Assessment of Ground Water Quality in Emohua Lga, Rivers State, Nigeria

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Abstract
The physico-chemical and microbial quality of ground water in Emohua, Rivers State were examined between December – February, 2015. Five commercial borehole from 5 different communities were analyzed for various physico-chemical parameters using standard methods. Electrical conductivity ranged from 10-97 µS/cm with mean value of 32.8±3.2 µS/cm, pH ranged from 6.34 – 6.6 with a mean value of 6.48±1.1, turbidity 0-34 with mean value of 1.02±0.1, alkalinity 4-8 mg/L with mean value of 5.6±0.5 mg/L, dissolved oxygen averaged 8.0±2.5 mg/L, biological oxygen demand 3.36-13.28 mg/L with a mean value of 6.912±0.6 mg/L, chemical oxygen demand 18.40-32.40 mg/L, with a mean value of 28.96±3.8 mg/L and temperature 24.6-25.7^{0}C with a mean value of 25.18^{0}C. Total hardness raged from 4-40 mg/L with mean value of 18.8 mg/L, total dissolved solids ranged from 40-80 with mean value of 32±2.5 mg/L and total suspended solids ranged from 20-140 with mean value of 44±3.1 mg/L. Values of microbial analysis ranged from 15-460 ml for faecal coliform count while total coliform count ranged from 7-43 ml. Some parameters were within SON/FEPA/WHO permissible limits. Only Borehole (B4) showed levels within WHO standard for total and faecal coliform but had the least and highest DO and BOD values respectively. More appropriate treatment is required before the consumption of water from boreholes based on the results of the present study. Regulatory authorities should supervise properly water being sold to the public to avoid long term accumulative health problems.
Keywords: Borehole water, communities, physico-chemical and microbial properties.

Introduction

Water resources have been the most exploited natural system since the world began and it is used for domestic, industrial and agricultural activities. The usage depends on the quality of water which is determined by its physical, chemical and microbiological characteristics. However, water quality depends on its origin and history and many factors accounts for variation in the quality of water obtained from various sources such as climatic, geographic and geologic factors. .

Water is one of the most essential needs of humans and is the most abundant natural resources on the surface of the earth (Oyinloye and Jegede, 2004), while groundwater is the largest reservoir of drinkable water and due to the natural filtration, it is less contaminated as compared to surface water (Aiyesammi *et al*, 2004). Ground water is an important source of water for agricultural and domestic use especially in developing countries like Nigeria, due to long retention time and natural filtration capacity of aquifers. However, solid waste is potential sources of contamination of both surface water and ground water (Odukoya *et al*, 2002). When water in its original sources is contaminated by domestic, industrial or agricultural waste sufficiently to render the water unacceptable for its best usage, it is said to be polluted (Ekpete, 2002).

Nigeria as a developing country is faced with all attendant consequences of poverty, overcrowding, environmental degradation, improper domestic and municipal waste disposal, inadequate or poor access to safe drinking water and sanitary facilities (Babatunde *et al.,* 2013). All these developmental challenges are orchestrated by corruption and misappropriation of resources.

At the study area, the problem of inadequate safe water is further exacerbated by contamination from a myriad of sources including industrial discharges, oil and gas activities, sewage disposal, domestic and municipal solid waste disposal. The poor state of solid waste management in rural and urban centres of developing countries is now not only an envi-ronmental problem but also a social handicap (Daskalopoulos *et al.,* 1998). Solid waste management in Nigeria is characterized by inefficient collection methods, insufficient coverage of the collection system and improper disposal despite huge budgets that are committed to MSWM. Local authorities in developing countries spend 77-95% of their revenue on collection and balance on disposal but can only achieve 50-70% collection of MSW (Ogwueleka, 2003). Most municipal waste which is usually dumped at open grounds is left to adorn the streets of residential areas and leachate produced from mechanical and chemical action by rain freely contaminates surface and ground water.

