Quality of Bottled Water in the Kingdom of Saudi Arabia: A Comparative Study with Jazan Water and Zamzam Water

Asia Ali Haider Alshikh

Girl's College of Educational, Jazan, Ministry of Higher Education, Jazan University, Kingdom of Saudi Arabia
Ziadahmed1020@hotmail.com

Abstract: It is needless to say that the quality of water is of vital importance to public health. Efficient surveillance and check strategies are important for executing a high quality management of this resource. Water samples were collected from different localities within Jazan and compared it with Zamzam water. All Water samples were subjected to Chemical and Bacteriological examination. All water samples taken in the study are almost following the WHO and US-EPA standards. Zamzam water has proven to contain high levels of fluoride, Mg, Ca, Chloride, sulfate, nitrate, nitrate, TDS, and alkalinity when compared it with Tap, drinking water. In Zamzam water, wells water, tap water, and drinking water samples there isn't any sign of biological growth.

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1.Introduction:

Zamzam water is located inside the Holy Mosque at about 20 Meters east of the Ka'ba in Makkah Al-Mukarramah, Saudi Arabia. The well of Zamzam is hand-excavated and is about 30.5 m deep, with an internal diameter ranging from 1.08 to 2.66 meters. Zamzam water is different from other water in many ways: first no bacteria can form at its source. Second it doesn't go mouldy nor does it change

colour, taste or smell (Koshak,1983). Biological growth and vegetation usually take place in most wells. This makes water unpalatable owing to the growth of algae leading to changes in taste and odour. However, in Zamzam water well, there isn't any sign of biological growth (Mashat, 2010). The Chemical analysis of Zamzam water contains some inorganic elements such as sodium (Na), calcium (Ca), magnesium (Mg), potassium (K), bicarbonate (HCO3), chloride (Cl), fluoride (Fl), nitrate (3– NO), sulfate (SO4), and totally dissolved

salts (TDS) (Al-Zuhair, 2005). In 1971, the Ministry of Agriculture and Water Resources sent samples of Aabe 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 drinking (The annual report of the ministry of agriculture and water resources, 1971). This fact has also been proven by a group of Pakistani researchers

(The annual report of the ministry of agriculture and water resources 1971) who analyzed the water and found identical results to that previously mentioned by 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 (cited from the institute of the Custodian of the Two Holy Mosques for Al Hajj research centre in Om Al Qura university (personal communication), 2005). After Zamzam water intake statistically significant decrease in the size of tumor (P<005), and increase in lymphocyte (P<0.05), zamzam water cause upregualtion of gene which stimulate reduction of tumor and down regulation of gene which increase in size in the tumor and its spread (Ali, 2009). Zamzam water effectively increase tooth resistance against acid dissolution, therefore it is useful to harden enamel surface against dental caries challenge (Hoobi, 2011). Drinking Zamzam water enhanced antioxidant power and reduced HbA1c significantly in type 2 diabetic patients. Further research is needed in this area to confirm the results and explore the mechanism behind HbA1c lowering effect produced by Zamzam water (Bamosa,2013).

2.Material and Method:

Collection of the samples:

Samples collection:

Included samples of Zamzam water, samples of bottled water Traded in markets and tap water samples from the city of Jizan. Tap water samples were chosen from Jibal Alhasher, Sabia, Jazan and Bani-Malik. All reagents used were of analytical grade. Samples were unfiltered and the concentration of the different parameters could correspond to the total concentration of the tap water elements was used by the consumers. Samples of wells water were collected in two times in dry season from the study area. Before water sampling, all the glass bottles were cleaned and rinsed thoroughly with water to be analyzed. All reagents used were analytical grade. Samples were unfiltered and the concentration of the different parameters could correspond to the total concentration if the groundwater was used by the consumers for drinking. The groundwater samples were stored at 1-4°C temperature prior to analysis in the laboratory.

