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Physico-Chemical and Microbiological Analyses of some Packaged Water Samples sold in Akure, Nigeria

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ABSTRACT

Potable water is essential to living things and the desire for quality water on daily basis is therefore on the rise. Four sachet and two bottled water brands were purchased from a store within The Federal University of Technology, Akure, Nigeria and were analysed for their physicochemical and microbiological parameters using standard analytical procedures. The samples were odourless and without colour. The pH values ranged between 7.32 – 7.84, the electrical conductivity ranged from 60 -161µS/cm, and the turbidity ranged from 0.3 – 0.4 NTU. The values obtained for pH, conductivity and turbidity were within the permissible limits specified by the World Health Organization (WHO). The acidity and alkalinity of the water samples were in the ranges of 10.8 – 27.36 and 113 – 232.26 mg/L, respectively, which were also within the recommended limits of WHO. Other parameters such as total suspended solids (TSS) recorded 20 – 120 mg/L; total dissolved solids (TDS) (100 – 120 mg/L); total solids (TS) (160 – 220 mg/L); dissolved oxygen (DO) (1.0 – 1.4 mg/L); biochemical oxygen demand (BOD) (0.1 – 0.2 mg/L); Nitrate (BDL – 7.5 mg/L); Chloride (12.24 – 34.40 mg/L); Sulphate (5.0 – 23.30 mg/L); and Phosphate (BDL – 5.0 mg/L) conformed to WHO permissible limits. Total Coliform and metal contents for the packaged water samples were within WHO permissible limits except sample B that has higher lead content. All the packaged water samples analysed were found to be within the permissible limits stated by WHO except sample B (sachet water) which had a relatively high lead content.

Keywords: *physico-chemical parameters, standards, packaged water, coliform*

INTRODUCTION

Water is an important component among natural resources and is essential for the existence of all living organisms. Water is a commodity with many uses such as transportation, electricity generation, agricultural uses, industrial application and sometimes recreation [1]. Fresh water supports life; without adequate clean and fresh water, sustainable development may be so difficult. Since life and water relationship cannot be overemphasised, it is therefore necessary to constantly consume quality water to maintain body system by keeping it properly hydrated. Fresh water is an antidote to fatigue, joint pain, and headaches and so on. Water is very useful for navigation. It plays a major role for the survival of fishes and wildlife [2].

Water in its natural form contains different impurities that are being introduced through different natural and artificial activities which include, soil leaching, weathering, aerosol particles dissolution, mining of natural minerals, using metals as precursor to finished materials [3]. The uncontrolled application of metal-based materials in industries and in agriculture could lead to upward turn in the concentrations of toxic materials even in fresh water as water run-offs most times end up in water bodies. Another major concern in fresh water is the level of faecal matters being introduced into water bodies via septic tank and sometimes open defecation. These render water unfit for human consumption and cause cholera, typhoid fever among other infections [4]. Industrial revolution has in no small measure generated effluents and other waste materials which negatively affect water bodies, most especially when the discharged materials are left untreated before being released into the environment [4]. Effluents from industries have been rocking the wholesomeness of water bodies, most especially in big towns and cities. African and Asian nations are undergoing rapid industrial revolution, making conservation of the environment a big issue. Human and animal lives are being threatened due to the changes in the physico-chemical and microbiological parameters of water and other natural endowments [5]. It is worthy of note that many educated people prefer packaged water to other sources from quality perspectives; it is therefore imperative to examine the status of some of these packaged water brands consumed at the Federal University of Technology, Akure, Nigeria as this will enable the consumers to safeguard their individual health.

MATERIALS AND METHODS

Scope of study

The study was carried out on a laboratory scale at Chemistry Department, The Federal University of Technology Akure, Nigeria. Six different water brands sold within Akure Township in Nigeria were purchased. Four of the brands were sachet water while two were bottled water (Table 1). The water samples were preserved according to the methods described by Bezuidenhout *et al.* [6].

Table 1 Description of water samples

Sample code	Type of sample
A	sachet water
B	sachet water
C	bottled water
D	sachet water
E	sachet water
F	bottled water

Physicochemical analysis

Various parameters such as pH; turbidity; conductivity; acidity and alkalinity; total solids; chloride, sulphate, nitrate, and phosphate contents; dissolved oxygen (DO); biochemical oxygen demand (BOD); calcium, magnesium and total hardness; and conductivity were analyzed using standard analytical procedures described by Bezuidenhout *et al.* [6].

The physico-chemical parameters were subjected to statistical analysis using SPSS (IBM SPSS Statistics 21).

