DECLARATION

This is to certify that the work presented in this thesis titled **“DEVELOPMENT OF A COST EFFECTIVE WATER SUPPLY SYSTEM BY ADAPTING MOTION SENSOR"** is an outcome of the investigation carried out by the authors under the supervision of DR ENGR MD ALAMGIR HOSSAIN, Professor, Department of Mechanical Engineering, Military institute of Science and Technology.

It is also declared that neither of this thesis paper nor any part of it has not been submitted elsewhere for the award of any other degree, diploma or any other similar title.

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SUPERVISOR CERTIFICATION

This thesis paper titled **“DEVELOPMENT OF A COST EFFECTIVE WATER SUPPLY SYSTEM BY ADAPTING MOTION SENSOR"** submitted by the group mentioned below has been accepted as satisfactory in partial fulfillment of the requirement for the degree B.Sc. in Mechanical Engineering on December 2017.

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ABSTRACT

Nowadays, energy audit is considered as one of the comprehensive methods in checking the energy usage and wastage in mosques. An energy audit is a study of a Plant or facility to determine how and where energy is used and to identify methods for energy savings. This paper presents the preliminary study of energy audit that has been done in General Mustafiz Tower Mosque, Military Institute of Science and Technology. Energy is the basis of life and it is our duty to save energy. If we can save water we can be able to save energy as water and energy is related to each other. Day by day, the gap between energy demand and supply is ramping up. One effective way to minimize the gap is to conduct energy audit in all sectors in regular basis. The aim of our thesis work is to perform energy audit to find out the energy loss, provide methods and techniques to compensate the loss. A survey of the energy end-use of tenants has been conducted to obtain information about water used in ablution and equipment loads in premise in the mosque. The thesis also focuses on the energy saving opportunities and the potentials to reduce early Operating cost. This is done by replacing conventional water tap with more energy efficient appliances to increase the efficiency. The simple payback period calculation and formulation of the energy audit is also discussed in this paper. The result of our study showed that, a substantial amount of energy and money can be conserved if thorough energy audit is practiced and executed.

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1.1 Introduction

At present per capita per day water consumption *as estimated by the utility, was about 130 liters in Dhaka*. Bangladesh, with its 160 million people in a land mass of 147,570 sq. km. has become a developing nation. Water consumption is rapidly increasing due to increased demand of population and development. But when a staggering 60% of the population that has to endure unsafe drinking water, the nation is in danger (1). Still about *95 percent of the water entering the supply lines goes down the drain. Thus waste both water and energy.* This situation can be improved by taking necessary steps (Automatic Sensor Faucet, Reuse of Grey Water, Rainwater Harvesting etc.). Maximum Urban commercial buildings do not implement water and energy saving technologies. If they use these technologies, the water and energy crisis of Bangladesh can be reduced to great extent.

1.2 Energy Efficiency for Water Utilities

Availability of clean water increases the quality of living of human life. But supply and generation of clean water requires energy. For many municipal governments, drinking water and wastewater plants typically are the largest energy consumers, often accounting for 30 to 40 percent of total energy consumed. Overall, drinking water and wastewater systems account for approximately 2 percent of energy use in Bangladesh (1). Billions of dollars have been spent to expand water supply to an increasing number of consumers in industry and housing estates world-wide. A rapid increase in water tariffs has spurred water conservation efforts, particularly in the communal sector. It has been reported that public use of water in some developed countries has been falling as a result of greater efficiency in the use, reuse and recycling of water. While industries and commercial enterprises have made significant progress in water efficiency, the achievement of the general public has been extremely poor, thereby resulting in urban water demand to increase steadily. This discrepancy can be attributed to low water tariffs and wide availability of potable water in urban areas. Consequently, the general public, particularly the urban population, has little consciousness of water savings and hence, the energy savings associated with water use.

1.3 Water Consumption in Urban Sector

The urban sector contributes a significant percentage of water consumption, particularly in developing countries of warmer climates. In Dhaka for example, the domestic sector con-tributes 60.1% of the total water consumption compared to the other sectors (2). The need for efficient water management in the urban sector is becoming ever more crucial due to a sharp increase in the price of fresh water. This trend is likely to continue in the near future due to the predicted shortage of fresh water, and hence, the possibilities of resorting to wastewater treatment, desalination, and inter-state water purchases as well as water transfer. Compared to the extensive amount of work conducted on water minimization in industry, there has been many fewer efforts towards water conservation in the urban sector. But the urban water can be aggravated by focusing on the use of water-saving gadgets.

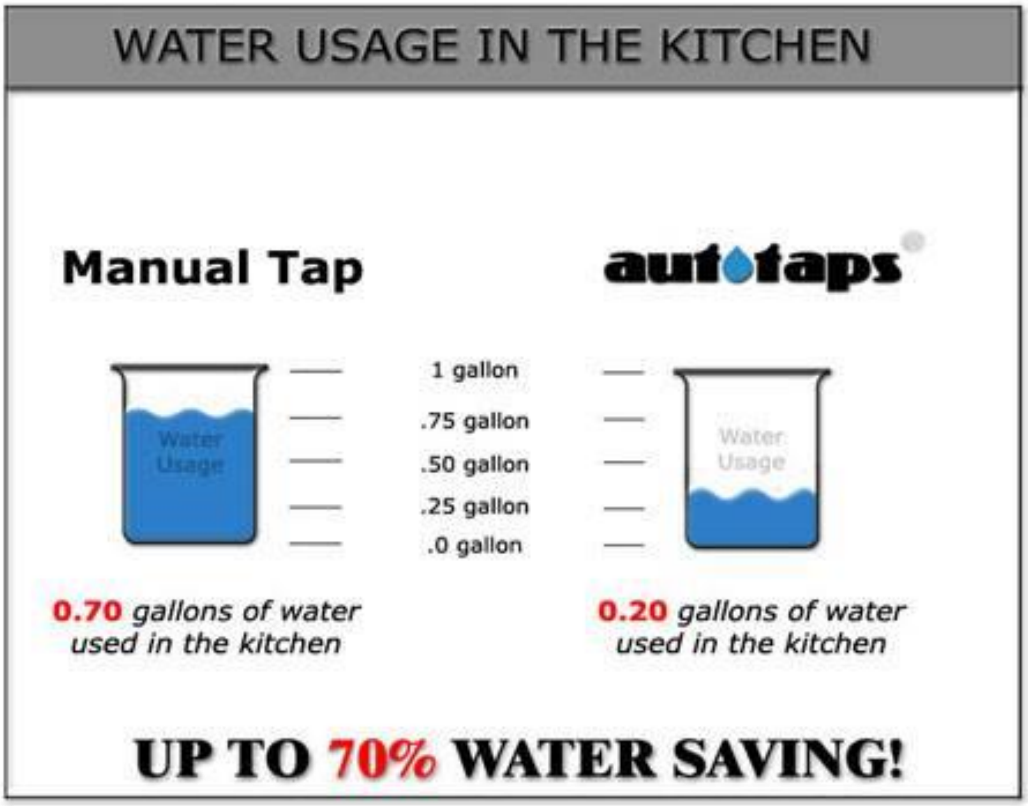


Figure 1.1: Water Saving Using Water Saving Gadget

1.4 Key Problems in The Water Sector

1.4.1 Waste of water:

Waste of water is any water that has been negatively impacted by human use. Waste of water is a byproduct of domestic, industrial, commercial or agricultural activities. In other words, wastewater is "used water from any combination of domestic, industrial, commercial or agricultural activities, surface runoff or storm water, and any sewer inflow or sewer infiltration". Wastewater contains a large number of physical, chemical and biological pollutants at varying concentration levels. Wastewater characteristics vary, depending on the source, namely whether it is domestic wastewater from households, municipal wastewater from communities or industrial waste water from industrial activities.

Mosque may produce wastewater by ablution, flushing toilet, washing basin, cleaning floor etc. But among these conventional system of ablution play a vital role in wasting water.

1.4.2 Decreasing the Level of Ground Water

There will be no ground water in future and our country will be paying more to buy water. Already we are fighting for water with other state and this is going to be the next problem. In many areas, ground water is not at all good and people are not even using that water for their daily work. The failure of the monsoon is one of the reason of the decreased ground water level. Groundwater is something that we need all over the world. Humans and animals need water in order to survive as our bodies could not function without it. We also need water to assist us in growing crops, powering equipment, and to keep us comfortable. Societies require much more clean water than we are afforded from precipitation and surface water, which is why groundwater is used so frequently. We may see the beautiful, flowing surface waters that make up the oceans, lakes and rivers, but this water is not always safe for consumption and is much more difficult to filter than groundwater. Consequently, water from the ground is especially valuable.

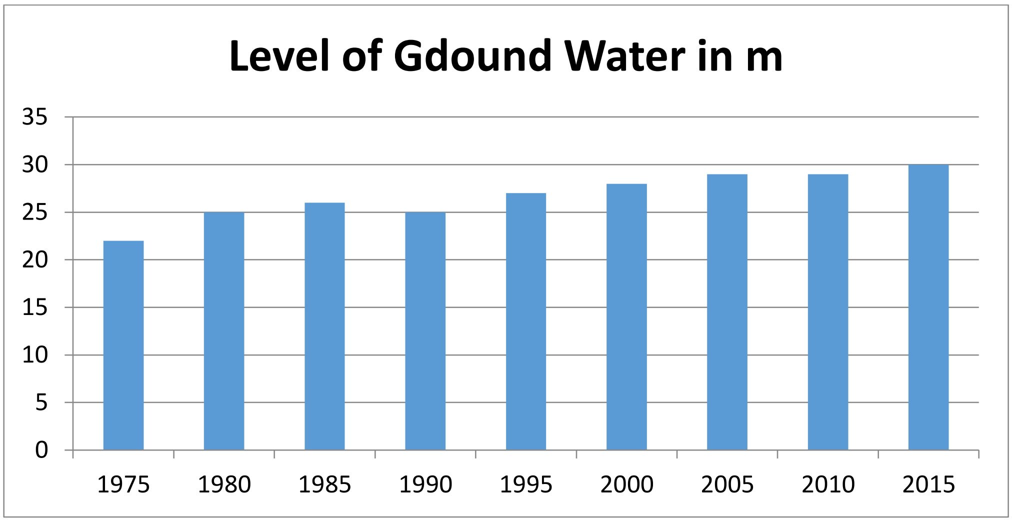


Figure 1.2: Level of Ground Water (2)

1.4.3 Waste of Energy

As water and energy related to each other, waste of water means waste of energy. That means if we waste water, we waste our value able energy . In this modern edge of science energy is the most valuable input of our developing processe. We need water for energy and energy for development.

Figure 1.3: Relation between water and energy

1.5 Thesis Overview

The primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. In order to reduce energy consumption it is necessary to reduce water use in communal sector. To make it possible reducing water consumptions in public or communal building/institute is essential. From the field survey it is found that while performing “Wudu” 30–47 % amount of water consumed in ablution from traditional taps is wasted than newly invented Sensor Faucets technologies (3). Therefore, a proposal of new Sensor Faucet in communal utility given in this thesis. It will be an energy efficient technology. it will also save national resources up to a great extent. This thesis will thoroughly analyze the present condition and future prospect of this proposal.

1.6 Thesis Organization

The subject matter of this thesis paper is described in the following according to the chapters.

Chapter One contains introduction, energy efficiency for water utility, water consumption in urban sector, key problems in water sector. A formal introduction of the thesis starts the chapter. Present scenario and water consumption is described afterwards along with some important statistics. The major problem of Bangladesh water crisis is described next. Key problems of water sectors is also discussed. Then objective of thesis is clearly described in another subtopic. With the organization of the thesis ends the first chapter.

Chapter Two contains literature review on ablution pattern. The articles are introduction, water consumption pattern in different tap, ablution water use scenario among modern Muslims.

Chapter Three contains definition of energy audit, types of energy audit, preliminary audit, detailed audit, pre audit, audit phase, post audit, about benchmarking and also energy audit instrument. This chapter starts with definition of energy audit. Different types of energy audit are described in the second topic. How preliminary and details energy audit work, different phase of detailed audit and their action are discussed in the next topic. A short description of various types of energy audit instrument also discussed.

Chapter Four focuses on the water consumption in a mosque. This chapter starts with a short introduction of water consumption. Then a brief history of energy auditing building and field survey area details are discussed. Different water consumption sources in the Building are discussed in the next topic. This chapter ends with our suggestion for reduction water consumption in MIST.

Chapter Five is our prime concern of the thesis, different water consumption data in MIST is analyzed. We use different data and statistics that help us to understand the impact on reducing annual water consumption of a building in MIST. First we start with a brief introduction with Automatic Sensor tap. Then Difference between Conventional and Sensor tap is discussed. How Automatic Sensor tap replacement impacts on previous conventional system and saving cost taken place in the following part. Water consume and Cost saving calculation by implementing an Automatic tap is discussed in the next part. Finally this chapter ends with a short conclusion.

Chapter Six based on result analysis and Recommendation section. Here, we first start with a short introduction. ln result analysis section, we decided that Automatic sensor Tap would be good for saving cost and power consumption in the auditing building. In recommendation section, we discuss how we can improve water and energy saving system and how should be the use by proper maintaining.

