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Full-Length Research Paper

Water Quality of Some Selected Communities in Odukpani Local Government Area of Cross River State, Nigeria

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ABSTRACT: The research looked at the water quality in some selected communities in the Odukpani Local Government Area of Cross River State, Nigeria. The research was carried out in November of 2021, when stream water was the only major source of domestic water supply. Four major streams were surveyed for water samples. Sample 1 (IdimIkot Offiong, Oboroko Stream), Sample 2 (Idim, Oboroko Stream), Sample 3 (IdimInua-Akpa Stream), and Sample 4 (IdimInua-Akpa Stream) are all from the Oboroko Stream (IdimUsusgode Stream). The samples were collected in clean plastic bottles and then rinsed with distill water after being treated with a 1:1 nitric acid solution. Physico-chemical heavy metals and bacteriological parameters were among the parameters examined. The investigation was conducted in accordance with the American Public Health Association's Standard Methods for the Examination of Water and Wastewater, 19th Edition (1995), and the World Health Organization's Standard for Drinking Water Quality (WHO, 2011). The study's findings show that all of the samples had PH levels that were lower than the WHO and NSDWQ standards. The same was true for dissolved oxygen (DO). Total Iron (mg/l), Manganese (mg/l), Nitrate (mg/l), Nickel (mg/l), Chromium (mg/l), Aluminum (mg/l), Feacal coliform, and total coliform all exceeded WHO, NSDWQ, NIS, and STDS standards. All of the other parameters were within the normal range. The statistical test results also show that there is no significant variation in water quality status across the four (4) streams, $F(3, 144) = 0.013$, $P = 0.998$. As a result, the null hypothesis, which states that there is no significant difference in water quality status across the four streams, was kept. Water from these streams, on the whole, needs to be treated before it can be consumed.

Keywords: Water quality, stream, parameters and communities

INTRODUCTION

Water is a unique substance with many physical properties that are distinct from those of other liquid, gaseous, or solid materials found on the earth's surface. It is not evenly distributed across the earth's surface; some areas have a fairly uniform and more than adequate supply for human needs, whereas many others region have a greater need for water (Mather, 1984; Nkemdirim et al., 2015). Water is required for the biochemical processes that occur in all living organisms and is a basic requirement for humans (Chima and Digha, 2009). Humanity relies heavily on water as a desirable natural resource for almost all of its activities, and the importance of its quality for domestic consumption cannot be overstated. Domestic water should be of the highest quality, according to Eziash (1999), while water for other purposes can be of good quality.

Unfortunately, most surface water sources are heavily contaminated by physical, chemical, and biological impurities such as trace elements, pesticides, and detergents (Parent et al., 2007). The presence of these contaminants in drinking water poses a significant risk to public health, resulting in a variety of diseases such as diarrhea, trachoma, abdominal pain, and vomiting (Chima and Digha, 2009; Digha and Abua, 2016).

Heavy metals in high concentrations in drinking water can cause diseases in humans such as neurological disorders and kidney problems (Yusuf and Sulaiman, 2016). Groundwater and surface water pollution has become a major environmental issue, especially where groundwater and surface water are the primary sources of drinking water (Maitera et al., 2011; Nwankwoala et al., 2011 and Olatunji et al., 2015; Gbadebo et al., 2016).

Heavy metals are metals with a high density that are toxic even at low concentrations. Arsenic (As), Chromium (Cr), Cadmium (Cd), Copper (Cu), Lead (Pb), Manganese (Mn), Mercury (Hg0), and Nickel (Ni) are heavy metals (Ni). While some heavy metals are required by living organisms in trace amounts, excessive metals can be harmful to life (Akhilesh et al, 2009). High concentrations of Aluminium, Arsenic, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Nickel, and Zinc in surface water can be harmful to human health and render the water unfit for drinking (SON, 2007). Chromium in water is usually found in the hexavalent form, which is highly toxic and carcinogenic at higher concentrations. Nickel (now considered a human carcinogen) in high concentrations as both soluble and sparingly soluble compounds may cause changes in muscle, brain, lungs, liver, and kidney, as well as cancer (WHO, 2004; Yirdaw, M. and Bamlaku, 2016). Despite the importance of good quality water in human life, supply has been insufficient to meet demand. This is because most rural communities still rely on streams, rivers, and wells as their primary source of domestic water (Udoh and Etim, 2007; Habib and Tasi, 2020). Many Nigerian villages, like those in most other developing countries, still rely on streams as their primary source of domestic water. The situation is similar in Cross River State's Odukpani Local Government Area, where many communities rely heavily on water for all of their activities. This is due to the fact that most settlements in the study area still use open latrines for faecal waste disposal. Furthermore, open dumping is a common practice in the study area. The contamination level of these streams has yet to be determined. As a result, the purpose of this research is to look into the water quality of a few streams in the Odukponi Local Government Area of Cross River State. the objectives of the study are as follows:

To examine the water quality status of some of the streams in the study area.

To ascertain the pollution level of the domestic water supply in the study area

MATERIALS AND METHODS

Odukponi Local Government Area is located in Cross River State, Nigeria, between longitudes 8^o, 10″ E and 8^o, 30″ E and latitudes 5^o, 00″ N and 5^o, 10″ N. The area is bordered on the north by Biase Local Government Area, on the east by Akampka Local Government Area, on the south by Calabar Municipality, and on the west by Akwa Ibom State (Figure 1).

There is a lot of relief in this area. Some of the slopes are extremely steep, with gullies cut out on the downward side by recurrent rains. The majority of the elevated landmass is made up of sandstone, limestone, clay, and shale, with sandstone, limestone, clay, and shale occupying the lowland areas (Eze and Abua, 2003). The major drainage arteries in the study area are southward flowing rivers (the Cross River and the Qua River). Several streams connect these rivers, draining the entry area during the rainy season).

Odukpani is located in southeastern Nigeria's Calabar flank sedimentary basin. The lithostratigraphic development of the flank appears to have been influenced by the transgressive and regressive phases of geomorphic processes occurring in Nigeria's coastal areas (Eze and Abua, 2003). Odukpani has an Equatorial tropical climate, which means that it rains almost all year. The annual rainfall averages 2650mm. The driest month is January, which receives 29mm of rain, while the wettest month is July, which receives 372mm of rain. Odukponi has an average temperature of 26.5°C. The temperature varies by 2.5^{o}C on an annual basis. The study area has a total population of 192, 884 people, with males accounting for 106,662 and females accounting for 86,202. Farmers, hunters, fishermen, and a few civil servants make up the majority of Odukpani's population (NPC, 2006).

