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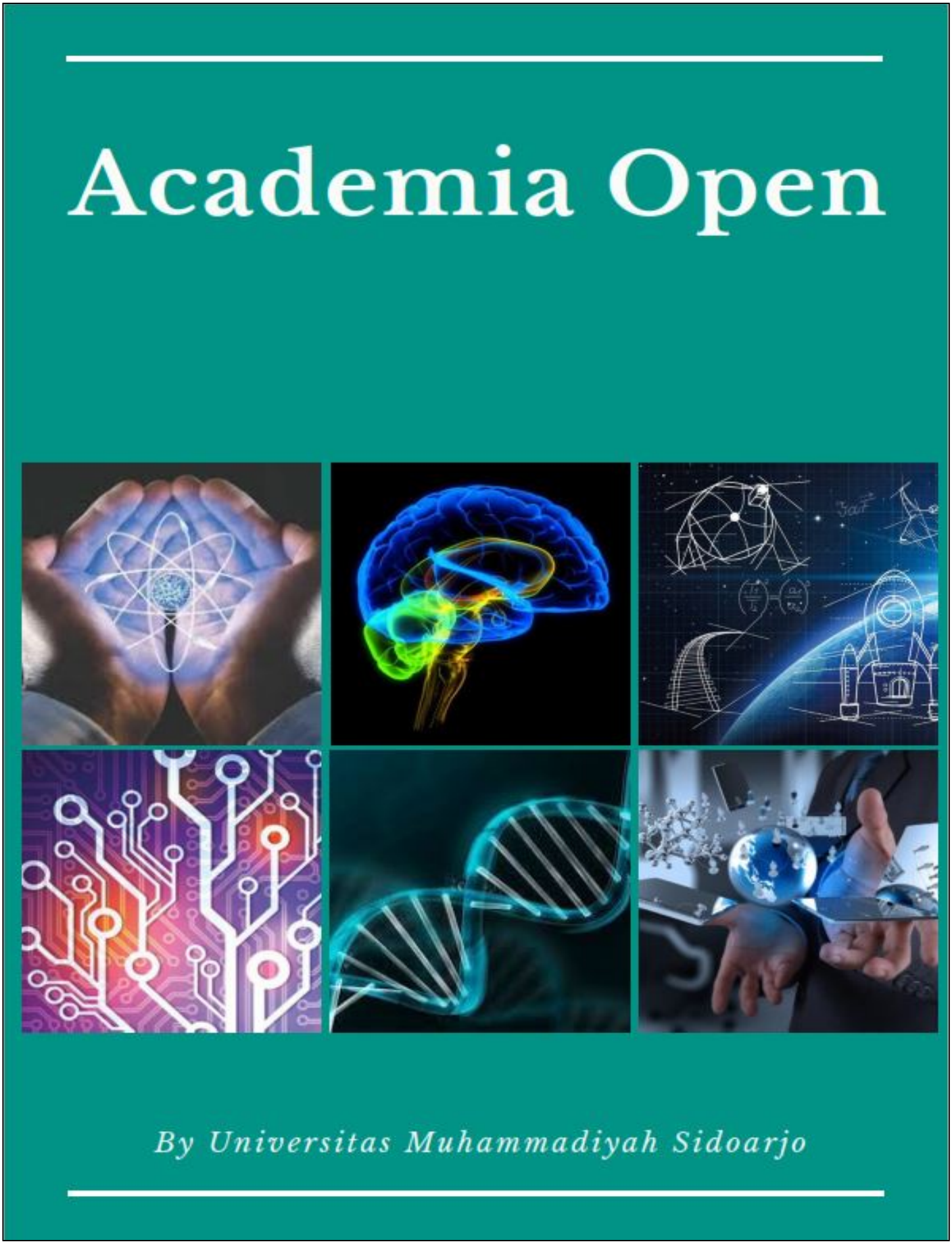

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Zamzam Water Surpasses Global Standards in Quality and Mineral Content

Air Zamzam Melampaui Standar Global dalam Kualitas dan Kandungan Mineral

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Abstract

This study investigates the physical, chemical, and bacteriological properties of Zamzam tap water and two popular bottled waters, "Rounaq" and "Naba' Al- Rayan," in Diyala Governorate. Conducted at Al-Rafidain University College and the Central Public Health Laboratory in Baghdad, the research analyzes taste, odor, color, pH, essential minerals, and bacterial contamination. Findings indicate that Zamzam water excels in sensory qualities and contains beneficial minerals like potassium and magnesium within safe limits, with no bacterial contamination detected. These results affirm Zamzam's superior quality and underline the necessity for regular quality checks of bottled waters to ensure public health safety.

