

## Bottled Water Market in Al Qurayyat City, Al Jouf Region, KSA: A case study

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### ABSTRACT

The study surveyed 15 kinds of the domestic and imported bottled water available in the water market in Al Qurayyat City, Al Jouf Region, northern Saudi Arabia. The domestic water brands included Al Qassim, Hilwa, Taiba, Hana, Nuva, Hijra, Dala, Aquafina, Arwa, Naba, Al Ghazal, Nestle and Yanabe Al Qassim. The imported water included Volvic and Evian. Each water brand attained a characteristic taste according to the chemical composition. Hydrogen ion concentration ranged between 6.8 and 7.4. All the water brands were free of bacteria. There was a marked difference in the concentrations of total dissolved solids, bicarbonates, total hardness, sulfates, chlorides, calcium, potassium, magnesium and sodium among the studies water brands. Evian water contains high level of bicarbonate (360 mg/l), total dissolved salts, calcium and magnesium. Arwa attained the highest level of sulfate (74.5 mg/l), Nestle recorded the highest level of chloride (68 mg/l), whereas Al Qassim showed the highest level of sodium (29 mg/liter) and nitrate (7.00 mg/l). However, Hilwa water has the highest level of potassium (7.9 mg/l). Only the domestic water brands were supplemented with fluoride. Chemical analysis illustrated that silica is only found in Volvic and Evian water brands, with concentrations of 31.7 and 15.00 mg/l, respectively. All water brands comply with the requirements of SASO, GCS and WHO. The study discussed the benefits/costs of the drinking bottled water which is used daily, in the light of the daily requirements of human, so and to their direct economic situation–the individual's social, family and community.

#### Keywords:

Bottled Water Market , domestic water brands , characteristic taste .

#### Introduction

KSA is the most important market for bottled water in the Middle East. Bottled water industry has been developed to meet the abnormal rate of water consumption, particularly during summer and the seasons of Hajj and Umrah. The factories operating in Saudi Arabia in the field of water packing represent 70 % of the total existing plants in the Arab Gulf States (Rodríguez, 2011; Water Technology, 2011). The number of water bottling factories in the Kingdom is approximately 65 plants, and the production capacity of these plants exceed 6.5 billion liters a year, while investment volume of that industry exceeds 2 billion riyals (NWC, 2013). Economic estimates revealed that the market of the bottled water in KSA exhibited a marked growth in recent years due to the ever-increasing population growth and tourism in the Kingdom (NWC, 2013). The healthy water becomes a requirement. Bottled water is the fastest growing drink choice worldwide. Many people fear that water obtained from the tap water is harmful. People are afraid of waterborne diseases or microbes due to considerable media coverage and intensive public discussions about illness coming from drinking municipal tap water (Gleick, 2010).

Environmental Protection Agency (EPA) classified plastics as the fourth largest category of municipal solid waste. Manufacturing plastic bottles consumes non renewable natural resources such as petroleum and may

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contribute to pollution, whilst being transported by trucks or ships around the world. Moreover, toxic byproducts are released during manufacture, for example styrene and benzene (FDA, 2006). Bottled water is packed individually, stored, shipped, refrigerated, bagged up and transported home by the consumer. Most of the water bottles end in landfills. Reused PET bottles can leach the carcinogenic adipate DEHA. Some types of plastic bottles release a potent carcinogen, namely dioxin (EPA, 2013).

The present study is a part of a project planned and directed to raise the awareness about the water issues and to assess the current status and future prospective of the water sector in Al Qurayyat City, Al Jouf Region, northern KSA. The questions to be answered: How much nutrients, for example calcium and silica, are in our bottled water? Does bottled water abundant in Al Qurayyat water market meet the specifications of the Saudi Standards, Metrology and Quality Organization (SASO), the Gulf Countries Standards (GCS) as well as standards of the World Health Organization (WHO)? What are the suggested future trends in bottled water industry in KSA?

