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Mineral Ion Content in Selected Water Bottle Samples Sold in Maldives

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Abstract: Majority of Maldivian population, especially those living in capital Male' uses bottled water as the main source of drinking water. The aim of this study is to determine the mineral ion content in some of the bottled water sold in Maldives. A total of seven water samples of three brands of water were collected. Two different samples from each brand were used in sampling as, they were the most widely sold brands in Maldives. An additional sample of tap water which is used in households of Male' was included as comparison. The samples were tested for the hydrogen ion concentration (pH), Electrical conductivity, total Dissolved solids (TDS), and amounts of calcium (Ca), magnesium (Mg), copper (Cu), and zinc (Zn). These results were then compared to the guidelines provided by the World Health Organization, (WHO) to determine the suitability for human consumption. It was found from the test results that all he bottled water samples were in accordance with the standards of WHO, except for pH values of three samples, which had a pH value below the WHO standard value of 6.5. The samples were also having lower values for EC and TDS, which indicates that they have less mineral ions which were removed by the treatment of water. This can lead to health problems in long term, if a person consumes only these bottled water as the source of drinking water. This problem can be overcome with a proper balanced diet. In general, the overall quality of the most commonly consumed bottled waters in Maldives was in accordance to standards set by WHO and safe for drinking.

Keywords: mineral ion content; bottled water; fresh water.

1. INTRODUCTION

Maldives is an island nation with more water than the land. But the fresh water which is available are the rain water which is harvested in rainwater tanks, groundwater, and desalinated water, with rainwater and desalinated water being particularly used for daily uses. Even now, rainwater is extensively used in some of the islands for drinking and other household uses even though desalinated water is now available in some of the islands.

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Since Male' houses about half of the population of Maldives, the need to cater for drinking water is high. Even in islands the water tanks are used up within few days of collection or in the dry monsoons. Because of this many people opt for bottled water as drinking water. Bottled water is drinking water collected from protected source, which is the treated to purify it and sometimes minerals added to enhance the quality and taste. This water is then packed in glass bottles or plastic bottles and sold in different places. [1]. Since the fresh water sources in Maldives are very few, all the bottled waters packed in Maldives are desalinated water. [2].

Few local brands and international brands of bottled water are sold in Maldives. But, the local brands of bottled water are mostly consumed as they are cheap and widely available. The main brands of water which were used in the study are TaZa, Life and Bonaqua.

TaZa brand of bottled water is produced by Island Beverages Maldives Pvt. Ltd (IBM) which is a subsidiary company of Male' Water and Sewerage company Pvt. Ltd. (MWSC) and was opened in 2004. They are also the utility water provider in greater Male' area and in most of the islands. TaZa is promoted as the only mineralized water produced in Maldives. [3].

"Life" water is produced and packed in Maldives by Happy Market Trading Company. [4] Bonaqua is produced by Male' Aerated Water Company, MAWC. (Male' Aerated Water Company, n.d.)

In recent years there has been rapid increase in the consumption of bottled water in Maldives. This increase is mainly because of the negative view of the public towards the tap water or rain water. A survey conducted by Latheef A (2019), on bottled water consumption in Male' Maldives, states that out of 384 people who participated in the survey, 70.50% people don't think tap water is safe for consumption as drinking water. People also choose bottled water, because they prefer the taste of specific water bottles over tap water or rain water. And also some people consider the bottle water to be healthier and safer choice over tap water or rain water.

A study conducted by Diduch M, Polkowska Z, and Namies'nik J [1] attribute the rise of the consuming of bottled water to several factors. This includes, doubts about the quality and safety of tap water, the availability of bottled water, marketing strategies used by companies, the fashion of trying to have a healthy life style users awareness about health benefits of regularly using bottled water. Some of the minerals which are important for body functions are present in water. Minerals such as sodium, potassium, magnesium and calcium are among them. However, consumption of bottled water can affect health, environment and economy. Consuming bottled water is costly and produces plastic waste [5].

The aim of this study was to determine the mineral ion content in most used brands of bottled water in Maldives. The main parameters focused are the hydrogen ion concentration (pH), Electrical conductivity (EC), Total Dissolved solids (TDS), amounts of Calcium (Ca), Potassium (K), Magnesium (Mg), Sodium (Na), Copper (Cu), and Zinc (Zn). These results were then compared to the guidelines provided by the World Health Organization, (WHO) [6] to determine the suitability for human consumption.