Determination of heavy metals

Fifty cubic centimetre (50 cm^3) of water sample was accurately measured and transferred into an evaporating dish, 5 cm^3 of concentrated HNO_3 was added and the solution was evaporated to near dryness in a fume cupboard. The remaining solution was then made up to the mark in a 250 cm^3 volumetric flask with distilled water. 50 cm^3 of the solution was measured and analysed for metal analysis using Atomic Absorption Spectrometer (AAS Buck Scientific 210/211 VGP), while the alkali metals were determined using a Flame Photometer (FP 640).

Microbiological analysis

Standard method [7] was used for the sampling and the microbial assessment of the water samples. Total heterotrophic bacteria (THB) and total coliforms (TC) were determined using nutrient agar medium and most probable number (MPN), respectively. Total coliform was carried out using 5-tubes MPN dilution method with MacConkey broth. 10, 1, and 0.1 mL of each water sample in respective dilution tubes containing inverted Durham's tubes were incubated at 37 ^oC for 48 h as described by Prescott *et al.* [8]. Formation of gas after incubation was presumed to be due to coliforms in the water sample. The most probable number in 100 mL of each sample was determined by matching the number of positive tubes with the Macready's statistical table [9]. Estimation of *E. coli* count of the samples was carried out using ten-fold dilution procedures in test tubes. 1 mL of the diluted sample was incubated at 37 ^oC for 24 h in sterile eosin methylene blue using pour plate method and the number of colonies for the sample was counted.

RESULTS AND DISCUSSION

The results of physico-chemical analysis of the water samples are presented in Table 2. The pH values of the samples ranged from 6.70 - 7.32, the highest pH was recorded for sample C while the lowest pH values were recorded for samples E and F. The values of pH for all the samples were within WHO permissible limits of 6.5 - 8.5 mg/L for potable water.

The lowest and highest desirable limits of alkalinity in potable water are 100 and 250mg/L according to WHO [10]. The alkalinity values of the samples ranged from 37.8 - 232.26 mg/L with samples C and B having the lowest (37.8 mg/L) and the highest (232.26 mg/L) values, respectively. The low value of Sample C compared to the WHO permissible limits could be as a result of low level salts in the water source. Ademoroti [11] reported that alkalinity in water is most times due to the presence of natural salt present in water sources. The various ionic species that contribute to the presence of alkalinity include bicarbonate, hydroxide, phosphate, borate and organic acids.

The Conductivity (60 – 212 μS/cm) and turbidity (0.3 – 0.4) values of all the water samples fell within the WHO permissible limits. Conductivity is directly linked with total dissolved solids (TDS), and it has to do with salinity which affects the taste of potable water. Conductivity is the ability of a solution to conduct electrical charge or ions within it [12].

The WHO maximum permissible limit for chloride is 250 mg/L. The chloride values obtained for the six water samples were within the permissible limits. The reduced level of chloride in a water sample may be due to inadequate natural processes such as the passage of water through natural salt formation in the earth, while high chloride value on the other side may be an indication of pollution from industrial or domestic sources. Chloride concentration in water could be as a result of the discharge of domestic waste containing a large amount of chlorides [13].

The results for total hardness in the samples were within WHO permissible limit which show that they are good for consumption. Values of calcium hardness in the six samples were below the WHO's minimum permissible limit (75 mg/L). The low values of calcium could be as a result of low leaching of calcium compounds within the soil. Magnesium hardness in the water samples ranged from 21.0 – 47.1 mg/L. Since the values were lower than the maximum permissible limit of 100 mg/L stipulated by WHO, it implies that the water samples are not hard but soft. WHO [14] reported that high magnesium content in water contributes highly to the hardness of water as well as total dissolved solids.

Phosphate was not detectable in samples A, B, C, and F but was detected in samples D and E. Absence of phosphate in samples A, B, C, and F is probably due to little or no pollution around the sources or locations of the water samples. Values of phosphate recorded in samples D and E could be as a result of domestic waste around the packaged water locations. Korostynska *et al.* [15] reported that phosphate level could increase to toxic level in water as a result of constant domestic waste disposal and runoff from fertilizers containing phosphates.

Sulphate was detected in Samples A, D, E, and F, with values ranging from 5.0 to 23.30 mg/L, but was below detection limit in samples B and C. High sulphate in water arises from the discharge of sulphate containing wastes, and runoffs conveying organic fertilizers from farmland [16]. Sulphate concentration according to Manivasakam [17] is within the range of 2 to 80 mg/L

Samples A, B and D showed the presence of nitrate while it was below detection limit in samples C, E and F. The absence of nitrate in the three samples could be as a result of reduced activity of nitrifying bacteria in the packaged water locations.

