



## RESEARCH ARTICLE

## PHYSICOCHEMICAL ANALYSIS OF SAMPLES OF WATER FOR DRINKING AND SANITARY PURPOSES IN SELECTED SCHOOLS IN PARTS OF RIVERS STATE, NIGERIA

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## ARTICLE DETAILS

## Article History:

Received 26 August 2022  
Accepted 28 September 2022  
Available online 07 October 2022

## ABSTRACT

The quality of water depends on the physicochemical and microbial characteristics. This study was carried out to analyze the quality of water for drinking and sanitary purposes in selected schools in part of Rivers State, Nigeria and was carried out using 30 water samples from 30 different schools selected randomly. Parameters analyzed include potency of hydrogen ( $P^H$ ), electrical conductivity (EC), turbidity, salinity, total dissolved solids (TDS), concentration of nitrate, sulphate, chloride, magnesium, calcium and some heavy metals: iron, copper, zinc, lead and manganese. The results obtained were compared with standards prescribed by World Health Organization (WHO) and Standard Organization of Nigeria (SON), the  $P^H$  values range between 3.78 and 7.72 for the water samples, thus are said to be acidic and not good for drinking, salinity values range from 0.018 – 0.202mg/l which makes the water very suitable for sanitary purposes and electrical conductivity values range from 38.8 – 378.7 $\mu$ S/cm. Other physiochemical parameters analyzed are within WHO and SON standard for drinking water except for magnesium for which 67% of the samples have elevated values ranging from 0.27 – 3.38mg/l, above the allowable limit stipulated by WHO and SON. All heavy metals present in the water samples are within the WHO and SON limits, making the water virtually free from dangers to the human body posed by the presence of heavy metals. The knowledge from this study can be applicable in water resources, environmental and health management as well as in hydrological activities.

## KEYWORDS

Turbidity, Salinity, Electrical Conductivity, Potency, Sulphate

## 1. INTRODUCTION

Water is extremely essential for the survival of living organisms and the quality of water is of great concern to mankind since it is directly linked with human welfare. Majority of the populace depend on groundwater as their source of drinking water supply. Groundwater is believed to be comparatively much clean and free from pollution than surface water. But prolonged discharge of industrial effluents, domestic sewage and solid waste dumps cause groundwater to become polluted and pose health problems (Raja *et al.*, 2002).

Water is the world's most abundant naturally occurring substance and it is in constant circulation. Without water, life cannot survive, it is absolutely essential to life, not only human but all life, plants and animals (Hussein *et al.*, 2012). Among the various natural resources, water is an essential input for all social, economic and developmental activities. The status of water resource is related to the type of soil, vegetation cover, human activities and utilization pattern. Water is the only chemical compound on the planet earth that exists in solid, liquid and gaseous state (Chavan and Zambare, 2013). Rainfall is the principal source of groundwater recharge, other sources include recharge from rivers, streams, irrigation water etc.

These are basic things that a good number of people take for granted. Every child has the right to be in a school that has safe drinking water,

healthy, sanitary and hygienic environment. Improved water supply reduces diarrhea morbidity by twenty-five percent and improvement in drinking water through proper storage in the home and chlorination reduces diarrhea episodes by thirty-nine percent (WHO, 2009).

## 2. GEOLOGY OF THE STUDY AREA

This study was carried out in parts of Rivers State. The study area covers 260km<sup>2</sup>, as at the year 2020, population was of 2667,435 persons (National Bureau of Statistics, 2021). The area is located in the south-south region of Nigeria as shown in Figure 1. It is located between Latitudes 4<sup>o</sup>45'E - 4<sup>o</sup>60'E and Longitudes 6<sup>o</sup>50'E - 8<sup>o</sup>00'E (Wokocha and Omenihu, 2015). Water samples were collected from 30 schools randomly selected across Rivers State.