CHAPTER TWO

LETERATURE REVIEW

2.1 Introduction

There is a lack of water resources and an extreme use of potable water in our country. Ablution from taps was studied since it is a repeated daily activity that consumes more water. Analyzing different experimental observations revealed that 22.7–28.8 % of ablution water is used for washing of feet and the largest water waste occurs during washing of face portions. Moreover, 30–47 % amount of water consumed in ablution from taps is wasted which can be saved if tap releases water only at moments of need (3). The push-type tap is being spread recently especially in airports. If it is intended for use in ablution facilities, batch duration and volume must be tuned. When each batch is 0.25 L of water and lasts for 3 s, 3 L are sufficient for one complete ablution in average which means considerable saving (4). Cost-benefit model proposed for using different tap types and an economic feasibility study performed on a case study can help us to design better ablution systems and thus saving energy.

2.2 Water Consumption Pattern in Different Taps

Water is the basis of life and it is our duty to save water and develop water resources. Ablution is a mandatory religious routine for Muslims that is repeated several times daily for prayers and other deeds. Ablution actions typically include washing of hands, face, mouth, nose, arms, swabbing on head, ears and feet. Conservation of water is a religious and national obligation especially with the lack of water resources.

In ablution process, the tap is usually left running, much good water is wasted in the process. It can be said that about half of the tap water flows directly to the drain without any contamination.

Tracking of water consumption patterns in ablution and washing in some public and private facilities in multiple regions, the most important observation confirmed by the researcher are:

– Handle taps consume extra amount of water during the moments of opening and closing because of using hands in turning the tap handles. Thus, cannot benefit of flowing water. Using slow closure mixer taps wastes about 30 % of the amount of water consumed (5).

– Mixer taps that mix hot and cold water consume more water every time of use at the start of opening because the user leaves the water flowing until its temperature reaches a suitable level.

– Mechanical push-button taps waste water because the amount of water in each batch (sometimes more than 1 L) is frequently more than the user need.

–Electronic taps are expensive and need electrical power and means of protection to isolate the wiring. Further, they have a time lag between the moment of cutting the beam and the onset of water flow and other time lag before it shuts down automatically.

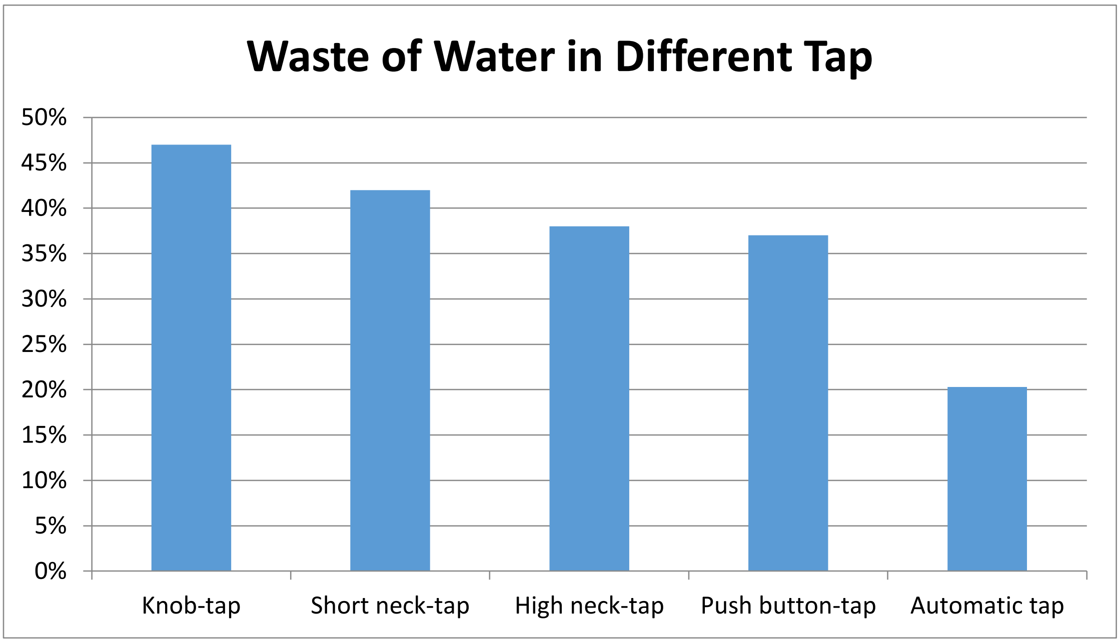


Figure 2.1: Waste of Water in Different Tap (6)

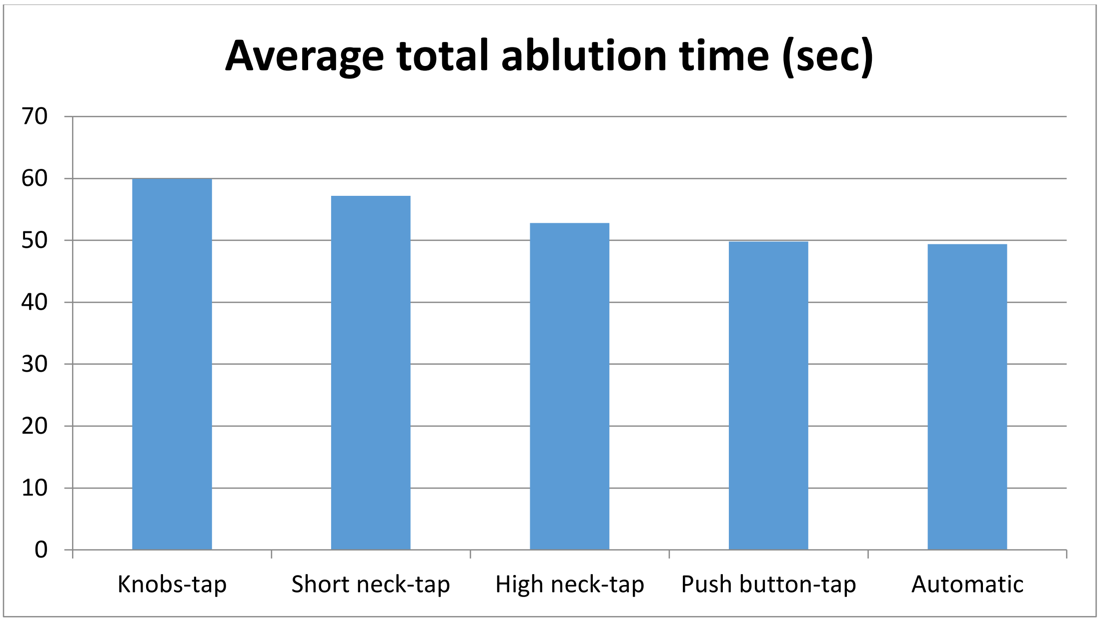


Figure 2.2: Average total ablution time (sec) (6)

2.3 Ablution Water Use Scenario among Modern Muslims

The amount that was used by the Holy Prophet Muhammad prayer and peace be upon him (PPBUH) for the performance of ablution is one full palms. The Islamic historical records indicated that Prophet Mohammad [peace be upon him] used to make ablution using one ‘‘Mudd’’ of water [Hadith from Bukhari and Muslim] which is equivalent to about 0.544 L of water (7). Others prove slightly higher evaluations but, anyhow the correct amount is less than 1 L.

At present, Muslims consume more water in their ablutions and previous studies showed different evaluations of the average amount of ablution water used. Abu Rozaiza (8) measured the amount of water used in ablution in nearly 40 Masjids and in the two holy Masjids, and found it 3–7 L per person at a time. In his other study, Abu Rozaiza (7) determined the average ablution water amount as 2.5–4.5 L/individual in some masjids, schools and governmental buildings. But he found that this amount increases to 5 L in the two holy Harams and 6–7.5 L/in-dividual in A’rafah and Muzdalifah in Hajj days.

In his project named ‘‘the islamic bathroom’’, Mohamed Ben-Ghalbon estimated average water amount consumed by an average Muslim in ablution as 10 L in the Gulf region and the Middle East. However, he confirms that same amount that was used by the PPBUH is one full palms (688 mL approximately) and it is sufficient. He proposed installation of a metal pot with a capacity of 688 mL beside the ablution basin. He had patent grants for this idea coded DE60232314D1, EP1372448A1 and WO2002071905A1. He supposes that the use of this low cost product will combat the waste of potable water and will be available for the majority of the Islamic world citizens other than the use of costly electronic taps. But the practical reality testifies that this idea is not popular yet.

Besari et al. (9) built an automatic ablution machine using camera as sensor and servomotor as an actuator. They stated that, by testing this machine, it will save 1–7 L during ablution. Their experiments revealed that manual ablution consumes about 2–9 L/individual in about 40–80 s of time where using automatic ablution machine decreased water consumption to about 2–3 L/individual in about 55–70 s.

Al-Mughalles et al. (10) studied water quantity consumed by one worshipper during the ablution in two masjids in Sana'a. They determined the average grey water quantity produced by one worshipper as 2.7 L.

Ablution process normally requires about 6–9 L of water volume, but according to Islamic hadiths, about half to two liters only will be used for ablution. Suratkon et al. (7) conducted a study to develop and verify a conceptual model of the ablution water recycling system, they observed the average volume of water required for a single ablution ritual as 5.0 L, obtained by monitoring a number of users at various prayer times in a day.

Figure 2.3: Ablution

In summary, PPBUH was using less than 1 L of water for his ablution while Muslims nowadays use 2–10 L. In this study, the researcher experimentally analyzes action and water use times in ablution from some tap types. A mathematical model is proposed for economic feasibility of using different taps. This analysis can help better design of ablution systems.

CHAPTER THREE

ENERGY AUDITING

3.1 Introduction

The need to cut back energy prices could be a crucial business apply for organizations, and energy audits have begun to play a lot of important role on managing energy expenses. Energy audits will include a spread of measure techniques however most ordinarily incorporates an analysis of energy usage at intervals a building or facility and its contained instrumentation. Energy audits are often ASHRAE Level l, ll, lll for conditioned house, or comprehensive or plan of action energy surveys for industrial facilities. Audits embrace comprehensive lists of energy potency measures derived from building and facility performance. Energy audits conjointly embrace money analysis for every known live. Energy audits will use data from building management systems (BMS) with the goal of reducing energy usage while not impacting the institute’s everyday practices.

3.2 Energy Auditing Definition

According to the definition within the ISO 50002 customary, an energy audit could be a systematic analysis of energy use and energy consumption at intervals an outlined energy audit scope, so as to spot, quantify and report on the opportunities for improved energy performance. As per the Energy Conservation Act, 2001, Energy Audit is outlined as "the verification, observation and analysis of use of energy as well as submission of technical report containing recommendations for up energy potency with price profit analysis and an action commit to cut back energy consumption".

Energy Audit can facilitate to know a lot of concerning the assorted ways in which energy square measure employed in any trade, and facilitate in distinguishing the areas wherever waste will occur and wherever scope for improvement exists. The primary National Energy Policy (NEP) of Asian country was developed in 1996 by the Ministry of Power, Energy and natural resource. It guarantee concerning correct distribution exploration, production, and rational use of energy resources to satisfy the growing energy demands of various zones. Energy Audit provides a reference point for managing energy within the organization and provides the idea for coming up with a more practical use of energy throughout the organization.

The four main objectives of an energy audit square measure as follows:

1. to determine an energy consumption baseline;
2. to quantify energy usage in step with its separate functions;
3. to benchmark with similar facilities underneath similar weather conditions; and four. To spot existing energy price reduction opportunities.

3.3 Types of Energy Audit

Thus Energy Audit can be classified into the following two types :

1. Preliminary Audit.
2. Detailed Audit.

3.3.1 Preliminary Energy Audit

The Preliminary energy audit is called a simple audit or walkthrough audit and is the most basic. It will identify area for more detailed study/measurement. It involves minimal interviews with site operating personnel, a brief review of facility utility bills and other operating data, and a walk-through of the facility, all geared toward the identification of glaring areas of energy waste or inefficiency. The data compiled is then used for the preliminary energy use analysis and a report detailing low-cost/no-cost measures and potential capital improvements for further study. Corrective measures are briefly described, and quick estimates of implementation costs, potential operating cost savings, and simple payback periods are provide. This level of detail is not sufficient for reaching a final decision.

3.3.2 Detailed Energy Audit

Detailed audit alternatively is called a comprehensive audit or technical analysis audit. This type of audit offers the most accurate estimate of energy savings and cost. it considers the interactive effects of all projects, accounts for the energy use of all major equipment, and includes detailed energy cost saving calculations and project cost. Detail audit is providing a dynamic model of energy use characteristics of both the existing facility and all energy conservation measures identified. Extensive attention is given to understanding not only the operating characteristics of all energy consuming systems, but also the situations that cause load profile variations on both an annual and a daily basis. Existing utility data is supplemented with sub-metering of major energy consuming systems and monitoring of system operating characteristics. This is based on an inventory of energy using systems, assumptions of current operating conditions and calculations of energy use. This estimated use is then compared to Utility bill charges.

Detailed energy auditing is carried out in three phases: Phase l, ll and lll.

Phase I - Pre Audit Phase.

