Physico-Chemical Analysis of Water from Different Sources in the Greater Port Harcourt City Development Area (GPHCDA) of Rivers State, Nigeria

Anyalebechi, Onyebuchi[1], Ogobiri Godwin[2], Igbudu Onukwurumege[3]

[1]Physics Department, University of Port Harcourt, Rivers State, Nigeria

[2]Physics Department, Niger Delta University, Wilberforce Island, Amassoma, Bayelsa State Nigeria

[3]Science Laboratory and Technology Department, Ken SaroWiwa Polytechnic, Bori, Rivers State, Nigeria

Abstract: ***The study of the physico-chemical analysis of the water from different sources in the Greater Port Harcourt Areas of Igwuruta, Omagwa and Isiokpo in Rivers State Nigeria has been carried out. The study involved twenty (20) water samples randomly collected from twenty different points from five (5) different water sources of pond, borehole, well, stream and river distributed in the three (3) different towns. The Samples were carefully analyzed using standard method for eleven (11) parameters of physico-chemical qualities. Results shows that borehole water, BWIG1 record pH value of 5.25, BWIG3 recorded 5.92 and well water, WWI18 had 7.67. in Electrical conductivity, pond water PWO13 expressed value 1195μs/cm and Well water WWIG4 recorded 77μs/cm. In total dissolved Solid (TDS), PWO13 showed value of 867(mg/L) and BWO9 had a value of 189(mg/L).In terms of dissolved oxygen BWO9 and BWI16 had value of 7.80ppm respectively and RWI20 value was 2.60ppm. comparatively, the borehole Samples expressed values which makes them more desirable than others in presence of poor water management.***

Keywords: Physico-chemical, parameters

1. Introduction

Quality fresh water and its availability has become a crucial issue and source of serious concern in recent times because of its increasing demand. It is important to health, agriculture, industries and the entire ecosystem. A major problem with global water distribution is its nonuniform supply with location and time. It is becoming more indispensable as the world supply of fresh water dwindles relative to demand.

Increase in population and living standard in pre-urban and urban areas cum industrial activities have given rise to greater demand for quality water as well as paving way for pollution issues. On the other hand, the issue of pollution invariably affects water quality where it is applicable. This is why issue of water quality is crucial. The expected properties of water quality should include amongst others adequate amount of dissolved oxygen, relatively low organic content, pH value near neutral since pH value is an intensity factor, moderate temperature and free from excessive amount of infectious agent, toxic substances and mineral matters. A major characteristic of unpolluted water is the quantity of gas solubility. (Oluyemi et al 2010; Priscilla et al 2013).

The issue of water quality is compounded in Niger Delta, the location of Greater Port Harcourt, the focus of this study by unplanned urbanization and industrial regime driven by oil and gas exploration and exploitation without end-of-the pipe approach, as a result, the region is motional but staggering as it confronts the consuming force of environmental degradation. The bulkof the waste generated by the growing population and the numerous industries found its way into the available water bodies (Anyalebechi et al 2007). This study focuses on the Greater Port Harcourt City Development Area (GPHCDA), spanning across eight local government areas of Rivers State with a population figure of one million, seven hundred and forty-nine thousand, two hundred and sixty-four (1,749,264) (2006 NPC Census figure).

The evolving case scenario is a major reason for determination or assessment of water quality in the urbanizing area of Greater PortHarcourt, to determine whether the physical and chemical properties are within acceptable or desirable limit. If they are not, the available water for human consumption (which include; drinking, production and recreation) may be classified as polluted. Water pollution involves the presence of a contaminant in its natural environment that causes an adverse change in its quality and value; physically, chemically and biologically. Pollution is often classified as point source or non-point source. The severity of pollution from a pollutant perspective depend largely on chemical concentration and its persistence in the receiving environment.

Since government at all levels in Nigeria do not prioritize the issue of provision of portable water, accessing quality water in the developing area such as Greater Port Harcourt will be difficult, without being prioritized, the supply and regulation that will guild the provision of quality water will not be visible. Available sources of water in the area under focus include; well, pond, stream, rivers and motorized drilled well (boreholes). These sources of water are not treated and are unregulated by any agency of the government. In a society where population growth is not planned, waste of all kind is largely disposed carelessly and unregulated. Water bodies become receptor of waste and contaminants. The result will be degraded water quality, distorted aesthetic value, loss of recreational value, general environmental health hazard and scarcity of useable water. All of these short falls will manifest in increase in rising case of water borne diseases in the face of failing health facilities, declining economic growth and lack of safety in the emerging urban centre (Schoonover et al, 2005).

Sequel to the importance of quality water to human, economy and sustainable development, many researchers have carried out studies on the state of water from various sources. Ogwo et al (2014) evaluated the physio-chemical and heavy metal properties of Igwi Stream in Abia State University, Uturu, Abia State, Nigeria. The result of the research revealed a pH of 5.0, indicating some level of acidity in the stream. Kerketta et al (2013) determined the physico-chemical properties and heavy metals in drinking water samples collected from different sources in and around RanchiThark Land, India. The authors concluded that, out of the collected water samples, sample from pond and rivers were highly contaminated: others include; Ojo et al (2012),Soronnadi-Ononiwu et al (2012), Bernard et al (2012), Mahananda et al (2010) and Hiyare (2008).