Highlights:

- Superior Sensory Qualities: Zamzam water was notably superior in taste, odor, and color compared to the other bottled waters tested.
- Mineral Content and Safety: All water samples contained essential minerals like potassium and magnesium within safe limits, confirming their nutritional value and compliance with health standards.
- Bacterial Purity: No bacterial or pathogenic contamination was detected in any of the water samples, ensuring their safety for consumption.

Keywords: Zamzam Water, Bottled Water Quality, Mineral Content, Bacteriological Safety, Sensory Properties

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Introduction

Water is one of the most important elements in nature, consisting primarily of two crucial elements: oxygen and hydrogen. Living organisms obtain water from various sources, including different bodies of water, groundwater wells, and rainfall. Due to water scarcity in some regions, there is a need to find multiple alternative sources that provide water for people living in those areas. The most prominent of these methods are seawater desalination and wastewater treatment [1].

Water plays a vital role in digestion, absorption, and waste elimination. Safe drinking water is an internationally accepted human right. The use of fertilisers, pesticides, animal and human waste, industrial wastewater discharge, oil spills, and industrial chemicals are the causes of drinking water pollution. Analyzing the quality (physical, chemical, and microbiological) of drinking water provides important evidence of water pollution sources and guidelines for health protection. Water contains significant elements such as sodium, calcium, and magnesium necessary to maintain biological life. Trace elements primarily act as catalysts for enzymatic activity in the human body. However, their accumulation becomes toxic to the human body and should be removed from drinking water [2].

Cobalt, chromium, iron, manganese, molybdenum, nickel, selenium, vanadium, and zinc are necessary for growth. However, high concentrations of these elements become toxic to the human body.

1. Water

Water is an essential requirement for various physiological functions in the human body. Humans can survive without food for a month but only without water for three days. Only 1.9% of the total water on Earth is freshwater, while the rest is saline water, which is difficult to use, according to the Food and Drug Administration (FGD). Despite the limited water sources in the world and the rapid depletion of current sources, there is a water source called Zamzam that provides water to millions of people.

2. Zamzam Water

Zamzam is a blessed and sacred water that quenches the thirst of travellers to Mecca and Medina for Hajj or Umrah. Zamzam water is known for its purity, coolness, and refreshing nature. It is associated with the prophets Ibrahim (peace be upon him), Ismail (peace be upon him), Prophet Muhammad (peace be upon him), and the wife of Prophet Ibrahim, Hajar (peace be upon her). The Zamzam well is located Mecca, a

few meters east of the Kaaba. The well has a depth of 35 meters [3]. This water source is located in Mecca, one of the holiest Muslim cities. This city is located in the western part of the Kingdom of Saudi Arabia, 70 kilometres south of Jeddah on the Red Sea coast. Geographically, it can be located at approximately 21°26'48" north latitude and 39°53'46" east longitude, with an elevation of about 1,399 feet above sea level [4].

The brief stories mentioning Zamzam are described in the holy books of various religions, including the Torah (Old Testament), the Bible, and the Quran. As mentioned in these holy books, Zamzam is considered holy water and is referred to as a great gift from God. It is claimed to be a branch of a sacred spring (currently in the form of a well) in the barren desert surrounding Mecca. Muslims use Zamzam water for healing; as Prophet Muhammad (peace be upon him) said, "Zamzam water is good for whatever it is drunk for." In another hadith, the Prophet (peace be upon him) said, "Zamzam water is a healer of all diseases." It is the place indicated by the angel Gabriel and dug by him.