The research was carried out in November 2021, when the inhabitants rely on stream water as their primary source of domestic water. The samples were collected in clean plastic bottles that were then rinsed with distill water after being treated with a 1:1 nitric acid solution (cadmium-free de-mineralized water). Before chemical analysis of trace elements and heavy metals, water samples were digested for six hours with the addition of 5ml concentrated nitric acid to preserve the water for a longer period against decomposition by bacteria.

Nickel, Magnesium, Chrome, Copper, Zinc, Silica, Lead, Manganese, Mercury, and Iron are some of the

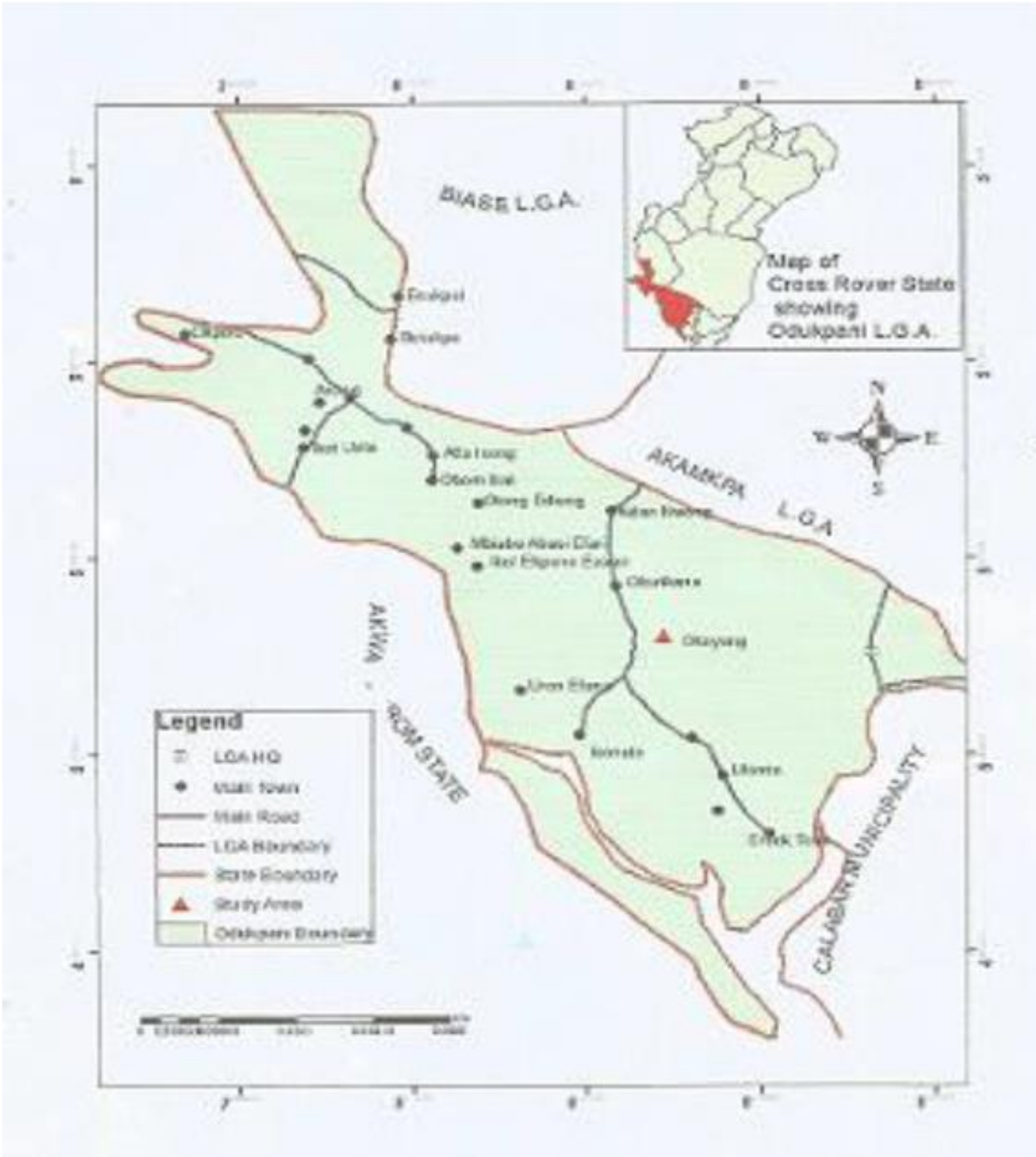

FIG. 1: Map of Odukpani showing Study Area

Source: Geographic Information System (GIS) Laboratory, Department of Geography and Environmental Science, University of Calabar.

heavy metals. An atomic absorption spectrophotometric technique was used to examine these heavy metals. Using media such as nutrient and Mac-Conkey agar, total and faecal coliform were determined using the multiple formation and most probable number (MPN) technique. The analysis took into account four variables: pH, temperature, electrical conductivity, and turbidity calibrated meters.

