A Preliminary Report on Drinking and Household Water Quality in Al Qurayyat: A Case Study

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Abstract

A survey has been done and a detailed account has been given of the sources and quality of the drinking and household water in Al Qurayyat City, Al Jouf Region, northern KSA. Seven local drinking and six household water brands were collected and subjected to bacteriological and chemical analysis at the laboratory of Al Qurayyat Water Treatment Plant. Each drinking water brand exhibited a characteristic taste depending on its chemical composition. There was a marked variability of the total dissolved solids (TDS), electrical conductivity (EC), total hardness and mineral nutrients among the studied water brands. A household water brand was invalid and showed high levels of TDS, EC, calcium and magnesium. Similarly, a local drinking water brand was invalid and recorded high levels of TDS, EC, calcium and magnesium. The vast majority of the drinking water brands adopted the standards of SASO, GCS and WHO. Hydrogen ion concentration (pH) of the drinking and household water brands was slightly alkaline. The health concerns related to the drinking and household water and the contribution of the beneficial nutrients found in the drinking water to human activities, their daily requirements, permissible concentrations and health impacts are discussed in detail. The authority of the Water and Electricity in Al Qurayyat should conduct an intensive monitoring of the drinking water facilities and implement a comprehensive education program to control over the quality and safety of the drinking water and to raise the awareness about the health concerns of the poor household and drinking water brands.

Introduction

Water is the most important natural resource because it is renewable but not replaceable (CBD, 2010). Different sectors of the society use water for different purposes; water fulfills a wide range of human needs such as nutrition, drinking,

a considerable threat to the human health and are a major cause of diarrhea (Al Mazrou *et al*., 1995; Al Otaibi, 2009).

Over the last two decades, a considerable research was made of the sources and quality of the drinking water in KSA (e.g. Al Redhaiman and Abdel Magid, 2002; Al–Turki and Abdel Magid, 2003, Al Othman *et al*., 2013; Aly *et al*., 2013). To the best of our knowledge, no previous studies were made of the sources and quality of the drinking and household water in Al Qurayyat. Currently, this area hosts several hundreds of thousands of people. The water needs of such growing population are increased and this necessitates a corresponding infrastructural development of the water facilities. The present study addresses the quality of the local drinking and household water supplied to a huge population in Al Qurayyat in aims to raise the awareness of sustainable approaches to managing drinking and household water, and to ensure control over the quality and safety of drinking water to the consumers. The questions to be answered: Whether the local water we are drinking in Al Qurayyat is safe and pure? Whether the infrastructural development conducted by the directorate of the Water and Electricity to meet the increasing water demand in Al Qurayyat is efficient?

improving sanitation and using energy (Gleick and Iwra, 1996). Healthy water is essential for the survival of the living organisms; it promotes optimal health and viability and facilitates all the biochemical mechanisms inside the human body. Water represents about 70% of the total body weight (CBD, 2010). Healthy water flushes out waste products, facilitates inhalation and digestion, transports absorbed food, regulates the body temperature, and optimizes the acid-base balance regime. Sawka *et al*. (2005) estimated that a daily water intake of 3.7 L for adult men and 2.7 L for adult women meets the needs of the vast majority of persons under normal conditions.

Polluted water has been reported to cause many health problems (WHO and UNICEF, 2000; Magram, 2009). Water–borne diseases have been documented in many environmental studies over the last few decades (Al Otaibi, 2009; Mara and Sleigh, 2010; Al Zahrani and Gherbawy, 2011; Aly *et al*., 2013). Previous studies recorded a variety of pathogens such as bacteria, protozoans and parasites in the drinking water. The most common pathogens in the drinking water are *Cryptosporidium* spp., *Giardia duodenalis*, *Coliform* and *Streptococcus* spp. (e.g. Hogue *et al*., 2002; Aly *et al*., 2013). These microorganisms were found to pose

incubated at a pre–set temperature for a specified time and at the end of the process the number of tubes with growth in was counted for each dilution. Statistical tables were then used to derive the concentration of organisms in the original sample.

Test tubes were placed in incubator at 35 C for 24 hours, for gas production. To confirm the presence of *Coliform*, gas is also produced in incubation into Brilliant Green Bile broth at 35 C for 24 hours. Water quality analysis was based on the most probable number of colony forming units (cfu) per 100 ml (Al Sabahi *et al*., 2009). Water samples were carefully filtered according to the method described by Bakir *et al*. (2003). Subsequently, the material resident on the filter was smeared in 0.9% saline solution and examined for parasite cyst, trophozoites and helminth eggs. Moreover, fresh preparations were examined visually at high-power light microscope (Bakir *et al*., 2003).