Phase ll - Audit Phase

Phase Ill - Post Audit Phase.

3.3.2.1 Phase l-Pre Audit Phase

Pre audit phase is consisting of following processes:

1. Tour the whole site accompanied by production.
2. Identify the main energy consuming areas.
3. Informal interview with energy, production manager.
4. A brief meeting awareness program with ail divisional heads and persons concerned.
5. Discuss economic guidelines associated with the recommendations of the audit.

3.3.2.2 Phase II-Audit phase

Audit phase is consisting of following processes:

1. Primary data gathering, Process Flow Diagram and Energy Utility Diagram.
2. Conduct survey and monitoring
3. Conduct of detailed trials for selected energy guzzlers

4. Analysis of energy use.
5. Identification and development of Energy Conservation opportunities.
6. Cost benefit analysis.
7. Reporting and presentation to the top Management.

3.2.2.3 Phase III. Post Audit phase

Post audit phase is consisting of following processes:

1. Assist and Implement ENCON recommendation measures and Monitor the performance.
2. Action plan, Schedule for implementation.
3. Follow-up and periodic review.

3.4 Benchmarking

Marking is a technique in which a company measures its performance against that of best in class companies, determines how those companies achieved their Performance levels and uses the information to improve its own performance. Subjects that can be benchmarked include strategies, operations and processes. In 2008 a comprehensive survey on benchmarking was commissioned by The Global Benchmarking Network. a network of benchmarking center representing 22 countries. Over 450 organizations responded from over 40 countries. 0ver 60% of organizations that are not currently using these tools indicated they are likely to use Win the next three years.

The following 10 steps will keep any organization on track in its benchmarking endeavors.

1. Determine processes to be benchmarked.
2. Determine organizations to be benchmarked.
3. Gather data.
4. Locate deficiencies.

5. Determine future trends.
6. Reveal results and sell the process.
7. Achieve consensus on revised goals.
8. Establish procedures.
9. Implement procedures and monitor results.
10. Recalibrate benchmarks.

3.5 Energy Audit Instrument

Auditors need some instruments to collect the data to identify and analyze the present energy consumption and to find the approximate saving from the analysis. The Common things required to find for a commercial building are the area of windows and rooms, leakage, air flow through leakage, light intensity, temperature and heat flow, liquid flow, gas flow etc. Basic Electrical Parameters in AC &DC systems Voltage (V), Current (I), Power factor, Active power (kW), apparent power (demand) (kVA), Reactive power (kVAr), Energy consumption (kWh), Frequency (Hz), Harmonics, etc. Commonly used instruments are mentioned below:

Measuring Tape

It is used to measure the dimension of the auditing building, classroom, Lab, Width and height of lift.

Hygrometer

A hygrometer is an instrument used for measuring the water vapor in the atmosphere. Humidity measurement instruments usually rely on measurements of some other quantity such as temperature, pressure, mass or a mechanical or electrical change in a substance as moisture is absorbed. By calibration and calculation, these measured quantities can lead to a measurement of humidity.

Stop Watch

A stopwatch is a handheld timepiece designed to measure the amount of time elapsed from a particular time when it is activated to the time when the piece is deactivated

Contact Thermometer

These are thermocouples which measures for example flue gas, hot air, hot water temperatures by insertion of probe into the stream. For surface temperature, a leaf type probe is used with the same instrument.

Water Flow Meter

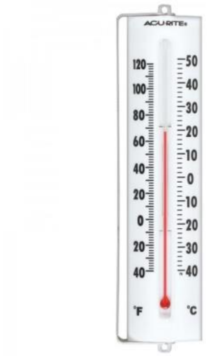
This non-contact flow measuring device using Doppler Effect / Ultra sonic principle. There is a transmitter and receiver which are positioned on opposite sides of the pipe. The meter directly gives the flow. Water and other flows can be easily measured with this meter.

Flow Meter

Measuring Tape

Hygrometer

Stop Watch



Thermometer

Figure 3.1: Different measuring instruments

3.6 Conclusion

From this chapter, a detailed idea about energy auditing is obtained. it is very important to audit energy of a building. Because to make a building more energy efficient it is important to know the load consumptions of the building. And it is only possible to get exact data by energy auditing process.

CHAPTER FOUR

WATER CONSUMPTION SCENARIO

4.1 Introduction

Bangladesh, a country of 160 million people is densely populated. Dhaka is one of the most densely populated city in the world. Development at this city is continuing very fast with respect to time. Number of multistoried buildings are increasing day by day. Which also increasing the demand of water. Ablution is a mandatory religious routine for Muslims that is repeated several times daily for prayers and other deeds. Ablution actions typically include washing of hands, face, mouth, nose, arms, swabbing on head, ears and feet. Conservation of water is a religious and national obligation especially with the lack of water resources. Ablution from taps was studied since it is a repeated daily activity that consumes more water. In this thesis paper, some method of reduction of Water consumption is proposed to make a Green Building. It will be an energy efficient as well as save national energy. The surplus energy can be used for development and production purpose in mills and factories.

4.2 Details of Survey Building

The survey building was GENEREL MUSTAFIZ TOWER also known as Tower Building 1, Military Institute of Science and Technology. This is an 11 storied commercial building. It has total gross floor area 10500sq. ft. This building have 12 classrooms, 8 laboratories, teacher's rooms, a prayer room, a conference room, a central tea room and an auditorium.

1. Average Prayer Performer : 230 to 250 (per day)
2. Number of Tap Used for Ablution: 4
3. Number of Washroom : 3
4. Number of Basin : 2
5. Source of Water : Ground Water
6. Reservoir Capacity : 2000 gallon (US)
7. Pump :
    A. Number- 3
    B. Power- 30hp (2)
    C. 20hp (1)

8. Run time of Pump: A 30hp pump for 20 min (twice per day)

4.3 Water Used in the Mosque

The sector of using water-

1. Ablution
2. Flushing toilet
3. Mosque cleaning
4. Wash basin

4.4 Field Survey: Present Scenario

Different amount of water used in different sector. Demand of water in different sector is given below,

1. Ablution - 86%
2. Flushing toilet - 7%
3. Mosque cleaning - 4%
4. Wash basin - 3%

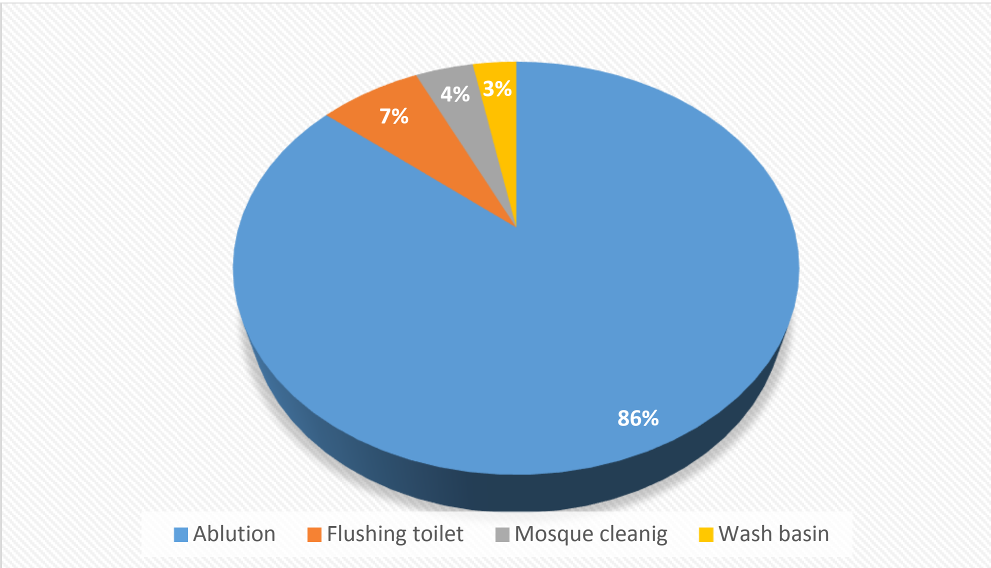


Figure 4.1 : Water Consumption in Mosque

4.5 Suggestion For Water Conservation Techniques At Ablution Site

- Use automatic taps (with button system). These taps will close automatically during the ablution rites
- Water used for ablution must be saved from the sewerage line
- Store ablution water in a small tank to be used later for watering plants
- Avoid using pipe for washing masjid or watering plants. This can be done with a bucket or a can
- Ensure regular maintenance and repair of all water infrastructure
- Institute periodic water audits
- Arrange for reuse of water harvested from the atmosphere (through cooling action of air conditioners)
- In Mosque appoint one or more person to take on water conservation responsibilities
- Make these responsibilities part of department goals, individual goals, and job descriptions
- Institute daily checks of all bathrooms, kitchens, work areas and outdoor spaces to ensure that all taps are closed tight and that there are no leakages before the office or school closes each day.

CHAPTER FIVE

METHODOLOGY AND DATA ANALYSIS

5.1 Introduction

In this chapter proposed methods of reducing water consumption will be discussed in details. Two combination sets along with necessary data and statistics will help to understand the impact of using automatic sensor tap on reducing annual water consumption for ablution and thus energy in a mosque.

5.2 Baseline Simulation Procedure

To understand the benefit of utilizing Automatic Sensor Tap, a baseline is need to be set up first. To accomplish this a detailed procedure was taken. First, total inventory of the mosque was calculated which included every types of installed Faucet. Next, manufacturer's information was gathered for various types of Automatic Sensor Tap including per minute discharge, electrical power consumption (wattage) and price of each tap.

For this test mosque, 4 traditional mechanical nob tap are currently installed. Per day 1141 L water is used from an overhead reservoir. The 100000L capacity reservoir is filled with a 30hp pump, (runtime: for 20min twice/per day).

All of these taps are operational. So, A model was created to calculate the water thus energy consumption which included 5 waqt prayer time ablution data in seven consecutive "typical days". Five typical "Weekdays" are followed by two typical "Weekend" days and this pattern is repeated for the 365 days of the calendar year.

For this base simulation, total water consumption during a day is 1250.9L which correspond to a total annual lighting water consumption of 456578.5 L.

With the baseline energy simulation known, two different sets of ablution conditions by traditional and automatic tap were simulated and the potential electrical energy consumed to supply that water.

5.3 Methodology

In this project our main objective was to reduce water loss & also to reduce energy loss . We are calculating the water loss & energy loss to pump the water for MIST ojukhana And for every waqt. We have to use a Automatic Sensor Tap for saving this water & energy loss .It is also called “Automatic Faucet”,” Touch less Faucet”, ”Sensor Faucet/Tap”. These tapes are supposed to reduce water consumption. This tape is equipped with a sensor and mechanism that opens its valve to allow water to flow in response to the presence of a hand or hands in close to the front of the tap (4). So the tap will supply water only when there will presence of hand in front of the tap ,only then the sensor will allow the valve open & flow water. In this way large amount of water can be saved every year along with the energy that is used to supply the water.

5.4 Experimentation

Experiments have been conducted on a group of mature Muslim males in order to identify real consumption of water in ablution. Experiments were carried out in the General Mustafiz tower mosque at military institute of science and technology (MIST) where single source of water is used so no time is consumed in tuning of water temperature. The participants are not told that their ablution processes is being observed, so that they behave in natural mode. More than 100 observations are conducted for ablution from 2 different tap types (Taps’ Images and specifications are shown in Table5.1) and 70 good cases are considered for analysis after excluding imperfect recording cases. In each ablution case waste water was collected in bucket and required time is measured using stop watch. The total time of each group is computed for each case and then statistical calculations are performed.

Table 5.1: Tap types used in ablution cases in this study

Valve Image	Description	Advantage	Disadvantage	No of observation
	Mechanical knobs open and close the tap in several revolutions Flow rate is up to 20 L/min	Most common	Slow manual open and close	35
	Electronic tap opens when hands cut infrared rays, Full opening water flow rate is up to 5 L/min	Automatic open and close; Reduce Water Consumption	Electricity is required; initial installation cost is high	35

5.5 Mechanism

Different components of the automatic sensor tap and its working principle i.e. the process or mechanism needed for running the tape will be discussed here. Besides diagram of automatic sensor tap facts and charts on sensor taps and manual taps be discussed here.

5.5.1 Different components of the automatic sensor tap

An automatic sensor tap has mainly four components. These are given below -

Solenoid valve,
Infrared sensor,
Power source,
A tap.

Solenoid Valve

It mainly converts electrical energy into motion. A solenoid valve is initially energized to start the water flow of the tap. Plunger driven into a range of a permanent magnet which in turn holds the plunger in the open position.

In order to return the plunger into the its original closed position, the solenoid is once again pulsed, but this there will be reversing polarity.

In solenoid valve two hybrid technologies are used-

i. Electromagnetism

ii. Fluid dynamics.

Solenoids operate at very low voltage. Usually they operate at 6V DC. Sometimes they also operate at 9V DC.

Infrared sensor

When sensor senses the presence of the object i.e. the user’s hand in front of the tap & sends a signal to the solenoid valve to initiate the flow of water. When the object is no longer present the infrared unit sends an electronic signal to the solenoid valve to terminate the flow of water usually after a few seconds.

