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Water Consumption Patterns in Greater Kuala Lumpur: Potential for Reduction

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Abstract: This study analyses residential water consumption data from Greater Kuala Lumpur obtained through a questionnaire-based survey. The data was analyzed by simple statistical analysis and Pearson Correlation Coefficient Analysis to find out the relationship between water consumption and socio-economic variables. The study found that per capita water consumption in the Greater Kuala Lumpur was 288 litres per day with a standard deviation of 73.9. The results indicated water consumption strongly varied by using different water equipments (such as low shower head, dual flush etc.) among the surveyed households. There was a positive significant relationship between water consumption and household size. The study also found a huge potential for water consumption reduction with the use of efficient water consuming equipment which specify 33%, 29% and 36% reduction by using low shower head, dual flush toilet and stopping a running tap respectively. The study provides an insight option for decision makers and civil society into the patterns of residential water consumption and the potential to reduce it.

Key words: Residential water, consumption pattern, reduction, Greater Kuala Lumpur.

Introduction

The world is increasingly facing water crisis over the years and, therefore, billions of people and surroundings suffer from water shortages either periodically or on permanent basis. Most of the developing countries are suffering droughts as they are located in areas that are dry during part of the year (Falkenmark, 1990). Compounded with world climate change, population increase and improvements in living standards, this places a terrible challenge within the developing continent. Water crisis is an environmental problem, even though countries with abundant water supply also face constraints in providing clean drinking water as a result of water contamination. Although industry and agriculture represent the majority of water demand, the proportion of household consumption in overall water consumption ranges from 10-30% in developed countries (Millock and Nauges, 2010). Bengtsson et al. (2005) stated that water consumption will increase in proportion to per capita GDP growth. In developing countries, as economic growth increases, in the near future, residential water consumption will increase and water consumption patterns will change significantly. Steel and Macghee (1979) stated that water can be differentiated according to its final consumption such as residential, commercial, industrial, public, loss and wastage and vary according to the living standards of

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consumers. For estimating water demand and water supply planning in such countries, it is important to know not only the total residential water consumption per capita, but also the residential water consumption by activities such as use of kitchen and toilet, showers, laundry use and gardening. Thus, such information of water consumption leads to more practical and correct demand estimations of the residential sector.

The consumption of water for residential purposes might be subdivided in food preparation and cooking, house cleaning, washing clothes and utensils, vegetable gardening, stock watering and other uses (Amin et al., 2011). The amount of water used is variable depending on the type of supply, cultural habit, settlement patterns, water source, etc. Hunnings (1996) revealed that the amount of water consumption depends on household size, household income, how water is consumed, level of maintenance of water supply system and some other factors such as level of education and age of the head of the household. Gazzinelli et al. (1998) and Keshavarzi et al. (2006) revealed that type of house, type of water supply, certain socio-economic and cultural factors, and a utility index were significantly correlated with water consumption.

In developing countries much research has been conducted to achieve knowledge on water consumption for different activities (Otaki et al., 2003). For example, Figure 1 shows the results of residential water consumption of different countries. The water consumption patterns differ from city-by-city. However, the city with a larger consumption level is not always the greater consumer with respect to every component. As an example, although Singapore's total water consumption is relatively small, its consumption for baths is the second largest among developed cities surveyed (Otaki et al., 2008). Even in the more developed countries where the price and availability of water do not impose constraints on consumption, there is a marked difference in demand depending on the socio-economic level.