Safe drinking water remains inaccessible for about 1.1 billion people in the world and the hourly toll from biological contamination of drinking water is about 400 deaths of children below the age five (Gadgil, 1998). According to United Nations International Children Emergency Fund (UNICEF) and World Health Organization (WHO) estimates, Nigeria is among a group of 10 countries that are home to almost two-thirds of the global population without access to improved drinking water sources. Almost 63.2 million people in Nigeria do not have access to safe water; over 112 million people don't have access to adequate sanitation in Nigeria (UNICEF, 2007;WHO/UNICEF, 2010). In Nigeria, borehole water now serves as the easily accessed and cheap commercial source of drinking water for a greater number of its about 140 million people. Therefore, the conformation of these sources of water to pysico-chemical and microbiological standards is of special interest because of its capacity to spread diseases within a large population. Several studies have examined the physicochemical parameters and microbiological properties of surface and borehole water in Niger Delta areas (Ohagi and Akujieze, 1989; Imeopkaria and Offor, 1992; Ayotamuno, 1994, 1997; Onyeike *et al.,* 2002; Ibe and Sowa, 2002; Oladeji, 2002; Erah *et al.,* 2002; Nwidu *et al.,* 2006).

Nearly 90% of diarrhoea related cases and deaths have been attributed to unsafe and/or inadequate water supplies and sanitation conditions (WHO, 2006, Abogan, 2014). Even in areas where there is adequate supply of water, pollution from one of the above mentioned sources cannot be ruled out, which brought about the agreement by UNEP and WHO (2006) that, it is not sufficient merely to have access to water in adequate quantities, the water also needs to be of adequate quality to maintain health and it must be free from harmful biological and chemical contamination. Over 50,000 people die daily due to water borne diseases (Herschy, 1999, Abogan, 2014) and mortality in children under five years from water related diseases annually is estimated to be about 4 million in developing countries (Warner, 1998). Worst still, 2.3 billion people worldwide have mortality and morbidity associated with water related ailment (WHO, 1997). These statistics though alarming definitely have impact on developmental efforts (Olshanky et al., 1997).

According to Ehirim and Ebeniro (2013), Port Harcourt and its environs including the study area has unconsolidated moderately porous and permeable sands with lenticular clays and shales at depth of up to 50 m. Sandy textured soils generally exhibit rapid permeability. This suggests that these soils will drain rapidly. The fine textured soils - those that contain clays exhibit very limited capacity to transmit liquid. The depth to the water table ranges between 3 to 15m, depending on the time of the year while a percolation rate of 15 mm/hour has been reported for the Port Harcourt Area (Ehirim and Ebeniro, 2013). This soil lithology predisposes the groundwater at the study area to easy contamination from the sources enumerated above. Groundwater at the study area and its environ must therefore be monitored continually to stall the wide spread of preventable diseases such as cholera, diarrhoea, typhoid, trachoma and others which have already been reported in the Niger Delta (Nwidu *et al.,* 2008; Oladeji, 2002; Erah *et al.,* 2002; Nwidu *et al.,* 2006).

Study Area

Emohua is a town and headquarters of Emohua Local Government Area in Rivers State, Nigeria Fig 1. It comprises eight (8) subvillages. The communities major source of livelihood include, farming, fishing and trading. The vegetation type is tropical rainforest. Although Choba River is a source of water to the community, individuals depend on underground water (borehole) as their source of cooking and drinkable water because the river has been reported to be polluted (Woke *et al.,* 2013). For the purpose of this study, the entire study area was divided into five communities: Borehole 1 (Oduoha-Emohua), Borehole 2 (Isiodu-Emohua), Borehole 3 (Rumuakunde-Emohua), Borehole 4 (Rumuhe-Emohua) and Borehole 5 (Mbu-eto-Emohua). Just like most communities in Nigeria, Emohua is laden with sanitary problems of improper disposal of sewage and solid waste (Babatunde *et al.,* 2013). The latter is disposed off in open dumpsites and the former in open creeks. Leachate from dumpsites has been reported to contaminate groundwater by several authors for example (Wale-Adeyemo and Bakare, 2005; Nwankwoala *et al*., 2011)

Materials and Methods

Water samples from the selected boreholes were collected at laminar flow according to prescribed sample collection procedure in pre-washed and clean 1500 ml screw cap plastic containers after the taps were allowed to flow for about three minutes to avoid any water retained in the pipe being taken as a sample(APHA, 2000; Bolaji and Tse, 2009). Because the chemistry of groundwater is sensitive to environmental changes, some of the parameters such as temperature, colour, pH, and electrical conductivity were measured and recorded *in situ*. Water samples were transported on ice chest the same day to the laborary and analysed according to APHA (2000) standard procedures and as reported in Nwala *et al.,* (2007) and Bolaji and Tse (2009). The results were compared with reported values for groundwater within the Niger Delta region, Nigeria Industrial Standards (NIS, 2007) and WHO (2006) safe limits for drinking water. A global positioning system (GPS), Germin 76 model was used for recording the geographical co-ordinates of the sampling points.

