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Original Research Article

Potability of Vended Water Quality from Source to Consumption: A Case of Anguwar Liman Area of Samaru-Zaria, Nigeria

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ABSTRACT

In recent years, vended water has become a major source of drinking water in most of the urban centers of developing countries due to inadequate piped water supplies. Hence, this study assessed the quality of vended water and its level of contamination at source, during transportation and at point of use in Unguwar Liman area of Samaru-Zaria, Nigeria during rainy and dry seasons. The method employed involved assessing the physicochemical and bacteriological quality of vended water at each point during both seasons and comparing the findings with regulatory standards. Laboratory analysis of the water samples was carried out for pH, turbidity, biological oxygen demand (BOD), nitrate, phosphate, colour, total dissolved solids (TDS) and total coliform (TC). The result of the findings showed that the mean concentrations of the three points assessed for TDS, BOD, nitrate and phosphate during dry and wet seasons were 670 and 257 mg/l; 1.052 and 0.928 mg/l; 0.105 and 0.178 mg/l then 0.0006 and 0.0068 mg/l respectively. Similarly, the mean values and concentrations for pH, turbidity and total coliform during dry and wet seasons were 8.3 and 7.3; 1.693 and 2.663 NTU, and 4 and 27 MPN/100ml respectively while the colour of all the samples during both seasons was constant at 5 TCU. It was established that the vended water of the study area possesses better quality during the dry season hence, inhabitants of the study area were advised to disinfect vended water mostly during the rainy season before consumption.

1. INTRODUCTION

Water vending is the practice of selling water to household by water haulers or water facility owners with the exception of bottled and packaged water (WHO, 2015). Water vending is a common practice in both under-developed and developing countries of the world due to the scarcity in supply as well as inadequate pipe distribution network from the source to users (Kjellen, 2006).

Boreholes and hand dug wells are the major sources of water to the dwellers of the study area (Anguwar Liman area of Samaru-Zaria, Nigeria) been an arid region. However, the high cost involved in drilling boreholes and digging of wells in arid regions, coupled with the absence of perennial streams around the study area made the residents of the study area to encourage water vending. Hence, people take advantage of the inadequacy in water supply, to go into water vending as a means of livelihood. Usually, the end users judge the quality of the water been supplied to them by mere observation of the appearance (colour) as well as taste without bothering with other physicochemical and bacteriological parameters. Vended water has been associated with outbreaks of cholera and diarrhea by Hutin *et al.* (2003) however, Whittington *et al.* (2009) attributed most of the risk of vended water contamination in Nigeria to the water vendors who retailed the water by jerry cans to individuals after purchasing directly from water facilities. Also, Ogbozige *et al.* (2018) have reported that water container materials, period of storage as well as storage condition affects the quality of water used at homes.

In Nigeria, the regulatory body for drinking water quality known as the National Agency for Food and Drug Administration and Control (NAFDAC) did not show much concern about certifying and licensing water vendors as they focused more on bottled and packaged water companies. Hence, it is important to monitor the quality of vended water of the study area from sources to the points of consumption during dry and wet seasons in other to understand the main sources of contamination so as to provide adequate measures against subsequent contamination that my lead to water related diseases.

2. MATERIALS AND METHODS

2.1. Study Area

The study area, Anguwan Liman is a district of Samaru-Zaria, Kaduna State in North-Western Nigeria. It is in between the Zaria-Sokoto Road and the railway that passes through Zaria (Figure 1), at 5.45 km away from the Ahmadu Bello University Teaching Hospital (ABUTH), Shika and 2.52 km away from the Nigerian College of Aviation Technology, Zaria. However, the source of vended water (borehole) in the study area is situated on latitude 11º 09' 46.21" N and longitude 07º 38' 59.80" E at an altitude of 611 meters above mean sea level (MSL).