Dissolved oxygen (DO) plays an important role in water quality as inadequate oxygen in the body leads to red blood cell defect [18]. Consuming water with low level of dissolved oxygen will further complicate the defect in the red blood cells. The DO values of the water samples ranged from 1.0 – 1.4 mg/L which were lower than the maximum permissible limit of 5 mg/L stated by WHO. The lower the dissolved oxygen in water, the higher the level of pollution [18].

Biochemical oxygen demand values of the water samples ranged from 0.1 – 0.2 mg/L which were within the permissible limit stated by WHO (BOD < 3). This implies that there are little or no organic pollutants in the packaged water brands.

The total suspended solids (TSS), total solids (TS), total dissolved solids (TDS) values ranged from 20 – 120, 120 – 220, and 100 – 120 mg/L, respectively. All the values were lower than the maximum limits of WHO. TSS content of water depends on the amounts of particle, soil and silt suspended in water and affects turbidity of water [16].

Table 2 Physico-chemical parameters of six packaged water samples sold in Akure, Nigeria

Parameters	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	WHO (2008)
pH	7.43	7.84	6.70	7.38	7.32	7.32	6.5-8.5
Turbidity (NTU)	0.30	0.30	0.40	0.30	0.30	0.30	5.0
Alkalinity (mg/L)	181.86	232.26	37.8	113.4	151.2	130.2	100-250
Acidity (mg/L)	20.16	27.36	15.48	14.4	10.8	18.0	4.5-82
Chloride (mg/L)	14.26	12.24	25.90	30.6	34.4	29.4	250
Ca^{2+} hardness (mg/L)	42.90	54.90	48.8	25.5	33	27	75-200
Mg^{2+} hardness (mg/L)	32.10	47.10	39.7	24.5	22	21	100
Total Hardness (mg/L)	75	102	88.5	50	55	48	200
Conductivity (µS/cm)	161	212	60	149	151	128	400
Phosphate (mg/L)	BDL	BDL	BDL	5.0	5.0	BDL	-
Nitrate (mg/L)	0.03	0.13	BDL	7.5	BDL	BDL	50
Sulphate (mg/L)	23.30	BDL	BDL	10.0	5.0	10.0	200
DO (mg/L)	1.0	1.2	1.4	1.0	1.2	1.4	5
BOD (mg/L)	0.2	0.1	0.2	0.2	0.1	0.2	3.0
TS (mg/L)	160	190	120	160	200	220	1000
TDS (mg/L)	120	120	100	120	120	100	500
TSS (mg/L)	40	70	20	40	80	120	500

BDL: below detection limit

Table 3 Correlation matrix of physicochemical parameters analysed in the water samples sold in Akure

	pH	Turb.	Alkal.	Total Hard.	Acid .	Ca^{2+}	Cl^-	Mg^{2+}	Cond.	PO_4^{3-}	NO_3^-	SO_4^{2-}	DO	BOD	TS	TDS	TSS
pH	1	-.85*	.95**	0.11	0.62	0.08	-0.48	0.14	.99**	0.04	0.08	0.16	-0.48	-0.53	0.60	0.68	0.40
Turb.		1	-0.77	0.41	-0.19	0.41	0.08	0.40	-.83*	-0.32	-0.21	-0.45	0.56	0.32	-0.76	-0.63	-0.57
Alkal.			1	0.25	0.66	0.26	-0.60	0.23	.96**	-0.10	-0.19	0.21	-0.43	-0.60	0.56	0.67	0.37
Total Hardness				1	0.70	.99**	-0.78	.99**	0.15	-0.60	-0.42	-0.38	0.12	-0.30	-0.42	0.05	-0.43
Acid.					1	0.65	-.90*	0.73	0.58	-0.69	-0.27	-0.03	-0.04	-0.19	0.12	0.13	0.08
Ca^{2+}						1	-0.77	.95**	0.14	-0.61	-0.53	-0.34	0.14	-0.34	-0.39	0.05	-0.41
Cl^-							1	-0.78	-0.49	0.68	0.32	-0.20	0.26	0.10	0.17	-0.27	0.24
Mg^{2+}								1	0.17	-0.57	-0.29	-0.41	0.09	-0.26	-0.44	0.05	-0.45
Cond.									1	0.10	0.07	0.16	-0.55	-0.59	0.54	0.77	0.31
PO_4^{3-}										1	0.63	-0.05	-0.43	-0.25	0.11	0.50	-0.04
NO_3^-											1	0.11	-0.55	0.31	-0.20	0.32	-0.30
SO_4^{2-}												1	-0.60	0.49	0.05	0.27	-0.03
DO													1	0	0.13	-.87*	0.37
BOD														1	-0.44	-0.50	-0.28
TS															1	0.11	.96**
TDS																1	-0.18
TSS																	1