According to Linkola (2013) in the Netherlands average per capita water consumption in household sector is 127.5 litres per day (L/d). In China, the per capita household water consumption is 70.2 L/d (Fan et al., 2013). Also in Australia the average household water consumption per capita is 128.2 L/d (Willis et al., 2011). The United Kingdom national survey of household water consumption showed the ratio of the water consumption of the two highest socio-economic groups to that of the two lowest groups was 1.47, namely 140 compared to 95 litres per head per day (Bradley, 2004; Bailey et al., 1986). A survey by Bradley (2004) showed that for owner occupied properties deemed to be higher income families, the average water consumption was 9.3 m^3 per month per household compared to 8 m^3 per month for privately rented houses, and 6.8 m^3 per month for local authority rented houses. The survey also showed detached houses averaging 11.2 m^3 per month per household, compared to about 8.6 m^3 per month for semi detached and terrace houses, and 5.1 m^3 per month for flats. In Malaysia, there is a

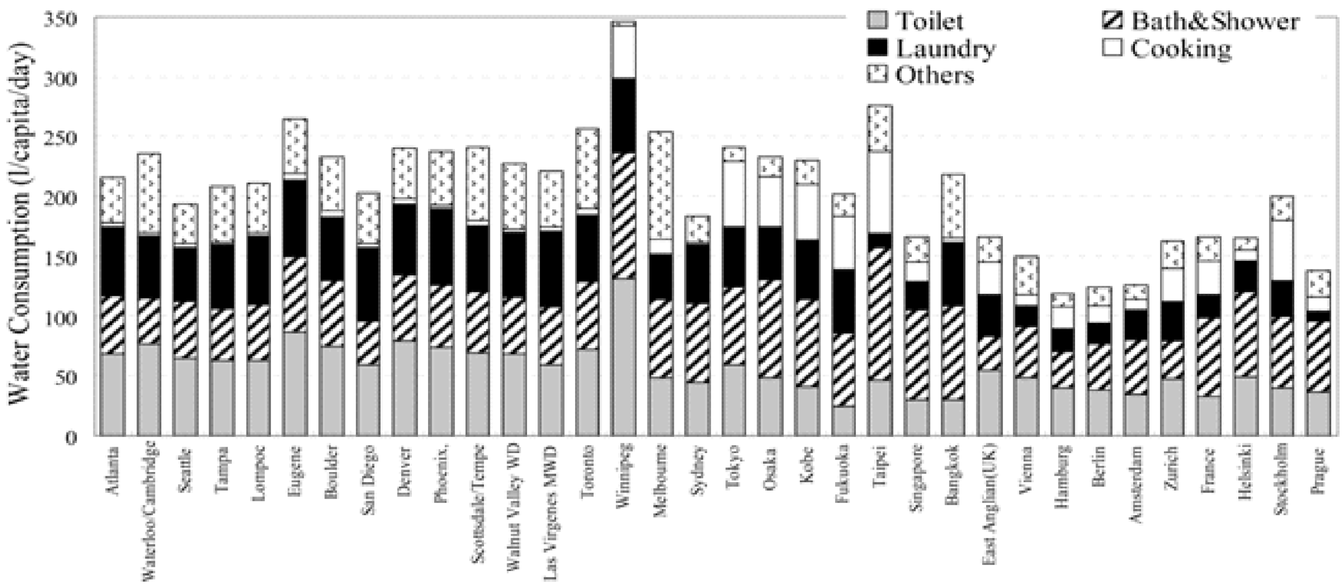

Figure 1: Residential water consumption of different cities.
Source: Otaki et al. (2008)

limited study on water consumption patterns by different residential activities. Therefore, this study attempts to measure per capita residential water consumption and its relationship with other socio-economic variables in Greater Kuala Lumpur. The study also provided a scenario for potential water consumption reduction by using efficiency equipments.

Materials and Methods

The survey area of Greater Kuala Lumpur covers 10 municipalities, each governed by local authorities in the Federal Territory of Malaysia and the state of Selangor. The area extends from Selayang in the north to Sepang in the south, encompassing Kuala Lumpur, Putrajaya, Shah Alam, Petaling Jaya, Klang, Kajang, Subang Jaya and Ampang (GoM, 2010). The survey covered residents living in areas of Kuala Lumpur, Rawang, Petaling Jaya, Kajang, Klang, Subang Jaya and Shah Alam among the 10 municipalities of Greater Kuala Lumpur.