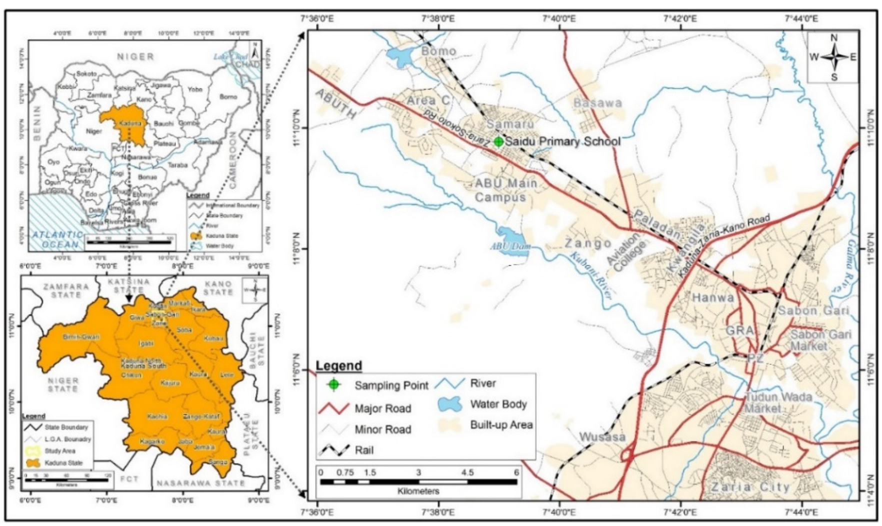

Figure 1: Map of Zaria showing source sampling point

The geology of Zaria is of the basement type with a lithology of lateritic layer (0 – 10 m) consisting of reddish-brown silty clay combine with reddish brown concretion and reddish-brown sandy clay with ferruginous concretions. The weathered basement layer (10 – 17 m) consist of grayish brown medium coarse sand containing gravels and pebbles while the fresh basement complex layer (17 – 55 m) is of quartzite and fresh crystalline rocks (Collins, 2017). The mean annual rainfall can be as high as 2000 mm in wet years and as low as 500 mm in drought years, but with a long term average of 1000 mm while the mean annual temperature is about 24.5 ºC (Sola and Adeniran, 2015).

2.2. Sampling Method and Laboratory Analysis

The major source of vended water in the study area was identified to be a borehole based on observation. However, the water vendors were interviewed to know if they were regular at fetching water from the identified borehole. Water samples were collected in sterile sample bottles from the fetching point (source), during transportation (vendors) and at the point of use (household). During each season (dry and wet), the sampling pattern was carried out with different vendors and households at a sampling frequency of two weeks for a period of two months, making a total of 24 samples for both seasons. The months of January and February were chosen as the sampling period during dry season while July and August were selected for the wet season period. These months correspond to the peak of dry and wet seasons in the study area respectively. Nevertheless, the water quality parameters monitored were total dissolved solids (TDS), biochemical oxygen demand (BOD), nitrate (NO_3), phosphate, (PO_4), pH, colour, turbidity and total coliform. Nitrate and phosphate were determined through the use of a multi-parameter photometer (model HI83200). On the other hand, TDS, pH, colour and turbidity were determined via gravimetric method, pH meter (model pHep01®,±0.1), lovibond comparator (model S1000) and turbidimeter (model HACH 2100N) respectively. BOD was analyzed by Winkler method while total coliform was determined using most probable number (MPN) technique. All laboratory analyses were done in line with APHA (2012) standard.

2.3. Statistical Analysis

At each sampling point (i.e. source, during transportation and household), the mean values of each of the analyzed parameters were computed during both seasons. Also, the mean and standard deviation of the source, transportation, and household of all the parameters were calculated and used in determining the coefficient of variation (CV) of the parameters from source, through vendors to household. However, the values of the examined parameters at each of the sampling points during both seasons were presented in multiple bar charts. The charts clearly revealed the trends in contamination of the analyzed parameters from the source (borehole) to the point of consumption (household) via colour legends allotted to each season.

3. RESULTS AND DISCUSSIONS

3.1. Total Dissolved Solids

The laboratory results obtained at the three points of sampling during both seasons are presented in Table 1. The value of total dissolved solids (TDS) of the water samples during the dry season were above the WHO permissible limit (≤ 500 mg/l) in all the three points of sampling while the reverse is the case during the wet season.

