

## Realization of sustainability through rationalization of water consumption for domestic.

(Case study of Erbil city – Iraq)

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**Abstract**— Water is the main life source for all the creatures on our planet. Erbil city has a rapid urban growth after 2003 due to fast increase in population. This increment in population caused by both natural and immigration, which has led to raise the need for water domestic use. This need added a further pressure on water consumption in Erbil city especially on the underground water level as the main water source in the city. All these influences will lead to an overall ecological concern. In parallel to the need for water, it has been emerging the unwise consumption of water by the citizen. Hence effect on wasting the precious substance on underground water which accumulated from thousands of years. The paper tries to investigate the causes of wasting clean water. A questionnaire of selected sample of Erbil's citizen was adopted for this purpose. This research hypothesized that the unwise use of water can be overcome by increasing the people awareness of hazards of water waste and accordingly its influence on ecological issues. Moreover, finding new sustainable approaches in using water, putting regulations for water use and educate people through authorities, society organizations and media, all these will effect substantially on eliminate water consumption and enhancing our environment overall.

**Keywords-component;** *Water consumption, water domestic use, ecological concerns, sustainable approach.*

### • **PROBLEM STATEMENT**

The majority of research projects have focused on highlighting the current water shortage and the increased use by the residential sector. Research on residential water on consumption in cities has been restricted to the capital. There are a lack of studies concerning other cities in Kurdistan Region especially Erbil city. Most of the information about household water use is reported within figures for total annual water consumption.

### • **Aims**

The aim of this project is to understand current household water use behaviour and water use patterns in Erbil city, to improve the efficiency of household water use, to encourage sustainable use and conservation of water resources.

### • **Objectives**

The top level objectives of this study were:

1. To investigate household water use behaviour and water appliance characteristics
2. Explore personal water usage habits which include appliance use frequency and the duration of each uses e.g. shower use frequency, duration of each shower Water appliance characteristics
3. To examine to what extent the social behavior of people using water influence on the overall water consumption.
4. To analyze any water-saving potential for the residential sector.

### I. INTRODUCTION

Water plays an essential and important role in social and economical development all over the world. Water is a gift from God to all creatures on our planet and its conservation is a responsibility for all civilized human beings. The combination of climate change, population growth, and limited environmental awareness effectively limits water resource management in Kurdistan region. In addition, the destruction of vital infrastructure, as a consequence of conflict, and a lack of capital investments have resulted in the deprivation of many people from access to potable water and basic sanitation facilities. Rationalization in water usage in Erbil city is facing different problems or obstacles:

- The climate of Erbil city is Mediterranean, with rainy and cold winter and dry and hot summer, which classified as semi assured rainfall area (350-500mm) [2].
- Erbil city is landlocked and has no river and mostly dependent on underground water which had been collected from thousands of years.
- The dramatic increase of population (either for natural growth of population or due to immigration from other Iraqi cities).
- Irrational and illegal use of underground water in residential, commercial, agricultural and industrial sectors.

According to [1] Statistical indicate that total number of exploited wells was about 4310 wells Erbil city only which

constitute 22,20% of the whole number of wells in Kurdistan region. 2,370 of them were used for drinking (55%), 85 wells used in agriculture, and the rest were exploited for industrial, and agricultural extension and research purposes. These factors influenced on decrease the level of underground water from (75m) depth of well to (350m) within 3 decades in Zanco district [1].

Kurdistan region has two main water reservoirs, the first one begins from Zakho till Sulaimania with average width of 70 kilometers. The second reservoirs also start from Zakho (Syrian boundary in Mosul city) and ending at Kirkuk, the depth of wells ranging between 5-70 meters. These reservoirs supply with water via rain water with an average of (1200mm) annually According to 2012 UNICEF report, 91 percent of the population has access to potable water with significant differences among governorates and between urban and rural areas. For example, in rural areas, only 77 percent of the population has access to improved drinking water sources compared to 98 percent in urban areas.

Although Kurdistan region in Iraq has four domestic small rivers, but it was recently used for domestic water supply and most of the remained water is used for agriculture or it feeds Tigris River "Table I". [2].

those projects. The Sustainable Home Code proposed considers of three group levels of water consumption as a mean of controlling and maintaining water sustainability in cities (the calculations depends on Home Code Water Calculator) "Table II". [3]

Maximum water consumption (litres/person/day)	Mandatory levels
120	Levels 1 and 2
110	
105	Levels 3 and 4
90	
80	Levels 5 and 6

Table II Maximum water consumption by Home Code of Water Sustainability /UK.

