

A comparative study between the chemical composition of potable water and Zamzam water in Saudi Arabia

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Abstract:

Objectives: The purpose of the present study was to analyze the chemical composition of potable water and compare it with that of Zamzam water.

Methodology: *Laboratory investigations* were carried out to analyze the chemical composition of Riyadh drinking tap water and compare it to that of Zamzam water

Results: *Laboratory investigations* of the chemical analysis of **Zamzam water** from both well and pipe sources demonstrated almost similar readings with no significant differences ; but when compared to **Riyadh tap water; Zamzam water from both sources showed highly significant** readings in all inorganic elements

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Introduction:

Water is one of the main dietary components. Its quality plays an important role for the safety of food particularly for infants. For the youngest children the ground water that provides excellent water sources free of microbiological pollution and with the proper chemical composition can be used. For infants, natural spring water and natural mineral water of low sodium concentration ($\leq 20\text{mg}/1\text{ dm}^3\text{ Na}^+$) and low mineralized ($\leq 500\text{mg}/1\text{ dm}^3$) dissolved solids is recommended. For older children the mineralization of water may be higher ($\leq 1000\text{mg}/1\text{ dm}^3$). Bioavailability of water macro- and microelements is high, so mineral water may be a good source of these elements in children's diet.¹

There are various types of drinking water available in Saudi Arabia; tap water, spring water, bottled and mineral water. The water from wells in Saudi Arabia is often high in mineral contents.²

According to Arab historians, the *Zamzam* Well has been in use for around 4000 years. The well marks the site of a spring where *Allah, in His mercy*, sent the *Angel Gabriel*, who scraped the ground, causing the spring to appear. That was when *Hajar Prophet Abraham's wife, and their infant son Ismail (PBUH)* had left in her desperate search for water, who was dying of thirst. On finding the spring, and fearing that it might run out of water, *Hajar* enclosed it in sand and stones. The name *Zamzam* originates from the phrase *Zomë Zomë*, meaning 'stop flowing'. The *Zamzam* well is located within the *Holy Mosque* at about 20 m east of the *Ka'ba in Makkah*³

In 1971, the Ministry of Agriculture and Water Resources sent samples of **Aab-e-Zamzam** for investigations to the European laboratories to test the potability of the water. The results of the water samples tested by the European laboratories showed that *Zamzam water* has a special physique that makes it advantageous water. The main difference between *Zamzam water* and other water (city water) was in the quantity of calcium and magnesium salts, the content of these was slightly higher in *Zamzam water*, but more significantly, the water contains fluorides that have an effective germicidal action. Moreover, the remarks of the European laboratories showed that the water was fit for drinking⁴

This fact has also been proven by a group of Pakistani researchers⁴ who analyzed the water and found identical results to that previously mentioned by the European Laboratories.

The institute of the Custodian of the Two Holy Mosques for Al Hajj research centre in Om Al Qura university also conducted a special research and examined the extent of purity of *Zamzam water* and found that it has a wonderful physique that makes it different from other drinkable liquids because it is naturally pure and sterile that has no germs in it.⁵

Zamzam Water has always maintained the same composition and taste ever since it came into existence. Water tastes different at different places. *Zamzam water's* appeal has always been universal. Biological growth and vegetation usually takes place in most wells. This makes the water unpalatable owing to the growth of algae causing taste and odour problems. But in the case of the *Zamzam water* well, there wasn't any sign of biological growth^{3,4}. The main source of *Zamzam water* is pure by itself but the

leakage of underground water and external usage of people cause its pollution. For this purpose ultraviolet rays is being used as a safe mean for sterilization. ⁶

The preponderance of evidence indicates that fluoride can reduce the incidence of dental caries and that fluoridation of drinking water can provide such protection. ^{7,8,9}

Zamzam water having high percentages of calcium, magnesium, sodium, potassium and fluorides in addition to other minerals and salts led us to the idea of the present research to study the chemical composition of *Zamzam water* and compare it to Riyadh drinking tap water.

Aim of the Present Research:

To analyze the chemical compositions of Riyadh drinking tap water and compare it with that of *Zamzam water*.

Materials and Methods:

Laboratory investigations were carried out to analyze the chemical composition of Riyadh drinking tap water and compare it to that of *Zamzam water*. Water samples from both sources were collected. For the tap water, it was collected during the day time. The tap water was allowed to run for a few minutes before obtaining the sample. The bottle was first washed three times with water prior to the collection of about 300 ml of the water sample in 500ml polythene bottle. For the *Zamzam water* two samples were collected from two places; One from the *Zamzam well* and the second from the *Al Haram* pipes. The collection of each was about 300 ml in 500 ml polythene bottles. The analysis was carried out within 24 hours. The analysis were for sodium (Na) , calcium (Ca), magnesium (Mg), potassium (K), chloride (Cl), fluoride (F), nitrate (NO₃) , bicarbonate (HCO₃), and sulphate (SO₄). The pH and the total dissolve alkalinity (TDS) were also measured using different instruments as shown in the *table (1)*.