In line with the works of Kerketta et al (2013), Soronnadi-Ononiwu et al (2012) and Mahannada et al (2010). This work considered the physico-chemical parameters of water from different sources in Igwuruta, Omagwa and Isiokpo areas in Greater Port Harcourt Area of Rivers State, Nigeria.

2. Materials and Method

Samples were randomly collected from different water sources within the listed study area. The sources include; borehole (motorize well), local wells, ponds, streams and River. The samples were collected in high grade plastic bottle thoroughly washed and sterilized. The bottles were rinsed once with distilled water and thrice with the respective water samples it will contain. Twenty (20) different sampling points in all were marked in three (3) different towns in the study area. Water samples were collected from twenty (20) different points from the five (5) different water sources. A total of 20 samples were taken from the different sources in the following order:

Borehole	=	9 points
Well	=	6 points
Pond	=	3 Points
Stream	=	1 point
River	=	1 point

Samples from surface water for physico-chemical analysis were collected mid-stream at a depth of 1.5 meters directly into a clean 1-liter bottle. Temperature and P^H were measured in-situ using a temperature probe and portable pH meter for dissolved oxygen (DO) determination. Other samples were collected into 300ml plain glass bottles and the dissolved oxygen fixed using oxide modification of Winkler's method.

The collected sample were taken to the laboratory and analyzed for eleven (11) parameters, such as; electrical conductivity (EC), total hardness (TH), total dissolved solid (TDS), iron (Fe), magnesium (Mg^{2+}), dissolved oxygen (DO), salinity calcium (Ca^{2+}), including temperature and pH. The physico-chemical analysis was concluded within 48 hours, while the samples were stored at room temperature. Generally standard methods were adopted for the physico-chemical analysis of the water samples. The sampling points were coded and GPS recorded as follows:

3. Results

Table 1: Details of Water Samples Sources and Codes

S/N	*Sample Code*	*Sample Location*	*GPS*	*Comments*
1	BWIG 1	Omuodukwu, Igwuruta	Alt 34.0m Lat 4:57:29.487N Long 7:00:24.953E	Borehole located at NDDC road, Omuodukwu.
2	BWIG 2	Omueke, Igwuruta	Alt 30m Lat 4:57:25.513N Long 7:00:38.477E	Located close to Ahia-Ordu market area, about 400m from pond shore.
3	BWIG 3	Igwuruta-ali, Igwuruta	Alt 32m Lat 4:58:005.847N Long 6:59:004.534E	Located within residential area.
4	WWIG 4	Omuodukwu, Igwuruta	Alt 34.0m Lat 4:57:29.487N Long 7:00:24.953E	Situated 200m from the pond shore at Omuikuga, Omuodukwu.
5	WWIG 5	Omuwei, Igwuruta	Alt 34m Lat 4:53:08.250N Long 7:01:10.284E	Located at Omuka, Omuwei commercial settlement.
6	PWIG 6	Omuodukwu, Igwuruta	Lat 4:57:45.037N Long 7:00:14.936E	Farming and fishing activities are high.
7	PWIG 7	Omueke, Igwuruta	Alt 38m Lat 4:57:19.608N Long 7:01:10.181E	Repository point for waste generated from Ahia-Ordu market.
8	BWO 8	Omuketu, Omagwa	Alt 23m Lat 4:58:58.588N Long 6:55:00.998E	Located within the market proximity.
9	BWO 9	Omuolo, Omagwa	Alt 33m	Located adjacent to the international airport area.

			Lat 4:58:50.256N Long 6:56:58.694E	
10	BWO 10	Okparagwa, Omagwa	Alt 25m Lat 4:58:30.401N Long 6:54:12.471E	Located 200m away from an AP filling station.
11	WWO 11	Okparagwa, Omagwa	Alt 26m Lat 4:59:04.409N Lat 6:55:43.101E	Located at a poorly sanitary area.
12	WWO 12	Imogu, Omagwa	Lat 49:59:03.038N Long 6:55:21.028E	Located at a densely populated area of local residence, agrarian.
13	PWO 13	Imogu, Omagwa	Alt 25m Lat 49:59:03.038N Long 6:55:21.028E	Located 100m from local residence with poor sanitary toilet
14	BWI 14	Adanta, Isiokpo	Alt 15m Lat 4:57:21.9709N Long 6:52:46.822E	
15	BWI 15	Alimini, Isiokpo	Alt 46m Lat 4:59:02.014N Long 6:52:44.215E	Located in Ikwerre Local Government Council premises.
16	BWI 16	Omueke, Isiokpo	Alt 31m Lat 4:58:42.529N Long 6:52:44.334E	Located opposite Isiokpo Magistrate court, 500m away from the stream.
17	WWI 17	Alimini, Isiokpo	Alt 62m Lat 5:00:54.603N Long 6:52:09.125E	Located within a construction area.
18	WWI 18	Mgboyo, Isiokpo	Alt 14m Lat 4:58:34.793N Long 6:52:56.567E	1200m close to the Azumini stream.
19	SWI 19	Mgboyo, Isiokpo	Alt 14m Lat 4:58:34.792N Long 6:52:56.460E	A local stream with high level of fishing activities including swimming.
20	RWI 20	Ogbodo, Isiokpo	Alt 19m Lat 4:56:54.537N Long 6:54:46.085E	Used for recreational activities like swimming and also for fishing and laundry.