## Materials and Methods

Al Qurayyat bottled water market is represented by a number of supermarkets that provide the population with a variety of domestic and imported water brands. The domestic water brands include Al Qassim, Hilwa, Taiba, Hana, Nuva, Hijra, Dala, Aquafina, Arwa, Naba, Al Ghazal, Nestle and Yanabe Al Qassim, whereas the imported water brands include Volvic and Evian. Rough economic estimates indicate that the population of Al Qurayyat City spends about 10000 SAR/ day to meet their water demands. The prices of the small bottles ranges from 0.5 SAR for domestic water brands to 6 SAR for imported water brands.

Data concerning the physicochemical and bacteriological requirements for drinking water of the Saudi Standards, Metrology and Quality Organization (SASO), the Gulf Countries Standards (GCS) as well as standards of the World Health Organization (WHO) are presented in table (1). Bacteriological and chemical analyses of the bottled water brands were carried out at the laboratory of Al Qurayyat Water Treatment Plant.

The quality of the bottled water is described in the label enveloping the bottle. The label accommodates valuable information about the volume, net nutritional contents, the name and address of the manufacturer, packer and distributor, the type of bottled water, its source and the treatment method. The label of each water brand was photographed and magnified using Galaxy IV mobile with a high resolution camera unit. The data available on the labels were compared to the report received from the laboratory of Al Qurayyat Water Treatment Plant to ensure the reality of the chemical constituents listed for each bottled water brand.

Total dissolved solids (TDS) indicate a composite of many organic and inorganic compounds in the water resources. The main sources of TDS in water are the agricultural and residential runoff and/or from industrial or sewage treatment discharges. The most common chemical constituents of TDS include sodium, calcium, potassium, phosphorus, chloride and nitrates. Total hardness of water refers to the concentration of dissolved minerals, such as calcium and magnesium in water. The values of Total Alkalinity, Total Dissolved Solids, Ammonia, Nitrates, Nitrites, Sulphates, Phosphates, Chlorine, Iron, Silica, Fluorine, Calcium and Magnesium are expressed as mg/l. Turbidity is expressed as Nephrometre Turbidity Units (NTU). Electrical Conductivity is expressed as  $\mu/cm$  at 20°C.

## Results

A total of 15 bottled water brands were encountered in Al Qurayyat City, Al Jouf Region, northern KSA. They comprised 13 domestic and 2 imported water brands. The data available on the labels were in agreement with the report received from the laboratory of Al Qurayyat Water Treatment Plant that aimed to ensure the reality of the chemical constituents listed for each bottled water brand. Data concerning the chemical and bacteriological analysis of each studied water brand are documented in tables (2 and 3). There is a marked difference in the concentrations of the cations and anions, total dissolved solids, total hardness and electrical conductivity among the studied water brands. From tables (2 and 3), it is clear that the hydrogen ion concentration (pH) fluctuated around the neutral scale, where it ranged between 6.8 and 7.4. Tables 2 and 3 and Figure 1 illustrate that only the two imported water brands (Volvic and Evian) water brands are supplemented with Silica, the values of which were 31.7 and 15.00 mg/l, respectively. In contrast, the domestic water brands were free of Silica.

Tables (2 and 3) indicate that the bromate is a constituent element of Al Qassim, Taiba, Hana, Arwa and Naba water brands, and attained a level below 10 µg/l. However, this constituent was not recorded in the other water brands. Unlike the imported water brands, all the domestic water brands were fluoridated. The level of fluoride ranged from 0.8 to 1.2 mg/l (Tables 2 and 3). Iron was found in all the water brands except for Al Qassim, Hana, Nuva, Al Ghazal, Evian and Volvic. The level of iron ranged from 0.02 to 0.05 mg/l.

As shown in Figure 2 and Tables (2 and 3), the bicarbonate content of the water brands under investigation. Evian water brand attained the highest bicarbonate content, while Aquafina water brand recorded the lowest value (Figure 2, Tables 2 and 3). Moderate bicarbonate values for Hilwa and Volvic and relatively low bicarbonate content for Al Qassim, Hijra, Arwa and Yanabe Al Qassim water brands could be seen in figure (2).