The geology of the study area is typical of the geology of Niger Delta. The Niger Delta is one of the world's largest wetlands with a total land area of approximately 29,000km<sup>2</sup>, excluding the continental shelf (Niger Delta Environmental Survey, 1997). The Niger Delta lies within the lower reaches of the Niger River, extending between Latitudes 4<sup>o</sup> and 7<sup>o</sup>N and Longitudes 3<sup>o</sup> and 9<sup>o</sup>E within the semi-equatorial region of the tropics. The Delta is among the 10 largest in the world, with a coastline of about 450 km which ends at Imo river entrance. The region encompasses an area of 20,000 km<sup>2</sup> and is the largest delta in Africa and the world's third largest (Uluocha and Okeke, 2004). About 2,370 km<sup>2</sup> of the Niger Delta area

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DOI:  
10.26480/ecr.02.2022.72.77

consists of rivers, creeks, estuaries and stagnant swamps. Approximately 50% of the Delta is covered with water accounting for 55% of all freshwater swamps in Nigeria (Ikelegbe, 2006). The Delta mangrove swamp spans about 1900 km<sup>2</sup> as the largest mangrove swamp in Africa and about one third of the Delta consists of wetlands. This system of wetlands was formed by the accumulation of sedimentary deposits, transported by rivers Benue and Niger (World Bank, 1995) and is considered one of the 10 most important wetlands and marine ecosystems in the world (Uluocha and Okeke, 2004).

The present knowledge of the geology of the Niger Delta was documented by several researchers (Allen, 1965; Reymen, 1965; Short and Stauble, 1967; Murat, 1972 and Weber and Dauoru, 1975). They gave both structural and stratigraphic frameworks for the evolution of the delta basin.

(Short and Stauble, 1967) described the three formations that make up the Niger Delta sedimentary region (in order of decreasing age) as Akata (Paleocene), Agbada (Eocene) and Benin (Miocene - Recent). Table 1 shows the various geomorphic units that underlie the subsurface geology of the Niger Delta.

### 2.1 Akata Formation

The Akata Formation is the basal major time-transgressive lithological unit in the Niger Delta. It consists mainly of marine shales with sandy and silty intervals thought to have been laid down as turbidity and continental slope channel fills. The shales are typically under-compacted and over pressured forming diapiric structures. The rich assemblage of planktonic foraminifera found in Akata Formation indicates deposition on shallow marine shelf environment (Whiteman, 1982). Total thickness of the Formation is not known but may not be less than 1,380m thick while the age ranges from Palaeocene to Recent. It represents the pro-delta megafacies of the deltaic sequence.

### 2.2 Agbada Formation

The Eocene to Recent Agbada Formation is essentially a cyclic succession of poorly consolidated, porous, permeable and friable sandstones and shales representing paralic deposits of the delta front megafacies. The maximum penetrated thickness of this unit is over 9000m. The characteristic features of the sandstones here are poor sorting, calcareous matrix and occurrence of shell fragments. The top of the formation is

sandy whereas the bottom is shaley because it gradually grades into the shaley Akata Formation at the base. The shales are denser at the base due to compaction process. While the sandy parts constitute the hydrocarbon reservoir, the shales form the cap rock. The Agbada Formation contains numerous growth faults with the associated development of rollover anticlines and constitutes about 90% of the petroleum reservoir rocks in the Niger Delta. The scramble for the Niger delta by oil majors represents a scramble for Agbada Formation. The surface outcrop equivalents of the Agbada Formation include the Ameki Formation and Nanka Sands in the east and the Ilaro and Oshoshun Formations in the west.

### 2.3 Benin Formation

The Benin Formation overlies the Agbada Formation conformably and comprises mainly loose unconsolidated fine to very coarse sands with pebbly and lignite horizons. Clay beds are often interbedded. These deposits are predominantly continental in origin and represent delta plain megafacies. The formation is made up of mainly freshwater continental, sands and gravels characterized with excellent aquifer properties with occasional intercalations of stones and clay stones (Olobaniyi and Owoyemi, 2006). Rain water, through direct precipitation where rainfall is as high as 2000-2400mm, infiltrates through highly permeable sands of the Benin formation to recharge the aquifers (Etu-Efeotor, 1981; Etu-Efeotor and Akpokodje 1990; Udom et al., 1999). The sandy clay layers, occurring in lenses 3 to 10 meters thick, constitute a system that is separated by aquitards which gives rise to a multi-aquifer system which characterizes the Niger Delta (Etu-Efeotor and Odigi, 2001). The Formation is recognized throughout the delta due to its few shale streaks, absence of brackish water and high percentage of sand. The maximum thickness is at the central part of the delta at 6000m. Geometrically, it is 'lens shaped', coinciding with the axis of maximum thickness of development. Surface outcrop equivalents of the Formation include the Coastal Plain Sands, the Ogwashi-Asaba and Ijebu Formations. The coarse texture of the sediments combines with high interconnectivity and large outcrop area to make the aquifers of the Benin Formation very prolific. Typically, the unit is covered by lateralized reddish brown sandy clay soil whose average thickness varies from 12m in the northern part of the study area, decreasing gradually towards the south to zero in the mangrove swamp areas where they grade into freshwater and brackish water clays. Generally, the aquifers have a south-west gradient towards the coast and thicken seawards in the same direction as groundwater movement. Potable groundwater is commonly abstracted from the upper part of this unit between a depth range of 15 to 150m.