Table 1: Statistical data of vended water at points of sampling

Parameter	Mean		SD		CV		WHO	NSDWQ
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season		
TDS (mg/l)	670	257	17.7951	12.8193	0.0266	0.0050	≤ 500	–
BOD (mg/l)	1.052	0.928	0.1563	0.1900	0.1486	0.2048	≤ 1.9	–
NO_3 (mg/l)	0.105	0.178	0.0000	0.0000	0.0000	0.0000	≤ 50	≤ 50
PO_4 (mg/l)	0.0006	0.00068	0.0000	0.0000	0.0000	0.0000	–	–
pH	8.3	7.3	0.0000	0.0000	0.0000	0.0000	6.5-8.5	6.5-8.5
Turbidity (NTU)	1.693	2.663	0.0000	0.0000	0.0000	0.0000	≤ 5.000	≤ 5.000
Colour (TCU)	5.000	5.000	0.0000	0.0000	0.0000	0.0000	≤ 15	≤ 15
TC (MPN/100ml)	4	27	1.6997	8.2865	0.4635	0.3069	0	≤ 10

SD = standard deviation, CV = coefficient of variation, WHO = World Health Organization Standard, NSDWQ = Nigerian Standard for Drinking Water Quality, TDS = total dissolved solids, BOD = biochemical oxygen demand, NO_3 = nitrate, PO_4 = phosphate, TC = total coliform, mg/l = milligram per liter, NTU = naphelometric turbidity unit, TCU = true colour unit, CFU = colony forming unit

The high concentrations of TDS during the dry season which is in line with Efe *et al.* (2005) might be attributed to weathering intensity of rocks in conjunction with less volume of groundwater. Nevertheless, Figure 2 revealed that TDS concentrations at the three points of sampling during both seasons is in the order: source < during transportation < point of use. This might be due to contamination by dust particles during transit as well as hygienic nature of containers used by consumers.

3.2. Biochemical Oxygen Demand

The concentrations of biochemical oxygen demand at the source (borehole) during the dry and wet seasons were 0.875 and 0.660 mg/l respectively, which are below the maximum permissible limits set by WHO (≤ 2.0 mg/l). In other words, the quality of the vended water at the source in terms of BOD were acceptable during both seasons. Figure 3 indicates that there was deterioration in BOD of the vended water in the course of transportation during both seasons. This suggests that the containers (jerry cans) use in conveying the vended water needs thorough and routine washing. The deterioration might as well be as a result of the fact that the 25 liter jerry cans used by hawking water vendors during transportation are usually black in colour thus, absorbing much solar heating which might have raised the temperature of the transported water (Ogbozige *et al.,* 2018). The rise in the water temperature consequently reduced the dissolved oxygen content of the water which inturn raised (little) the BOD content (deterioration). The slight drop in BOD at the point of use or household (compared to transportation phase) during both seasons could be caused by the oxygenation of the water while pouring from the conveying jerry cans into the storage containers used by household. All the same, the BOD content during both seasons in all the three points of sampling (i.e. at source, during transportation and at the point of use) were within the permissible limit of WHO.