Other parameters such as alkalinity, total dissolved solids, and chloride were determined using a different laboratory titration technique. Above all, the parameters were examined using the Standard Methods for the

Table 1: physic-chemical and bacteriological laboratory analysis results of the four streams

S/N	PARAMETERS/ UNIT	NIS STDS	NDWQS/WHO STANDARD	LATEST WHO 4TH EDITION (2011) GUIDELINE VALUE	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4
1.	Appearance	Unobtainable	Clear	Clear	unobtainable	unobtainable	unobtainable	unobtainable
2.	Colour (pt Co sc)	20	<5	5 Hazen units	8.6	8.9	7.9	10.2
3.	Temperature (°C)	Ambient	Ambient	Ambient	30.3	28.2	27.3	30
4.	Ph	6.5-8.5	6.5-8.5	8.2 – 8.8	5.38 low	6.0 low	5.0low	6.24 low
5.	Turbidity (NTU)	5	<5	0.3 – 1.0	2.63	3.02	3.0	3.56
6.	Conductivity (Us/cm)	500	1000	500	257.32	325.28	324.24	268.23
7.	Dissolved oxygen (mg/l)	14		14	2.5 low	2.6	2.4 low	3.6 low
8.	Total dissolved solids (mg/l)	1000	500	1000	154.39	137.32	132.32	148.32
9.	Suspended solids (mg/l)	0.1	0		0.001	0.001	0.002	0.003
10.	Total iron (mg/l) Fe	0.3	0.3	0.1	0.49 high	0.34 high	0.31 high	0.52 high
11.	Total hardness (mg/l) $CaCOS_3$	500	150	500	51.3	48.4	46.2	60.4
12.	Total Alkalinity (mg/l) $CaCOS_3$	400	100	400	106	103	96	97
13.	Total Chlorine (mg/l)	0.5	0.5	5 (C)	0.5	0.6	0.4	0.4
14.	Free Chlorine (mg/l)	0.2	0.5	0.5-1.5	0.6	0.5	0.6	0.4
15.	Manganese (mg/l) Mn	0.05	100	0.05	0.054 high	0.07 high	0.08 high	0.062 high
16.	Nitrate (mg/l) NO^{-}_3	50	50	50	24.0	24	27	23.0
17.	Nitrite (mg/l) N	0.1	0.2	3	33 high	32 high	37 high	28 high
18.	Phosphate (mg/l) PO_4	100	3.5		0.64	0.78	0.59	0.72
19.	Nickel (mg/l) Ni	0.02	0.07	0.07	0.072 high	0.082 high	0.64 high	0.58 high
20.	Calcium (mg/l) Ca	50	200	50	1.88	2.78	3.82	2.76
21.	Magnesium (mg/l) Mg	20	150	20	5.21	6.02	8.74	7.34
22.	Chloride (mg/l) Cl^-	100	250	700	46.15	47.12	58.41	37.12
23.	Fluoride (mg/l) F^-	1.5	1.5	0.5	BDL	BDL	0.76	0.56
24.	Chromium (mg/l) Cr	0.005	0.05	300	0.050 high	0.046 high	0.60	2.046 high
25.	Salinity (ppm)	200	100		1.2	1.3	1.2	0.13
26.	Aluminum (mg/l) Al	0.2	0.2	0.10	1.996 high	1.87 high	1.96 high	2.44 high
27.	Copper (mg/l) Cu	1.0	1	2	0.28	0.24	0.22	0.30
28.	Lead (mg/l) Pb	0.01	0.01	0.01	0.003	0.003	0.001	0.004
29.	Ammonia (mg/l) NH^3	0.5	0.4	-	0.01	0.02	0.02	0.02
30.	Feacal coliform count/100m	0	0	0	11	10	15	28
31	Total coliform count/100m	3	0	0	108	112	18	126
32.	Cobalt (mg/l0 Co	0.001	<5		0.16	0.018	0.014	0.016
33.	Cyanide (mg/l) CN^-	0.01	0.07		0.008	0.018	0.014	0.016
34.	BOD_5 Cl25 °C	-			12	23.14	17.13	14
35.	Sulphate (mg/l) S^-	100	400		19.12	15.6	12.5	20.31
36.	Potassium (mg/l)	200	10-12		14.4	18.6	16.7	16.8
37	Zinc (mg/l) Zn	0.2	3	30	0.35	0.57	0.72	0.72
38	Silica (mg/l) Si	15.0			6.15	6.18	2.24	8.63

BDL = detection level
Sample 1 = (Idim Ikot Offiong, Oboroko Stream)
Sample 2 = (Idim Odoro, Oboroko Stream)
Sample 3 = (Idim Inua-Akpa Stream)
Sample 4 = (Idim Usugode, Oboroko Stream)
Idim = means stream (water).

Examination of Water and Wastewater of the American Public Health Association (APHA, 2005).

RESULTS AND DISCUSSIONS

Hypothesis

H0: There is no significant variation in water quality status across the four sampled streams.
H1: there is a significant variation in water quality status across the four sampled streams.

The result of the one-way analysis of variance (one-way ANOVA) is found in (Tables 2 and 3). Table 2 shows descriptive statistics of the data while Table 3 presents the result of the ANOVA test.

From (Table 3), it can be seen that the variation in water quality status across the four streams is not significant, $F (3,144) = 0.013$, $P= 0.998$. Hence, the null hypothesis was retained. The values for these streams are plotted in (Figure 2).

The ambient value of surface water temperature 28.2°C obtained during the period of study are considered normal with reference to the location in the Niger Delta Region which NEDECO (1961) described as a humid semi hot equatorial climate, while Alabaster and Lloyd (1980) reported that temperature of nature inland waters in the tropics generally varies between 25°C and 35°C. the shows that the temperature of water from these streams were within the WHO standard, 30.3, 28.2, 27.3 and 30^{0}C.

Figure 2 shows the comparison of the value is relatively high and also agrees with other studies on other water bodies in the region, (Hart and Zabbey, 2005), reported temperature values between 26.3°C and 30.4°C, Braide et al. (2004) reported 26.64°C. This high value is attributed to the dry season as the relative humidity was low.

The colour which was below the proposed standard was attributed less rain in the study area before samples that tropical waters are highly sediment (Adefemi and Awokunmi 2009). This also effect colour of surface water including run-off from urban area. This result of this study indicates that colour is within the limits for the streams
Considering the low pH values as at the period of study, the water body is slightly acidic and this is attributed to the decaying of domestic waste in the stream. Abowei (2010) also recorded values of acidic water bodies. However, the pH value recorded by this study is lower than the prescribed limit for domestic and other uses, 5.38, 6.0, 5.0 and 6.24. (Figure 3).

On the average, the value of conductivity values from the study shows that the section of Okoyong stream sampled contained appreciable amount of dissolved ion thus, forming a barrier for the survival of sensitive organism (Bhatia, 2009; Abowei, 2010 and Abowei et al., 2012).

Alkalinity causes physiological stress when consumed, turbidity increases the total available surface area of solids in suspension upon which bacteria can grow. High turbidity reduces light penetration and impairs photosynthesis of submerged vegetation and algae. This in turn reduces plant growth and may suppress fish production. It also interferes with disinfection of drinking water and is aesthetically unpleasant (Chapman and Kinstach 1992) (Figure 3).