The devices used in the study:

1-pH: by a pH electrode.
2-TDS: by measuring device electrical conductivity
3-Turbidity: device by optical absorption.
4-Total hardness: by titration with a solution(EDTA)
5-Calcium hardness: by titration with a solution (EDTA).
6-Magnesium hardness = Total hardness - Calcium hardness.
7-Total alkalinity: by titration with a solution HCL
8-Chloride: by titration with a solution of silver nitrate ($AgNO_3$).
9- Ammonia, Nitrate, Nitrite, Fluoride and Sulfate by device spectrophotometer (DR2800 _ DR5000)**.**

3.Results and Discussion:

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 (Challis *et al.,* 1987). In Saudi Arabia, drinking water is obtained from several sources including desalinated seawater, as well as ground water from wells (Abdulla *et al.,* 1997), bottled water has been gaining popularity (Paul *et al.,* 1998). Figure 1. Give the summary of the results obtained in this study for concentrations of anions in the ground, drinking, tap, zamzam waters. The concentration level ranged from 0.006 mg/L to 390 mg/L. The SAS states that the optimum value for the maximum allowable value is 600mg/L. Using this standards all of the water samples within the optimum value are over the maximum allowable value of anions. This would indicate that most water samples are suitable to use as water. The results showed high Florid concentration in ground water was 355 mg/l. Followed by Zamzam water was 0.23 mg/l, then drinking water and Tap water were 0.0 mg/l. The World Health Organization regards 1.5 ppm as the upper limit of fluoride exposure that is appropriate (WHO, 1984). It has been suggested that the optimal fluoride level in drinking water in communities where ambient temperature is above 27^{o}C should be approximately 0.6 – 0.8 ppm 17 in consistent to the present findings. The preponderance of evidence indicates that fluoride can reduce the incidence of dental caries and that fluoridation of drinking water can provide such protection (Pervianen *et al.,* 1977, Kaminsky *et al.,* 1990; Ripa,1993). 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 (Dean *et al.,* 1942). 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 people (Amjad *et al.,* 1999). 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 (Brambilla and Fluoride, 2001). 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 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 (Hubert *et al.,* 2002). 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 (Rudzka – kantoch and Weker, 2000). On the other hand, several other studies have reported a low caries experience with increasing level of fluoride concentration in drinking water (Angellillo *et al.,* 1996). Fluoride is found naturally in low concentration in drinking water and foods (WHO, 2000). In these small naturally occurring amounts fluoride is beneficial, and the fluoridation of water is known to prevent tooth decay (Griffin, 2007). Figure 1. Give the summary of the

results obtained in this study for concentrations of Chloride in water. It were highest in the wells water, it were (390 mg/l). Following Zamzam water were (89.1 mg/l). Then drinking water were (42.6 mg/l). Finally tap water were (21.3 mg/l).Zamzam water is 100 percent natural and there is no chlorine in it, nor is it chemically treated in any way," he said (Al-Sibai, 2009). drinking, tap and zamzam waters. The concentration level ranged from 0.006 mg/L to 390 mg/L. The SAS states that the optimum value for the maximum allowable value is 600mg/L. Using this standards all of the water samples within the optimum value are over the maximum allowable value of anions. This would indicate that most water samples are suitable to use as water. Figure 1. Give the summary of the results obtained in this study for concentrations of sulfate in water. It were lowest in the Tap water, it were (2.5 mg/l). Then drinking water were (30 mg/l). Following zamzam water were (97.5 mg/l). Finally ground water were (240 mg/l). According to the World Health Organization, some chemicals in water have no guideline values such as, Bromide which occurs in drinking-water at concentrations well below those of health concern, Chloride and Sulphate because it is not of health concern at levels found in drinking-water, however, Excessive chloride concentrations increase rates of corrosion of metals in the distribution system, depending on the alkalinity of the water, Sulfate is one of the least toxic anions. The presence of a high concentration in the drinking water may lead to dehydration, stomach complaints, and possibly diarrhea. In general, the adverse affect on the taste is said to be minimal at levels lower than 250 mg/l for both chloride and sulphate. Figure 1. Give the summary of the results obtained in this study for concentrations of nitrate in water. It were lower in the Tap water were (2.1 mg/l) Then drinking water were (3.2 mg/l). while Zamzam water were (11.8 mg/l). Finally ground water were (38.9 mg/l). Also figure 1. Give the summary of the results obtained in this study for concentrations of nitrite in water. Also It were lower in the Tap water were (0.01 mg/l) Then drinking water were (0.02 mg/l). while ground water were (0.033 mg/l). Finally Zamzam water were (0.52 mg/l).