2. LITERATURE REVIEW

Literature review

Water is an important substance which should be available for all living things for a sustainable life. Moreover, safe drinking water is vital for human health and effort should be made to make the water safe for drinking. Diseases related to contamination of drinking water are a major threat to human health. Efforts to improve the quality of drinking water helps in improving health benefits. [6]. Water is found in nature in its pure form. It gets its impurities during the hydrological cycle because of human activities and water use. So, its quality needs to be determined to find whether it's suitable for use or not. [7]

Although tap water and rainwater are available for most of the population of Maldives, a lot of people tend to choose bottled water as their primary source of drinking water for personal reasons and considering the availability of certain types of water.

The source of bottled water, which are packed in Maldives and sold is desalinated water. Though salt water is rich in dissolved ions, the desalination process removes almost all these ions from water. So, someone who normally drinks desalinated water will be getting less dissolved ions compared to a person who drinks water form more natural sources. This could become a health concern in the long term if these mineral ions are not provided by other dietary measures. So desalinated water is often stabilized by lime and blending. [8] A significant study about the mineral content of bottled water sold in Maldives has not been conducted yet, there are many studies conducted on analyzing the content of mineral water sold in other parts of the world.

There are several minerals which are important for human health. Drinking water can provide some of these minerals. The amounts of these minerals present in water, their pH and several other factors and guidelines are provided by the World Health Organization. These values and guidelines are to protect public health associated with drinking water quality. [6]

The acidity of the drinking water is determined by its pH, which stands for the potential of hydrogen ion concentration in solution, or the amount of hydrogen ion found in the substance. If the pH level of water is above 8.5, it shows the presence of a high amount of alkaline minerals. Drinking water with high alkalinity is not risky but can affect the taste of the water. [9]. pH does not have a direct effect on consumers, so no health based guideline value has been proposed for pH. Instead, to guarantee acceptable water clarification and disinfection the pH of water is controlled and assessed [6].

Electrical conductivity, (EC) of water is the measure of the water to pass electric current. Dissolved inorganic anions and cations in water can affect the conductivity of water. It can also be affected by temperature, the higher the temperature, the higher the conductivity. [10]. The standard value for the electrical conductivity of drinking water should not be more than 250μS/cm, (Microsemens /cm). Electrical conductivity and total dissolved solids (TDS) are

very much related as total dissolved solids represent the total concentration of dissolved substances in water. TDS is considered an aesthetic factor, as TDS gives taste to water. In a study conducted by world health organization, a panel of taste testers were used to test the water for TDS levels. They concluded that the taste of water with TDS levels below 300 were excellent, TDS levels in the range 300 to 600 were good, TDS levels in the range 600 to 900 were fair, TDS levels in the range 900 to 1200 were poor, and above 1200 were unacceptable. [11]. Generally drinking water with TDS levels lower than 600mg/l is considered to be good. [6].

Mineral ions or inorganic chemicals in water can result naturally or from many sources. The amount or type of ions can differ depending on their source, purification method, or treatment method. It also could result from contamination because of human settlement, agriculture or industry.

3. METHODS

The tests were carried out in water quality assurance laboratory of MWSC (Maldives Water and Sewerage Company). MWSC has an ISO 17025 certified state-of-the-art laboratory. There are many brands of water available in the shops of Male' including international brands. However, the most consumed brands are the once which are packed in Maldives. Totals of 6 samples from the common brands of bottled water consumed in Maldives were collected for this study. All the bottles were purchased randomly from a supermarket. Two samples from each brand which were of different batches were included. Another sample of tap water was collected from a random household and was used as the 7th sample. The samples were collected in pre-washed and dried 500 ml sample bottles, and code names were given to keep the brand names anonymous. These codes were used in the rest of the study. The samples with code names were then sent to Water Quality Assurance Laboratory of MWSC, in Male'. The following carried physical and chemical aspects of water samples were tested using the explained methods.

Physicochemical analysis such as pH was measured using a METTLER TOLEDO pH meter, employing electrometry methods to evaluate the electrical properties of the solution. Electrical conductivity, indicating the presence of salts, was measured using a METTLER TOLEDO meter. For simplicity, MWSC used electrical conductivity values to estimate TDS, correlating conductivity with TDS through an experimentally determined factor. Zinc was measured using DR6000 UV-Vis Spectrophotometer.

Electrical Conductivity measurement: To measure conductivity, conductivity, laboratory method was used. In this method conductance or resistance for a standard KCl, (potassium Chloride) solution is measured and then a cell constant is calculated from the obtained conductivity, once the value is set, the conductivity of the sample will be displayed. This method is used to identify the conductivity in surface waters, drinking water and wastewater.

pH measurement: pH value in water by potentiometry using a standard hydrogen electrode was used to measure the pH. This method uses a pH meter to determine the water pH.

