

SOURCES AND POTABILITY OF DRINKING WATER IN NURSERY AND PRIMARY SCHOOLS IN OBIO-AKPOR LOCAL GOVERNMENT AREA, RIVERS STATE, NIGERIA

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Abstract

The paper describes an effort to identify the sources and assess the potability of water consumed by pupils in Nursery and Primary schools in Obio/Akpor Local Government Area of Rivers State, Nigeria. The study became necessary since infants are 70% - 80% water and hence the quality of water ingested by pupils plays significant role in their health and wellbeing. Moreover, establishing and running private Nursery and Secondary schools have become a big business not only in Rivers state but throughout Nigeria due mainly to high rate of return on investments in schools. The study showed that water supply for all the schools come from shallow boreholes haphazardly located anywhere on the school premises. Some are located only a few meters away from the septic tanks. Water samples were collected from 17 boreholes in 17 schools located strategically in the 17 wards of Obio-Akpor L.G.A, and analysed for physico-chemical and microbiological characteristics as well as heavy metal concentration using standard methods. The results were compared with the Standard Organisation of Nigeria (SON) and World Health Organisation (WHO) standards for drinking water supply. The study showed that 81% of the parameters studied per sample occurred in acceptable concentration on both WHO and NSO standards for safe drinking water. However, 19% of the parameters namely: pH, alkalinity, iron, magnesium and Total Heterotrophic Bacteria (THB) occur in objectionable concentrations in most of the samples. Magnesium (Mg^{2+}) occurred in excessive concentration (0.4mg/l – 1.8mg/l) in 65% of the samples. This value is 2 -9 times higher than SON (2007) limit of 0.2mg/l. However, Mg^{2+} was not detected in 35% of the samples. Fe occurred in excessive concentration in 17.6% of the samples and within limits of acceptability in 82.4% of the water samples. Total Heterotrophic Bacteria was high in 41.2% of boreholes while 58.8% of the boreholes had THB within the guideline maximum limit of 10cfu/ml. pH is within acceptable limit in only 6% of the borehole water samples while 94% of the samples showed mild to highly acidic water. The low value of alkalinity (0 -6 mg/l) tend to agree with the acidic nature of the water. This result shows how detrimental the available drinking water is to the health of pupils in the study area. It is concluded that groundwater which forms the only source of water supply to schools in the study area is not, in its untreated form potable. The high acidity and high THB counts renders it unfit for drinking unless treated. Until a treatment system is installed and commissioned, it is strongly recommended that parents equip their wards with larger water containers to take potable water from homes to schools. Schools management should also put up bold inscription by the water taps discouraging innocent pupils from ingesting dilute to strong acid in the name of water.

INTRODUCTION

Water is essential for life and is a resource that is invaluable to the existence of all living organisms. The amount of drinking water required for human beings varies depending on physical activity, age, health condition of the individuals and some environmental conditions such as climate. In the United States, the average daily drinking water requirement is about one

litre with 95 % drinking less than three liters per day. Those working in exceptionally hot climate, drink up to 16 liters a day (National Centre for Environmental Assessment, 2011). Water makes up about 60 % of weight in men and 55 % in women (Miller, 2006). Infants are about 70 % - 80 % water while the elderly are around 45 % (Jones and Bartlett, 2012). That water constitutes a large portion of the weight of

human beings makes it imperative to monitor the quality of water ingested by human beings. In 60 countries in the developing world, over half of the primary schools have inadequate water supply facilities and almost two thirds invariably lack adequate sanitation, (United Nations Children's Fund and partners, 2010).

Schools, particularly those in rural areas, often completely lack potable water and sanitation facilities, or have facilities that are inadequate in both quality and quantity. Schools with poor drinking water, sanitation and hygiene conditions, and intense levels of person-to-person contact are high-risk environments for children, and exacerbate children's particular susceptibility to environmental health hazard (WHO, 2004b). Diseases related to unsafe drinking water, sanitation and hygiene are a huge burden in developing countries (Adams *et al.*, 2009). It is estimated that 88 % of diarrheal disease is caused by unsafe drinking water supply, and inadequate sanitation and hygiene (WHO, 2004c). Many schools serve communities that have a high prevalence of diseases related to unsafe drinking water supply, (Adams *et al.*, 2009).

Unsafe water, inadequate sanitation and lack of hygiene not only affect the health, safety and quality of life of children, they also claim lives of an estimated 1.5 million children under the age of five who die each year from diarrhea (WHO, 2009). Children's ability to learn may be affected in several ways. Firstly, helminth infections, which affect hundreds of millions of school-age children, can impair children's physical development and reduce their cognitive

development, through pain and discomfort, competition for nutrients, anaemia, and damage to tissues and organs (WHO, 2009). Long-term exposure to chemical contaminants in water (for example, lead) may impair learning ability. Diarrheal diseases can force many school children to be absent from school. The effect of disease in teachers, impairing performance and increasing absenteeism, also has a direct impact on learning, and teachers' work is made harder by the learning difficulties faced by school children (WHO, 2004b).

Providing pupils with access to safe, free drinking water throughout the school day is one strategy nursery and primary schools can use to create an enabling environment that supports good health and sound learning. Potable drinking water can contribute to good health, and schools are in a unique position to promote healthy dietary behaviors. Healthy and calorie free, water is the perfect hydrating beverage and an ideal alternative to sugary drinks. Also, adequate hydration may improve cognitive function among children and adolescents, which is important for learning (Centre for Disease Control and Prevention, 2014).

In Rivers State as in other parts of Nigeria, starting and running private Nursery and Primary schools have become a big business mainly due to the large population and fast rate of return on such investments. Most of these schools do not have safe sources of drinking water supply UNICEF/IWSC (2007). Water supply for the schools come from shallow boreholes haphazardly located anywhere on the

school premises. Some are located a few meters away from the septic tanks. The health hazard implicit on this type of practice needs no emphasis. Even the Unity schools are not protected from health hazards arising from unsafe water supply. In March 2017, Queens College, Lagos, Nigeria was shut down indefinitely because of outbreak of water-borne disease which claimed the lives of two students with over 50 others admitted in the Intensive Care Unit (ICU) of University of Lagos Teaching Hospital. Analysis of the water samples revealed high bacteria content in the water in the school kitchen, the dining hall and in Queen's Delight, the schools water factory (Vanguard Newspaper, 2017).

Low access to safe water in Nigeria has been attributed to the enormous socio-economic development, poor planning, growing industrial base, haphazard implementation and insufficient funding, Oluwasanya (2009). In spite of the considerable investments of Nigerian Government in water supply programmes, over 52 % of its population has no access to potable water Oluwasnya (2009).

