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DEVELOPMENT OF METHODOLOGY TO DETERMINE WATER CONSUMPTION PATTERN AND PER CAPITA DEMAND

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ABSTRACT
Knowing the water consumption per capita per day is an important information regarding design and planning of water supply system. This paper aims to develop methodology for water consumption per capita per day and consumption pattern. The methodologies used for finding demand and pattern of water consumption are mostly based on questionnaire which having less accuracy. There was no study found that are based on real time water consumption pattern and per capita water consumption. In this study special type of device Arduino flow meter were used which were installed in the outlet of storage tank to student residence to find water consumption pattern and per capita demand. The study shows that the per capita consumption of water in a student hostel was 74.5 Liters on test day and the maximum consumption per capita was reaching to 8.2 liter on 14:00 hours having peaking factor of 2.64. The study recommend a special type device Aurdino flow meter for the measurement of real time per capita consumption and time series pattern of water consumption. The Aurdino water flow meter can provide the water consumption and pattern data with maximum precession.

Keywords:
Water consumption pattern, Arduino flow meter.

INTRODUCTION

Water is crucial for maintaining quality of life on earth. The sustainability of socially sensitive good such as water depends on effective and efficient use of available water resources. The extensive use of water has increased globally and the strength of supply side measure is questionable. Due to severe increase in population, technological advancement and economic growth; the demand for water supplies is continuously increasing. Many researchers has stressed on water demand Management rather than only the supply side management.

The race for water consumption from urbanization, agricultural crops and industrial sector is very vast. The earth population will increase by the year 2050 to 9 billion so more water be needed to produce food [1]. Clean water is not abundant in nature. Although our planet 2/3 part is covered with water. The amount of water available for our use on the earth is limited. In the available water, the 97% is saltish water (sea water) and 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 [2]. A decade ago the Department for the Environmental Food and Rural Affairs UK forecast that there might be shortage of water resources to meet demand after 2025 [6].

The population of Pakistan rises from 34 million in 1951 to 170 Million through the year 2010. The Proportion of urban population jumps from 17% in 1951 to 36% by 2010 with urban population of 58 million and population density of more than 209 persons per square kilometer. High population growth rate and Rapid urbanization directly impact the water demand for domestic, industrial and agricultural sectors. In Pakistan, the agricultural sector utilize about 96 percent of available water and the rest of the 4 percent, 2 percent for industrial and the remaining 2 percent is used by the domestic sector. About 35percent of domestic water supply is unaccounted for water. [3].

Traditional water supply planning is based on fixed water requirements and the critical mechanisms to deliver the water to meet those demands [7]. The growing costs to attain 100% water supply reliability and the necessity for more sustainable management of scarce water resources have led to the renowned concept of Integrated Water Resources Management (IWRM). The concept of IWRM has been recently recognized as a practical strategy for achieving effective, equitable and sustainable development and management of the world´ s limited water resources [8].

The water shortage level increases every year, therefore it is important to estimate the statistics of water consumption and consumption pattern to fulfil the need of community. It is important that water planners must understand present water consumption pattern of the local dwellers, the water consumption Patterns fluctuate from country to country and community to community because of Having different cultural socio-economic and climatic condition as well as water availability and accessibility. To identify water demand and consumption patterns various methodologies used in the different region of the world.

A survey conducted in Dhaka city on daily water consumption based on a questionnaire developed and a special sort of bucket used for water for numerous purposes in hoseholds.The results of study shows that water consumption in middle class families is 200-300 liters per capita per day [2]. WHO recommends 50–100 l of water per capita per day (LCPD) to perform domestic needs such as personal hygiene, laundry and cleaning [4].