The water minerals such as calcium, magnesium and iron were estimated using Flame Photometer. Other cations and anions were determined according to standard methods. The colour, odour and transparency/turbidity of the water samples were recorded. Moreover, hydrogen ion concentration (pH), total dissolved solids (TDS), electrical

Materials and Methods

The study area is located in Al Qurayyat City which is located in Al Jouf Region, northern Saudi Arabia. It is 30 km from the border of Jordan. Al Qurayyat had a population of 360000 at the 2013 Census. It is a small city with a very big market. Al Qurayyat is known for its olives and salt (Wikipedia, 2013).

Water samples were collected in sterilized, clean and dry bottles to assure the accuracy of the results. A total of 6 brands of the local drinking water and 7 brands of the household water were collected. Each water brand was represented by three randomly selected specimens. Incubation of water samples into lactose broth as presumptive test. At the laboratory, water samples were analyzed for essential minerals, dissolved solids and surveyed for bacteria. Water samples subjected to bacteriological analysis were sent to the laboratory one hour post sampling.

A measured sub-sample (perhaps 10 ml) was diluted with 100 ml of sterile growth medium and an aliquot of 10 ml was then decanted into each of the ten tubes. The remaining 10 ml was then diluted again and the process repeated. At the end of 5 dilutions this produces 50 tubes covering the dilution range of 1:10 through to 1: 10000. The tubes were then

water treatment plants (C, D and E), while the remainder brand originated from private wells (F) operated by Saudis. From Figure 2A, it is obvious that TDS values in the investigated household water brands attained relatively high values (more than 1000 mg/l), however the water brands D and E showed normal TDS levels (560 mg/l and 610 mg/l, respectively). It is clear that the water brand extracted from the private wells had comparatively high TDS level (2320 mg/l). This water brand is widely used by academic staff members, employees and students of the Community College in Al Qurayyat since 2005.

A similar trend was documented for the electrical conductivity (EC) that merely depends on the total dissolved solids (Figures 1B and 2B). The hydrogen ion concentration (pH) of the local drinking and household water brands lies on the alkaline scale (Figure 1C and 2C). However, the pH values measured in the household water brands were slightly higher than those recorded for the local drinking water brands (Figures 1C and 2C).

Figure 1D shows the total hardness in the local drinking water brands. It is obvious that the highest level is recorded for the water brand G (110 mg/l), one of the most common drinking water sources supplied for the Community College.

conductivity (EC) and total hardness were estimated.

Data obtained were compared to the standards of the Saudi Arabia Standards Organization (SASO), Gulf Countries Standards (GCS) and World Health Organization (WHO) (Table 1) to demonstrate whether the water brands comply with such specifications and standards. Total hardness is measured in parts per million (ppm). If water contains less than 60 ppm, it is considered soft water. If it contains more than 120 ppm, it is considered hard water. If it contains more than 180 ppm, it is considered very hard (Ellis, 1970).

Results

Figure 1A illustrates the levels of the total dissolved solids in a variety of local drinking water brands supplied to the population of Al Qurayyat. From Figure 1A, it is obvious that the TDS level in all the local drinking water brands lies in the normal range of the freshwater. The maximum TDS level was recorded for the water brand C (669 mg/l), while the minimum level was recorded for the water brand E (104.4 mg/l). Figure 2A illustrates the levels of the total dissolved solids in a variety of household water brands. Some of these brands originated from Al Qurayyat water treatment plant (A and B), some brands from Busaita and Tabarjal

Magnesium values in seven brands of the local drinking water are illustrated in Figure 1F. The water brand G is magnesium-rich (68 mg/l). Other water brands attained low magnesium levels (Figure 1F). Comparatively, the household water brands had higher magnesium values (Figure 2F), The water brand F recorded an extremely high magnesium level (250 mg/l). Relatively high magnesium levels could be noticed for the water brands A, B and C (Figure 2F).

As shown in Figures 1G and 2G, the local drinking water brands contained higher silica levels than the household water brands. Regarding the drinking water brands, the maximum silica content was attained by the water brand B (3.1 mg/l). Other drinking water brands had little amounts of silica (Figure 1G). On the other hand, all the household water brands attained negligible amounts of silica (0.2 mg/l or less) (Figure 2G).

Iron levels were markedly low either in the drinking water brands (Figure 1H) or in the household water brands (Figure 2H). The highest level of iron in the drinking and household water brands was 0.1 mg/l and 0.2 mg/l, respectively. In contrast, the lowest level of iron in the drinking and household water brands was 0.006 mg/l and 0.03 mg/l, respectively.

Other water brands exhibited little hardness (Figure 1D). The values of the total hardness in different household water brands supplied to the population of Al Qurayyat are presented in Figure 2D. An extremely high total hardness could be noticed for the water brand G (old unclean tank) (450 mg/l), indicating the inefficiency of this water source in washing and cleaning purposes, a problem frequently experienced in the Community College. Other water brands seem adequate for household purposes (Figure 2D).

