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Physico-chemical analysis of the quality of sachet water and their source point sold in Bwari Area Council Federal Capital Territory, Nigeria

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Abstract

Monitoring of the physicochemical water quality parameters plays a vital role in assessing the water environment, and restoring water quality. This study was conducted to assess the physicochemical parameters of four brand of sachet water, and their source points using standard methods of American Public Health Association (APHA). The values for physical parameters which include temperature, colour, turbidity, total dissolved solid, and conductivity were all within the World Health Organization (WHO) permissible limit for both the source of water and sachet water. Chemical parameters include pH, chloride ion, electrical conductivity and alkalinity were also all within the WHO limit except total hardness which had a value of 222 mg/L for source of water (brand A) which was above the 200 mg/L limit of the WHO. The analysis of the heavy metals showed that iron and cadmium were not detected in all the samples analyzed, chromium was only found in brand A, with 0.10mg/mL for the source of water and 0.12 mg/L for the sachet water and this was above the WHO maximum contamination level of 0.05 mg/ml. Copper was found in all the samples ranging from 0.19 - 0.27 mg/ml for the source of water while a range of 0.15 - 0.24 mg/ml was recorded for the sachet water. There was no significant difference ($p \geq 0.05$) in the values of heavy metals obtained. The values recorded for the source of water in this study was higher than the values for sachet water for most of the physicochemical parameters analyzed which could indicate that there is an effect of the treatment process on the sachet water.

Keywords: Fungi; Source of water; Sachet water; Physico-chemical parameters; Heavy metals

1. Introduction

Water is the most abundant substances found in nature. Potable water is water that is clear, without disagreeable taste, colour or odour therefore fit for human and animal consumption [1]. The availability of water varies widely with local geological condition. Neither ground water nor surface water has ever been chemically pure since water contains small amount of gases, minerals and organic matter of natural origin [2]. Natural processes and human activities are the main factors to contaminate and pollute the water sources overtime that lead to decrease of potable water. The quality of surface water and ground water is a function of both natural and human influences [3].

There are three water quality parameters that help to measure the quality of water, which include physical parameters, chemical parameters, and biological parameters. These parameters can affect the drinking water quality if their values are in higher concentrations than the safe limits set by the World Health Organization (WHO) and other regulatory bodies [4]. The quality of drinking-water can also be controlled through a combination of protection of water sources, control of treatment processes and management of the distribution and handling of the water. There is need to continuously assess the quality of ground and surface water sources [5].

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Heavy metals are natural component of the earth crust that cannot be degraded or destroyed. They enter our bodies through food, drinking water or air. Heavy metals poisoning could result from drinking contaminated water e.g. lead pipes, high ambient air concentration near emission sources or intake via food chain [6]. The presence of heavy metals in water is caused by two factors, the first one is generated by weathering of soils and rocks [7] and the second is caused by anthropogenic activities that disturb the natural distribution of heavy metals in the groundwater aquifers which could potentially be hazardous to the local environment and human health [8]. Guidelines for the presence of heavy metals in drinking water have been set by different international organizations such as WHO, EPA and the European Union Commission.

Toxicity can result from any of the heavy metals if they are present more or less from its original limits in drinking water. Drinking water is obtained from a variety of sources like wells, rivers, lakes, reservoirs, ponds etc. Toxicity level depends on the type of metal, its biological role and the type of organisms that are exposed to it [9]. The heavy metals in drinking water linked most often to human poisoning are lead, iron, cadmium copper, zinc and chromium. [9]. They are required by the body in small amounts and can be toxic in large doses. They constitute one important group of environmentally hazardous substances if present [9]. Heavy metals are dangerous because they tend to bio-accumulate which is an increase in the concentration of a chemical in a biological organism over time compared to the chemical concentration in the environment [6]. Metals are required for various biochemical and physiological functions [10]. Five metals are ranked among the priority metals because of their great public health significance, they are arsenic, cadmium, chromium, lead and mercury [11]. They are all systemic toxicants and are known to induce multiple organ damage even at lower levels of exposure [11]. This study was carried out to determine the effect of water treatment on the physicochemical and heavy metal content of sachet water.

2. Material and methods

2.1 Physicochemical Parameters

Physicochemical property was determined using standard methods American Public Health Association [12]. Parameters include temperature, colour, turbidity, pH, electrical conductivity, total alkanlity, total Hardness, total dissolved Solids, chloride, salinity, resistivity. While spectrophotometer was employed to determine iron [13].