Power Source

Most of the sensor taps that are available nowadays have 2 types of powers sources. One type is that have self-power source i.e. the tap will have own power source. Example: Battery.

Another, source is the electrical circuit source. The will be connected with the circuit current in this way. The tap we used in our thesis has also these 2 types of power sources.

Solid Brash Body

The body / shell delivers the water & its main purpose is only supply water. But, its design can different types. It can be said that, its design mainly its buyer's .Actually design varies for several applications. Some are used for lab, some are used for bathroom .Its design also varies depending on the amount of the water & also on the flow rate.

Other Components

Beside these major components there are some other components present in the sensor tape. They are-

1. Sensor cable

2. Control box

3. Transformer

4. Control box (controls the flow of water)

5. AC transformer, also remain in the sensor tap.

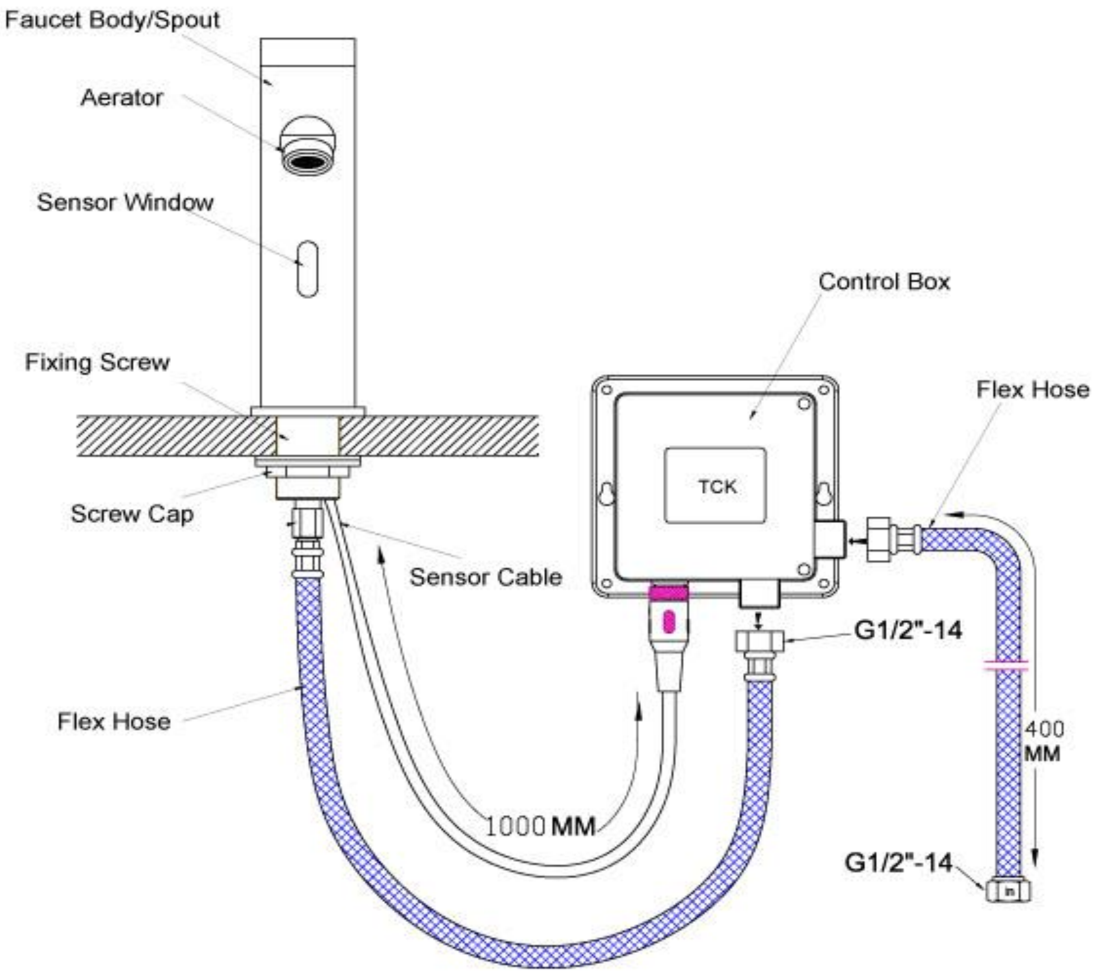


Figure 5.1: Diagram of A Automatic Sensor Tap

5.5.2 Working Principle With Detailed Explanation

Working principle of a sensor tap can divided it into 8 steps. The following steps are maintained for a sensor tape:

Step 1

An object i.e. hands approaches the sensor eye 3. The infrared proximity is disrupted if any object enters in the infrared sensing zone 2.

Step 2

In the infrared sensing zone 2 has a typical sensor range. The sensor ranges from the surroundings of its 20-26 cm wide area.

Step 3

There is a sensor eye 3 in the sensor tape. This part has the function to beams out infrared signal mainly.

Step 4

Sensor signal wire 4 also a part of the of the automatic sensor tap. The sensor signal wire 4 transfers / sends an electronic signal to the solenoid valve 5 to OPEN OR CLOSE.

Step 5

In this step function of solenoid valve comes. This solenoid valve acts as a latching mechanism that restricts or allows water to flow through it. At first, the valve opens & releases water through the flexible hose7. And it will happen when an electronic signal is received from the sensor 3. The solenoid valve always remains in the closed condition & opens only when an electronic signal is received. If there is no electronic signal then solenoid valve will be closed as usual. And if the object / hands 1 leave the infrared sensing zone 2, then it goes back to CLOSED position again.

Step 6

In the figure water in 6 is shown. In is mainly the entry path of water supply. Hot, cold, and also premix water enters through it.

Step 7

Here comes the step which is the water out step. In the figure a flexible hose 7 shown. Flexible hose transfers water released from the solenoid valve 5 to the sensor tap 8.

Step 8

This step is about to water exit. Water through solenoid valve comes out through the solenoid valve.

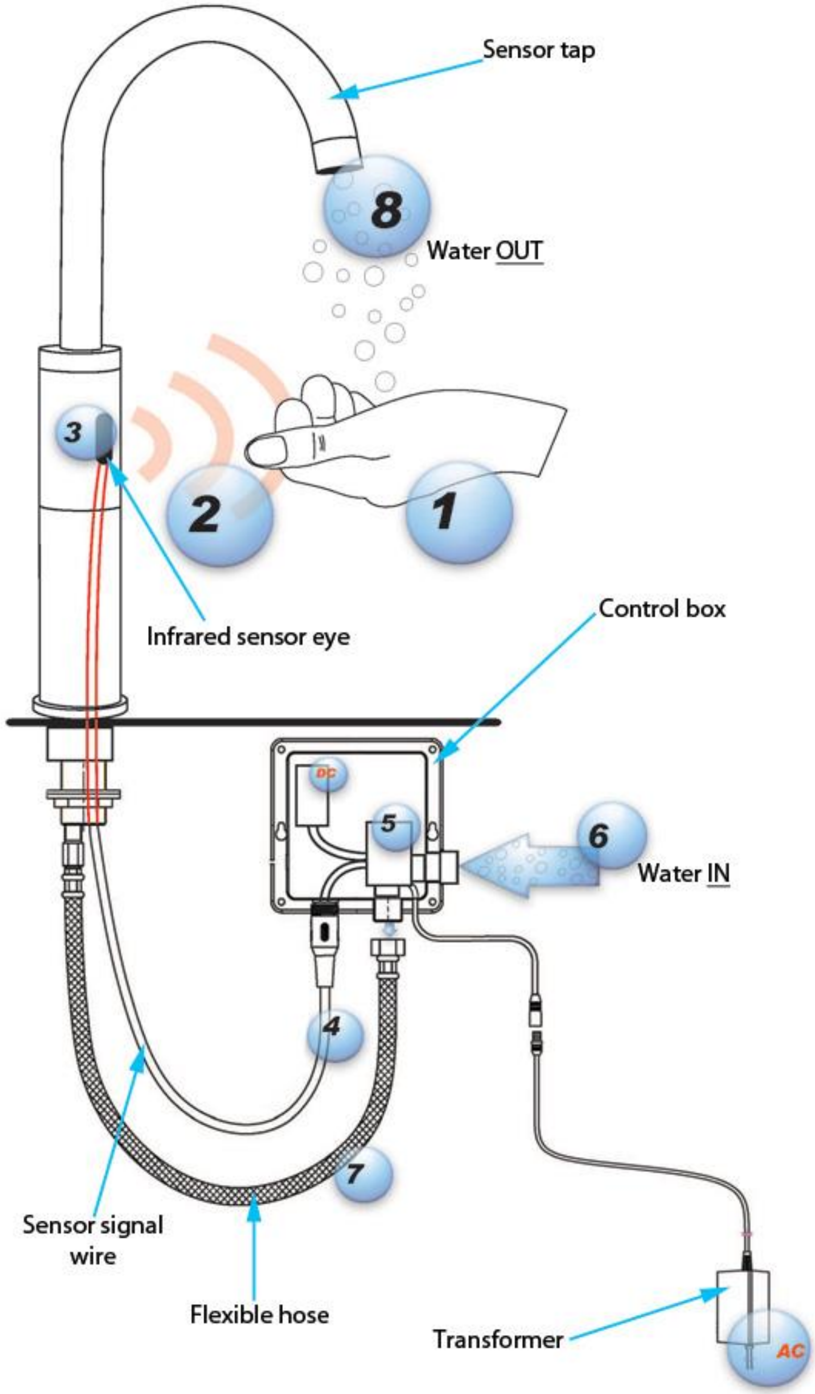


Figure 5.2: Working Principle (12)

5.5.3 Installation

This sensor tap installed using battery power option. Though circuit connection could be used But, electricity supply is not be available in wash room / Ojukhana of MIST always. Before that adequate water supply pressure was ensured. Before the installation of pipe we, the system properly was flushed to avoid dirt in the solenoid valve. Safe water temperature was also ensured.

Installation of the sensor follows the steps given below:

Step 1

Flexible hose are connected with the sensor tap. Flexible hose is connected to the base of tap.

Step 2

Then we have to securely place the sensor tap on safe place, so that we can safely do the work.

Step 3

Placing the control box very nearly to the sensor tap. If a fixed place i.e. a fixed place that in the wall where the tap is installed. And as we use here battery so we have to install batteries in the control box. Alkaline batteries can be used here. Control box should be kept away from moisture as it is supplying the current.

Step 4

Connecting the flexible hose from the sensor tape to the control box.

Step 5

After that connecting the sensor tap with the main water supply source by using flexible hose.

Step 6

Making sure the safe water temperature for the sensor tap and the control box. After that fulfilling all the steps we will connect the main power supply from the control box.

Step 7

Connect the sensor wire cable to the control box and then switch on the main water supply.

And then water will be supplied if we put any object or put our hand under the sensor tap.

Step 8

Finally, the tap will be fully prepared to use. If we normally put our hands under the tap & then our hand remaining in the infrared sensing zone and sensor eye will sense it & then send signal & at last solenoid valve will open, the water will flow through the tap.

5.5.4 Safety Issues

1. Safe water temperature and water pressure
2. Keeping Sensor tap away from sunshine.
3. Keeping control box away from moisture.
4. Flushing the full system before starting.
5. Before switching on checking all connection & see if there is any leakage.

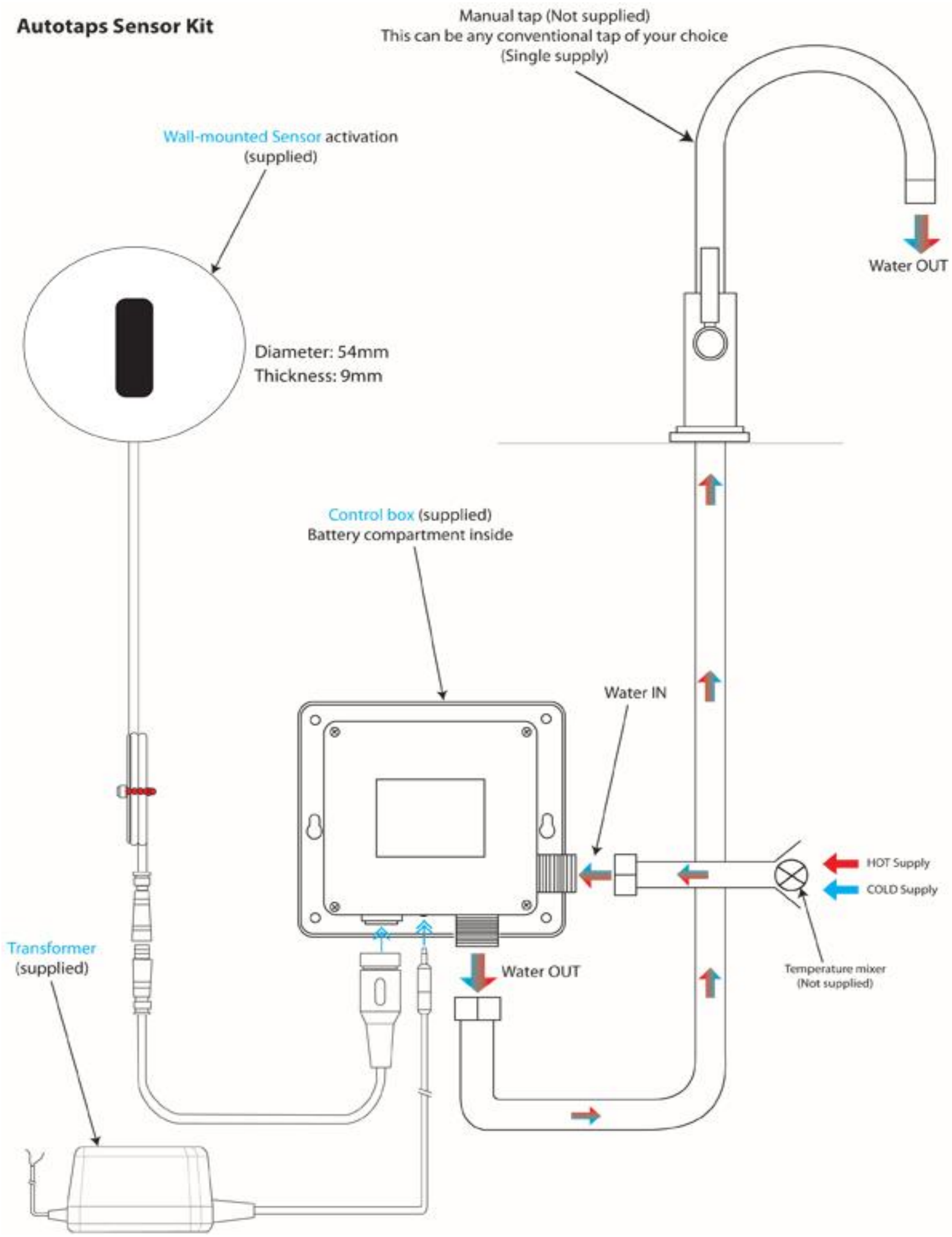


Figure 5.3 : Installation (12)

After all this process the automatic sensor tape was installed and used for taking data for the main calculation.

