Investigation of Water Consumption   Pattern in Students Hostels

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Abstract

    To investigated the per capita demand and water consumption pattern using Ardino acquisition system and flow meter sensor. The water flow sensors were installed in the outlet pipe from water storage tank to hostel. The Ardino flow meter records the water flow for every moment. Also the student attendance on daily basis were also recorded each day during the survey period. The survey results were analyzed using Microsoft Excel 2016 and Minitab 18. The study results shows that the per capita consumption varies considerably each day the average per capita consumption was found 99.65 ± 21.79.There was a strong correlation found between the number of student available per day and the total water consumed in LPD having The R2 value was 0.8978.which shows that the students are the major consumer and the other categories of water consumption uses very low amount.

    There was no correlation found between the per capita water consumption in LPD and the maximum and minimum temperature humidity wind speed. There was no effect of humidex found on water consumption per capita LPD.

    The average water consumption pattern per capita per day shows some random peaks in the graph which mean that there is difference in routines of students. They have different class, sleeping, and wake up timing. The two major peaks observed one in morning time and one in evening time the water consumption. The morning peak between 08:00 to 09:00. While the evening peak starts from 13:00 to 14:00.the morning peak is higher than evening peak but the evening peak is broader than morning peak.

    Three types of peaking factors were calculated from the study data which are for 15 minutes, hourly and daily factors. In 15 minutes water consumption interval per capita per day average highest peaking factor found in the morning between 8:45 and 9:00 which was 3.0 and in average hourly peaking factor the highest peak factor found between 13:00 and 15:00 which was 2.4.while in average week days water consumption per capita per day the average consumption was high on the Saturday having peak factor of 1.15.

Keywords: Student hostel, water consumption pattern, per capita demand, Arduino flow meter, peaking factors.

I. Introduction

The order less, colorless and tasteless liquid known as water.it is necessary for all sorts of growth development of human kind, plants and animals.as an elementary need for human we cannot create it but preserve it, water plays an important role in development and prosperity of any country in the world [I].

Clean water is not abundant in nature. Although our planet 2/3 part is covered with water. The amount of water available for use on the earth is limited.in the available water, the 97% is saltish water (sea water). And in the remaining 3 percent is potable in which 2 percent of which is frozen in glaciers and polar ice caps, and the only 1 percent as serviceable water [III]. For human development fresh water scarcity is now a global challenge. Insufficient freshwater supply, Human interference, and unsuitable managing leads to more pollutant load of water. Thus, growing water demand for human consumption and agricultural production the recycle of municipal wastewater is becoming a critical matter [II].
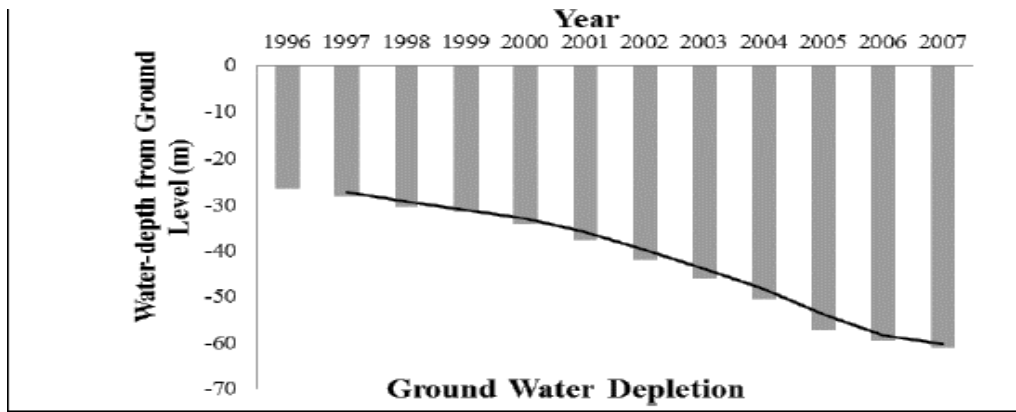

Figure1.Ground water depletion in Dhaka city [IV]

In Figure1 shows the ground water table going down rapidly every year. In 1996 in Dhaka city ground water was 25 meter below ground level. And in 2007 it reaches to 60 m. In a matter of about 11 years it gone twice .

Ia. Fresh water scarcity condition in Pakistan

Pakistan, earlier a water surplus country, is now considered as a water scarce country. Pakistan's gross water demand for non-irrigation purposes was estimated at about 8.5 billion m3 in 2007, which is expected to rise up to 11.2 billion m^3 in year 2025, with the growing rate of 1.5 % per [V] Pakistan has been always blessed in having rich fresh water reserves, however the growing population and overexploitation of surface and ground water over the past few decades has caused in water scarcity in many areas of the country. Per capita water availability in Pakistan has decreased from 5,000 m^3 (cubic meter) in 1951 to 1038 m^3 cubic meter per year in 2010 as shown in Figure2. Which is slightly above the internationally standard scarcity level of 1000 m^3 [VI].
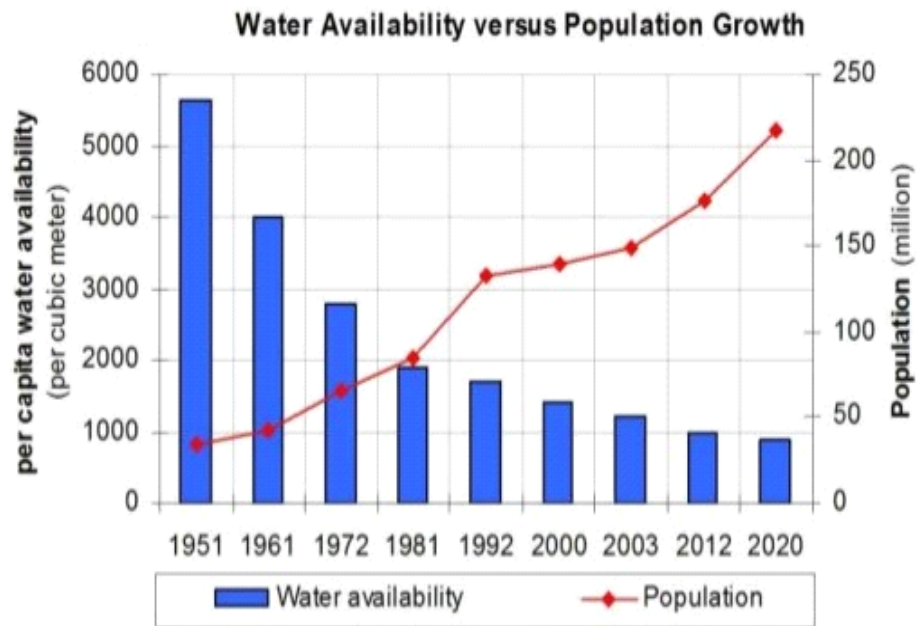
Figure2: Water availability VS population growth in Pakistan [VII]