Water hardness also reflects the amount of waste in the aquatic system, and total hardness, calcium hardness, and magnesium hardness were all high, indicating and reflecting the amount of waste. Calcium concentration is a result of the layout's tannery and slaughter industries (Bhatia 2008). The hardness of the water prevents it from forming leather, which has an impact on domestic use. The study's findings indicate that the total hardness of the four streams was within acceptable limits. Stream 1 has a rating of 51.8, Stream 2 has a rating of 43.4, Stream 3 has a rating of 46.2, and Stream 4 has a rating of 60.4 (Figure 3). The biochemical oxygen demand indicates the level of pollution in the water, and the proposed value, which was supposed to be $0mgl^{-1}$, has been altered in the stream, indicating that there is a level of pollution in the water.

Figure 3 clearly shows the low level of dissolved oxygen in the water body. This demonstrates that the water is not adequately aerated (Narayanan, 2009). It also indicates the extent of organic matter pollution (Chapman and Kinstach, 1992). This will have an impact on fish and other desirable aquatic species. It also has an impact on the biological degradation of both natural and man-made materials that find their way into bodies of water (Asikong and Udofia, 2005). These low values are due to the nature of effluents/waste discharged into water bodies, which places a demand on dissolved oxygen, increasing the bio-chemical oxygen demand value.

Water nutrients such as nitrogen and phosphorus had a high value as well. The high concentrations of nitrite, nitrate, and ammonia were attributed to food processing industries, livestock rearing, and domestic activities in the area.

Ammonia emits an ammoniacal offensive odor, rendering water unfit for domestic use (Bhatia 2009). Other nutrients promote the growth of aquatic plants, which impedes water use. As a result, decay increases BOD while decreasing dissolved oxygen (Asikong and Udofia, 2005).

Total dissolved solids (mg/l) for Idim Ikot Offiong, Oboroko Stream, sample 2 are 137.32 (mg/l), 123.32 (mg/l) for Idim Inua-Akpa Stream, sample 3 is 123.32 (mg/l), and 148.32 (mg/l) for Idim Usugose, Ohoroo Stream, sample 4. The highest value is 154.39 (mg/l) for Sample 1 Idim Ikot Offiong, Oboroko Stream. However,

Table 2: Statistics for data.

	N	Mean	Std. Dev.	Std Error	95% Confidence Internal for Mean Lower Bound	Upper Bound
Stream A	37	24.286486	52.5149033	8.6333969	6.777146	41.795827
Stream B	37	26.421351	60.2106615	9.8985718	6.346117	46.496585
Stream C	37	26.568027	59.9557029	9.8566568	6.577800	46.558254
Stream D	37	25.636162	53.7859202	8.8423508	7.703044	43.569281
Total	148	25.728007	56.1501937	4.6155175	16.606667	34.849346

Table 3: ANOVA

	Sum of Squares	df	Mean Square	F	Sig
Between Groups	121.093	3	40.364	.013	.998
Within Groups	463347.012	144	3217.688		
Total	463468.105	147			

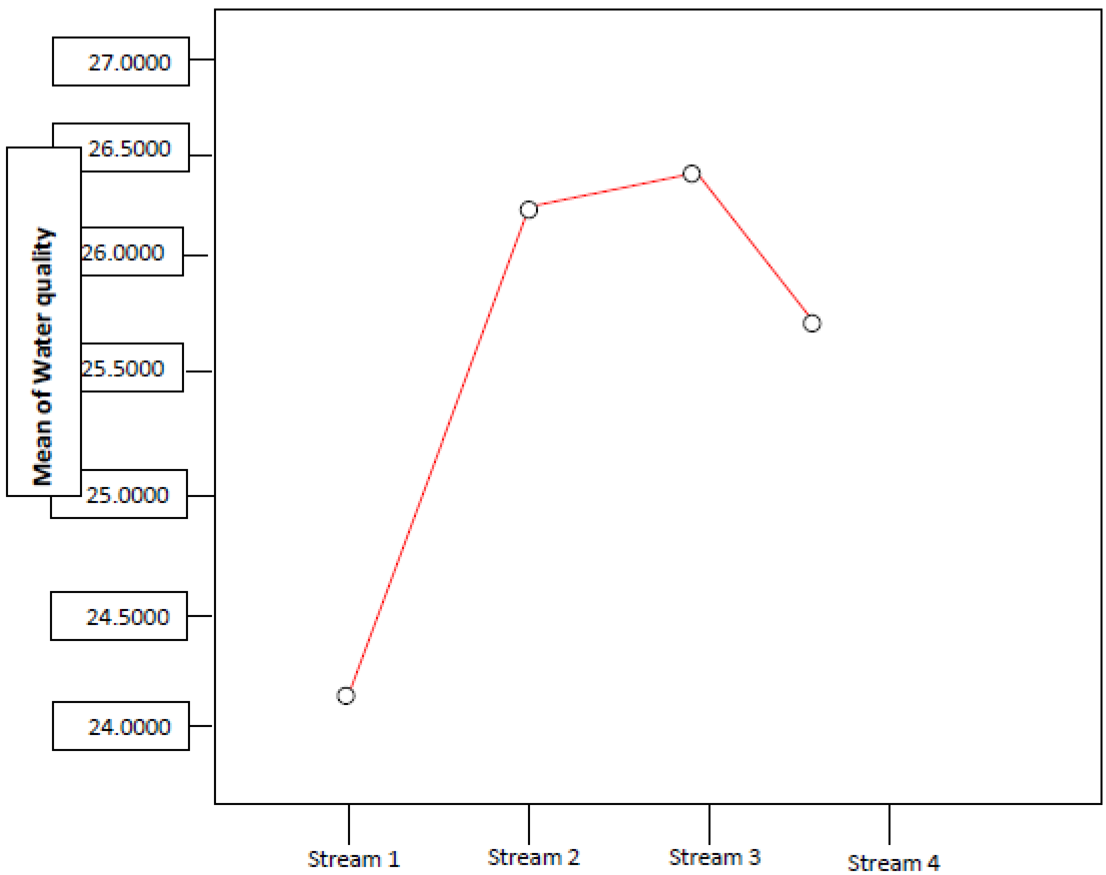

Figure 2: Mean values of water quality status across the four streams.

