supplies and un-wholesome sanitation conditions can result in poor human health. Perhaps, the most significant environmental problem and threat to public health of the developing countries today is inadequate access to potable water and sanitation facilities (Hague, 2015) [21]. An important factor influencing water quality in relatively still, deep waters, such as lakes and reservoirs, is stratification. Stratification occurs when the water in a lake or reservoir acts as two different bodies with different densities, one floating on the other. It is most commonly caused by temperature differences, leading to differences in density (water has maximum density at 4 °C), but occasionally by differences in solute concentrations. Water quality in the two bodies of water is also subject to different influences (Meybeck et al 1996) [22].

The South Eastern Region of Nigeria is comprised of five states namely, Abia, Imo, Anambra, Enugu and Ebonyi States. It is the home of the Igbo speaking people of Nigeria. It is located within latitudes 4° 47‟N and 7° 7‟N, and longitudes 7° 54‟E and 8° 27‟E in the tropical rain forest zone of Nigeria, with mean maximum temperature of 27^{o}C, and total annual rainfall exceeding 2500mm. The region is largely agrarian and there is thus much dependence on land resources, due to its dense population average to about 1000 people/km (Anejionu & Nwilo, 2013) [23]. The study focused on quality analysis of drinking water from major urban cities of the region and evaluation based on WHO standards.

II. METHODOLOGY

Fifteen sites were selected within fifteen designated areas that make up the study area. The samples were numbered with subscripts A –O. S_A – S_D represent samples from Anambra state, S_E-S_H for samples from Imo. Similarly, Si-Sj, S_K-S_L, S_M-S_O for samples from Abia, Ebonyi and Enugu states respectively.

Physico-chemical and bacteriological tests were carried out based standard methods for testing of water quality. Some of the measurements like temperature, pH, etc., were done in-situ. Turbdity meter was used to measure Turbidity in NTU, while Ph meter and conductivity meter were used measure the hydrogen ion concentration and total dissolved solids in the samples respectively. The presence of pathogens was analyzed by E-coli Test. Sequel to the coliform test, the positive presumptive tube was picked and a portion of it inoculated into a fresh broth. This was incubated in a water bath at 45^{o}C for 24hrs. At the end of the incubation period, the Durham tube was checked for gas or evidence of fermentation. The presence of trapped gas or evidence of fermentation indicates positive result. The number of bacteria was counted using colony counter after the mixture of water sample and nutrient agar was incubated at 35^{o}C for 24hrs. The results are tabulated and compared with WHO permissible values.

III. RESULTS PRESENTAION

The results of tests for ph and bacteriological characteristics (E-Coli and Total Coliform) are presented in Tables 1 and 2. Also Figs 1-4 present results of tests on Chemical parameters.

TABLE I. RESULTS OF DRINKING WATER QUALITY ANALYSIS OF SAMPLES COLLECTED FROM ANAMBRA AND IMO STATES

Parameters	Units	S_a	S_b	S_C	S_D	S_e	S_f	S_g	S_h	W.H.O
Turbidity	NTU	11.87	12.21	11.94	11.38	9.8	12.61	18.01	11.96	5.0
Color	TCU	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	50
Odour		UnObj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj
pH@30^{o}C		6.96	6.98	6.95	6.99	6.92	6.98	6.95	7.17	6.5-8.5
Conductivity	ohm/cm	11.45	9.9	9.21	9.37	5.54	9.1	16.78	8.98	1000
T D S	Mg/l	10.44	8.9	8.11	7.34	8.66	8.05	10.36	6.98	500
T S S	Mg/l	1.83	1.58	1.49	1.26	1.16	1.48	3.64	1.54	-
Total Solids	Mg/i	12.27	10.48	9.60	8.60	9.82	9.53	14.00	8.52	1000
E-coli	Per100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.0
Total Coliform	Per100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0
T P C at 35^{0}C after 24hrs	Per ml	No Growth	No Growth	No Growth	No Growth	No Growth	No Growth	No Growth	No Growth	-