3. The Benefits of Zamzam Water

a. Therapeutic Benefits

Zamzam water possesses healing properties due to its rich calcium and magnesium content, which help reduce fatigue and illness. It benefits pregnant women who may experience fatigue during pregnancy.

1) It promotes the growth of healthy bones, attributed to the calcium content in Zamzam water, which is essential for bone growth and health.

2) It enhances energy in human cells, as it has been found to increase energy levels in the body's cellular systems, positively influencing metabolism and making a person more active and healthier.

3) It kills intestinal acidity as Zamzam water is alkaline, neutralising excess acids formed in the stomach, thus benefiting acid reflux and heartburn.

4) It is also beneficial in treating various eye disorders [5].

5) It is beneficial for heart health, helping to improve blood circulation and reduce the occurrence of coronary heart diseases [6].

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b. Immunological Benefits

It boosts the body's immunity, including platelet count, white blood cells, and red blood cells, and removes toxins from the body [7].

c. Preventive Benefits

Zamzam water protects against various diseases, such as kidney problems, and has a strong anti-inflammatory effect.

4. Drinkable Water

Drinking water is safe for human consumption and for preparing food without causing health problems. It is characterised by its cleanliness and freedom from harmful substances or microorganisms. Governments establish specifications for water provided to the public for drinking, bathing, and washing purposes.

In recent years, there has been a global focus on water in general and drinking water in particular, especially with the advancements in water filtration and purification technologies. Traditional water filtration methods, such as using surface water sources, have raised concerns about the purity and safety of the water from a health perspective. The elements present in water have specific universal limits and concentrations, exceeding which can adversely affect human health. As a result, people have turned to Reverse Osmosis (RO) technology to purify water. Reverse osmosis is a process that involves the movement of water from a higher-concentration solution to a lower-concentration solution through a semi-permeable membrane using pressure. It is a widely used method for water purification, where water passes through multiple stages to separate it from salts and other minerals. Reverse osmosis is commonly used in countries with saline water sources. On the other hand, freshwater sources are typically purified using filtration methods [8]. In Iraq, drinking water is closely related to the spread of diseases. Reports from the World Health Organization (WHO) indicate that over 3.4 million people die annually due to waterborne diarrheal diseases, with approximately one-third of these cases affecting children under the age of five. This is attributed to disease-causing agents that are transmitted through water. Environmental statistics from 2005 revealed that there were approximately 920,000 cases of diarrhoea among patients in healthcare facilities and those under the age of five in Iraq [9]. Contaminated water carries pathogenic agents that can cause various diseases such as polio, hepatitis A, typhoid, cholera, and others. Therefore, the contamination of drinking water poses inherent risks. Parasites can also be transmitted to humans

through drinking water, including Entamoeba histolytica, which causes amoebic dysentery, and Giardia lamblia, which causes epidemic intestinal inflammation in children [10]. Iraq used to have efficient water systems in the 1980s and before, with a population of 95% in urban areas and 75% in rural areas having access to safe drinking water. However, the deterioration of service sectors due to years of war, blockade, drought conditions, revenue shortages in the Tigris and Euphrates rivers, and management and operational problems with dams have hurt water quality. Due to the importance of this issue and its direct impact on human life, numerous studies have been conducted on drinking water's physical, chemical, and biological characteristics, comparing them with established standards [11].

Method

A. Collect Water Samples

Zamzam water was purchased from local markets in Makkah and packaged in plastic bottles for physical, chemical, and bacteriological examination. Two common types of mineral water in the local markets of Diyala Governorate, namely "Rounaq" and "Naba' Al-Rayan," which were packaged in small and tightly sealed bottles, were selected to assess their physical, chemical, and bacteriological properties and compare them with Zamzam water.