Water use standards for domestic use vary according to the climatic conditions, life style, culture, technology and economy [4]. There is no fixed data to estimate the amount of water needed to maintain acceptable of minimum living standard [5]. A water use standard identified about thirty years ago. In 1977, the United Nations determined the concept of a water use standard to meet people's basic need for water.

... All people, whatever their stage of development and their social and economic conditions, have the right to have access to drinking water in quantities and of a quality equal to their basic needs. [6]

This concept developed further by the united nation 1997 as, ... It is essential for water planning to secure basic human and environmental needs for water... develop sustainable water strategies that address basic human needs, as well as the preservation of ecosystem. [6]

The new concept is more towards the environment and sustainable development. Water comes from the natural environment, so the usage of water needs planning to make sure that there is enough for current needs without damaging the environment and compromise the need for the future generation. Study by Glerick estimated the basic water requirement at 50 l/p/c/d for meeting four household basic needs: drinking, sanitation, bathing and cooking [7]. Higher standards of living are changing water demand patterns. This reflected mainly in increased domestic water use, especially for personal hygiene [8]. Most European countries have indoor toilets, showers and baths for daily use. Most of urban water consumption is for domestic use. "Fig.1". shows the patterns of water use by households in UK and Canada.



Figure 1 Household water consumption patterns in UK and Canada

NUMBER OF HOUSE	PERIOD OF WASTING WATER	AMOUNT OF WATER WASTE L/MIN	AMOUNT OF WATER WASTED/D AY/L/DAY	AMOUNT OF WATER WASTED/ MONTH L/M	AMOUNT OF WATER WASTED/Y EAR/L/YEAR
1000	180 min	1	180 000	5400 000	64 800 000

Table I the amount of water wasted in different way in domestic areas in Erbil city

## I. LITERATURE REVIEW

### 1. Domestic water and water consumption :

Water is the most precious mater to keep all human and creatures on our planet alive; in addition of using water as a medium for many kinds of industry. Human begins are the main water consumers directly or indirectly for different domestic proposes. The source of domestic water is from underground water which had been depleting unless it should have aided by some other sources as surface water (rivers or channels). Nowadays this amount of water used in Erbil city and is about (%12.5) of the whole water consumed in the domestic non domestic water systems. It is a fact that the hygienic water must be of a (7.8ph<sup>1</sup>) which is up to standards [14].

The amount of water is enough in Erbil for domestic purposes because we miss all projects, industrial, agriculture, and economic... etc. That cause our water sources previously and now being far from contaminations, which may be caused by

<sup>1</sup> The pH of water is a measure of its acidity,

Some typical water consumption figures for „traditional“ domestic appliances in Europe are shown in “Table II”.

Appliances	UK	Finland	France	Germany
Toilet	9.5 l flush	6 l flush	9 l flush	9 l flush
Washing machine	30 l cycle	74-117 l cycle	75 l cycle	72-90 l cycle
Dishwasher	35 l cycle	25 l cycle	24 l cycle	27-47 l cycle
Shower	35 l shower	60 l shower	16 l shower	30-50 l shower
Bath	80 l bath	150-200 l bath	100 l bath	120-150 l bath

Table III. THE average appliance consumption in UK, Finland, France and Germany  
Source: [10]

## II. METHODOLOGY

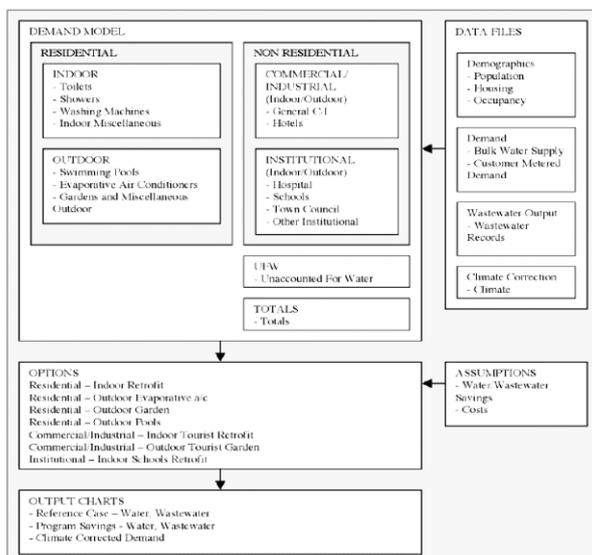
### • Primary data

The present research carried out in Erbil city – Kurdistan region Iraq. The primary data collected in three ways: A survey questionnaire (Paper-pencil-questionnaire) designed to gather required information on household’s perception and behaviour on water use.