According to the water stress index, when a country having fresh water per person per year less than 1000 m³then the country will be considered a water deficient country; and if the fresh water availability is under 500 m³, the country is in absolutely water scarce country. It is stated that presently almost 1.2 billion people in the world having no access to quality drinking water and this figure will increase to 2.7 to 3.5 billion people by the year 2025 if no effective steps are taken to diminish the water insufficiency problem [VII].

Ib. Global freshwater vulnerability

Freshwater resources scarcity has becoming one of the major Challenge in the whole world. This has caused from many interconnected issues such as the rapidly growing population, and worldwide climate change. The growth in global population in a matter of five decades has augmented from 3 to 7 billion. The rainfall is inadequate to meet the mounting requirements of water. Additionally, it is predicted that the constant increase in water demand will lead to a severe scarcity of water in the future [VIII].

It is predicted that the world 67% population by the year 2025, will face moderate to high water stress and half of them will be facing their water supply limitations. The increase in population is putting much pressure on the water resources in Arab countries reported that in Arab countries are consuming 100 percent of their renewable water source already as shown in Table 1.

Table 1: Water stress in different Arabs countries [IX]

Level of Water Stress (m^3/Capita)	Stress Level
1700-3000	Iraq
1000-1700	Mild Water Stress Situation Syria
500-1000	Severe Water Shortage
200-500	Critical Water Shortage
<200	Acute Shortage

Supplying water to the world's population between now and 2030 from an absolutely finite supply is recognized as a clear and major challenge. Because of the fact of availability of only one percent water which is accessible to use for humans are poorly managed. While the rapidly growing population is a main issue causing water scarcity, the global climate change, the living standards are improving, urbanization and supply variability due to also enhance pressure on water deficiency in many parts of the world [X].

Table 2: Per capita water availability in different Countries [X]

Country	Water Per Capita (Cubic meters)
Canada	98,462
Barazil	98,462
Russian Federation	42,957
United States	30,599
China	9,413
India	3,440
World	7,176

Ic. Water is a fundamental need of humans

Approximately 1.8 million people in the word died due to contaminated potable water and diarrhea according to WHO report. The use of potable water should be made according to strict policy and varies standards. The main reason for detoriating the quality of water is due to the non-efficiency of managing authorities. Policy also made implemented for the water use efficiency and recycling and developing the concept of water saving technologies [XI].

Everybody, whatever their phase of life style and their social and financial conditions, have the right to have get accessibility to quality and quantity of potable water equal to their basic needs. Residentially water is used for different household purposes, such as bathing washing, flushing toilets drinking, meal preparation, bathing, washing clothes, flushing toilets, and watering lawns and gardens. According to WHO drinking water guidelines define domestic water as being "water used for all usual domestic purposes including consumption, bathing and food preparation" . Domestic Water consumptions depends on different life style climatic condition,

culture and socioeconomic status [XII]. There are three important variables in domestic water consumption that affect the water consumption rate which are Household size, Socio-economic status, Seasonal climatic changes.

Water demand pattern changes with life style. This is revealed residential water use, mostly for individual cleanness. Maximum European countries have indoor toilets, baths and showers for daily use. Maximum amount of water consumed domestically. In Spain 70 percent of total urban water in used in houses, 24 percent in small industries while 6 percent for public services [XIII].

In Figure 3 shows different water consumption percentage for different household purposes chart shows the domestic percentage of water used for different purposes. Most of water consumed in toilet which are 27% Cloth washing 22% showers 17% faucet 16 % bath 2% dishwasher 2% leaks 14% and other 3%.
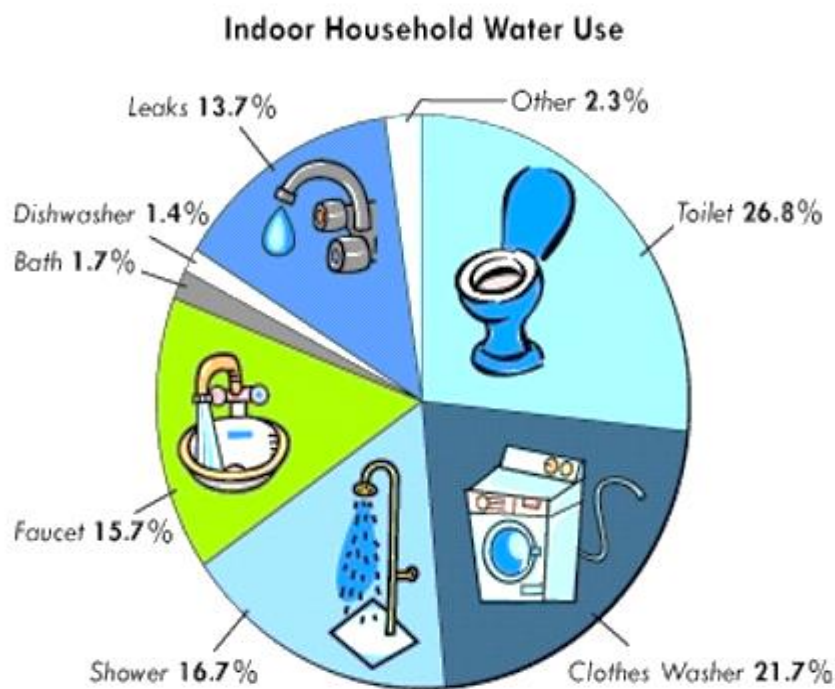