B. Tests Performed on Water

1. Physical Examination

a. Temperature

The temperature of the water was measured using a thermometer. Changes in the surface water temperature can affect the dissolution of gases such as oxygen and carbon dioxide (oxygen is more soluble in cold water than in warm water).

b. Dissolved Oxygen

A (DO2 meter 9071 type Jenway) was used to measure the amount of dissolved oxygen. The meter was calibrated

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with a special calibration solution provided with the device. Before starting the measurements, two readings were taken in the calibration solution and air. The measurements were expressed in mg/l.

c. Turbidity Measurement

A (Nephelometric) turbidity meter was used to measure the turbidity of the water. The meter was powered and left for some time to increase its temperature. The test tube was filled with the water sample using a pipette and placed in the device to determine the turbidity level. The results were expressed in NTU.

d. Taste Examination

The water samples were tasted and compared with reference samples, and the final evaluation was made.

e. Odor Examination

The smell of the water was detected by heating 150 ml of water in a glass container at a temperature below boiling point for 5 minutes, and then the smell of the rising steam was sniffed.

f. Color Examination

The colour was examined using a platinum cobalt colourimeter. The water was placed in a Nessler tube, and its colour was compared with the standard tubes to determine its clarity.

2. Chemical Examination

The chemical examination included the analysis of sodium (Na), calcium (Ca), magnesium (Mg), potassium (K), nitrates (NO3), bicarbonates (HCO3), and sulfates (SO4). The pH value and total dissolved solids (TDS) were also measured using various tools. As shown in the following table:

Elements	Devices used
Na	Flame photometer
Ca	Titration EDTA
Mg	Titration EDTA
K	Flame photometer
HCO3	Titration acid
NO3	Ion chromatograph
SO4	Ion chromatograph
pH	PH meter
TDS	Conductivity.T.D.S.Meter type Cyberscan

Figure 1. ***Equipment used in the S tudy***

The tests were conducted at the Central Public Health Laboratories in Baghdad, and the following procedures were used:

with different concentrations were prepared to calibrate the ion chromatography. The concentrations of sulfates and nitrates in the samples were recorded in (mg/l).

1. Measurement of acidity (pH): The pH value was measured using a pH meter. The meter was calibrated using buffer solutions, and the readings were expressed on a scale of 4 to 14.

2. Total Dissolved Solids (TDS): The TDS of the samples was measured at the laboratory temperature using a (Conductivity. T.D.S. Meter Cyberscan). The results were expressed in milligrams per litre (mg/l). The calculation formula used was 4. V(H2SO4)×Nx61×1000/V of Sample.

3. Analysis of sulfates (SO4) and nitrates (NO3): Ion chromatography was used to analyse sulfates and nitrates. The instrument was operated for one hour, and standards

4. Analysis of bicarbonates (HCO3): The titration method was used with sulfuric acid (H2SO4) of concentration 0.2N. Methyl red indicator was used to determine the value of bicarbonates according to the following equation.

5. Analysis of sodium (Na) and potassium (K): A flame photometer was used to analyse sodium and potassium. The instrument was operated for 15 minutes under stable conditions. A series of standards were prepared to calibrate the flame photometer, and the readings were recorded in units of 1/mg.

6. Analysis of calcium (Ca): The (Titration) method was used with ethylene diamine tetraacetate acid (Na-EDTA) in a basic medium (pH=10) using the (Miroxide) indicator to determine the concentration of calcium.

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7. Analysis of magnesium (Mg): The titration method was used for hardness in a basic medium (pH=10) with Na-EDTA solution. The (T-black Isocrom) indicator was used with a regulating solution to determine the concentration of magnesium according to the following equation:

VT.H - Vca = VMg,

VMg x 4.88 = Concentration of Magnesium.

Where:

H. VT = total hardness concentration.

VCa = calcium concentration.

VMg = magnesium concentration.

C. Bacteriological Examination

The bacteriological examination was performed using the serial dilution method. This was done by diluting the samples at four and without dilution. Afterwards, the bacteria present were classified and counted after being cultured on (MacConkey Agar) and (Nutrient Agar) media. The cultures were incubated for 24 hours, followed by microscopic examination.

D. Statistical Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 22. The variables with numerical characteristics were described using measures such as mean and standard error of the mean. The arithmetic means of the samples under study were compared using the Duncan test at a significance level 0.05.

Results and Discussion

A. Physical Examination

1. Temperature

Temperature effectively affects the dissolution of substances and gases in water, especially oxygen and carbon dioxide. It is also an important factor in determining the activity and effectiveness of aquatic organisms and bacteria, as well as in determining some properties of water, such as density and viscosity. Therefore, examining and recording the temperature of the samples is an essential test to understand the nature of water. The temperature was within an acceptable range for all tested samples.