- **End Use Analysis (EUA)** is one of a number of techniques that can assist water utilities to understand the demand for water, and water consumption within deferent sectors. It focuses on the factors and technologies that affect water use, including “emerging trends, so historical patterns are less relevant” [11]

A typical urban community normally disaggregated into residential, commercial/industrial and institutional customers. The residential sector is further disaggregated into single and multi residential customers and into specific end uses such as toilets, showers, baths and washing machines for the indoor component (going to sewer) and garden irrigation and car washing for the outdoor component. By disaggregation of water, use in this way could a detailed understanding of water demand for each end use. The typical end use model is shown in “Fig.2” [11].

Figure 2 Typical End use model



Household water use defined as that within a house and surrounding area within the residential property boundary. Normally residential end-use divided into two components: indoor use and outdoor use. Different regions will have different end use. For example, in Erbil, washing garage, street, cars, and garden irrigation with lawn watering could be significant outdoor end uses. However, the main indoor end uses of Erbil household is classified as flowing: “Table IV ”

Indoor end use of Erbil city Column 1		Outdoor end use of Erbil city. column2	
1	Bathroom Shower Basin Taps	1	Washing garage
2	Toilet Cistern	2	Washing street
3	Kitchen Sink taps Dish washing machine	3	Cars washing
4	Laundry Washing Machine	4	Irrigation
		5	other social habits

Table IV indoor and outdoor end use in Erbil City  
Source: by Author

Questions were divided into four sections asking the respondents about their water usage depend on the division collected by the (EUA). The sections were questionnaire (See appendix A);

- Face to face, question; the face-to-face survey consisted of 10 questions, which were also divided by different water use purposes. Most of questions were closed questions. The age, family income, different districts and type of house were also set up and reflected the different groups of households.
- Habits of water drinking and individual water-use patterns: part one includes questions were asked of households about the types of water- using appliances. Questions of part two referred to household water using behaviour. These questions divided into different household water using purposes, which included shower, washing clothes and washing up which divide into indoor and outdoor consumption.
- Social habits; which contains questions that become part of Kurdish house habitats and has a major influence on usage of the water.

About forty questions were closed questions because closed questions are more specific than open ones, and could detect differences among respondents more accurately. Some questions asked respondents what kind of water appliances used at home. Closed questions and picture options provided which could be easy for the respondent to answer. The research used SPSS statistics program to analysis the questionnaires and to get results. The respondents were random architecture students from architecture department at Salahaddin University in Erbil city. The researched focused

on students from fourth and fifth stages as they have more knowledge about their way of consumption on their residence.

### III. RESULTS AND DISCUSSION

#### A. Habits of Indoor water use

The water use pattern in Erbil city is slightly different from one are to another, a small percentage of total water is used for drinking, cooking and kitchen which is only 32 l/c/w while large volumes of water are used for bathing either from bath or shower “Table V”.

Habits of water consume per capita per week l/c/w				
Drinking/ cooking	Kitchen sink	shower	bath	Toilet and cleaning
32	26.7	220	825	190

Table V. Habits of water consumption

The results show that most households were using high flow rate showerheads (65%) only (35%) of households used bath. The habits in the shower, almost half of the respondents spent between 20-30 min in the shower, while over one-third spent between 45-60 min especially during the summer season. The remainder claimed to spend more than 10 min under the shower. One of the usual ways of wasting water in the shower is to let the water flow until it reaches a comfortable temperature (specially for winter season) or flow continuously during the whole period of shower. There are further water and energy savings made by reducing the average shower duration to 5 minutes or less. This could potentially save up water consumption per person, which equates to 7% of overall usage, which reduce the overall water consumption in Erbil city by 16%.

