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Comparative Study of Physico-Chemical Parameters and Heavy Metals Concentration of Some Selected Borehole Water and Sachet Water in Igboora, Ibarapa Central Local Government, Oyo State

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Key words: Physico-chemical parameters, COD, Nitrate, and heavy metals, sachet water and Igboora

Abstract: The study was carried out on comparative analysis of the physico-chemical parameters and heavy metals concentrations on three water samples each from borehole and sachet water selected randomly from Igboora in Ibarapa central local government area of Oyo State. The physico-chemical parameters were measured using standard method while the heavy metal concentrations were examined using Atomic Absorption Spectrophotometer (AAS). The result of the physico-chemical parameters showed that turbidity ranged between (0.000) Ntu across samples examined, NO_3^- ranges between (5.04-19.99 mg L^{-1}) with highest sample in sample A (Surulere borehole water), PO_4^- ranged between (0.74-2.65 mg L^{-1}), pH (6.70-6.94 mg L^{-1}), EC ranged (199.20-374.00) µs cm^{-1} with the highest value recorded in sample C, respectively. Heavy metals were detected below limits in borehole water samples. However, sachet water samples recorded 9.875 Ntu for turbidity, EC ranged between (149.900-162.000) µs cm^{-1}, higher pH values were also recorded for sachet water which is between (7.490-7.620 mg L^{-1}). Similarly, heavy metal concentrations were detected below limit for both borehole and sachet water except that manganese and zinc revealed values in some samples, respectively. It was noted that all physico-chemical parameters examined for borehole and sachet water were within WHO threshold limits except for values of NO_3^-, COD and BOD. The water is safe for drinking if the appropriate measure is taken to regulate high parameters.

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INTRODUCTION

Water is the most significant nutrient essential to the survival of all humankind due to its involvement in energy bodily function and make up about 75% of complete body weight (Mack and Nadel, 2011). The absence of this important mineral can lead to serious diseases such as hypertension, high cholesterol and heart disease. Current studies have also associated the lack of water to headaches, arthritis and heartburn

(Batmanghelidj and Page, 2012). Therefore, it is prescribed that one should drink at least 64 tounce of water everyday (Bellisle *et al*., 2010). However, in spite of the need to ensure adequate water quality, one of the biggest development challenges is the contamination of this water sources (Gundry *et al*., 2003).

Distribution of safe drinking water is one of the most complex difficulties majority of the continent had faced in recent times as indicated by World Health Organization. More than 3.4 million people die each year from water sanitation and hygiene-related causes and majority of these are in Africa, the impact of drinking unsafe water in Africa has been felt which results into the emergency of different diseases. Emphasis has been placed on diversifying water source asides that of surface water which include rainwater and ground water. Traditionally, many societies have depended on surface water as a source of drinkable water, however with increasing challenges of contamination, resulting in diseases like Bilharziasis, sleeping sickness, river blindness and Guinea worm. As a result of this mess, many societies have adopted digging of borehole (Carpenter *et al*., 1998). A borehole is a narrow shaft bored in the ground, either vertically or horizontally. A borehole may be constructed for different purposes such as the extraction of water or other liquid like petroleum or gases as part of geotechnical examination, environmental site evaluation, mineral exploration, temperature estimation as a pilot hole for installing pipes or underground utilities for geothermal installations. However, digging of borehole is encouraged by local, national and international organizations as alternative to polluted surface drinking water sources. The quality of borehole water depends upon several factors including, local geology, hydrology and geochemical characteristics of the aquifers (Bhattacharya *et al*., 1997). Aside these factors, the activities of micro-organisms, temperature and pressure are also responsible for the chemical characteristics of ground water. Therefore borehole water regularly contains dissolved mineral ions whose type and concentration can influence their quality.