2. Dissolved Oxygen

Table (2) shows the dissolved oxygen concentrations for the three types of waterfall within the natural ratios of their oxygen content, containing significant amounts of dissolved oxygen. The three samples recorded similar ratios.

The Water of Al-Rayan Spring (MEAN±S.E)	Water of Elegance (MEAN±S.E)	Zamzam Water (MEAN±S.E)
c 7.2 ± 1.1	b 7.5 ± 0.8	a 8.3 ± 0.6

Table 1. ***Dissolved Oxygen Quantity in mg/l.***

3. Turbidity

Table (3) indicates the nephelometric turbidity unit's (NTU) turbidity level for the studied samples. It shows that Zamzam water has the lowest readings, followed by Elegance water and then Al-Rayan water:

The Water of Al-Rayan Spring (MEAN±S.E)	Water of Elegance (MEAN±S.E)	Zamzam Water (MEAN±S.E)
c 1.8 ± 1.1	b 1.2 ± 0.8	a one ± 0.6

Table 2. ***Turbidity Ratio in NTU.***

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4. Taste Test

Ten students from the University of Bilaad Al-Rafidain's College of Water Resources tasted the three samples and compared them with three reference samples. It was found that the Ronaq water divided the students into two options: five students said it had an acceptable taste, and five others said it was tasteless. As for the Rayaan Spring water, six students said it had an acceptable taste, and four students said it was tasteless. As for Zamzam water, all students said it is tasteless, as shown in Table number (4).

Sample name	It has anunacceptable taste	It has anacceptable taste	It is natural andtasteless
Ronaq water	□□□	5	5
Rayaan Springwater	□□□	6	4
Zamzam water	□□□	□□□	10

Table 3. ***Shows the Taste Evaluation***

Zamzam water	Number of repetitions	percentage
It has an unacceptable taste	0	0
It has an acceptable taste	0	0
It is natural and tasteless	10	100%

Ronaq water	Number of repetitions	percentage
It has an unacceptable taste	0	0
It has an acceptable taste	5	50%
It is natural and tasteless	5	50%

Rayaan Spring water	Number of repetitions	percent age
It has an unacceptable taste	0	0
It has an acceptable taste	6	60%
It is natural and tasteless	4	40%

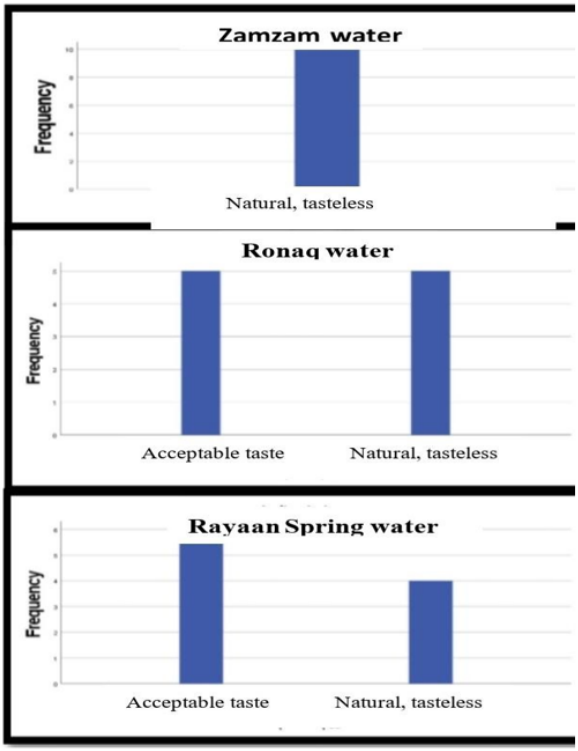

Figure 2.

boiling point for 5 minutes with ten students from Al-Rafidain University College. All the samples had a natural scent, as shown in Table (5).