Research conducted in Toowoomba 10 house was chosen in which high resolution water meter and data loggers were installed to the main water supply pipe inlet into the houses, for a period of 138 days the water supply data was recorded for every 10 seconds time interval. The average water consumption was determined to be 112 LPCD (liter per capita per day) in the selected houses [5]. Further 763 household's questionnaire and interview based surveys observed the households daily and activity based water consumption, source, quality frequency and duration of water supply. The volumes of container in which occupants used to stock the water were measured and also the running tapes for different activities and time span of tap opened and the discharge were observed, the study revealed that the average per capita daily consumption of the study area was 117.0 LPCD, while for low income families it was 97 LPCD. [1].

Most of the water consumption per capita was found on the basis of questionnaire and no study was found regarding water consumption pattern because the typical water meters are not able to give the consumption pattern it just give the total volume of water consumed. Water consumption pattern is very essential information for water supply design. Usually the water per capita demand can be found with help water meter but unfortunately there is no water meter system available in Pakistan. And almost our water supply system are intermittent and in intermittent supply system the water meters are unable to record the water flow accurately so this paper introduce a special type of Arduino water flow meter which can give us water consumption record with time.

MATERIAL & METHODS

In this research a special device were used for water consumption measuring information known as Arduino water flow meter. Arduino flow meter consist of flow meter sensor and the Arduino acquisition system. The Arduino acquisitions system is programmed in such a way that the water passes through the flow meter sensor strike the propeller and rotate propeller which pass the signal of rotation to the Arduino acquisition system. The Arduino acquisition system multiply rotation with the conversion factor and gave the flow per second. To get the accurate conversion factor a calibrated bucket was used by filling it frequently from water which pass through the sensor and by adjusted the actual flow and the flow recorded by flow meter using auto calibration option in the flow meter.

Study area:

The test study was performed in a student hostel located in university of engineering and technology Peshawar named Mehmood Ghaznavi hostel. The hostel have the capacity of 120 students and consist of four water supply tank having a continuous water supply from the main source. The flow meter was attached in parallel to the outlet of storage tank as shown in **Figure.1** to the hostel instead of main water supply to the tank because the use of water from the storage tank was directly by student and the main supply line was giving water to the hostel tanks therefore the flow meter were installed at out let of storage tank to record the water consumption pattern and the total water consumed by students. The study was performed on Monday January 8, 2018.

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International Journal of Engineering Technology Research & Management

Figure.2 Arduino flow meter system

The meter were run for a period of 24 hour and the attendance of the student for the same period were recorded to get the per capita water consumption. Using Microsoft excel 2016 for the calculation of water consumption pattern and per capita water demand. After importing the data from text file to Microsoft excel. The total flow for each hourly interval was calculated. Dividing the total flow by the number of students present it gave the number liters per capita consumption. And also calculated hourly per capita water consumption by dividing the total hourly water consumption by number of present students it gave the per capita hourly consumption.

RESULT & ANALYSIS

The total water consumed in 24 hours of January 8, 2018 was 7755 liter and the total number of student present were 104, so per capita water use on that day was 74.5 LPCD.The hourly water consumption period while time plotted on X axis and the total water consumed in liter in each hour on y axis as shown in **Figure.3**. The total water consumption was 511 liter on 1:00 hour and then the flow getting minimum up to 6:00 hour morning. The flow start increasing from 6:00 morning which is wake up time of students for prayer (Nimaze Fajar) and on 8:00 hours the total flow was 491.45 liter. The peak flow of water consumption occurring on 14:00 evening which was 851.4 liter.