5.5.5 Facts and Charts on Sensor Taps And Manual Taps

(A)

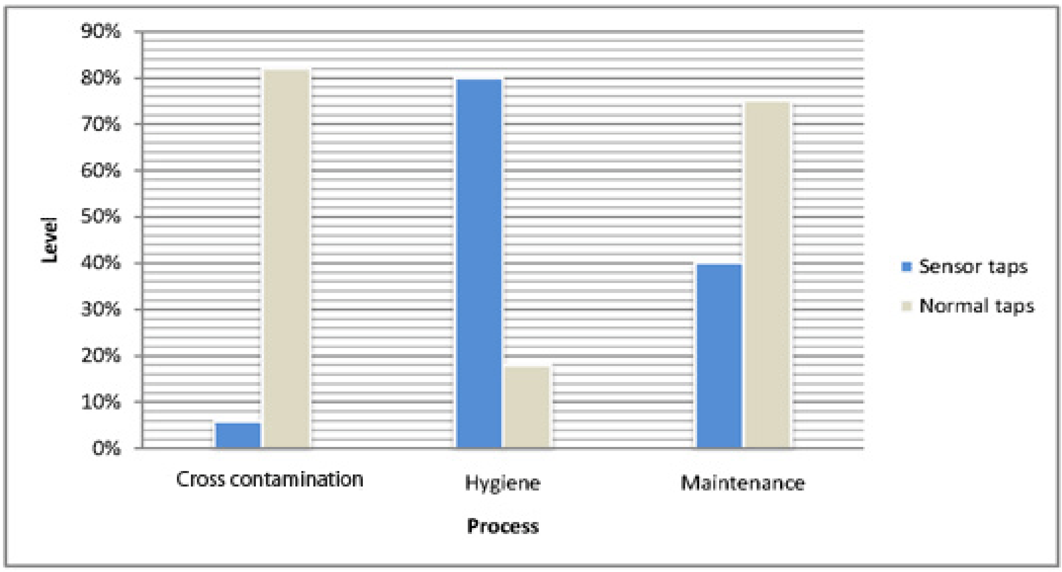


Figure 5.4: Cross contamination, Hygiene, maintenance level chart (4)

Cross Contamination

The level of cross contamination when using a manual tap is significantly higher than sensor tap. With sensor taps, the user does not need to touch the tap to get water. Water is dispensed automatically using infrared sensor activation.

Hygiene

With nothing to reach or touch, sensor taps are more hygienic and promotes germ-free environment. With manual taps, germs and dirt are easily transferred from user to tap or vice versa.

Maintenance

Automatic taps requires less maintenance in terms of parts replacement, cleaning and every day wear and tear.

(B)

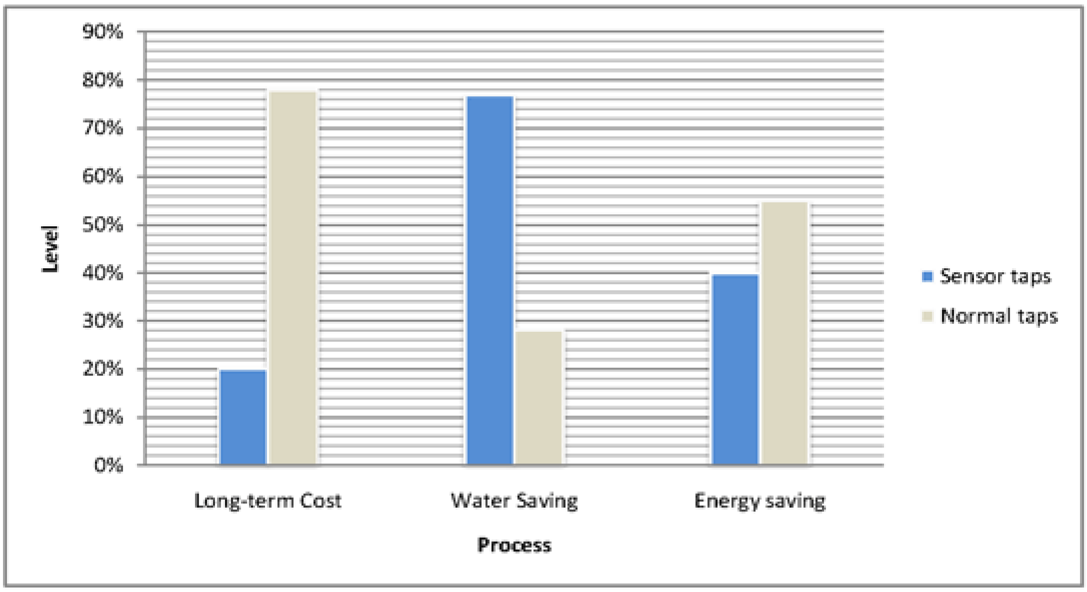


Figure 5.5 : Long-term Cost, Water Saving & energy Saving Chart (4)

Long-Term Cost

Taking water conservation into consideration which in turn saves money on water bills, sensor activated taps saves more money long term.

Water Saving

Users can save up to 70% on water conservation when compared with manual activated taps. A lot of water is wasted when turning the tap on and off manually. With sensor taps, the tap is activated or deactivated within 0.5 second, and does not drip, a common problem with manual taps.

Energy Saving

There's more energy needed when producing sensor taps, but this is greatly reduced when it comes to the amount of water it saves long-term. With manual taps, a lot more water is wasted, which means that a lot of energy is needed to re-process the wastage water back to the consumer.

With sensor tap, less water is wasted and less water for processing plants to process. The level of energy saved is usually not apparent at short-term, but adds up at long-term basis.

(C)

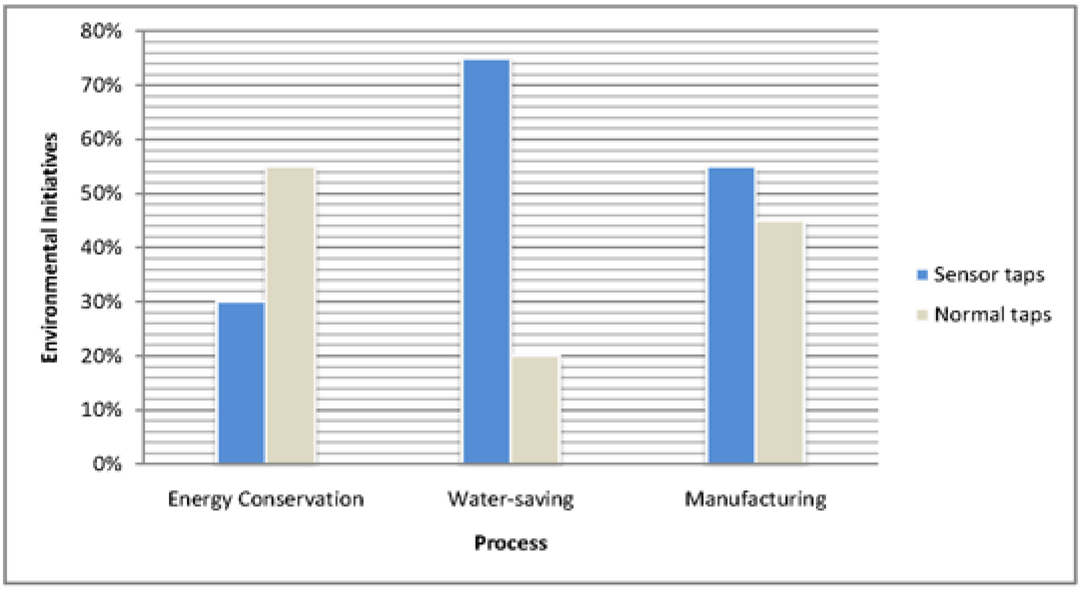


Figure 5.6: Energy Conservation, Water-Saving & Manufacturing Chart

Energy Conservation

In terms of environmental impact, manual taps are discarded in higher percentage than sensor automatic taps. With higher rate, more energy or resources are needed to dispose or recycle them. With most places using normal or conventional taps, the energy cost is considerably higher. Once sensor taps market penetration begins to increase, the graph above will start to change.

Water Conservation

Users can save up to 70% on water conservation when compared with manual activated taps. A lot of water is wasted when turning the tap on and off manually. With sensor taps, the tap is activated or deactivated within 0.5 second, and does not drip, a common problem with manual taps.

Manufacturing

The level of environmental impact of manufacturing is higher in sensor tap. Sensor taps comes with more parts and accessories. As technology and manufacturing process improves, sensor taps will require less parts and less energy in making them.

5.5.6 Times Spent and Water Used in Ablution Sensor Taps And Manual Taps

Regarding the analyzed 70 cases, the total time used in ablution is 33–109.5 s and the amount of water used from all tap types is 0.65–7.33 L. The average total ablution time from the two different tap types is affected by their flow rate and design.

(A)

Table 5.2: Times Spent And Water Used in Ablution from The Mechanical Knob Tap (10)

Actions of Ablution / Times (seconds)		Minimum	Maximum	Average
Opening of water tap and moving palms to water stream		0.5	2.6	1.2
Washing of hands and collecting water in palms for washing of mouth and nose		3.2	17.6	7.6
Washings of mouth and nose cavity, and moving palms to water stream		2.3	19.1	7.6
Collecting water in palms for face wash		1.2	11.0	3.2
Moving palms to water stream, washings of face and bringing arms under water stream		2.2	17.9	6.6
Washing of arms, collecting water in palms for swabbing on head and cleaning of ears		2.6	15.8	7.2
Swabbing on head, cleaning of ears and moving palms and legs to water stream		0.0	17.1	7.4
Washings of legs		4.8	29.5	13.6
Taking legs away from water stream and closing of water tap		2.8	8.0	5.6
Total amounts	Total time that tap maintains open (Seconds)	33.1	109.5	59.9
	Actual total time of using water in ablution (Seconds)	16.6	66.8	31.5
	Total time that water is running without use (Seconds)	10.5	49.2	28.4
	Total amount of water used in ablution (Liters)	0.65	7.33	3.99
	Percentage of tap water wasted during ablution from the tap			**47%**

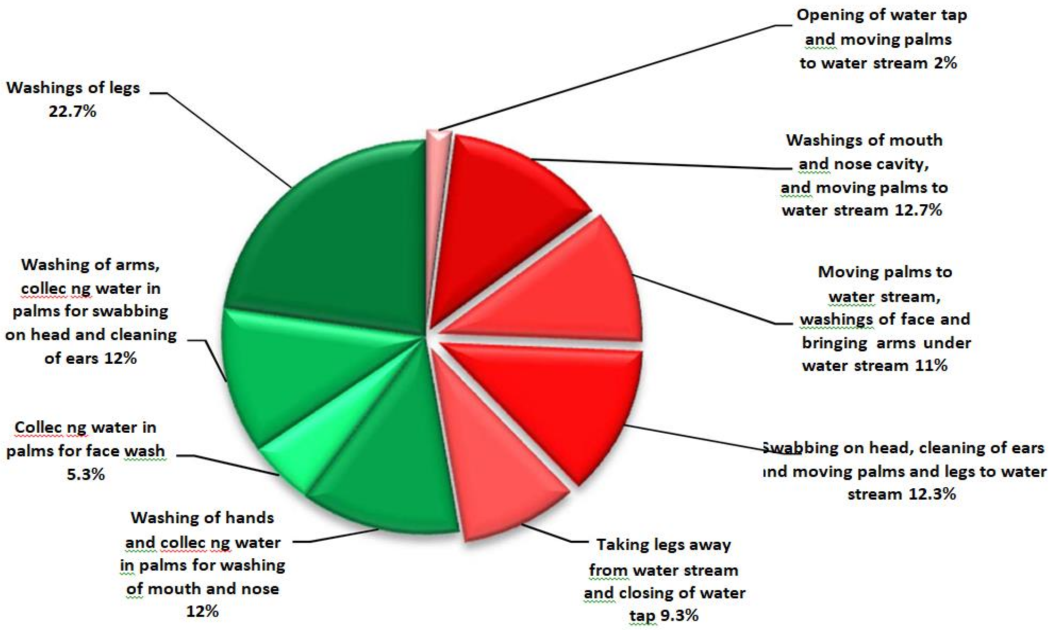


Figure 5.7: Average Time Distribution In Ablution From Slow Opening Knob Tap (10)