Figure 3:Indoor water consumption [XIII]

Another study performed for a period of three years in United States of Canada about the water consumption and water end use. Survey conducted in 1188 hoseholds.The half of total water consumption was found about 58 % was used for external activities. And the highest consumption in the houses were found in toilet which is about 76.1 LPCD, washing machine 56.8 LPCD, shower 50.3 LPCD, toilet flush tanks 36.3 LPCD [XIV].

i) **Factors influencing consumption pattern**

The consumption of water varies from one region to another region due to, culture, climate, individual demands, economy, occupant appliance characteristics and attributes. [V]. the water consumption per capita is influenced by number of factors such as income, water price, household characteristics, and housing internal appliances and rainfall [X]. Another study states that the community water consumption is dependent on number of variables such as climate weather. Local customs and cultural habits [VII].

A research determined that both average summer temperatures and income had a major impact on Chicago's water demand [VI]. In Swaziland a study also established that domestic water demand depends on factors such as household size, income and distance from residence to water sources [XI].

ii) **Size of households**

The households in Swaziland family size of five or less collect small amount of water (0-100 liters/day) while bigger households having number of greater than five are likely to collect water of more than 100 liters per day. The size of a household therefore influences the quantity of water it consumes [VIII].

In England Anglian water survey found that the water consumption per capita decreases with the increase in house hold size. A single person household per capita water consumption was 40 % more than the household of two persons and 73 % more water consumption found in household having 4 person than a household of 5 persons. Hence in United Kingdom the increase in house hold size decrease the water consumption in LPCD [II].

iii) **Frequency of water supply**

The consumption pattern is influenced by the frequency of supply. According to a research in various income group consumption is depend on flow condition the consumer use high amount of water when the flow is continuous and while the intermittent supply consumer use less amount of [I].

Furthermore, a study by indicated that residential water use depends on suitability of water supply, and concluded that with even enough pressure and short duration of water supply than with less pressure long duration can gratify the user demand [VIII].

iv) **Income levels**

The income of a people in particular and a country in general influences how water is consumed. According to UNESCO, industrial use of water is directly relation with country income, in low in middle countries income uses 10 % of water while high countries income consume 59 % of water of the available water resources[IX].

A research done in India revealed that the water demand in different cities of India varies with socio-economic status [VI]. According to [VIII] the per capita water consumption in Kumasi ranges between 177 LPCD for high income households to 70 LPCD For low income households under continuous water supply.

In Figure4 shows that there is significant correlation between the house hold income and the per capita consumption.as the income of householder increase the per capita of water demand also increase .
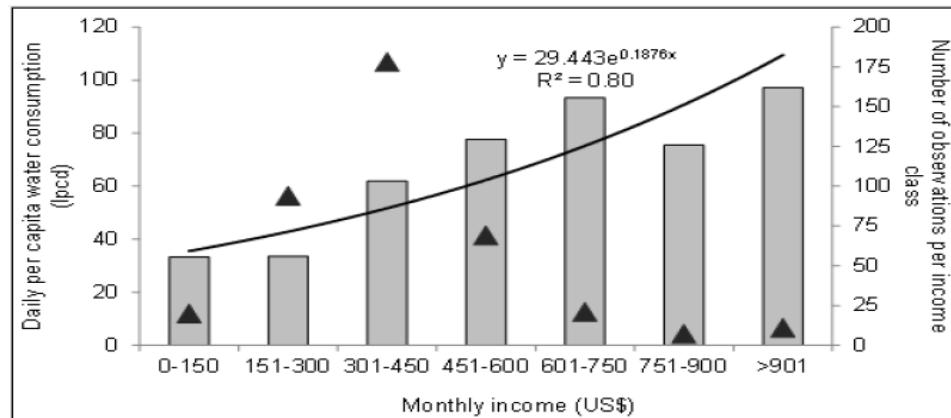
Figure 4:Per capita water consumption among various income groups [IX].

v)   **Network pressure**

The pressure levels in pipelines greatly influence the water consumption pattern. High pressures in pipelines are accompanied by high consumption. According to [XIII] usually, in water supply network in which the pipe either or nearly to fill the cross-sectional area but don't have sufficient pressure to push out the pipe to user. [XII] Mentions that the hydraulic pressure experiencing by the end zone in water supply network may start off but drops rapidly. Hence, those user which are closest to the main supply source receiving sufficient amount of water than those of located away.

vi)   **Climatic change**

The change in climate can cause the decrease in rain fall and increase the drought condition. In this condition increase the water demand for domestic purpose as well as for irrigation purposes and industrial purposes. During the climate change the high temperature may also worsen the water quality as the water temperature increase they increase the internal bio chemical operation and deplete the dissolved oxygen level in water [V].