Figure 1E shows the calcium content in the local drinking water brands in Al Qurayyat. The water brand G is relatively calcium-rich water source (42 mg/l). Figure 1E also indicates that the water brands A and B accommodated considerable amounts of calcium. In contrast, other water brands contained little amounts of calcium (Figure 1E). Calcium levels in the household water brands are illustrated in Figure 2E. The highest calcium level was recorded for the water brand F (200 mg/l), while the lowest level was recorded for the water brand E (33 mg/l). It can be noticed from Figure 2E that the water brands A, B and C have considerable amounts of this mineral nutrient (122 mg/l, 103 mg/l and 90 mg/l, respectively).

NTU). On the other hand, the household water brands attained higher turbidity values (Figure 2L). The water brand D had the highest turbidity level (6.1 NTU), however the lowest value was recorded for the water brand C (0.85 NTU). A higher turbidity value could be also observed for the water brand F (5.4 NTU) (Figure 2L).

Bacteriological analysis indicated that all the local drinking water brands are free of bacteria. Only one brand belonging to the household water showed positive bacteriological test (the water brand D, with a total coliform count of 16 μm/100).

Discussion

Rapid population growth, together with inadequate efforts to improve access to clean water and improper water management indicate that the problem will grow worse. This problem should be a priority for governments, water companies and related international organizations. Long-term planning for the management and allocation of freshwater resources is a global water issue. A great deal of attention has been paid by the government of KSA to meet the basic water requirements for human activities. The Middle–East is the largest desalination market in the world with Saudi Arabia leading the worldwide production of desalinated water, as it obtains approximately 70% of the drinking water

All the studied water brands were fluoridated, but to varying degrees (Figures 1I and 2I). The fluoride content of the studied water brands ranged between 0.61 mg/l and 1.4 mg/l in the drinking water brands and 0.62 mg/l and 1.2 mg/l in the household water brands. Similarly, all the studied water brands were chlourinated (Figures 1J and 2J). However, the chlourine content in the water brands was markedly low (Figures 1J and 2J).

Nitrate content in the local drinking water brands is shown in Figure 1K. It is clear that the local drinking water brands are safe with respect to their nitrate content. The highest nitrate level was recorded for the water brand C (6 mg/l) while the lowest level was recorded for the water brands B and F (4 mg/l) (Figure 1K). Figure 2K illustrates the nitrate content in a variety of the household water brands. It can be seen from Figure 2K that the nitrate levels are relatively high, with the maximum value recorded for the water brand D (9 mg/l). However, the minimum value was recorded for the water brands D and E (3 mg/l).

All the studied local drinking water brands were transparent; they showed low turbidity levels (Figure 1L). The highest value was recorded for the water brand A (1.1 NTU) and the lowest value was recorded for the water brand D (0.18

taste and colour, might not be noticed initially. However, rust chemicals are known to pose a negative impacts on the human health. The sign of dirt and algae buildup in the tank occurs when the water tank acquires a strange taste. Buildup of dirt and grime can happen due to improper cleaning techniques or inefficient access points. The dirt layer will act as a fertile breeding ground of bacteria and microorganisms and can spread a lot of diseases inside your home.

Microbial contamination or corrosion of the household water tanks gives off many toxic chemicals and biohazards and could induce many health problems (Ali and Sadik, 2009). Household water tanks are daily exposed to various contaminating sources relating to the purification of water tanks (50%), engineering problems (19%), problematic tank design (8%), presence of colloidal matrices (13%), petroleum contaminants (4%), discharge of contaminated water into the tanks (4%) and due to remaining stagnant water in the tanks (2%) (Nath *et al*., 2006). A study by de Carvalho (2007) revealed that the household water tanks were more contaminated with coliforms and faecal coliform unlike the original water source. As a result of unhygienic practices in cleaning household water-storage tanks, faecal coliform infections

supply with the aid of 30 operating desalination plants (Water Technology, 2011). According to Saudi Press Agency (2010), more than 1,103 million cubic meters of desalinated water was produced, with Jebel Ali Plant in Jubail being the largest water desalination plant in the world. Apart from these acknowledged efforts, the application of a mandatory control system for drinking water is strongly recommended in remote areas such as Al Qurayyat Governorate that showed marked population growth and increased human activities over the last decade.

The present study revealed that the vast majority of the drinking water brands adopted the standards of the Saudi Arabia Standards Organization (SASO), Gulf Countries Standards (GCS) and World Health Organization (WHO). However, the levels of the nutrient elements in the drinking water are unfortunately low. One of the household water brands in the present study showed high turbidity level (6.1 NTU), high calcium (50 mg/l), high magnesium (80 mg/l), high nitrate (9 mg/l), high total hardness (130 mg/l) and bacterial growth (16 µm/100). This water brand was withdrawn from an old, unclean plastic tank. The tank pipes can slowly rust away, thus contaminating the water. The change in the quality of water in terms of

metals, most commonly calcium and magnesium. Hard water is typically defined as water that has a high mineral content. While large amounts of calcium are often to blame for the development of hard water, high stores of copper and magnesium can also contribute to poor water quality.