Tables (2 and 3) and Figure 3 document the level of T.D.S in bottled water brands available in Al Qurayyat water market. Evian water brand recorded an extremely high value (309 mg/l), followed by Nestle water brand (235 mg/l). In contrast, Hijra and Al Ghazal water brands attained the lowest T.D.S value (100 mg/l). Other water brands showed relatively moderate T.D.S values (Figure 3, Tables 2 and 3).

The sulphate content in domestic and imported water brands is shown in Figure (4) and Tables (2 and 3). The highest sulphate content is represented by Arwa water brand, while the lowest content is represented by Volvic water brand. Markedly low sulphate content could be recognized for Hijra, Naba, Al Ghazal and Taiba water brands. Comparatively, high values are shown for Aquafina, Yanabe Al Qassim, Hilwa and Dala water brands.

Figure 5 and Tables 2 and 3 show the concentration of chloride in bottled water brands available in Al Qurayyat water market. The highest chloride content is recorded by Nestle water brand, while the lowest content is recorded by Arwa water brand (less than 1.00 mg/l). Relatively high levels of chloride could be observed for Al Ghazal and Al Qassim water brands. Calcium content in domestic and imported water brands is shown in Figure (6) and Tables (2 and 3). Calcium content attained marked variability and fluctuated between extremely low value (< 1 mg / l) in Arwa brand and an extremely high value in Evian water brand (80 mg / l). A similar trend was recorded for the cations magnesium, potassium and sodium and the anion nitrate (Tables 2 and 3).

In Al Qurayyat City, approximately 10000 plastic bottles are consumed daily. Intensive field observations revealed that the vast majority of these bottles end up in landfills, along roadways and a small proportion is tossed into a garbage can. Most single-serve bottles are either buried in landfills or burned in incinerators, or they make their way along roadways.

## Discussion

There are several factors led to the widespread use of bottled water in the Kingdom. Among these factors, the belief that public water network nourishing homes is polluted and invalid for drinking is the most common. However, periodic reports of the Ministry of Water and Electricity in Saudi Arabia indicate that the water produced by their widespread plants meet the international standards for drinking water. The construction of ground water reservoirs near the absorption pits that aggregate the household liquid waste disposal and the lack of regular cleaning and disinfection of the reservoirs seem likely to increase that belief. Moreover, the extreme summer heat, up to 50°C, causes excessive water loss from the body, and subsequent need to compensate for water loss. The season of Hajj, Ramadan, Umrah and the days of Arafah, Muzdalifah and Mina represent a special status in the use of huge amounts of bottled water.

Unlike the imported bottled water brands (Volvic and Evian), all the domestic water brands were fluoridated. Fluoride content ranged from 0.8 to 1.2 mg / l. These values comply with the requirements and specifications of SASO, WHO as well as MWE. Water fluoridation refers to the supplementation of the drinking water with fluorine at a level effective for preventing tooth decay and cavities (Petersen and Lennon, 2004, Pizzo et al., 2007). Fluoridated water acts to reduce the levels of fluoride in saliva, leading to the reduction of the demineralization rate and increasing remineralization rate of the tooth enamel in an earlier stage of cavity (Pizzo et al., 2007). According to Petersen and Lennon (2004), dental caries affects 60- 90% of the schoolchildren as well as adults.

Drinking water is regarded as the largest source of the daily intake of fluorine (Fawell et al., 2006). Other sources include fluoridation of toothpaste, salt and milk (Jones et al., 2005). The normal level of fluoride in the drinking water ranges from 0.7 to 1.2 mg / l (Al Khateeb, et al., 1990). The authors found that the fluoride level of the drinking water was 2.5 mg / l in

Mecca. In other localities, fluoride in groundwater is greatly reduced (Al Abdula'aly, 1997).