2.2 Determination of Total Iron

FerroVer Powder Pillows Method 8008 using the Hach DR 5000 spectrophotometer was used for the analysis. A clean sample cell was filled with 10 ml of sample. Contents of one FerroVer Iron Reagent Powder Pillow was added to the sample and allowed to react for 3 minutes. The instrument is zeroed with 10 ml of the sample. The reacted sample was placed in the cell holder and result is displayed and recorded in mg/L Fe. When the spectrometer as set at 265 and 510 nm). FerroVer Iron Reagent converts all soluble iron and most insoluble forms of iron in the sample to soluble ferrous iron. The ferrous iron reacts with the 1, 10 phenanthroline indicator in the reagent to form an orange color in proportion to the iron concentration. Test results were measured at 510 nm and recorded in mg/L. [13].

2.3 Determination of Heavy Metals

Cadmium, chromium and copper were tested in all the samples. Bulk Scientific Atomic Absorption Spectrophotometer (AAS) was used to measure the heavy metals. About 100 ml of each water sample were acidified with 20 ml of nitric acid. The mixture was digested in a fume cupboard for one hour at 100 ºC until a clear solution was seen and the volume reduces to 20 ml. The mixture was transferred to 100 ml volumetric flask and diluted with deionized water and the mixture made up to 100 ml mark. The mixture was filtered with filter paper after cooling and analyzed for lead, chromium, cadmium, manganese and copper using the Atomic Absorption Spectrophotometer (HACH D5000) [14].

2.4 Preparation of Standard Solution

Standard solutions were prepared with the salts of the various metals to be analysed. The amount to be dissolved in 1 litre of distilled water was calculated by dividing the molecular weight by the atomic mass. Copper sulphate has molecular weight of 249.68 and copper has an atomic mass of 63.55. Therefore 249.68/ 63.55= 3.93 g of copper sulphate was dissolved in 1 litre of distilled water. Same was done for all the salts. The following salts were used for the metals respectively. Cadmium sulphate ($CdSO_4$) was used for cadmium, lead nitrate ($PbNO_3)_2$ was used for lead, Chromium sulphate ($ZnSO_4$) was used for zinc, Copper sulphate ($CuSO_4.5H_2O$) was used for copper. The standard solutions were prepared and analyzed in the AAS to get the absorbance and to prepare a calibration curve, from which the concentration of the heavy metal was read directly using distilled water as blanks.

3. Results and discussion

Table 1 and 2 show the result of physicochemical analysis of the source of water and sachet water for four brands of sachet water sold in Bwari Area Council, FCT Abuja. All the physicochemical parameters analyzed at ambient temperature were within the permissible limit set by World Health Organization, except for total hardness for brand A 222 mg/L which is above the WHO set value. Meanwhile the result for the heavy metal of the samples are shown in table 3 and 4. From the result it was observed that iron and cadmium were not detected in any of the sachet water analyzed. However, all values obtained were within the WHO permissible limit.

Table 1 Physicochemical Parameters of the source of water for Brands of Sachet Water Sold in Bwari Area Council

Parameter/Samples	Brand A	Brand B	Brand C	Brand D	WHO
Temperature (°C)	26.6±0.08 [a]	26±0.06[b]	25.9±0.07 [a]	25.3±0.06 [a]	Ambient
Colour	2±2.61 [b]	-36±0.85 [a]	-27±0.64 [a]	-45±1.05 [b]	15TCU
Chloride ion (mg/L)	28.4±0.15 [a]	22.56±0.065[a]	29.8±1.96 [b]	25.5±0.06 [a]	<250
Ph	7.6±0.05[a]	7.4±0.02 [a]	7.2±0.1[b]	6.0±0.13 [a]	6.5-8.5
Turbidity	2.04±0.03 [a]	1.72±0.01 [a]	1.83±0.01 [a]	1.60±0.01[a]	<4
Total hardness(mg/L)	222±1.10 [a]	184±1.31 [b]	110±2.17 [b]	86±0.99 [a]	<200
TDS (ppm)	158.8±0.09 [a]	124.1±0.15 [a]	89.5±0.08 [a]	70.6±2.77 [b]	<600
Conductivity (µs/cm)	262±0.52 [a]	208±1.32 [b]	149.4±0.94 [a]	177.7±0.17 [a]	1000
Total alkalinity	28±0.63[a]	72±0.64 [a]	74±0.63 [a]	52±1.45 [b]	
Salinity	0.4±0.01 [a]	0.4±0.01 [a]	0.3±0.02[a]	0.4±0.02 [a]	
Resistivity	-1±0.28 [a]	-1±0.24 [a]	0.02±0.91 [a]	0.02±0.08 [a]	

Keys: Brand=Codes representing the trade names of sachet water from location A, B, C and D; TDS= Total Dissolved Solids; TCU= True Colour Units; NTU= Nephelometric Turbidity Units; Mg/l= Milligram Per Liters; PPM= Part Per Million; Mean with the same superscript across the rows are not significantly different (P≥0.05)

Table 2 Physicochemical Parameters of four Brands of Sachet Water Sold in Bwari Area Council