Hard water can cause damage to healthy skin cells. The elements such as zinc, lead, magnesium and calcium found undissolved in hard water will break down the elastin and collagen found in healthy skin cells and tissues. As a result, the skin becomes vulnerable to harmful ultraviolet rays. Acne can occur on a more frequent basis. Hard water dries out the skin, depriving it of natural oils. This causes skin irritation, which leads to acne breakouts. The insoluble minerals found in hard water wind up settling on the surface of the skin and cause itchiness and dryness. In severe cases, the skin will become inflamed, crack, and bleed. Moreover, Skin is more prone to germs when washed with hard water because it actually coats the skin with a dull film, due to the insoluble minerals in it. When this happens, the body's natural oils are unable to reach the epidermis of the skin, and this leads to failure in the skin's natural antimicrobial properties. It is worth noting that the tap

occurred in 155 children between 1-5 years age (Nath *et al*., 2006). Storage of water in tanks was responsible for intestinal faecal infections in the eastern region of KSA (Abou Malah, 1999). The author reported that 58 % outbreaks infected from fresh water, and 42 % outbreaks infected from desalinated water. Most outbreaks were from drinking fresh water (77 %) in contrast to 63 % outbreaks from drinking desalinated water. A high percentage of the tanks in Al Qurayyat seem likely to suffer from contamination through microbial growth. An intensive awareness campaign is strongly recommended to educate the public how to maintain their drinking and household water sources safe.

A second household water brand showed extremely high total dissolved solids (TDS = 2320 mg/l; total hardness = 450 mg/l and electrical conductivity = 4520 µs/cm). This water brand is the most common source of water in Community College in Al Qurayyat where it is used daily by approximately 500 individuals. The same water brand contains high levels of calcium (200 mg/l), magnesium (250 mg/l) and attained the highest pH value (8.2). Hard water requires more soap and synthetic detergents for home laundry and washing, and contributes to scaling in boilers and industrial equipment. Water hardness is caused by compounds of

water could be behind breakouts, redness and even eczema.

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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 **pH**		6.50 –8.50	6.50 –8.50	6.00 –8.50
Electric Conductivity	µ/cm at 20ºC	800 – 2300	160 – 1600	
Total Dissolved Solids **T.D.S**	mg/l	1500	100 – 1000	1000
Colour	True Colour Units **TCU**	50.00 TCU	15.00 TCU	15.00 TCU
Turbidity	Nephrometre Turbidity Units **NTU**	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 $CaCo_3$	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 – 1.20	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

Figure 1A. Total Dissolved Solids (TDS) of a variety of local drinking water brands in Al Qurayyat.

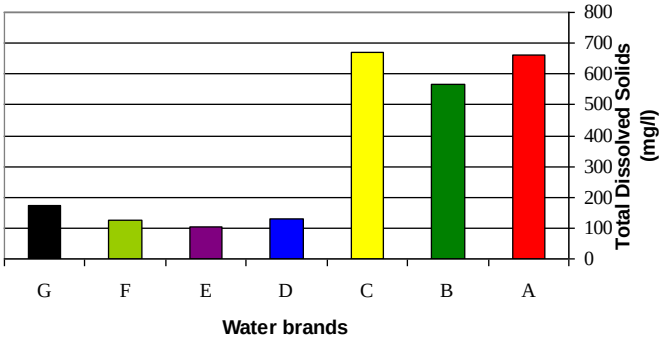

Figure 1B. Electrical Conductivity of a variety of local drinking water brands in Al Qurayyat.

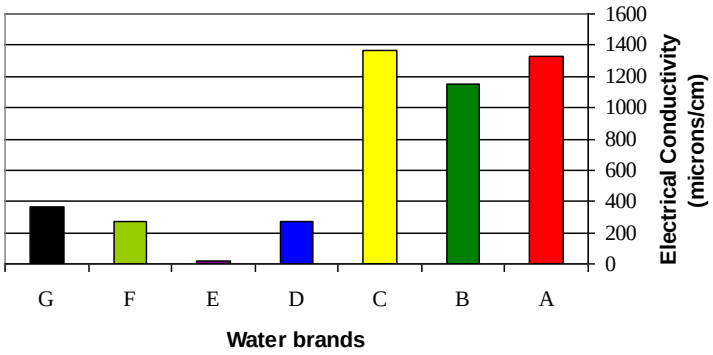

Figure 1C. Hydrogen ion concentration (pH) in a variety of local drinking water brands in Al Qurayyat.

