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Quality evaluation of commercially sold table water samples in Michael Okpara University of Agriculture, Umudike, Nigeria and surrounding environments

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ABSTRACT

In Michael Okpara University of Agriculture, Umudike, Nigeria (MOUAU) and surrounding environments, table water of different brands is commercially hawked by vendors. To the best of our knowledge, there is no scientific documentation on the quality of these water samples. Hence this study which evaluated the quality of different brands of water samples commercially sold in MOUAU and surrounding environments. The physicochemical properties (pH, total dissolved solids (TDS), biochemical oxygen demand (BOD), total hardness, dissolved oxygen, Cl, NO_3, ammonium nitrogen (NH_3N), turbidity, total suspended solids (TSS), Ca, Mg, Na and K) of the water samples as indices of their quality were carried out using standard techniques. Results obtained from this study indicated that most of the chemical constituents of these table water samples commercially sold in Umudike environment conformed to the standards given by the Nigerian Industrial Standard (NIS), World Health Organization (WHO) and American Public Health Association (APHA), respectively, while values obtained for ammonium nitrogen in these water samples calls for serious checks on methods of their production and delivery to the end users.

1. Introduction

It has been established that water with good quality produces healthier humans than one with poor quality [1]. Water quality is essentially determined by its physical, chemical as well as microbiological characteristics [2]. Such water should be palatable, oxygenated, colorless, odorless, and free from harmful organisms and salts of heavy metals. However, the quality of water, both for drinking and other uses deteriorates due to inadequacy of treatment plants, direct discharge of untreated sewage into rivers and stream in addition to inefficient management of piped water distribution system [3]. This therefore has serious health implications for the users.

The ability to control the quality of water is based on routine tests, the results of which are compared with established standards. Chemical and microbial analysis can thus give an idea of the possibility of water being polluted, the extent of its pollution and the possibility of it containing pathogenic micro-organisms [4,5].

In the chemical analysis of water, the major parameters commonly analyzed for include: Ca^{2+}, Mg^{2+}, CO_3^{2-}, SO_4^{2-}, total hardness as $CaCO_3$, Mg-hardness, as well as minor ions such as: Fe^{2+}, Fe^{3+}, NO_3, NH_3 (Nitrate and Ammonia) and Nitrogen. These ions are important parameters because of their sensitive effects on human health [6].

In Michael Okpara University of Agriculture, Umudike, Nigeria and surrounding environments, table water of different brands is commercially hawked by vendors. To the best of our knowledge, there is no scientific documentation on the quality of these water

Abbreviations: Ca^{2+}, calcium ion; Cl^-, chloride ion; Mg^{2+}, magnesium ion; Na^+, sodium ion; K^+, potassium ion; BOD, biochemical oxygen demand; NH_3-N, ammonium nitrogen; SO_4^{2-}, sulphate ion; EDTA, ethylenediaminetetraacetic acid.

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samples. The fact that there have been occasional reports of food poisoning among people residing within the study area underscores the need for analysis of these water samples.

In order to ensure that these water samples do not contain contaminants that exceed the health based standards as stipulated by APHA [4], WHO [10,11] and NIS [12] thereby indicating health risk for the consumer, this study was set up to investigate the physicochemical properties of these water samples.

2. Materials and methods

The water samples that were used for the experiment were randomly collected from three branded table water samples- MOUAU table water, Aqua table water and Mowo table water commercially sold in Umudike environment.

3. Sampling procedures and analysis

The chemical analysis of the water samples was carried out at the Chemistry Laboratory of National Root Crops Research Institute, Umudike, Umuahia, Abia State, Nigeria. Analysis was done approximately 24 h after collection of the samples.

4. Physicochemical analysis

The pH of the water samples was determined using a pH meter (Hana 211), the Brucine method [7] was used for determination of nitrates, the Mohr's argentometric titration method [8] was used for the determination of chlorides, measurement of turbidity was carried out using a turbidity meter, the Winkler method with azide modification [4] was used for the determination of dissolved oxygen, total hardness was determined using the EDTA titrimetric method [4], the gravimetric method was used for the determination of total dissolved solids (TDS) and total suspended solids (TSS), the Winkler method [4] was used in the determination of the biochemical oxygen demand (BOD), ammonium nitrogen (NH_3-N) was determined using a spectrophotometer [9], Na and K were determined using a flame photometer, Ca was determined using an atomic absorption spectrophotometer (Analyst 200, PerkinElmer, Waltham, MA, USA) while Mg was determined using the EDTA titrimetric method [8]. All chemicals used were of analytical grade.

5. Statistical analysis

The statistical package for social sciences (SPSS Inc., Chicago, IL, USA), version 17.0 was used to analyze all data. Results are presented as means ± standard deviation. One-way analysis of variance (ANOVA) was used for comparison of means. Differences between means were considered to be significant when $p < 0.05$.

6. Results

The standard for drinking water as given by WHO [10,11], NIS [12] and APHA [4] is shown in Table 1.