Water should be free from high values of physical, chemical or bacteriological contaminant. Rather unfortunate, water is not always found pure. It is for such reason that water supplies must be free from contaminations to ensure the protection of public health. This is even more essential now because the chemical quality of drinking water during recent years has deteriorated greatly due to the presence of toxic element which even in trace amount can cause serious health hazard (Ikem *et al*., 2002). Sachet water can be referred to as a ready to drink packed water in a machine-sealed nylon, this is referred to as pure water by many of the local community in Nigeria and other African neighboring countries like Togo, Ghana, etc. Sachet water is also sold in hand filled, hand-tied nylon which is locally referred to as ice-water. The main source of sachet water is water from borehole, sachet water produced in small scale industries is mainly treated by aeration, double or single filtration using porcelain molecules candle filter or membrane filters and in rare instances, disinfectant is applied. The level of treatment generally depends on the source of water. Sachet water has gained popularity and has been embraced by the the generality of people because it is cheap, ready to drink and accessible always, it was introduced into the Nigeria market as a less expensive water and improvement over former types of drinking water packaged for sales in hand filled and hand tied nylons. The introduction of sachet water also provides instant drinking water to the public but the question is how clean, portable and safe it is for consumption? Therefore, this research work intends to analyze and compare some selected boreholes and sachets water in Igboora to test if they are potable and safe for drinking.

MATERIALS AND METHODS

Description of the study area: The study area is in Igboora, Oyo State, Nigeria. Igboora is a major district among the seven Ibarapas which is the headquarter of the Ibarapa central local government area of Oyo State. It is derived in the savanna zone of 7°15’ North and 3° 30’ East of the equator with an average annual rainfall of 1278 mm and annual monthly temperature of 27°C (Sanusi, 2011).

Collection and treatment of water samples: Water samples were collected from three different random selected borehole water site in Igboora which are Surulere, Igbole and Olohunsogo, labelled as samples A, B and C. The sachet water samples were also purchased at different companies within Igboora area. The three types of sachet water sample are Ibukun Oluwa, Vaceed and Amadsul, labeled as sample A, B, C. Both the sachet water and borehole water sample that was collected were put in a sterilized bottle.

Determination of physical and chemical parameters: The physical and chemical parameters of the water samples were determined according to standard methods following the procedures by Ude and Ugbogu (2012). TDS, pH, COD, NO_3, PO_4, BOD and electrical conductivity were measured using standard methods by Ademoroti (1996). Turbidity was measured using Hach turbidometer. Heavy metal concentrations while metal concentrations such as Zn, Fe, Mn, Cd and Pb were done using Atomic Absorption Spectrophotometer (AAS) following the procedures of AWWA/APHA (1992).

RESULTS AND DISCUSSION

The result showed that turbidity were 0.000 Ntu across samples of borehole also the result for sachet water for sample A has value of 9.875 Ntu. Nitrate value for borehole water were all higher than WHO standards, whereas nitrate value for sachet water was below the recommended value of WHO. The value of phosphate for borehole are 1.451 mg L^{-1}, 2.648 mg L^{-1}, 0.734 mg L^{-1} for sample A, B, C, respectively and for sachet water are 1.611 mg L^{-1} (A&C) 2.249 mg L^{-1}, 1.611 mg L^{-1} for B, C, respectively. The conductivity value for both sachet water and borehole water were within the recommended value of WHO (1000 mg L^{-1}). The pH values recorded for the three samples of borehole and sachet water values were below the standard limit of WHO. Total dissolved solids in Table 1 are 224.0 mg L^{-1}, 132.0 mg L^{-1}, 252.0 mg L^{-1} for sample A, B, C, respectively and for sachet water as shown in Table 2 are 108.0 mg L^{-1}, 98.50 mg L^{-1}, 99.50 mg L^{-1} for samples A, B, C. The alkalinity of the samples analyzed as shown in Table 1 ranges between 40.00-70.00 mg L^{-1} for borehole water and 40.000-60.000 mg L^{-1} for sachet water. The COD and BOD values for both borehole and sachet water as shown in Table 1 and 2 were above the recommended value of WHO (7.5 and 2-6 mg L^{-1}) standards. The result in Table 1 shows that the manganese value for borehole water and sachet water were within the recommended value set by WHO. Zinc were below detection limit in all samples of water analyzed except for sample C of borehole water that has a value of 0.019 mg L^{-1}. The rest heavy metal concentrations such as Cd and Pb that was examined in borehole and sachet water samples were below detection limit across samples of the water.

The less turbidity values for borehole and sachet water for the present study indicated purity and less floating particles in the water samples, except that of Ibunkunoluwa (A) that revealed high values of turbidity. Similar observations were reported by Mgbemena *et al.* (2014) in Abia State, Adiotomre and Agbale (2015) in Benin city and Nwaka *et al.* (2017) in Owerri Imo State. similarly, Abdul *et al*. (2014), reported turbidity values of sachet water in the Kumasi metropolis of Ghana to range from 0.31-0.81 Ntu and also Saeed and Mahmoud (2014), reported the mean values from Fagge, LGA of Kano metropolis, Kano State Nigeria to be 0.57+0.02 Ntu which was below the WHO standard limits.

