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Research Article
Water Quality of Different Brands of Packaged Water Consumed Within the University of Port Harcourt Community

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Abstract

Background and Objective: The quality of consumed water is a prevailing environmental determinant of health and a good foundation for preventing and control of water related diseases depends on the assurances of the drinking water safety. This study investigated the quality of selected brands of packaged water consumed within the University of Port Harcourt community, Rivers state, Nigeria. **Materials and Methods:** Water quality parameters such as physicochemical (temperature, electrical conductivity, total suspended solid (TSS), turbidity, total dissolved solid, odour, colour, taste, appearance, acidity, pH, chloride, sodium chloride, total alkalinity, total hardness, calcium hardness, magnesium hardness, total iron, sulphate, bicarbonate, saline and free ammonia, nitrate and dissolved free carbon IV oxide and microbiological (total and fecal coliform counts) were determined using standard procedures. **Results:** The results obtained from sachet and bottled water samples were compared to the reservoir water samples and set standards. Results showed both sachet and bottled water samples complied with set standards by World Health Organization (WHO) and Nigeria Standard for Drinking Water Quality (NSDWQ) for drinking water purposes indicative that the quality of the sachet and bottled water brands were healthy for human consumption. **Conclusion:** It is therefore imperative to enlighten consumers on the necessity to go for treated water to be used for drinking and domestic purposes.

Key words: Potable water, water quality, water analysis, packaged water, reservoir water, physicochemical analysis, bacteriological analysis

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Water is one of the most essential requirements needed by man for both domestic and commercial purposes and required for sustaining plant, animal and human life[1]. It plays a crucial role in the body metabolism and proper functioning of cells and abundant in nature occupying about 71% of the earth surface albeit only 1% is accessible for human consumption[2]. The quality of water is a major concern with reference to public health; as health and well being of the human populace is closely tied up with the quality of water human consume[3]. Sustaining good health for all humans requires good drinking water quality as this is important owing to its use for various purposes[4].

The natural resources that can be used as potable water without further treatment are very limited. Thus, before water can be described as potable, it has to comply with certain physical, chemical and microbiological standards, which are designed to ensure that the water is safe for drinking[5]. These standards are defined globally by potable water standards issued by WHO[6] and NSDWQ[7]. These standards generally conformed that potable water must be clear, physiologically and hygienically sound, palatable, neutral in smell, have taste appeal before it is drunk and must not be too salty.

According to WHO[6], about 80% of sicknesses and deaths among children in the world are caused by unsafe drinking water. It is therefore imperative, that water be examined regularly as contamination may be intermittent and may not be detected without standard tests. It has also been reported that 780 million people worldwide do not have access to improved water source[8] and an estimated 2.5 billion people lack access to improved sanitation (more than 35% of the world's population)[9]. Sub-Saharan Africa (31%), Southern Asia (33%) and Eastern Asia (65%) were the indicated regions with the lowest coverage of improved sanitation in 2006 and seven out of ten people without access to improved sanitation were rural inhabitants[8].

Liu *et al.*[10] reported that an estimated 801,000 children younger than 5 years of age perish from diarrhea each year, mostly in developing counties. This is about 11% of the 7.6 million deaths of children under the age of five and shows that 2,200 children are dying every day as a result of diarrheal disease. Prüss-Üstün *et al.*[9] thus stated that unsafe drinking water, inadequate availability of water for hygiene and lack of access to sanitation together contribute to about 88% of death from diarrheal diseases. This study was therefore carried out to investigate the quality of packaged water consumed within the University of Port Harcourt community as it is imperative to ensure that water generally consumed conforms to set standards.

MATERIALS AND METHODS

Study area: The University of Port Harcourt, Port Harcourt, Rivers State of Nigeria, is a public institution of higher learning. It is located (4.9069°N, 6.9170°E) along the East/West road of Choba community, a community 20 km north-west of the Garden city of Port Harcourt, the oil and gas capital of Nigeria. Sampling for the packaged water was carried out at her three campuses; Abuja, Choba and Delta, while sampling of the reservoir water was done at the factories of the selected brands.