For not trusting the source and quality of drinking water in schools, most parents usually provide little amount of drinking water for their children, as most lunch boxes come in small sizes with water bottles to fit their lunch packs. However, pupils need enough water throughout the day, as they spend, at least, 6 hours in school daily. It has been observed that to satisfy their thirst, most children request for more water during and after lunch. They are compelled to either make do with the

little provided by their parents or drink from the school source of water, whose quality is often unknown even to the school authorities.

It is with the aim of identifying the sources and assessing portability of water consumed by pupils in Nursery and Primary schools that this research was undertaken in Obio/Akpor Local Government Area of Rivers State, Nigeria. The result will provide a planning input for education managers and planners, architects and urban planners, school boards and, Parents Teachers Associations of the schools.

The Study Area

The study was carried out in Obio-Akpor Local Government Area of Rivers State covering an area of about 260 Km² and holding a population of 464,789 persons (National Bureau on Statistics, 2006). It is located in the South-South geopolitical region of Nigeria (Niger Delta Region) and lies between latitudes 4°45' E and 4°60' E and longitudes 6°50' E and 8°00' E (Figure 1), (Wokocha and Omenihu, 2015).

Rainfall is high in the area (mean, 300 mm/yr). Evapotranspiration and Relative humidity are high and remain high all the year round. This is due, mainly, to the coastal nature of the area. Moderately high temperature (24 °C – 34.5 °C) and long periods of sunshine prevail. Human beings perspire profusely under the intense heat of the sun necessitating frequent desire for water to remain hydrated. The relief is generally low with average elevation between 20 m and 30 m above sea level

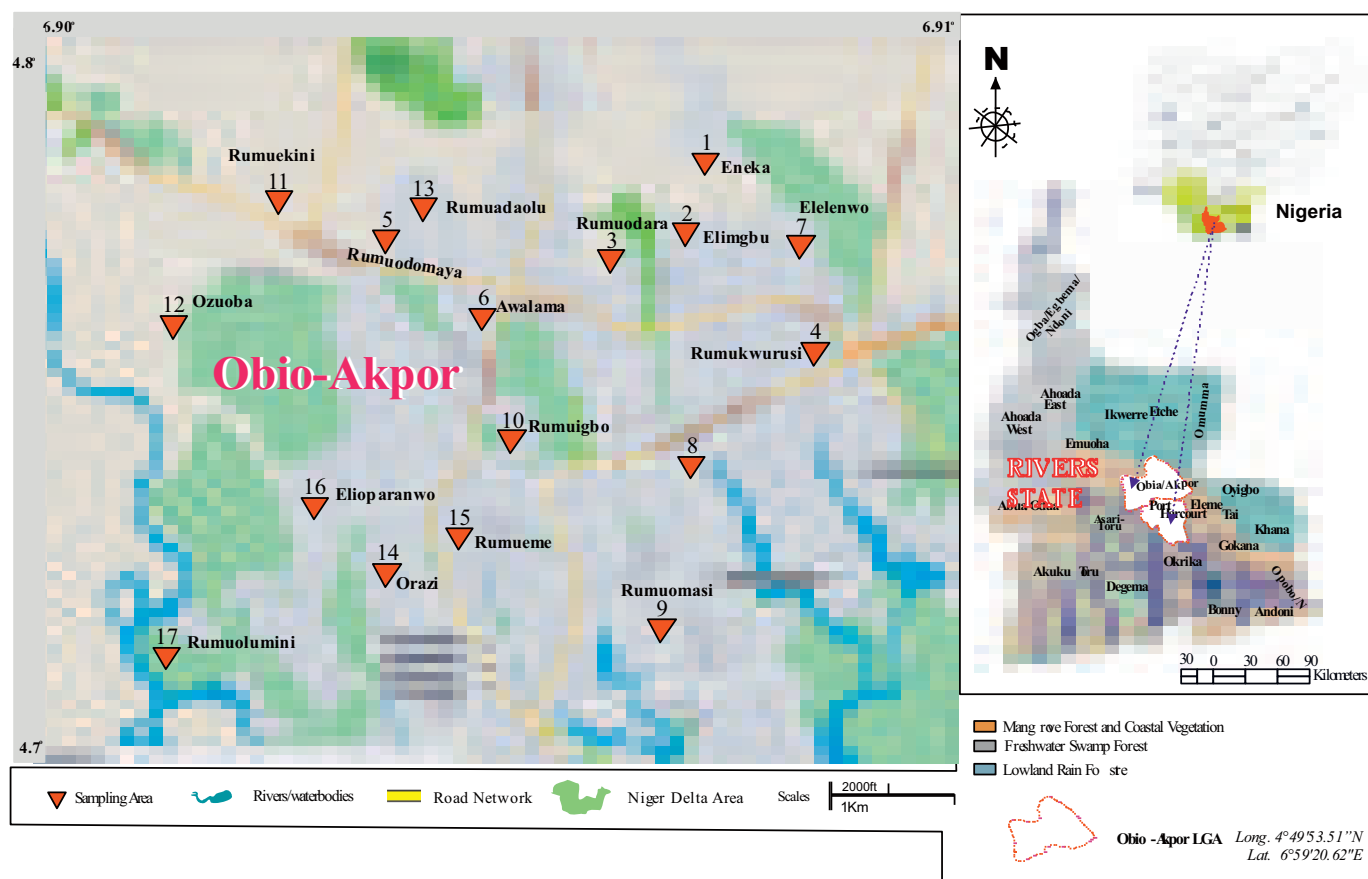


Figure 1. Map of Nigeria, showing Rivers State and the Location of the Study Area, (Adapted from Wokocha and Omenihu, 2015).

and gently sloping seaward (Wokocha and Omenihu, 2015).

The vegetation in the area includes raffia palms, secondary regrowth complexes and thick rain forest. The soil is usually sandy or sandy loam underlain by a layer impervious pan and is always leached due to the heavy rainfall. Overland flow is high due to continuous heavy rainfall and built-up nature of the area resulting in severe annual flooding.

The geology of the area is typical of the geology of Niger Delta with an overall sedimentary sequence which is dominantly composed of sand, clay and shale, with the sand forming the major aquifers in the area. Water table is shallow in most parts of the area, fluctuating between 5 m - 18 m (Ngah, 2009). Influent conditions between water

levels in the rivers and the shallow aquifers occur in some places in the dry season. The water level usually drops below the river water level, creating a head differential, which induces flow of river waters into the aquifers. The rivers, therefore, partly recharge the upper aquifers and may pollute them with dissolved toxic or hazardous materials (Ngah, 2009). The quaternary deposits obtain steady recharge by direct precipitation. The main body of groundwater in the Niger Delta is contained in the very thick and extensive sand and gravel aquifers. Three main zones have been differentiated. These are: a northern bordering zone consisting of shallow aquifers of predominantly continental materials and a coastal zone of intermixing

marine and continental deposits (Etu-Efeotor and Odigi 1983, Amajor, 1986, Etu-Efeotor and Akpokodje, 1990). The aquifers in the study area are more continental in character, being composed of river loads coming from the hinter lands. They are encountered at very shallow depths that shallow boreholes can be completed even at less than 20 m using manual drilling methods. All the schools obtain their water from this shallow aquifer.