The high nitrate value range recorded in the borehole water and sachet water were within the WHO required

Table 1: Physico-chemical parameters and heavy metals concentration of borehole water

Parameters	Sample A	Sample B	Sample C	WHO limit
Turbidity (Ntu)	0.000	0.000	0.000	5.0
NO_3^- (mg L^{-1})	19.990	5.040	16.720	10.0
PO_4^- (mg L^{-1})	1.451	2.648	0.734	5.0
Conductivity (µs cm^{-1})	332.000	199.200	374.000	1000
pH	6.680	6.720	6.940	6.5-8.5
TDS (mg L^{-1})	224.000	132.000	252.000	250-500
Alkalinity (mg L^{-1})	40.000	50.000	70.000	600
COD (mg L^{-1})	168.080	134.460	67.230	7.5
BOD (mg L^{-1})	23.000	18.800	11.400	2.0.6.0
Mn (mg L^{-1})	0.010	0.080	0.030	0.1-0.5
Fe (mg L^{-1})	BDL	BDL	BDL	0.3
Zn (mg L^{-1})	BLD	BLD	0.019	5.0
Cd (mg L^{-1})	BDL	BDL	BDL	0.005
Pb (mg L^{-1})	BDL	BDL	BDL	0.001

WHO = World Health Organization; Sample A = Surulere; Sample B = Igbole; Sample C = Olohunsogo

Table 2: Physico-chemical parameters and heavy metals concentration of sachet water

Parameters	Sample A	Sample B	Sample C	WHO limit
Turbidity (Ntu)	9.875	0.000	0.000	5.0
NO_3^- (mg L^{-1})	0.040	0.380	0.010	10.0
PO_4^- (mg L^{-1})	1.611	2.249	1.611	5.0
Conductivity (µs cm^{-1})	162.000	149.900	150.600	1000
pH (mg L^{-1})	7.490	7.620	7.560	6.5-8.5
TDS (mg L^{-1})	108.000	98.50	99.500	250-500
Alkalinity (mg L^{-1})	50.000	60.000	40.000	600
COD (mg L^{-1})	168.080	134.460	67.230	7.5
BOD (mg L^{-1})	23.000	18.800	11.400	2.0-6.0
Mn (mg L^{-1})	0.010	BDL	0.060	0.1-0.5
Fe (mg L^{-1})	BDL	BDL	BDL	0.3
Zn (mg L^{-1})	BDL	BDL	BDL	5.0
Cd (mg L^{-1})	BDL	BDL	BDL	0.005
Pb (mg L^{-1})	BDL	BDL	BDL	0.01

WHO = World Health Organization; Sample A = Ibukunoluwa; Sample B = Vaceed; Sample C = Amadsul limit of 10 mg L^{-1}. The samples A and C that has high value indicated threat to the users of the borehole waters in those locations. Nitrate concentration above 10 mg L^{-1} had been reported to be dangerous to pregnant women and poses a serious health threat to infants less than six month of age because of its ability to cause blue baby syndrome in which blood loses its ability to carry sufficient oxygen (Burkart and Kolpin, 1993). This implies that sample A and C borehole water is unfit for drinking at its present state. Same observation was reported by Ude and Ugbogu (2012) that recorded higher nitrate values (4.56-86.59 mg L^{-1}) of water source in Ishiagu, Ebonyi State while low nitrate values of 1.9300 and 0.11-0.78 mg L^{-1} were also observed by Agwu *et al.* (2013) and Abdul *et al*. (2014) which are lower compared to the observation of the present study.

