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Analysis of Physiochemical Parameters of Bottled Water sold in Umuahia Metropolis, Abia State, Nigeria

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ABSTRACT

The analysis of physiochemical parameters of bottled water sold in Umuahia Metropolis were investigated using standard method for water quality analysis. The results of the brands of bottled water obtained showed that brands labeled A, B, C, D, and E had variations in acceptable values as compared to WHO standards. Mean values of analysis obtained for physiochemical parameters are: Colour A(0.04$_{ebc\ unit}$); B(0.03 $_{ebc\ unit}$); C(0.011 $_{ebc\ unit}$); D(0.010 $_{ebc\ unit}$); E(0.004 $_{ebc\ unit}$)}, Temperature A(29.80°C); B(30.00°C); C(29.80°C); D(29.80°C); E(30.10°C)}, DO A(156.10 $_{mg/L}$); B(167.50 $_{mg/L}$); C(175.50 $_{mg/L}$); D(149.80 $_{mg/L}$); E(128.20 $_{mg/L}$)}, Cl (mg/L $_{mg/L}$) {A(152.44 $_{mg/L}$); B(138.26 $_{mg/L}$); C(124.08 $_{mg/L}$); D(120.52 $_{mg/L}$); E(113.44 $_{mg/L}$)}, and BOD A(178.90 $_{mg/L}$); B(188.40 $_{mg/L}$); C(188.90 $_{mg/L}$); D(160.20 $_{mg/L}$); E(139.50 $_{mg/L}$)}. When comparing result to WHO standards, the samples had a huge variance for maximum permissible limits. The results obtained from the present study reveals that there should be further investigation of the brands of bottled water available in Umuahia Metropolis to ascertain their quality in respects to drinking water standards as recommended by WHO.

Keywords: Water quality, pollution control, water, pH, BOD, COD, Umuahia Metropolis

INTRODUCTION

Water is essential to all life forms. It constitutes an essential component of living systems, and is very vital for the biochemistry of living things. Serious dehydration of the body may lead to electrolyte imbalance and even death. Yet, WHO (2012) and UNICEF (2012) estimates that 36% per cent of the world's population (2.5 billion people) still resort to unsafe drinking water sources. Women and children are compelled to spend large parts of their day fetching water leading to low productivity; which ultimately affects the economies of many developing nations.

Inadequate access to safe water and sanitation services causes sicknesses and often death of thousands of children every day. Ninety percent of human infections in less developed countries can be traced to use of unsanitary sources of drinking water (Pimentel *et al.*, 2004; WHO, 2012). Many studies have

revealed that tap water do not always guarantee the quality of water. Rising concern about public health has lead people to choose bottled water over tap water.

People buy bottled water for a variety of reasons, including fear of contamination, convenience, fashion, and taste or on the assumption that they are pure and fit for human consumption. As a result, global market for bottled water has witnessed tremendous growth in recent years as rising health awareness and increased need for convenience products have combined to drive sales.

Nigeria ranks third on the list of countries with inadequate water supply and sanitation coverage globally (Igali, 2012). This situation has opened up a whole world of drinking water business in Nigeria by private investors and has led to the production of many brands of bottled and sachet ('pure') water in virtually every nook and cranny of the country, available on sale. Yet, little or nothing is known to the consuming public about the physical, chemical, microbiological and biological parameters of the water they buy and consume.

In Umuahia, the capital city of Abia State, several brands of bottled water are available on sale. Chukwu and Nwachukwu (2013); Onwuhara *et al.*, (2013); Abii and Nwabienvinne (2007); Nwakanma and Oleh (2013); Ijeh and Nze (2013) have investigated ground water quality available from boreholes consumed within Umuahia metropolis. Hardly have any studies been carried out on the quality of bottled water available and consumed in this area; hence the present study sets out to investigate the physicochemical and bacteriological parameters of bottled water available in Umuahia Metropolis. Safe drinking water is defined as water with microbial, chemical and physical characteristics that meet WHO guidelines of national standards on drinking water quality (WHO, 2013). This is reflected by various physical, chemical and biological conditions which in turn are influenced by natural and anthropogenic sources. Water quality parameters like alkalinity, hardness, Dissolved Oxygen (DO), chloride, Total Dissolved Solid (TDS) etc add to the aesthetic value of water, while parameters like ammonia, lead, arsenic, nitrate etc may cause adverse health effects.