Sample name	Unacceptable	Acceptable	Natural
Ronaq water	□□□	□□□	10
Rayaan Spring water	□□□	□□□	10
Zamzam water	□□□	□□□	10

Table 4. ***Shows the Odour Evaluation***

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Zamzam water	Number of repetitions	percentage
Unacceptable	0	0
Acceptable	0	0
Natural	10	100%

Ronaq water	Number of repetitions	percentage
Unacceptable	0	0
Acceptable	0	0
Natural	10	100%

Rayaan Spring water	Number of repetitions	percentage
Unacceptable	0	0
Acceptable	0	0
Natural	10	100%

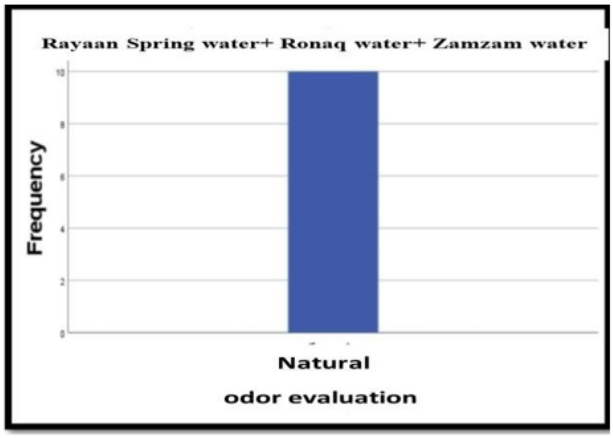

Figure 3.

5. Color Check

Colour was examined using the "platinum cobalt scale." A Nessler tube with a capacity of (50 ml) was filled with the sample to be tested, and the colour of the sample was compared to the colours of standard solutions. This comparison was done by vertically looking down through the tubes towards a smooth white surface at an angle that allows light to reflect through the liquid columns. Ten students from Al- Rafidain University College observed the three samples, and it was found that all the samples were colourless, as shown in Table (6).

Sample name	Distinctive color	Indistinct colour	Without colour
Ronaq	□□□	□□□	10
Rayaan Spring	□□□	□□□	10
Zamzam	□□□	□□□	10

Table 5. ***S hows the Colour Evaluation***

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Zamzam water	Number of repetitions	percentage
Distinctive color	0	0
Indistinct colour	0	0
Without colour	10	100%

Ronaq water	Number of repetitions	percentage
Distinctive color	0	0
Indistinct colour	0	0
Without colour	10	100%

Rayaan Spring water	Number of repetitions	percentage
Distinctive color	0	0
Indistinct colour	0	0
Without colour	10	100%

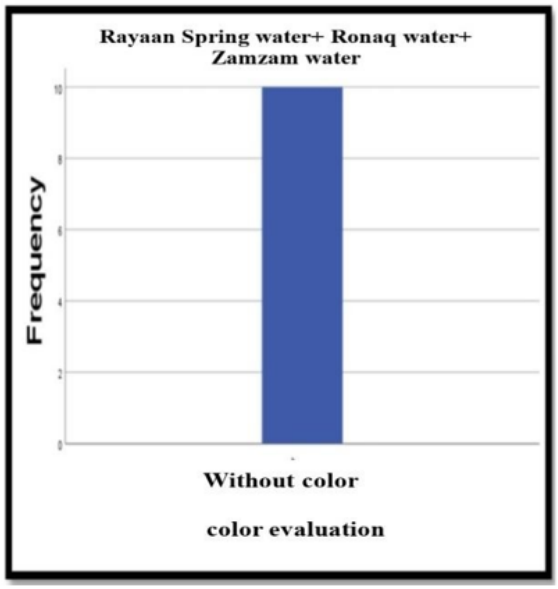

Figure 4.

B. Chemical Examination

1. pH Total Dissolved Salts (TDS)

Table number (7) indicates the total dissolved salt percentage (705) and the percentage (0|4) for the studied samples. It is evident from the table that the acidity levels of all the samples were acceptable and close to neutral, which aligns with the information provided by Abdul Sultan Hassan in "Lectures on Animal Environment" (2006), where it is mentioned that drinking water should have a pH level of (6.5 - 9.5).

As for the total dissolved salt percentage, the results shown in Table number (7) indicate that Zamzam water contains a high percentage of dissolved salts due to its high content of salts and minerals [12].