The analyses were carried out at the King Abdul Aziz City of Science and Technology (KACST) and the following procedures were used for:

1) Analysis of Chloride (Cl), Sulphate (SO₄), Nitrate (NO₃), and Fluoride (F):

The IC (Ion Chromatography) was used and run for one hour to reach stable conditions. Standards of different concentrations were prepared to calibrate the IC (Ion Chromatography) using the calibration standards for required parameters for Chloride (Cl) Sulphate (SO₄) Nitrate (NO₃) and Fluoride (F).After calibration of the water , samples were run and the concentration of the samples were recorded as mg/l.

2) Analysis of Sodium (Na) and Potassium (K):

Flame Photometer was used and run for 15 minutes for stable conditions. A series of calibration standards were prepared to calibrate Flame Photometer. The lowest standard was used prior to the higher standard. The readings were recorded and calibration curve was prepared. The water samples were run and the concentration was calculated.

3) Analysis of Total Hardness, Calcium (Ca) and Magnesium (Mg) by titration:

- (a) Standard solutions EDTA of (0.02N) were prepared. The water sample was taken, and buffer solution was added to adjust the pH. Hardness indicator was added, and titrated with EDTA. The volume used was recorded and the Total Hardness as CaCO₃ was calculated.
- (b) Another volume of the sample was taken. Calcium buffer and indicator were added, and titrated with EDTA. The volume of EDTA used was recorded and the Calcium Hardness was calculated. The Calcium Hardness was subtracted from the Total Hardness and Magnesium Hardness was calculated, then Calcium as (Ca) and Magnesium as (Mg) was also calculated.

4) Total Alkalinity as CaCO₃, Carbonate (CO₃) and Bicarbonate (HCO₃):

Sulphuric acid of (0.02N) was prepared. The water sample was taken and the reagent was added and titrated with H₂SO₄. The volume of acid was recorded, and then the Total Alkalinity as CaCO₃ was calculated. Similarly the Carbonate (CO₃) and Bicarbonate (HCO₃) were also calculated

Results:

Laboratory investigations for the chemical analysis of *Zamzam water* from both well and pipe sources demonstrated almost similar readings with no significant differences in all the inorganic elements and pH as shown in table 2; but when compared to *Riyadh tap water*; ***Zamzam water from both sources showed*** highly significant readings in all inorganic elements: Na, Ca, Mg, K, HCO₃, Cl, F, NO₃, SO₄, TDS (total dissolve alkalinity) except the pH which was almost similar in Riyadh tap water (7.2) to that of *Zamzam water* (7.9 – 8)

Discussion:

The following research was undertaken to analyze the chemical composition of Riyadh drinking tap water and compare it with that of *Zamzam water*.

The chemical analysis of *Zamzam water* from both well and pipe sources demonstrated highly significant readings in all inorganic elements including higher levels of fluoride when compared to tap water.

Exposure to fluoride in drinking water has been shown to be beneficial for oral and general health, especially in relation to dental caries and osteoporosis.¹⁰

In Saudi Arabia, drinking water is obtained from several sources including desalinated seawater, as well as ground water from wells,¹¹ more recently; bottled water has been gaining popularity.¹²

Kordy and Fonseka¹³ have reported that public water supply in Riyadh city was within the optimal range for dental health, while Mohamed and Fattah¹⁴ reported fluoride levels of 0.26 – 0.43 ppm in the drinking water of Riyadh similar to the present findings where the fluoride level in Riyadh was found to be 0.28 ppm whereas the mean fluoride level collected from Zamzam water from both well and pipe sources was 0.72 ppm and 0.68 ppm respectively in accordance to the results obtained from the institute of the Custodian of the Two Holy Mosques for Al Hajj research centre in Om Al Qura university where they reported that the mean fluoride level in Zamzam water was 0.6 ppm.⁵

Al Dosari et al¹⁵ reported that the mean fluoride levels in drinking water of most of the categories in Makkah region were lower than the aggregate values, with maximum mean fluoride value from wells (0.66 – 0.90).