Appropriate amount of chloride content and hardness are desirable but higher content of the same makes the water unaesthetic. Similarly higher content of phosphate, nitrate, ammonia, iron, are undesirable. Some other chemical constituents like arsenic, lead etc. may be toxic. From microbiological point of view, drinking water should be free from any kinds of pathogens as well as opportunistic

micro flora. Although there are a number of micro-organisms present in water that may pose health threat like Salmonella spp, Shigella spp, Coliforms, Mycobacterium spp etc., coliforms are used to assess water quality. Safe drinking water is defined as water with microbial, chemical and physical characteristics that meet WHO guidelines of national standards on drinking water quality (WHO, 2013). This is reflected by various physical, chemical and biological conditions which in turn are influenced by natural and anthropogenic sources. Water quality parameters like alkalinity, hardness, Dissolved Oxygen (DO), chloride, Total Dissolved Solid (TDS) etc add to the aesthetic value of water, while parameters like ammonia, lead, arsenic, nitrate etc may cause adverse health effects. Appropriate amount of chloride content and hardness are desirable but higher content of the same makes the water unaesthetic. Similarly higher content of phosphate, nitrate, ammonia, iron, are undesirable. Some other chemical constituents like arsenic, lead etc. may be toxic. From microbiological point of view, drinking water should be free from any kinds of pathogens as well as opportunistic micro flora. Although there are a number of micro-organisms present in water that may pose health threat like *Salmonella spp, Shigella spp, Coliforms, Mycobacterium spp* (Budhathoki, 2010). The aim of this paper is to investigate the water quality of the bottled water sold in Umuahia Metropolis.

MATERIALS AND METHODS

Samples of five brands of bottled water of 1.5 litre capacity were collected randomly from various sales outlets and restaurants in Umuahia with brand name labeled A, B, C, D & E. and taken to the laboratory for analysis of their physicochemical and bacteriological parameters. Water quality was analyzed twice for each brand of bottle water over a period of two months to capture differences in daily temperatures that may occur. The methodologies used to analyze various parameters are provided in Table 1 below using recommended methods for physicochemical and microbial analysis of water and waste water (APHA, 1998). Parameters such as pH, Electrical conductivity (EC), Total Hardness (TH), chloride (CL^-), Nitrate ($No_3^-{}^N$), Calcium (Ca), Nitrogen (NO_3), ammonium (NH_4^{-N}), Magnesium (Mg), Phosphate (P), Sodium (Na), Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), and Chemical Oxygen Demand (COD), Temperature, Colour and Turbidity were analyzed. Obtained mean parameters of the brands were compared with WHO (2012) standards for drinking water.

Table 1: Methods applied for the Analysis of Water Samples for Physical and Chemical parameters for Bottled Water in Umuahia Metropolis

S/No.	Parameter	Equipment / Method
1	Colour	Spectrophotometer
2	Turbidity	Spectrophotometer
3	Temperature	mercury Thermometer
4	BOD	Titrametric Method
5	DO	Titrametric Method
6	COD	Titrametric Method
7	Potassium (K)	Flamephotometer
8	Calcium (Ca)	EDTA Complexometric Titration
9	Magnesuim(Mg)	EDTA Complexometric Method
10	pH	pH meter
11	Conductivity(EC)	Conductivity meter
12	Total hardness	EDTA method
13	Chloride (Cl^-)	Titration method
14	Nitrate (NO^3)	Kjedhadly
15	Amonia (NH^4	Kjedhadly
16	Phosphate (P)	Spectrophotometer
17	Sodium (Na)	Flame photometer

Source: Budhathoki, 2010

RESULTS AND DISCUSSION

Results of this research study are presented in Table 2 and 3 below:

Table 2: Mean Values of Physical and Biochemical Parameters of some Table Water Brands sold in Umuahia Metropolis