Similar to maximum metropolitan regions, Portland's water intake shows seasonal patterns Figure 3 During the cooler, wet duration from November to April, monthly average water intake is normal and in the month of February lowest consumption occur. In the month of (May to October) throughout the dry heat month the consumption of water is much high. Peak average water consumption occurs in the month of July which is 66 percent more than the average water consumption in February. The total average water consumption from June to September is about 41% of the total yearly consumption [VIII]. Another research estimated that by year 2040, the demand of Portland water increases 8 % in hot weather and the rivers of the region will experience shortage in flow. Weather-prompted water intake is projected to growth by 8 % in summer season primarily based on average month-to-month variation in precipitation and temperature.
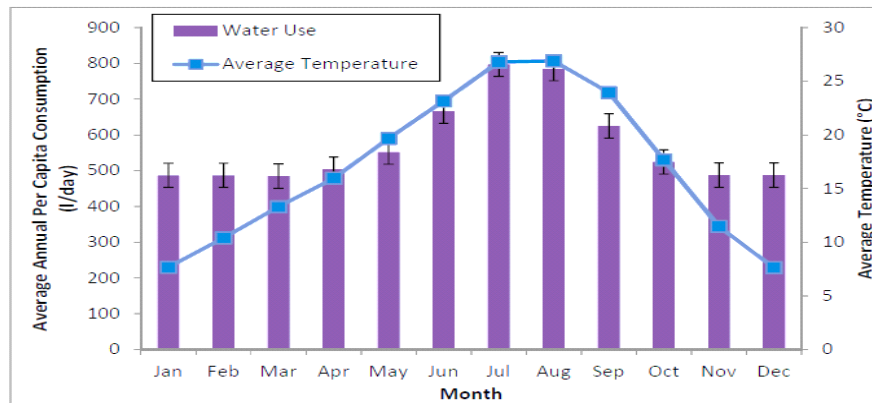
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Figure 5 Portland, distribution of average monthly water consumption per day and average maximum temperature (°C) [IV].

vii)   **Presence of water meters**

The presence of water meters helps in regulating the water consumed by consumers.in a study in United Kingdom on household technology and the domestic demand for water established that not only will the level of consumption be lowered by metering, but its subsequent growth rate will also decrease [IV].

II.   Water Consumption and Demand Studies

Work reported in Dhaka city on daily water consumption a questionnaire was administrated and special type of bucket used for water for different purposes in houses the research shows water consumption in middle class families is 200-300 liters per capita per day [V]. WHO recommends 50–100 l of water per capita per day (LCPD) to meet domestic needs such as personal hygiene, washing and cleaning [VI]. According to [VIII] work done in India with mix methods approach combining limited metered data storage container inventories, and structured observations they developed a typology of household water access according to infrastructure conditions based on the presence of an overhead storage tank and a shared tap. They used the water use calculations at household level and in the distribution system. Very few households used 135 L/person/ day and most of them water consumption is below 135 liters/capita/day.

A study conducted in Toowoomba ten house was selected having water high resolution water meter and data loggers to the main water supply pipe inlet to the houses. For a period of 138 days the water supply data were calculated for every 10 seconds interval. The average water consumption was found 112 LPCD (liter per capita per day) in the selected houses ,another763 household's questionnaires and interview based surveys observed the households daily and activity wise water consumption, source, quality frequency and duration of water supply. The volumes of container in which householder used to store the water were measured .and also the running tapes for different purposes and duration of tap opened and measured the per minute flow of tap opened were observed in the study revealed that the per capita

daily consumption of the study area was found average 117.0. And for low income families it was 97 LPCD.

Study performed in low income 27 single families located in Paulina, Brazil to find the water consumption pattern. The study was questionnaire and interview based and observing the operational condition of water appliances or fixtures.it was revealed that the water consumption per month varying from 3 to 25 cubic meter, while consumption per person also varied from 46 to 309 LPCD. The average per capita consumption per day and monthly consumption were 113 LPCD and 12 m^3 respectively .

To examine the water consumption pattern in buildings is major information for water supply system designing of water supply system. The study performed in Florianopolis, Southern Brazil in low income houses in the region to evaluate the water consumption pattern. The interview based data collection was performed from house holders and also measuring the existing appliances and fixtures flow rate. The outcomes of the study shows the highest amount of water consumed by shower in house which is about 30%-36% of the average water consumption. The toilet consume 18%-20%.the total average consumption of the house holder was 111 to 152 LPCD depending on their incomes [X].

Huge portion of population in the society (in both urban and rural areas) spends their valuable time in collecting water for their regular needs. Hence, the water consumption pattern information of a population is necessary in order to assess the best planning of the current water resources. Such type of surveys adopts importance in executing of a broad water policy for the rural areas which will fulfill the rising needs of the population. A series of viable water managing practices and principles can be introduced to guarantee the secure supply of urban water.

III.   Methodology

In this study the University of Engineering Technology of Peshawar hostel #8 (Mehmood Ghaznavi Hostel) was selected to obtain the water consumption pattern and per capita demands of students. The Mehmood Ghaznavi hostel or hostel #08 is located in university of Peshawar Pakistan.

The selected hostel for the study consist of 108 rooms, cafeteria, TV long, Majid and a broad green lawn. The total residence capacity of the students are 237.and the upper portion of the hostel having 54 rooms and a capacity of 122 students. Schematic diagram of top view of UET hostel # 08, shown in Figure 6.
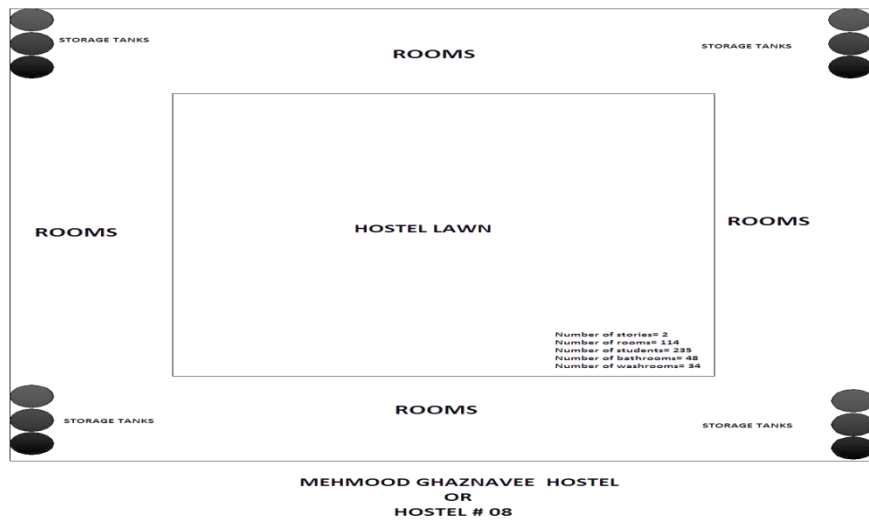
Figure 6: Hostel Rough Plan

IIIa.   Arduino flow meter:

Water meter is consist of Arduino acquisition system and flow meter sensor. The Arduino flow meter working on conversion factor value and the propeller rotation in the flow meter sensor. The conversion factor multiplied with the propeller it will give us the discharge value.