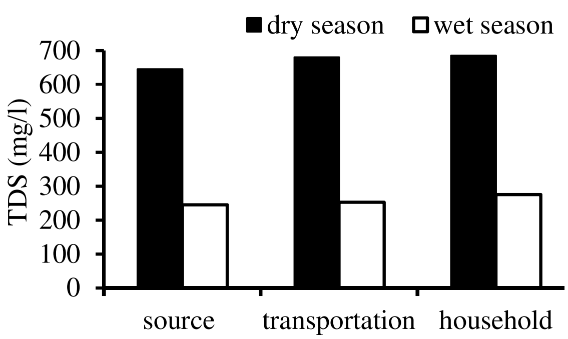

Figure 2: Mean concentration of TDS in vended water at each sampling point

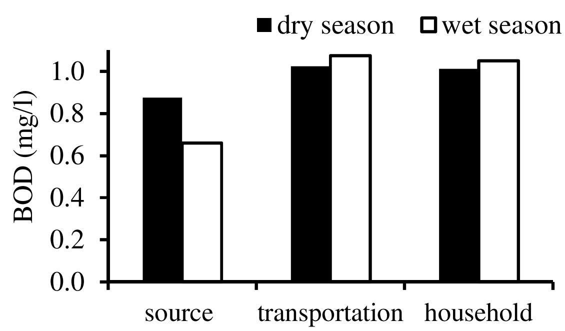

Figure 3: Mean concentration of BOD of vended water at each sampling point

3.3. Nitrate

Consumption of water with nitrate (NO_3) concentration above 50 mg/l, being the limit set by both WHO and NSDWQ may produce a disease known as methemoglobinemia (blue baby syndrome). Conversely, the concentrations of NO_3 in the borehole water that served as source of vended water were very minute during the dry and wet seasons (0.105 and 0.178 mg/l respectively) as shown in Figure 4. Hence, the NO_3 concentration of the source of vended water in the study area is said to be suitable for human health. Low concentration of NO_3 in the groundwater of Zaria metropolis had earlier been reported by Samuel (2013). Figure 4 informed that the NO_3 content of the vended water did not increase in the course of transportation and at the point of use (household). This is obvious because nitrate usually get increased in water when there is an inflow of nutrient especially from agricultural runoff, abattoir effluents, failed septic tanks as well as municipal effluents which are not obtainable when transporting water in jerry cans.

3.4. Phosphate

The concentrations of phosphate (PO_4) in the borehole that served as source of vended water were infinitesimal (approximately zero) as 0.0006 and 0.00068 mg/l were recorded during the dry and wet seasons respectively. The low concentrations of PO_4 at the source suggests that there is absence or little inflow of nutirent into the aquifer. The costant concentrations of PO_4 from the source to the point of use (household) as shown in Figure 5 could be attributed to the same reason responsible for nitrate (section 3.3).

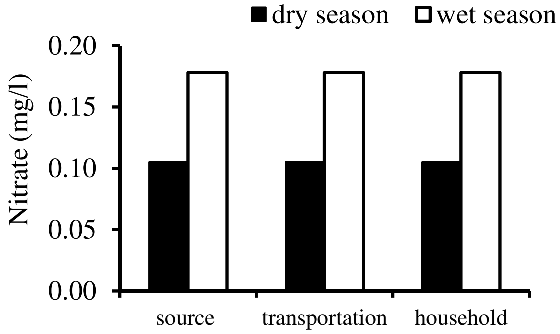

Figure 4: Mean concentration of NO_3 in vended water at each sampling point

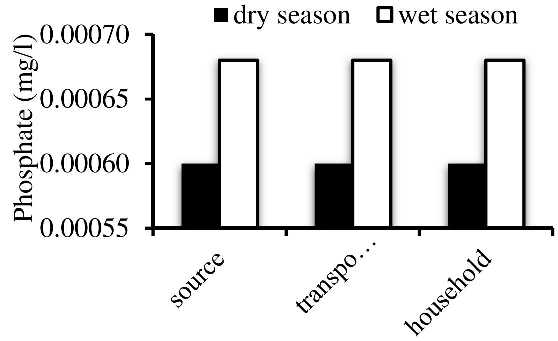

Figure 5: Mean concentration of PO_4 in vended water at each sampling point

3.5. pH

The pH of water is important because many biological activities can occur only within a narrow range, thus any variations beyond an acceptable limit could be fatal to a particular organism. In the present study, the pH of the borehole water (source) during both seasons were within the permissible limits set by WHO and NSDWQ (6.5 – 6.8) as could be seen in Figure 6. In addition, Figure 6 informed that the pH of the vended water during transportation and at the point of use (household) were the same as that of the source during both seasons. In other words, the vended water been distributed in the study area is safe in terms of pH. Atmospheric pollutants, mostly oxides of sulphur and nitrogen generated by anthropogenic activities such as burning of fossil fuels (coal, oil and gas), can cause precipitation to become acidic when converted to sulphuric and nitric acids. Hence, the drop in pH during the wet season could be attributed to the effect of groundwater recharge by acid rain. The drop in pH during the wet season agreed with the report of Ishaku (2012).