Two microbial analysis of the water sample, faecal coliform count and total coliform count were carried out, both were incubated for 24 and 48 hours at 48^0C, using confirmed test plates of erosin methylene blue agar for faecal coliform count while completed test of nutrient agar slant was used for total coliform count (Nwala *et al.,* 2007).

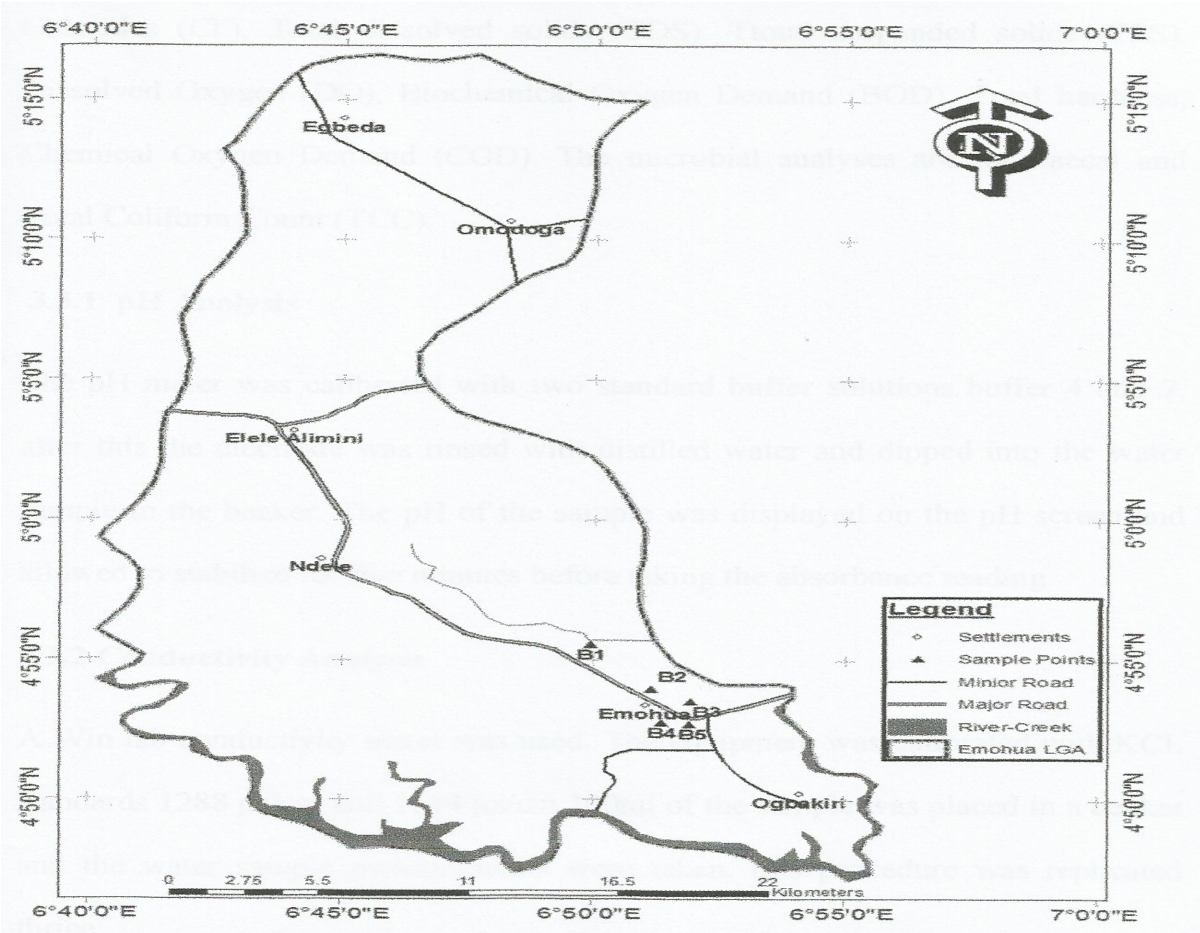

Fig. 1: Map of Emohua showing sampling locations

Quality control

Each sample was analysed in triplicate, and a blank determination was carried out with every batch of samples. All reagents used were of AnalaR grade and all glassware and polyethylene were properly cleaned with acid and rinsed thoroughly with distilled deionised water. The blank values were generally low and below the detection limits of the instrument for the parameters (ISO, 1990). Furthermore, all measurements were done in triplicates enabling the calculation of average values and standard deviations were generally below 10% of measured values.