Table 2: The results of the physico-chemical parameters of the water collected from different sources as presented in Table 1.

Location of Sample	Number of Sample	Parameters										
		p^H	EC (μs/cm)	TH (mg/l)	TDS (mg/l)	F_e (mg/l)	Hardness Mg^{2+} (mg/l)	DO (ppm)	Salinity (ppt)	Hardness Ca^{2-}(mg/l)	Colour	Temperature (°C)
IGWURUTA	**BWIG1**	5.25 ± 0.05	506 ± 5.06	71.4 ± 0.71	367 ± 3.67	0.28 ± 0.00	33.40 ± 0.53	7.20 ± 0.07	0.22 ± 0.00	38.00 ± 0.38	18.00 ± 0.18	30.07 ± 0.30
	BWIG2	6.70 ± 0.06	456 ± 4.56	71.30 ± 0.71	331 ± 3.31	0.17 ± 0.00	22.10 ± 0.22	6.60 ± 0.06	0.28 ± 0.03	39.20 ± 0.39	13.00 ± 0.13	29.00 ± 0.02
	BWIG3	5.92 ± 0.05	401 ± 4.01	69.50 ± 0.69	289 ± 2.89	0.22 ± 0.00	34.50 ± 0.34	7.00 ± 0.07	0.22 ± 0.00	35.00 ± 0.53	20.00 ± 0.20	30.02 ± 0.30
	WWIG4	6.70 ± 0.06	77 ± 7.72	98.41 ± 0.98	560 ± 5.60	0.28 ± 0.00	45.41 ± 0.45	6.30 ± 0.06	0.30 ± 0.00	53.00 ± 0.53	20.05 ± 0.20	28.00 ± 0.02
	WWIG5	6.30 ± 0.06	855 ± 8.55	115.00 ± 1.15	620 ± 6.20	0.3 ± 0.00	56.00 ± 0.56	3.10 ± 0.03	0.37 ± 0.00	49.00 ± 0.49	21.02 ± 0.21	29.04 ± 0.29
	PWIG6	6.50 ± 0.06	1122 ± 11.22	141.30 ± 1.41	814 ± 8.14	0.44 ± 0.00	79.30 ± 0.79	4.00 ± 0.04	0.18 ± 0.00	62.00 ± 0.62	29.07 ± 0.29	28.03 ± 0.28
	PWIG7	6.20 ± 0.06	1042 ± 10.22	140.00 ± 1.40	756 ± 7.56	0.12 ± 0.00	63.00 ± 0.63	2.90 ± 0.03	0.25 ± 0.00	77.00 ± 0.77	18.00 ± 0.18	30.00 ± 0.03
OMAGWA	**BWO8**	7.20 ± 0.07	373± 3.37	93.10 ± 0.93	271 ± 2.71	0.30 ± 0.00	54.60 ± 0.54	7.00 ± 0.07	0.30 ± 0.00	38.50 ± 0.38	14.00 ± 0.14	31.00 ± 0.31
	BWO9	6.85 ± 0.06	260 ± 2.60	86.30 ± 0.86	189 ± 1.89	0.16 ± 0.00	42.00 ± 0.42	7.80 ± 0.08	0.10 ± 0.00	44.30 ± 0.44	12.00 ± 0.12	28.05 ± 0.28
	BWO10	6.70 ± 0.06	332 ± 3.32	61.00 ± 0.61	241 ± 2.41	0.19 ± 0.00	33.00 ± 0.33	6.60 ± 0.07	0.18 ± 0.00	28.00 ± 0.8	15.40 ± 0.15	31.00 ± 0.31
	WWO11	6.40 ± 0.06	937 ± 9.37	77.00 ± 0.77	680 ± 6.80	0.20 ± 0.00	37.00 ± 0.37	5.00 ± 0.05	0.38 ± 0.00	40.00 ± 0.04	25.00 ± 0.25	29.00 ± 0.29
	WWO12	6.34 ± 0.63	790 ± 7.90	74.09 ± 0.74	573 ± 5.73	0.29 ± 0.00	38.04 ± 0.38	3.60 ± 0.03	0.40 ± 0.00	36.05 ± 0.36	28.00 ± 0.28	29.05 ± 0.29
	PWO13	6.80 ± 0.06	1195 ± 11.95	139.40 ± 1.394	867 ± 8.67	0.42 ± 0.00	65.40 ± 0.65	4.00 ± 0.04	0.26 ± 0.00	74.00 ± 0.74	29.00 ± 0.29	28.00 ± 0.28
ISIOKP	**BWI14**	6.18 ± 0.06	350 ± 3.50	81.00 ± 0.81	254 ± 2.54	0.04 ± 0.00	37.00 ± 0.57	6.80 ± 0.06	0.29 ± 0.00	44.00 ± 0.44	11.06 ± 0.11	27.04 ± 0.27
	BWI15	7.10 ±	405 ±	88.00 ±	290 ±	0.11 ±	41.00 ±	6.30 ±	0.08 ±	39.00 ±	10.01 ±	30.00 ±