all of the samples tested were within the NIS, STDS, NDWQS, and WHO (2011) limits (Table 1 and Figure 5).
The dissolved oxygen (mg/l) in sample 1 Idim Ikot Offiong, Oboroko Stream is 2.5 (mg/l), Sample 2, Idim Odoro Oboroko Stream is 2.6 (mg/l), Sample 3, Idim Inua-Akpa Stream has a value of 2.4, and Sample 4, Idim Usugode, Oboroko Stream has a value of 3.6 (mg/l). All of the samples had low values, indicating that these

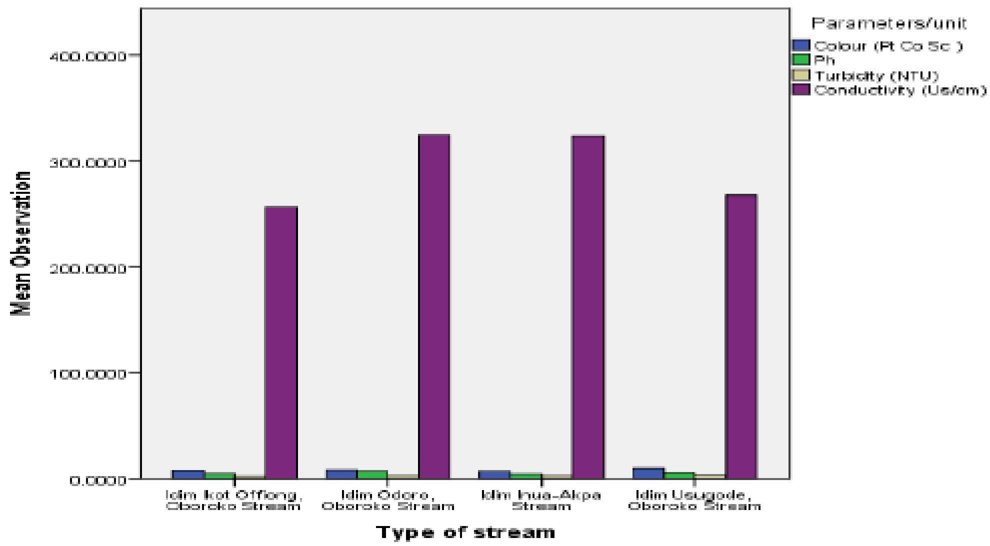

Figure 3: Concentration of parameters, colour, pH, turbidity and conductivity of the four streams.

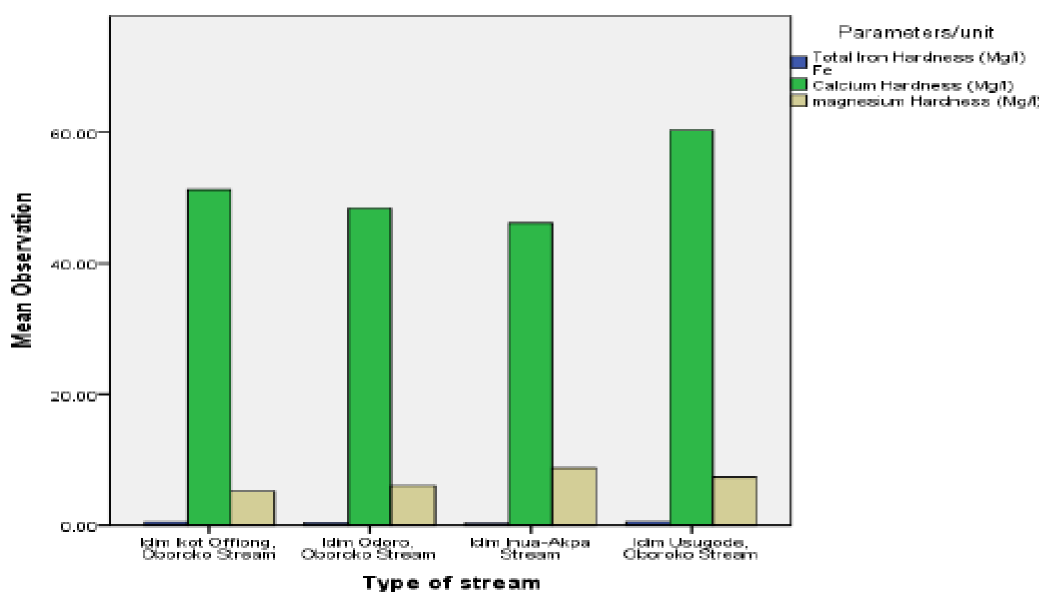

Figure 4: Concentration of parameters, total iron hardness, calcium hardness and magnesium hardness for the four streams.

streams are unsuitable for aquaculture production (Table 1 and Figure 5).

The analysis of the water samples shows that sample 1 has a BOD5 Cl25^{0}C value of 12, sample 2, BOD5 Cl25^{0}C value of 23-14, sample 3, BOD5 Cl25^{0}C value of 17-13, while sample 4 has a value of BOD5 Cl25^{0}C, 14.00 (Table 1 and Figure 5).

The laboratory results of the water sample also indicate, that total suspended solids (mg/l) for sample 1 is 0.0001, sample 2, 0.001 (mg/l), sample 3, 0.002 (mg/l) and sample 4, 0.003 (mg/l). (see table 1 and figure 5). These figures were slightly above the WHO standards for drinking water quality.

Heavy metal and trace metal concentrations were above proposed standard. Copper concentrations were higher than the proposed standard, posing a risk to human health and rendering the water unfit for domestic use. Other metals analyzed showed insignificant changes in value with tidal change, with values similar to those obtained by Adefemi and Awokunmi (2009).

