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Some Physicochemical Charactistics of Bottled Drinking Water Samples

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Abstract The used samples were produced from Almazaq factory Khartoum, Sudan and have been treated by chlorine ultra violet radiations and ozone gases, four samples of bottled drinking water were taken and Some "tests", to determine physicochemical properties were carried out. pH and electric conductivity of bottled drinking water were determined according to standard methods for the examination of water and wastewater, magnesium, calcium, potassium, sodium, aluminum, sulfate, chloride, phosphate, nitrate and nitrite were determined by Ion Chromatography (IC). The results obtained were compared with parameters of drinking water recommended by the International Bottled Water Association (IBWA), United States Food and Drug Administration (FDA), United States Environmental Protection Agency (EPA) and the World Health Organization (WHO) drinking water standard. All obtained results were found within the right permissible ranges.

Keywords Bottled drinking water, Physical characteristics of water, Chemical characteristics of water

1. Introduction

According to the International Bottled Water Association (IBWA), [1] drinking water has become extremely popular with a current U.S. market of more than 11 billion American dollars. Its consumption has tripled in the past 10 years, making it the second largest beverage product consumed, behind soft drinks. USA consumption in the year 2006 was 32 billion liters compared to 20 billion liters in the year 2001. The average number of liters consumed by person per year in the USA is 90.5 and the global average is 24.2 liters. Such tremendous growth in the bottled water industry is presumably a result of people's demand for of pure, safe, better taste, convenience, and increasing public awareness of fitness and beneficial effects of drinking water on health. More than half of Americans drink bottled water, and approximately one-third of the public consumes it regularly. [2] Bottled water is regulated by the International Bottled Water Association (Alexandria, Virginia). However, regulations are less stringent compared to U.S. Environmental Protection Agency (U.S. EPA) regulations for tap water. [3, 4] Bottled water is considered a food product and is also regulated by the Food and Drug Administration (FDA) (Rockville, Maryland). All bottled water products must comply with FDA's quality standards, labeling regulations, and Good Manufacturing Practices. [1, 4] Recently, an increasingly worldwide concern about the quality of bottled water regarding their chemical contents has risen. [5-9] Water quality can be measured by means of its concentration in organic and inorganic chemicals. As part of our ongoing research on the assessment of human exposure to toxic chemicals, chemical, physical and microbial evaluations of local bottled drinking water were conducted. This paper discusses the levels of some physicochemical of different four bottled drinking water samples produced from Almazaq water factory Khartoum, Sudan.

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2. Methodology

2.1. Samples Collection

Four bottles of bottled drinking water were purchased randomly from different supermarkets in Khartoum, Sudan, during the summer of 2015. All samples were in plastic containers with plastic screw caps. Table 1 presents the classification of the bottled water samples in terms of brands, types, sources and volumes.

2.2. PH and Electric Conductivity of Samples

About 250 mL of samples was taken and transferred into deferent four clean beakers, the PH electrode was attached to a HACK instruments model (2432 PH and conductivity). Then the pH electrometer was calibrated by 4, 7 and 10 buffer solutions, the PH of samples was determined directly.

Electric conductivity was determined directly by selective electrode, used HACK instruments (2432) [22].

2.3. Ion Chromatography

Ion chromatography was carried out using a Dionex gradient HPLC system (Sunnyvale, CA) equipped with a CD20 conductivity detector. Isocratic separations of both cations and anions were performed on CS12 and AS 14 analytical columns, respectively. Dedicated guard columns and suppressor systems to either cationic or anionic analyses were also used in connection with the analytical columns. Methanesulphonic acid (20 mM) was used as the mobile phase for eluting cations, while a mixture of 3.5 mM Na2 CO3 /1.0 mM NaHCO3 was used as the mobile phase for eluting the anions. Data acquisition and instrument settings were performed by Peaknet software (Dionex, CA). Primary calibration standard solutions (1000 ppm) for ions were prepared from their ultra-pure salts. Working standard solutions were prepared from the primary solutions following proper serial dilutions. The concentrations were measured using external calibration method and the analyses were carried out in triplicate and the average values were reported. Instrument precision was determined by introducing the same quantity of one sample 10 times, then the relative standard deviation was calculated and found to be less than 8%.