		0.05	4.06	0.88	2.90	0.00	0.41	0.63	0.00	0.39	0.10	0.30
	BWI16	6.42 ± 0.06	289 ± 2.89	80.00 ± 0.08	210 ± 2.10	0.08 ± 0.00	38.00 ± 0.38	7.80 ± 0.78	0.10 ± 0.00	42.00 ± 0.42	4.09 ± 0.41	29.02 ± 0.29
	WWI17	7.10 ± 0.07	855 ± 8.55	88.00 ± 0.88	620 ± 6.20	0.15 ± 0.00	54.00 ± 0.54	3.00 ± 0.03	0.35 ± 0.00	34.00 ± 0.34	20.00 ± 0.20	30.00 ± 0.30
	WWI18	7.67 ± 0.06	809 ± 8.09	99.90 ± 0.99	587 ± 5.87	0.18 ± 0.00	48.30 ± 0.48	4.60 ± 0.04	0.24 ± 0.00	51.60 ± 0.51	13.04 ± 0.13	28.04 ± 0.28
	SWI19	6.80± 0.06	1150± 11.50	119.00± 1.19	843± 8.34	0.42± 0.00	68.00± 0.68	3.40± 0.03	0.15± 0.00	51.00± 0.51	36.00± 0.36	29.01± 0.29
	RW120	6.70± 0.06	1169± 11.69	141.39± 1.41	848± 8.48	0.26± 0.00	78.39± 0.78	2.60± 0.02	0.28± 0.00	63.00± 0.63	23.00± 0.23	32.00± 0.32

Comparative analysis of major physicochemical parameters of twenty water samples collected from five different water sources in Igwuruta, Omagwa and Isiokpo towns of GPHCDA