TDS measurements: To measure the total dissolved solids, electrometry was used. Electrometry uses an instrument, to detect the potential difference or ionizing radiations by using the force of attraction or repulsion between charged bodies. Electrical conductivity is related to amount of dissolved ions in water. These ions help the water to conduct an electric current, which then can be measured using a conductivity meter.

Measuring of mineral ions: To measure the amount of mineral ions, copper, magnesium, calcium and zinc, HACH (Housing Authority of City of Houston) methods were used. HACH is a company which produces water quality testing and analytical instruments.

Mg was determined by using digital titrator and Zn was analyzed using spectrophotometer DR 6000.

4. RESULTS

All the brands of bottled water which are packed in Maldives and used in this research are desalinated water. Desalination removes most of the ions present in water. These desalinated water bottles are mineralized after desalination, to make it more aesthetically pleasing for the consumers. So each brand have different ion levels, though all of them have comparatively lower levels of ions. In this study chemical composition of seven samples were tested, this includes six samples from three brands of water and another additional tap water sample was used for comparison. The following tables summarizes the results obtained, each parameter is analyzed separately and compared to WHO specifications.

From Table 1, the electrical conductivity values are found to be varied from 3.81 to 22.7 µS/cm. The standard for electrical conductivity of drinking water in WHO guideline is <400 µS/cm. The sample results lay in the WHO standard specification for electrical conductivity of drinking water.

Table 1. Electrical Conductivity of the samples

Sample	Results, µS/cm	WHO Specification, µS/cm
A1	3.81	<400
A2	8.44	<400
B1	8.70	<400
B2	10.73	<400
C1	22.7	<400
C2	22.4	<400
D	22.4	<400

From Table 2, pH values were found to be varied 6.25 to 6.70. The standard for pH of drinking water in WHO guidelines is 6.5 to 8.5. [12]. Samples, A1, C1, C2 and D are below the standard value. The result of other samples lie between the standard specifications.

Table 2. pH of the samples

Sample	Results	WHO Specification
A1	6.49	6.5-8.5
A2	6.58	6.5-8.5
B1	6.70	6.5-8.5
B2	6.64	6.5-8.5
C1	6.29	6.5-8.5
C2	6.32	6.5-8.5
D	6.25	6.5-8.5

From Table 3, TDS values were found to be varied from 1.90 to 11.4 mg/L. The standard for TDS of drinking water in WHO guideline is <1000 mg/L. The sample results lied in the standard specification.

Table 3. TDS levels in the samples

Sample	Results mg/L	WHO Specification mg/L
A1	1.90	<1000
A2	4.22	<1000
B1	4.35	<1000
B2	5.36	<1000
C1	11.3	<1000
C2	11.2	<1000
D	11.4	<1000

From Table 4, the amount of copper in the samples were found to be less than 0.1 mg/L. This value is the limit of quantification of copper in drinking water. Since the amount of copper in the samples were below 0.1 mg/L, it was not detected. The standard for amount of copper in drinking water in WHO guideline is <2 mg/L. The sample results lied in the standard specification

Table 4. Amount of copper in the samples

Sample	Results mg/L	WHO Specification mg/L
A1	<0.1	<2
A2	<0.1	<2
B1	<0.1	<2
B2	<0.1	<2
C1	<0.1	<2
C2	<0.1	<2
D	<0.1	<2

From Table 5, the amount of magnesium in the samples were found to be less than 0.98mg/L. This value is the limit of quantification of magnesium in drinking water. Since the amount of magnesium in the samples were below 0.1mg/L, it was not detected. The standard for amount of magnesium in drinking water in WHO guideline is <50mg/L. The sample results lied in the standard specification

Table 5. Amount of Magnesium in the samples

Sample	Results mg/L	WHO Specification mg/L
A1	<0.98	<50
A2	<0.98	<50
B1	<0.98	<50
B2	<0.98	<50
C1	<0.98	<50
C2	<0.98	<50
D	<0.98	<50

From Table 6, the amount of calcium in the samples A1, A2, B1, and B2, were found to be less than 1.6mg/L. This value is the limit of quantification of copper in drinking water. Since the amount of copper is below 1.6mg/L, it was not detected. Sample C1, C2 and D contains calcium in detectable levels. The standard amount of copper in drinking water in WHO guideline is <75mg/L. The samples results lied in the standard specification

Table 6. Amount of Calcium in the samples

Sample	Results mg/L	WHO Specification mg/L
A1	<1.6	<75
A2	<1.6	<75
B1	<1.6	<75
B2	<1.6	<75
C1	1.8	<75
C2	1.6	<75
D	2.16	<75

From Table 7, the amount of zinc in the samples were found to be varied from 0.01 to 0.04. The standard for amount of zinc in drinking water in WHO guideline is to be less than 3mg/L. [12]. The results lie between the standard specifications.