The WHO has established revised guidelines for drinking water quality that can be applied to national standards and legislation, taking into account the national climatic, geographic socioeconomic and infrastructural characteristics, as well as national health-based targets (WHO, 2004).The pHs of all water samples are collected in Table (1) showing slightly alkaline behavior in the range (7.00 - 7.48). However, Kellas *et al.,* 1996 stated that alkaline drinking water plays an important role in ridding the body of mercury and other toxins The more acidic the body is the more it holds onto oxidative stress that acidifies the body. Consequently) heavy) metals. Heavy metals in turn create a high density and healing (Wynn *et al.,* 2009).

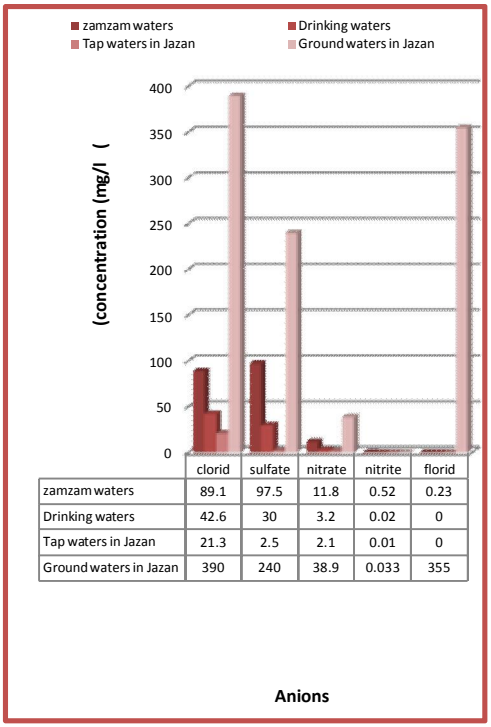

Figure 1. Concentration of Anions of water sample.

Table 1. Show the chemical parameters of the waters. They have been analyzed using SPSS program, at significant ($P < 0.01$). The pH of waters were within the Saudi Arabian Specification Standards (SAS) that requires the pH range to be 7.0–8.5. All the pH values were within the United Stated Environmental Protection Agency (USEPA) standards that requires the pH to be in the range of 6.5–8.5 for waters. The results in Table (1) showed that the Total soluble solid salts or total dissolved solids (TDS) ranges from 65 to 1476 mg/L, samples (Tap water) which showed TDS = 65 ppm it is the lowest concentration, then drinking water and samples (commercial zamzam) which showed TDS = 522 mg/L, which make samples classified as moderate mineral water (Lind, 1979) while ground water which showed TDS = 1476 mg/L it is highest concentration. The total dissolved solids of the wells waters samples 1476mg/L. The SAS states that the optimum value for the maximum allowable value is 500mg/L. Using this standards all of the wells water

samples exceeded the optimum value are over the maximum allowable value of total dissolved solids. The USEPA standards maximum allowable value is 500mg/L. The total dissolved solids differ from one location to another and from one well to well. This is indicating the difference of the types of soil and rock that the ground water passes through. The total dissolved solids and the total alkalinity in all wells especially exceeded the maximum allowable value in the SAS and USEPA limits, which make their drinking use impossible before remove the exceeding total dissolved solids and the total alkalinity or dilution with water of low total dissolved solids and the total alkalinity concentrations. It was found that the ZamZam water has a curative effect. Alkaline in nature, the ZamZam water can neutralise excess hydrochloric acid formed in the stomach and reduces heartburn (Careem, 2005). Table 1. Give the summary of the results obtained in this study for concentrations of Total alkalinity in water. It were highest in the Zamzam water, it were (30 mg/l). Following Ground water were (20.5 mg/l). Then drinking water and tap water were (20 mg/l). Table 1. Give the summary of the results obtained in this study for concentrations of Ammonia in water. It were highest in the Zamzam water, it were (0.07 mg/l). Following Ground water and drinking water were (0.03 mg/l). Then tap water were (0.02 mg/l).

Table 1. Give the summary of the results obtained in this study for Chemical Parameter.