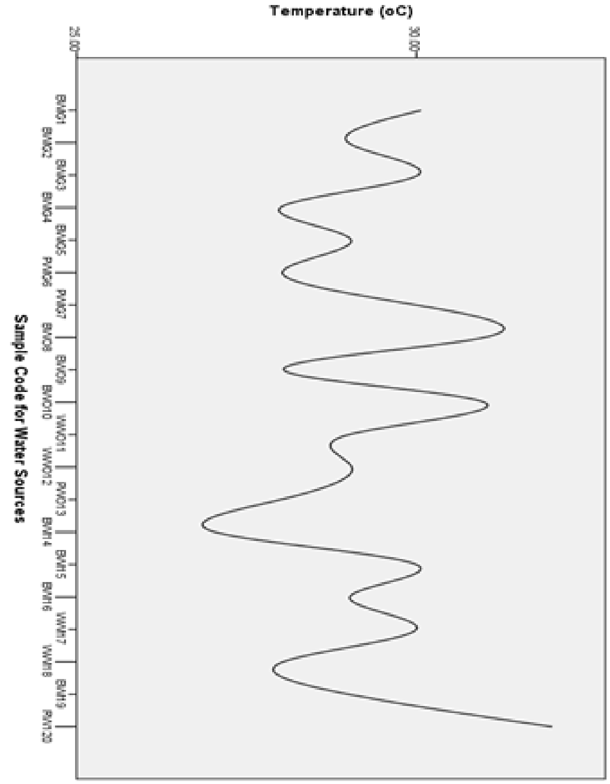

Fig. 1: Showing Temperature Variations across Water Sources

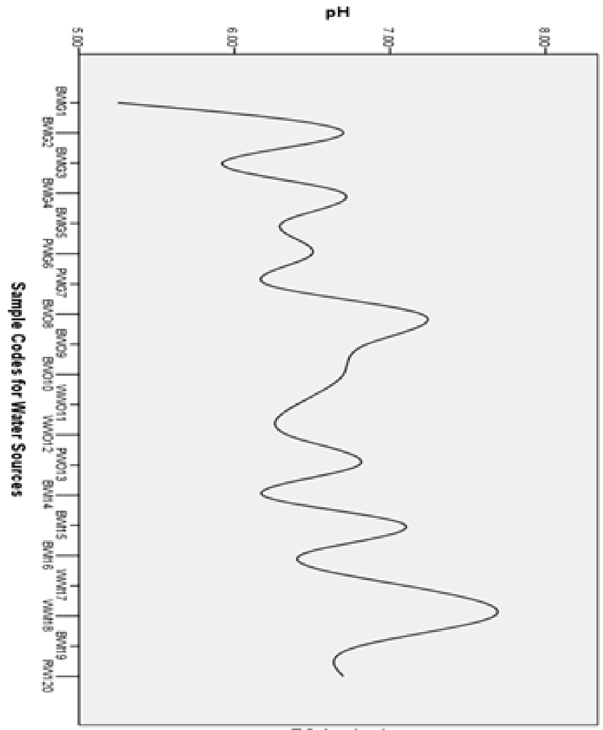

Fig. 2: Showing Variation in pH value for the Water Samples

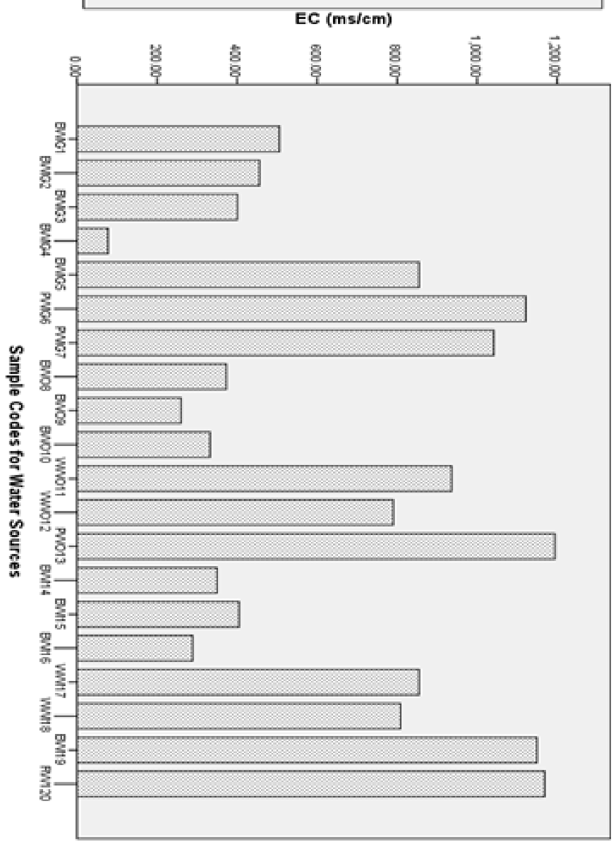

Fig.3: Showing Electrical Conductivity for Various Water Samples

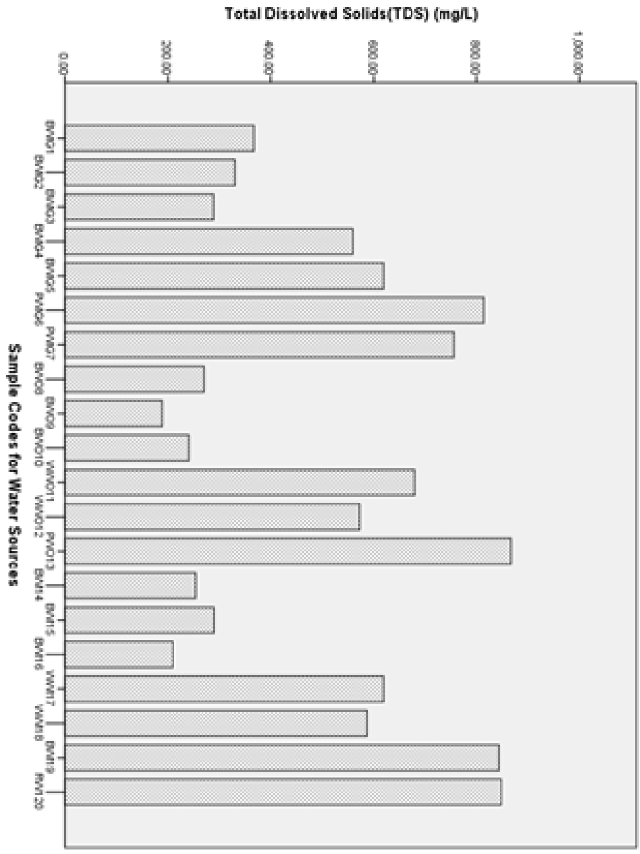

Fig.4 : Showing Total Dissolved Solids across Water Samples

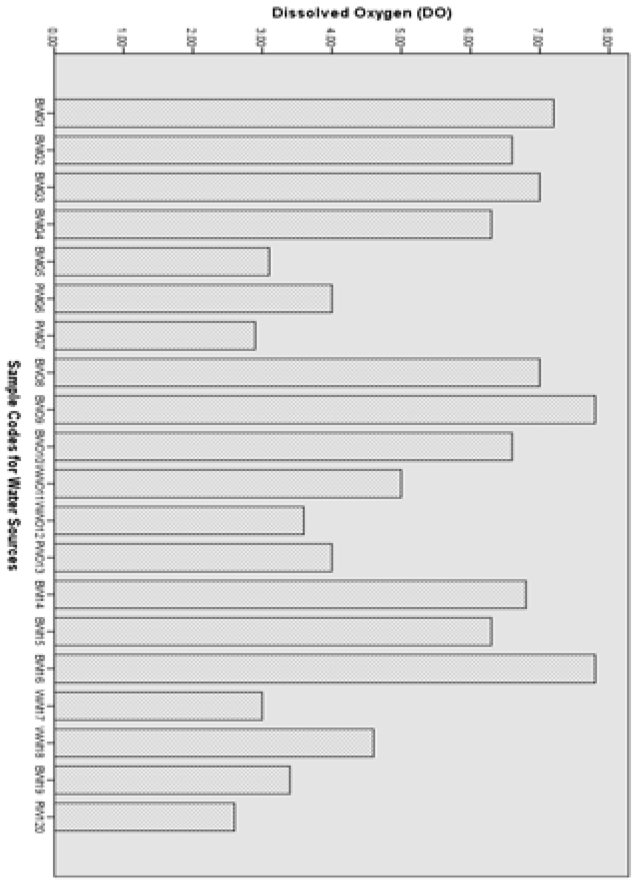

Fig.6: Showing Dissolved Oxygen for various Water Samples

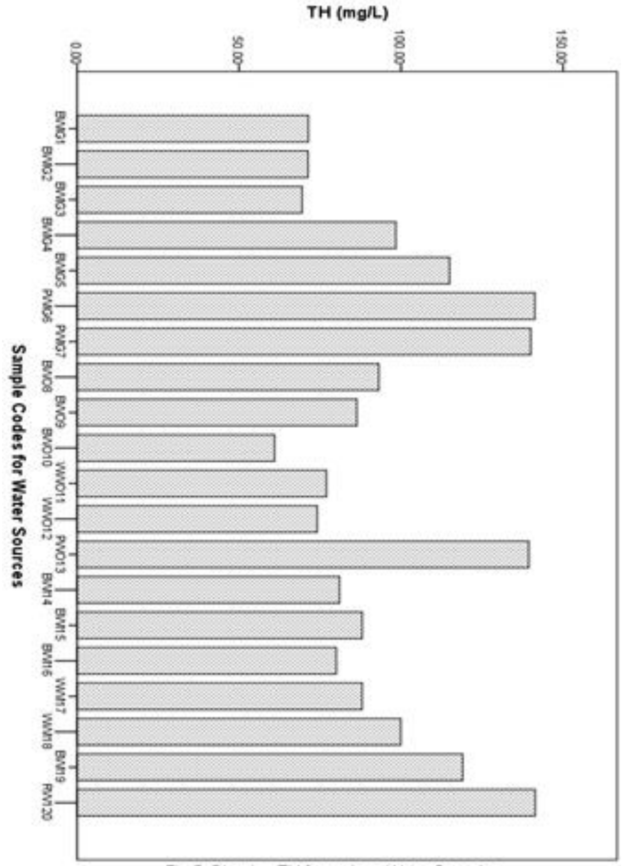

Fig.5: Showing TH for various Water Samples

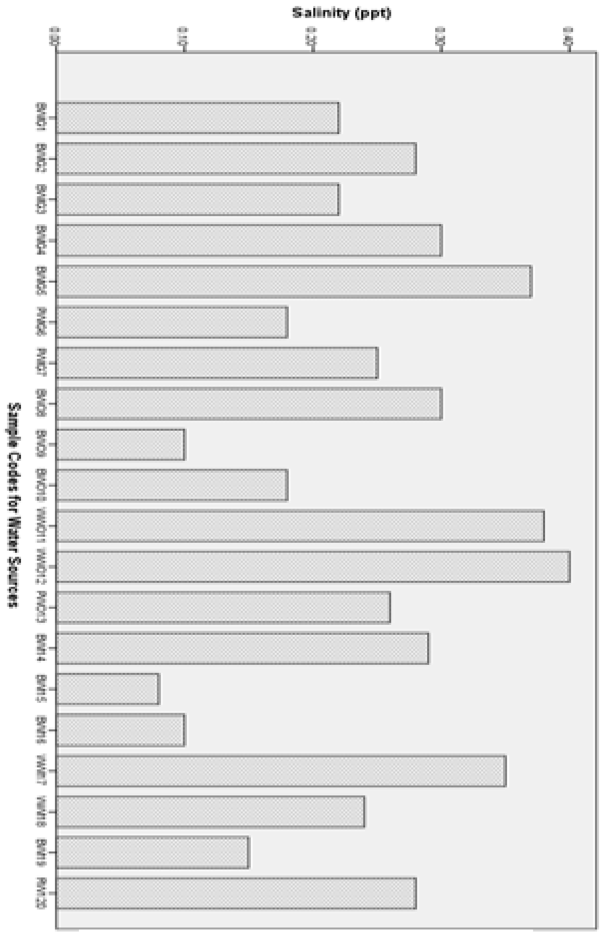

Fig.7: Showing Salinity for various Water Samples

4. Discussion

The result of the physico-chemical analysis of the twenty water samples collected from different sources and locations is presented in table 2 and discussed here.

Iron (Fe): the highest concentration of Fe in this study was recorded in the water sample PWIG6 which was 0.44mg/l. second highest were SWI19 and PWO13 with 0.42mg/l respectively. BWO13 recorded the lowest with 0.04mg/l. water containing iron(Fe) concentration value up to 0.3mg/l is classified as desirable (WHO) but objectionable if it exceeds it (Cohen etal 1960). However, the water sample BWO8 of 0.30mg/l lies within the threshold. The higher values record by the open water bodies like stream and pond might be the result of infiltration of pollutants containing Fe deposit from refuse site and hazardous waste dumps in integrated waste site. Conversely heavy drawdown can result in infiltration of pollutant from sources such as septic tanks and waste dumps in terms of the value record for BWO8. When soluble Iron (II) is present in ground water, exposure to air at the well wall can result in the formation of deposit of insoluble iron (III) produced by bacterially catalyzed oxidation process;