CF = x

Where CF is the conversion factor litres/minutes
r= total rotation of propeller
q= actual flow recorded

 The flow meter sensor shown in Figure 7consist of propeller, when the water flow hit the propeller it starts rotation and pass the signals to the Arduino acquisition system. And then by default Arduino system multiply the number of rotation with conversion factor it gives the flow readings.
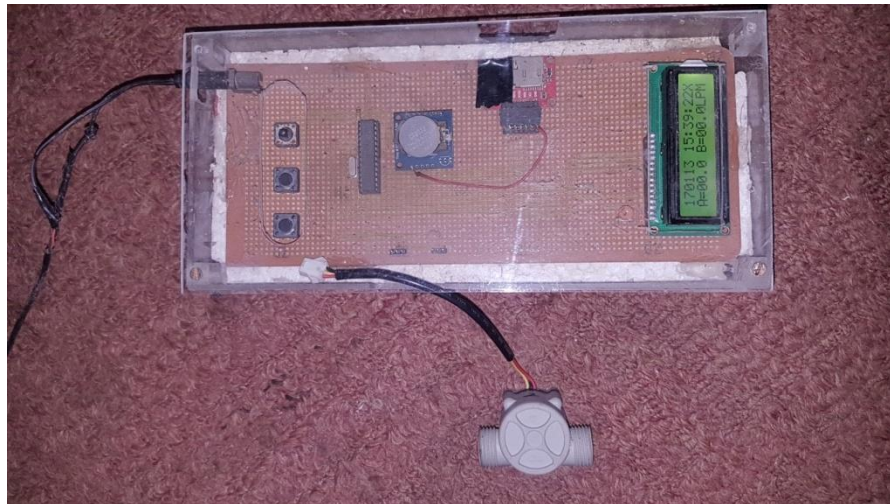
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Figure 7:Arduino flow meter

To collect the water consumption per capita demand and water consumption pattern of student for this purpose water meters were installed in the main outlet of water storage tanks to the upper portion of the hostel. The amount of the amount water using for different purposes such as ablution bathing washing etc. was recorded continuously over a period of 7 weeks.

III.b.   Calibration studies before installation at site

Before installation on at site I performed calibration studies by installing the flow meter in different places shown in Figure 8(a).it was the concluded that the conversion factor changes slightly in but it but the flow result remain the same. As by using Mini tab 18 show the three types of flow rates full flow, half flow and quarter flow as show in Figure 8(b) having no outliers found. The CF value changes slightly in every flow rate but it does not affect the actual flow.
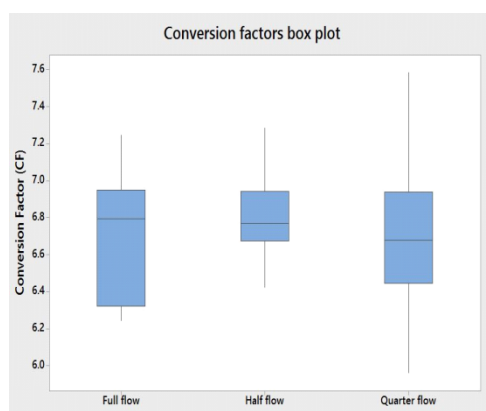

Figure 8(a) (b) Calibration of flow meter and box and whisker plot of CF value

IIIc. Arduino flow meter installation at site

For primary data of water consumption four Arduino flow meter were installed at study site at the main out lets of the storage tank to hostel to collect the accurate water consumption pattern and per capita demand. The flow meter sensor were installed parallel shown in Figure 4.4 in the main supply line from storage tank to hostel to minimize the head loss. It was assumed that the clean water running through the flow meter represents the amount of water consumed. The digital flow meter was accompanied by Arduino data acquisition system which store the flow data in memory card which was removed on daily basis for transferring data to laptop.

Figure 9:Arduino Flow Meter

i) Flow meter calibration at site

The flow meter sensor was installed parallel in main supply from storage tank to hostel to minimize the head loss in supply line. Then I did the calibration of the Arduino flow meter to obtain the accurate reading of water consumption in hostel. I calibrated a water bucket manually with the interval of 3 litres as shown in Figure 10. And then started the calibration of Arduino flow meter.

The bucket was filled frequently from the main water supply line having attached flow meter. By performing the test on different flow rates, I Adjusted the actual value of flow with flow meter calculated flow it by Auto calibration option in the flow meter device it gave a conversion factor value (C.F). The process was repeated several times to minimise the error in flow reading between the actual discharge and the flow meter discharge value.