Results

The results of the physico-chemical parameters and microbial analysis of borehole water samples from Emohua community are presented in Table 1, 2 and mean values in Fig 2 respectively.

Table 1: Results of the physico-chemical analysis of borehole water in Emohua

Samples/Station	B_1	B_2	B_3	B_4	B_5	NIS/FEPA
pH	6.34	6.6	6.6	6.50	6.4	6.5-8.5
Conductivity/Ns/cm	97	30.0	17	10.0	10	500
Chloride (mg/L)	40	4.0	4.0	40	8.0	250
Alkalinity (mg/L)	40	40	80	40	40	30
Temperature (^{0}C)	24.6	25.7	25.3	25.6	24.7	27-30
Total hardness (mg/L)	40	4.0	6.0	40	4.0	150
TDS(mg/L)	80	20	20	20	20	500
TSS(mg/L)	140	20	20	20	20	30
Turbidity (NTU)	Nil	Nil	1.7	Nil	3.4	5
DO (mg/L)	8.0	8.0	8.0	6.0	8.0	>5
COD(mg/L)	31.2	18.4	32.4	30.4	32.4	50
BOD mg/L (mg/L)	3.8	4.6	3.4	13.3	9.4	10

Table 2: Microbial results from five boreholes in Emohua LGA

Samples/Station	B_1	B_2	B_3	B_4	B_5	SON
Total coliform	460/100ml	75/100ml	15/100ml	Nil	240/100ml	10
Faecal coliform	43/100ml	15/100ml	Nil	Nil	7/100ml	0

The physico-chemical parameters determined during the three (3) months, December – February, 2015 sampling periods of five boreholes water samples in the Emohua Local Government Area showed Electrical conductivity ranged from 10-97 µS/cm with mean value of 32.8±3.2 µS/cm, pH ranged from 6.34 – 6.6 with a mean value of 6.48±1.1, turbidity 0-34 with mean value of 1.02±0.1, alkalinity 4-8 mg/L with mean value of 5.6±0.5 mg/L, dissolved oxygen averaged 8.0±2.5 mg/L, biological oxygen demand 3.36-13.28 mg/L with a mean value of 6.912±0.6 mg/L, chemical oxygen demand 18.40-32.40 mg/L, with a mean value of 28.96±3.8 mg/L and temperature 24.6-25.7^{0}C with a mean value of 25.18^{0}C. Total hardness raged from 4-40 mg/L with mean value of 18.8 mg/L, total dissolved solids ranged from 40-80 with mean value of 32±2.5 mg/L and total suspended solids ranged from 20-140 with mean value of 44±3.1 mg/L Table 1 and Fig 1. Values of microbial analysis ranged from 15-460 ml for faecal coliform count while total coliform count ranged from 7-43 ml Table 2.