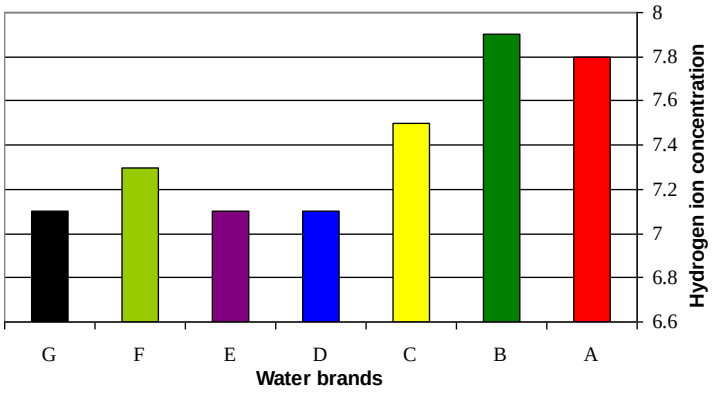

Figure 1D. Total Hardness of a variety of local drinking water brands in Al Qurayyat.

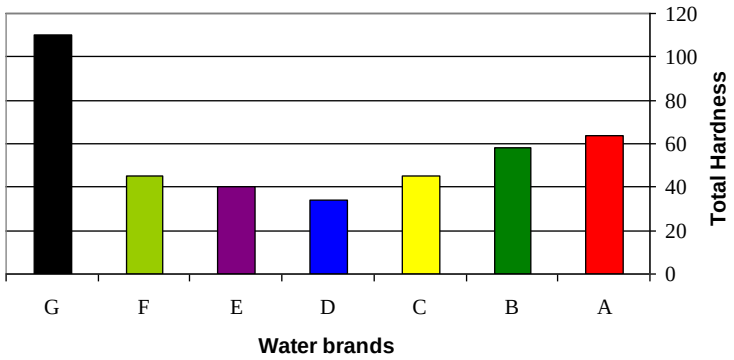

Figure 1E. Calcium content in a variety of local drinking water brands in Al Qurayyat.

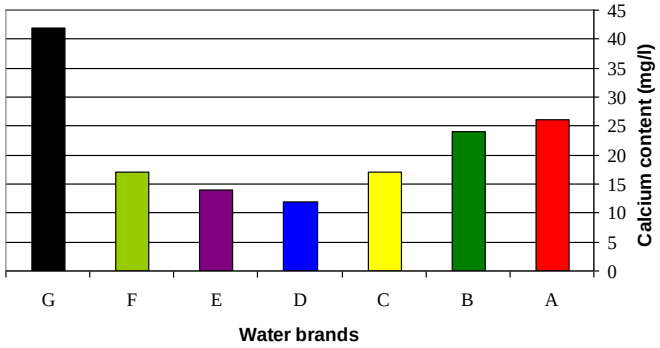

Figure 1F. Magnesium content in a variety of local drinking water brands in Al Qurayyat.

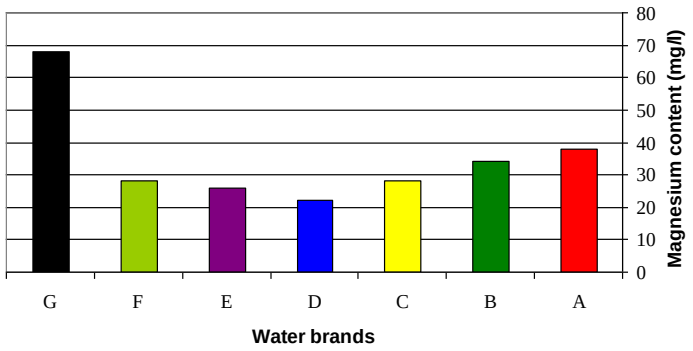

Figure 1G. Silicon content in a variety of local drinking water brands in Al Qurayyat.

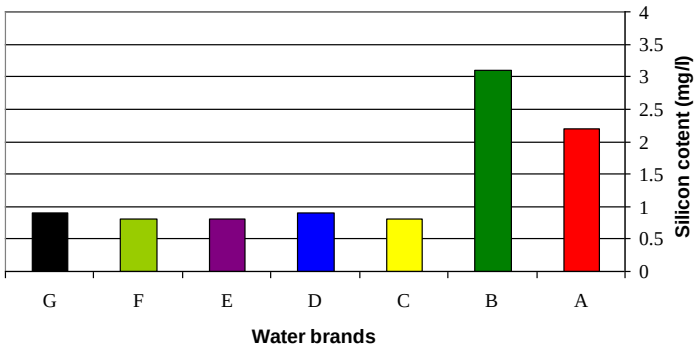

Figure 1H. Iron levels in a variety of local drinking water brands in Al Qurayyat.

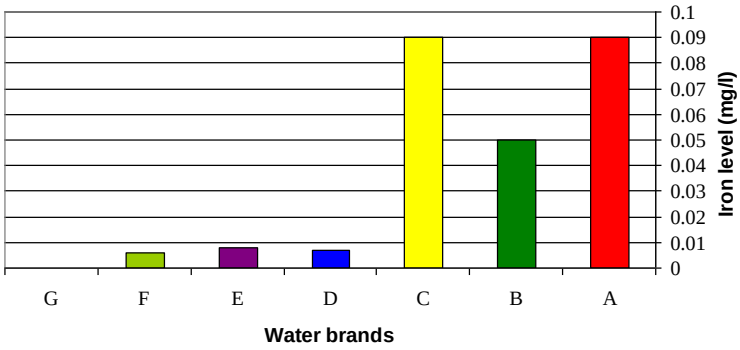

Figure 1I. Fluorine content in a variety of local drinking water brands in Al Qurayyat.