3. Results and Discussion

PH and electrical conductivity and concentrations of major cations and anions in bottled water samples are shown in Table 3 and Table 4. The Drinking water recommended standards set by the IBWA, FDA, EPA and the WHO are shown in Table 5.

Table 1. Bottled drinking water samples and it's a volumes

Sample Number	Volume
S1	350 mL
S2	700mL
S3	5000 mL
S4	19000 mL

Table 2. Analytical techniques that were used for water analysis and their detection limits (µg/L)

Analytes	IC
Cl	170
NH_4	7
SO_4	100
PO_4	190
NO_3	100
NO_2	60
Na	5
K	6
Ca	6
Mg	5
Al	0.3

Table 3. PH and electric conductivity of bottled drinking water samples

Sample	PH (22.4°C)	Conductivity (µs/Cm)
Sample 1	7.64	230
Sample 2	7.80	232
Sample 3	7.50	235
Sample 4	7.30	233

Table 4. Some chemical characteristics of bottled drinking water samples produced from Almazaq water factory

Anion & cation	Concentration ppm			
	Sample 1	**Sample 2**	**Sample 3**	**Sample 4**
Cl	7.1	6	7.7	5.1
SO_4	4	3.5	3	2.9
PO_4	0.09	0.09	0.1	ND
NO_3	1.112	1.30	1.4	0.87
NO_2	0.003	0.003	0.025	ND
Na	53.1	50	54	39.6
K	1.88	1.50	4	0.5
Ca	9	7.2	12	6.5
Mg	1.5	1.5	1.5	1.5
Al	ND	ND	ND	ND

Physical properties

The obtained results from PH test of four samples within the recommended range (6.5 – 8.5) in table 5.

Electric conductivity (EC) generally reflects total dissolved solids in drinking water. It was found within the range assigned by FAO. An elevated TDS concentration is not a health hazard. It was regulated by WHO recommendations because it is more of an aesthetic rather than being harmful to health, the results of PH and electric conductivity were shown in figure 1 and figure 2 respectively.

Anions

Chloride, sulfate, phosphate, nitrate and nitrite in bottled drinking water samples were analyzed by ion chromatography. The concentrations of chloride in bottled water samples was found within the permissible ranges assigned by IBWA, FDA, USEPA AND WHO. Sample 4 showed the least concentration in comparison with other three samples.

Chloride levels in excess of 250 mg/L can give rise to unpleasant taste in water, but the threshold depends on the associated cations. [27] Taste thresholds for NaCl and CaCl2 in water are in the range of 200–300 mg/L. Consumption of drinking water containing chloride is not harmful to health. High amounts of chloride can give a salty taste to water.

Concentrations of Sulfates in samples was found to be 4, 3.5, 3 and 2.9 these results within the ranges assigned by IBWA, FDA, USEPA and WHO (Table 5). Sulfate is one of the least toxic anions, the lethal dose for humans as potassium or zinc sulfate is 45 g. The major physiological effects resulting from the ingestion of large quantities of sulfate are catharsis, dehydration, and gastrointestinal irritation. No health-based assigned value for sulfate in drinking water is proposed by either WHO or EPA. However, because of the gastrointestinal effects resulting from the ingestion of drinking water containing high sulfate levels, it is recommended that health authorities be notified of sources of drinking water that contain sulfate concentrations in excess of 500 mg/L.

The concentrations of phosphates within the permissible ranges assigned by IBWA, FDA, USEPA and WHO (Table 5). Sample 4 showed the least concentration. No health-based value assigned for phosphate in drinking water is proposed by either WHO or EPA.

The concentration of Nitrate and nitrite in marked bottled water samples was found lower than permissible limits assigned by IBWA, FDA, USEPA and WHO (Table 5), sample four showed the least concentrations. contamination of drinking water with nitrate presents a health hazard, because nitrate ion can be converted to nitrite ion in the gastrointestinal tract. [29, 30] High nitrate levels can cause blue syndrome and certain forms of cancer. Scientific literature suggests that neither nitrate nor nitrite acts directly as a carcinogen in animals, but there is some concern about a possible increased risk of cancer in humans from the endogenous and exogenous formation of N-nitrosamine compounds, many of which are carcinogenic in animals. The WHO's recommended value for nitrate in drinking water is established solely to prevent methemoglobinemia, which depends on the conversion of nitrate to nitrite. The results of anions concentration in used bottled samples was shown in figure 3.