Parameter/Samples	Brand A	Brand B	Brand C	Brand D	WHO
Temperature (°C)	25.7±0.12 [a]	25.4±0.085[b]	25.8±0.1 [a]	25.3±0.1 [a]	Ambient
Colour	ND	ND	ND	ND	15TCU
Chloride ion (mg/L)	22.72±0.88 [a]	22.72±0.62 [a]	32.66±0.78 [a]	32.66±0.85 [a]	<250
pH	7.2±0.08 [a]	6.2±0.13 [a]	7.4±0.11 [a]	7.2±0.07 [a]	6.5-8.5
Turbidity	1.71±0.03 [a]	1.54±0.00 [a]	1.77±0.03 [a]	1.38±0.01[a]	<4
Total hardness (mg/L)	40±1.51 [b]	102±1.36 [b]	38±0.75 [a]	46±0.79 [a]	<200
TDS (ppm)	19.48±0.11 [b]	85.2±0.00 [a]	26.1±0.15 [a]	36.9±0.11 [b]	<600
Conductivity (µs/cm)	32.3±0.4 [a]	14.4±0.20 [a]	44.2±0.15 [a]	62.2±0.53 [a]	1000
Total alkalinity	40±0.64[a]	70±0.63 [a]	32±2.05 [b]	40±1.55 [a]	
Salinity	0.3±0.00 [a]	0.4±0.00 [a]	0.4±0.00 [a]	0.4±0.02 [a]	
Resistivity	0.03±0.12 [a]	-1±0.05 [a]	-1±0.22 [a]	-1±0.06 [b]	

Keys: Brand=Codes representing the trade names of sachet water from location A, B, C and D ;TDS= Total Dissolved Solids, TCU= True Colour Units; NTU= Nephelometric Turbidity Units; Mg/l= Milligram Per Liters; PPM= Part Per Million; ND=Not Detected; Mean with the same superscript across the rows are not significantly different (P≥0.05)

Table 3 Heavy metals concentrations of the source of water for sachet water brand sold in Bwari Area Council, Abuja

Parameter/Samples	Brand A	Brand B	Brand C	Brand D	WHO
Chromium	0.12±0.00	ND	ND	ND	0.05
Iron	ND	ND	ND	ND	<0.3
Copper	0.19±0.00a	0.27±0.03 a	0.27±0.01 a	0.27±0.01 a	2.00
Cadmium	ND	ND	ND	ND	0.003

Keys: Brand=Codes representing the trade names of sachet water from location A, B, C and D; ND=Not Detected; WHO= World health organization; Mean with the same superscript are not significantly different (P≥0.05)

Table 4 Heavy metals concentrations of the sachet water sold in Bwari Area Council, Abuja

Parameter/Samples	Brand A	Brand B	Brand C	Brand D	WHO
Chromium	0.10±0.00	ND	ND	ND	0.05
Iron	ND	ND	ND	ND	<0.3
Copper	0.15±0.00a	0.17±0.00 a	0.23±0.01 a	0.24±0.00 a	2.00
Cadmium	ND	ND	ND	ND	0.003

Keys: Brand=Codes representing the trade names of sachet water from location A, B, C and D; ND=Not Detected; WHO= World health organization; Mean with the same superscript are not significantly different (P≥0.05)

Water must be treated to ensure that the quality is at an acceptable level for a wide range of essential processes. Potable water must meet internationally acceptable standards and be in line with guidelines stipulated by the world health organization (WHO). In this paper, we assessed the quality of sachet water which serves as a major drinking water source for residents of Bwari Area council. There has been growing trend in the consumption of sachet water in most low income areas which lack municipally supplied water.

Temperature in all the samples were at ambient, the values ranged from 25.3 ^{o}C to 26.6 ^{o}C for both the sachet water and the source of water. Colour was not detected in the sachet water sample but there was some indication of colour in the source of water 2 TCU, which is well below the 15 TCU set by the WHO. It was earlier reported that high temperatures have the tendency of developing undesirable taste and odour in water with time [15]. Turbidity for the source of water and the sachet water were all within the WHO permissible limit sample. The range for the source of water varied from 1.60 - 2.04 mg/L while the sachet water varied from 1.38 - 1.77 mg/L which is higher than a a value that had been reported 0.73 mg/L and 0.93 mg/L [16]. Electrical conductivity of sachet water samples ranged from as low as 14-62 µS/cm while the source of water had a range of 149 - 262 µs/cm. The source of water had a higher value of conductivity, this could be due to the presence of dissolved minerals. Similar result 92-251 µs/cm was reported of sachet water in Jigawa state of Nigeria [17]. Groundwater that is heavily ionized from dissolved minerals will increase the conductivity of water [18]. According to the report of a researcher [19] low Electrical conductivity value denotes the presence of minimal amount of dissolved salts (mineral elements such as calcium, magnesium and fluoride) in water. Total dissolved solids range from 70 – 158 mg/L for the source of water and 19 – 85 mg/L for the sachet water. All values were below the WHO maximum permissible limit. The values for the source of water were higher than the sachet water, this could be attributed to the filtration beds used by the manufacturers during production that may have been able to trap some of the dissolved solids. Similar value of 46 – 128 mg/L for sachet water was recorded by [17]. There was no significant difference (p>0.05) in the values obtained from the source of water and the sachet water samples.

