Water consumption evaluation in Kuwait

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ABSTRACT

The problem of gaining and securing reliable water supplies has been an issue of great importance to the people of Kuwait, ever since the earliest days of settlement in the region. This problem continues today and promises to become more acute as the population continues to grow and development of additional water supplies proves more difficult. This paper reports the results of a research study undertaken to determine the water consumption of households in Metropolitan Kuwait. The water consumption and other related data were collected randomly from different households from the five different governorates of Metropolitan Kuwait. Results of the analyses indicated that there is considerable waste of fresh water by the average Kuwaiti household. The outcome of this study, with recommendations on rationalization of water usage, was submitted to both the authority and the citizens of Kuwait.

Key words | brackish water, fresh water, households, Kuwait, water consumption

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INTRODUCTION

The problem of gaining and securing reliable water supplies has been an issue of great importance to the people of Kuwait ever since the earliest days of settlement in the region. Today, as the population and industrial developments grow, the problem of water scarcity promises to become more acute.

Signs of water scarcity worldwide are numerous. Water tables are falling, lakes are shrinking, rivers are becoming more polluted, and wetlands are disappearing. Engineering solutions to water shortages include schemes such as building river diversions (e.g. California, USA), construction of dams, and other expensive projects, some with questionable environmental consequences (Postel 1992).

The provision of water to urban areas requires major capital investment in storage, treatment, and supply networks. The demand for water increases with population growth and with industrial and commercial developments. Furthermore, the per capita consumption of water has generally tended to increase rather than decrease, although this can be expected to be largely a function of life style and population density (Power *et al.* 1983). Since

1950, global water demand has more than tripled to an estimated annual level of 4,340 km^3 in 1993 (Shiklomanov 1990). Because of improved standards of living, the per capita water use worldwide has increased dramatically to 800 m^3 (193,600 gallons) per year. This amount is 50% more than what it was in 1950 and it continues to grow (WRI 1992–1993). To meet this rising demand, responsible policy-makers have mainly emphasized the construction of 'water development' projects, particularly dams and river diversions. Today, more than 36,000 large dams have been built around the world to control floods, and to provide energy, irrigation, industrial supplies and drinking water to a growing global population (Falkenmark 1989).

Kuwait is an arid region that receives only about 100 mm (3.937 inches) of rain annually. This precipitation varies greatly from year to year (40–240 mm) and groundwater is scarce, complicating water development efforts (Al-Ruwaih 1998). In the past the people of Kuwait relied on a scant number of wells to satisfy their water needs. Those wells, supplemented by fresh water transported by boats from Basra, Iraq, were the main source of water for

the people. Transporting water by boats continued for some time, and in 1939 a company was established to manage the fleet of water carriers from Iraq, by constructing three reservoirs on the shore for storage. The first major breakthrough came in 1951 when the Kuwait Oil Company (KOC) built a small seawater desalination plant with a capacity of 363.6 m^3 (80,000 gallons) per day at the port of Al-Ahmadi (Mina Al-Ahmadi), and distributed some of the water to the towns of Kuwait. The first major desalination plant was built in 1953 with a capacity of 4,545 m^3/day (1 million gallons/day). In 1978, another desalination plant was built in Doha. The capacity of the Doha plant is 190,890 m^3/day (42 million gallons/day) (MEW 1998; MOP 2000).

The country was, and still is, very anxious to exploit all available groundwater, both fresh water for drinking and brackish water for irrigation. As for fresh groundwater, it is considered a matter of prime importance. Fresh groundwater was discovered in limited quantities in the north of the country at both Al-Rawdhatain and Umm Al-Aish fields. Pumping operations commenced in 1962, and the estimated natural reserve of both fields is about 181.8 m^3 (40,000 million gallons). In 1980, the Rawdhatain Water Production and Bottling Projects started to produce 1800 m^3/year (396,039.6 gallons/year) of mineral water. The Umm Al-Aish field is currently producing 8000 m^3/year (1,760,176 gallons/year) of water (Al-Ibrahim 1991; Omar *et al*. 1996).