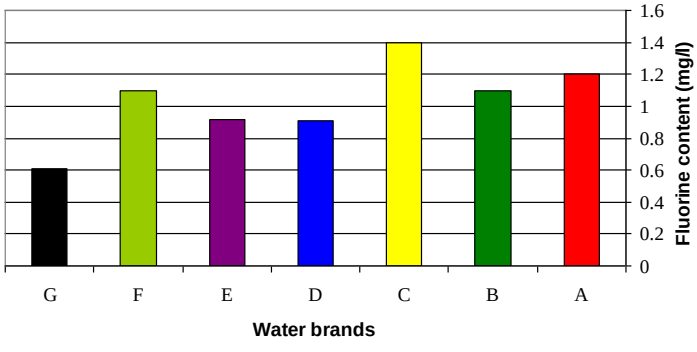

Figure 1J. Free Chlorine content in a variety of local drinking water brands in Al Qurayyat.

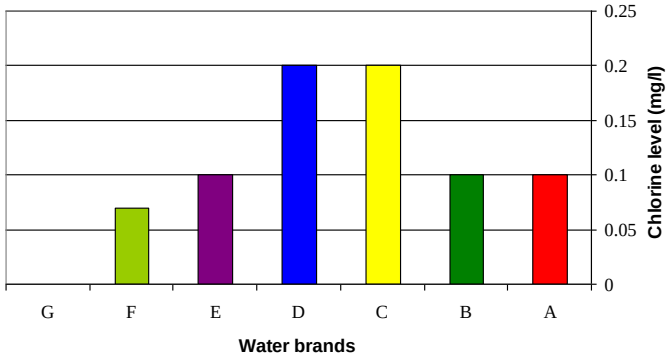

Figure 1K. Nitrate concentration in a variety of local drinking water brands in Al Qurayyat.

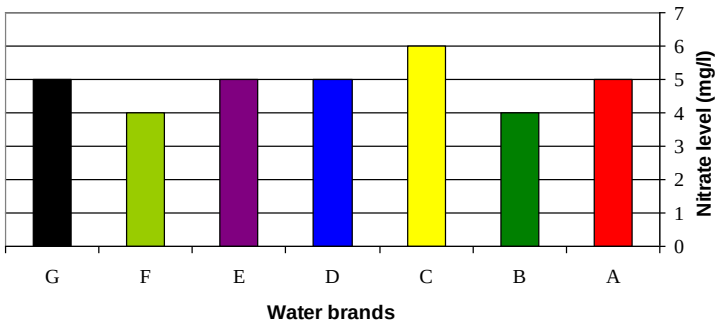

Figure 1L. Turbidity level in a variety of local drinking water brands in Al Qurayyat.

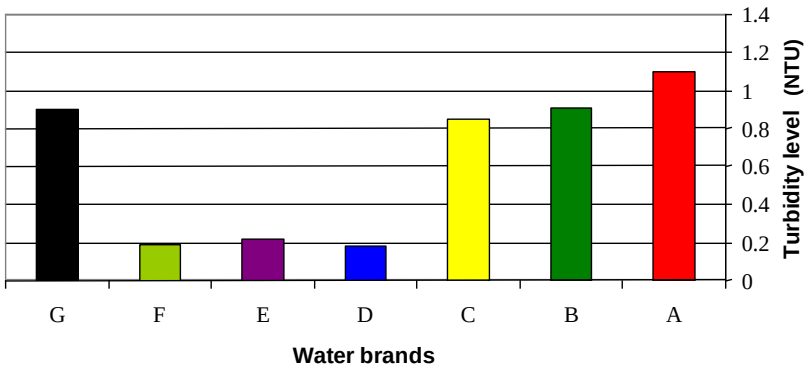

Figure 2A. Total Dissolved Solids (TDS) of a variety of local household water brands in Al Qurayyat.

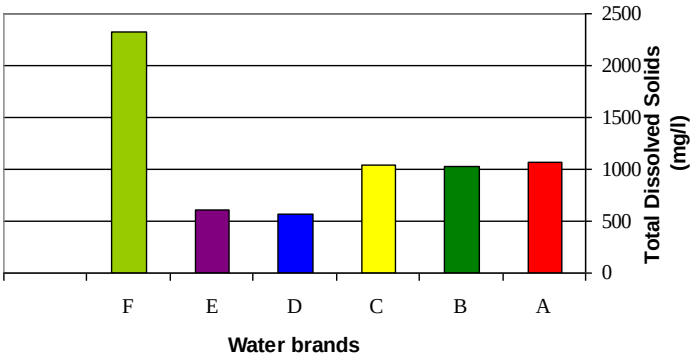

Figure 2B. Electrical Conductivity of a variety of local household water brands in Al Qurayyat.