$$4Fe^{2-}(aq) + O_2 + 10H_2O \rightarrow 4Fe(OH)_3(S) + 8H^-$$

This deposit of iron (III) resulting from the process coat and seal the surface from which water flows into the well with relatively
impermeable material which imped the flow of water into the well from the water bearing aquifer (Stummetal, 1981). Generally, beside the issue of colouration, ingestion of large quantities of Fe can result in haemochromatosis, a condition in which normal regulatory mechanism do not operate effectively leading to tissue damage (Diliman et al, 1987)

pH: The pHvalues of the water samples ranged from 5.25 to 7.67. WHO prescribed pH range of 6.5 – 8.5 as the permissible range. Water sample BWIG1 recorded pH of 5.25 followed by BWIG3 with 5.92 pH value indicating acidic behavior. Others are BWI14; 6.18 pH value, PWIG7 with 6.20 and BWI16 6.42 pH value. These low pH values for some of the water mainly from Igwuruta is in the line with the results of (Sororinadi-Ononiwuetal, 2012). The researches opined that the acidity is probably caused by the presence of organic matter in the soil. The highest value was noted for WWI18 with a pH value of 7.67, making it slightly alkaline. High alkaline water often has a high pH. alkalinity serve as a pH buffer and reservoir for inorganic carbon thus helping to determine the ability of water to support algae growth. Alkalinity is a capacity factor. However low pH induces corrosion in distribution pipes and enable the release of toxic metals such as pb, cd, Zn etc. the low pH water can cause sufficient damage to water supply system resulting from complex interaction between pH and other physico-chemical parameters (Tihansky, 1974).