TABLE II. RESULTS OF DRINKING WATER QUALITY ANALYSIS OF SAMPLES COLLECTED FROM ABIA AND ENUGU STATES

Parameters	Units	S_i	S_j	S_k	S_L	**S_M**	**S_N**	**S_O**	W.H.O
Turbidity	NTU	12.15	12.66	15.45	15.1	1.0	14.38	12.18	5.0
Color	TCU	Nil	Nil	Nil	Nil	Nil	Nil	Nil	50
Odour		Unobj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj
pH@30^{o}C		7.01	7.11	6.9	6.98	6.4	7.2	6.95	6.5-8.5
Conductivity	ohm/cm	10.60	9.73	10.61	10.67	77.4	9.13	9.86	1000
TDS	Mg/l	9.21	8.64	13.53	9.61	50.31	9.28	7.63	500
TSS	Mg/l	1.98	1.13	2.63	2.23	0.05	2.01	1.6	-
Total Solids	Mg/i	11.19	9.77	16.16	10.84	50.36	11.29	9.23	1000
E-coli	Per100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.0
Total Coliform	Per100ml	No Growth	No Growth	No Growth	Nil	Nil	Nil	Nil	0
T P C at 35^{0}C after 24hrs	Per ml				No Growth	No Growth	No Growth	No Growth	-

NTU=Nephelometric Turbidity Unit, TCU= True Color Unit, mg/l=milligram per litre, Unobj=, S_L= sample L, S_M=sample M, S_N= sample N, S_O= sample O, WHO= World Health Organization, T.P.C= Total Plate Count, T.S.S= Total Suspended Solids, T.D.S= Total Dissolved Solids