The data were obtained through a questionnaire survey and purposive random sampling method was followed to collect the data from the secondary and pre-university students of Methodists Girls School Kuala Lumpur and Taylor's College Subang Jaya respectively. The questionnaire was finalised after the modification of the pre-test for 30 respondents. A total of 197 households were surveyed in which each respondent represented one household. The questionnaire was prepared by considering related questions and variables of water consumption patterns and socio-economic characteristics of individual household. Data were collected from November, 2011 to March, 2012.

The following equation was used to calculate the direct residential water consumption which was adopted from Hoekstra et al. (2005).

$$TW_{cons} = T_{shower} + T_{hand,wash} + T_{brushing} + T_{flush} + T_{dish,wash} + T_{cloth,wash} + T_{garden}$$

where

TW_{cons} = Total water consumption,
T_{shower} = Total water use for shower,
$T_{hand,wash}$ = Total water use for hand wash,
$T_{brushing}$ = Total water use for teeth brushing,
T_{flush} = Total water use for flushing,
$T_{dish,wash}$ = Total water use for dish washing,
$T_{cloth,wash}$ = Total water use for cloth washing, and
T_{garden} = Total water use for garden.

The survey data were analyzed by statistical analysis such as mean and standard deviation as well as Pearson Correlation Coefficient to find out the relationship between water consumption and socio-economic variables as expressed by the following equation.

$$r = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}}$$

where r is correlation,

$\sum_{i=1}^{n}(Xi - \bar{X})(Yi - \bar{Y})$ = Co-variation of X and Y,

$\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2}$ = Unique variation in X and

$\sqrt{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}$ = Unique variation in Y.

Survey Results

To calculate the per capita water consumption, households were divided into three groups such as low, less than 250 litres per capita per day (Lpcd); medium, 250–350 Lpcd and high, more than 350 Lpcd as described in Figure 2. Thirty four percent (34%) of respondents represent low consumption group while 42% and 24% represent medium and high level of water consumption group. Table 1 shows the calculation of per capita water consumption for different household activities where the average water consumption was 288.4 litres per person per day with a standard deviation of 73.9. The most water consuming activities are showering (125 lpcd), toilet use (63 lpcd), washing hand and brushing teeth (32 lpcd) and dish washing (30 lpcd) with a standard deviation of 54.2, 17.6, 21.3 and

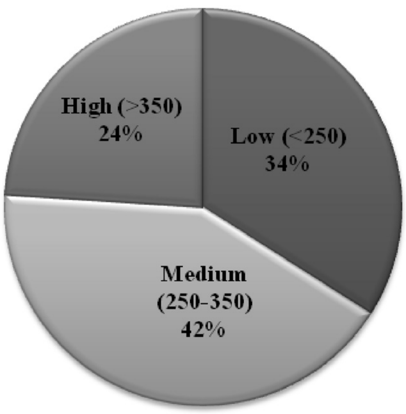

Figure 2: Residential water consumption by litres per capita per day (lpcd).

Table 1: Per capita water consumption for different household activities

Activities	*Water consumption (mean)*	*Standard deviation*
Showering (lpcd)	124.8	54.2
Hand washing and brushing teeth (lpcd)	31.5	21.3
Toileting (lpcd)	62.6	17.6
Dish washing (lpcd)	30.1	10.3
Washing clothes (lpcd)	18.3	6.6
Gardening (lpcd)	21.1	23.1
For all purposes (lpcd)	288.4	73.9

N.B. Litres per capita day (lpcd) is mostly common unit used in every country and previous analysis.

10.3 respectively. The least water consuming activities are gardening (21 lpcd) and washing clothes (18 lpcd) with a standard deviation of 23.1 and 6.6 respectively.