The present study revealed that only Volvic and Evian water brands were supplemented with silica, the magic element that attained a level of 31.7 and 15 mg/l in the two water brands, respectively. In contrast, the domestic water brands did not include silicon among their constituent elements. Silicon is a highly important mineral and may play a role in preventing or delaying Alzheimer disease, a characteristic aspect of the elderly. Silicon also lowers bad cholesterol and blood pressure, brings the skin, hair, nails and joints healthy, fades age spots, chelates heavy metals, acts as an anti-inflammatory and a normal diuretic agent, prevents kidney stones and normalizes circulation (Ittekkot et al., 2006).

In this respect, these high priced, silicon-rich water brands may be considered in the elderly care programs, whenever they do not interfere with any prescribed medications. The local factories producing bottled water in KSA should reconsider this fact and supplement the domestic water brands with such power supplying element. It should be mentioned that there are foods that are natural sources of silica, for example cucumber, tomato, wheat, onions, oats, strawberries, avocados and brown rice. However, some of these silicon-rich foods seem likely uncommon in our meals; therefore, supplements may be necessary to increase the amount of silica in our bodies. It is worth noting that silicon-rich, imported water brands are not available for many population groups where it costs 5 or 6 SAR/500 ml bottle.

In the present study, Evian water brand attained the highest TDS value (309 mg/l) followed by Nestle water brand (235 mg/l). A relatively moderate value was recorded by Hilwa water brand (185 mg/l). Comparatively low TDS levels, ranging from 100 to 140 mg/l, were recorded for the remainder of the water brands. The total dissolved solids reflect the taste of the drinking water and supply human body with a variety of nutrients to support the physiological activities.

Bicarbonate acts to reduce the acidity of proteins in the diet. Recent studies highlight that mineral water containing high levels of bicarbonate could prevent the recurrence of renal stones induced by uric acid and calcium oxalate. Bicarbonate in drinking water could also prevent dental cavities and decrease dental plaque acidity. Moreover, bicarbonate is known to increase the level of hydrogen ion concentration in the mouth and this neutralizes the metabolic acids created by bacteria prevailing therein.

Our data revealed that the bicarbonate level varied significantly among different water brands. Evian water brand recorded the highest bicarbonate level (360 mg/l), while Aquafina water brand had the lowest level (1.3 mg/l). Our data also indicated moderate bicarbonate values for Hilwa and Volvic and relatively low bicarbonate content for Al Qassim, Hijra, Arwa and Yanabe Al Qassim water brands. Except for Evian, Hilwa and Volvic water brands, all bicarbonate levels are below the standards of the Ministry of Water and Electricity in KSA. It should be mentioned that Evian water brand may be harmful for people who experience high acidity in the stomach and this seems likely to disturb the digestion. On the other hand, this brand of water may be beneficial for people experiencing high stomach acidity or those who eat protein-rich food.

The level of calcium varied considerably among different water brands of the present investigation. Except for Nestle, Hilwa and Naba, the domestic bottled water brands contained a negligible calcium concentration. Nordin (2000) found that standard calcium levels achieves maximum bone mass and prevents osteoporosis. Foods items rich in calcium are leafy, green vegetables, yogurt, milk and cheese. Calcium demand in the growing children is greater than young adults. However, calcium demand in older women is comparatively higher, in order to prevent osteoporosis (Roza, 2007). Calcium level up to 2,000 mg/day seems to be safe (Cotruvo, 2006). According to Shier et al. (2012), some water brands may provide approximately 40% of the daily requirement for calcium. This highlights the importance of the drinking water in compensating for the shortage of this essential mineral in the diet.

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**Table 1. Drinking water quality standards of the Saudi Arabia Standards Organization (SASO), Gulf Countries Standards (GCS) and World Health Organization (WHO).**