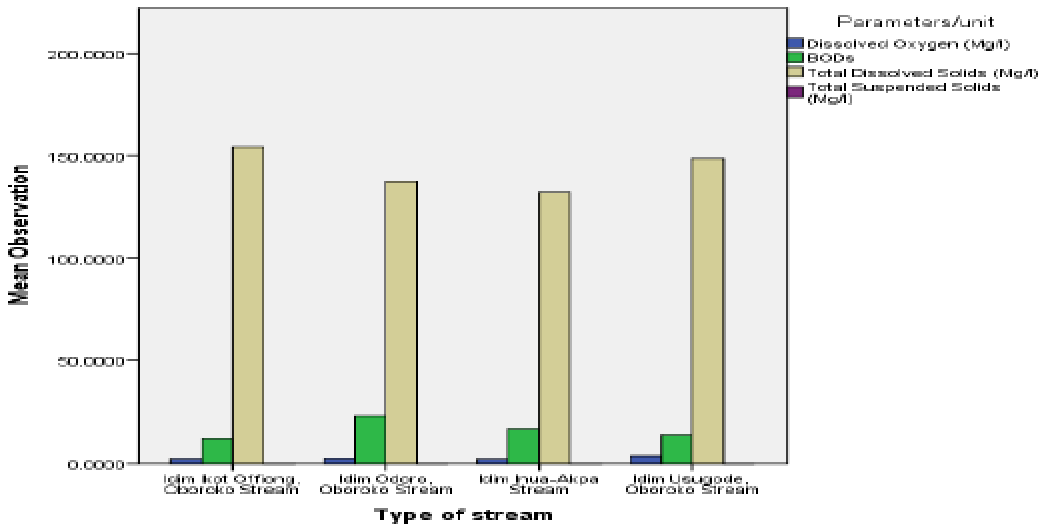

Figure 5: Concentration of parameters, dissolved oxygen, BODs, Total Dissolved Solids and Total Suspended solid for the four Streams.

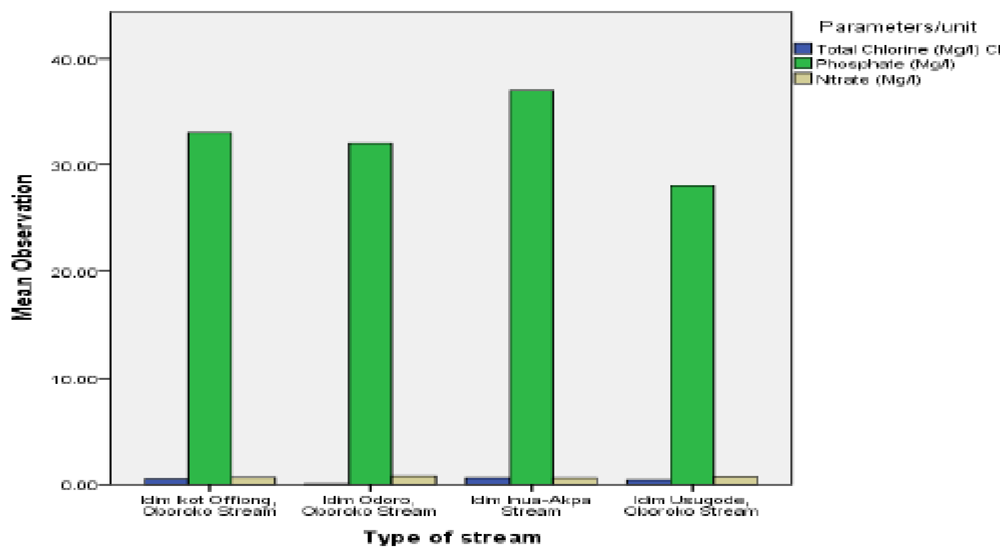

Figure 6: Concentration of parameters, Total Chlorine, Phosphate and Nitrate for the four stream.

Despite the presence of a few metals at low concentrations, iron and manganese recorded very high values, indicating high concentrations above the proposed standard. Although iron is abundant in Nigerian soil, manganese concentrations are attributed to iron foundry services along the watershed.

Lead, arsenic, and cyanide are extremely toxic to both humans and aquatic life. They are detected at low concentrations and are undesirable, but they may be bio-concentration in the food chain, causing health issues.

The concentrations of sulphate (mg/L) 5 indicate that the four samples met the NIS, STDs, and WHO (2011) drinking water quality standards. When sulphate concentrations exceed 250 mg/L, water takes on a bitter or medicinal flavor. Drinking water may become unpleasant as a result of this. Plumbing, particularly copper piping, may be corroded by higher levels of sulphate. Echoke, Nadana, and Idowu discovered these results in line values (2018). The concentrations of potassium (mg/L) in the four sampled streams were slightly higher than the NSDWQ and WHO values of 10-12, with the following results: stream 1 14.4 (mg/L), stream 2 18.2 (mg/L), stream 3 16.7 (mg/L), and stream 4 16.8 (mg/L).

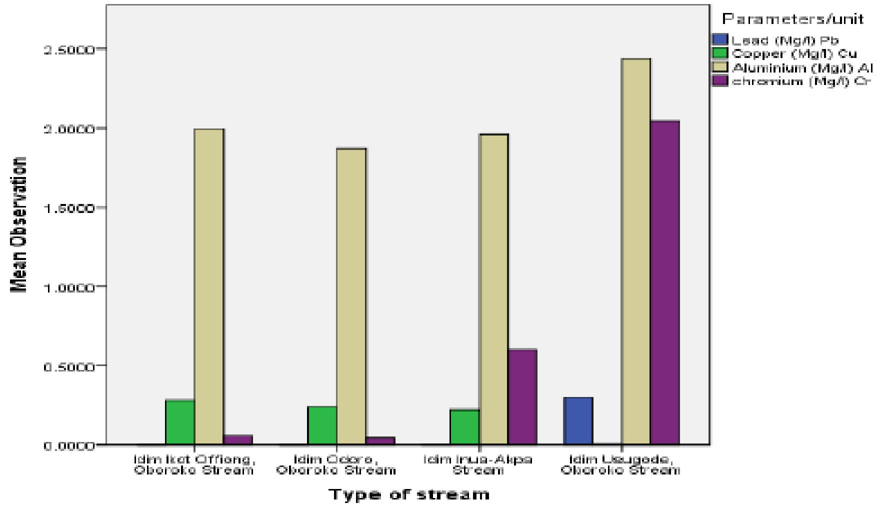

Figure 7: Concentration of parameters, lead, copper, aluminium and chromium for the four streams.