Cations

Sodium, potassium, magnesium and calcium concentrations in the bottled water samples were analyzed by ion chromatography as shown in the experimental section. The results are shown in Table 4 and figure 4.

The sodium concentrations of bottled sample1, 2,3 and 4 was found to be 53.1, 50, 54 and 39.6 respectively, these results are lower than the limit assigned by WHO but not limits of sodium concentrations assigned by the IBWA, FDA and USEPA. None of the values exceeded the sodium maximum limit of 200 mg/L (Table 5) guidelines for aesthetic quality. Most water contains some sodium, which naturally leaches from rocks and soils. An excess of sodium more than 200 mg/L in drinking water may cause a salty taste or odor, as well as presenting long-term health effects like. [25].

Potassium concentration of bottled water sample 1, 2, 3 and 4 were found to be 1.88, 1.50, 4 and 0.5 respectively, sample 4 showed a lower by potassium content. The obtained potassium concentrations within the permissible range assigned by WHO.

Table 5. Show for the maximum allowable levels of contaminants in drinking Water

Analytes	Permissible ranges (ppm)			
	IBWA	FDA	USEPA	WHO
Cl	250	250	250	250
SO_4	250	250	250	500
PO_4	Na	Na	Na	5
NO_3	45	45	45	50
NO_2	3.3	3.3	3.3	3
Na	Na	Na	Na	200
K	Na	Na	Na	12
Ca	Na	Na	Na	75
Mg	Na	Na	50	Na
Al	0.20	0.20	0.20	0.20
PH	6.5 – 6.8	Na	6.5 – 6.8	6.5 – 6.8
EC(µs/Cm)	Na	Na	Na	400