In addition to fresh groundwater, the country makes use of its large supply of brackish groundwater. The Ministry of Electricity and Water (MEW) in Kuwait distributes water to consumers through a separate network which runs in parallel with the fresh water network. The brackish water is intended to be used for various purposes, such as blending with distilled water, irrigation, livestock watering and construction works.

The consumption of both fresh and brackish water, illustrated in Figure 1, has naturally been increasing with the increase in population. The production of both fresh and brackish water has the same trend, which means that almost all the water that is produced is consumed.

As shown in Figure 1 the average consumption, and therefore production, of water has increased gradually with the exception of the years 1990 and 1991. One should
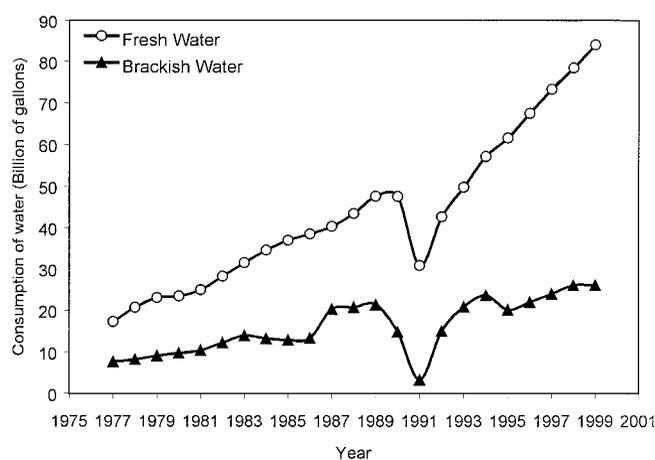

Figure 1 | Consumption of fresh and brackish water in Kuwait.

note that this decrease is due to the invasion of Iraq and the start of the Gulf war. The number of consumers connected to the fresh water network was 94,488 in 1997, while 63,047 consumers were connected to the brackish water network by the end of the same year (MEW 1998).

In the affluent State of Kuwait, nearly 98% of the population resides in Metropolitan Kuwait. A unique characteristic of the State of Kuwait, and other nations of the Gulf Cooperation Council (GCC), is the constant change in the expatriate population from year to year. Each year, a significant percentage of Kuwait's expatriate population (62% of Kuwait's population are non-Kuwaitis), leave the State upon termination of their contracts. These individuals are replaced by incoming expatriate workers mostly from Egypt, India, Bangladesh, and Sri Lanka. Figure 2 shows the consumption of water in Kuwait and the other GCC countries. As in the case of Kuwait, the production of water in the GCC countries takes on the same trend as the consumption. This means that almost all water that is produced is consumed.

RESEARCH METHODS

Following a comprehensive review of the related literature and the establishment of an organizational structure for
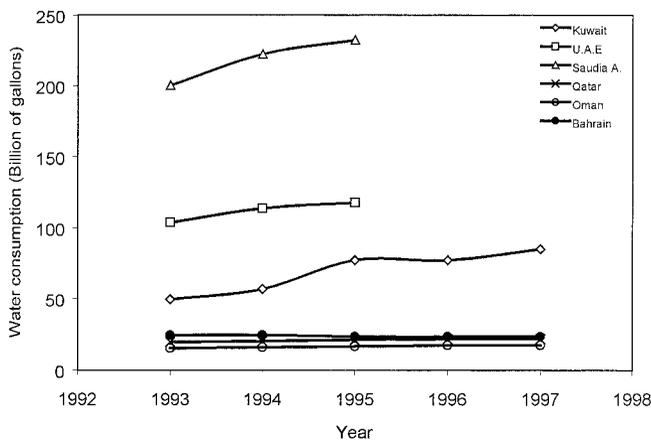
Figure 2 | Consumption of water in Kuwait and other GCC countries.

the implementation of the research, a survey plan was designed. The computation of the sample size, the development of a questionnaire, the determination of sampling techniques and the sample population were all addressed in the survey design. The computation of the sample size was made in accordance with the commonly utilized statistical equation (Walpole & Myers 1985). A confidence level of 95%, and an error level of ± 5% were considered to be appropriate by the research team. By utilizing a recommended value of 0.5 for the standard deviation (for maximum possible standard error of the mean), the minimum required sample size may be computed from the following equation:

$$\sqrt{N} = [(Z_{1-\alpha/2} * S)/e] \tag{1}$$

where:

N = the minimum required sample size

Z = the number of units of the standard deviation in a standard normal distribution curve ($Z = 1.96\%$, $\alpha = 5\%$)

α = significance level

S = standard deviation (0.5 when the true population standard deviation is not known)

e = acceptable error (± 5%)

Equation 1 and the above input values resulted in a minimum sample size of 385.