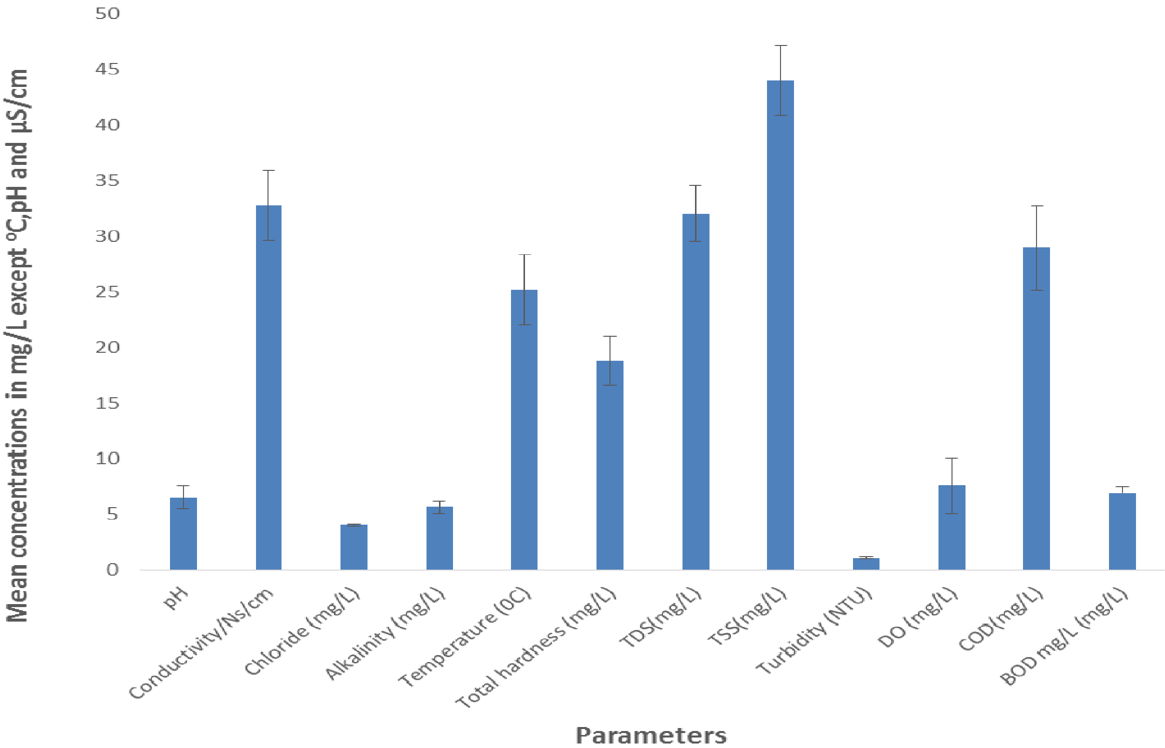

Fig. 2: Mean values of the physico-chemical parameters of five bore hole water samples from Emohua

Discussion

Borehole 1 recorded the highest values in most parameters although most of them were still within permissible limits, Alkalinity and TSS were higher than stipulated safe limits for drinking water by Nigeria Industrial Standard (NIS, 2007) and Federal Environmental Protection Agency (FEPA, 1991). Alkalinity recorded its highest value of 80 mg/L at Borehole 3 and BOD recorded its highest value at Borehole 4 which was the only water sample with BOD value higher than maximum permissible limit. All other parameters were within stipulated safe limits for drinking water in Nigeria by (NIS, 2007 and FEPA, 1991). Most of the values obtained in the present study were not far from similar studies in the Niger Delta area (Ohagi and Akujieze, 1989; Bolaji and Tse, 2009; Imeopkaria and Offor, 1992; Ayotamuno, 1994, 1997; Onyeike *et al.,* 2002; Ibe and Sowa, 2002; Oladeji, 2002; Erah *et al.,* 2002; Nwidu *et al.,* 2006; Nwala *et al.,* 2007,. However, the study of groundwater in Port Harcourt by Eze and Eze, (2015) and in Yenagoa by Agbalagba *et al.,* (2011) showed more acidic groundwater water samples. TDS and conductivity in Port Harcourt studies by Fashola *et al.,* (2013) and Eze and Eze, (2015) were higher than present study. Fashola *et al.,* (2013) believed the acidic nature of groundwater samples in Port Harcourt was as a result of dissolved CO_2 during aquifer recharge by rain water. The levels of dissolved oxygen recorded agreed with the report of Akhionbare, (1998) and was higher than the minimum 5 mg/L acceptable for safe drinking water by NIS and FEPA. This is perhaps the reason people may still be able to consume such water with one or two questionable acceptable limits. Tekenah *et al.,* (2014) opined that Oxygen availability in an aquatic ecosystem is an indication of the systems health and general well-being. This is further supported by the Prati *et al.,* (1971) scale of classifying safe water (Table 3) which would indict most of the borehole water samples in the present study as slightly to polluted but has DO range within excellent to acceptable levels making the water consumable coupled with macroscopic observation which showed no objectionable colour nor smell. However, the other parameters including microbial components showed all borehole water samples from the study area may not be fit for human consumption.

Table 3: Prati et al., 1971 classification of safe water

Parameter	Class 1	Class 2	Class 3	Class 4	Class 5
pH	6.5 – 8.0	6.0 – 8.4	5.0 – 9.0	3.9 – 10.1	<3.9 – > 10.1
DO	7.8	6.2	4.6	1.8	<1.8
BOD	1.5	3	6	12.1	>12.1
COD	10	20	40	80	>80
TSS	20	40	100	278	>278

Value of classes; Class 1= excellent, Class 2 = acceptable, Class 3 = slightly polluted, Class 4 = polluted, Class 5=heavily polluted. (Source Prati et al. 1971.) All parameters in mg/l except pH