Sampling: To ensure adequately representative sampling, a preliminary survey was carried out before selection of the water brands to be analyzed. Geographical zoning was done using the location of the three campuses . Inquiries were also undertaken at randomly chosen locations, such as restaurants, students' hostels, senior staff quarters, retail and wholesale outlets to identify popular brand names commonly patronized in the market zones of the study area. Following this procedure, four brands of packaged water were identified. Water samples were collected for both physico-chemical and bacteriological analysis. A total of 9 samples (three from sachet, three from bottled and three from reservoir) from each identified brand with the exception of one brand from which just six samples (three from sachet and three from bottled) were collected which accounted for 33 water samples analyzed. Samples were collected aseptically in sterile containers during the day between 9:00 and 13:00 h, labeled appropriately and transferred to the laboratory for analyses.

Physical examination: This involved visual examination of features external to the water itself such as the label, presence of certification number and other product information. Specific odour and appearance (colour, turbidity and presence and/or absence of floating particles or extraneous materials) were also noted following the method described by Oyeku *et al.*[11].

Laboratory analyses

Physicochemical: The physicochemical tests included the determination of turbidity, odour, colour, total dissolved solid, total suspended solid, pH, conductivity, acidity, chloride, sodium chloride, total alkalinity, total hardness, calcium hardness, magnesium hardness, total iron, sulphate, bicarbonate ion, saline and free ammonia, nitrate and dissolved free CO_2, using analytical methods that complied with WHO and NSDWQ standard[6,7].

Bacteriological: The total and fecal coliform counts were determined using nutrient broth employing the pour plate technique[7]. For total coliform count, incubation was carried out at 44°C for 24 h, while for faecal coliform count incubation was carried out at 37°C for 24 h. Observation of different colour spots indicated the different species.

RESULTS AND DISCUSSION

The physicochemical analyses (colour, odour, turbidity, total dissolved solid, total suspended solid, total hardness, calcium hardness, magnesium hardness, acidity, chloride, total iron, sodium chloride, total alkalinity, pH, sulphate, bicarbonate ion, saline and free ammonia, nitrate, taste, appearance and dissolved free CO_2) were presented in Table 1-3. Compared to the set limits of 6.5-8.5 by NSDWQ[7]

Table 1: Physicochemical analysis of sachet water samples

Parameters	Sample A sachet water 1	Sample B sachet water 2	Sample C sachet water 3	Sample D sachet water 4	WHO standard	NSDWQ standard
pH	6.98	6.26	7.20	7.10	6.5-8.5	6.5-8.5
Conductivity (µS/cm)	37.0	22.6	146.1	72.0	1000	1000
Colour (HU)	5	5	5	5	15	15
Odour	U	U	U	U	U	U
Turbidity (NTU)	0.73	0.33	0.81	0.27	6.0	5.0
TSS (mg L^{-1})	0.05	0.05	0.05	0.05	2.5	2.5
TDS (mg L^{-1})	9	11	8	9	500	500
Acidity	25	28	18	12	Ns	Ns
Total hardness (mg L^{-1})	24	20	28	25	150	150
Ca^{2+} hardness (mg L^{-1})	14	12	18	15	75	Ns
Mg^{2+} hardness (mg L^{-1})	10	8	10	10	50	50
Chloride (mg L^{-1})	2.3	2.5	2.0	2.1	250	230
Sodium chloride (mg L^{-1})	2.8	3.0	2.1	3.5	150	250
Total alkalinity (mg L^{-1})	37	34	40	40	500	Ns
Total iron (mg L^{-1})	0.001	0.001	0.001	0.001	0.3	0.3
SO_4^{2-} (mg L^{-1})	0.08	0.07	0.08	0.07	250	100
HCO^{3-} (mg L^{-1})	37	34	40	40	Ns	Ns
Saline and free ammonia (mg L^{-1})	Nil	Nil	Nil	Nil	Ns	0.05
Nitrate (mg L^{-1})	0.01	0.01	Nil	0.01	50	50
Dissolved free CO_2 (mg L^{-1})	20	22	16	-	Ns	Ns
Taste	U	U	U	U	Ns	Ns
Appearance	Clear	Clear	Clear	Clear	Ns	Ns