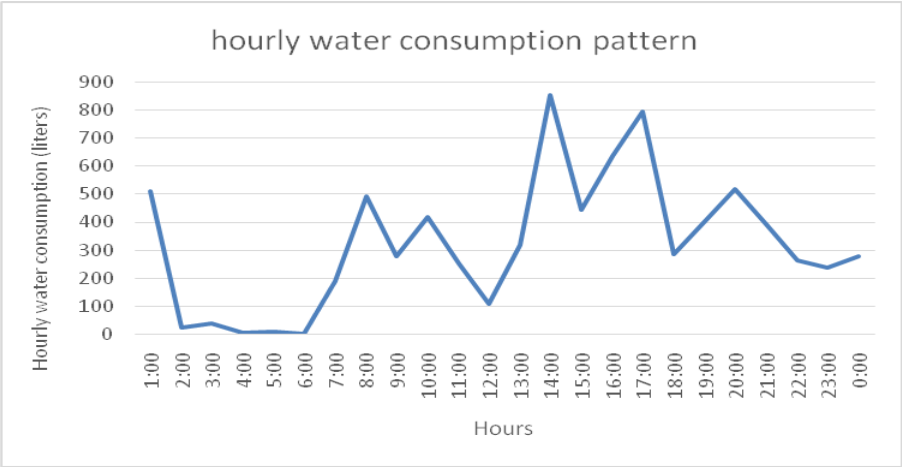

Figure.4 Total hourly water consumption in student hostel

The per capita water consumption pattern was calculated by dividing each hourly flow interval by number of student present on that day which gave the per capita consumption on each hourly interval as shown in the **Figure.5**. So the average per capita maximum consumption was 8.2 liter occurring on 14:00 hour and the peaking factor was 2.64. The average per capita hourly consumption was 3.11 liter.

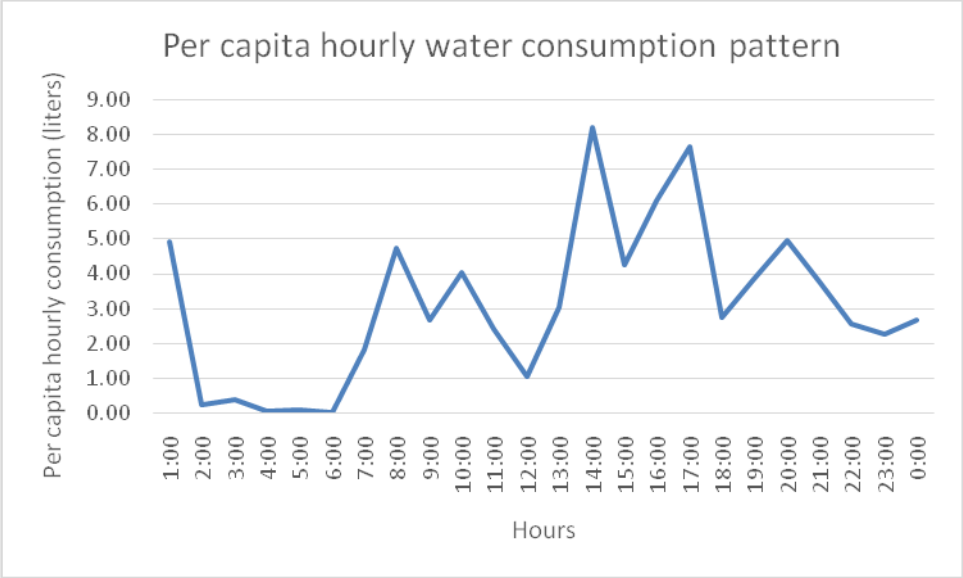

Figure.6 Per capita hourly water consumption (liters) in student hostel

CONCLUSION & RECOMMENDATION

For the detail of water consumption it has been proved that Aurdino water flow meter can provide accurate information. For sustainable development of water supply networks it is very essential to find the accurate information regarding water consumption such is per capita demand and water consumption pattern.

It was determined that the water consumption was 74.5 liter / capita / day in students residence.

From water consumption pattern it was observed that the water consumption was starting from 6:00 morning and the consumption was high on 14:00 evening reaches to 8.2 LPCH which having a peaking factor of 2.64 and the average per capita hourly consumption was 3.11 liter.

Hence for accurate estimation of water consumption pattern and per capita demand it is recommended to utilize Arduino flow meter instead of questionnaire and typical water meters or general observation for water consumption pattern with time.

Although this research is to develop a methodology to calculate water consumption pattern and per capita demand, Hence it is recommended to continue the research for several years to capture the cultural, seasonal, not only in institutional hostels level but also in residential societies.

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