The values obtained for both and total coliform counts for all the sample stations were far above acceptable limits as specified by WHO (2006), NIS, (2007) and FEPA, (1991) for safe drinking water. The presence of *E. coli* implies faecal contamination of the water samples analysed in the present study and strongly suggests the possible presence of enteric pathogenic bacteria as well as other parasites. This may not be unconnected to several confirmed and unconfirmed diarrhoea and cholera pandemic in the study area and most of the Niger Delta as supported by the reports of (Agbalagba *et al.,* 2011; Fashola *et al.,* 2013; Eze and Eze, 2015; Nwidu *et al.,* 2008; Oladeji, 2002; Erah *et al.,* 2002; Nwidu *et al.,* 2006). Consumption of water contaminated by disease causing agents (pathogens) or toxic chemicals is known to cause health problems like diarrhea, cholera, typhoid, dysentery, cancer and skin diseases (Fashola *et al.,* 2013).

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Statistical Correlation Analysis

Correlation coefficient is a commonly used measure to assess the relationship between two variables. It is a simple measure to exhibit how well one variable predicts the other. The correlation matrixes for the different variables of the parameters are shown in Table 4. A correlation coefficient (r) of +1 indicates that two variables are perfectly related in a positive linear sense, but r = -1 indicates a negative linear correlation. However, no relationship between two variables exists if r = 0. Thus, two variables having a positive correlation coefficient inferred that they may have a common source and as one increases, so does the other, while negative correlation coefficient may indicate a different source and as one increases, the other decreases. Electrical conductivity (EC) which is the measure of concentration of ionized substances in water has demonstrated positive correlation between TDS and TSS in the present study Table 4 and supported by (Fashola et al., 2013). Negative correlation was also demonstrated by the relationship between DO and BOD where increase BOD would mean a decrease in DO which is typical as more microbial entities remove oxygen for degradation of organic matter in any water sample, the DO is bound to be decreasing.

Table 4: Correlation matrix of parameters measured in groundwater from Emohua LGA

	pH	*µS/cm*	*Cl*	*Alkalinity*	*Temp*	*Total hardness*	*TDS*	*TSS*	*Turbidity*	*DO*	*COD*	*BOD*
pH	1											
µS/cm	-0.57	1.00										
Cl	-0.59	0.50	1.00									
Alkalinity	0.09	-0.48	-0.63	1.00								
Temp	0.86	-0.53	-0.20	-0.32	1.00							
Total hardness	-0.51	0.51	0.99	-0.65	-0.14	1.00						
TDS	-0.71	0.98	0.61	-0.41	-0.64	0.61	1.00					
TSS	-0.71	0.98	0.61	-0.41	-0.64	0.61	1.00	1.00				
Turbidity	-0.15	-0.47	-0.55	0.92	-0.46	-0.61	-0.38	-0.38	1.00			
DO	-0.08	0.45	-0.52	0.36	-0.49	-0.51	0.35	0.35	0.29	1.00		
COD	-0.51	0.01	0.32	0.53	-0.61	0.30	0.21	0.21	0.48	-0.09	1.00	
BOD	-0.17	-0.54	0.39	-0.11	0.19	0.33	-0.40	-0.40	0.10	-0.89	0.22	1

Conclusion

The evaluation of the physico-chemical and microbial parameters of borehole water sampled in five communities in Emohua LGA showed that most of the physicochemical parameters of the borehole water samples were within the Federal/International standards limits for drinking water and compared closely to other reported values for the same parameters in the Niger Delta region where the study area is located. However, results of the total and faecal coliform failed expected maximum limit for safe drinking water by Federal/International standards and some parameters such as BOD and Alkalinity exceeded maximum safe limits for drinking water. The safe Oxygen levels in the water samples may have accounted for the non-objectionable status of the water which allows consumers to drink it without complain. The results of the present study however indicates that consumption of water samples from the five boreholes may pose potential harm to human health. A position buttressed by application of the Prati *et al.,* (1971) safe water classification which would otherwise place most of the borehole water samples studied here in the slightly to polluted categories making them unsafe for human consumption. This paper strongly recommends the strictly supervision of water sold to the public to ensure compliance to regulatory limits in order to avoid incidences of diarrhoea, cholera and other public health problems. Water pollution is a major global problem which requires ongoing evaluation and revision of water resource policy at all levels (international down to individual aquifers and wells). It has been suggested that it is the leading worldwide cause of deaths and diseases and that it accounts for the deaths of more than 14,000 people daily (Aboyeji, 2013). We therefore advocate for safe water policy redress and enforcement of standards on commercial water sold to the public.

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