Samples	TDS (MEAN±S.E)	PH (MEAN±S.E)
Zamzam water	a 890± 1.3	a 8.3± 0.14
Ronaq water	b 91.4± 1.3	a 7.5± 0.14
Rayaan Spring water	c 81.4± 1.1	a 7.3± 0.13

Table 6. ***S hows the pH and Total Dissolved Salts Analysed Statistically using the Mean and Standard Error.***

The lowercase letters represented vertically indicate significant differences at a level of ($p < 0.05$).

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2. Inorganic Materials

The laboratory studies on the chemical analysis of Zamzam water, Rownaq water, and Rayan Spring water, as indicated in Table 8, showed very important readings for all the inorganic elements: sulfate (SO4), bicarbonate (HCO3), sodium (Na), potassium (K), nitrate (NO3), calcium (Ca), and magnesium (Mg). By comparing the results presented in Table (8), it is evident that Zamzam water is richer in essential inorganic elements than other types. The readings are as follows:

Samples	So4 (MEAN±S.E)	HCO3 (MEAN±S.E)	Na (MEAN±S.E)	No3 (MEAN±S.E)	Ca (MEAN±S.E)	Mg (MEAN±S.E)	K (MEAN±S.E)
Zamzam water	a 192.8± 0.8	a 180.4±2.07	a 129.8±1.3	a 96.2±0.8	a 95± 0.7	a 38.4± 1.1	a 34.2± 1.3
Ronaq water	c 8.3±1.08	c 16.6±0.9	c 7.9± 0.2	c 2.4± 0.3	c 12.1±0.7	c 3.7± 0.5	c 3.1± 0.2
Rayaan Spring water	b 16.2±1.3	b 33.8±0.8	b 7.2±0.11	b 1.2±0.12	b 16.8±0.8	b 5.2± 0.07	b 1.32±0.13

Table 7. ***Results of Chemical Analysis of Inorganic Substances for Zamzam water, Al Rawnaq Water, and Al Rayyan Spring Water, Statistically Analysed using the Mean and Standard Error***

The lowercase letters represented vertically indicate significant differences at a level of ($p < 0.05$).

a. SO4

Sulfate ions (SO4) are present in water at various concentrations, and high concentrations can cause diarrhoea and a metallic taste. Chemical analysis of the studied samples revealed that the highest reading was found in Zamzam water (192.8 mg/l), while the lowest reading was in Ronq water (8.3 mg/l). The average reading was in Riyan spring water (16.2 mg/l). Based on these readings, it can be observed that the sulfate concentration in Zamzam waterfalls is within the permissible limit (25-400 mg/l) according to the World Health Organization (WHO) specifications. These results align with the findings mentioned by Siraj. However, Ronq water and Riyan spring water had lower levels than required.

b. Bicarbonate (HCO3)

Bicarbonate ions are a major component of natural water and are formed by the reaction of carbon dioxide dissolved in water with limestone rocks predominantly composed of calcium carbonate. During the chemical analysis of the samples, Zamzam water recorded a high concentration (180.4 mg/l) of bicarbonate. In comparison, Al Rawnaq water had a concentration of 16.6 mg/l, and Al Rayyan Spring water had a concentration of 33.8 mg/l. It is noteworthy that the bicarbonate concentration in Zamzam waterfalls is within the permissible limit (225-400 mg/l) according to the World Health Organization (WHO) specifications. Al Rayyan Spring water also falls within the permissible limits, but Al Rawnaq water has a concentration lower than the required limit.

c. Sodium (Na)

Sodium ions are an important component of potable water, but their presence in high concentrations can lead to various health issues, such as hypertension and urinary tract infections [13]. The chemical analysis revealed a significant sodium concentration in Zamzam water, measuring (129.8 mg/l). In comparison, the lowest concentration was found in Al Rayyan Spring water (1.7 mg/l), and the average concentration in Al Rawnaq water was (1.79 mg/l). It is worth mentioning that the sodium concentration in Zamzam waterfalls within the permissible limit for drinking water (25-250 mg/l) according to the World Health Organization (WHO)