(B)

Table 5.3: Times Spent And Water Used in Ablution from The Automatic Tap (10)

Actions of Ablution / Times (seconds)		Minimum	Maximum	Average
Moving palms under tap waiting for water stream (No water flows)		1.2	2.1	1.5
Washing of hands and collecting water in palms for washing of mouth and nose		4.1	5.7	4.63
Washings of mouth and nose cavity, and moving palms to water stream		3	4.2	3.3
Collecting water in palms for face wash		5.8	7.3	6.72
Moving palms to water stream, washings of face and bringing arms under water stream		2.2	16.7	6.5
Washing of arms, collecting water in palms for swabbing on head and cleaning of ears		7.1	8.5	7.6
Swabbing on head, cleaning of ears and moving palms and legs to water stream		3.6	6.6	4.0
Washings of legs		10.1	19.2	13
Taking legs away from water stream and stopping of tap water		0.0	0.6	0.1
Total amounts	Total time that tap maintains open (Seconds)	33	69	45.85
	Actual total time of using water in ablution (Seconds)	18	47	32
	Total time that water is running without use (Seconds)	8	24	13.9
	Total amount of water used in ablution (Liters)	1	3	2
	Percentage of tap water wasted during ablution from the tap			**30.3%**

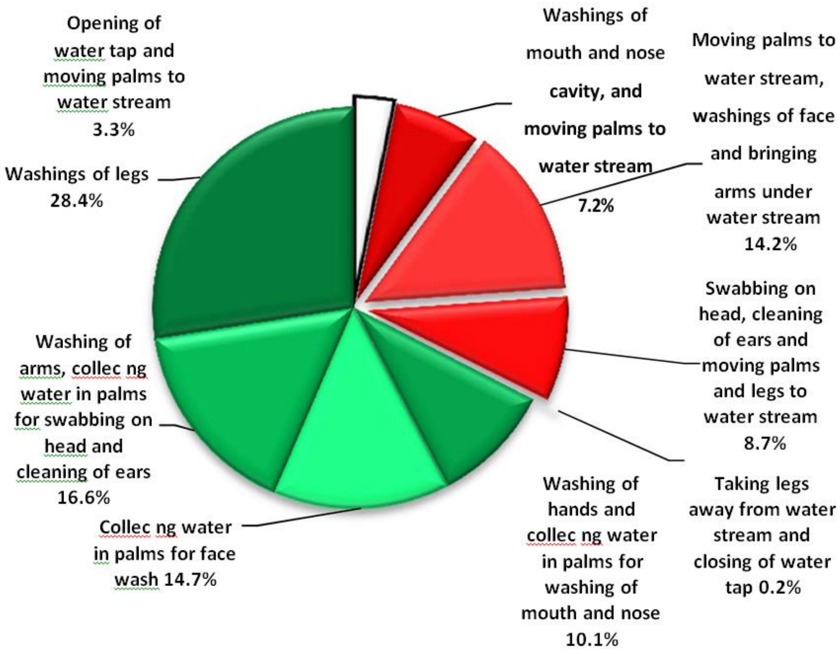


Figure 5.8: Average Time Distribution In Ablution From Automatic Sensor Tap (10)

5.6 Water Consumption Data and Energy Saving Analysis

In this thesis water loss & energy loss was calculated. Firstly, water used in normal tap was calculated. Then, water used in sensor tap was calculated. After taking data for both case both of them were calculated. Then the saved amount of water was found.

5.6.1 Pump Specification

The specifications of the pump are given below:

1. Power: 30 hp

2. Pump Type: End Suction

3. Typical Efficiency: 75% (8)

4. Height of the reservoir from ground level: 170 ft= 51.86m

5 Tank capacity: 100000 L

6. Time required to fill the tank = 32 min = 0.533 hrs

5.6.2 Calculation for pump output

We know,

E = Pt/1000 kWh……………………………………………………… (1)

1 hp = 0.0746 kWh

Assuming 75% efficiency; Input power = $(\frac{30}{.0746 \times .75})$ kWh

=53.62 kWh

5.6.3 Calculation for Traditional Tap

Average water Consumption: Conventional Tap (per day) = 1250.9 L (Appendix-G)

To reserve 100000L time needed= 32 min/60 = 0.533 hrs

,, 1 L time needed $= \frac{0.533}{100000}$ hrs

,, 1250.9 L time needed = $0.533 \times \frac{1250.9}{100000}$ hrs

= 0.006667 hrs

Energy required every day, E = $53620 \times \frac{0.006667}{1000}$ kWh/day

= 0.35764 kWh/day

So, Energy consumption in 1 year (normal tap) = 0.35764 × 365

= 130.54 kWh/year

5.6.4 Calculation for Sensor Tap

Average water Consumption: Conventional Tap (per day) = 1250.9 L (Appendix-G)

Average water Consumption: Sensor Tap (per day) = 767.98 L (Appendix-G)

Water Saving (per day) = 482.92 L

To reserve 100000 L time needed = 32 min/60

= 0.533 hrs

,, 1 L time needed $= \frac{0.533}{100000}$ hrs

,, 767.98 L time needed $= 0.533 \times \frac{482.92}{100000}$ hrs

= 0.00257hrs

We know,

E = Pt/1000 kWh ……………………………………………………………(1)

Energy Saved every day , E $= 53620 \times \frac{0.00257}{1000}$ kw/day

= 0.1378 kWh/day

So, Energy Saved in 1 year = 0.1378 × 365

=50.3 kWh/year

5.6.5 Percentage of Saving

Water Saving

Annual Water Consumption (Conventional Tap) = 456578.5 L (Appendix-H)

Water Saved in 1 year = 176265.8 L

So, Percentage of Water Saved $= \frac{Saved\ Water}{Consumed\ water} \times 100\%$ ……………………...(2)

$= \frac{176265.8}{456578.5} \times 100\%$

= 38.6%

Energy Saving

Annual Energy Consumption (Conventional Tap) = 97.853 kWh

Energy Saved in 1 year = 37.78 kWh

So, Percentage of Energy Saved $= \frac{Saved\ Energy}{Consumed\ energy} \times 100\%$ ………………..(2)

$= \frac{50.3}{130.54} \times 100\%$

= 38.3%

5.6.6 Predicted Total saving of Resources In 4 tower's of MIST

Here , Number of Test Taps = 4

Annual Save In 4 Taps = 176265.8 L

Number of Taps In Tower-1 = 149 …………………….(Appendix-A)

So, Annual Water Save In Tower-1 = $\frac{176265.8 \times 149}{4}$ L

$= 6565901$ L

To reserve 100000L time needed = 32 min/60

$= 0.533$ hrs

,, 1 L time needed $= \frac{0.533}{100000}$ hrs

,, 6565901 L time needed $= 0.533 \times \frac{6565901}{100000}$ hrs

$= 35$ hrs

So, Energy Saved, E $= 53620 \times \frac{35}{1000}$ kWh/year

$= 1876.7$ kWh/year

Commercial Unit Price of Electricity =BDT 30 (2)

Commercial Unit Price of Water = BDT 33.6/1000 L (13)

Annually Saved Resources

Water Save = BDT $(6565901 \times \frac{33.6}{1000})$

= BDT 220614

Electricity save = BDT (30×1876.7)

= BDT 56301

Total = BDT 276,915

So, In four Towers Annual Saving = (276915×4)

= BDT 11,07,660

5.7 Conclusion

From the available data and calculation it is proved that the Automatic Tap imposed in this thesis have a good perspective on reducing the water and energy consumption. Thus a good amount of energy and money can be saved, which can be used in other productions and developments.

CHAPTER SIX

RESULT ANALYSIS AND DISCUSSION

6.1 Introduction

Now-days. Ensuring reliable and quality water supply has become a great challenge for the Government. Limitation of supply and distribution networks, inundation of water layer of Dhaka city is a great threat to sustainable urban life. Bangladesh Government have taken many projects to improve the situation. There is no alternative to minimize water consumption thus increasing energy efficiency to become a developed country. Initiatives should be taken minimize water consumption in communal organizations. Solving the problem of excess water consumption can be achieved technically through good tap control design. The tap design affects the water consumption fashions, thus a good tap deign can greatly help the user to save more water.

6.2 Result Analysis

1. The mechanical knobs tap requires long time for ablution because of the uncomfortable design

2. The relatively long time for the Automatic Tap may be related to its low water flow rate.

3. The largest water amount is used in feet washings and the largest water amount is wasted during washings of face and bringing arms under water stream.

4. The Mechanical knob tap is worse in wasting (38.6 %) . This means that about 35–40 % of the amount of water consumed in ablution from a these taps can be saved if tap releases water only at moments of need.

5. Regarding the Mechanical knob tap, it was found that amount of water released each batch is 3.7 – 11.4 L with an average of 6.8 L and the batch duration is 85-120 s with an average of 87 s. The average water batch released a time is more than the amount that was used by the Holy Prophet.

6. based on these results and data and analysis for best design; discharge during batch time must be decreased.

6.3 Conclusion

Finally to reduce national water crisis, use of efficient water saving technology should be encouraged throughout the country. Institute like MIST can be pioneer by taking steps like installing Automatic sensor Taps. This will also promote social awareness among students which will also play important role to reduce the water consumption of Dhaka.

CHAPTER SEVEN

CONCLUTION AND RECOMMENDATION

7.1 Introduction

Now-a-days water and energy crisis has become a vital problem in the world. Even water and energy crisis is more severe than petroleum. It is said that the third world war will be because of water. So it is our earnest duty to take necessary steps to save water and energy in a modern way.

7.2 Recommendation and Future Work

The detailed results of this thesis shows that Automatic Sensor Tap system shows great promise in both water & energy saving and cost minimization. For using of the Automatic tap in ablution facilities, more studies are required to determine the optimal batch duration and volume for maximum saving. This should be aimed at reducing the initial investment while maintaining the most energy savings possible. Detailed results of this thesis shows that a good amount of energy can be saved by implementing the describe processes. Surplus energy can be used in developments of other sectors.

7.3 Conclusion

With the increasing demand of water and energy in the world, the sources are not increasing. It is very much necessary now to introduce new and newer technologies to rationing water and energy. Motion sensor can be an effective and smart solution on this aspect.

CHAPTER EIGHT

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Appendix A: Installed Traditional Water Tap in Building

Floor	Place	No. of Tap
Ground	Ablution	4
	Basin	2
	Washroom	3
1st	Washroom	8
	Basin	6
2nd	Washroom	8
	Basin	6
3rd	Washroom	8
	Basin	6
4th	Washroom	8
	Basin	6
5th	Washroom	8
	Basin	6
6th	Washroom	8
	Basin	6

7^{th}	Washroom	8
	Basin	6
8^{th}	Washroom	8
	Basin	6
9^{th}	Washroom	8
	Basin	6
10^{th}	Washroom	8
	Basin	6
		Total =149

Appendix B

Table-1: Average flow rate measurment			
Water taken to obtain flowrate litre (L)	Time consumed, (Sec)	Flow rate, (L/s)	Average flow rate, (L/s)
10	2 min 38 sec	0.063	0.063
	2 min 40 sec	0.063	
	2 min 0 sec	0.083	
	1 min 59 sec	0.056	
	3 min 25 sec	0.049	

Appendix B (Continued)

Table-2: Daily Water Consumption (08/09/2017)							
Fazr							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**63**	0.063	**3.954**	**4.669**	**23**	**107.385**
2	**Person-02**	**77**		**4.832**			
3	**Person-03**	**69**		**4.330**			
4	**Person-04**	**88**		**5.522**			
5	**Person-05**	**75**		**4.707**			
Juhr							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**67**	0.063	**4.205**	**4.681**	**82**	**383.880**
2	**Person-02**	**84**		**5.271**			
3	**Person-03**	**57**		**3.577**			
4	**Person-04**	**93**		**5.836**			
5	**Person-05**	**72**		**4.518**			

Asr							
Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	54	0.063	3.389	4.606	31	142.791
2	Person-02	69		4.330			
3	Person-03	74		4.644			
4	Person-04	91		5.711			
5	Person-05	79		4.958			
Maghrib							
Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	127	0.063	7.970	5.547	46	255.184
2	Person-02	78		4.895			
3	Person-03	65		4.079			
4	Person-04	107		6.715			
5	Person-05	65		4.079			
Isha							
Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)