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. Quaternary deposits comprising recent deltaic sediments made up of rapidly alternating sequences of sand, silt and clay/shale interbeds cover the Benin Formation in the swampy delta areas. Seawards, the silt/clay interbeds become increasingly more prominent than the sands. Thickness of the Quaternary deposits ranges between 40 m-150 m (Etu-Efeotor and Akpokodje, 1990).

Table 1: Geomorphic units overlying the subsurface geology of the Niger Delta

Geological Unit	Lithology	Age
Alluvium (general) 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 plain	Sand, clay, and some silt	
Benin Formation (Coastal Plain Sand)	Coarse to medium sand with subordinate silt and clay lenses. Fluvial marine.	Miocene
Agbada Formation	Mixture of sand, clay and silt, fluvial marine	Eocene
Akata Formation	Clay	Paleocene

Sources of Water Supply to the Schools

The main source of water supply to the schools in Port Harcourt and Obio Akpor LGAs is groundwater. Shallow, small diameter boreholes are often unprofessionally drilled into the first aquifer and completed with PVC pipes. A submersible pump is installed in the boreholes. The water in the borehole is pumped into an overhead storage via a conduit system, usually PVC pipe. The water in the overhead storage then flows to the taps and fetching points by gravity drainage via a network of PVC pipes. When the storage is depleted, more water is pumped into the tank. There is hardly any attempt to sterilize the storage or flow path. It was observed that most of the overhead tanks do not have cover and birds and rodents droppings usually find their way to the tanks. At times lizards and rats fall into the open, water-containing tanks, die and decay there. This same water will be discharged through the piping system and out from the taps from where pupils fetch it. The structural integrity of the tank support structure is another cause for worry as some tanks are seen standing on highly rusted and even bent stanchions.

Drinking Water Quality Parameters

Physical parameters affect the aesthetics and taste of the drinking water. Chemical parameters pose more of health risk through build-up of heavy metals although nitrates/nitrites have a more immediate impact (WHO, 2004). Physical and Chemical parameters include heavy metals, trace organic compounds, total

dissolved solids (TDS), turbidity, pH, salinity, among others. Apart from quality status inherent in the source and host rock, water being such a good solvent, readily dissolves objects on its flow path within the environment. The dissolved objects release cations and anions that react with existing ions in solution to further complicate the chemistry of the groundwater.

MATERIALS AND METHODS

Water samples were collected from 17 nursery and primary schools in the study area, one sample each from each of the wards that make up Obio-Akpor LGA, (Figure 1). A Global Positioning System was used to determine the coordinates of the sampled boreholes. Standard field methods (APHA, 1998) were applied for sample collection as ice-packed coolers were used for storing and conveying the samples to the laboratories of the Institute of Pollution Studies, Rivers State University and Rofnel Energy Services Limited, all in Port Harcourt; to ensure the integrity of the samples. pH, Electrical Conductivity, Dissolved Oxygen (DO), Turbidity and Total Dissolved Solids (TDS) were measured using HANNA range of in-situ meters while the physico-chemical, heavy metals and microbiology were determined in the laboratories.

Samples for heavy metal analysis were collected in plastic containers, as certain cations such as Zinc (Zn), Manganese (Mn), Cadmium (Cd), Copper (Cu), Iron (Fe), Sodium (Na), Potassium (K) and Lead (Pb) are subject to loss by adsorption or ion-exchange with walls of

Table 2: Location and Coordinates of Sampling points

School Ownership	School	Location	Borehole Code	Coordinates	Colour	Smell
Government	Community Primary School	Eneka	BH1	N04 53°53.3' E007 02°17.9'	Colourless	None
Government	State primary School	Elimgbu	BH2	N04 52°21.1' E007 03°15.0'	Colourless	None
Private	Princess International School	Rumuodara	BH3	N04 51°37.0' E007 01°48.8'	Colourless	None
Church	All saints Anglican School	Rumuokwurusi	BH4	N04 51°16.1' E007 06°22.6'	Colourless	None
Private	Benviatto School	Rumuodomaya	BH5	N04 51°12.2' E007 04°88.4'	Colourless	None
Church	Emmanuel Anglican School	Awalama	BH6	N04 51°33.8' E007 01°13.4'	Colourless	None
Private	Unibek School	Elelenwo	BH7	N04 50°55.0' E007 04°01.2'	Colourless	None
Private	Hallel College	Rumuogba	BH8	N04 50°45.3' E007 02°06.5'	Colourless	None
Church	St. Michaels Anglican School	Rumuomasi	BH9	N04 50°07.4' E007 01°31.4'	Colourless	None
Private	Haruk Group of Schools	Rumuigbo	BH10	N04 52°47.2' E006 56°26.8'	Colourless	None
Government	Community Primary School	Rumuekini	BH11	N04 83°79.5' E007 94°07.8'	Colourless	None
Private	Gafed School	Ozuoba	BH12	N04 52°18.9' E006 55°58.5'	Colourless	None
Private	Olivet Heights School	Rumuadaolu	BH13	N06 98°55.0' E004 84°95.0'	Colourless	None
Private	Gracefield International School	Oroazi/Eligbam	BH14	N06 98°55.2' E004 84°94.7'	Colourless	None
Church	St. John's Anglican School	Rumueme	BH15	N06 52°46.4' E004 42°33.9'	Colourless	None
Private	Divine Cephas School	Elioparanwo	BH16	N04 50°49.7' E006 55°42.6'	Colourless	None
Private	A-Knorr's Little Angels School	Rumuolumini	BH17	N04 47°47.5' E006 55°42.6'	Colourless	None

glass containers.

The results obtained from the analysis were compared with that of the World Health Organisation (WHO, 2011) and the Standard Organisation of Nigeria (SON, 2007) standard for safe drinking water, to ascertain its potability.