Table 2 shows the result of the Pearson Correlation coefficient between per capita water consumption and other variables. The results indicated that the water consumption strongly varies by using different water utility and equipments (such as low shower head, dual flush etc.) among the surveyed households. There was a positive significant relationship between water consumption and household size. Details on households were categorised according to Types of house, Household income, Father's and Mother's education, Father's and Mother's occupation and Willingness to pay (WTP) for green product. There were also positive but not significant relationships between water consumption and types of house and household income. The relationship between water consumption and mother's occupation was found to be negatively significant. This indicates that housewife, student and retired mothers consume more household water compared to the mothers with occupation business, NGO, private and government. There is also a negative but insignificant relation between father's education,

Table 2: Relationship between per capita water consumption and other variables (Results from Pearson Correlation Coefficient Analysis)

	Water consumption	*Household size*	*Types of house*	*Household income*	*Father's education*	*Mother's education*	*Father's occupation*	*Mother's occupation*	*WTP for green product*
Water consumption	1								
Household size	**0.264(**)**	1							
Types of house	0.062	0.019	1						
Household income	0.081	0.058	0.477	1					
Father's education	-0.038	-0.054	0.403	0.519	1				
Mother's education	-0.012	-0.037	0.441	0.480	0.614	1			
Father's occupation	-0.017	-0.010	-0.163	-0.005	-0.115	-0.157	1		
Mother's occupation	**-0.151(*)**	-0.144	-0.081	0.050	0.113	0.274	0.164	1	
WTP for green product	-0.059	-0.134	0.244	0.290	0.121	0.109	0.030	0.050	1

**Correlation is significant at 0.01 level.

*Correlation is significant at 0.05 level.

mother's education, father's occupation and WTP for green product which means that these variables do not influence the household water consumption.

Table 3 shows a scenario of potential water consumption reduction by using efficient water consuming equipments. The usage of low shower head can save up to 8194 litres (33%) of water whereas up to 3525 litres (29%) of water can be saved by using dual flush toilet system. However, 2240 litres (36%) of water consumption can be reduced by behavioural changes such as, stop running tap when brushing teeth and washing hand with soap.

Discussion and Conclusion

The availability of adequate water infrastructure and reasonable water services are important contributors to the economic growth and development, especially for the emerging nations. Thus it is important to measure the patterns of residential water consumption and its potential for reduction. The study found per capita water consumption per day for showering amounted 124.8 litres, which is the highest residential water consumption activity, and almost double to the estimation of 78 litres per day calculated for Thailand (Otaki et al., 2008). According to the study of Otaki et al. (2008), in Thailand water consumption per person per day for toilet, dish washing, washing cloth and other purposes were 31 litres, 4 litres, 52 litres and 28 litres respectively. Compared to this study, water consumption for toileting and washing dishes in Greater Kuala Lumpur are significantly higher than that of Thailand. This difference may be due to the availability of water supply (15,285 million litres of water per day in 2010) to consumers in Malaysia (Kim, 2013).

There was a positive significant relationship (r = 0.264) with household size and water consumption indicating that larger family members household consumes more water which is logically sound. On the other hand, the relationship between water consumption and mother's occupation was found negatively significant. Where mothers who work consume less water than house wives and retired mothers because they are out of the home most of the time they stay outside. The analyses also show positive but not significant relationships between water consumption and types of house and household income. Economic growth within Malaysia has been significantly increased over the past few years, and its water consumption is also expected to increase from hereon.

The most water consuming activities are showering which account for about 125 lpcd of total residential water consumption in GKL. By replacing standard to low showerhead, per capita water consumption can be reduced approximately 42 litres per day, as in Washington. For example, the estimated water use per person dropped 6.4% after installation of low-flow showerheads (EPA, 2012). Whereas this study estimated that the usage of low shower head can be reduced by up to 8194 litres (33%) of water consumption. On the other hand, 3525 litres of water per day can be reduced by using dual flush toilet system. Changing behaviour such as stopping a running tap when brushing teeth and washing hands can influence the water consumption by saving up to 2240 litres per day.