Specifications. However, it should be noted that the readings for Al Rawnaq water and Al Rayyan Spring water were below the reference values.

d. Nitrate (NO3)

The concentration of nitrate ions in the analysed samples was found to be high in Zamzam water (96.2 mg/l), exceeding the permissible limit (1-50 mg/l) set by the World Health Organization (WHO). Al Rawnaq water had a concentration of 1.2 mg/l, while Al Rayyan Spring water had a concentration of 2.4 mg/l.

e. Calcium (Ca)

The results presented in Table (5) indicate that Zamzam water had the highest concentration of calcium (95 mg/l), while the lowest concentration was found in Rawnaq water (12.1 mg/l). The average readings for Al-Rayyan Spring water were

16.8 mg/l. Based on these readings, it can be observed that the calcium concentration in Zamzam waterfalls is within the permissible limit (50-150 mg/l) recommended by the World Health Organization (WHO). However, Al

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Rawnaq water and Al Rayyan Spring water had lower concentrations.

f. Magnesium (Mg)

The results presented in Table (5) indicate that Zamzam water had the highest magnesium concentration (38.4 mg/l). In comparison, the lowest concentration was found in Al Rawnaq water (3.7 mg/l), and the average readings for Al Rayyan Spring water were (5.2 mg/l). It is noteworthy that the magnesium concentration in Zamzam Waterfalls is within the permissible limit (25-50 mg/l) according to the World Health Organization (WHO). However, Al Rawnaq and Al Rayyan Spring water concentrations were relatively low.

g. Potassium (K)

According to the results in Table (5), Zamzam water exhibited the highest potassium concentration (34.2 mg/l). Al-Rayyan Spring water had the lowest concentration (1.3 mg/l), and the average readings for Al-Rawnaq water were 3.1 mg/l. These concentrations fall within the permissible limit (1-50 mg/l) as defined by the World Health Organization (WHO).

C. Bacteriological Examination

The bacteriological examination is crucial for assessing the level of microbial contamination in water. Table (9) presents the results of the bacterial examination using dilution on (MacConkey Agar). The findings indicate that Zamzam, Al- Rawnaq, and Al-Rayyan spring water were free from bacterial and pathogenic contamination. The bacterial colony count for these samples was within the normal range (0.0%). When the samples were studied by dilution on Nutrient agar, Zamzam water showed normal results, followed by Al-Rayyan Spring water and Al-Rawnaq water. These results fall within the typical range of bacterial colony counts [14]. (30-300 cells/ml). Furthermore, when the samples were studied without dilution on Nutrient agar, Zamzam water, Al-Rayyan Spring water, and Al-Rawnaq water, they were found to be normal and free from bacterial and pathological contamination. These results align with the normal bacterial colony count (30-300 cells/ml) [14].

Samples	Bacteria without dilution		Bacteria with dilution	
	Nutrient ager(MEAN∓S.E)	MacConkeyager(MEAN∓S.E)	Nutrient ager(MEAN∓S.E)	MacConkeyager(MEAN∓S.E)
Zamzam water	a0.00∓ 0.00	a0.00∓ 0.00	a0.00∓ 0.00	a0.00∓ 0.00
Ronaq water	C9.12∓ 1.7	a0.00∓ 0.00	C6.10∓ 1.23	a0.00∓ 0.00
Rayaan Spring water	B8.33∓ 2.31	a0.00∓ 0.00	B5.23∓ 1.4	a0.00∓ 0.00

Table 8. ***Bacteriological Examination Results were Analysed Statistically using the Mean and Standard Error***

The lowercase letters represented vertically indicate significant differences at a level of ($p < 0.05$).

Conclusion

Water is considered one of the most important substances on Earth, as all plants and animals need water to survive. Without water, there would be no life on Earth. This study demonstrates the following:

a. There are significant differences between bottled water and Zamzam water in terms of pH, total dissolved solids, and inorganic elements at a constant temperature.

b. Zamzam water contains good amounts of mineral elements such as potassium, calcium, magnesium, and sodium, giving it distinctive nutritional value.

c. Some physical and chemical criteria for bottled drinking water were within the permissible limits according to Iraqi and international standards, while others were below the required threshold.

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