RESULTS AND DISCUSSION

Table 2 shows the location and co-ordinates of the sampled water boreholes. The results of the analysis are presented and discussed under three headings: physico-chemical parameters, heavy metals and microbiology.

a) Physico-chemical Parameters

The results of analysis of physico-chemical parameters are presented in Table 2. All the physico-chemical parameters fall within WHO and SON standard except pH, alkalinity. Only those parameters with objectionable

concentrations are discussed.

pH

Groundwater in the area is generally acidic with pH ranging from 3.3 in BH6 to 6.1 in BH5 with a mean value of 4.2. Not even one sample has pH value within the WHO and SON acceptable limit of 6.5 – 8.5; 59 % of the samples have pH values between 4.0-6.0. According to Hem (1989), water is usually associated with small amount of mineral acids from sulphide sources and/or organic acids. Similarly, 41 % has pH less than 4.0 and represents water that contains free acid. Generally, the relationship between CO_2 and HCO_3 is what controls most of the pH in most ground water. Acidic water is unhealthy as it may contain toxins whereas alkaline water contains healthy minerals. Prolonged intake of acidic water may predispose one, particularly children, to the dangers of acidosis, which may lead

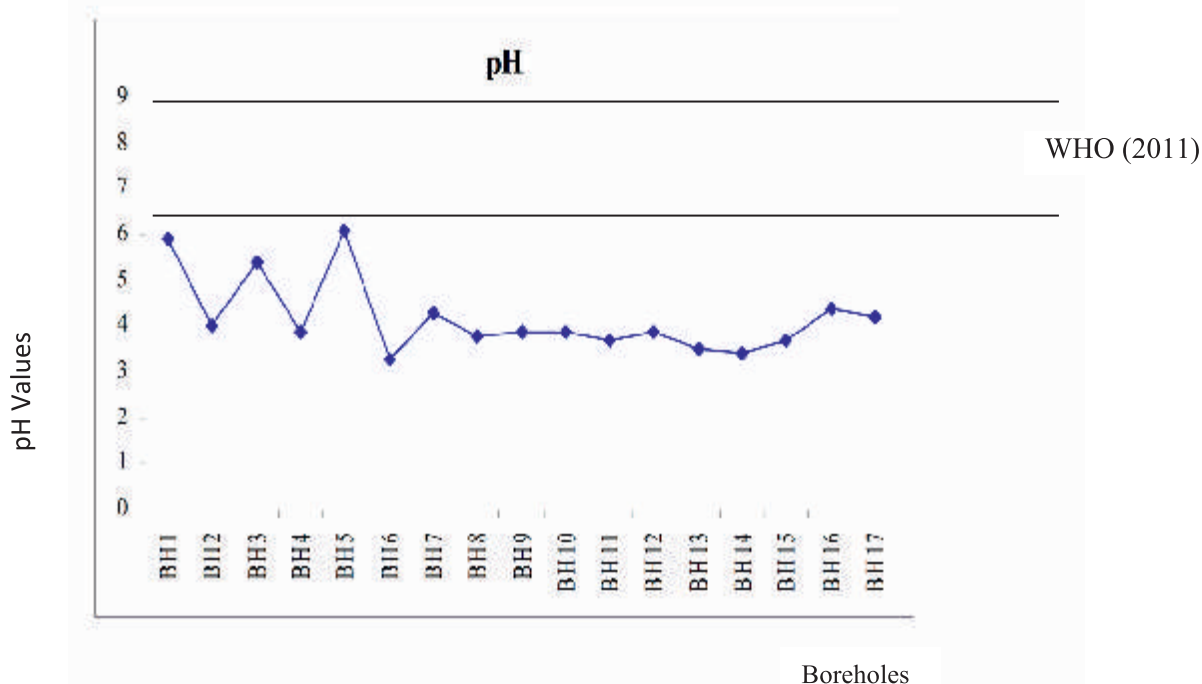


Figure 2. Values of pH in Borehole Samples in Obio-Akpor LGA

to cancer or cardio-vascular (CV) damage including the constriction of blood vessels and reduction in oxygen supply, even at mild levels (Ogundipe & Obinna, 2008). Intake of acidic water, over time could also cause leaching of valuable minerals Ca, Mg and Na from the body (Ubong *et al.*, 2016). Figure 2 is a graphical representation of pH values in the study area.

Closely related to the pH is Alkalinity - a measure of the buffering capacity of the system Alkalinity values of all the samples ranged from 0 – 6mg/l. This may be due to bicarbonate content. The low results of acidity agree with the acidic nature of the study area. The range of alkalinity is shown in Figure 3.

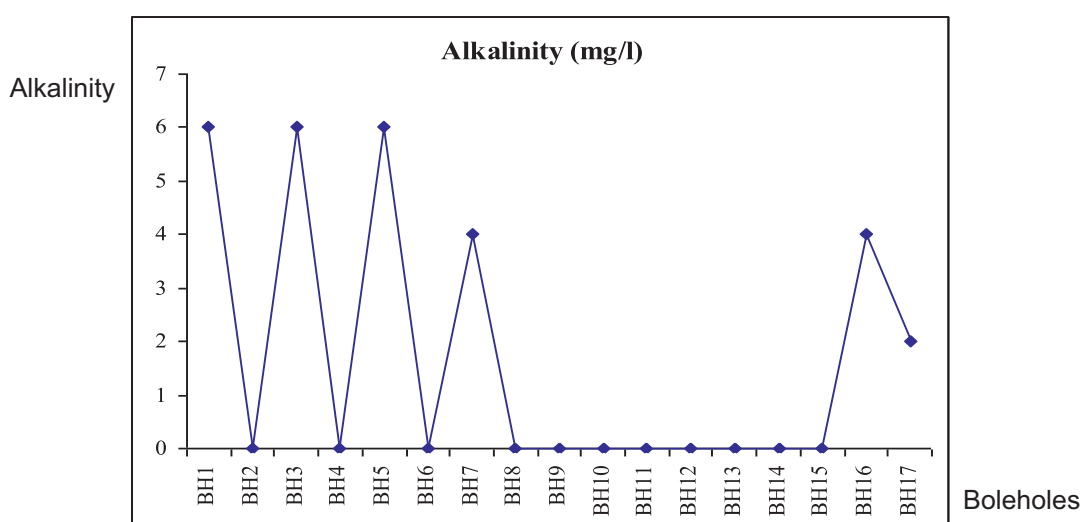


Figure 3. Range of Alkalinity in Borehole Samples in Obio-Akpor LGA.

Temperature values fluctuated between 27.1 to 27.6 °C with a mean of 26.96 °C in the samples, (Table 2). Not only is temperature important for the chemical and biological reactions of organisms in water, it also affects the volume of dissolved oxygen (APHA, 1998). Electrical conductivity ranged from 8 – 226 $\mu\text{S}/\text{cm}$, (mean, 61.6) falling within allowable limit of 1000 $\mu\text{S}/\text{cm}$ (SON, 2007). This is in agreement with low TDS in the samples which ranged between 5 mg/l (BH1, BH16) – 228 mg/l (BH14). Conductivity is due to ionizable salt content or ionizable dissolved substances in solution. For dilute solutions, it is approximately proportional to the TDS content (Ubong and Gobo,

2001). The Total Dissolved Solids (TDS) gives an overall impression of the quality of water. 1 mg/l TDS = 156 $\mu\text{S}/\text{cm}$. The higher the TDS, the lower the quality of water. Total Hardness ranged from 3.8 – 7.6, well below the set limit of 150mg/l. Turbidity levels were all within limits of 5 NTU (SON, 2007), with a value of zero (0 NTU). Turbidity is a measure of water clarity (APHA, 1998) and resulted in all the water samples being characteristically transparent and colourless. Salinity ranged from <0.01 mg/l – 0.15 mg/l with a mean value of 0.03 mg/l, well below the set limit (SON, 2007).