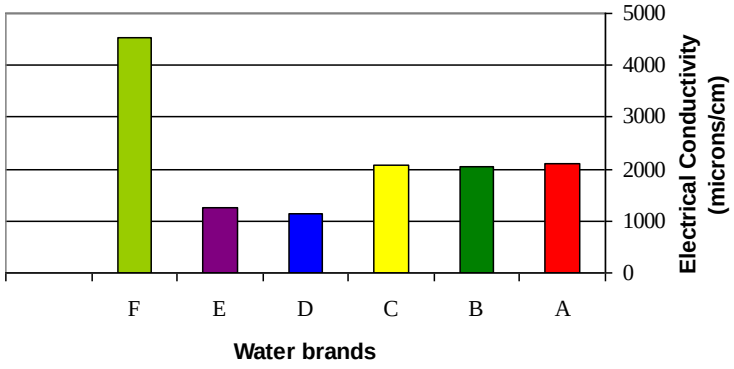

Figure 2C. Hydrogen ion concentration (pH) in a variety of local household water brands in Al Qurayyat.

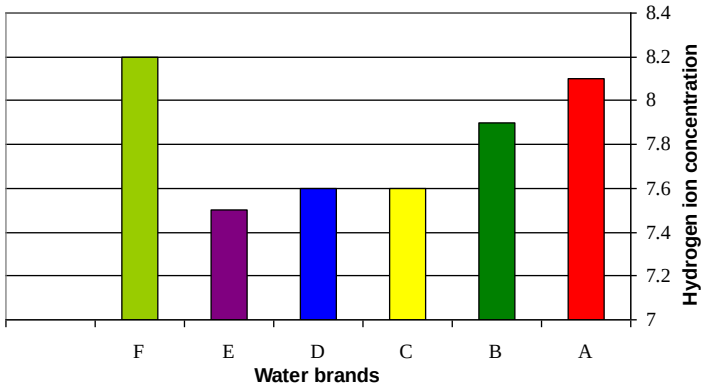

Figure 2D. Total Hardness of a variety of local household water brands in Al Qurayyat.

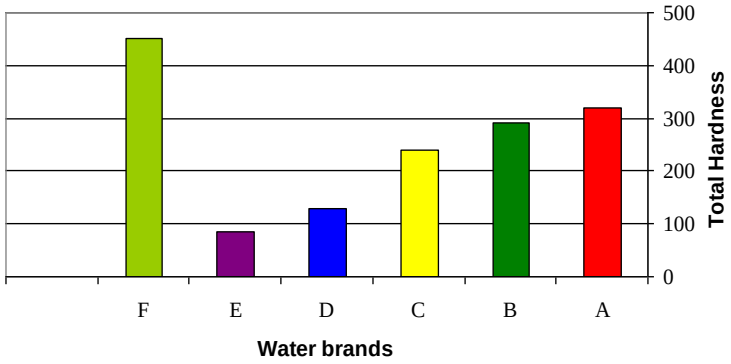

Figure 2E. Calcium content in a variety of local household water brands in Al Qurayyat.

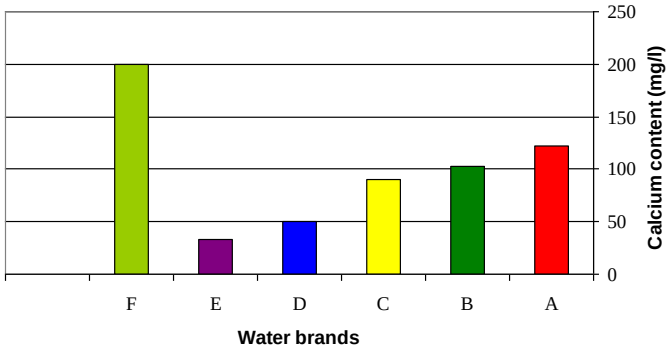

Figure 2F. Magnesium content in a variety of local drinking water brands in Al Qurayyat.

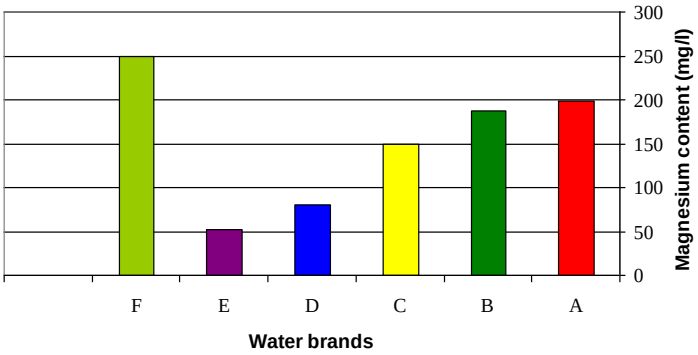

Figure 2G. Silicon content in a variety of local household water brands in Al Qurayyat.

