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Quality Assessment of Borehole and Sachet Water Samples in Kaduna South Metropolis

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Abstract: *The physicochemical properties of six samples each of borehole and sachet water in Kaduna South were determined and contrasted with the WHO permissible limit. It was discovered that the concentration of heavy metals such as lead and cadmium were higher than WHO tolerable limit. Also, some samples had TSS, TDS. nitrates, conductivity, which ranged from: 0 – 8, 12.9 - 18.9, 1.5 - 4.2, 002 - 070 against the WHO range of 500 mg/l, 500 – 1500 mg/l, 25 mg/l and 1000 µs/cm respectively. None of the analysed water met the microbial quality requirement for portable water. Therefore, there is need for environmental re-assessment of licensed water producers, their industrial installation and health impact of their products.*

Key Words: *Water quality, Southern Kaduna, Sachet and Bore Hole*

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1.0 Introduction

One of the major challenges facing the global society is availability of portable water. According to the United nation reports, there are more contaminated water then portable water in the global water system (UN WWAP, 2003). Consequently, the probability of meeting the demand for portable water is strictly limited. Unfortunately, humans can not exit or even remain comfortable if they do not drink water. Water is also use for washing, for cooking, for irrigation and other domestic purposes (Onweluzo and Akugbazie, 2010). Industrial sectors seem to be the greatest consumer of water and they also constitute the major source of water contamination (Eddy and Udoh, 2006).

In most parts of Nigeria, access to portable water is strongly limited by cost, availability, nearness and other factors indicating that consumers are compelled to accept what they can afford or what is available. Water assumed to be pure by the producers and consumers (commonly called sachet water) is the most available source of water to most citizens of Nigeria, including Kaduna State. Others have bore hole water as the nearest alternative. Studies have shown that these sources can be enriched with wide varieties of contaminants and could threaten public health (Eddy and Ekop, 2007). For example, Omalu *et al*. (2011) reported that the presence of *Bacillus sp.*, *Pseudomonas sp.*, *Klebsiella sp*., *Streptococcus sp*., and *oocysts of Cryptosporidia sp* in some sachet water within Nigeria. Similar findings were reported by Edema *et al*. (2011) on bacteriological quality of sachet water in some part of Nigeria (excluding Kaduna State). Odiongenyi *et al*. (2015) reported observed deviation from WHO permissible quality of sachet water distributed in Akwa Ibom State. They reported possible public health threat if the concentrations of ammonium and nitrate as well as conductivity and the bacteriological quality of most of the sachet water are not adjusted significantly. According to Egwari *et al*. (2005), most sachet water acquired microorganism through poor handling processes.

In Nigeria, various contaminant has been detected in water samples from different part of the country. Contamination of bore hole water has been reported for different parts of Nigeria (Abdullahi *et al.*, 2013; Akinola *et al*., 2018; Ibe and Okpalenye, 2005; Joshiah *et al*., 22014; Onuorah *et al*., 2018; Uhuo *et al*., 2014; Ukpong and Okon, 2013).

Arising from the possibility of having contaminants in sachet water and bore hole water, there is need to monitor several sachets and bore hole water within Kaduna State because literature is scanty on the provision of water pollution mapping in Kaduna State. Hence the present study is aimed at assessing and comparing the quality of sachet water and bore hole water, which are the commonest source of water for drinking.

2.0 Materials and Methods

The containers were washed thoroughly and dried before the samples were collected, after which the water samples were collected from 12 different locations within Kaduna metropolis. Each sample container was labelled upon collection as A, B, C, D, E, F, G, H, I, J, K and L respectively.

The standard solution of each metal ion was prepared using their appropriate salts/metal. The required mass of each metallic salt needed to prepare a standard solution of 1000 ppm that was dissolved in one litre of distilled water were as follows: 1.00 g of lead metal was weighed and was dissolved in 30 cm^3 of 6 M HNO_3 solution and was transferred into a 1000 cm^3 volumetric flask and was made up to mark with distilled water and this gave a stock solution of 1000 ppm of lead ion. The working standard solution of 2 ppm, 4 ppm, 6 ppm, 8 ppm, 10 ppm were prepared from the stock solution by serial dilution. Also, standard solutions of cadmium and zinc of 2 ppm, 4 ppm, 6 ppm, 8 ppm, 10 ppm were also prepared. Furthermore, the samples were digested with nitric acid in order to avoid interference, decompose organic substance that might be present in the water sample, dissolve element in the sample and to homogenize the mixture.