Table Water Brand	Colour EBC-Unit	Turbidity λ 700nm	Temp. °C	BOD Mg/l	DO Mg/l	COD Mg/l	K Mg/l	Ca Mg/l	Mg Mg/l
A (A-Nestle pure life)	0.010	0.004	29.80	178.90	156.10	217.71	0.80	40.10	7.29
B (Eva water)	0.003	0.002	30.00	188.40	167.50	142.54	0.60	20.04	17.02
C (Gossy water)	0.011	0.007	29.80	188.90	175.50	170.20	0.61	16.03	12.16
D (St. Nick water)	0.010	0.016	29.90	160.20	149.80	123.38	1.05	28.06	9.73
E (Udex water)	0.004	0.002	30.10	139.50	128.20	255.30	0.69	20.04	12.16
WHO MPL (2006)	15	5	25°C	5 - 100	5 - 50	5 - 100	>100	250	250

Key 1 (a): Explanation of Symbols

BOD = Biological Oxygen Demand, DO = Dissolved Oxygen, COD = Chemical Oxygen Demand, K = Potassium, Ca = Calcium, Mg = Magnesium, WHO-World Health Organisation; MPL - Maximum Permissible Limit.

Key 2 (a): Explanation of Units of Measurement

EBC-Unit – Standard Reference Method (SRM) = (Abs 430 – Abs 700)

λ 700nm – Absorbance at 700 nm wavelength

°C – Degrees Celsius

Mg/l (Mg/l) - Milligrams / liter

Mean values of the physical and biochemical qualities of five brands of table water available and consumed in Umuahia Metropolis are shown in Table 2. The colour was calculated from values of absorbance measured at 430nm wavelength less that obtained at 700nm wavelength and expressed as EBC – Units. The range of the colour values is 0.004 – 0.011 EBC-Units; while the turbidity had a range of 0.007 – 0.016 % absorbance. The level of the turbidity of the water brands was moderate, indicating a healthy and moderate amount of the solids and planktons in the samples and the potential for longer shelf life. Which is in agreement with the report that higher levels of turbidity in drinking water would pose several problems as that would mean ample availability of solids and planktons to fuel the food chain in the water (Okorie and Nwosu, 2014). The temperatures of the water brands ranged from 39.80°C to 30.10°C. DO values ranged from 128.20 to 175.50mg/L while BOD of the water Brands ranged from 139.50 to188 mgl^{-1}

The COD of the samples were 123.38 to 255.30mgl^{-1}.

Table 3: Mean Values of Chemical Parameters of some Table Water available in Umuahia Metropolis

BRAND	pH	EC µm	TH Mg/l	Cl^- Mg/l	No_3^{-N} Mg/l	NH_4^{-N} Mg/l	P Mg/l	Na Mg/l
A (Nestle pure life)	6.94	0.14	65.05	152.44	2.80	8.40	18.62	2.10
B (Eva water)	6.80	0.28	60.05	138.26	4.20	7.00	27.34	3.50
C (Gossy water)	6.77	0.39	45.04	124.08	8.40	11.20	37.84	3.90
D(St. Nick water)	6.40	0.19	55.10	120.52	7.00	12.40	36.51	2.40
E (Udex water)	6.90	0.40	50.05	113.44	11.20	18.20	18.19	2.30
WHO MPL (2006)	6.5 - 9.2	100	100 - 200	>100	30	50	<100	100

Key 1 (b): Explanation of Symbols

pH = Hydrogen ion concentration, EC = Electrical conductivity, TH = Total Hardness CL^- = chloride, No_3^{-N} = Nitrate, NO_3 = Nitrogen, NH_4^{-N} = ammonium, P = phosphate, Na = Sodium, WHO-World Health Organisation; MPL -Maximum Permissible Limit. µm – Electrical conductivity

Mean values of the chemical parameters of five brands of table water available and consumed in Umuahia Metropolis are shown in Table 3. The pH of the samples ranged from 6.40 – 6.94. The water brands were weakly acidic to near neutral level and the most acceptable pH for good drinking water is between 6.50 – 7.0. The conductivity ranged from 0.14 – 0.40 μS. High conductivity of EC can cause water balance problems for aquatic organism and decrease dissolved oxygen levels. (Sridhar *et al.,* 2006), hardness is frequently used as an assessment of the quality of water supplies. The hardness of a water is governed by the content of calcium and magnesium salts (temporary hardness, and largely combined with bicarbonates and carbonates with sulfates, chlorides and other anions. (Venkate-Sharaju *et al.,* 2010). The levels of hardness in the water brands were 45.04 – 65.05mgl^{-1}. Chloride content ranged from 113.44 – 152.44mgl^{-1}; while NO_3^{-N} and NH_4^{-N} had a range of 2.80 – 11.20 and 7.00 – 18.20mgl^{-1} respectively. . Phosphorus is often the limiting nutrient for plant growth. It is one of the most important nutrients for maintaining aquatic