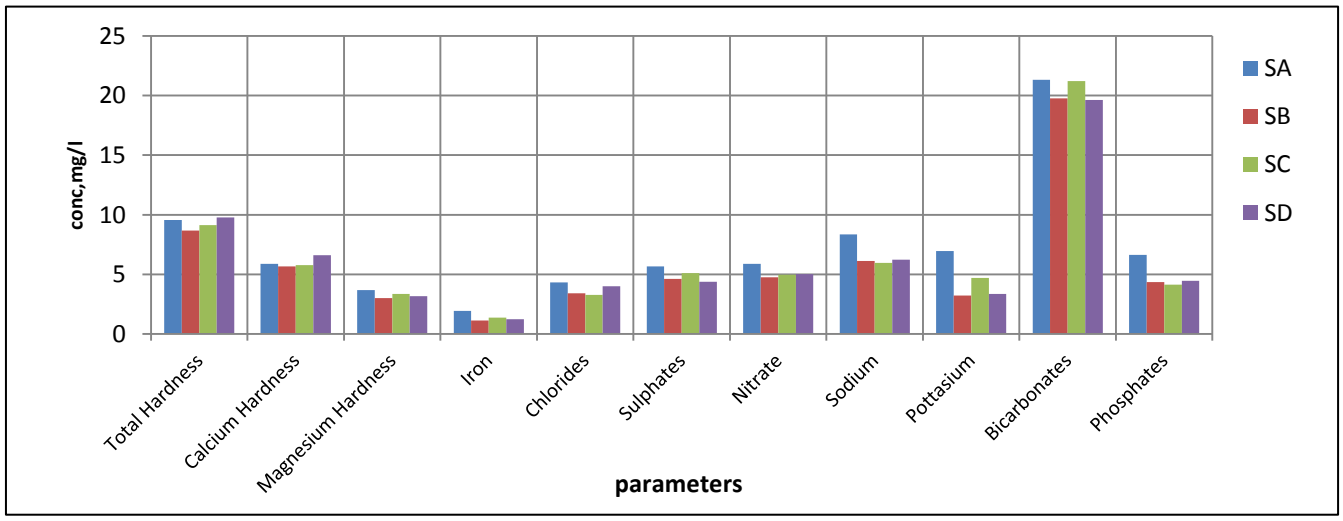

Figure 1. Result of Chemical Analysis on Samples from Anambra state

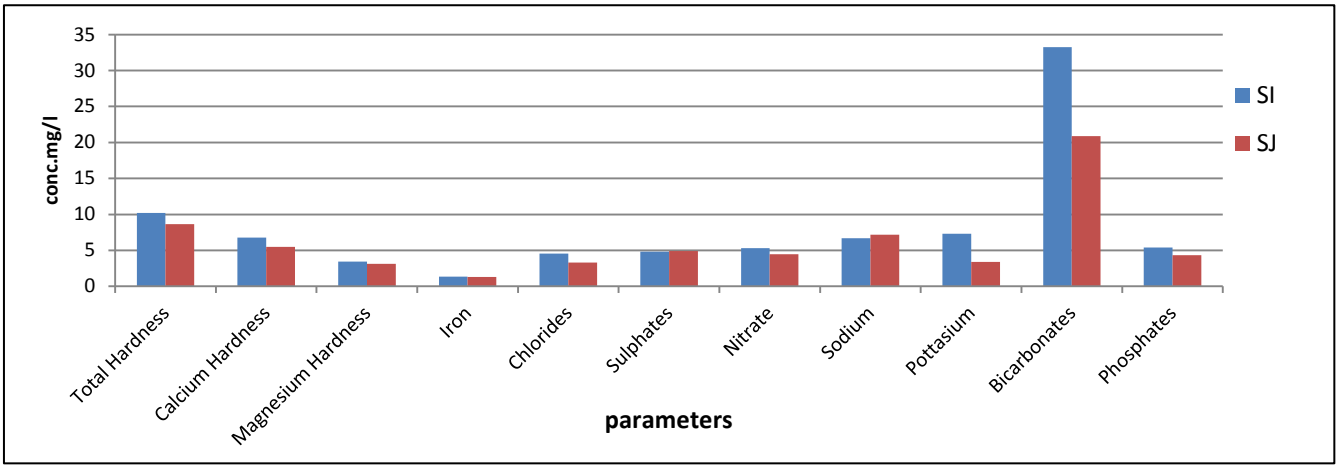

Figure 2. Result of Chemical Analysis on Samples from Abia state

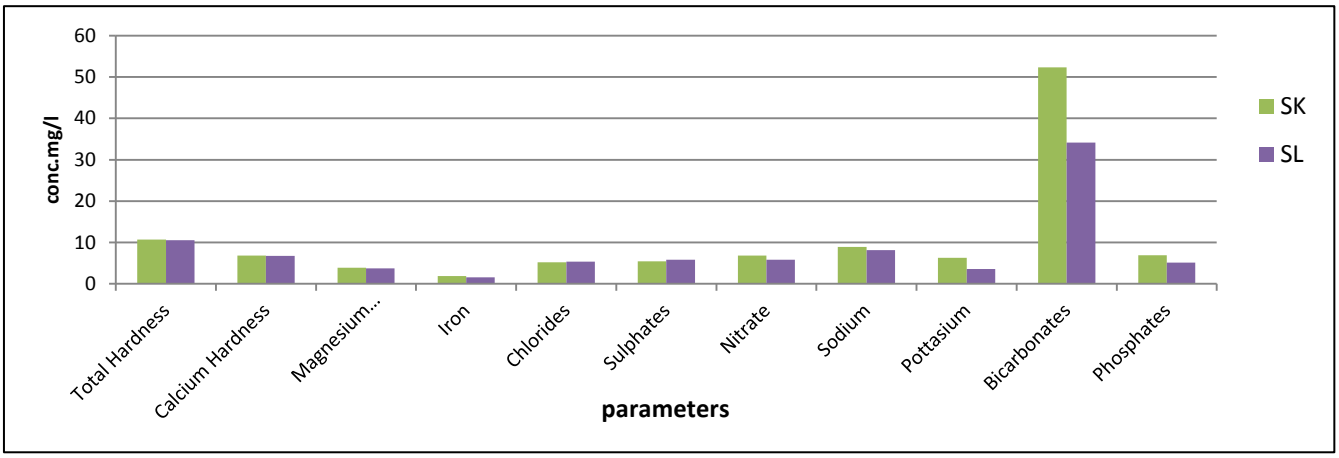

Figure 3. Result of Chemical Analysis on samples from Ebonyi state

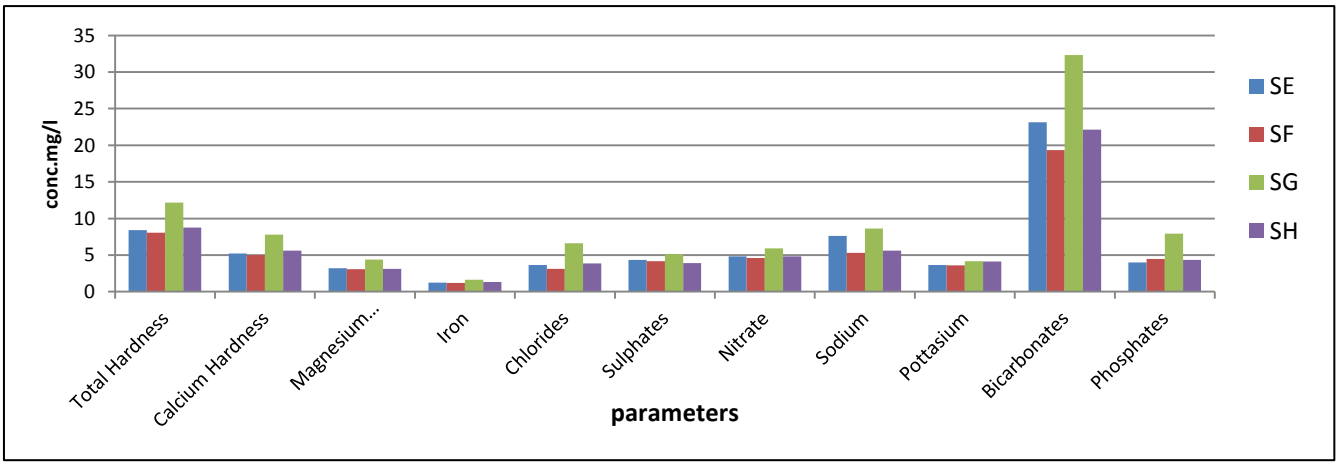

Figure 4. Result of Chemical Analysis on Samples from Imo state

The turbidity of sample from surface water source ranges from 1-18.01(µs/cm). While that of groundwater source range between 11.38 and 15.1(µs/cm). By the WHO standard, turbidity exceeding 5mg/l is not good for human consumption. The pH of the surface water ranges from 6.4-7.2mg/l, while that of groundwater source ranges from 6.95-7.12.mg/l, It is also worthy of note that the pH of surface water source is less than other ground water samples analyzed. Enugu state recorded the most acidic; Imo state recorded a neutral value which is pure while Abia state recorded most basic. The pH is within the WHO guideline for drinking water which is between 6.5 – 8.5 mg/L. The conductivity of groundwater samples ranges between 8.98-11.45µs/cm while that of surface water ranges between 5.54-77.4µs/cm. This conductivity does not exceed the WHO standard. Therefore it is permissible. From the analysis, the TDS in the study area is not high therefore it is considered good. TDS for groundwater ranges from 6.98-10.44mg/l. while that of surface water ranges between 8.05-13.53mg/l Total dissolved solids indicate the amount of chemical substances dissolved in the water. At increasing levels, palatability decreases. Levels in excess of 1000 mg/L may produce a bad taste.