The anions PO_4^{2-} , SO_4^{2-} , NO_3^- , Cl^- , HCO_3^- and cation Ca^{2+} all have

concentrations within the WHO (2011) and SON (2007) limits (Table 2) and do not present a water quality issue in the area. Chloride values were within the allowable limit of 200 mg/l (WHO, 2011). Its values ranged from 0 – 15.8 mg/l with a mean value of 5.1 mg/l. Although all the samples were within the allowable limit, it was observed that BH14 recorded the highest

chloride content of 15.8 mg/l. The Bicarbonate (HCO_3^-) content in the water samples ranged from 0.040 mg/l – 0.080 mg/l, with a mean value of 0.056 mg/l. BH12 recorded the highest in bicarbonate content with a concentration of 0.080 mg/l, while BH14 had a concentration of 0.040 mg/l. (Figure 4).

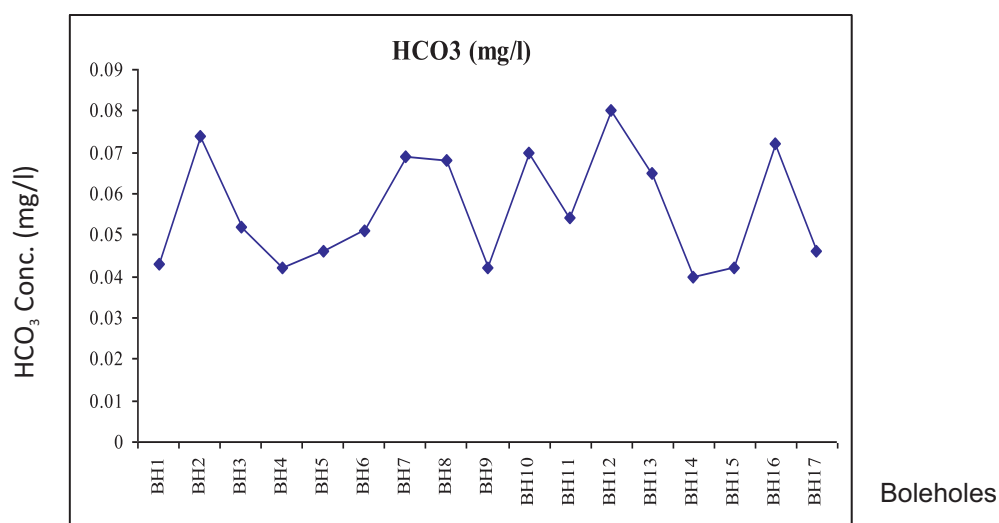


Figure 4. Concentration of Bicarbonate (HCO_3^-) in Schools' Boreholes Samples in Obio-Akpor LGA.

Although there is no stated limit for bicarbonates concentration in drinking water by WHO (2011) and SON (2007), studies have shown that people who live in areas with high amounts of bicarbonate in their drinking water have a strikingly decreased prevalence of disease, (Mark 2012). Bicarbonate is an alkaline substance naturally produced in the body that buffers acids and helps keep pH in check. Spring water contains bicarbonate ions which are coupled mainly with sodium, calcium or magnesium ions. A deficiency in bicarbonate ions in the body contributes to a range of chronic diseases and medical conditions including cancer (Whitaker, 2012). One of the ways to reduce the

harmful effect of drinking highly acidic water is to introduce the use of baking soda (bicarbonates) in every school and home. Nitrates content ranged from less than 0.05 to 5.40 mg/l. This meets the WHO (2011) and SON (2007) standard of 50 mg/l for drinking water. High nitrates have known human health impacts primarily in infants where it affects blood haemoglobin and impairs oxygen transport in babies' blood. Infants so affected are said to have 'blue baby syndrome' (Ayantobo *et al.*, 2010). The most common origin of nitrate in groundwater is from agricultural activities and disposal of untreated human waste (Ayantobo *et al.*, 2010). Magnesium (Mg^{2+}) was not detected (ND)

in about 35 % of the water samples (BH1, BH5, BH11, BH12, BH16 & BH17). However, 65 % of the samples had elevated values that ranged from 0.4 – 1.8 mg/l well above (2 – 9 times) the allowable limit, Figure 5. Calcium and Magnesium play important roles in bone structure,

muscle contraction, nerve impulse transmission blood clotting and cell signaling. Magnesium deficiency affects neurological and neuromuscular function resulting in muscular weakness and unsteady gait (WHO, 2009).