However, a small number (12%) of respondents admitted to taking a bath on a daily basis while nearly 56% take showers every 2 days in week. The findings also indicate a large percent of household water used for flushing toilet, personal hygiene uses, and washing clothes with dishwashing “Table V I”.

Habits of water consume for domestic			
Flushing toilets	Dishwashing by hand	Dish washing Machine	clothes washing machine
190	350	70	160
l/p/w	l/wash/week	l/wash/week	l/wash/week

Table VI Habits of water consume for domestic use

Most of the surveyed did not have a dishwasher, while observe that 70 % of those who did used it on one time a day or on a weekly basis. In any case, most of the surveyed said that they washed the dishes by hand on a daily basis three times during a day at least. Average 10.5 liters of water used per person, each day. When washing the normal amount of dishes by

hand, whereas according to the quality of available dishwashers in Erbil, dishwashers use only 2.27 liters of water to wash the same amount of dishes (per person, per day) and would require less energy to heat up the smaller amount of water.

The research also found that the volume of water consumption per person decreases with increasing household size. Per capita volume of water consumption in a one-person household is nearly twice that used in a six people household. “Fig. 3” shows that the amount of the water used for hygiene purposes grows slightly with increase household size. However, other types of water use by households are decrease with increased household size.

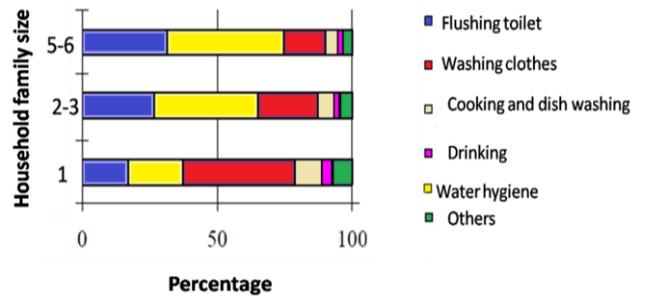


Figure 3 Household water consumption according to different family size (%)

The questionnaire intends to investigate to what extent participants’ awareness of the waste in water through the appliances. Regarding on the question number (9) and (10) which intends to ask the student about their knowledge on their house taps leak “Fig. 4” and “Fig. 5”. The results indicate that more than half percent of the participant 63%, 56% respectively do not know whether there is leak or not. Although 14%, 28% say that yes they are aware about the leak, only 30% of the total household will receive prompt maintenance when they needed.

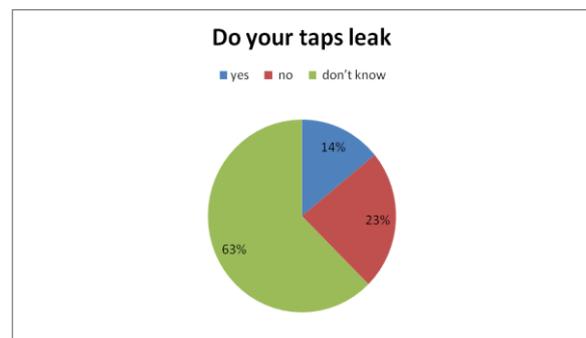


Figure 4 Question No.9 Do your taps leak.

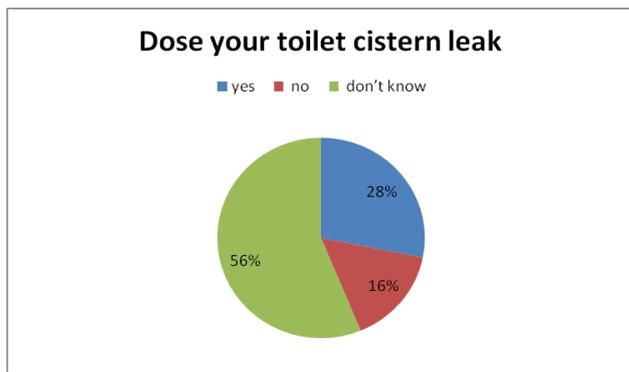


Figure 5 Question NO.10 Dose your toilets cistern leak

According to the study and survey by [12] the quantity of the water leaks showed a statistically significant relationship between the price of the water and the price of the sewer. Results imply that 1% increase of the water price will lead to decrease the amount of the water leaks by 0.49%. While 1% of increase of the price of the sewer will lead to decrease by 0.12% of total amount the water leaks. These findings seem to verify that higher prices lead to some degree of leak detection and correction. With regard to correcting leaks, renters as group had a lower amount of leakage than non-renters. This may confirm the expectation that property owners seek to minimizing costs. Moreover, people that have moved recently to the house suffer less leak in compare with those been there for more than 10 years.