Figure10:Aurdino Flow Meter Calibration at site

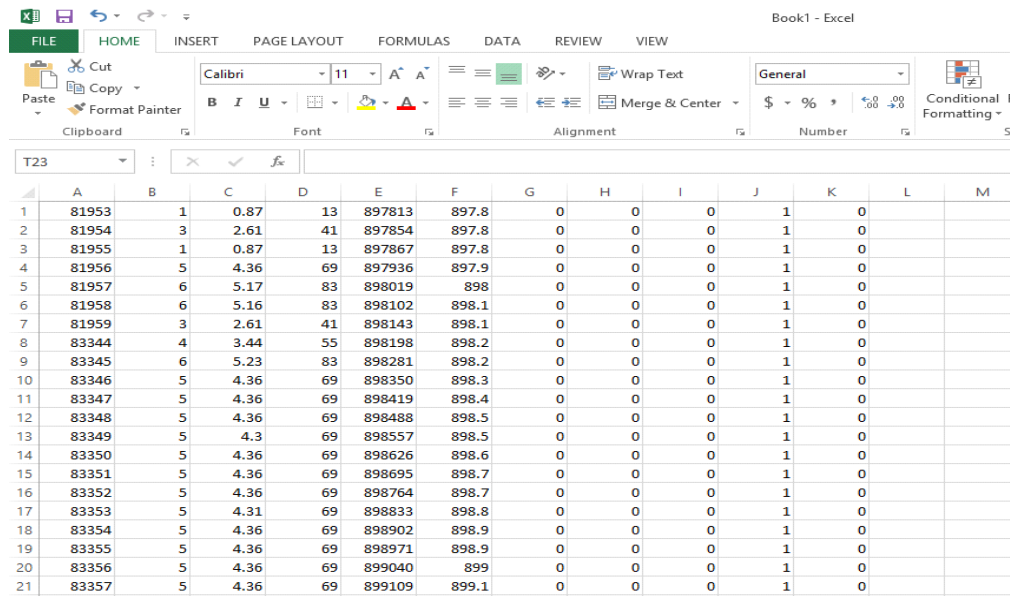### ii) Water consumption data

After installation and calibration of water meter in main outlet of storage tank to hostel. I collected the reading of water supply for 45 days consecutively. The Daily flow data for the previous 24 hours on a daily basis at 7:00 am by removing the memory card and inserting the fresh one in Arduino system.

iii) Data formatting of water consumption from Aurdino flow meter

The Arduino acquisition system provide the data in "text" file format as shown in Figure 11.The first column shows the time data in hours minutes and the 2nd column shows the data of rotation of propeller (Flow sensor) in per second the third column shows the per minute flow in liters. The fourth column shows the reading of flow through pipe in ml/sec. the number fifth column shows the cumulative flow in mille liters while the fifth column shows the total water flow in liters. The same data was imported by simply copy and paste in Microsoft excel 2013 for further analysis as shown in Figure 12.

Figure 11: Water flow data in "text" file

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	81953	1	0.87	13	897813	897.8	0	0	0	1	0		
2	81954	3	2.61	41	897854	897.8	0	0	0	1	0		
3	81955	1	0.87	13	897867	897.8	0	0	0	1	0		
4	81956	5	4.36	69	897936	897.9	0	0	0	1	0		
5	81957	6	5.17	83	898019	898	0	0	0	1	0		
6	81958	6	5.16	83	898102	898.1	0	0	0	1	0		
7	81959	3	2.61	41	898143	898.1	0	0	0	1	0		
8	83344	4	3.44	55	898198	898.2	0	0	0	1	0		
9	83345	6	5.23	83	898281	898.2	0	0	0	1	0		
10	83346	5	4.36	69	898350	898.3	0	0	0	1	0		
11	83347	5	4.36	69	898419	898.4	0	0	0	1	0		
12	83348	5	4.36	69	898488	898.5	0	0	0	1	0		
13	83349	5	4.3	69	898557	898.5	0	0	0	1	0		
14	83350	5	4.36	69	898626	898.6	0	0	0	1	0		
15	83351	5	4.36	69	898695	898.7	0	0	0	1	0		
16	83352	5	4.36	69	898764	898.7	0	0	0	1	0		
17	83353	5	4.31	69	898833	898.8	0	0	0	1	0		
18	83354	5	4.36	69	898902	898.9	0	0	0	1	0		
19	83355	5	4.36	69	898971	898.9	0	0	0	1	0		
20	83356	5	4.36	69	899040	899	0	0	0	1	0		
21	83357	5	4.36	69	899109	899.1	0	0	0	1	0		

Figure 12: Water flow data from note paid to excel 2013

iv)   Daily student attendance recording

The daily student attendance was recorded for the calculation per student water consumption demand and water consumption pattern. Water consumption in liter per capita per day (q)

Where the total volume of water is consumed (Liters) in 24 hours, and is the number of persons using water during that period

v)   Daily temperature humidity and wind speed records

The daily maximum and minimum temperature humidity and the wind speed records were provided by metrological department Peshawar to find the correlation of these variables with daily per capita water demand.

IV.   Results and Discussion

The water consumption data for period of seven week were recorded Microsoft Excel 2016 and Minitab 18 were used for the data analysis.

After the data recording of each day data of water consumption by the Arduino meter each and then imported the data from the data files of each day to Microsoft Excel to calculate the total flow.

Calculation of water flow for every 15 minutes intervals for each day through which total 96 values were obtained. And then taking summation the whole 15 minutes to get total flow per day was calculated .Assigned dates and day of week to total flow calculated on the same day.

i)   Per capita water consumption of the hostel residents:

After calculating the total water consumed per day by dividing the total water consumed by total number of students present on the same day so the water consumed in LPCD was calculated. The daily per capita water consumption were obtained for a

period of 49 days were obtained. The average per capita water consumption was 102 LPCD with standard deviation 31.44 LPCD.The per capita consumption for each day was varying each day having lowest consumption of 60.58 LPCD and maximum value of 228.73 LPCD and no mode value were found in per capita water consumption.