Chemical Parameter	Mean ± S.D.			
	Zamzam waters	Drinking waters	Tap waters	Ground waters
pH – Value (25ºC)	7.33 ± 0.0013	7.00 ± 0.002	7.48 ± 0.0032	7 ± 0.0001
Total soluble solid salts (TDS)	522 ± 0.0023	128.0 ± 0.001	65 ± 0.0031	1476 ± 0.0003
Total alkalinity (mg/l)	30 ± 0.0027	20± 0.001	20 ± 0.0018	20.5± 0.0002
Ammonia (mg/l)	0.07 ± 0.0028	0.03± 0.004	0.02 ± 0.0019	0.03± 0.00012

Figure 2. Give the summary of the results obtained in this study for concentrations of Total Hardness in water. Also It were lower in the Tap water were (51.7 mg/l) Then drinking water were (109 mg/l). while Zamzam water were (192 mg/l). Finally ground water were (430 mg/l).

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 (Remer, 1994). Ionic calcium in water is the best form to use, being the only physiologically active form of this element (Remer, 1994). 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 (Remer, 1994).

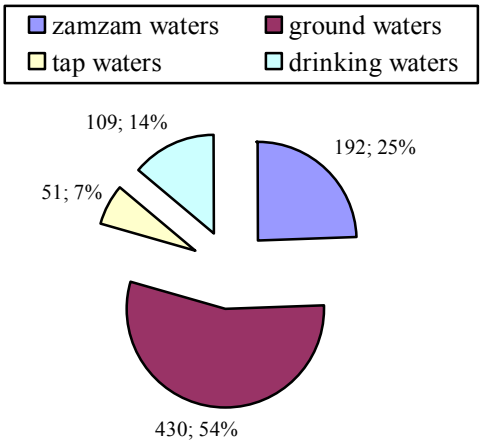

Fig.2: Total Hardness

Figure 3. The results showed low calcium concentration in tap water were 34 mg/l, 43%. while high calcium concentration in the water of Zamzam were 176 mg/l, 44%, and then the groundwater and drinking water were 100 mg/l, 24%. Ionic calcium in water is the best form to use, being the only physiologically active form of this element (Remer, 1994).

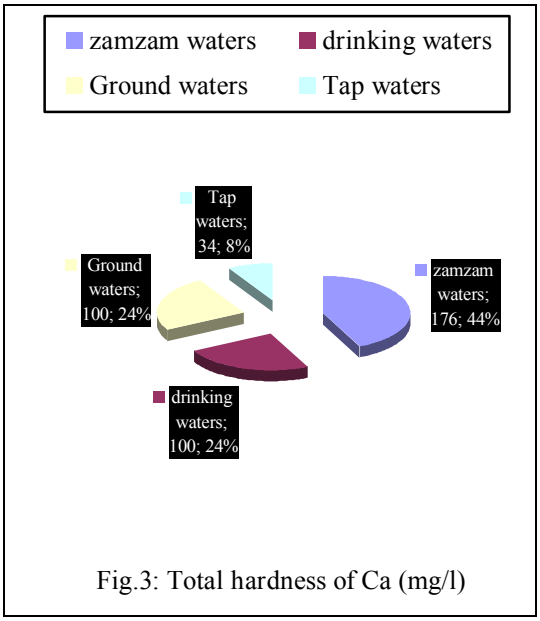

Fig.3: Total hardness of Ca (mg/l)

Figure 4. The results showed Magnesium concentration in tap water were 17.6 mg/l, 6%. While high concentration in the water of Zamzam were 176mg/l, 35%, and then the groundwater were 100 mg/l, 20% and finally drinking water were 9 mg/l, 3%.