Values are mean of triplicate determinations, U: Un-objectionable, NS: No standard

Table 2: Physicochemical analysis of bottled water samples

Parameters	Sample E bottled water 1	Sample F bottled water 2	Sample G bottled water 3	Sample H bottled water 4	WHO standard	NSDWQ standard
pH	6.70	6.30	6.70	6.55	6.5-8.5	6.5-8.5
Conductivity (µS cm^{-1})	63.5	77.6	169.1	130.0	1000	1000
Colour (HU)	5	5	5	5	15	15
Odour	U	U	U	U	U	U
Turbidity (NTU)	0.36	0.38	0.20	0.37	6.0	5.0
TSS (mg L^{-1})	0.05	0.05	0.05	0.05	2.5	2.5
TDS (mg L^{-1})	7	8	7	9	500	500
Acidity	14	13	14	20	Ns	Ns
Total hardness (mg L^{-1})	20	18	20	40	150	150
Ca^{2+} hardness (mg L^{-1})	12	13	12	30	75	Ns
Mg^{2+} hardness (mg L^{-1})	8	5	8	10	50	50
Chloride (mg L^{-1})	2.3	2.9	3.0	2.1	250	230
Sodium chloride (mg L^{-1})	4.0	4.6	4.0	2.8	150	250
Total alkalinity (mg L^{-1})	38	35	38	35	500	Ns
Total iron (mg L^{-1})	0.001	0.001	0.001	0.001	0.3	0.3
SO_4^{2-} (mg L^{-1})	0.08	0.08	0.08	1.20	250	100
HCO^{3-} (mg L^{-1})	38	35	40	35	Ns	Ns
Saline and free ammonia (mg L^{-1})	Nil	Nil	Nil	Nil	Ns	0.05
Nitrate (mg L^{-1})	0.01	0.01	0.01	0.01	50	50
Dissolved free CO_2 (mg L^{-1})	-	-	-	15	Ns	Ns
Taste	U	U	U	U	Ns	Ns
Appearance	Clear	Clear	Clear	Clear	Ns	Ns

Values are mean of triplicate determinations, U: Un-objectionable, NS: No standard

Table 3: Physicochemical analysis of reservoir water samples

Parameters	Sample I reservoir water 1	Sample J reservoir water 2	Sample K reservoir water 3	WHO standard	NSDWQ standard
pH	6.30	5.80	4.70	6.5-8.5	6.5-8.5
Conductivity ($\mu S\ cm^{-1}$)	63.4	48.8	288.0	1000	1000
Colour (HU)	5	5	5	15	15
Odour	U	U	U	U	U
Turbidity (NTU)	0.12	0.12	0.20	6.0	5.0
TSS ($mg\ L^{-1}$)	0.05	0.20	0.20	2.5	2.5
TDS ($mg\ L^{-1}$)	11	14	14	500	500
Acidity	22	37	40	Ns	Ns
Total hardness ($mg\ L^{-1}$)	26	9	9	150	150
Ca^{2+} hardness ($mg\ L^{-1}$)	15	7	17	75	Ns
Mg^{2+} hardness ($mg\ L^{-1}$)	11	2	2	50	50
Chloride ($mg\ L^{-1}$)	2.9	4.0	4.0	250	230
Sodium chloride ($mg\ L^{-1}$)	3.0	6.1	6.2	150	250
Total alkalinity ($mg\ L^{-1}$)	33	10	10	500	Ns
Total iron ($mg\ L^{-1}$)	0.001	0.01	0.01	0.3	0.3
SO_4^{2-} ($mg\ L^{-1}$)	1.0	0.08	0.08	250	100
HCO^{3-} ($mg\ L^{-1}$)	33	10	10	Ns	Ns
Saline and free ammonia ($mg\ L^{-1}$)	Nil	0.1	0.1	Ns	0.05
Nitrate ($mg\ L^{-1}$)	0.01	3.2	3.2	50	50
Dissolved free CO_2 ($mg\ L^{-1}$)	17	30	35	Ns	Ns
Taste	U	U	U	Ns	Ns
Appearance	Clear	Clear	Clear	Ns	Ns