ii)   Outliers in per capita water consumption

For finding outliers in per capita water consumed each day using Mini tab 18 to find the outliers as shown in Figure 13.No lower outliers were found but upper outlier of 228.73 LPCD were found. The data in Quartile 1 shows 80.9152 median or Quartile 2 shows 90.1852 and Quartile 3 shows value of 128.249 and the IQR was 47.3342.the lower whiskers shows the lower limit of data which are 60.5818 and the value of upper whisker or upper limit of data was 152.625. So only one outlier were found as Shown in Figure# which was successfully removed for further analysis. After removing the outliers the average per capita consumption was found 99.65 ± 21.79.
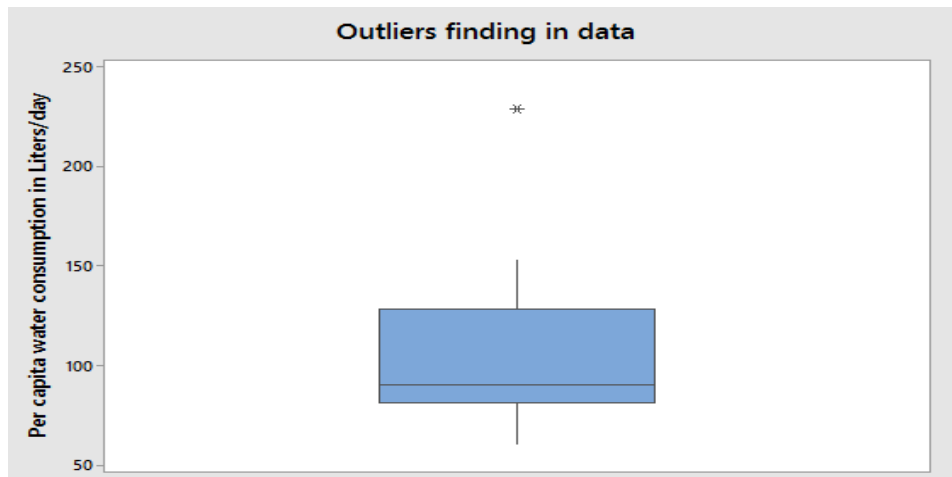
Figure 13:LPCD water consumption box and whisker plot

iii)   Effect of number of student present in the hostel on total water

consumption

An attempt was made to check if there is any correlation between number of students available per day and the total water consumption per day. Figure 5.2 shows general increase of water consumption per day as number of student increases per day the R^2 value was 0.8978 which mean there is positive and strong correlation between total water consumed per day and the number of student present per day. There was 88% direct correlation between the water consumption per and the number students present per day. Which shows clearly that students are the major consumers and the other categories of water use such is kitchen and lawn watering etc. are also seems to be very small.

iv)   Effect of temperature on per capita water consumption

Another hypothesis tested on the available data to check if there is any correlation between the maximum or minimum daily temperature with the per capita water consumption per day.it is a general hypothesis that the increase of temperature lead to higher consumption of water while when the temperature is lower the water consumption decreases. Figure 5.3 shows the correlation of maximum temperature and per capita consumption of water on the same day show a very shows the value of R^2 is 0.0058.it shows that the correlation is in minus so it mean that the maximum temperature and in the per capita consumption is no correlation in winter seasons. While Figure 5.4 show the correlation between the minimum day temperatures with total water consumption per capita per day R^2 value of 0.0016 mean that there is also no effect of minimum daily temperature on per capita consumption per day. Hence it was verified that the indoor water consumption in winter season is independent of temperature.

v)   Effect of humidity on per capita water consumption

To check if there is any effect of humidity on water consumption.by doing regression analysis of daily maximum humidity and the per capita consumption. Whereas the value of R^2 was 0.0781 it mean that there is no correlation between the daily maximum humidity and per capita consumption per day. Also shows that the R^2 value for the minimum humidity per day and the   per capita consumption was 0.0521 means there is no effect of minimum humidity and the per capita consumption per day.

Time	LPCH	Avg LPCH	Peaking factor	Time	LPCH	Avg LPCH	Peaking factor
1:00	0.00	4.17	0.00	13:00	11.25	4.17	2.70
2:00	0.33	4.17	0.08	14:00	26.91	4.17	6.45
3:00	0.39	4.17	0.09	15:00	2.84	4.17	0.68
4:00	0.00	4.17	0.00	16:00	14.10	4.17	3.38
5:00	0.96	4.17	0.23	17:00	19.69	4.17	4.72
6:00	0.00	4.17	0.00	18:00	16.20	4.17	3.89
7:00	13.68	4.17	3.28	19:00	0.00	4.17	0.00
8:00	0.00	4.17	0.00	20:00	7.64	4.17	1.83
9:00	0.00	4.17	0.00	21:00	14.44	4.17	3.46
10:00	8.61	4.17	2.07	22:00	0.70	4.17	0.17
11:00	6.01	4.17	1.44	23:00	1.46	4.17	0.35
12:00	5.24	4.17	1.26	0:00	2.23	4.17	0.53

Table 3: Maximum day hourly consumption and peaking factor

Time	LPCH	Avg LPCH	Peaking factor	Time	LPCH	Avg LPCH	Peaking factor
1:00	2.64	4.17	0.63	13:00	1.61	4.17	0.39
2:00	1.37	4.17	0.33	14:00	3.52	4.17	0.84
3:00	0.10	4.17	0.02	15:00	3.21	4.17	0.77
4:00	1.41	4.17	0.34	16:00	4.24	4.17	1.02
5:00	0.84	4.17	0.20	17:00	4.96	4.17	1.19
6:00	0.53	4.17	0.13	18:00	5.83	4.17	1.40
7:00	1.49	4.17	0.36	19:00	0.93	4.17	0.22
8:00	4.12	4.17	0.99	20:00	4.17	4.17	1.00
9:00	4.76	4.17	1.14	21:00	2.26	4.17	0.54
10:00	1.54	4.17	0.37	22:00	1.79	4.17	0.43
11:00	0.65	4.17	0.16	23:00	4.11	4.17	0.99
12:00	2.86	4.17	0.69	0:00	1.64	4.17	0.39

Table 4: Average hourly water consumption and peaking factors

Week days	Average water consumption each week day (L)	Week days peaking factors
MONDAY	94.3	0.93
TUESDAY	96.1	0.95
WEDNESDAY	94.7	0.93
THURSDAY	97.5	0.96
FRIDAY	114.6	1.13
SATURDAY	115.6	1.14
SUNDAY	97.8	0.96
Average water consumption	101.5	

Table 5: Average water per capita water consumption and peaking factors week days

V.   Conclusion

This study proved that the Arduino water flow meters can provide the detail of water consumption. To estimate the accurate use of water consumption is an essential aspect for sustainable development of water supply system. Thus it is important to measure water consumption pattern per capita per day.