While the pH of MOUAU water was significantly higher ($p < 0.05$) than MOWA water, it did not differ significantly ($p > 0.05$) from that of AQUA water (Table 2a).

Whereas the TDS of AQUA and MOUAU water samples did not differ significantly from each other ($p > 0.05$) (Table 2a), they were significantly higher ($p < 0.05$) than that of MOUAU water.

There were no significant differences ($p > 0.05$) in the levels of BOD in the three different brands of water samples investigated (Table 2a).

Table 1
Maximum permissible limits of drinking water quality.

Groups	APHA	WHO	NIS
pH	6.5–8.5	6.5–8.5	6.5–8.5
Chlorides (mg/L)	250	200	250
Turbidity (NTU)		10	10
Total hardness (as $CaCO_3$) (mg/L)	–	500	150
Calcium (mg/L)	–	200	200
Sulphate (mg/L)	–	400	400
Sodium (mg/L)	–	–	200
Nitrate (NO_3) (mg/L)	–	50	NR
NH_3-N (mg/L)	–	1.5	–
Magnesium (mg/L)	–	150	0.2
Dissolved solids (mg/L)	–	2000	500
Suspended solids (mg/L)	–	150	150

Sources: [10,11], [12]; [4]; NTU – nephelometric turbidity units; NR – no relaxation.

Table 2a
Physicochemical properties of water samples (mg/L).

Groups	pH	TDS	BOD	Total hardness	Dissolved oxygen
MOUA	6.95 ± 0.10^{b}	270 ± 0.28^{a}	14.3 ± 2.41^{a}	9.30 ± 1.27^{a}	3.08 ± 0.91^{c}
AQUA	6.81 ± 0.01^{ab}	501 ± 1.91^{b}	8.84 ± 3.20^{a}	23.0 ± 1.63^{b}	1.89 ± 0.67^{a}
MOWA	6.15 ± 0.35^{a}	505 ± 0.99^{b}	15.2 ± 3.30^{a}	41.3 ± 0.64^{c}	2.67 ± 0.02^{b}

Values are means ± SD of three determinations. a–c Means with different superscripts along each column are significantly different ($p < 0.05$). N – 5 bottled water samples per brand; Total hard – Total hardness; BOD – Biochemical oxygen demand; DO – Dissolved oxygen (mg/L).

In terms of total hardness, while AQUA water contained significantly higher levels ($p < 0.05$) compared with other water samples studied, MOUAU water had the least (Table 2a).

MOUAU water sample contained significantly higher levels ($p < 0.05$) of dissolved oxygen (DO) compared with other water samples studied, AQUA water had the least (Table 2a).

While the chloride levels of AQUA and MOWA water samples did not differ significantly from each other ($p > 0.05$), they were significantly lower ($p < 0.05$) than that of MOUAU water (Table 2b).

Whereas the nitrate and NH_3-N levels in MOUAU and MOWA water samples did not differ significantly from each other ($p > 0.05$), they were significantly lower ($p < 0.05$) than that of AQUA water (Table 2b).

As shown in Table 2b, the turbidity of these water samples ranged from 0.54 to 1.04 NTU. There were no significant differences ($p > 0.05$) in the turbidity of all the water samples studied.

In terms of TSS, MOWA water contained significantly higher levels ($p < 0.05$) compared other brands of water samples investigated (Table 2b).

The Ca contents of AQUA and MOWA water samples did not differ significantly from each other ($p > 0.05$) but were significantly lower ($p < 0.05$) than MOUAU water sample (Table 3).

The Mg contents of AQUA and MOWA water samples did not differ ($p > 0.05$) from each other while the Mg contents of MOWA water significantly lower ($p < 0.05$) than MOUAU water (Table 3).

There were no significant differences ($p > 0.05$) in the Na contents of all the water samples studied (Table 3).

Table 2b
Physicochemical contents of water sources (mg/L).

Groups	Cl^-	NO_3^-	NH_3-N	Turbidity	TSS
MOUAU	180 ± 3.47^{b}	10.5 ± 4.95^{a}	2.8 ± 0.0^{a}	0.9 ± 0.1^{a}	27.8 ± 7.5^{a}
AQUA	35.2 ± 5.23^{a}	26.8 ± 1.77^{b}	4.2 ± 0.0^{b}	0.65 ± 0.1^{a}	19.5 ± 6.0^{b}
MOWA	38.8 ± 0.07^{a}	9.1 ± 0.99^{a}	2.1 ± 9.8^{a}	0.90 ± 0.0^{a}	34.1 ± 4.90^{c}

Values are means ± SD of two determinations. a–c Means with different superscripts along each column are significantly different ($p < 0.05$). N – 5 bottled water samples per brand Turbidity-NTU.

Table 3
Mineral contents of water sources.