Furthermore, 70% of student show their willing and interested in participating in water conservation activities in their house through reading the water meter regularly or maintained of the appliances. While about 22% of them did not and only 11% of students were neutral “Fig.6 “.

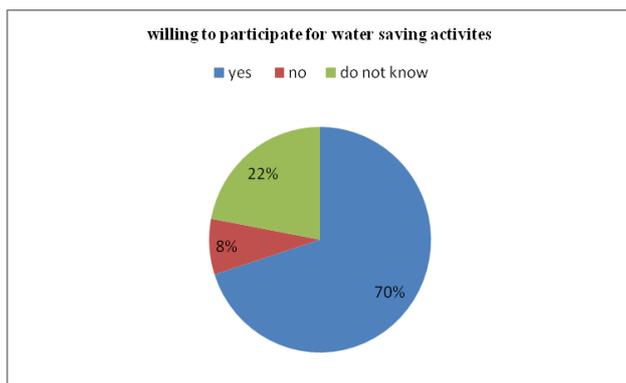


Figure 6 Student willingness to participate on the warter conservations activity

### B. Social habits of water end use

Social habits related to the habits of using water by people of Erbil city. These habits have influence on increasing the water consumption. While outdoor water use varies between households and from one society to another, it can account for about most of the household water use especially during summer. ‘Outdoor use’ includes uses such as irrigation, car washing, topping up swimming pools, and cleaning (such as washing front and back yard or even washing the street

walk way; however, garden irrigation is the main outdoor use [13]. The results were as “Fig.7 “and “Fig.7 “.

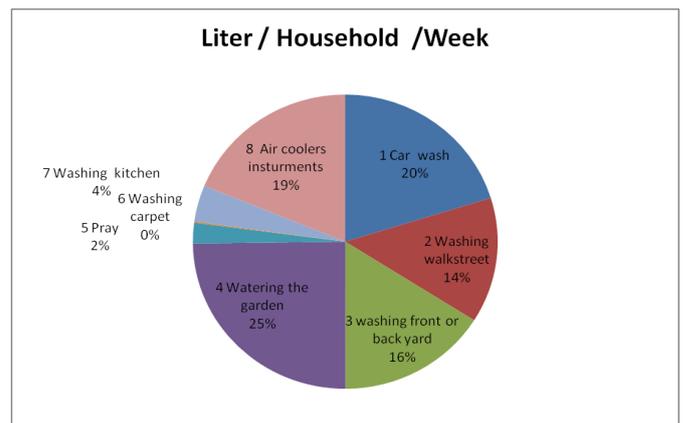


Figure 7 The percentages of the water consumption for social habits per capita per week.

Irrigation tend to be largest component of scheme water use for the avarage Erbil household accounting of 25 % of all reseditional water consumption. Watering gardens consume nearly 680 l/h/w which is use for watering lawans and plants and gardens dayliiy due to hot conditions environemt. 50% of this water is wasted due to evapotion.

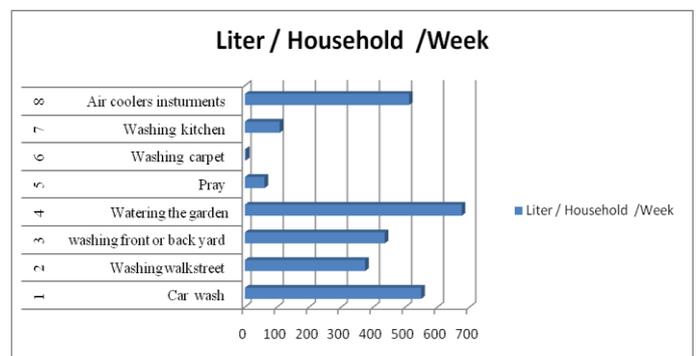


Figure 8 water consumption for social habits per capita per week.

Car wash has also indicated a significant amount of water consumption with result of 20%. The same issue with washing carpet though it consumes less water as it washes annually with nearly 4 l/p/w. Washing car at home not only consume large amount of water 550 l/p/w, but also concern on Water pollution. This pollution can end up in groundwater, lakes, rivers, and streams and hurt the wildlife found there. There is potential of saving water while washing car on grass so water soaks into the ground.