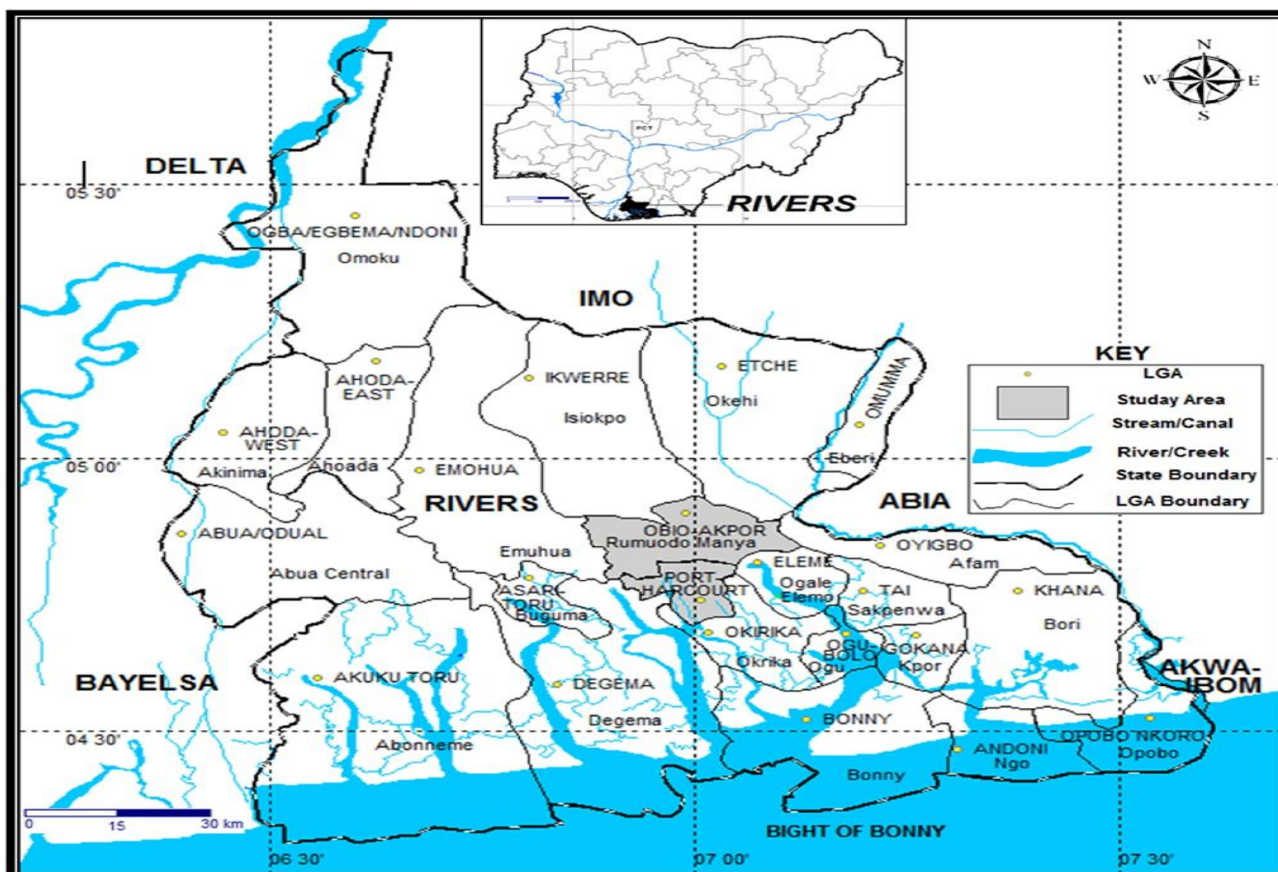


Figure 1: Map Showing the Study Area

**Table 1:** Various Geomorphic Units Overlying the Subsurface Geology of the Niger Delta.

Geological	Lithology	Age
Freshwater/back-swamp, Meander belt	Sand, clay, some silt gravel	
Mangrove and salt water/back-swamps	Medium-fine sands, clay and some silt	Quaternary
Active/abandoned beach ridges	Sand, clay and some silt	
Sombreiro-Warri deltaic plan	Sand, clay, and some silt	
Benin Formation (Coastal Plan Sand)	Coarse to medium sand with subordinate silt and clay lenses	Miocene
Agbada Formation	Mixture of sand, clay and silt	Eocene
Akata Formation	Clay	Paleocene

### 3. MATERIALS AND METHOD

The materials used for this study are water samples, one liter white plastic canes, P<sup>H</sup> meter, turbidity meter, mercury in glass thermometer, conductivity meter, Global Positioning System (GPS), Iced-pack coolers, glass laboratory bottles, notebook and pen and Atomic Absorption Spectrophotometer (AAS).

#### 3.1 Preparation of Water Samples

Water samples were collected from water borehole tanks from 30 different secondary schools, randomly selected from schools in Rivers State using small white canes of one liter capacity, and sterilized glass bottles. These bottles were first washed using laboratory grade detergent and rinsed with the appropriate solvent to avoid contamination by any physical or chemical means. The collected borehole water samples were then labeled immediately on the field using appropriate codes and transferred into sterile ice-packed coolers.

#### 3.2 Laboratory Process

To ensure accurate analysis of the physicochemical parameters, temperature of the samples were measured at the point of collection of samples. The samples were then taken to the Institute of Pollution Studies Laboratory at the Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, for physicochemical analysis.