Constituent	Units	SASO	GCS	WHO
Hydrogen ion concentration <b>pH</b>		6.50 – 8.50	6.50 – 8.50	6.00 – 8.50
Electric Conductivity	µ/cm at 20°C	800 – 2300	160 – 1600	
Total Dissolved Solids <b>T.D.S</b>	Mg / l	1500	100 – 1000	1000
Colour	True Colour Units <b>TCU</b>	50.00 TCU	15.00 TCU	15.00 TCU
Turbidity	Nephrometre Turbidity Units <b>NTU</b>	25.00 NTU	5.00 NTU	5.00 NTU
Taste		acceptable	acceptable	inoffensive
Odour		acceptable	acceptable	inoffensive
Calcium	Ca mg / l	200	200	
Magnesium	Mg mg / l	30 – 150	150	
Total Hardness	mg/l CaCO <sub>3</sub>	500	500	500
Manganese	Mn mg / l	0.05	0.1	0.1
Sodium	Na mg / l		200	200
Chloride	Cl mg / l	600	250	250
Fluoride	Fl mg / l	0.7 – 1.50	0.6 – 1.70	1.50
Nitrate	mg / l		< 1.00	
Nitrite	mg / l	45	10	10
Sulphate	mg / l	400	400	400
Iron	Fe mg / l	1.00	0.3	0.3
Free residual chlorine	mg / l	0.2 – 1.00	0.2 – 0.5	
Bacteria	no./100 ml	nil	nil	nil

Table 2. Comparison between the physicochemical characteristics of 15 water brands available in Al Qurayyat water market during the last quarter of 2013. The values of Bicarbonate Alkalinity, Total Dissolved Solids, Nitrates, Sulphates, Chlorides, Iron, Fluorides, Calcium, Potassium, Magnesium Sodium and Iron are expressed as mg/l. Electrical

Conductivity is expressed as  $\mu/cm$  at 20°C.

Water Criterion	Al Qassim	Hilwa	Taiba	Hana	Nuva	Hijra	Dala	Arwa
pH	7.10	7.40	7.30	7.20	7.00	7.20	7.40	6.80
Bicarbonate	7.00	84.30	26.00	26	20.04	60.60	25.00	7.70
T. D. S	160.0	185.0	140.0	127.0	120.0	9.00	125.0	121.0
Sulphates	16.0	45.50	12.00	32.00	35.00	9.00	42.00	74.50
Chlorides	47.0	29.0	36.00	40.00	17.00	42.00	29.00	<1.00
Nitrates	7.0	0.00	2.70	3.00	3.08	5.00	5.50	<1.00
Fluorine	0.95	0.80	0.80	1.00	0.80	1.00	0.85	1.00
Calcium	8.40	23.50	2.00	8.00	10.00	13.00	12.00	<1.00
Potassium	1.40	7.90	1.20	1.00	1.05	0.10	1.90	<1.00
Magnesium	1.00	7.10	1.20	3.00	4.45	6.00	3.70	21.10
Sodium	29.0	18.90	19.00	22.00	16.79	13.00	28.00	3.00
Iron	0.00	0.01	0.01	0.00	0.00	0.01	0.02	<0.10
Bromates	<10.0	0.00	<3.00	<10.0	0.00	0.00	0.00	<10.0

Table 3. Comparison between the physicochemical characteristics of 15 water brands available in Al Qurayyat water market during the last quarter of 2013. The values of Bicarbonate Alkalinity, Total Dissolved Solids, Nitrates, Sulphates, Chlorides, Iron, Fluorides, Calcium, Potassium, Magnesium Sodium and Iron are expressed as mg/l. Electrical Conductivity is expressed as  $\mu/cm$  at 20°C.

Water Criterion	Aquafina	Al Ghazal	Naba	Nestle	Yanabe Al Qassim	Volvic	Evian
pH	7.00	7.10	7.10	7.10	7.00	7.00	7.20
Bicarbonate	1.30	36.60	50.00	42.00	12.00	71.00	360.0
T. D. S	110.0	100.0	125.0	235.0	110.0	130.0	309.0
Sulphates	51.00	11.00	10.00	22.00	50.00	8.10	12.60
Chlorides	27.50	49.70	0.00	68	14.00	13.50	6.80
Nitrates	<0.10	5.50	1.00	<1.00	4.00	6.30	3.70
Fluorine	0.80	0.80	1.00	0.90	0.90	-	-
Calcium	<5.00	2.37	20.00	36.00	15.00	11.50	80.00
Potassium	1.00	1.46	0.20	0.20	0.90	6.20	1.00
Magnesium	13.00	0.97	3.00	4.70	4.00	8.00	26.00
Sodium	16.00	26.60	21.00	18.00	13.00	11.60	6.50
Iron	0.01	0.00	0.02	0.02	0.02	-	-

Figure 1. Silica concentration of two imported bottled water brands, namely Volvaic and Evian (bottled in France).