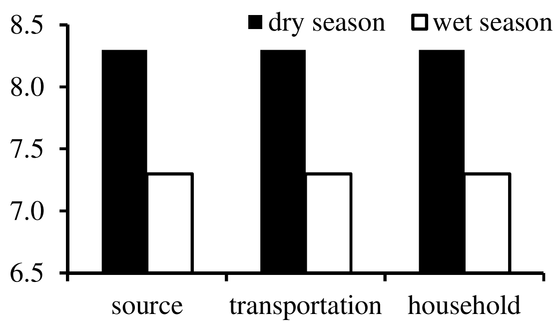

Figure 6: Mean pH value of vended water at each sampling point

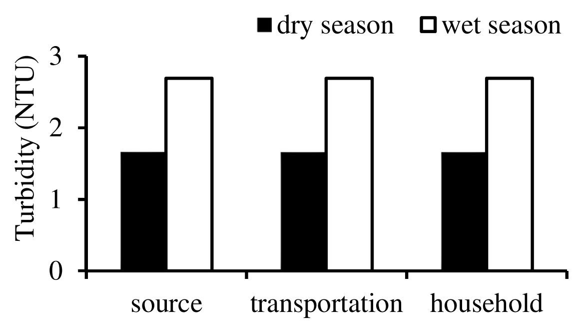

Figure 7: Mean turbidity of vended water at each sampling point

3.6. Turbidity

Turbidity measures the scattering and absorbing effect that suspended particles in water have on light. In other words, turbidity measures the clarity or cloudiness of water. Figure 7 indicates that during each season, the turbidity value of the vended water in all the points remained constant with a value accepted by WHO and NSDWQ (≤ 5 NTU). This suggests that the vended water did not get contaminated by turbidity causing materials in the course of transporting to household. However, the turbidity of the water was higher during the wet season. This might be as a result of increased infiltration into the aquifer during the wet season which increased the dissolution of substances that made the ground water turbid. On the contrary, during the dry season, there was virtually no infiltration into the aquifer hence, most of the dissolved substances settle down leading to a reduction in the overall turbidity of the water.

3.7. Colour

Consumers of vended water mostly used the colour or appearance of the water in ascertaining the fitness of the water for consumption. This is because potable water is supposed to be colourless hence, the perception of many people is that coloured water is not fit for consumption even if the water did not contain any toxic substance. However, colourless water might contain more toxic substances than certain coloured water. In other words, the impact of colour is more of aesthetic. Unlike the other parameters examined, the colour of the vended water is the same (5 TCU) irrespective of season and point of sampling as could be seen in Figure 8. Thus, suggesting that the hawking water vendors were careful enough in preserving the colour of the water during the period of transportation. Turbidity is a factor known to have influence on the colour or appearance of water however, the present study informed that the colour of the water samples were not influenced by their respective turbidity values. This could be linked to the accuracy of the device used in determining the colour of the water samples. Nevertheless, the colour of the vended water at each point of sampling during both seasons (5 TCU) is well acceptable by WHO and NSDWQ.

3.8. Total Coliform

The bacteriological results of the source of vended water (borehole) did not comply with the zero count per 100 ml for both regulatory bodies (WHO and NSDWQ) and this stands as a great health risk to consumers. The information in Figure 9 indicates that the groundwater contamination with coliform was higher during the wet season. This could be attributed to the recharge of groundwater by infiltrated rainfall already contaminated by bacteria at ground surface. It could also be inferred from Figure 9 that the bacteriological quality (total coliform) of the water deteriorated during the transportation period and got worst at the point of use (household) during both seasons. This might be due to the fact that bacteria proliferate with time once the environment is conducive. In addition, the deterioration during the transportation period as well as at the household suggests that the containers use in conveying as well as storing the vended water needs thorough and routine washing.