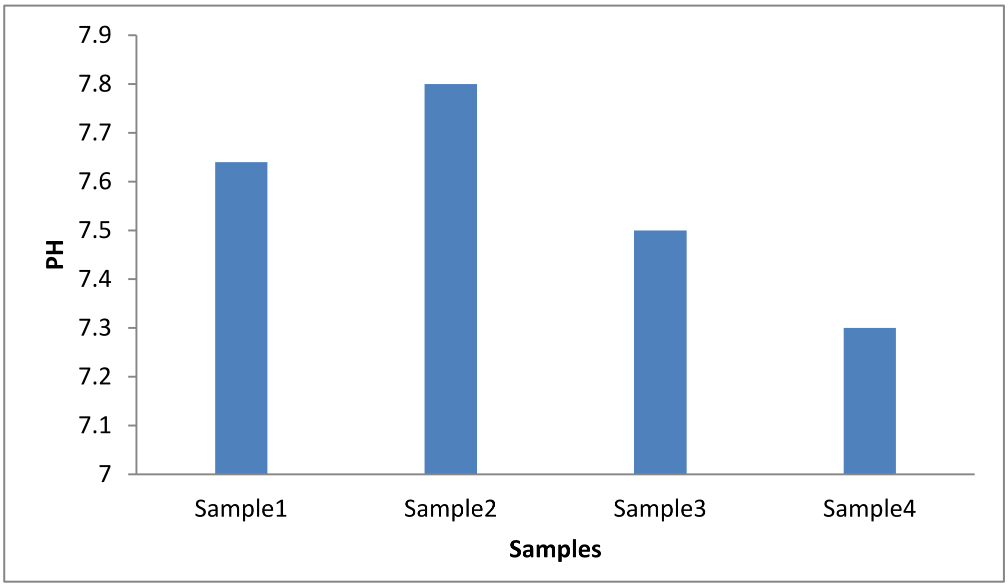

Figure 1. PH of analyzed bottled drinking water samples

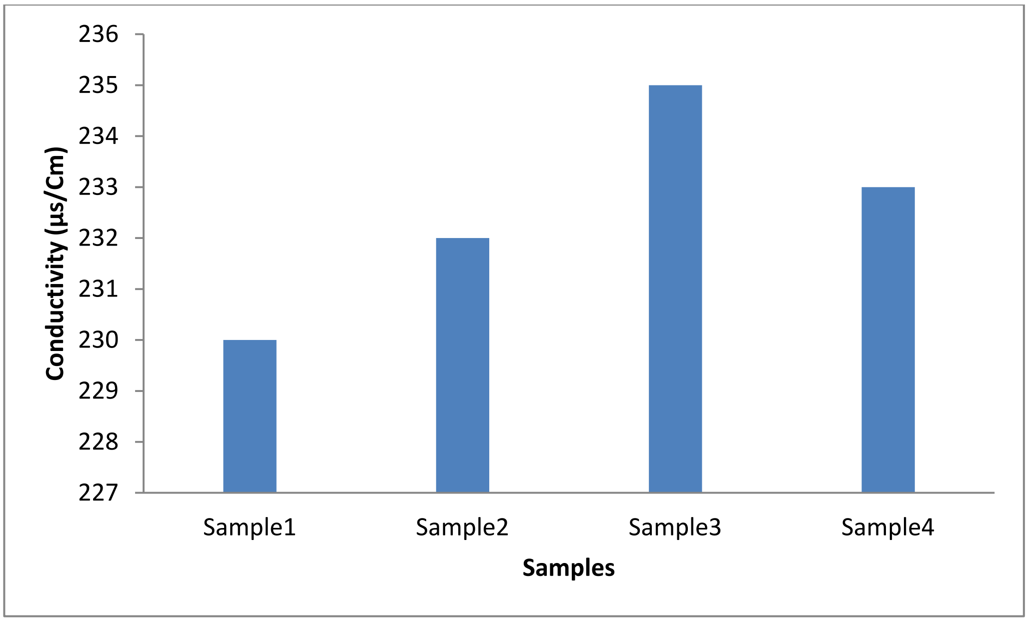

Figure 2. Electric conductivity of bottled drinking water samples

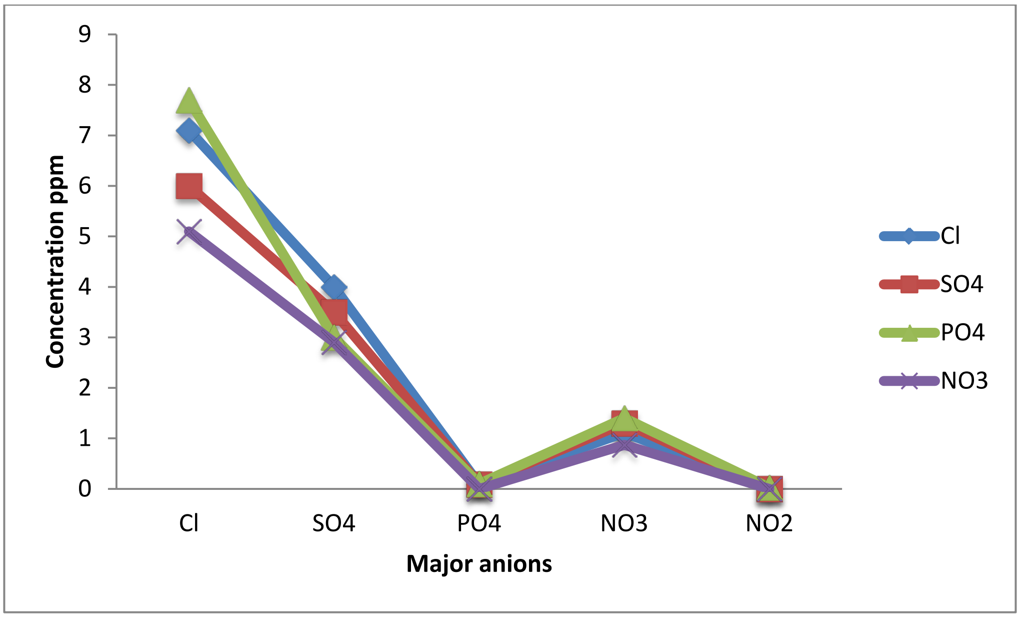

Figure 3. The concentration of major anions in Bottled drinking water samples

Calcium concentrations of bottled samples in Table 4 were found within the permissible rang assigned by WHO. Natural water sources typically contained concentrations of up to 10 mg/L for calcium. However, levels up to 800 mg/L were found in natural water. [26] The threshold for the calcium ion is in the range 100 to 300 mg/L, depending on the associated anion, but higher concentrations are acceptable to consumers. Hardness levels above 500 mg/L are generally considered to be aesthetically unacceptable, although this level is tolerated in some communities. [27] Calcium is one of the major elements responsible for water hardness. Water containing less than 60 mg/L of Ca is considered as soft water. There does not appear to be any convincing evidence that water hardness causes adverse health effects in humans. In contrast, the results of a number of epidemiological studies have suggested that water hardness may protect against disease. [25].