1	**Person-01**	**57**	0.063	**3.577**	**4.794**	**86**	**412.320**
2	**Person-02**	**83**		**5.209**			
3	**Person-03**	**91**		**5.711**			
4	**Person-04**	**107**		**6.715**			
5	**Person-05**	**44**		**2.761**			
Total Water consumption							1301.559

Appendix B (Continued)

Table-3: Daily water consumption (09-09-2017)							
Fazr							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**77**	0.063	**4.832**	**4.794**	**24**	**115.066**
2	**Person-02**	**72**		**4.518**			
3	**Person-03**	**70**		**4.393**			
4	**Person-04**	**85**		**5.334**			
5	**Person-05**	**78**		**4.895**			
Juhr							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**62**	0.063	**3.891**	**4.418**	**63**	**278.327**
2	**Person-02**	**72**		**4.518**			
3	**Person-03**	**82**		**5.146**			
4	**Person-04**	**64**		**4.016**			
5	**Person-05**	**72**		**4.518**			
Asr							

Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	100	0.063	6.275	5.083	42	213.490
2	Person-02	92		5.773			
3	Person-03	70		4.393			
4	Person-04	74		4.644			
5	Person-05	69		4.330			
Maghrib							
Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	62	0.063	3.891	4.242	70	301.195
2	Person-02	80		5.020			
3	Person-03	45		2.824			
4	Person-04	82		5.146			
5	Person-05	69		4.330			
Isha							
Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	88	0.063	5.522	4.644	81	376.149

2	Person-02	52		3.263			
3	Person-03	69		4.330			
4	Person-04	75		4.707			
5	Person-05	86		5.397			
Total Water consumption							1284.226

Appendix B (Continued)

Table-4: Daily water consumption (10-09-2017)							
Fazr							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**62**	0.063	**3.891**	**4.242**	**23**	**97.570**
2	**Person-02**	**79**		**4.958**			
3	**Person-03**	**66**		**4.142**			
4	**Person-04**	**59**		**3.702**			
5	**Person-05**	**72**		**4.518**			
Juhr							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**57**	0.063	**3.577**	**4.418**	**88**	**388.775**
2	**Person-02**	**79**		**4.958**			
3	**Person-03**	**58**		**3.640**			
4	**Person-04**	**89**		**5.585**			
5	**Person-05**	**69**		**4.330**			
Asr							

Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	55		3.451			
2	Person-02	82		5.146			
3	Person-03	127	0.063	7.970	6.514	35	227.986
4	Person-04	137		8.597			
5	Person-05	118		7.405			
Maghrib							
Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	77		4.832			
2	Person-02	131		8.221			
3	Person-03	182	0.063	11.421	7.028	49	344.395
4	Person-04	88		5.522			
5	Person-05	82		5.146			
Isha							
Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	71		4.456			
2	Person-02	54		3.389			
3	Person-03	138	0.063	8.660	5.911	24	141.875
4	Person-04	91		5.711			
5	Person-05	117		7.342			
Total Water consumption							1200.600

Appendix B (Continued)

Table-5: Daily water consumption (11-09-2017)							
Fazr							
Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	60	0.063	3.765	4.518	24	108.439
2	Person-02	81		5.083			
3	Person-03	76		4.769			
4	Person-04	65		4.079			
5	Person-05	78		4.895			
Juhr							
Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	79	0.063	4.958	5.711	92	525.378
2	Person-02	59		3.702			
3	Person-03	122		7.656			
4	Person-04	108		6.777			
5	Person-05	87		5.460			
Asr							
Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	111	0.063	6.966	5.660	33	186.794
2	Person-02	63		3.954			
3	Person-03	132		8.284			

4	**Person-04**	**78**		**4.895**			
5	**Person-05**	**67**		**4.205**			
Maghrib							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**57**	0.063	**3.577**	**6.225**	**46**	**286.360**
2	**Person-02**	**95**		**5.962**			
3	**Person-03**	**126**		**7.907**			
4	**Person-04**	**134**		**8.409**			
5	**Person-05**	**84**		**5.271**			
Isha							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**71**	0.063	**4.456**	**6.439**	**27**	**173.842**
2	**Person-02**	**138**		**8.660**			
3	**Person-03**	**102**		**6.401**			
4	**Person-04**	**118**		**7.405**			
5	**Person-05**	**84**		**5.271**			
Total Water consumption							1280.813

Appendix B (Continued)

Table-6: Daily water consumption (12-09-2017)							
Fazr							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**63**	0.063	**3.954**	**4.493**	**25**	**112.330**
2	**Person-02**	**79**		**4.958**			
3	**Person-03**	**78**		**4.895**			
4	**Person-04**	**62**		**3.891**			
5	**Person-05**	**76**		**4.769**			
Juhr							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**70**	0.063	**4.393**	**5.397**	**87**	**469.527**
2	**Person-02**	**93**		**5.836**			
3	**Person-03**	**78**		**4.895**			
4	**Person-04**	**81**		**5.083**			
5	**Person-05**	**108**		**6.777**			
Asr							

Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	78	0.063	4.895	7.681	39	299.563
2	Person-02	144		9.037			
3	Person-03	108		6.777			
4	Person-04	173		10.856			
5	Person-05	109		6.840			
Maghrib							
Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	80	0.063	5.020	5.485	51	279.720
2	Person-02	77		4.832			
3	Person-03	92		5.773			
4	Person-04	84		5.271			
5	Person-05	104		6.526			
Isha							
Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	78	0.063	4.895	6.476	30	194.287

2	**Person-02**	**144**		**9.037**			
3	**Person-03**	**108**		**6.777**			
4	**Person-04**	**77**		**4.832**			
5	**Person-05**	**109**		**6.840**			
Total Water consumption							1355.427

Appendix B (Continued)

Table-7: Daily water consumption (13-09-2017)							
Fazr							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**59**	0.063	**3.702**	**4.456**	**25**	**111.389**
2	**Person-02**	**77**		**4.832**			
3	**Person-03**	**75**		**4.707**			
4	**Person-04**	**66**		**4.142**			
5	**Person-05**	**78**		**4.895**			
Juhr							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**71**	0.063	**4.456**	**6.413**	**81**	**519.492**
2	**Person-02**	**139**		**8.723**			

3	**Person-03**	**102**		**6.401**			
4	**Person-04**	**118**		**7.405**			
5	**Person-05**	**81**		**5.083**			
Asr							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**80**	0.063	**5.020**	**5.485**	**29**	**159.057**
2	**Person-02**	**77**		**4.832**			
3	**Person-03**	**92**		**5.773**			
4	**Person-04**	**84**		**5.271**			
5	**Person-05**	**104**		**6.526**			
Maghrib							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**118**	0.063	**7.405**	**6.514**	**46**	**299.639**
2	**Person-02**	**137**		**8.597**			
3	**Person-03**	**55**		**3.451**			
4	**Person-04**	**82**		**5.146**			
5	**Person-05**	**127**		**7.970**			

Isha							
Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	78	0.063	4.895	6.275	25	156.885
2	Person-02	72		4.518			
3	Person-03	131		8.221			
4	Person-04	124		7.782			
5	Person-05	95		5.962			
Total Water consumption							1246.461

Appendix B (Continued)

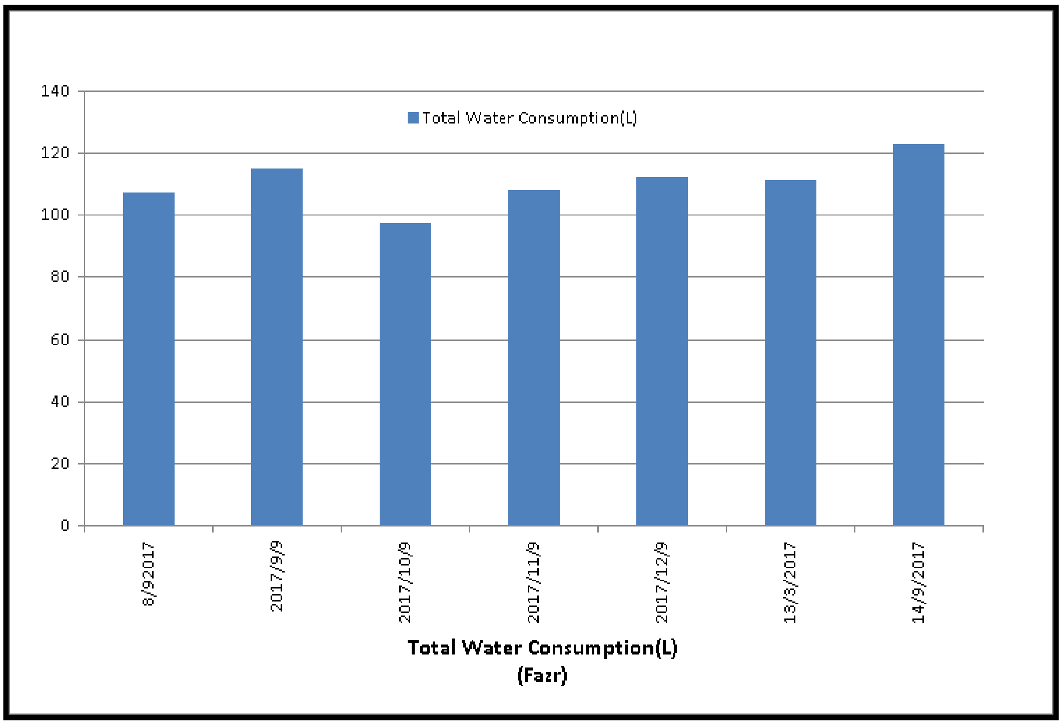
Table-8: Daily water consumption (14-09-2017)							
Fazr							
Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	Person-01	63	0.063	3.954	4.732	26	123.023
2	Person-02	70		4.393			
3	Person-03	83		5.209			
4	Person-04	72		4.518			
5	Person-05	89		5.585			
Juhr							

Serial	Observation	Time. (sec)	Avg. Flow rate, (L/s)	Water consumed per person, (L)	Avg. Water consumed, (L)	Total consumer	Total water consumed, (L)
1	**Person-01**	**67**	0.063	**4.205**	**5.811**	**84**	**488.127**
2	**Person-02**	**109**		**6.840**			
3	**Person-03**	**89**		**5.585**			
4	**Person-04**	**76**		**4.769**			
5	**Person-05**	**122**		**7.656**			
<u>Asr</u>							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**85**	0.063	**5.334**	**6.263**	**32**	**200.412**
2	**Person-02**	**112**		**7.028**			
3	**Person-03**	**79**		**4.958**			
4	**Person-04**	**136**		**8.535**			
5	**Person-05**	**87**		**5.460**			
<u>Maghrib</u>							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**77**	0.063	**4.832**	**6.188**	**47**	**290.815**

2	**Person-02**	**131**		**8.221**			
3	**Person-03**	**85**		**5.334**			
4	**Person-04**	**98**		**6.150**			
5	**Person-05**	**102**		**6.401**			
Isha							
Serial	**Observation**	**Time. (sec)**	**Avg. Flow rate, (L/s)**	**Water consumed per person, (L)**	**Avg. Water consumed, (L)**	**Total consumer**	**Total water consumed, (L)**
1	**Person-01**	**58**	0.063	**3.640**	**4.794**	**28**	**134.244**
2	**Person-02**	**69**		**4.330**			
3	**Person-03**	**82**		**5.146**			
4	**Person-04**	**78**		**4.895**			
5	**Person-05**	**95**		**5.962**			
Total Water consumption							1236.621

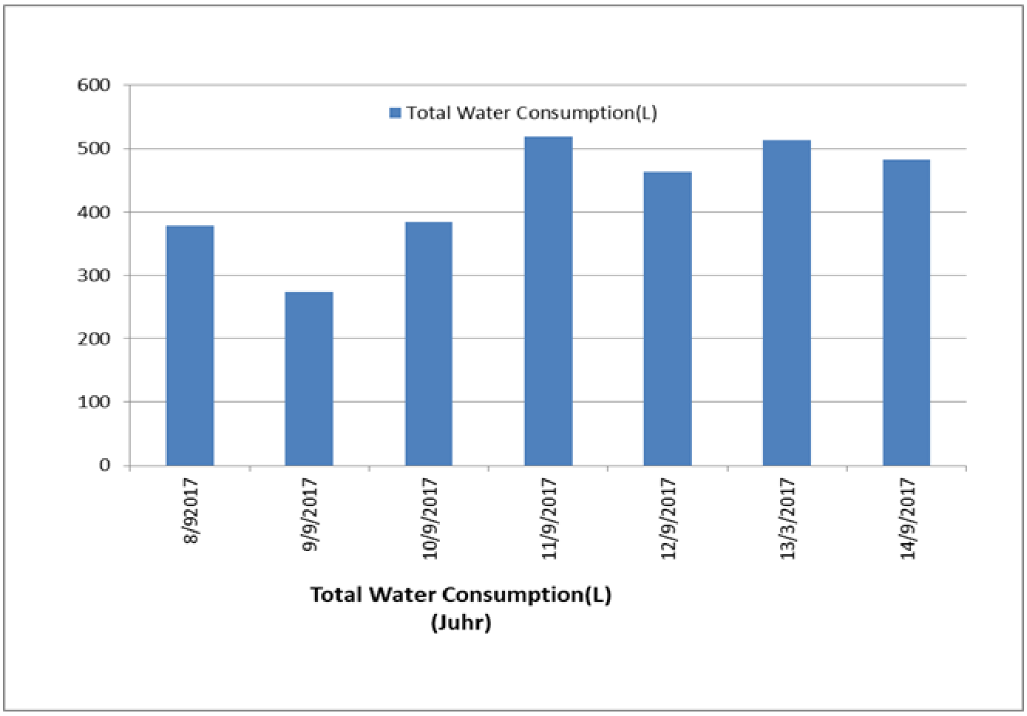
Appendix C

table-9: Per Waqt water consumption (fazr)				
Serial No	Date	Total Water Consumption(L)	Total water consumption in week (L)	Average Water Consumption/day (L)
1	8/92017	107.385	775.203	110.7433
2	2017/9/9	115.066		
3	2017/10/9	97.570		
4	2017/11/9	108.439		
5	2017/12/9	112.330		
6	13/3/2017	111.389		
7	14/9/2017	123.023		