Table 4 summarizes the comparison of residential water consumption for household activities between GKL and other countries. Residential water consumption is ranked in the flowing order, shower (47%) > toilet (24%) > dish washing (15%) > others (9%) (hand washing, brushing teeth and gardening) > washing clothes (7%). In line with the per capita water consumption of other countries, it can be assumed that the consumption of GKL would not be much different for the water consumption of urban Malaysia as a whole. The water consumption for showering in GKL is higher compared to other countries that might be not using low shower head. The comparison of residential water consumption between GKL and Thailand revealed that the water consumption was higher in GKL in all sectors (Otaki et al., 2008). In general, there were two to eight taps per household in Thailand (Otaki et al., 2008) whereas for GKL on average 9 (Min: 5, Max: 35) taps per household for water consumption.

Table 3: Different option of using efficient equipments for potential water consumption reduction

Options	*Current (lpcd)*	*Estimated (lpcd)*	*Potential reduction (lpcd)*	*%*
Using low showerhead	24582	16388	8194	33
Using dual flush toilet	12339	8814	3525	29
Stop running tap when brush your teeth and wash your hands	6202	3962	2240	36

Table 4: Comparison per capita water consumption with other countries

Activities	*Grater Kuala Lumpur*		*Thailand*		*Korea*		*U.K.*		*U.S. pre-retrofit*		*U.S. post-retrofit*	
	Lpcd	*%*	*Lpcd*	*%*	*Lpcd*	*%*	*Lpcd*	*%*	*Lpcd*	*%*	*Lpcd*	*%*
Bathing/showering	125	47	78	40	27	23	33	26	48	22	43	30
Toilet	63	24	31	16	52	45	44	34	71	33	30	21
Washing cloth	18	7	52	27	13	11	15	12	56	26	35	24
Kitchen	39	15	4	2	23	20	36	28	40	19	35	25
Others	23	9	28	15	-	-	-	-	-	-	-	-
Total	268	100	217	100	115	100	128	100	215	100	143	100

Source: Malaysia (Author's Survey); Thailand (Otaki et al., 2008); Republic of Korea (Bradley, 1985); U.K. (Hodges, 1998); and U.S. (Deoreo et al., 2001).

Houses using low-tank bowl toilets had a flush volume of about 16 litres, compared to houses with high-tank squat toilets, where the flush volume was about six litres and the toilet use averaged about 21% of the total internal household water consumption (Bradley et al., 2002). Compared with the GKL it is also very high because of using normal flushing toilet and the flush volume are nine litres (Bathroom Manufactures Association, 2010). However, the residential water consumption of UK also demonstrated the similar pattern. It is apparent from Table 3 that potential reduction can be achieved with the utilization of efficient equipments and appliances. The U.S. studies revealed that by focusing particularly on toilets installing dual-flush units resulted in an average flush of 5.2 L compared to 13.7 L prior to the retrofit, the total residential water consumption was reduced by one third (Deoreo et al., 2001). Water consumption in US due to toilet flushing was comparatively higher than that of GKL before retrofitting whereas after retrofitting, that consumption reduced approximately 50%. However, the higher consumption rate in GKL might be very low of usage of dual flush in the toilets.

Several countries have promoted rebate programmes for the installation of water efficient technologies. Currently Malaysian government offers rebates for series of efficient products, including rainwater tanks, dual flush toilets and water efficient shower head. But there is still lack of public response, strict rules and regulations as well as suitable policies from government and public sectors. Therefore, the findings of this study would be useful for the water demand management such as reducing leakages and non-revenue water, raising public awareness on water conservation, as well as might be useful for introducing new policies to conserve water through efficiency. However, the present study recommends promotion for water efficient equipment, behavioural based approach for conserving water, and develops special training for future generation for potential reduction of water consumption in Malaysia.

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