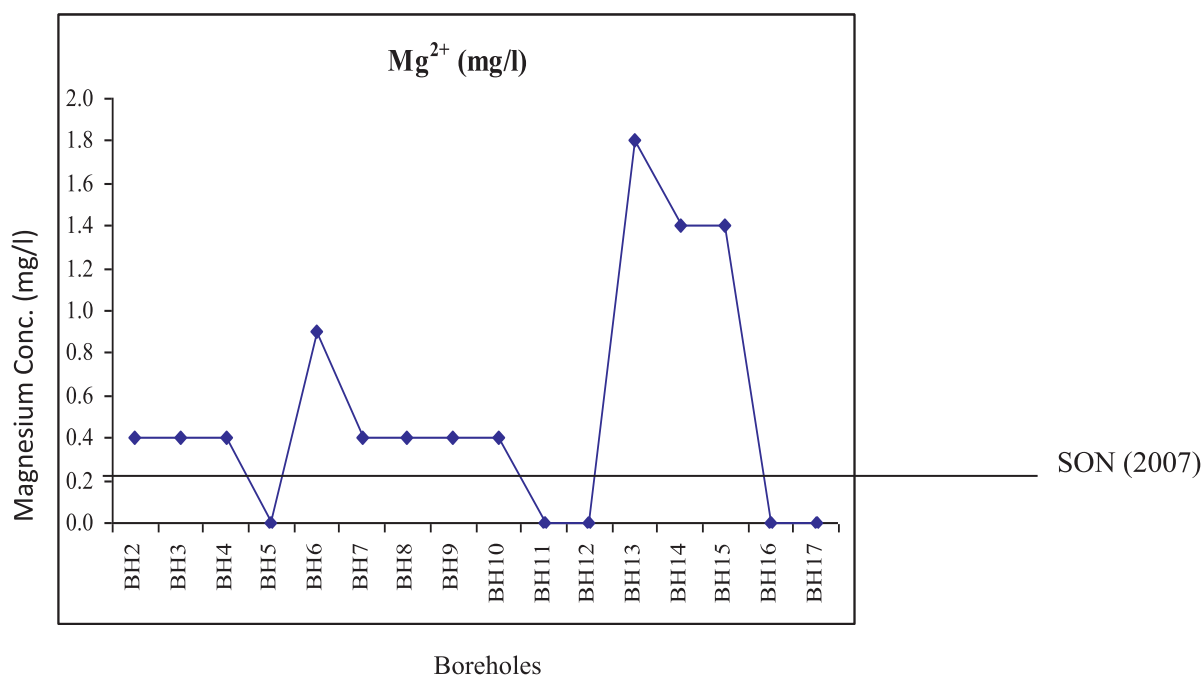


Figure 5. Concentration of Magnesium in borehole samples in Obio Akpor LGA.

A trilinear plot of the physico-chemical properties of the borehole water samples showing the dominant anions and cations in the water samples (Figure 6). BH9 and BH17 are characterized by non-carbonate alkali elements while BH3 and BH10 are characterized by no cation–anion pair exceeding 50 %. The water types in all the boreholes (76.5 % of the samples), except BH3, 9, 10 and 17, are characterized by non-carbonate hardness.

Heavy Metals

Table 3 shows the concentration of the heavy metals in the boreholes

supplying the schools (Fe, Cu, Pb, Cd and Zn). Except for iron, all the heavy metals analysed showed concentrations below both WHO (2011) and SON (2007) limit for acceptability. High heavy metals concentration in water is very harmful because of the ability of heavy metals to bio-accumulate in the different parts of the body. They are non-degradable in nature and have long biological half-lives. Heavy metals though essential components in metabolism are also toxic when present in high concentration and over a long period of time.

High bivalent-iron content is one of the

Table 3: Physicochemical Parameters of Borehole water samples from schools in Obio-Akpor Local Government Area.

Parameters	pH	Temperature (°C)	Electrical Conductivity (µS/cm)	Salinity (mg/l)	Turbidity (NTU)	TDS (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	PO ₄ ³⁻ (mg/l)	SO ₄ ²⁻ (mg/l)	NO ₃ ⁻ (mg/l)	Cl ⁻ (mg/l)	Mg ²⁺ (mg/l)	Ca ²⁺ (mg/l)	HCO ₃ (mg/l)
BH1	5.9	27.3	7.2	0.01	0	5	6	ND	0.05	1	0.7	1	ND	ND	0.043
BH2	4	27.2	24.7	0.01	0	18	ND	3.8	0.05	1	0.8	3.9	0.4	0.7	0.074
BH3	5.4	27.2	33.7	0.01	0	22	6	3.8	0.05	1.4	1.6	3.4	0.4	0.7	0.052
BH4	3.9	27.2	55.8	0.02	0	39	ND	3.8	0.05	1	1.6	5.4	0.4	0.7	0.042
BH5	6.1	22.3	13.8	0.1	0	10	6	ND	0.05	1	0.7	1.9	ND	ND	0.046
BH6	3.3	27.2	124.3	0.05	0	87	ND	7.6	0.05	1.4	2	5.4	0.9	1.5	0.051
BH7	4.3	27.1	35.3	0.01	0	23	4	3.8	0.05	1	1.3	5.9	0.4	0.7	0.069
BH8	3.8	27.3	38.4	0.01	0	27	ND	5.7	0.05	1.4	1.4	2.4	0.4	1.5	0.068
BH9	3.9	27.3	28.6	0.01	0	20	ND	3.8	0.05	1	0.7	1.4	0.4	0.7	0.042
BH10	3.9	27.2	57.7	0.02	0	42	ND	3.8	0.06	1.6	4.3	5.9	0.4	0.7	0.070
BH11	3.7	27.1	37.8	0.01	0	27	ND	ND	0.05	1.3	2.5	4.9	ND	ND	0.054
BH12	3.9	27.3	14.8	0.01	0	10	ND	ND	0.05	1.6	0.05	1.9	ND	ND	0.080
BH13	3.5	27.6	239	0.11	0	168	ND	15.3	0.05	3.4	4.4	13.3	1.8	3	0.065
BH14	3.4	27.2	32.4	0.15	0	228	ND	13.4	0.05	3.4	1.2	15.8	1.4	3	0.040
BH15	3.7	27.3	226	0.1	0	151	ND	7.6	0.05	2.7	5.4	13.3	1.4	0.7	0.042
BH16	4.4	27.3	8	0.01	0	5	4	ND	0.05	1	0.05	1	ND	ND	0.072
BH17	4.2	27.5	14.8	0.01	0	11	2	ND	0.05	1	0.05	1.4	ND	ND	0.046
Range	3.3-6.1	22.3 - 27.6	8 – 239	0.01-0.15	0	5 - 228	2 – 6	3.8 - 15.3	0.05-0.6	1 - 3.4	0.05-5.4	1-15.8	0.4 1.8	0.7 – 3	0.040-0.080
Mean	4.1	26.96	61.6	0.04	0	55.5	4.4	6.58	0.05	1.58	1.75	5.5	0.75	1.26	0.056
WHO (2011)	6.5-9.0				5	600			0.5	250	50			100	
SON (2007)	6.5-8.5		1000	250	5	500		150		100	50		0.2		

Note: BH = Borehole; ND = Not detected;