It was found that the average per capita water consumption of hostel students was 99.65 ± 21.79 LPCD.The per capita consumption for each day was varying having lowest consumption of 60.58 LPCD and maximum value of 228.73 LPCD and no mode value were found in per capita water consumption.There was strong correlation found between number of students available per day and the total water consumption per day. The R2 value was 0.8978 which mean there is positive and strong correlation

of 88% between total water consumed per day and the number of student present per day which also shows clearly that students are the major consumers and the other categories of water use such is kitchen and lawn watering etc. are also seems to be very small.There was no correlation found between maximum and minimum temperature vs per capita water consumption per day as well as the minimum and maximum humidity also have no effect on water consumption per capita per day. The maximum wind speed and minimums wind speed have no effect on water consumption per capita per day.The humidex of daily temperature and the humidity and the humidex of daily temperature and wind speed also have no effect on water consumption per capita per day.Hence it was concluded that in winter season there is no effect of water temperature, humidity, wind speed, and humidex have no effect on water consumption per capita per day. The average water consumption pattern per capita per day shows some random peaks in the graph which mean that there is difference in routines of students. They have different class, sleeping, and wake up timing. The hostel not contain all the students of same semester and discipline. They contain students of different semester and discipline so they have different routine of different activities and hence in average consumption pattern they shows certain random peaks. The water consumption starts from morning 6:00 am and continues to late night. The two major peaks observed one in morning time and one in evening time the water consumption. The morning peak between 08:00 to 09:00. While the evening peak starts from 13:00 to 14:00.the morning peak is higher than evening peak but the evening peak is broader than morning peak. The water consumption in morning in is more in evening hour compare to morning hours. Most of the minor peaks occurs during the prayer timing.

VI. Recommendation

The water use information is very necessary for water supply system planning and designing.in this research the water per capita demand and water consumption pattern of student hostel was investigated which is very important for the designing of water supply and also for waste water systems. The piping network for the water supply should be efficiently designed to meet the exact demand of water supply and therefore it is necessary to know the actual consumption per capita and consumption pattern.

•   For the accurate estimation of water per capita demand it is recommended to use Arduino water flow meter instead of using general questionnaire or other observation for water consumption and consumption pattern .it provide the precise measurement of water consumption with time.

•   Although this research is to address the institutional water demand and consumption pattern but it provide a basic guide lines and methodology for calculating per capita water consumption and water consumption pattern.
•   It is recommended to continue the research for several years to capture different seasonal, cultural, cultural factors not only in institutional level but also in residential houses. To observe different activities of water consumption in the residence would be investigated. Also take into consideration the different behavioral change communications strategies for influencing water conservation.

VII.   Acknowledgement

References

I.   Azad, A. P., & Ahmed, R. (2006). A Geographical Study of Land-Use in the Commercial Heart of Karachi (Saddar). Pakistan Geographical Review, 61(2), 64-82.

II.   Abedin, S. B., & Rakib, Z. B. (2013). Generation and quality analysis of greywater at Dhaka City. Environmental Research, Engineering and Management, 64(2), 29-41.

III.   Falkenmark, M., Lundqvist, J., & Widstrand, C. (1989, November). Macro- scale water scarcity requires micro- scale approaches. In Natural resources forum (Vol. 13, No. 4, pp. 258-267). Blackwell Publishing Ltd.

IV.   Haydar, S., Hussain, G., Nadeem, O., Aziz, J. A., Bari, A. J., & Asif, M. (2016). Water Conservation Initiatives and Performance Evaluation of Wastewater Treatment Facility in a Local Beverage Industry in Lahore. Pakistan Journal of Engineering and Applied Sciences.

V.   Jury, W. A., & Vaux, H. (2005). The role of science in solving the world's emerging water problems. Proceedings of the national academy of sciences of the united states of america, 102(44), 15715-15720.

VI.   Kumpel, E., Woelfle- Erskine, C., Ray, I., & Nelson, K. L. (2017). Measuring household consumption and waste in unmetered, intermittent piped water systems. Water Resources Research, 53(1), 302-315.

VII.   Murad, A. A., Al Nuaimi, H., & Al Hammadi, M. (2007). Comprehensive assessment of water resources in the United Arab Emirates (UAE). Water Resources Management, 21(9), 1449-1463.

VIII. Mead, N. (2008). Investigation of domestic water end use.

IX.   Nyong, A. O., & Kanaroglou, P. S. (2001). A survey of household domestic water-use patterns in rural semi-arid Nigeria. Journal of Arid Environments, 49(2), 387-400.

X.   Singh, O., & Turkiya, S. (2013). A survey of household domestic water consumption patterns in rural semi-arid village, India. GeoJournal, 78(5), 777-790.

XI.   Shankhwar, A. K., Ramola, S., Mishra, T., & Srivastava, R. K. (2015). Grey water pollutant loads in residential colony and its economic management. Renewables: Wind, Water, and Solar, 2(1), 5.

XII.   Sadr, S. M., Memon, F. A., Jain, A., Gulati, S., Duncan, A. P., Hussein, W. E., ... & Butler, D. (2016). An Analysis of Domestic Water Consumption in Jaipur, India.

XIII. Tabassum, R., Arsalan, M. H., & Imam, N. Estimation of Water Demand For Commercial Units in Karachi City

XIV.   Zakar, M. Z., Zakar, R., & Fischer, F. (2012). Climate change-induced water scarcity: A threat to human health. South Asian Studies, 27(2), 293.