A simple, but structured, questionnaire was designed and pre-tested to obtain information on households'

socio-economic traits and residence characteristics, as well as the daily water-consuming activities of sample households. The questionnaire, after being pre-tested and modified, was distributed to a systematic-random sample of 3,000 households residing in the five governorates of Metropolitan Kuwait. Special care was taken to ensure that the various socio-economic groups in the sample were representative. A total of 2,705 completed questionnaires were processed for analysis. The objective of the study was to examine the water supply and consumption situation in Kuwait.

FINDINGS

The results of the analysis of mean statistics indicated that an average sample household spent KD 23 (US$75.9) per month ($\sigma = 1.0$) on water consumption. The average size of a household was 6.9 family members ($\sigma = 4.2$), and 1.8 maids ($\sigma = 1.0$), increasing the number of persons per sample household to nearly 9 persons. The mean sample car ownership rate was 3.8 cars per household ($\sigma = 1.4$). In an average household there were 2.4 employees ($\sigma = 1.3$); a shower or bath was taken at least 5 times a week ($\sigma = 0.66$); clothes were washed (machine-washed) at least 4 times a week ($\sigma = 1.1$) and the entire house was washed (floor scrubbing) twice a week ($\sigma = 1.0$). Also, it was found that 43% of the households use bottled water alone for drinking, while 17% use tap water alone, and 40% use both for drinking.

Finally, an attempt was made to find out what aspects of tap water the people of Kuwait most dislike and are concerned about. It was found that they are most concerned about the colour of the water. The results showed that 59% of households are concerned about the colour of the water, 26% are concerned about the taste, and 21% are concerned about the impurity of the water. Note that the total exceeds 100% (exactly 106%), which means that some people are concerned about more than one item at the same time. These findings all point to the significant characteristics of Kuwaiti households: large families, big houses, a high car ownership rate, and multiple servants and drivers – all contributing to the daily consumption of water.

Table 1 │ Correlation matrix

Var.	Var.							
	AWB	**RT**	**HS**	**NOO**	**NOC**	**CWPW**	**PSPW**	**HMI**
AWB	1.00	0.317	0.307	0.218	0.195	0.302	0.298	0.231
RT		1.00	0.278	0.304	0.173	0.082	0.017	0.121
HS			1.00	0.223	0.174	0.152	0.185	0.278
NOO				1.00	0.455	0.303	0.164	0.162
NOC					1.00	0.103	0.043	0.310
CWPW						1.00	0.117	0.211
PSPW							1.00	0.108
HMI								1.00

Where: AWB: average water bill; RT: residence type; HS: house size (m^2); NOO: number of occupants in the household; NOC: number of cars in the household; CLPW: clothes washes per week; PSPW: people showering/bathing per week; HMI: household monthly income.

ANALYSIS OF CORRELATIONS

The quantity of water consumed daily by a household is, to a large extent, a function of the household's socio-economic characteristics. Factors such as household size, income, and its members' social habits (number of cars, type of residence), all affect the daily water consumption rate of the household. Therefore, a correlation analysis was performed on the data to quantify the magnitude of these associations.

As presented in Table 1, all of the sample households' socio-economic factors were positively and significantly associated with the quantity of water consumed. The variable most strongly correlated with the level of daily water consumption was the residence type. This indicates that households residing in villas (single-unit residences) consume significantly more water than those which reside in apartments ($r_{xy} = 0.317$, $p < 0.0001$) (this indicates that there is a one in ten thousand probability that the value of r_{xy} is not significantly different than zero).