Groups	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}
MOUAU	28.1 ± 0.0^{b}	8.40 ± 1.9^{a}	3.05 ± 0.4^{a}	1.54 ± 0.1^{a}
AQUA	22.1 ± 2.9^{a}	12.20 ± 0.0^{ab}	2.65 ± 0.1^{a}	1.90 ± 0.1^{a}
MOWA	19.6 ± 0.6^{a}	13.15 ± 1.3^{b}	2.38 ± 0.1^{a}	2.60 ± 0.2^{b}

Values are means ± SD of two determinations. a and b Means with different superscripts along each column are significantly different ($p < 0.05$). N – 5 bottled water samples per brand.

Table 4
Pearson correlation between water quality parameters.

	Biochemical oxygen demand	Total soluble solids
Turbidity	0.868**	0.815**
Total soluble solids	0.862**	

** Highly significant at $p < 0.01$.

MOWA water contained significantly higher ($p < 0.05$) levels of K compared with other water samples studied while the K contents of MOUAU and AQUA water samples were not significantly different ($p > 0.05$) (Table 3).

There was a significant positive correlation between turbidity, BOD and TSS of the water samples ($r = 0.815$ to 0.868; $p < 0.01$; Table 4)

7. Discussion

Results obtained indicate that the pH of MOUAU and AQUA water samples were within the permissible levels given by WHO [10,11], NIS [12] and APHA [4], respectively, while the pH of MOWA water was lower than the permissible levels. The observed low pH may be due to uptake of CO_2 from the air and or temperature deviations in the sample and as such, may not pose any significant health risk.

Total dissolved solid is a good indicator of dissolved ions in water [13,14]. The study showed that while the TDS in MOUAU water samples fell within the permissible ranges given by WHO and NIS, the levels found in AQUA and MOWA water samples were higher than the permissible range given by NIS but within the permissible range given by WHO [10,11].

Biochemical oxygen demand (BOD) is the amount of dissolved oxygen needed by aerobic biological organisms in a body of water. BOD is widely used as an indicator of the organic quality of water [15]. The criteria for BOD in drinking water were given to be 4 mg/L [16]. Values obtained for these water samples were lower than this reference range.

Hardness is defined as the sum of calcium and magnesium concentrations and is a measure of the capacity of water to form lather with soap. Although AQUA water contained higher levels of these ions compared with other brands of water investigated, values obtained for these water samples which were lower than the permissible ranges given by WHO and NIS, suggest that these water samples are not hard.

Dissolved oxygen (DO) measures the amount of oxygen dissolved in an aqueous solution [17]. Adequate dissolved oxygen is necessary for good water quality. The criteria for DO in drinking water were given to be 4 mg/L [16]. Although MOUAU water contained higher levels of DO compared with other brands of water samples investigated, values obtained for all the brands of water samples were lower than this reference range.

Chloride is an inorganic compound resulting from the combination of chlorine with metal. Some common chlorides include sodium chloride (NaCl) and magnesium chloride ($MgCl_2$). Environmental impact of chlorides is not usually harmful to human health; however, the sodium part of sodium chloride has been linked to heart and kidney diseases [17]. Public drinking water standards require chloride level not to exceed 250 mg/L [17]. Furthermore, the chloride levels in these brands of water samples were within the permissible ranges given by WHO, USEPA and NIS, respectively.

High level of nitrate in drinking water due to excessive use of agriculture fertilizers or domestic wastes has become a serious problem as it has been implicated in some disease conditions [17]. Values obtained for these water samples were within the permissible range (50 mg/L) given by WHO.

Ammonium nitrogen is an inorganic pollutant of water, formed at low concentration through nitrogen mineralization process from organic matter. The presence of NH_3-N can affect the taste and odor of water and also carries some health risks to humans. Results obtained for NH_3-N in these water samples, which values were higher than the reference range given by WHO, calls for serious checks on the processes of production of these water samples.

Turbidity is caused by particles suspended or dissolved in water that scatter light making the water appear cloudy or murk. Values obtained for turbidity and TSS in these water samples were within the permissible ranges set by WHO and NIS.

Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+} are known as major cations and they constitute more than 30% of the total content of elements in the earth's crust. Calcium is one of the principal cations associated with hardness in drinking water. The hardness of water can range from less than 75 mg/L as $CaCO_3$ (considered a soft water) to more than 300 mg/L as $CaCO_3$ (considered a very hard water) [18]. The presence of calcium in drinking water could reduce the availability of copper as a result of the less aggressive leaching of copper in the delivery system [19]. Values obtained for Ca^{2+}, Na^{+} and K^{+} in the water samples were within the permissible limits set by WHO and NIS indicating that their levels in these water samples could not be considered hazardous to human consumption.

In terms of magnesium, while values obtained for these water samples were higher than the permissible range given by NIS, they fell within the permissible range given by WHO.

Finally, the significant correlation between turbidity, BOD and TSS of the water samples suggests an additive effect between these parameters.

8. Conclusion

Results obtained from this study indicated that most of the chemical constituents of these table water samples commercially sold in Umudike environs conformed to acceptable standards. However, values obtained for nitrates and ammonium nitrogen in these water samples calls for serious checks on methods of their production and delivery to the end users.

Conflicts of interest

We declare none.

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