fertility. It usually occurs in nature as phosphate. The results from this study revealed that the concentration of PO_4 in the water brands ranged from 18.19mgl^{-1} to 37.84mgl^{-1}. In addition, the analysis of Sodium, Potassium, Calcium and Magnesium from Table 3 revealed that their concentrations were 2.10mgl^{-1} to 3.90mgl^{-1} Na, 0.60mgl^{-1} to 1.05mgl^{-1} K, 16.03mgl^{-1} to 40.10mgl^{-1} Ca and 7.29mgl^{-1} to 17.02mgl^{-1} Mg. These cations are usually associated with the pH, electrical conductivity and temporary hardness in portable water. They also serve as natural buffers that can remove excess hydrogen ions that are usually responsible for high acidity level of water (APHA, 2005).

Comparing the results with WHO standards (Maximum Permissible Limits), huge variance exists in virtually all the parameters tested, save in the case of pH. In Colour, while WHO permissible EBC-Unit stands at 15, those for the samples ranged from 0.003 – 0.011. In the case of turbidity, WHO permissible Absorbance at 700 nm wavelength is 5, 0.002 – 0.007. While a temperature of 25°C is permissible by the WHO, all study samples overshot this with values ranging from 29.90 – 30.10°C. The local environment might go to explain this. Umuahia is located in the tropical rainforest climatic zone of Nigeria. Also, the season of the year during which the tests were run can further explain the high temperatures obtained.- having been conducted in April with temperatures that are notably high in the study area). Atmospheric temperature is likely to affect that of bottled water in uncontrolled environment. While the standard limits for BOD range from 5 – 100 Mgl^{-1}, all the study samples were above this limit with range from 139.50 – 188.90 Mgl^{-1}. In DO and COD parameters, the study samples were above the WHO's Maximum Permissible Limits of 5 – 50 Mgl^{-1} and 50 – 100 Mgl^{-1} respectively with ranges = 128.20 – 175.50 Mgl^{-1} and 123.38 - 255.30 Mgl^{-1} respectively. Potassium (K) content was sparse in all study samples relative to the WHO standard. While the WHO specifies >100 Mgl^{-1}, those of the study samples ranged from as low as 0.60 – 1.05 Mgl^{-1}. These, however were all compliant with prescribed standards. Calcium and Magnesium levels of the samples were also low and normal – ranging from 16.03 – 40.10 Mgl^{-1} and 7.29 – 17.02 Mgl^{-1}, as against the prescribed 250 Mgl^{-1} in each case. The pH of the samples were all normal – varying from 6.40 – 6.94, conforming to the WHO standard of 6.5 – 9.2. Electrical conductivity (EC) and total hardness (TH) of the study samples were considerable low. While the WHO recommends 100 and 100 – 200 in each case, EC and TH ranged between 0.14 µm and 0.40 µm and 45.04 and 65.05 respectively. Chlorine

(Cl^-), Nitrite (No_3^{-N}), Nitrate (NH_4^{-N}), Phosphorus (P) and Sodium (Na) contents of the samples were all found to be low – all falling below the WHO prescribed limits. However, the climatic setting of the study area and the season within which period was conducted are thought to account for the cases of disparities from the prescribed standards observed. All the physical, biochemical and chemical properties of the brands of water were found to be within the desirable limits, save for those as may have been influenced by the local environmental conditions of the study area – which represents the setting in which the brands are produced, marketed and consumed. In addition, the levels of chlorine and phosphate presuppose that most of the water brands studied had some water treatments. The results obtained from the present investigation shall be useful in the future in monitoring the inflow of water brands around the Umuahia metropolis. In conclusion, it is recommended that bottled water companies should endeavor to fulfill the basic water quality standards given by Government of Nigeria and also ensure to regularly check or monitor the water quality of each production to ensure purity and safety of the drinking water. In addition, awareness should be created to the public for either using of disinfectants or boiling water before use rather than rely on the belief of purity for bottled water.

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