The size of the household villa was the second most influential factor in the consumption of water, as may be expected ($r_{xy} = 0.307$, $p < 0.0001$). This was followed by the number of weekly clothes washes ($r_{xy} = 0.302$, $p < 0.0001$), the number of weekly showers/baths taken ($r_{xy} = 0.298$, $p < 0.0001$), the number of people residing in the household ($r_{xy} = 0.218$, $p < 0.0001$), the mean number of cars owned by the household ($r_{xy} = 0.195$, $p < 0.0007$), and the household monthly income ($r_{xy} = 0.231$, $p < 0.0001$). All of these findings conform to expectations.
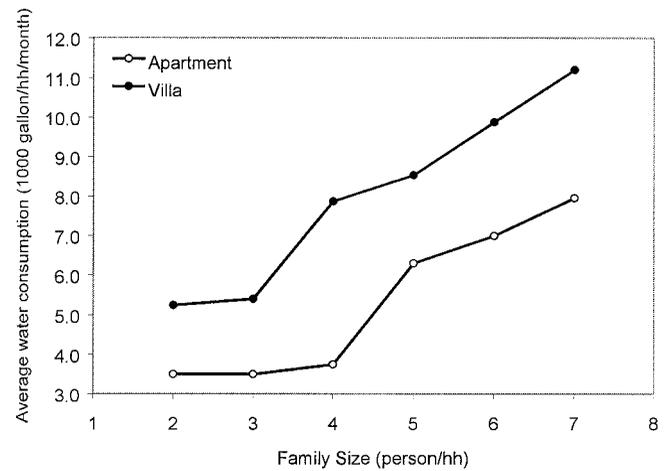
HOUSEHOLD TRAITS AND WATER CONSUMPTION RATES

Summary analysis was employed to determine the mean quantity of water consumed as a function of the households' socio-economic traits. The mean daily water consumption by the sample households varied significantly by residential type as shown in Figure 3. Households residing in villas consume a greater quantity of water per day when compared with those residing in apartments, and this difference was statistically significant at the 99% significance level ($\hat{Z} = 9.1 > 2.57$).
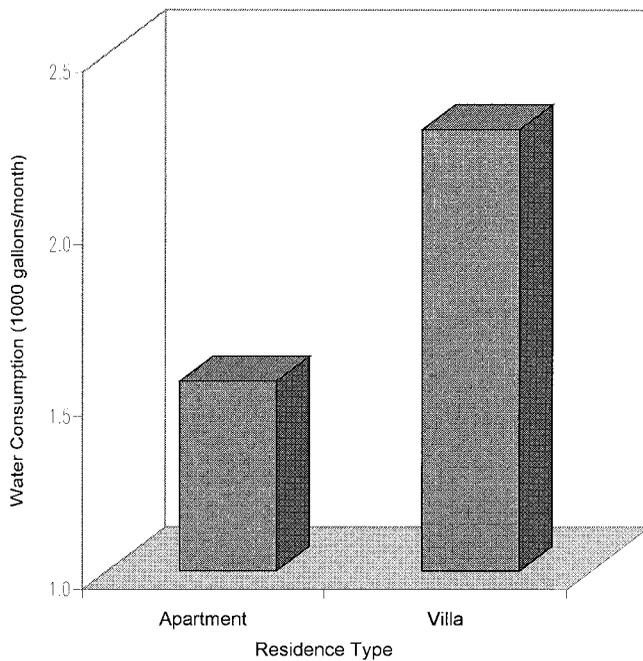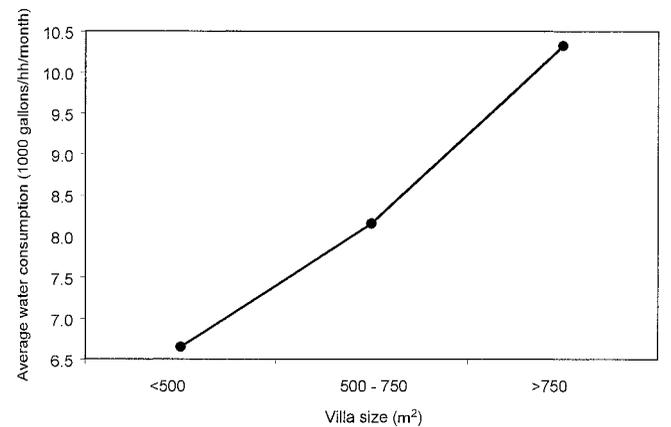
Figure 3 │ Household residential type and water consumption.