The low phosphate values recorded for borehole and sachet water across samples could be attributed to lack of agricultural field and washing down of detergent very close to the water source. The values obtained were within the recommended standard of 5.0 mg L^{-1} standards set by WHO. The low values reported for the present study is in line with the report by Mgbemena *et al.* (2014) deviated with the observation by Ude and Ugbogu (2012) who reported high values more than WHO limits. Hydrogen ion concentration values of borehole are acidic and that of sachet water are neutral across samples. The acidic nature of the pH in borehole could impair the health of the consumers. These values are within the minimum and maximum limit of the WHO Standards specification for drinking water. The values recorded for pH in water samples is similar to the ranged reported by Abdul *et al*. (2014), Mgbemena *et al.* (2014), Soom *et al.* (2017) and Nwaka *et al.* (2017) for Izzy sachet water in Owerri. Similar observation of low values of pH in borehole water was also reported by Ikeme *et al*. (2014) and associated it to being slightly acidic as observed in Umuihi town, Imo State and is within WHO standards. When the pH values in water are low it could be attributed to industrial waste, mining, sewage and waste dumping through leaching into the soil which ultimately increase the soil acidity. The conductivity values of all the three samples of borehole and sachet water were all below the recommendation levels of 1000 μs cm^{-1} set by WHO. The values for the present study were low compared to the values recorded by Ikeme *et al*. (2014). The present study is in line with the observation made by Abdul *et al*. (2014), Mgbemena *et al*. (2014) and Sheshe and Magashi (2015), respectively. However, lower values of EC (0.4321 and 11.00 μs cm^{-1}) were reported for borehole and sachet water by Agwu *et al.* (2013) and Soom *et al.* (2017), respectively. This implies that the lower the conductivity values of water the lower the conductance of the solution and dissolved solids.

The values of TDS of borehole and sachet water showed that the two water sources has moderate dissolved solid which in turn affects the electrical conductivity to be moderate also and fall within the acceptable limits of WHO for drinking water. The high level of total dissolved solids reduces water clarity. The present study reported values of TDS that were below the required limits as also observed by Sheshe and Magashi (2015), Ikeme *et al.* (2014) and Nwaka *et al.* (2017) for sachet and borehole water in their study.

The values of TA observed for sachet and borehole water were below the required limits of WHO, however, the values were higher when compared with values observed by Agwu *et al.* (2013), Abdul *et al*. (2014), Saeed and Mahmoud (2014), Soom *et al.* (2017) respectively. Chemical Dissolved Oxygen (COD) and Biochemical Oxygen Demand (BOD) values observed for this study showed that the sample water examined revealed higher values in borehole and sachet water more than the recommended limits of WHO and it implies that there is organic decomposition leading to microbial activities taking place in the water samples of borehole and sachet water. Similar observation was made by Amadi *et al*. (2006). High values of BOD and COD shows that the water samples have been contaminated with some pollutant (Oladiji *et al*., 2004).

The minimum and maximum concentration of manganese metal ion obtained from borehole water and sachet water of three samples analyzed were all lower than the maximum permissible limit of WHO which is 0.1 mg L^{-1}. These values are also higher when compared with the report by Gimba *et al*. (2015) who observed manganese values that ranged from 0.046-1.850 mg L^{-1}. Iron (Fe), Zinc (Zn), Cadmium (Cd) and Lead (Pb) that showed zero level or below detection implies that the water samples examined did not contain heavy metals that can impact health of the consumer negatively and to some extent fit for drinking. Similar, observation of zero level of heavy metals were also reported by Mgbemena *et al.* (2014) for borehole in Abia State and Soom *et al.* (2017) for sachet water in Benue State.

CONCLUSION

The unique role of good water quality as contributed to human health status cannot be overlooked. Increase in population coupled with the increase in anthropogenic activities had made it difficult to have safe drinkable water in our environment. The present study revealed that organic decomposition and microbial activities takes place in the water samples which may be due to heat and storage method of the sachet water. However, natural geology of the soil for borehole or suspended particles could have impact on it. The low turbidity across samples and low level of heavy metal concentration still indicated that the water is safe for drinking. This was further confirmed by values of majority of physico-chemical parameters falling below and within the recommended limits of World Health Organization (WHO) standards for drinking waters with the exception of NO_3^- for borehole and COD and BOD for borehole and sachet water that exceeded the limits by World Health Organization.

Though, the examined drinkable water in Igboora showed some amount of impurity and that accurate measure should be taken to combat it so as not to affect the healthy status of the consumers.

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RECOMMENDATIONS

From the result obtained it could be recommended that water quality monitoring should be a continuous process and Proper sanitation should be strictly observed around the vicinity where there is boreholes. The producers of sachet water should be mandated to get their company registered with NAFDAC. Further, analysis should be carried out on this research such as microbial analysis, and some other physico-chemical parameters such as Total Suspended Solids (TSS), Dissolved Oxygen (DO) and acidity, so as to ascertain the level of pollutant of these water samples.

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