Values are mean of triplicate determinations, U: Un-objectionable, NS: No standard

Table 4: Bacteriological analysis of sachet water samples

Sample code	Sachet water	Total coliform count ($mg\ L^{-1}$)	Faecal coliform count ($mg\ L^{-1}$)
L	1	Nil	Nil
M	2	Nil	Nil
N	3	Nil	Nil
O	4	Nil	Nil
	WHO standard	Nil/100 $mg\ L^{-1}$	Nil/100 $mg\ L^{-1}$
	NSDWQ standard	Nil/100 $mg\ L^{-1}$	Nil/100 $mg\ L^{-1}$

Values are mean of triplicate determinations

Table 5: Bacteriological analysis of bottled water samples

Sample code	Sachet water	Total coliform count ($mg\ L^{-1}$)	Faecal coliform count ($mg\ L^{-1}$)
P	Bottled water 1	Nil	Nil
Q	Bottled water 2	Nil	Nil
R	Bottled water 3	Nil	Nil
S	Bottled water 4	Nil	Nil
	WHO standard	Nil/100 $mg\ L^{-1}$	Nil/100 $mg\ L^{-1}$
	NSDWQ standard	Nil/100 $mg\ L^{-1}$	Nil/100 $mg\ L^{-1}$

Values are mean of triplicate determinations

Table 6: Bacteriological analysis of reservoir water samples

Sample code	Sachet water	Total coliform count ($mg\ L^{-1}$)	Faecal coliform count ($mg\ L^{-1}$)
T	Reservoir water 1	Nil	Nil
U	Reservoir water 2	1	Nil
V	Reservoir water 3	3	Nil
	WHO standard	Nil/100 $mg\ L^{-1}$	Nil/100 $mg\ L^{-1}$
	NSDWQ standard	Nil/100 $mg\ L^{-1}$	Nil/100 $mg\ L^{-1}$

Values are mean of triplicate determinations

and WHO[12], the pH and turbidity of the sachet and bottled water samples conformed to the stipulated limits for suitable drinking water and this corroborates reports of Singworth[13], Hale *et al.*[14] and Sheshe and Magashie[15]. Colour, taste, appearance, odour, total hardness, Ca^{2+} and Mg^{2+} hardness, the total iron content, saline and free ammonia, total alkalinity, sulphate content, nitrate content, total dissolved solid and total suspended solid observed in the sachet and bottled water samples were in agreement with the set standard. The microbiological analyses (total and fecal coliform counts) were presented in Table 4-6. The total and fecal coliform counts for the packaged water samples were below the

NSDWQ[7], WHO[12], EPA[16] and maximum contamination level (MCL) for coliform bacteria in drinking water of zero per 100 mg L^{-1}. The results for all the parameters analyzed conform to the findings of Orlu *et al.*[17], albeit recording contrary findings for pH and bacteria levels.

CONCLUSION

Overall, the quality of packaged water samples analyzed are in agreement with WHO and NSDWQ standards, indicating compliance by the water-producing companies in ensuring safe water for consumption and other related purposes. Nonetheless, there is an urgent need for awareness to be created about the present sanitation of drinking water, to enlighten the people on the necessity to go for treated water to be used for drinking and domestic purposes.

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