Table 7. Amount of Zinc in the samples

Sample	Results mg/L	WHO Specification mg/L
A1	0.02	<3
A2	0.02	<3
B1	0.04	<3
B2	0.01	<3
C1	0.04	<3
C2	0.02	<3
D	0.04	<3

Table 8. Water analysis for all the samples

Sample	Conductivity µS/cm	pH	TDS mg/L	Copper mg/L	Magnesium mg/L	Calcium mg/L	Zinc mg/L
A1	3.81	6.49	1.90	<0.1	<0.98	<1.6	0.02
A2	8.44	6.58	4.22	<0.1	<0.98	<1.6	0.02
B1	8.70	6.70	4.35	<0.1	<0.98	<1.6	0.04
B2	10.73	6.64	5.36	<0.1	<0.98	<1.6	0.01
C1	22.7	6.29	11.3	<0.1	<0.98	1.8	0.04
C2	22.4	6.32	11.2	<0.1	<0.98	1.6	0.02
D	22.4	6.25	11.4	<0.1	<0.98	2.16	0.04

5. DISCUSSION

Electrical conductivity, (EC) measures the ionic process of a solution that helps in conduction of electricity. Pure water is not a good conductor of electricity as it does not have many dissolved ions in it. So, a higher EC value suggest more dissolved substances in solution. According to WHO standards, the EC values should not be more than 400 µS/cm. The conductivity values of the samples were very low. This is acceptable because the samples were desalinated water, and desalination removes most of the dissolved ions in the solution.

Scientifically, pH measures the amount of hydrogen ions in a solution. The pH value also indicates if the water is hard or soft. The pH value of pure water is 7, and a pH lower than 7 is considered acidic and greater than 7 is considered a basic. The standard values for pH of drinking water is 6.5 to 8.5. If the water is very acidic or basic, then it can affect your health, by damaging the tissues or organs. [13]. From the samples tested, 57% of the samples were having pH values below the WHO standard values. Water with low pH values can be corrosive. They can leach metals form pipes and damage them, causing metallic taste and stains. [14].

Total dissolved solids (TDS) show the combined amount of both organic and inorganic substances dissolved in the solution. These organic substances include calcium, magnesium, potassium, sodium, carbonate, hydrogen carbonate, chloride, sulphate and nitrate ions. [15] In general, TDS values below 300 mg/L is considered very good water for drinking water. TDS values above 1000 mg/L is considered not safe for consumption. No recent data on health effects associated with the ingestion of TDS in drinking-water appear to exist; however, associations between various health effects and hardness, rather than TDS content, have been investigated in many studies. [15] . The TDS values of the samples tested are very low compared to the WHO standard values.

From the ions present in water, Magnesium and Calcium are present in salt water at a very high concentration. They are the substances which make the water hard, and can be very effectively removed from salt water by desalination, making the bottled waters low in ions. These ions are mostly added back to water, to neutralize the acidic nature of water after desalination. Results obtained from the study show that the mineral ions were very low, some of the ions were even undetectable. The low concentration of ions could pose health risks if water low in ions are consumed for a longer time. Calcium and Magnesium plays an important role in human dietary needs. [16]. So, a moderate consumption of bottled water and a balanced diet is the key maintain a healthy balance of the ions in the body.

The number of samples used for this study were very less considering the time limitation and the availability of resources, and testing. If more samples were included, a more detailed values and study could be obtained.

6. CONCLUSION

In this study, concentration of some ions, and physical aspect of 3 brands of most widely consumed water brands in Maldives were analyzed. The physical parameters and the ion concentrations were not very much variable. This is because of the factor that all these brands were desalinated water and doesn't include ions contributed to drinking water due to geological settings, climate and topography, as in waters packed from springs and other water sources. The amount of calcium in tap water was higher compared to the bottled water samples, this could be because of buildups in taps and piping. Changes to the concentration of ions may also occur during shipping and storage, especially if the bottles are exposed to direct sunlight or kept in stock for too long. In general, the overall quality of the most commonly consumed bottled waters in Maldives was in accordance to standards set by WHO and safe for drinking.

7. RECOMMENDATIONS

The findings from this study can be used for baseline data in future references. Moreover, a more detailed study of concentrations of ions and a comparison of natural sources of water, will be beneficial in the next step of the study. To ensure the safety of bottled water furthermore, a research on the presence of carcinogenic substances or hormone mimicking substances could be carried out

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