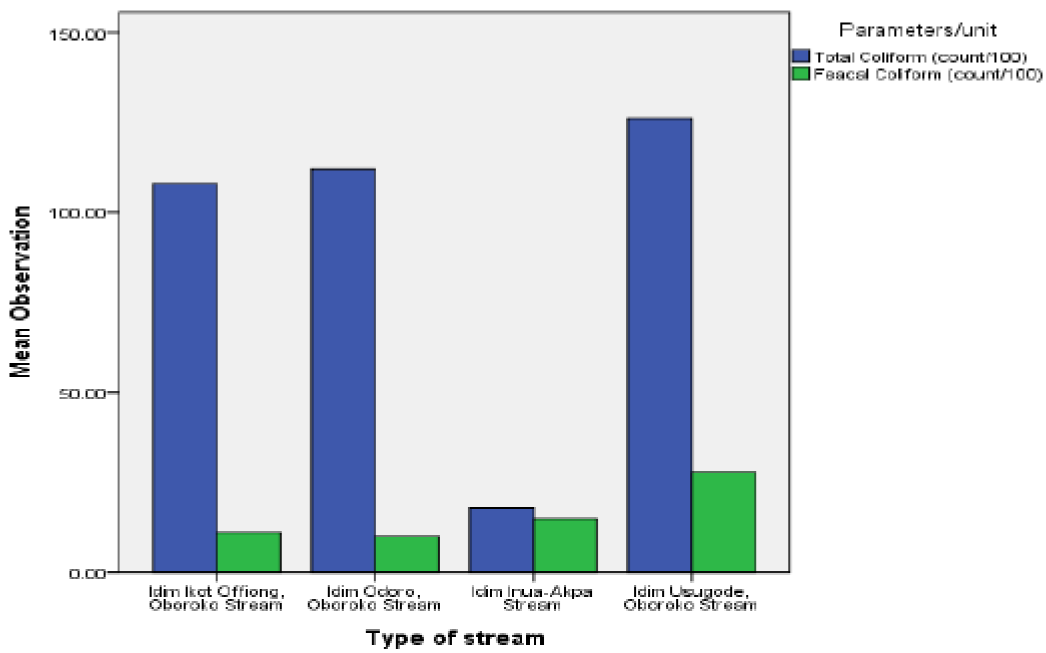

Figure 8: Concentration of parameters, total coliform and faecal coliform for the four stream.

The results also show that Zinc (mg/L) Zn was within the WHO standard with values of stream 1 0.35(mg/L), stream 2 0.57, stream 3 0.72(mg/L), and stream 4 0.72(mg/L). 0.2 and 3 values in NIS and STDS standards. Finally, the concentrations of silica (mg/L) Si in the four streams, sample 1, 615(mg/L), sample 2, 6.18(mg/L), sample 3, 2.24(mg/L), and sample 4, 8.63(mg/L), were all within NIS, STDS, and WHO limits.
Total coliform, sample 1 has 108 counts/100ml, sample 2 has 112 counts/100ml, sample 3 has 18 counts/100ml, and sample 4 has 126 counts/100ml, whereas fecal coliform has 11 counts/100ml, sample 2 has 10 counts/100ml, sample 3 has 15 counts/100ml, and sample 4 has 28 counts/100ml. All of the samples exceeded the NIS, STDS, and WHO drinking quality standards. This demonstrates a high level of bacterial activity, rendering the water unfit for most domestic uses and exceeding the limit for the survival of most aquatic life forms. The salinity levels were within the NIS, STDS, and WHO guidelines. These findings were consistent with Agbo et al. (2019); Hassane et al. (2020). From (Figure 8) above, there is a degree of pollution at the four streams in Okoyong by domestic activities or waste discharged into the water body directly or indirectly.

Conclusion

The physico-chemical parameters monitored in the samples revealed a high level of heavy metal concentration, in most cases exceeding the permissive limit, based on the data collected in the study. This is reflected in the high level of conductivity as well. In addition, there is a low level of dissolved oxygen and a high concentration of water nutrients. This was most likely due to the nature of the effluent discharged into the river by domestic activities. Because most concentrations were above the World Health Organization and Nigerian Standard for Domestic Water Quality permissible limits, residents along the streams should avoid discharging wastes that are harmful to the environment into rivers and streams. Finally, the water from the sample site is not completely free of pollution and cannot be used for domestic purposes, livestock rearing, or drinking without treatment.

Recommendations

Establishing standard for water pollution control. There should be uniform standard, uniform permissible limit for parameters between different organizations.

Domestic and industrial activities within watersheds should be check-mated.

Licensing of discharging effluents for preventing water pollution.

Monitoring network of water quality should be the lead way in the area.

Environmental impact assessment of activities going on the area be carried out.

Water pollution control boards should be set up in the study area.

Need to create public awareness among the inhabitance of the study area.

Individual should avoid discharge of waste that is not environmental friendly into streams and surface bodies.

REFERENCES

Abowei (2010). Salinity, Dissolved Oxygen, PH and surface Water temperature. Condition in Nkoro River, Niger Delta, Nigeria. *Advance Journal of Food Science and Technology*. 2:36-40

Abowei, J.F.N Ezekiel, E.N. and Hanson, U. (2012). Effects of Water Pollution on Phytopl Niger Delta Area, Nigeria. *International Journal of Fisheries and Aquatic Science* 1(2): 39 44

Adefemi S.O. and Awokunmi, E.E. (2009). The impact of Municipal Solid Waste Disposal in Ado-Ekiti Metropolis, Ekiti-State, Nigeria. *African Journal of Environmental science and Technology*. 3(8): 186-189.

Agbo, B.E., Ogar, A.V., Akpan, U. L and Mboto, C.I. (2019). Physico-chemical and Bacteriological Quality of Drinking Water Sources in Calabar Municipality, *Nigeria-Journal of Advances in Microbiology*. 14(4):1-22

Akhilesh, J., Savita, D., and Suman, M. (2009). Some trace elements investigation in groundwater of Bhopal and Sehore District in Madhya Predesl, India. *Journal of Applied Science and Environmental Management, 13(4):47-50.*

Alabaster, J.S. and Lloyed, R. (1980). *Water Quality for fresh Fish*. 1st Edition, Butter Worths, London. 283

APHA (2005). *Standard methods for the examination of water and waste water*, 21st Edition. American Public Health Association Washington.