Electrical Conductance (EC): Pure water does not conduct electricity but that containing dissolved salts does. The electrical conductance of water is its ability to conduct current. In the present work, the highest EC value was recorded in the water sample PWO13 (1195µs/cm) while water sample BWO9 recorded the lowest value of 260µs/cm. it was observed that all higher values were recorded for open waters. For instance, RWI20 has EC value (1169µs/cm), SWI19 (1150µs/cm) and PWIG6 (1122µs/cm). The corresponding value of TDS in the study and other ionized materials may be contributing factor in the observed pattern of result reported for this study. Aydin 2007 presented a direct relationship between EC and TDS in water. Strikingly higher-level correlation significance of EC with many of the water quality parameter such as TDS, TH and magnesium exist (Mahajan etal, 2005). The report study result expressed that the water samples from pond, river and stream exhibited higher EC tendencies. However, all recorded sample values are within acceptable limit. It should be noted that conductivity is easier to measure and used in algorithm to estimate salinity and TDS both of which affect water aquatic life.

Total Hardness(TH): Total hardness in water results from the presence of divalent metallic cations of which ca^{2+} and mg^{2+} are the most abundant (Soromadi-ononiwuetal2012 and Subinetal, 2013). The present study reported for the water samples, TH values ranging from (61.00 – 141.39)mg/L for the twenty coded samples. Comparatively, the open water source of sample RW120 recorded 141.39mg/L, followed closely by PWIG6 with value of 141.30mg/L while the lowest was record in BWO10 (61.00mg/L) which came from a motorized well source. The noted difference might be aided by sewage discharges and anthropogenic source that quickly access the open water bodies. Trees in the open water bodies shade their leaves in the water, this can account for mg^{2+} content. These presented values in the Table 2 did not exceed WHO acceptable limit of 500mg/L as expressed in the adopted Table 3.

Total Dissolved Solids (TDS): the total dissolved solid in the water samples ranged from 189mg/L to 867mg/L. water samples PWO13 (867mg/L), RWI20 (848), PWIG6 (814) and PWIG7 (756) are well out of limit for desirable drinking purposes, according to (WHO) limit. They are hence tilting to the limit of permissible under unavoidable situation. Comparatively the samples with lower values of BWO9 (189mg/L), BWI16 (210mg/L), BWI14 (254mg/L), BWO10 (241mg/L) and some others from the reported table 2 fall within the acceptable limit and hence desirable for drinking water purpose. Total dissolved solid in any water sample is commonly affected by organic matter and inorganic salts (Olumuyinaetal, 2012). The chemical species may originate from different sources such as effluent discharge, urban run-off, sewage, leachates etc depending on the water body. Olumuyiwaetal (2012) contended that TDS level in water is the geochemical characteristics of the ground it comes in contact with. PWO13, RWI20, PWIG6 and PWIG7 are permissible for irrigation.

Dissolve Oxygen (DO): the sampled water sources exhibited dissolved oxygen results measured in parts per million (ppm) that ranged from 2.60 per million (ppm) to 7.80ppm. Dissolved Oxygen (DO) has to do with the level of free compound oxygen present in water or other liquids. It is an essential water quality parameter. A Dissolved Oxygen (DO) level that is too high or low can affect aquatic life. Generally, it indicates pollution or desirability of water.

Results obtained shows lower values were observed in water samples from river, pond, well and stream. For instance, the lowest DO of 2.60ppm was recorded for RWI20 followed by PWIG7 (2.90ppm) and WWI17 (3.00ppm), in all DO was below 5ppm. Motorized borehole water samples from Omagwa and Isiokpo BWO9 and BWI16 had DO value of 7.80ppm respectively. Water samples with low DO indicate presence of pollution and activities increasing Biological Oxygen Demand (BOD), the degree of oxygen consumption by microbially mediated oxidation of contaminants in water. BOD as a parameter is commonly measured by determining the quantity of oxygen utilized by suitable aquatic microorganism.

Salinity (ppt): the result of the determined salinity of the various water samples were reported in parts per thousand. Salinity of a water measures usually the concentration of dissolved salts in a given volume of water. From the presented figures in Table 2. The highest salinity value was reported in salinity value was reported in WWO12 (0.40ppt), this was followed by BWO11 (0.38ppt) and WWIG5 (0.37ppt). At the lowest range, report showed BWI16 (0.10ppt) and BWO9 (0.10ppt) respectively. This salinity figure was within the acceptable limit given the salinity of 0.5ppt for river water and 35ppt or 3.5% for Ocean. Salinity is necessary in a way as it impact on dissolved oxygen solubility. Mineral weathering or gradual withdrawal of an Ocean can cause salinization. Again, the vaporization in to atmosphere of water molecules caused it to leave salt behind. This increases the salinity of the water and making the water to be denser. The well waters recorded the highest salt content. The geochemical nature of the aquifer and infiltration from seepages peculating from underground pollutant might be contributory factors. A higher in increase well beyond the report result may affect aquatic and plant life. There may be the tendency for water to flow from the plant roof within the context region of the ground water back into the soil resulting in dehydration of the plant. The consequent economic effect will be better imagined.