The salts of calcium, together with those of magnesium, are responsible for the hardness of water. This analysis revealed that the magnesium ion concentration in water samples in the study area ranges between 3.01 - 4.37mg/l. The magnesium content from groundwater source ranges between 3.01-3.77mg/l while that of surface water source ranged between 3.06 - 4.37mg/l. WHO standards indicate that the permissible limit is 50mg/l. This implies that from our sources in the study area, they have low concentrations of Mg2+. Iron mostly occurs in the form of ferrous bicarbonates (Fe $(HC03)^2$), ferrous sulphate ($FeS0_4$), or ferrous chloride ($FeCl^2$). The concentration of iron (Fe^{2+}) in the study area range between 1.12-1.92mg/l and the maximum value was recorded in Anambra state. WHO guideline indicates a permissible Fe^{2+} value of 0.3mg/l. This implies that water sources in the study area exceeded the WHO acceptable limits. Excessive iron may result in staining (reddish brown) of laundry, plumbing fixtures, and even hair. It may also cause undesirable taste in beverages. High iron levels also encourage the growth of iron bacteria.

Potassium (K^+) and sodium (Na^+) are present in natural waters. The concentrations of sodium Na^+ and Potassium K^+ is not high in the study area according to WHO standard. This analysis revealed that the Sodium concentration in water samples in the study area ranges between 5.33-8.91mg/l. while that of potassium ranges between 3.23-7.31mg/l. Enugu state recorded the lowest average concentration of Potassium with 3.36mg/l. while Ebonyi state recorded the highest average concentration of Potassium with 4.98mg/l. the concentration of sodium from groundwater source ranges between 5.61-8.34mg/l while that of surface water source ranges from 5.33-8.91mg/l. There is no apparent hazard to people in good health. For sodium, Over 200 mg/L is considered high and may cause corrosion of the water supply system particularly if the water is warm and alkaline. For people on salt-restricted diets or those suffering from hypertension, congestive heart failure or heart disease, the sodium WHO recommended limit is 200 mg/L the concentration of potassium from groundwater source ranges between 3.23-7.31mg/l while that of surface water source ranges between 3.62-6.43mg/l. The WHO recommended limit is 20 mg/L. Levels above 100 mg/L may cause a laxative effect, while levels above 340 mg/L may affect taste. Enugu state recorded the lowest average sodium concentration of 5.41mg/l while Abia state recorded the highest average sodium concentration of 8.52mg/l.

Bicarbonate ions (HCO_3) are present in natural waters and have been associated with the alkalinity and hardness of water. The major sources of these ions in water include the dissolution of limestone, dolomite, chalk, and other carbonate - rich rocks. The concentration of Bicarbonate ions ranges between 19.35-52.34mgl for surface water sources. While that of groundwater source ranges between 19.76-34.12mg/l. The recommended WHO limit is for Bicarbonates is 1000 mg/L. Sulphate Ions (SO_4^{2+}) are present in natural waters; mostly occur as a result of the oxidation of sulphide ores, gypsum and anhydrite. They can also occur as leachates from their ores and other minerals. Sulphate could constitute an oxygen source for bacteria, which chemosynthetically converts it to hydrogen sulphide (H_2S) in anaerobic conditions. This process causes odour in water. The concentration of sulphate in the study area ranges between 3.93-9.205mg/l. This is below the WHO recommended standards for drinking water, and hence permissible. The concentration of Cl^- in each state within the study area is excessively low in some places. However, the bacteriological qualities are generally acceptable as no growth was recorded at 35^oC after 24hrs and there was absence of E-coli.

IV. CONCLUSION

The study has revealed marked fluctuations in the physico-chemical properties of drinking water from the various sources within the region. The poor state of public water schemes has caused people to embark on ground water development through boreholes that are not monitored. Others resort to the use of surface water without further treatment. The high iron content is a major concern that could lead to health problems. Turbidity levels are also generally higher than acceptable limits. It is however noteworthy that the bacteriological characteristics of the water samples are acceptable.

This study covered only the urban areas that have have relatively more access to potable water compared to rural communities. The situation will definitely be worse in the rural areas. We therefore recommend that further studies be extended to the rural communities.

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