The third large outdoor water consuming is through air cooler instrument (512 l/p/w). Water use in evaporative systems is mainly controlled by user behaviour, with the duration of (8 hours in summer season) being the most significant factor. Maintenance and configuration also influence efficiency.

There is some potential to reduce water use in evaporative air conditioners through a combination of education and

promotion of water efficient evaporative air conditioning systems.

Increasing the penetration of refrigerated air conditioners is not advocated due to the adverse broader sustainability impacts, including higher energy use.

Washing front or back yard of the house has another impact on consume large amount of water by daily family use which consume nearly 450 l/h/w along with water waste through washing kitchen (110 l/h/w). Not only that but also washing walk way street is one of outdoor activities for using water by households. The results also indicate that Walk way washing can consume up to 14% of household the total water consumption by households in Erbil city.

#### IV. CONCLUSION

The current water crisis in Erbil city is not just a crisis of low source of water supply to the city or low underground water and climate change, but also a cultural and socio technical crisis where technologies, natures and cultures are all in flux. Collectively, households still have the greatest potential to make a significant contribution to reducing water use, as they are by far are the highest users of water.

The Water Corporation is also looking at ways to further improve the efficiency of business water use and reduce system leakage (non-revenue water).

- a. Recommendation upon legislations and general enhancement
  - Reduce shower times (saving water as well as energy);
  - Optimize the use of their evaporative air conditioners;
  - Plant gardens that need less water if possible e.g. group plants according to water needs.
  - Initiate legal punishments for illegal use of water infra structures.
- b. Recommendations upon technical improvements:
  1. Identify and fix leaks in and around the home.
  2. The replacement of inefficient water using appliances and fixtures around the home not only reduces consumption of water use but also 'hard wires' these savings in the long term.
  3. Areas which have the most potential include:
    - use of tap flow control valves or aerators (particularly in bathrooms);
    - Promotion of water efficient washing machines.
- c. Recommendations upon social and individual awareness:
  - Use programs to enhance water efficiency will aim to provide a suite of initiatives that promote a combination of behavioral change and continued uptake of water efficient appliances and fixtures.
  - According to a Greener Choices report, the most efficient water saving dishwasher per cycle uses 11.3 liters (3 gallons) of water and is better to use the machine with full capacity.
  - Use of arm or pedal type to control hand washing basins water flow or use of laser controlled taps instead if possible.
  - Use of municipal smart assumption metering system.
  - Use of new pricing, system increasing price on the increase of water consumption.
  - Use of new technical irrigation system, drip type or spray controlled system with time monitoring system.
  - Reuse of wastewater, rainwater harvesting for housing gardens.
  - Rehabilitation of traditional water-management systems.
  - Use of Ultra -low-flow- toilet (ULFT) to minimize water consumption per flush.
  - Use of small showerheads to reduce water consumption.
  - Implement clothes washing machines instead of using hand wash clothes to decrease water consumption.
- Implement Public Medias to declare the strategic importance of water on a national level.
- Water awareness and importance for all generations starting from kindergartens, schools and universities
- Conducting seminars and workshops to declare the importance water consumption strategies.
- Conducting researches by universities and research centers about water issues as; hydrological investigations, water qualitative and quantitative assessment, water management etc... considering water sustainability on a national level.

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(Appendix A )

Questionnaire on Water use and habits for domestic use

**QUESTIONNAIRE ON WATER USE AND HABITS FOR DOMISTIC USE**

Dear Customer,

Good day! this is a questionnaire for calculating for domestic. Use through this brief survey, your answers will be helpful for this research in order to investigate new sustainable strategies for reducing water consumptions.

Please select one best answer for each question. Two more choice is regarded proper only for questions we specially marked out.

Questionnaire for water consumption habits

**Individual Information.**

1. Gender: (1) Male (2) Female.
2. Place of birth: .....
3. Date of birth: .....
4. Home address: ..... Room ..... Building ..... Road ..... Lane .....
5. How long have you lived in this place? ..... years.
6. Education: (1) middle school or below (2) high school (3) college/university (4) above university.
7. Current occupation : .....
8. Size of your family .....