The media was prepared by weighing 9 g of eosine methylene blue (EMB) which was dissolved in distilled water contained in a 250 ml conical flask. The solution was thoroughly stirred and the conical flask was later covered with cotton wool and foil paper. The solution was later placed on a hot plate and allowed to boil for some minutes, after which, it was cooled and autoclave for 15minutes at 121^0C . It was then removed and allowed to cool.

The surface of the table was disinfected by cleaning with a disinfectant. The petri dishes, spirit lamp, and media were kept on the disinfected surface, the spirit lamp was ignited and was used to disinfect the tip of the conical flask containing the media before the media was poured into various plates or petri dishes and was allowed to solidify.

The pH, total dissolved samples (TDS), nitrate content, turbidity and conductivity of each water sample were determined using: pH meter, TDS meter probe, DR 2010 spectrophotometer and conductivity meter respectively. The results obtained was compared with that of the World Health recommended parameters.

3.0 Results and Discussion

Values of physico- chemical parameters and faecal coliform count of some borehole and sachet water samples from Kaduna South are presented in Tables 1 to 5. ~~I.~~

Table 1: Physico-chemical parameters of sachet water samples

Parameters	*A*	*B*	*C*	*D*	*E*	*F*	*WHO*
pH	6.02	6.73	6.27	7.12	6.78	6.38	6.5 – 8.5
Turbidity(NTU)	0	8	12	14	9	6	0 – 5
Conductivity(μs/cm)	016	018	005	039	021	002	1000
TDS(mg/l)	18.3	15.6	18.0	18.0	18.6	12.9	500-1500
DO(mg/l)	27.4	27.9	27.7	27.5	27.2	24.4	4
TSS(mg/l)	1	5	2	0	7	5	500
Nitrates(mg/l)	4.2	2.1	3.2	2.1	2.0	1.5	25
Zn(mg/l)	0.0027	0.0031	0.0021	0.0019	0.0020	0.0028	3
Cd(mg/l)	0.014	0.0096	0.0127	0.0107	0.0090	0.098	0.003
Pb(mg/l)	0.0257	0.0230	0.0213	0.1834	0.0164	0.0293	0.01
Faecal coliform count	32	55	45	78	63	60	0/100ml

Table 2: Physico-chemical parameters of borehole water samples

Parameters/Unit	*G*	*H*	*I*	*J*	*K*	*L*	*WHO*
pH	6.92	7.47	7.03	7.12	7.78	7.45	6.5 – 8.5
Turbidity(NTU)	3	4	6	12	6	3	0 – 5
Conductivity(µs/cm)	028	054	034	038	070	054	1000
TDS(mg/l)	18.9	15.3	14.4	15.6	13.5	16.8	500-1500
DO(mg/l)	27.8	27.9	24.1	28.1	25.0	27.8	4
TSS(mg/l)	2	1	6	2	1	8	500
Nitrates(mg/l)	3.1	2.8	1.9	3.3	2.1	3.0	25
Zinc(mg/l)	0.0001	0.0019	0.0030	0.0011	0.0028	0.0023	3
Cadmium(mg/l)	0.0048	0.0084	0.0048	0.0018	0.0055	0.0054	0.003
Pb(mg/l)	0.0699	0.0760	0.0365	0.0258	0.0101	0.0440	0.01
Faecal coliform count	38	37	36	34	38	30	0/100ml

****WHO = World Health Organization standard for drinking water**

The pH of the samples analysed ranges from 6.02 – 7.78 with samples A, C and F exhibiting pH values that are below the world health organization standard of 6.5 – 8.5. Hence water samples A, C and F are mildly acidic whereas, samples B, D, E, G, H, I, J, K and L fell within the range. This pH range is close to neutral and may allow the growth of most bacterial species if the water from these sources are not properly handled (Eniola *et al*., 2007) . The results falls within the range of data obtained by Yisa *et al*.(2012) for well water samples from Doko village in Niger state.

The measured values of turbidity for the borehole and sachet water samples were found to be within the range of 0 NTU to 14 NTU and compares favourable with permissible limit of 5.0 NTU (WHO, 1983). Turbidity is due to the presence of colloidal particles arising from clay and silt during rainfall, or from discharges of sewage and industrial waste.