#### 3.3 Sample Storage

Ice-packed coolers were used to store and preserve the water samples collected in accordance with Standard Guidelines. Samples for metal analysis were collected in plastic containers in order to prevent loss by adsorption or ion-exchange with walls of glass containers. The containers for metals were acidified with Nitric acid to a pH below 2.0, to prevent any physicochemical reaction (Ubong and Gobo, 2001).

#### 3.4 Physicochemical Analysis

Analysis was carried out for various water quality parameters in the laboratory in less than 48 hours of sampling, using the World Health Organization (WHO) and Standard Organization of Nigeria (SON) standard method (APHA, 1995).

Physicochemical parameters examined include potency of hydrogen (P<sup>H</sup>), salinity, electrical conductivity (EC), turbidity, temperature, total dissolved solids (TDS), concentration of nitrate, sulphate, chloride, magnesium, calcium and some heavy metals: iron, copper, zinc, lead, manganese etc.

### 4. RESULTS AND DISCUSSION

The values of the physicochemical parameters obtained from the laboratory analysis of the water samples are shown in Tables 2 and 3.

#### 4.1 Potency of Hydrogen (P<sup>H</sup>)

Potency of hydrogen (P<sup>H</sup>) defines intensity of acidity or alkalinity of a solution. It controls the chemical state of many nutrients, including dissolved oxygen, phosphate, nitrate etc (De, 2002). All the water samples are acidic in nature, having P<sup>H</sup> value range between 3.78 and 7.72. This is as a due to the presence of chemical or heavy metal pollution resulting from industrial activities within the area, chemical dumps, power plants and leaching. Although, the World Health Organization (WHO) and

Standard Organization of Nigeria (SON) recommend that the desirable and healthy P<sup>H</sup> value for drinking water range is between 6.5 to 8.5. Water sample at sample 11 recorded the highest P<sup>H</sup> value of 7.72, whereas sample 4 recorded the least P<sup>H</sup> value of 3.78.