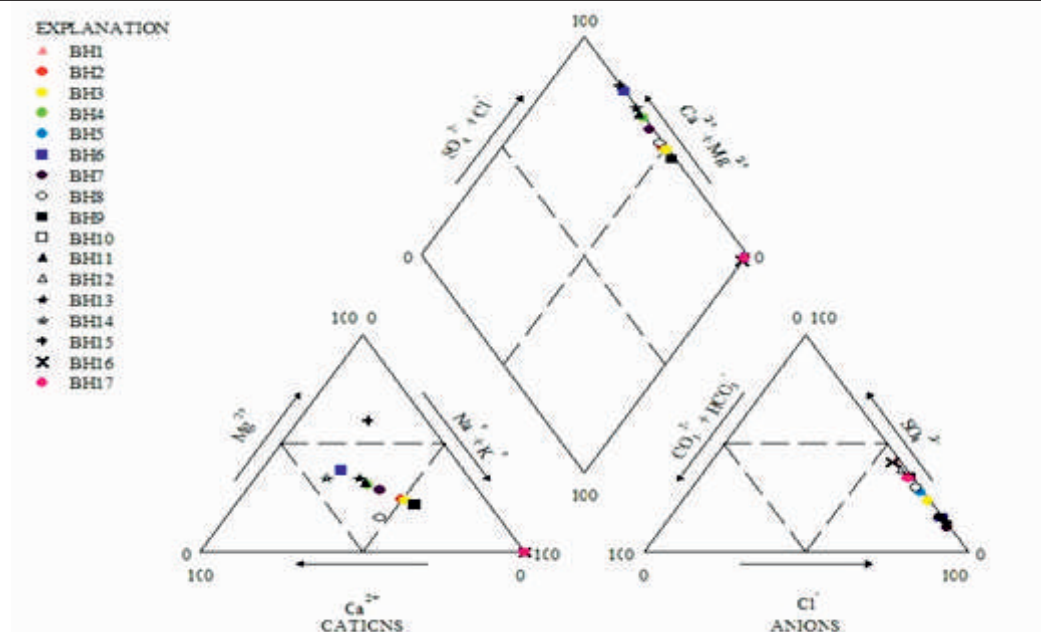


Figure 6. Tri-linear plots of Borehole Water Samples from schools in Obio-Akpor LGA.

most prominent water quality issues in the Niger Delta particularly in the meander belt region. Iron content in the water samples analysed ranged from 0 – 1.550 mg/l (mean, 0.182 mg/l). 82.4 % of the samples show iron content below WHO limit of 0.3 mg/l. Only 17.6 % of the samples have iron in excess of 0.3 mg/l. BH15 had the highest iron content (1.55 mg/l), while the lowest value (<0.001 mg/l) was measured in BH1 – BH4, BH6, BH13 and BH14 (Figure 7).

Water with high concentration of iron or manganese may cause the staining of plumbing fixtures or laundry. Groundwater in the Niger Delta often has iron concentrations ranging from 0.4 – 10 mg/l making most water boreholes in the unfit for human consumption in its natural state (Ngah and Nwankwoala, 2013). Iron actually presents no health hazards even in excess concentration except for imparting a metallic taste to water if the concentration is above 1.8 mg/l. It is mainly for aesthetic

reasons that large concentrations of iron in water are undesirable (Etu-Efeotor, 1998).

There were traces of Zinc and Copper elements in the water samples. Zinc content ranged from 0 - 0.090 mg/l (mean, 0.037 mg/l) while Copper concentration ranged from 0-0.60 mg/l (mean, 0.030 mg/l), all within allowable WHO (2011) and SON (2007) limits of 3 mg/l and 2 mg/l respectively. Zinc is essential to man but the concern for its level in water supply, however, is not in regard to toxicity but taste and quite high levels are permissible (WHO, 1993). Although the REDOX chemistry catalyzed by copper is essential for a number of immune functions, copper may also play a role in Alzheimer's disease. Copper levels generally rise in the body with age and rises more sharply in those with Alzheimer's disease. (Bush and Tanzi, 2008). Lead and Cadmium were not detected in the water samples.

The results of the microbial analysis of

Table 4. Heavy metal concentration in borehole water samples from Schools in Obio-Akpor L.G.A.

Borehole Codes	Fe (mg/l)	Pb (mg/l)	Zn (mg/l)	Cd (mg/l)	Cu (mg/l)
BH1	<0.001	<0.001	0.040	<0.001	0.017
BH2	<0.001	<0.001	0.026	<0.001	0.011
BH3	<0.001	<0.001	0.060	<0.001	0.042
BH4	<0.001	<0.001	0.025	<0.001	0.035
BH5	0.251	<0.001	0.050	<0.001	0.005
BH6	<0.001	<0.001	0.035	<0.001	<0.001
BH7	0.055	<0.001	0.033	<0.001	0.010
BH8	0.151	<0.001	0.037	<0.001	0.057
BH9	0.072	<0.001	0.071	<0.001	0.031
BH10	0.500	<0.001	0.043	<0.001	0.010
BH11	0.012	<0.001	0.015	<0.001	0.042
BH12	0.351	<0.001	<0.001	<0.001	<0.001
BH13	<0.001	<0.001	0.083	<0.001	0.020
BH14	<0.001	<0.001	0.021	<0.001	<0.001
BH15	1.550	<0.001	<0.001	<0.001	0.060
BH16	0.060	<0.001	<0.001	<0.001	0.050
BH17	0.100	<0.001	0.090	<0.001	0.027
RANGE	0 – 1.550	0 – 0.0009	0 – 0.090	0 – 0.0009	0 – 0.060
MEAN	0.182	-	0.037	-	0.030
WHO (2011)	0.3	0.01	3	-	2
SON (2007)	0.3	0.01	3	0.003	1

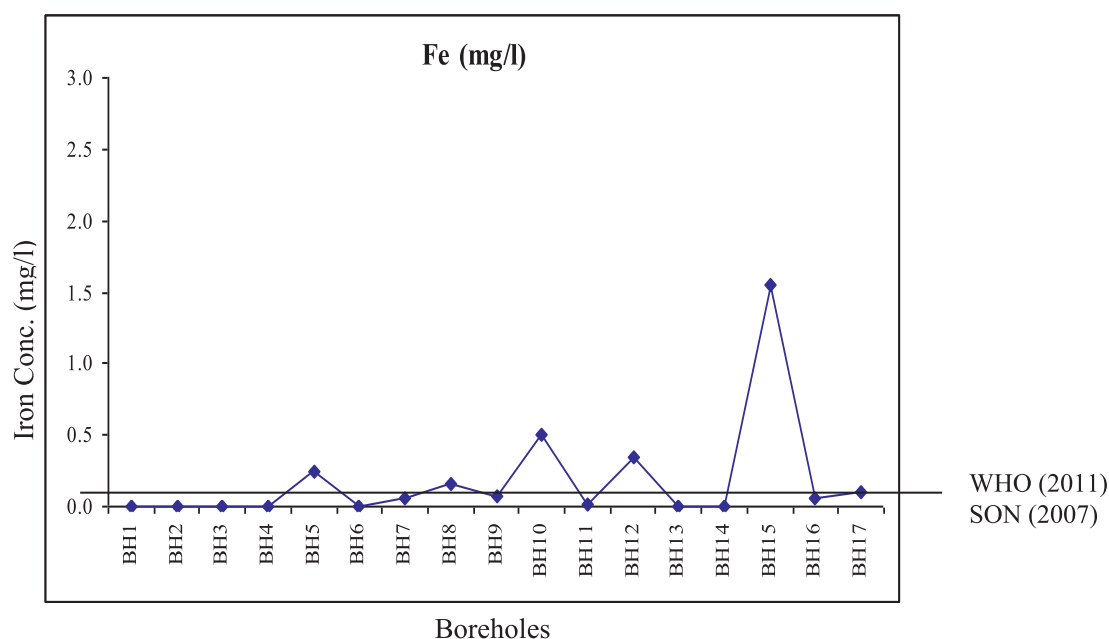


Figure 7. Concentration of Iron (Fe) in Borehole Samples in Obio-Akpor LGA.

the water samples are presented in Table 4. The analysis detected no coliform bacteria and no faecal coliform bacteria. However, total heterotrophic bacterial count was more in excess of both WHO and NSO acceptable limit in 41 % of the samples, (Figure 8).