Brand C and D recorded similar values for chloride ion (32.6 mg/L) as the highest for sachet water while the source of water for brand C (29.8 mg/L) recorded the highest value. The result is appreciably within the WHO value of maximum permissible concentration of 250 mg/L. A report from Ghana observed a range of 1.71 - 58.20 mg/L for sachet water [20]. Hydrogen ion concentration of the samples also ranged from 6.0-7.6 for brand D and A for the source of water while a range of 6.2-7.4 for brand B and C was recorded for the sachet water. All values were within the WHO set limit of 6.5-8.5 for drinking water. The difference in these values could be associated with the presence of ion which increases the acidity of the water, thereby resulting in a low pH value [21]. Total hardness for the source of water had a value of 222 m/L for brand A which is above the WHO permissible limit, while the sachet water had 102 mg/L as the highest values. The difference in the values could be attributed to the purification process during the sachet water production. Hardness in water can be tolerated for up to 500 mg/L for some consumers [22] but depending on other factors such as pH and alkalinity, water with a hardness of above 200 mg/l may cause scale deposition [22]. The values for alkalinity for the sachet water samples range from 32-70 mg/L while the source of water is 28-74 mg/L. There is no WHO specified limit for alkalinity but in the absence of alternative source of water alkalinity up to 600mg/L is acceptable for drinking [23]. Alkaline water has a higher Ph level than regular drinking water, because of this some advocates of alkaline believes it can neutralize the acid in one's body. Water that is naturally alkaline occurs when water passes over rocks like spring and picks up mineral which increases it's alkaline level [24]. Another study suggested that drinking alkaline water may have benefits for people with high blood pressure, diabetics and high cholesterol [24]. There was no significant difference ($p>0.05$) in the values obtained from the source of water and the sachet water samples.

Heavy metals enter the environment via natural and anthropogenic means. Such sources include industrial discharges, mining, erosion, sewage discharge water, waste effluents etc. the main route of exposure for most people is through food and water. According to [25] consistent exposure to heavy metals at low levels can cause great adverse effects. Heavy metals have toxic effects on humans, animals, fishes and plants.

From the analysis carried out on the sachet water samples, it was discovered that chromium was only found in brand A, 0.10 mg/ml in the source of water while 0.12mg/ml in the sachet water. All values were above the WHO maximum contaminate level (MCL) of 0.05 mg/ml. Similar values for chromium ranging from 0.01-0.16 mg/ml have been reported [26]. Iron was not detected in both the source of water and the sachet water. This was not the case for a previous researcher who reported a range of 0.01-0.4 mg/ml for all the fifteen (15) samples analyzed with one sample above the permissible limit 0f 0.3 mg/ml [26]. Copper levels recorded in this research ranged 0.19-0.27 mg/ml for the source of water while a range of 0.15-0.25 mg/ml for sachet water was reported. All values were within the WHO MCL of 2.00 mg/ml. Copper values of 0.018 - 1.401 mg/ml for sachet water sold in eastern Nigeria had been reported [27]. Cadmium was not detected in all the samples analyzed in this research. Cadmium levels ranging from 0.002 to 0.036 mg/ml was reported in 8 samples of sachet water analyzed [27]. There was no significant difference ($p\geq0.05$) in the values of heavy metals obtained from the water samples. Earlier report that concentrations of heavy metals in drinking water samples collected from Northern Ethiopia have some physiochemical parameter values higher than WHO recommended limits [28].

4. Conclusion

The study assessed and compared results obtained from laboratory analysis of source of water and sachet water used for sachet water (pure water) production in Bwari Area council. Values for most of the physicochemical parameters analyzed were higher for the source of water than the sachet water. This could indicate that the treatment processes which were adopted and practiced by this water manufacturers have shown to be beneficial in reducing the quantities of these parameters especially toxic heavy metals. Further research could explore bottled water to know if a difference exists between the physicochemical parameters' values of the source of water and the bottled water. Finally, there is need for NAFDAC to organize regular hygiene, water production monitoring and sensitization programs to enable the continuous production and sale of potable and hygienic sachet water.

Compliance with ethical standards

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Disclosure of conflict of interest

There was no conflict of interest /competing interest.

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