*. Correlation is significant at the 0.05 level (2-tailed)

**. Correlation is significant at the 0.01 level (2-tailed)

Table 4 Metal concentrations (mg/L) in the packaged water samples sold in Akure, Nigeria

Parameters	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	WHO (2008)
K	2.02	3.32	0.31	2.01	5.72	0.50	-
Na	6.63	6.68	0.88	8.62	5.11	0.50	0 - 200
Mn	BDL	BDL	BDL	BDL	BDL	BDL	0 - 0.05
Fe	0.10	0.11	BDL	0.10	0.10	BDL	0.3
Cu	BDL	BDL	BDL	0.01	0.06	0.02	1.0
Zn	0.01	0.02	0.02	0.17	0.07	0.05	0. 5
Cr	BDL	BDL	BDL	BDL	0.02	BDL	0.05
Pb	BDL	0.69	BDL	BDL	BDL	BDL	0.05
Ni	BDL	BDL	BDL	BDL	0.01	BDL	0 - 0.02

BDL: Below detection limit

Table 3 shows the correlation matrix of physicochemical parameters of the water samples. There was positive correlation between pH and alkalinity (r = 0.95); pH and conductivity (r = 0.99); alkalinity and conductivity (r = 0.96); total hardness and calcilum hardness (r = 0.99); total hardness and magnesium hardness (r = 0.99); calcium hardness and magnesium hardness (r = 0.95); total solids and total suspended solids (r = 0.96). Meanwhile there was negative correlation between pH and turbidity (r = -0.85); turbidity and conductivity (r = -0.83); dissolved oxygen and total dissolved solids (r = -0.87). The negative correlation could be as a result of different pollution loads inherent from the packaged water sites.

Table 4 shows the levels of metals (K, Na, Mn, Fe, Cu, Zn, Cr, Pb, and Ni) in the six packaged water samples. Mn was not detectable in all the water samples. The concentration of iron was within permissible limit of WHO but below detection limits in samples C and F. High iron concentration could impact taste to water. However, the levels of iron in samples A, B, D, and E were not above the permissible limit of 0.3 mg/L stipulated by WHO. Iron in high amounts affects the taste of beverages. It also contributes to the growth of bacteria in water which makes water distasteful [19].

The presence of lead in sample B with a value of 0.69 mg/L which is higher than 0.05 mg/L specified by WHO poses a great risk to human health, although it was not detectable in the remaining packaged water samples. The high content of lead in water could be caused by incessant refuse and sewage disposal which could invariably seep into the water source. Washing and dumping of pigments such as paint materials close to the water source could also contribute to the high level of lead in the water. Sunday and Innocent [20] reported that high concentration of lead in human causes cancer, anaemia etc.

The concentration of zinc was below the maximum permissible limit of 0.5 mg/L stated by WHO. Though zinc is important in human's diet, zinc deficiency causes retardation of growth of foetus during pregnancy. High concentration of zinc in human challenges health, causing anaemia; it affects vital organs like pancreas and kidney [21].

Copper was not detectable in samples A, B, and C but was detected in samples D, E, and F though their levels were below the maximum permissible limit set by WHO. This implies that the packaged water samples are free

Table 5 Microbial analysis of packaged water samples sold in Akure, Nigeria

Water Sample	Heterotrophic Count	*E. Coli* Count	MPN
A	ND	ND	ND
B	ND	ND	ND
C	ND	ND	ND
D	ND	ND	ND
E	ND	ND	ND
F	ND	ND	ND

ND: not detectable from copper poisoning.

MPN = most probable number

Table 5 shows the microbial loads of the six packaged water samples. Bacterial count, heterotrophic count and the total coliforms were not detectable in all the samples which indicate that the packaged water brands are free from bacteriological infringement.

CONCLUSION

Generally, from the results obtained for the physicochemical and microbial analyses of the six packaged water samples. It can be concluded that most of the samples conformed to the standards for drinking water as stipulated by the World Health Organization. Only sample B gave a high value of lead which was higher than the maximum permissible limit. Hence, there is the need to ascertain how such high level of lead was present in the sachet water.

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