#### 4.2 Electrical Conductivity

Electrical Conductivity is a measure of the ability of the water to conduct electricity or allow the passage of electrical current. It signifies the total number of dissolved salts in water. The values of electrical conductivity range from 38.3 to 378.7µS/cm. Sample 4 recorded the highest electrical conductivity of 378.7µS/cm whereas the lowest value was recorded from sample 10 with a value of 38.3µS/cm.

#### 4.3 Salinity

This indicates the amount of salt in water, the salinity for the water samples from all the schools ranged from 0.018 – 0.202mg/l. Water sample 4 recorded the highest, with salinity value of 0.202mg/l, while samples 10 and 17 recorded the lowest, with equal salinity value of 0.018mg/l.

#### 4.4 Turbidity

The turbidity value for the water samples ranged from 0.2NTU – 1.1NTU. Sample 6 recorded the highest turbidity of 1.1NTU while sample 10 recorded the lowest with a value of 0.2NTU.

#### 4.5 Total Dissolved Solids (TDS)

The value of the total dissolved solids concentration in the water samples from the schools range from 26.7mg/l – 263.0mg/l. The highest concentration or value of TDS of 263.0mg/l was recorded at sample 4 while the least concentration of TDS of 26.7mg/l was recorded with sample 17.

#### 4.6 Nitrate

The nitrate concentration value in the water samples ranges between 0.02mg/l and 3.00mg/l. The highest value of 3.00mg/l was recorded from sample 8 whereas the lowest value of 0.02mg/l was recorded with sample 6.

#### 4.7 Sulphate

The sulphate concentration of the water samples ranges from <1.0mg/l – 17.2mg/l. Sample 4 recorded the highest sulphate concentration of 17.2mg/l, while sample 1, sample 5, samples 7-20 and samples 22-27 recorded the least concentration of less than 1.0mg/l.

#### 4.8 Chloride

The chloride concentration of the water samples ranges from <1.0mg/l – 24.0mg/l. Sample 4 recorded the highest value of chloride concentration of 24.0mg/l while the lowest value was observed in samples 9, 10, 11 and 15 with a value of less than 1.0mg/l.

#### 4.9 Magnesium

The values of magnesium concentration in the water samples range from 0.05mg/l – 3.38mg/l. Sample 19 recorded the highest value of magnesium concentration of 3.38mg/l while the lowest value of 0.005mg/l was recorded at sample 17.

#### 4.10 Calcium (Ca)

The values of the concentration of calcium in the water samples range between <0.20 and 11.83mg/l. Highest value of 11.83mg/l for the concentration of calcium was recorded at sample 4 while the lowest value of <0.20mg/l was recorded at samples 10, 15 and 21.

#### 4.11 Iron (Fe)

The values of the concentration of iron in the water samples range from <0.005 – 0.043mg/l. The highest iron concentration was recorded at sample 28 with a value of 0.043mg/l, while the lowest was recorded at samples 1-3, 9, 11-12, 14, 17-18, 20, 22-25, with values less than 0.005mg/l.

#### 4.12 Copper (Cu)

The values of copper concentration in the water samples range from <0.001mg/l – 0.063mg/l. The highest copper concentration was recorded at sample 15 with a value of 0.063mg/l, while the lowest was recorded at samples 1-4, 6-7, 9-14, 16 and 19, with a value of less than 0.001mg/l.

#### 4.13 Zinc (Zn)

The zinc concentration in the water samples ranges from <0.001mg/l – 0.040mg/l. The highest zinc concentration was recorded at Government Comprehensive Secondary School, Borokiri (sample 1) with a value of 0.040mg/l, while the lowest zinc concentration values of less than 0.001mg/l were recorded samples 3-4, 6-24 and 26-30.

#### 4.14 Lead (Pb)

The lead concentration in the water samples range from <0.010mg/l – 0.423mg/l. The highest copper concentration was recorded at sample 13 with a value of 0.423mg/l, while the lowest concentration was recorded at samples 1-2, 15-16 and 28-29 with a value of less than 0.010mg/l.

#### 4.15 Manganese (Mn)

The concentration of manganese in the water samples ranges from 0.001mg/l – 0.607mg/l. The highest manganese concentration was recorded at sample 29 with a value of 0.607mg/l, while the lowest was recorded at sample 9, with a value of 0.001mg/l.