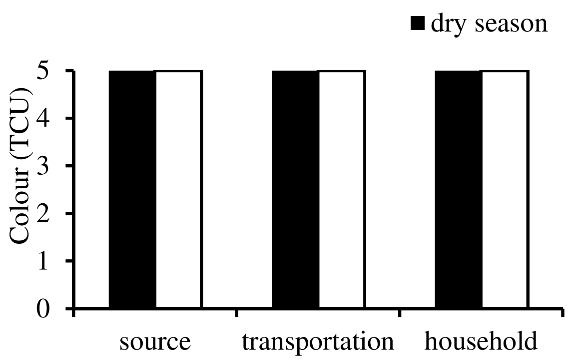

Figure 8: Mean colour of vended water at each sampling point

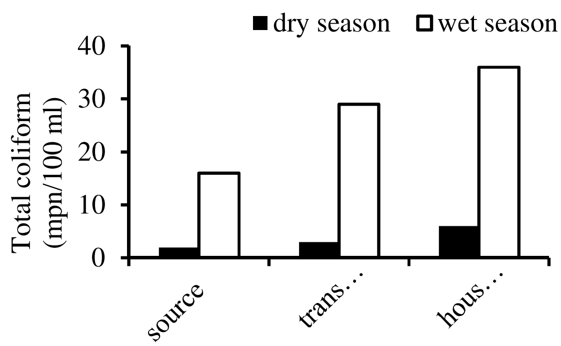

Figure 9: Mean concentration of total coliform in vended water at each sampling point

4. CONCLUSION

Vended water from the study area was found to be of good physicochemical quality as virtually all the physicochemical parameters fall within the permissible standard set by WHO and NSDWQ (apart from TDS during wet season). However, vended water in the study area is of poor microbial quality. This is evidenced by the high contamination level of the Total Coliform (TC) which was beyond the acceptable standard set by the WHO and NSDWQ in all the points of sampling during both seasons. This could enhance the susceptibility of the inhabitants to water-related diseases. Comparison of the water quality in the two seasons revealed that the quality of the vended water was better during the dry season, especially the coliform count. Hence, there is need to enlighten the inhabitants of the study area on the disinfection of vended water mostly during the rainy season before consumption.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

6. ACKNOWLEDGEMENT

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REFERENCES

American Public Health Association (APHA) (2012). Standard Methods for Examination of Water and Wastewater (22nd Edition). American Public Health Association (APHA), American Water Works Association (AWWA), Water Pollution Control Federation (WPCF), Washington DC.

Collins, C.C. (2017). Using Conventional Refraction Travel Time Plot to Establish the First Breaks of Refraction Events, Necessary for Tomography Inversion in Regions with Substantial Complexity. *Elixir Earth Science* 109, pp. 47952-47956.

Efe, S.I., Ogban, F.E, Horsfall, M Jnr. and Akporhonor, E.E. (2005). Seasonal Variations of Physico-chemical Characteristics in Water Resources Quality in Western Niger Delta Region, Nigeria. *Journal of Applied Sciences and Environmental Management,* 9 (1), pp. 191 – 195.

Hutin, Y., Luby, S., and Paquet, C. (2003). A Large Cholera Outbreak in Kano City, Nigeria: The Importance of Hand Washing with Soap and Dangers of Street-Vended Water. *Journal of Water and Health*, 1(1), pp. 45-52.

Ishaku, J.M. (2012). Investigation of Seasonal Variation of Groundwater Quality in Jimeta-Yola Area Northeastern Nigeria. *Global Journal of Geological Sciences,* 10(1), pp. 15-36.

Kjellen, M. (2006). From Public Pipes to Private Hands: Water Access and Distribution in Stockholm University, Dar es Salaam Tanzania, *Water Resources Development,* 16 (1), pp. 143- 154.

Ogbozige, F.J., Ibrahim, F.B. and Adie, D.B. (2018). Effect of Storage Time and Container Material on Potable Water Quality. *Ife Journal of Science and Technology,* 1(2), pp. 59-71.

Samuel, Y. (2013). Assessment of Water Quality of Hand-Dug Wells in Zaria LGA of Kaduna State, Nigeria. *International Journal of Engineering and Science,* 2(2), pp. 1-4.

Sola, A.P. and Adeniran, J.G. (2015). Global Climatic Change and Sustainable Water Management for Energy Production in the Niger Basin of Nigeria. *Earth Environmental Science,* 6(29), pp. 4275-4283.

Whittington, D., Lauria, D.T., Mu X. (2009). A study of Water Vending and Willingness to Pay for Water in Onitsha, Nigeria. *World Development*, 19 (2/3), pp. 179-198.

World Health Organization (WHO) (2015). Guidelines for Drinking Water Quality, Vol. 5, 2nd Edition. Health Criteria and Supporting Information. Genera, p. 271.