Magnesium and aluminum concentrations of bottled drinking water samples in Table 4 were lower than permissible range assigned by marked organizations but the IBWA, FDA and WHO would not set limits for magnesium concentrations in drinking water. All Physicochemical characteristics within the limits of detection show in Table 2.

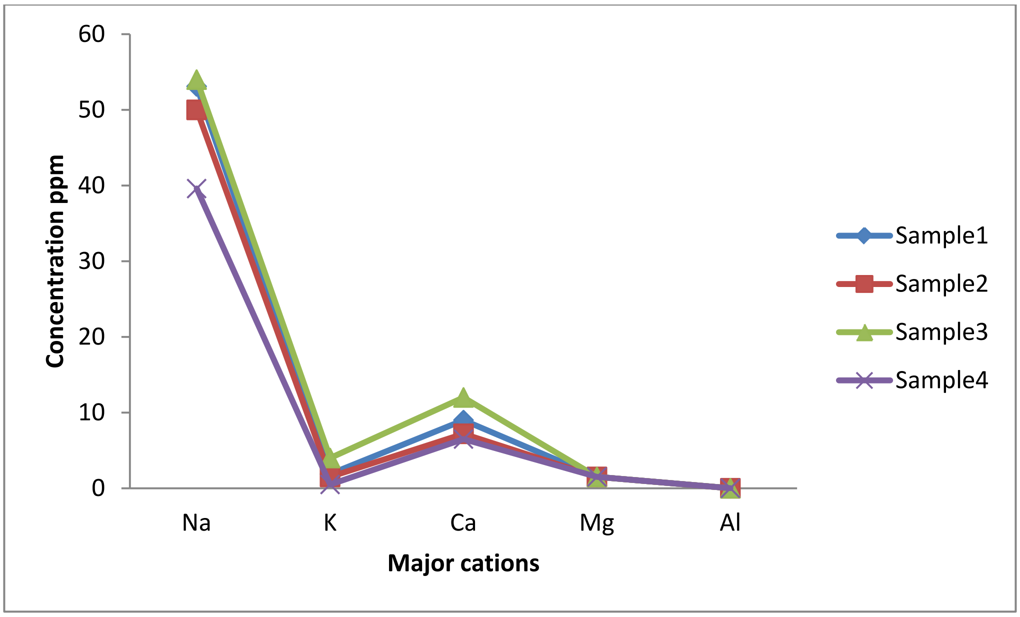

Figure 4. The concentration of major cations in bottled drinking water

4. Conclusions

Based on the previously discussed analyses, the following conclusions can be summarized as.

- Four samples of bottled drinking water samples produced from Almazaq bottled drinking water were purchased randomly from different supermarkets in Khartoum, Sudan, during the summer of 2015. The water produced from Almazaq factory have been treated by chlorine, ultra violet radiations and ozone gases.
- PH and Electric Conductivity (EC) were found within the recommended range assigned by IBWA, USEPA and WHO.
- The major anions and cations included chloride, sulfate, phosphate, nitrate, nitrite, sodium, potassium, calcium, magnesium and aluminum were analyzed by Ion Chromatography (IC).
- The obtained results from analysis of anions and cations in marked bottled drinking water samples were lower than limits recommended by IBWA, FDA, USEPA and WHO.

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