**Table 2:** Physicochemical Parameters of Borehole Water Samples from Selected Schools in Rivers State.

Sample Code	P <sup>H</sup>	Temp <sup>t</sup> . °C	EC µS/cm	Salinity ‰	Turbidity NTU	TDS mg/l	NO <sub>3</sub> - mg/l	SO <sub>4</sub> -2 mg/l	Cl- mg/l	Ca <sup>2+</sup> mg/l
Sample 1	6.67	29.4	230.7	0.111	0.9	164.7	1.90	<1.0	11.4	5.07
Sample 2	5.41	29.6	194.3	0.091	0.5	135.3	2.24	4.1	16.3	5.38
Sample 3	4.08	29.5	266.3	0.125	0.3	185.7	2.24	4.5	12.8	3.12
Sample 4	3.78	29.4	378.7	0.202	0.5	263.0	2.82	17.2	24.0	9.83
Sample 5	4.66	29.6	210.3	0.100	0.3	146.7	2.69	<1.0	9.5	5.61
Sample 6	3.87	29.7	322.7	0.152	0.3	225.0	2.86	3.5	15.2	0.81
Sample 7	6.62	29.7	92.7	0.043	0.5	64.3	1.95	<1.0	5.3	0.13
Sample 8	4.52	29.8	199.3	0.093	0.3	139.7	3.00	<1.0	9.3	3.79
Sample 9	6.87	30.4	47.0	0.022	0.3	32.7	0.47	<1.0	0.4	0.43
Sample 10	6.85	30.3	38.3	0.018	0.2	27.3	0.56	<1.0	1.0	0.27
Sample 11	5.94	30.4	92.7	0.043	0.3	65.3	2.39	<1.0	3.3	0.26
Sample 12	4.59	30.4	155.7	0.074	0.2	109	2.85	<1.0	6.8	4.32
Sample 13	4.62	30.4	237.0	0.111	0.3	165.3	2.61	<1.0	20.7	1.09
Sample 14	4.39	30.4	289.3	0.136	0.3	202.7	2.89	<1.0	23.5	0.42
Sample 15	4.63	30.6	177.0	0.083	0.2	123.7	2.66	<1.0	9.6	1.25
Sample 16	4.73	30.5	150.0	0.077	0.3	114	0.82	<1.0	6.5	1.46
Sample 17	5.63	30.4	38.0	0.018	0.3	26.7	0.56	<1.0	1.4	0.22
Sample 18	5.47	30.4	48.0	0.023	0.3	34	0.59	<1.0	1.1	0.09
Sample 19	7.23	30.4	325.3	0.153	0.4	226.7	0.91	<1.0	17.9	10.12
Sample 20	7.18	30.5	112.0	0.052	0.3	77.7	0.75	<1.0	6.6	1.47
Sample 21	7.07	30.3	163.3	0.077	0.3	115	0.52	1.7	11.4	<0.02
Sample 22	5.27	29.5	132.3	0.062	0.7	93	0.50	<1.0	10.4	0.51
Sample 23	5.59	29.5	98.7	0.046	0.3	66.7	0.72	<1.0	4.9	0.60
Sample 24	6.24	29.5	53.7	0.025	0.4	37.7	0.61	<1.0	1.6	0.33
Sample 25	7.24	29.7	60.0	0.029	0.4	42	0.16	<1.0	1.0	0.20
Sample 26	4.87	29.8	133.3	0.064	0.2	93.3	0.64	<1.0	7.1	0.38
Sample 27	4.51	30.0	229.7	0.108	0.3	161	0.79	<1.0	9.9	1.75
Sample 28	5.28	29.7	123.7	0.059	0.3	87.7	0.57	1.0	5.1	0.02
Sample 29	5.01	29.6	161.7	0.078	0.4	114	0.73	0.5	7.7	0.02
Sample 30	5.50	29.6	107.0	0.050	0.2	74.7	0.75	0.3	3.5	0.23