Figure 4 │ Water consumption by household size and residence type.

Figure 5 │ Villa size (m^2) and water consumption.

In general, a major factor contributing to the consumption of household water is the size of the household. The larger the family, the greater the quantity of water consumed. However, in addition to the size of the family, a number of other household socio-economic variables may also significantly affect the daily water consumption rate of households residing in single-unit villas. The frequency of clothes washing constitutes one such variable which contributes to greater water consumption by the residents of single-unit villas. To test this hypothesis, a summary analysis was performed on the data with the aim of determining the daily water consumption for households of equal sizes but of different residential types. The results are presented in Figure 4. Quite clearly, and as hypothesized, individuals residing in villas consume considerably greater quantities of water each day, when compared with households of equal size but living in apartments.

Another household socio-economic variable which demonstrated a positive and significant correlation with water consumption was the size (area in m^2) of the villa. As presented in Figure 5, a significant difference in the rate of daily water consumption is observed for villas with an area of less than 500 m^2, between 500 and 750 m^2, and those larger than 750 m^2.

CONCLUSIONS AND RECOMMENDATIONS

The development of the State of Kuwait, or any other nation, inevitably involves increased water consumption. Since water consumption and the deterioration in the quality of available natural water will inevitably continue, it is imperative that, to allow society to develop normally,

the replenishment and qualitative improvement of natural waters must proceed faster than their consumption and deterioration. There is evidence of lavish use of water by the people of Kuwait, e.g. in washing their cars, houses (floor scrubbing), clothes, etc. We estimated that the amount of water used in washing a car varies from 0.034 m^3 (9 gallons) for those who use buckets, to 0.231 m^3 (61 gallons) and higher for those who use water hoses directly fitted onto water taps. Also, it is apparent that people in Kuwait are concerned about the colour of their household water. That is why a high percentage of the people surveyed use bottled water for drinking rather than tap water.

The analysis of correlations indicated that, in order of importance: the type of dwelling, the size of the dwelling, clothes washing, personal washing/bathing, the size of the family, the income, and the number of cars, all positively and significantly contribute to the daily water consumption in Kuwait.

An educational programme for the general public on conserving water should be implemented to reduce or slow down the increase in domestic per capita consumption of water. One way to encourage people to conserve water is by increasing the charges for water use. The water rates charged throughout the country are very low, while 4500 litres (1000 gallons) of water costs the authority KD 2.7 to produce, the customer is charged KD 0.8 for it. In view of the rapidly increasing cost of water supply schemes, inflation, and the financial crises the country is going through (especially after the Gulf war), the above rates seem to be unreasonably low. The water authority should also advise consumers on using more of the brackish water for their daily requirements, such as irrigation, landscape watering, household purposes, livestock watering and construction works. They could also put in a separate network of brackish water for toilet flushing. Perhaps the water authority should have two different water rates, one for fresh water and a lower one for brackish water. By the same token, the water authority should study the reduction in the volume of water consumed for personal washing and bathing by replacing conventional sprays with ones that could reduce water flow.

The Ministry of Electricity and Water should think seriously about reusing treated wastewater effluents. In many places around the world secondary treated wastewater is used for irrigation. On the other hand, tertiary treated effluents are produced in Kuwait. Such high quality effluents can be used for irrigation without reluctance. Alternatively, they could be discharged into artificially constructed wetlands, which may represent a viable option. In addition, the cost of producing tertiary effluents is very low compared to fresh water in Kuwait. It cost less than KD 0.6 to produce 4500 litres (1000 gallons) of tertiary treated effluent compared to KD 2.75 per 4500 litres (1000 gallons) of fresh water.

ACKNOWLEDGEMENTS

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