5. Conclusion

This research work carried out in three towns of Isiokpo, Igwuruta and Omagwa in Greater Port Harcourt City development of Rivers State which span across eight L.G. A has shown the desirability of Borehole water against other sources of water in the three towns and twenty water points under focus. Given the number of L. G. A in GPHCDA, more studies must be carried out to examine the nature of water in other areas including the re-examination of *the already studied areas due to development impacts.*

6. National and International Standards

National and international standards adopted from (Ogwe et al 2014, Subin et al, 2012) are presented in the table below:

Table 3: Some standards that are generally accepted

	WHO	BIS	EPA	N
PH	6.5	6.5-8.5	6.5-8.5	6.5-8.5
Colour (Hu)	6		15	
Total Dissolved Solid (TDS)(mg/L)	500	500	500	500
Total Hardness	500	300	500	
Ca^{2+} Hardness (mg/L)	75	75	65	
Mg^{2+} Hardness (mg/L)	30	30-100	50	
Iron (mg/L)	0.3	0.3	0.3	0.3
Electrical Conductivity us/cm)	A/S	A/S	1000	1000

Terms
ALT – Altitude **LAT** – Latitude
LONG - Longitude **BW** – Borehole Water
WW -Well Water **SW** - Stream Water
RW -Pond Water **PW** - Pond Water
IG – Igwuruta **I** – Isiokpo
O – Omagwa

References

[1] Anyalebechi, O. Abbey, T.M. and Akonye, L.A. (2007): Spread of Composite Pollutants in Shallow Waters of the Niger Delta. Journal of Applied Science and Environmental Management (2007), Vol. 11(2) 5-11.
[2] Ayindin A. (2007) The Microbiological and Physcio-chemical quality of ground water in West in West Threce, Turkey, Polish J. Environ. Stud; 16(3), 377-383
[3] Bernard, E. and Ayeni, N. (2017): Physico-Chemical Analysis of Groundwater Samples Bichi Local Government Area of Kano State of Nigeria. ARFN, Science Technology; 2:2225-7212.
[4] Cohen, J.M, Lamphake I.J, Harris E.K, Woodward R.L in drinking water, J.AM. water works Assoc, 52, 660 (1960).
[5] Diliman, E, Gale, C., Green, W.E., Johnson, D.G., Mackler, B and Finch C; Hypothermia in iron deficiency due to altered triiodo-thyronine metabolism, AM. J of physiol. 2 (1987)
[6] Hijare, M.S. (2008): Seasonal Variation of Physico-Chemical Parameters in the Perennial Tank of Talsande, Maharashtra. Ecotoxicol Environ. Monitor, 18(3): 233-242.
[7] Kerketta, P. Bxia, S.L. Gora, R.H. Kumari, S. and Roushan, R.K. (2003): Analysis of Physico-Chemical Properties and Heavy Metals in Drinking Water from Different Sources in and Around Ranchi, Sharkland, India: Vetworld 6(7); 370-375, doi: 10.5455/Vetworld.
[8] Mahajan S.V, Savita Khare, Shrivastava V.S, (2005) A Correlation and Regression Study, Indian J. Environ protect 25(3), 254 – 259.
[9] National Population Commission of Nigeria (2006) Census figure for GPHCDA L.G. As of Rivers State Nigeria.
[10] Ogwo, P.A. Okoronkwo, C.U. Okereke, V.E. and Udensi, E.A. (2014): Evaluation of Igwi-Stream in Abia State University, Utune, Abia State, Nigeria. 10SR: Journal of Environmental Science, Toxicology and Food Technology (10SR-JESTFT); Vol. 8, issue 7, Ver 111, pp 54-57.
[11] Ojo, O.I. Otieno, F.A. and Ochieng, G.M. (2012): Ground Water. Characteristics, Qualities, Pollutions and Treatment: An Overview. International Journal of Water

Resources and Environmental Engineering, Vol. 4(6) pp 162-170.

[12] Oluyemi, E.A. Adekunle, A.S. Adenuga, A.A. and Makinde, W.O. (2010): Physico-Chemical Properties and Heavy Metal Content of Water Sources in Ie North Local Government Area of Osun State, Nigeria; African Journal of Environmental Science and Technology 4(10): 691-197.

[13] Schoonover, J.E., Lockaby, B.G. and Pan, S. (2005): Changes in Chemical and Physical Properties of Stream Water Across an Urban-Rural Gradient in Western Georgia. Urban Ecosystem, 8: 107-124 2005 (c) 2005 Springer Science + Business Media.

[14] Soronnadi-Ononiwu, C.G. Omoboriowo, A.O. and Alozie B.E. (2012): Quality Status of Groundwater in Igwunita Area, Ikwerre L.G.A, Rivers State, Nigeria. International Journal of Earth Science and Engineering; ISSN 0974-5904, Vol. 05, No. 04.

[15] Stumm, W and Morgan, J.J. (1981) Aquatic Chemistry 2nd Edition, New York, NY: Wiley-interScience.

[16] Tihansky D.P, Economic damages from residential use of Mineralized water supply, water Resource. Res; 10 (2), 145