**Table 3: Heavy Metal Parameters of Borehole Water Samples from Selected Schools in Rivers State.**

	<b>Mg</b>	<b>Cu</b>	<b>Fe</b>	<b>Mn</b>	<b>Pb</b>	<b>Zn</b>
<b>Sample codes</b>	<b>mg/l</b>	<b>mg/l</b>	<b>mg/l</b>	<b>mg/l</b>	<b>mg/l</b>	<b>mg/l</b>
Sample 1	0.19	<0.001	<0.005	0.013	<0.010	0.040
Sample 2	1.68	<0.001	<0.005	0.038	<0.010	0.022
Sample 3	0.91	<0.001	<0.005	0.105	0.186	<0.001
Sample 4	2.70	<0.001	0.008	0.101	0.183	<0.001
Sample 5	1.32	0.045	0.032	0.231	0.191	0.155
Sample 6	0.96	<0.001	0.039	0.201	0.100	<0.001
Sample 7	1.14	<0.001	0.018	0.035	0.067	<0.001
Sample 8	1.41	0.010	0.004	0.219	0.024	<0.001
Sample 9	0.13	<0.001	<0.005	0.001	0.024	<0.001
Sample 10	0.13	<0.001	0.012	0.021	0.021	<0.001
Sample 11	0.33	<0.001	<0.005	0.042	0.014	<0.001
Sample 12	0.97	<0.001	<0.005	0.183	0.141	<0.001
Sample 13	1.38	<0.001	0.013	0.126	0.423	<0.001
Sample 14	1.01	<0.001	<0.005	0.106	0.021	<0.001
Sample 15	0.65	0.013	0.010	0.072	<0.010	<0.001
Sample 16	0.54	<0.001	0.014	0.048	<0.010	<0.001
Sample 17	0.05	0.026	<0.005	0.026	0.069	<0.001
Sample 18	0.17	0.012	<0.005	0.028	0.057	<0.001
Sample 19	3.38	<0.001	0.018	0.516	0.043	<0.001
Sample 20	0.46	0.020	<0.005	0.025	0.138	<0.001
Sample 21	0.16	0.003	0.011	0.094	0.124	<0.001
Sample 22	0.62	0.018	<0.005	0.058	0.026	<0.001
Sample 23	0.27	0.026	<0.005	0.066	0.107	<0.001
Sample 24	0.10	0.032	<0.005	0.031	0.184	<0.001
Sample 25	0.11	0.038	<0.005	0.028	0.115	0.034
Sample 26	0.49	0.029	0.014	0.088	0.155	<0.001
Sample 27	0.94	0.026	0.016	0.164	0.210	0.000
Sample 28	0.34	0.018	0.043	0.083	<0.010	<0.001
Sample 29	1.42	0.016	0.011	0.607	<0.010	<0.001
Sample 30	0.15	0.031	0.011	0.047	0.057	<0.001

## 5. CONCLUSION

After successful analysis of the water samples, the following conclusions are drawn from this research:

- From the recorded P<sup>H</sup> range of 3.78 - 7.72, 60% of the water samples showed that the drinking water in some secondary schools is acidic and well below the stipulated range of 6.5 - 8.5.
- The water samples are generally good for sanitary purposes due to the salinity values range between 0.018mg/l and 0.202mg/l.
- Electrical conductivity values in all the boreholes were within allowable limits of 1000µS/cm (SON, 2007).
- Turbidity values ranging from 0.2NTU - 1.1NTU show that the water samples have characteristics of transparency and being colorless and are all within limits of 5.0NTU prescribed by Standard Organization of Nigeria [27].
- Magnesium (Mg<sup>2+</sup>) concentration values ranging from 0.05mg/l - 3.38mg/l show that about 33% of the water samples met the 0.20 mg/l limit by [27] and 67% have elevated values that ranged from 0.27 - 3.38mg/l, above (up to 12 times) the allowable limit.
- Calcium (Ca<sup>2+</sup>) concentration values recorded are within allowable limits of 100mg/l, with a range of <0.20 - 11.83mg/l.

## ACKNOWLEDGMENT

The authors are grateful to God for the grace and wisdom to successfully complete this study, we are also grateful to the director and management

of Institute of Geosciences and Environmental Management (IGEM) of Rivers State University, Port Harcourt for the assistance received. We also express our sincere gratitude to the Lab Technician at the Institute of Pollution Studies.

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