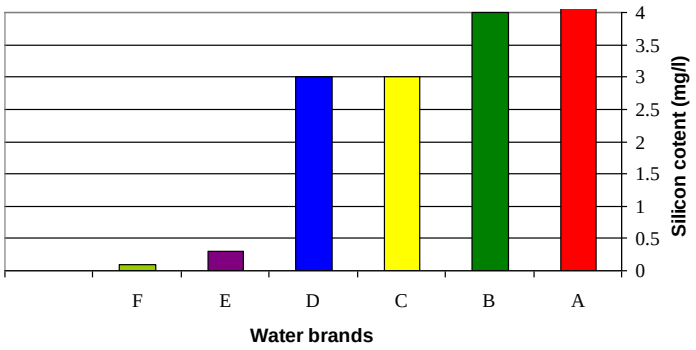

Figure 2H. Iron levels in a variety of local household water brands in Al Qurayyat.

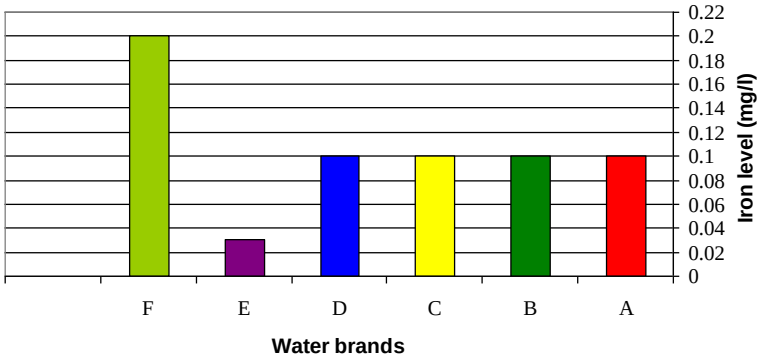

Figure 2I. Fluorine content in a variety of local household water brands in Al Qurayyat.

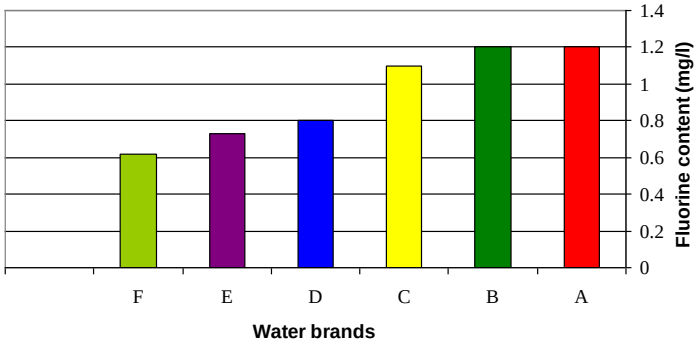

Figure 2J. Free Chlorine content in a variety of local household water brands in Al Qurayyat.

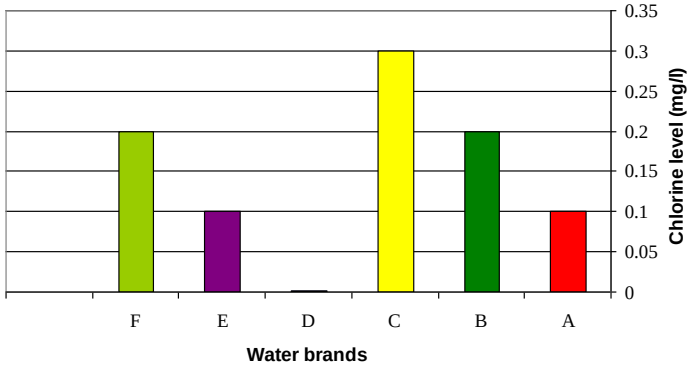

Figure 2K. Nitrate concentration in a variety of local household water brands in Al Qurayyat.

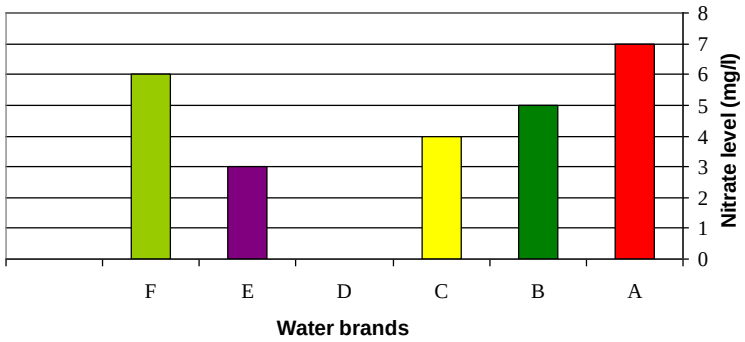

Figure 2L. Turbidity level in a variety of local household water brands in Al Qurayyat.