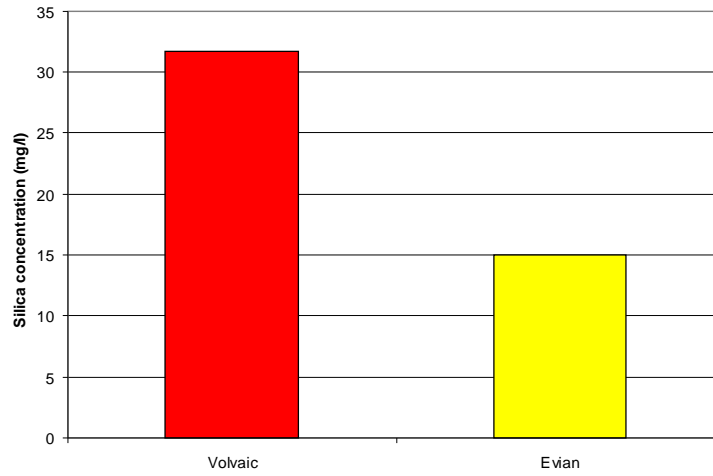


Figure 2. Bicarbonate content of different bottled water brands available in Al Qurayyat.

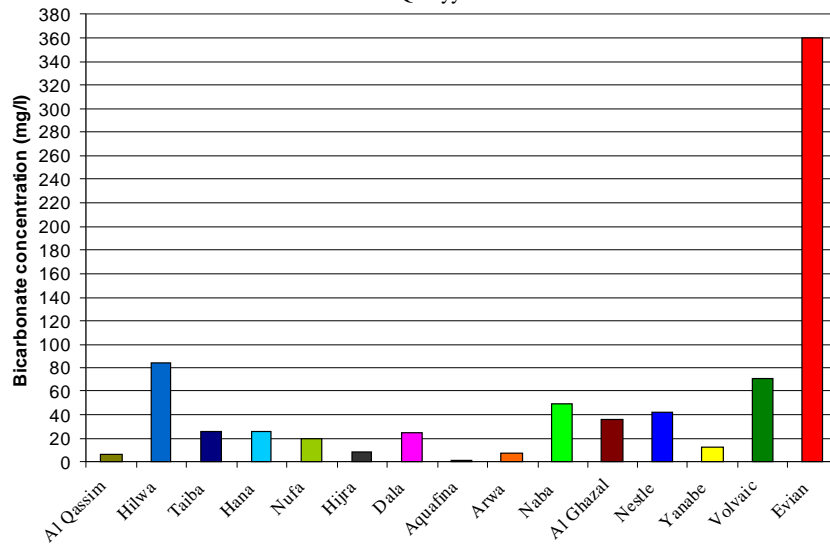


Figure 3. Total dissolved solids of different bottled water brands available in Al Qurayyat.