Asikong, B.E. and Udofia, U.U. (2005). *Introduction to Environmental Microbiology, Pollution and Waste Management.* 20-22.

Bhatia S.C. (2008). *Environmental Chemistry*. Amazon.com

Braide, S.A., Izonfuo, W.A.L; Adiukuru, P.U. Chindah, A.C. and Obunwo, C.C. (2004). Water Quality of Miniweja Stream, a swamp forest stream receiving non-point source Waste discharges in eastern Niger Delta. *Nigeria Scientia/J.F.N./ Africana* 3(1): 1-8.

Chapman, D. and Kinstach V. (1992). *The Selection Water Quality Variables*. In Deborah Chapman (Ed), Water Quality Assessments. A guide to the use of biota sediments and water in Environmental Monitoring. London: Chapman and Hall, 51-117

Chima, G.N and Digha, O.N. (2009). Community water supply and human health in Ogbia L.G.A. of Bayelsa State, Central Niger Delta, Nigeria. *Journal of Medical and Pharmaceutical Sciences. 5(1) 105-111.*

Digha, O.N and Abua, M.A. (2016). *Assessment of pollution status of Ikwette Stream at Obudu Cattle Ranch Bottom Hill, Cross River State Calabar Nigeria. 343-352.*

Digha, O. N. (2021). Evaluation of Groundwater Quality using pollution Index in some communities of Bayelsa state, Nigeria. *International Journal of Innovation Environmental Studies Research* 9(3): 1-9.

Echoke, J.C., Nadana, R.W. and Idowu, R.T. (2018). Water Quality Index as a tool for the assessment of the Health of Usuma Reservoir, FCT Abuja Nigeria. *Direct Research Journal of Public Health and Environmental Technology.* 3 (6): 73-80

Eze, B.E. and Abua, A.M (2003). *Morphometric Parameter of the Calabar River Basin*. Calabar: Ushie Printers.

Eziash , A.C. (1999). Surface water pollution in Nigeria causes, consequences and solutions. *J. Public Priv. Law.* 1(3):111-124.

Gbadebo, A.O, Agbaja, O.B., Jimoh, O.D and Adesiji, A.R (2016). Application of GIS and Remote sensing in the Assessment of Groundwater Potential (case study of FUT Minna Gidan-Kwano Campus). *Nigeria Assessment of Hydrological Sciences (NAHS). Proceedings of the International Conference. Theme: Water Resources and sustainable Development. pp.218-233*.

Habib, M.G. and Tasi, Y.R. (2020). Groundwater potential Assess for Rural Water Supply in Yauri Kebbi State, Nigeria. *Nigerian Journal of Hydrological Sciences*. 8(2020): 31-45.

Hart, A.I. and Zabbey, N. (2005). Physico-Chemistry and Benthic Fowna of Woji Creek in the Lower Niger Delta, Nigeria. *Environment & Ecology* 23(2): 361-368.

Hassane, A. Boubacar, I., Seyeni, S. Rabani A., Saflietou, S. and Stefan, L. (2020). Physico-Chemica; and bacteriological quality of groundwater in rural area of Western Niger: a case study of Bankoukou *Journal of Water and Health.* 18(1): 1-13.

Maitera, O.N, Ogugbuaja, V.O, and Barminas J.T., (2011). Determination of trace metal levels in water and sediments of River Benue in Adamawa State, Nigeria. *Journal of Ecology and natural Environment, 3(4):149-156*.

Mather, J.R (1984). *Water Resources: Distribution*, UK and Management. (New York John Willey).

Narayanan, P. (2006). *Environmental Pollution Principles Analysis and Control*. CBS publishers and Distributors, New Delhi, Bangalore India.

Narayanan, P. (2009). *Environmental Pollution Principles Analysis and Control*. CBS Now Delhi Bomgalore (India).

NEDECO (1961). *The Water of the western Niger Delta Report on investigation* by NEDECO Hague: Netherland Engineering consultation.

Nkemdirim, V.U., Nwokoro, N.R. and Digha, O.N. (2015). Implication of Rainfall changes on water resources potential in Nigeria. *Journal of arts, science and Development. A Multidisciplinary Journal of Society* *and Development issues. 1:112-119.*

NPC (2006). *National population census of the Federal Republic of Nigeria. Analytical Report at the National level*. National Population commission Abuja.

NPC, (2006). *Nigeria. Federal States and Cities Statistics and Maps on City Population*. City Population Africa, Available at: http//www.citypopulation.de/Nigeria.html

NSDWQ (2007). *Nigerian Standard for Drinking Water Quality*. Nigerian Industrial Standard. NIS 554, 13-14

Nwankwoala, H.O., Udom, G. J., and Ugwu, A.S. (2011). Some Heavy Metal Investigation in Groundwater Sources in Yenagoa Bayelsa State, Nigeria. *Journal of Applied Technology in Environmental sanitation,1(2):163-170.*

Olatunji, J.A., Odediran, O.A, Obaro, R.I. and Olasehinde, P.I. (2015). Assessment of groundwater quality of Ilorin metropolis using water quality index approach. *Nigerian Journal of Technological Development12(1):18-21.*

SON (2007). *Nigeria standard organization Act for Drinking water quality, 1-30*.

Udoh, E.J and Etim N.A (2007). Analysis of Domestic Water Consumption pattern by farming households in Itu, Akwa Ibom State, Nigeria. *European Journal of social science, 6(2):76-82.*

WHO (2011) *Guidelines for Drinking Water Quality Geneva,* 4rd Edition.

WHO (2004). *Guidelines for drinking water quality Geneva*, 3rd Edition.

Yirdaw, M. and Bamlaku, A.C. (2016). Drinking Water Quality Assessment and its Effects on Residents Health in Wondo Genet Campus Ethiopia. *Environmental Systems Research*. 5(1): 1-7.

Yusuf, K.O. and A Sulaiman (2016). Assessment of heavy metal concentration in Borehole water of Sango Ward Ilorn, Kwara State. *Nigerian Journal of Hydrological science*, *4:137-146*.