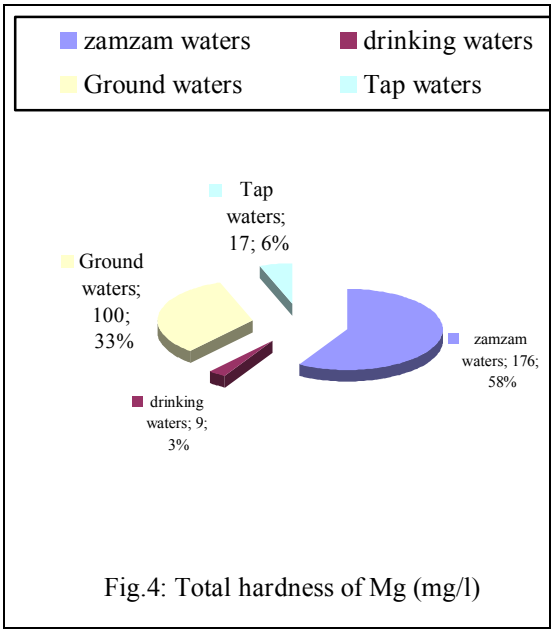

Fig.4: Total hardness of Mg (mg/l)

Figures 2, 3, 4. Shows total hardness, Ca concentrations and Mg concentrations of waters samples. The SAS states that the optimum value for the maximum allowable value of Ca concentrations, Mg concentrations and total hardness were 200,150 and 500mg/L respectively. Using this standards all of waters samples suitable the optimum value. This would indicate that waters samples are suitable to use. Water-related diseases are responsible for 80% of all illnesses/deaths in developing countries, and kill more than 5 million people every year (UNESCO, 2007). Water is a medium of thousands of microorganisms some of which are disease causing. Diseases in humans can be caused by the presence of certain pathogenic bacteria and other organisms such as viruses, protozoa and worms. Pathogens, causing diarrhoea-related illness such as cholera, are commonly derived from human faecal material. Globally, 4 billion cases of diarrhoea are reported every year causing 1.8 million deaths, out of which about 90% are children under five (UNESCO, 2007). Pathogens can readily be washed into water bodies such as shallow wells. Without treatment, such water is a major cause of illness if consumed and may result in loss of productivity and increased medical costs. Potable water is defined as water that is free from pathogens, low in compounds that are acutely toxic or that have grave long-term effects on human health (Shultz and Okun, 1984). Potable water should also be free from compounds that can cause colour, taste (high salinity) and odour. Shallow wells are normally located in the valleys where the groundwater table is relatively high (1–4 m below ground level) and infiltration of rain and river water plays a main part in groundwater recharge. Boreholes however draw water from deep (20–80 more) aquifers. 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 (cited from the institute of the Custodian of the Two Holy Mosques for Al Hajj research centre in Om Al Qura university (personal communication, 2005). 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 (Cited from The Saudi Geological Survey. 5th June, 2005; the annual report of the ministry of agriculture and water resources 1971). The main source of *Zamzam water* is pure by itself but the 3 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 (Yahya, 1983). Total coliform and *E. coli* counts are used worldwide as indicators for faecal contamination of drinking and recreational bathing water (Rompre *et al.,* 2002). Safe drinking

water should have nil *E. coli* in 100 ml of water)WHO, 1993). Contamination after collection and during transportation and storage is increasingly being recognized worldwide as an issue of public health importance (Lindskog and Lindskog, 1988). To our knowledge, no specific study has been done to assess microbiological quality of drinking water resources in Tabuk (KSA)Zamzam water is different from other water in many ways: first no bacteria can form at its source. Second it doesn't go mouldy nor does it change colour, taste or smell (Koshak,1983). Biological growth and vegetation usually take place in most wells. This makes water unpalatable owing to the growth of algae leading to changes in taste and odour. However, in Zamzam water well, there isn't any sign of biological growth (Mashat, 2010). In Zamzam water well and all water samples, there isn't any sign of biological growth. Table 2. shows bacteriological parameters of water samples, All the water samples were suitable. It approved that no bacterial contamination is not presented (*E. coli* bacteria, Fecal coliform and total count of bacteria).

Table 2. bacteriological parameters of water samples.

Bacteriology parameters	Mean ± S.D.			
	Zamzam water	Wells water	Tap water	Drinking water
Total count of bacteria	-ve	-ve	-ve	ve-
E.coli bacteria	-ve	-ve	-ve	-ve
Fecal coliform	-ve	-ve	ve-	-ve

Corresponding Author:
Dr. Asia Ali Alshaik
Kingdom Of Saudi Arabia, Ministry of Higher Education, Jizan University, Deanship of Scientific Research, Girl's College of Educational, Jizan.
E-mail: Ziadahmed1020@hotmail.com

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