The concentration of nitrate in water samples depends on the nitrification activities of micro-organisms. Nitrate is particular harmful to babies and at excess concentration, it can initiate a health challenge called methemoglobinemia. Besides, nitrate can impart upon the odour and taste of water (Akinbile, 2006). Measured concentration of nitrate in the water sample ranged 0.30 to 4.60 mg/l and were within the WHO permissible limits for nitrate in drinking water indicating that the water is not polluted with respect to nitrate. Nitrate concentration in water upto 50 mg/l has been reported in areas where water is excessive contamination has been pronounced (Makhijani and Manoharan,1999). In certified sachet water samples from Ghana, average nitrate concentration was reported to range from 0.00 to 0.50 mg/l, which is within the acceptable range (Animah and Ofosu, 2012). High level of nitrate in drinking water has been reported to be due to excessive use of agriculture fertilizers, , domestic effluent, sewage disposal industrial discharges, leachable from refuse dumps, and atmospheric precipitation has become a serious problem.

Mean values of conductivity of the water samples was observed to range from 002 to 070 µs/cm and were below the maximum permissible limits of 1000 µs/cm set by the standard organization of Nigeria (SON) and WHO Purechemistry, 2001. . The observed conductivity values suggest that the water sample do not have excessive electrolytes that may be precursor for the precipitation of other products that could affect the water quality. However, some electrolyte are necessary for the body, therefore, some of these water samples may not have significant concentration of essential electrolytes.

One of the major challenges in achieving the United Nation goal for the provision of portable water is the presence of heavy metals. Heavy metals are those metals whose density is greater than 5 g/cm^3 and are toxic above certain concentration (Eddy *et al*., 2004). Measured concentrations of lead and cadmium in water sample A, B, C, D, E, F, G, H, I, J and L were above the WHO permissible limits (WHO, 2003). Hoever, only sample K had values within the limit. Common sources of cadmium and lead contamination include the presence of old pipes and industrial pollution, (Gebrekidan and Samuel 2011)., effect of combustion of petrol, (Hardman *et al.*,1999) and gasoline Banat *et al*., (1998). Toxic concentration of cadmium and lead can cause damage to the brain and kidney (Hanaa *et al.*,2000). The accumulation of these heavy metals may also be attributed to poor handling, anthropogenic and industrial activities, which end their activities when these metal dissolve on the land and penetrate the earth crust upto the water table (Hanaa *et al.*,2000; Nassef *et al.*, 2006; Rajappa *et al.*, 2010).

In all the water samples, zinc contamination was not detected. Measured concentrations of zinc ranged from 0.0001 - 0.003mg/l which were below the WHO threshold limit of 3 mg/l. However, considering the biochemical role of zinc in the body, most of these water sample require addition of zinc ion. of (3mg/l).

The 1958 WHO *International Standards for Drinking-water* suggested that concentrations of zinc greater than 15 mg/litre would markedly impair the potability of the water. The 1963 and 1971 International Standards retained this value. as a maximum allowable or permissible concentration. In the first edition of the *Guidelines for Drinking-water Quality*, published in 1984, a guideline value of 5.0 mg/l was established for zinc, based on taste considerations. The 1993 Guidelines concluded that, taking into account recent studies on humans, the derivation of a guideline value was not required at this time. However, drinking-water containing zinc at levels above 3mg/l may not be useful to to consumers who do not have zinc deficiency.

The results of the total dissolved solid (TDS) samples ranged from 12.9 to 18.9mg/l. And below the WHO permissible level of 1000 mg/l (WHO, 1973).The concentration of the total dissolved solids were below the permissible limits of (500-1500mg/l) set by SON and WHO.

These finding are not in line with (Pandey and Shanmukha, 2012) who reported the TDS values ranging from 145 to 245 mg/l for some sachet water samples. However, the presence of high level of TDS in water may be objectionable to consumers owing to the resulting taste and to excessive scaling in water pipes, heaters, boilers, and household appliances. Some dissolved organic matter may contribute to increased level of TDS which also indicates that the water is polluted (Rao,*et al.*,2012).