Total Heterotrophic Bacteria (THB)

The total heterotrophic bacteria content in the water samples ranged from 0.3 cfu/ml-230 cfu/ml with a mean value of 37.5 cfu/ml. Gafed Nursery and Primary School (BH12) recorded the highest total heterotrophic bacteria of 230 cfu/ml while the lowest was observed in BH3 and BH7 with a zero (0) cfu/ml content. (Figure 8).

Table 5. Microbial Properties of Borehole Water Samples from Schools in Obio-Akpor LGA.

Borehole Codes	THB (x10 cfu/ml)	TCB (MPN/100ml)	FCB (MPN/100ml)
BH1	0.5	0	0
BH2	1.2	0	0
BH3	0	0	0
BH4	0.3	0	0
BH5	0.6	0	0
BH6	15	0	0
BH7	0	0	0
BH8	150	0	0
BH9	7	0	0
BH10	140	0	0
BH11	2.5	0	0
BH12	230	0	0
BH13	44	0	0
BH14	4	0	0
BH15	24	0	0
BH16	3	0	0
BH17	15.5	0	0
RANGE	0 – 230	0	0
MEAN	37.5	0	0
WHO (2011)	-	0 per 100 ml	0 per 100 ml
SON (2007)	10 cfu/ml	0 per 100 ml	0 per 100 ml

4.0 Conclusion

The quality of groundwater which serves as source of water supply in nursery and primary schools in Obio-Akpor Local Government Area of Rivers State has been assessed with a view to determining its potability. One water sample was collected from a school in each of the 17 Wards that make up Obio Akpor LGA and 26 parameters determined in each of the water samples.

81 % of the parameters studied per sample occurred in acceptable concentration on WHO and SON standards for safe drinking water. However, 19% of the parameters namely: pH, alkalinity, iron, magnesium and Total Heterotrophic Bacteria (THB) occur in objectionable concentration in most of the samples. Magnesium (Mg^{2+}) occurred in excessive concentration (0.4 mg/l – 1.8 mg/l) in 65 % of the samples. This value is 2 -9 times higher than SON (2007) limit of 0.2 mg/l. However, Mg^{2+} was not detected in 35 % of the samples. Fe occurred in excessive concentration in 17.6 % of the samples and within limits of acceptability in 82.4 % of the water samples.

Total Heterotrophic Bacteria was high in 41.2 % of boreholes while 58.8 % of the boreholes had THB within the guideline maximum limit of 10 cfu/ml by the WHO (2011). pH is within

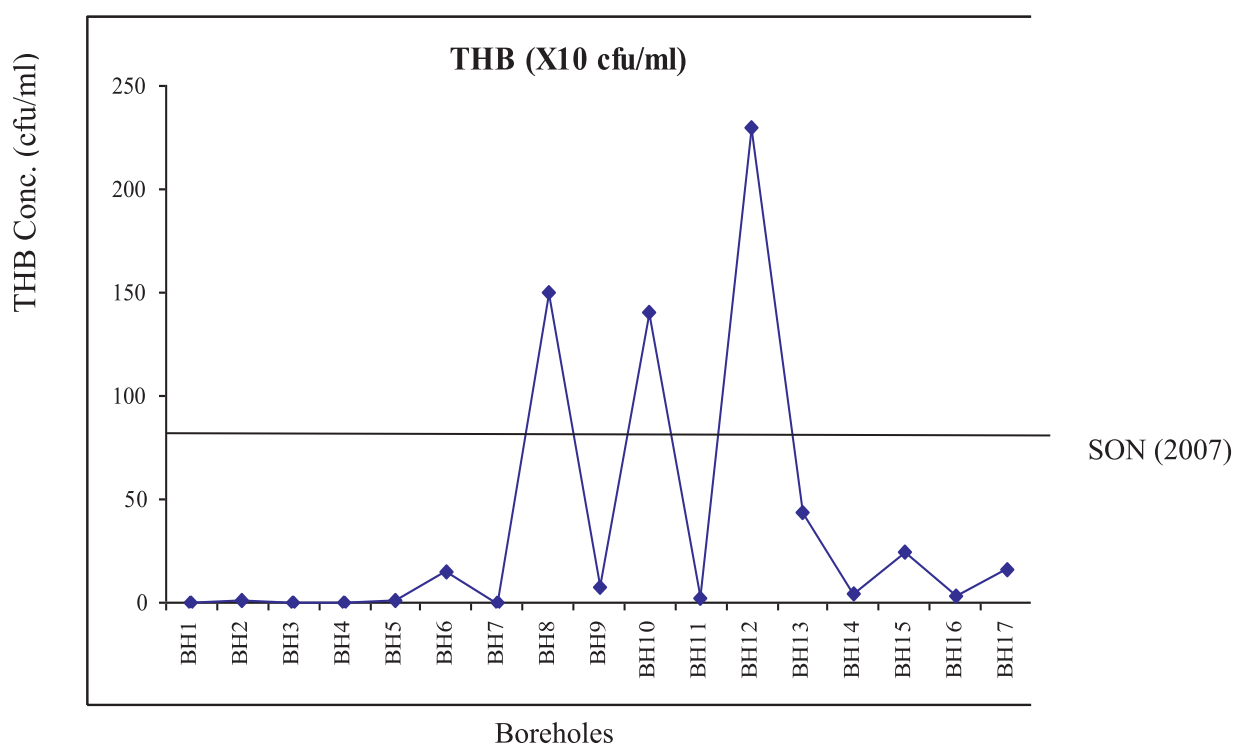


Figure 8. Concentration of THB in Borehole Samples in Obio-Akpor LGA

acceptable limit in only 6 % of the borehole water samples while 94 % of the samples showed mild to highly acidic water. The low value of alkalinity (0-6 mg/l) agrees with the acidic nature of the water.

The result showed how detrimental the available drinking water is to the health of pupils in Obio-Akpor L.G.A. Groundwater which forms the only source of water supply to schools in the study area is not, in its untreated form potable. The high acidity and high THB counts renders it unfit for drinking unless treated. Until a treatment system is installed and commissioned, it is strongly recommended that parents equip their wards with larger water containers to take potable water to school. Schools management should also put up bold inscription by the water taps discouraging innocent pupils from ingesting dilute to strong acid in the name of water.

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