The World Health Organization regards 1.5 ppm as the upper limit of fluoride exposure that is appropriate.¹⁶

It has been suggested that the optimal fluoride level in drinking water in communities where ambient temperature is above 27°C should be approximately 0.6 – 0.8 ppm¹⁷ in consistent to the present findings.

The role of fluoride in the prevention of dental caries is very well established. Since 1942, Dean et al reported an inverse relationship between caries prevalence and drinking water with different fluoride levels stating that exposure to water containing about 1 ppm fluoride in drinking water reduces caries experience by 50 % whereas fluoride levels higher than 1.5 ppm in temperate countries is known to cause dental fluorosis.¹⁸

Fluoride is incorporated into the enamel surface both before and after eruption of the teeth. The major source of fluoride post-eruptively is fluoridated dentifrices, professionally applied topical applications, mouth rinses and fluoride containing water. Fluoride ingested through food, supplements and water returns to mouth in saliva and enhances remineralization. Community water fluoridation is the most effective and least expensive way of providing fluoride to groups of people¹⁹.

Calcium is the most abundant and the most important mineral in the body, yet it is the most difficult to get absorbed and utilized by the cells. It raises the body's resistance to viruses, parasites, cancer as well as bacteria which causes tooth decay. Calcium naturally occurs as a compound molecule (i.e. Calcium carbonate, Calcium lactate or Calcium gluconate). When Calcium is in a compound form, magnesium and vitamin D increase its absorption. Sodium helps keep Calcium in soluble form in the body. To be usable in the body, Calcium must be water-soluble. The human body needs water soluble calcium with water soluble magnesium. If your body does not have about two parts magnesium for every one part calcium, the calcium becomes pollution for the body while magnesium helps keep bone from becoming brittle.²⁰

Ionic calcium in water is the best form to use, being the only physiologically active form of this element. ²⁰ All sources of this mineral compounds, whether through the diet or from the bones (serve as a storage deposit) and teeth must be broken down to its ionic form before it can be used by the body. Usually calcium absorption takes place in duodenum on the other hand **ionic calcium** digestion is not required, the body will absorb minerals immediately upon entering the mouth and a majority of the minerals will be absorbed before it ever enters the lower stomach, needs no stomach acid to be absorbed and assimilated. Calcium absorbed in our bodies from **calcium lactate** compound (commonly found in dairy product) is 33% or 105mg of usable calcium while 98% or 392mg in **ionic calcium** is absorbed.²⁰

Since then, a large number of studies have confirmed the beneficial effects of fluoride in the drinking water. According to Hubert et al, in a recent study in France, he stated that various types of water can be advised to patients, including tap water, most types of spring water, but not all mineral waters.²¹ Whereas other investigators reported that the mineral water may be a good source of elements such as sodium, in addition to mineralized and dissolved solids specially in children's diet. ¹

On the other hand, several other studies have reported a low caries experience with increasing level of fluoride concentration in drinking water. ²²

Conclusion:

Within the limitation of the present research, the following conclusions seem appropriate:

- This study has provided an essential base – line data regarding the analysis of the chemical composition of Riyadh drinking tap water and to compare it with that of Zamzam water.
- The preponderance of evidence indicates that fluoride can reduce the incidence of dental caries and that fluoridation of potable water can provide such protection
- Zamzam water from both sources (well and pipes) has proven to contain high levels of fluoride when compared to potable water
- Ionic calcium in water is the best form to use to insure its proper absorption by the bones and teeth
- Due to the ubiquitous nature of exposure to fluoride sources other than potable water; it is currently impossible to draw firm conclusions thus further studies are needed to study the independent effect of solely drinking Zamzam water and its advantages over potable water.

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Appendix (tables) :

<i>Elements</i>	<i>Devices used</i>
Na	Flame photometer
Ca	Titration EDTA
Mg	Titration EDTA
K	Flame photometer
HCO ₃	Titration acid
Cl	Ion chromatograph
Fl	Ion chromatograph
NO ₃	Ion chromatograph
SO ₄	Ion chromatograph
PH	PH meter
TDS	Oven 105°C

Table 1: Various Devices used for the elemental analysis

Elements	Tap water	Zamzam well water	Zamzam pipe water
Na	37.8	133	135
Ca	75.2	96	96
Mg	6.8	38.88	38.88
K	2.7	43.3	43.2
HCO₃	70.2	195.4	195.4
Cl	73.3	163.3	159.7
Fl	0.28	0.72	0.68
NO₃	2.6	124.8	126.1
SO₄	107	124	123.3
PH	7.2	8	7.90
TDS	350	835	840

Note: all values except pH are in mg/l

Table 2: Chemical Analysis of Tap and Zamzam water