In a similar study conducted by Farah *et al.* (2002) the TDS of water samples were found to range from 666.7 to 3666.6mg/l, before treatment but within the range of 509.2 to 1472.3mg/l after treatment. This result is in disagreement with the range of values (240 to 1650mg/) reported by Suresh and Kottureshwara (2009).

Water with extremely low concentrations of TDS may also be unacceptable to consumers because of its flat and insipid taste. Reliable data on possible health effects associated with the ingestion of TDS in drinking-water are not available, and no health-based guideline value is proposed. However, the presence of high levels of TDS in drinking-water may be objectionable to consumers. (WHO, 2003). According to WHO 2003, concentrations of TDS in water vary considerably in different geological regions owing to differences in the solubilities of minerals.

The concentration of suspended solid in all the water samples falls within the value of 0 – 8 mg/l, with sample L (sachet water) exhibiting the highest value of 8 mg/l and sample D (borehole water) having the least value of 0 mg/l.

Water with extremely low total dissolved solid and total suspended solid concentration may be objection because of its flat, insipid taste. High concentration of total dissolved solid and total suspended solid causes some physiological problems. (Prescott *et al*., 1999).

Concentrations of dissolved oxygen in the water samples found to range 24.1 to 27.9 mg/l with a mean value of 26.9mg/l. It was observed that in all the samples, the dissolved oxygen content was higher than WHO permissible limit of 4.6 to 6.0mg/l. Although high concentration of dissolved oxygen in water can increase satisfactory taste, it has the tendency of accelerating corrosion of metals

The bacteriological analysis of water determines the portability of water. The primary sources of these bacteria in water are animal and human wastes and are mostly transported by surface runoff, pasture, seepage or discharge from septic tanks, sewage treatment facilities and natural soil/ plant bacteria (EPA, 2002). These contaminants are reflected in the highest bacterial load obtained in this study for the borehole and sachet water samples. Generally, underground water is believed to be the purest known (Gordan and John,1996; Prescott *et al.*,2002) because of the purification properties of the soil however, it can also be contaminated. Groundwater is found to be contaminated due to improper construction, shallowness, animal wastes, proximity to toilet facilities, sewage, refuse dump sites, and various human activities around the water source (Bitton, 1994).

Faecal coliform count for all samples were exceedingly higher than the EPA maximum contamination level (MCL) for coliform bacteria in drinking water (i. e, zero total coliform per 100ml of water) (EPA, 2003). The high coliform count obtained in the samples may be an indication that the water sources are contaminated by coliform (EPA, 2003; Osuinde and Enuezie, 1999). None of the water samples complies with EPA and WHO standard for coliform population. According to EPA standard, every water sample that has coliform must be analyzed for either feacal coliform or *E. coli* (EPA, 2003) in order to ascertain if contamination with human or animal waste and possibly pathogenic bacteria or organism, such as Gardia and Cryptosporidium may be present (EPA,2003). The presence of coliform in water is indicative of pollution. The presence of coliform in the present study may be due to the unhygienic environment of the boreholes and factories where the sachet water is packaged. Most of the boreholes were sited close to septic tanks, and the points of collection of the water were not kept clean. Similar results have been reported for microbial analysis in sachet water sold in Nnewi, Ibadan, Oyigbo Lagos, and Ogbomosho (Egwari *et al*.,2005, Adekunle et al.,2004, Ezeugwunne *et al*.,2009) in Nigeria. The presence of coliforms in these towns were attributed to poor water treatment and handling methods of the producers such as poor sanitary conditions of the packaging environment, inadequate sterilization of the packaging material and contamination by the sealing machine used.

4.0 Conclusion

In conclusion, the qualities of the borehole water and sachet water samples with respect to the determined physicochemical parameters were not within the WHO permissible limit except for the TSS TDS. Nitrates, conductivity, which ranged from 0 – 8, 12.9 - 18.9, 1.5 - 4.2, 002 - 070 against the WHO range of 500mg/l, 500 – 1500mg/l, 25mg/l and 1000μs/cm respectively. The microbial quality of the water samples does not meet the set standards**.** proper ground water location and construction, control of human activities to prevent sewage from entering water body is the key to the avoiding bacteria contamination of drinking water. The water samples collected from the above mentioned sources, the concentration of heavy metals such as lead and cadmium were extremely higher than WHO permissible limit.

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