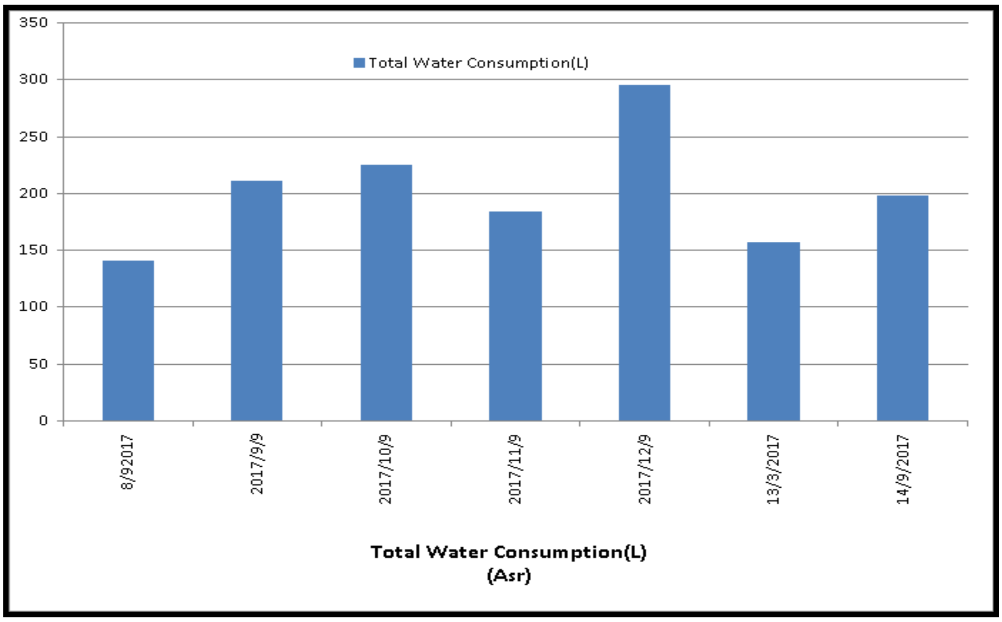
Appendix C (Continued)

Table-10: Per waqt water consumption (Juhr)				
Serial No	Date	Total Water Consumption(L)	Total water consumption in week (L)	Average Water Consumption/day (L)
1	8/92017	379.250	3016.622	430.946
2	2017/9/9	274.932		
3	2017/10/9	384.032		
4	2017/11/9	519.064		
5	2017/12/9	463.884		
6	13/3/2017	513.216		
7	14/9/2017	482.244		



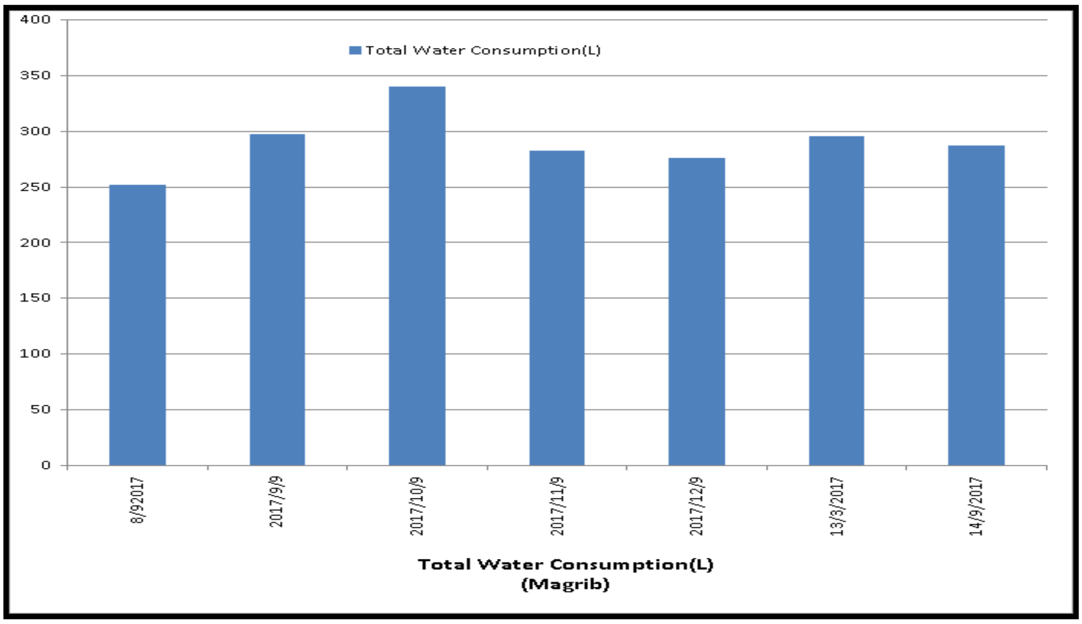
Appendix C (Continued)

Table-11: Per Waqt water consumption (Asr)				
Serial No	Date	Total Water Consumption(L)	Total water consumption in week (L)	Average Water Consumption/day (L)
1	8/92017	141.050	1412.773	201.825
2	2017/9/9	210.924		
3	2017/10/9	225.225		
4	2017/11/9	184.536		
5	2017/12/9	295.932		
6	13/3/2017	157.122		
7	14/9/2017	197.984		



Appendix C (Continued)

Table-12: Per waqt water consumption(Maghrib)				
Serial No	Date	Total Water Consumption(L)	Total water consumption in week (L)	Average Water Consumption/day (L)
1	8/92017	252.080	2032.436	290.348
2	2017/9/9	297.561		
3	2017/10/9	340.256		
4	2017/11/9	282.9		
5	2017/12/9	276.318		
6	13/3/2017	296.01		
7	14/9/2017	287.311		

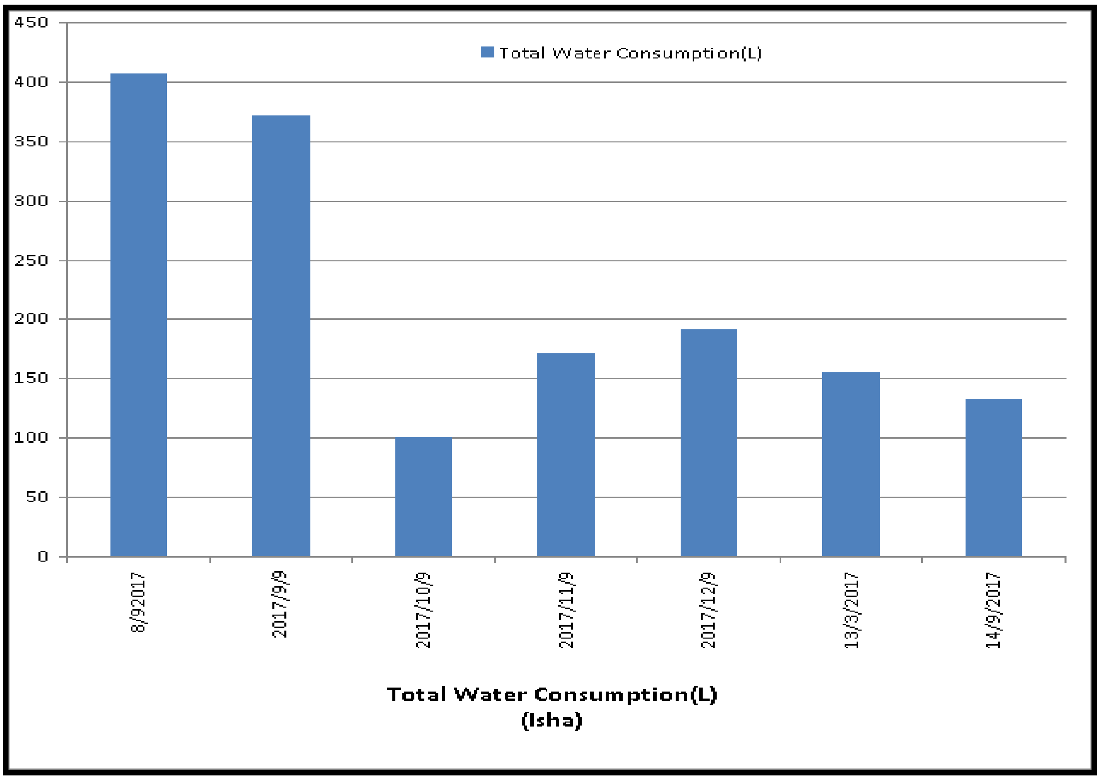


Appendix C (Continued)

Table-13: Per Waqt water consumption (Isa)

Serial No	Date	Total Water Consumption(L)	Total water consumption in week (L)	Average Water Consumption/day (L)
1	8/92017	407.296	1531.369	218.767
2	2017/9/9	371.618		
3	2017/10/9	101.16		
4	2017/11/9	171.747		

5	2017/12/9	191.94		
6	13/3/2017	155		
7	14/9/2017	132.608		



Appendix D

Table-14: Total water Consumption in one year

Serial	Name of the Waqt	Water Consumption Per day per Waqt(L)	Daily Water Consumption	Total Water Consumption Per Year(L)
1	Fazr	110.743	1250.909	456581.785
2	Juhr	430.946		
3	Asr	201.819		
4	Maghrib	290.348		
5	Isha	217.053		

Appendix E

	Table-15: Average Number of People				
Serial	Date	Name of waqt	No. of People Per Waqt	Total No. of People Per Day	Average No. of People
1	08.08.17 (Tuesday)	Fazr	23	268	235
		Juhr	82		
		Asr	31		
		Maghrib	46		
		Isha	86		
2	09.08.17 (Wednesday)	Fazr	24	281	
		Juhr	63		
		Asr	42		
		Magrib	71		
		Isha	81		
3	10.08.17 (Thursday)	Fazr	24	220	
		Juhr	88		
		Asar	35		
		Maghrib	49		
		Isha	24		
4	11.08.17 (Friday)	Fazr	24	222	

		Juhr	92		
		Asr	33		
		Maghrib	46		
		Isha	27		
5	12.08.17 (satday)	Fazr	25	232	
		Juhr	87		
		Asar	39		
		Maghrib	51		
		Isha	30		
6	13.08.17 (sunday)	Fazr	25	206	
		Juhr	81		
		Asr	29		
		Maghrib	46		
		Isha	25		
7	14.08.17 (Monday)	Fazr	26	217	
		Juhr	84		
		Asr	32		
		Maghrib	47		
		Isha	28		

Appendix F

Table-16: Data Collection for Sensor Tap

Serial	Obs No:	Water Consumption (L)	Total Water Consumption(L)	Water Consumption for per person per waqt (L)
1	Person 1	3.23	32.68	3.268
2	Person 2	3.41		
3	Person 3	3.32		
4	Person 4	3.17		
5	Person 5	3.05		
6	Person 6	3.12		
7	Person 7	3.4		
8	Person 8	3.11		
9	Person 9	3.23		
10	Person 10	3.64		

Appendix G

Table-17: Annual Water Saving					
Average Water Consumption : sensor Tap per person (L)	Average No of People Prayed per day	Average Total Water Consumed: Sensored Tap per day (L)	Avarage Total Water Consumption: conventional Tap per day(L)	Water Saved per day (L)	Water saved Annually(L)
3.27	235.00	767.98	1250.9	482.92	176265.8

Appendix H

Table-18: Relation Between humidity and Average Water Consumption

Humidity(%)	Total water consumed for 5 persons(L)	Average water consumed per person(L)
63	29.32	5.86
67	34.1	6.82
69	22.4	4.48
71	16.66	3.33
72	21.79	4.36
74	19.11	3.82
75	23.61	4.72
77	25.19	5.04
78	23.4	4.68
79	18.53	3.71
80	27.42	5.48
82	22.23	4.45
84	22.18	4.54
	22.98	
	22.98	
86	16.56	3.31
87	23.73	4.98
	26.05	
90	25.13	4.95
	24.34	
91	17.53	3.51
92	24.93	4.99

94	23.49	4.85
	24.98	
96	24.39	5.95
	26.05	
	38.88	
98	29.79	5.96