**What type of building it?**

- [1] High rise (higher than 7 with elevator) [2] Multi-story housing (less than 7)  
[3] Courtyard or two story housing [4] Infill housing (less than 7 stories) [9] other : Specify  
.....

I.Habits of drinkoing water							
1	what kind of water do you usually take at home ?	tap water	barreled water	bottled water	filtrated water		
2	what kind of water do you usually take at work ?	tap water	barreled water	bottled water	filtrated water		
3	in in spring / autumn ,how much water do you drink on average day?	2 cup	3 cup	4 cup	5 cup		( ____ ml/cup)
4	in summer ,how much water do you drink on average day?	5 cup	7 cup	8 cup	9 cup		( ____ ml/cup)
5	in winter ,how much water do you drink on average day?	1 cup	2 cup	3 cup	4 cup		( ____ ml/cup)
II.Habits of indoor water use							
1	Your usual way of washing yourself is ?	shower	bath	rubbing with towel			
2	In spring/autumn,your frequency of shower is	once every day	once every 2 day	once every 23-4days	once every 5-7days		longer
2.1	Time length of each shower	in 10 min	20 min	30 min	45 min	60 min	>60 min
3	in summer,your frequency of shower is	more than once every day	once every day	once every 3 day			longer
3.1	Time length of each shower	10 min	20 min	30 min	45 min	60 min	>60 min
4	IN WINTER,YOUR FREQUENCY OF shower	Once every day	once every 2 day	once every 3-4 day	once every 5-7days		longer
4.1	Time length of each shower	10 min	20 min	30 min	45 min	60 min	>60 min
5	do you bath in bathtub	yes	no	sometimes			(if no,please go to q6)
5.1	season of bath :	spring	summer	autumn	winter		{you may choose one more choice}
5.2	Frequency of bath :	daily	once every 2-4 day	once every 5-7days	longer		
5.3	Time length of each bath:	15 min	20 min	30 min	45 min	60 min	>60 min
6	How many time you wash your face and hand	1	3	5	7		
6	time you spent to wash your face and hand	1 min	2 min	5min			>5min
III.Other Habits							
1	do you wash dishes at home ?	yes	no	sometimes			( if no .please go to q2)
2	Frequency of washing:	once every day	once every 2 day	once every 3-5 day	once every 5-7days		
3	Time length of each shower :	10 min	20 min	30 min	45 min	60 min	>60 min
4	How do you wash your dishes:	Hands	washing machine				
5	do you wash clothes by	Hands	washing machine				
6	how many times do you wash clothes						
7	how many taps are there in the household	one	two	three	four	fiveand more	other:specify
8	does your toilet cistern leak ?	yes	no	do not know			
9	do you taps leak	yes	no	do not know			
10	Are willing to participate in the water saving activity	yes	no	do not know			
11	do you taps usually have brown water running out?	yes	no	do not know			
12	do you receive prompt maintenace whenever it is needed	yes	no	other:specify ____			
13	How often is the water meter read ?	once a month	twice a month	other:specify ____			
14	How much of water does your household use each month?						( in cubic meters )
IIII.Social Habits							
1	How many time you washing your car in a week	once every day	once every 2 day	once every 3-5day	once every 6-7days		other : specify ____
2	Time length of each wash :(1) (2) - 30 min (3) >30 min	10 min	30 min	>30 min			other : specify ____
3	How many time your family washing yard	once every day	once every 2 day	once every 3-5day	once every 6-7days		other : specify ____
4	Time length of each wash	10 min	30 min	>30 min			other : specify ____
5	How many time your Fmily washing walkstreet	once every days	once every 2 days	once every 3-5days	once every 6-7 days		other : specify ____
6	Time length of each wash	10 min	30 min	>30 min			other : specify ____
7	How MANY TIME YOUR FAMILY WATER THE GARDEN	once every days	once every 2 days	once every 3-5 days	once every 6-7days		other : specify ____
8	Time length of garden water	10 min	30 min	>30 min			other : specify ____
9	do you pray	yes	no				
10	How many carpet do you was manually						
11	do you wash you kitchen	yes	no				
12	How many water air coolers insturments do you have ?	1	2	3	4		
13	what are the capacity of your water air cooler	1500cfm	2500cfm	3500cfm	4500cfm		cfm=cube feet per minute