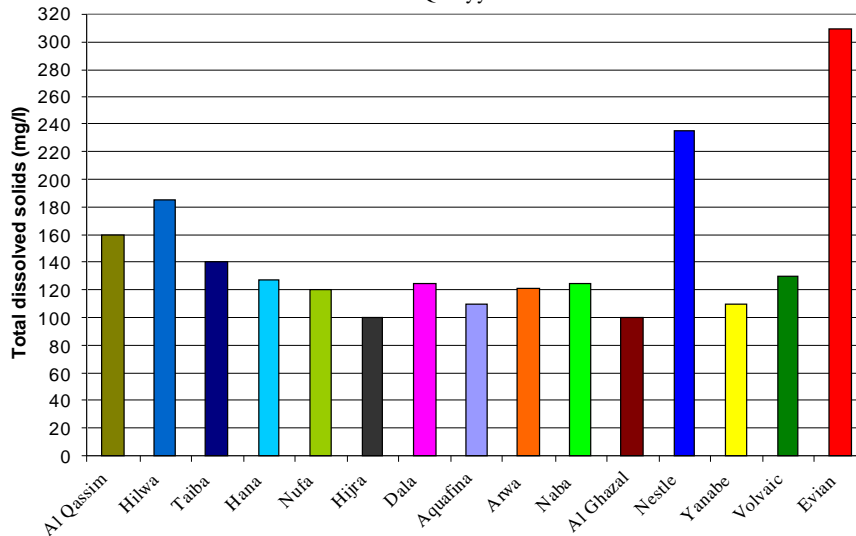


Figure 4. Sulphate content of different bottled water brands available in Al Qurayyat.

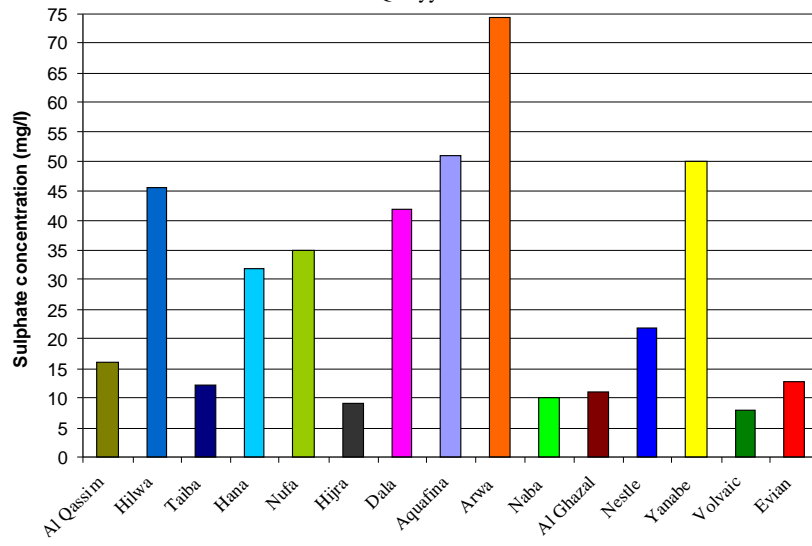


Figure 5. Chloride content of different bottled water brands available in Al Qurayyat.

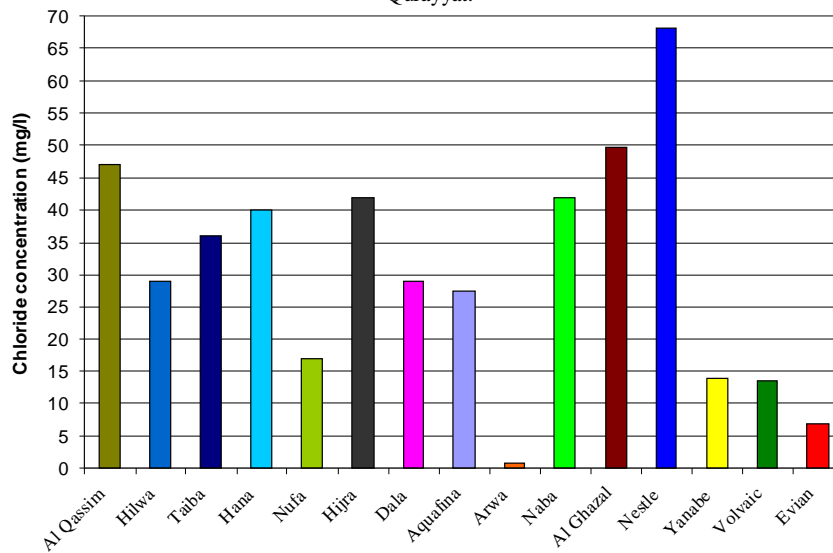


Figure 6. Calcium content of different bottled water brands available in Al Qurayyat.

