WATER CONSUMPTION PATTERN IN HIGH RISING BUILDINGS AND EVOLVING WATER MANAGEMENT & CONSERVATION OPTIONS

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ABSTRACT

Water Conservation *in Buildings has received increasing attention in recent years due to ever growing water scarcity. The situation is going to be worse because of rapid urbanization and population growth. A number of water consumption studies in high rising buildings have reported a huge potential in water saving options. However it is agonizing to see that this potential is not properly harnessed in our country. There is a general lack of awareness on the importance of reducing specific water consumption. Authorities of many high rising government and corporate buildings have generally ignored the importance (economic as well as resource conservation) of saving water, possibly due to lack of awareness.*

This work aims to address the lack of coverage in academic literature by presenting a review of water use in a high rising building, water usage pattern, water conservation and exploring the potential of water management. The work findings pertain to a real life case study of a high rising building in the national capital of India (New Delhi). The flow rates of the conduits in the distribution system were determined by an ultrasonic flow meter and by filling method. The main objectives are to quantify water usage, provide a profile of the distribution system and to identify areas where water consumption can be reduced, thereby facilitating easier and effective management of water resources and improved reliability.

This case study helps to understand the actual demand, wastage points, estimation of the saving potential and the ways to achieve savings.

1.0 INTRODUCTION

We all know that water is essential for all forms of life in the planet. So far as fresh water is concerned, it is unique, crucial and very scarce resource. It cannot be substituted by any other substance in the world for its specific purpose.

With unabated industrial and infrastructural development and population growth, requirement of all natural resources, especially water has drastically increased in recent years.[1] Water, as per our needs/ requirements is not available. Supply is not adequate as per the demand. The demand- supply gap is increasing day by day and is set to become worse in coming future.

Out of the total water content in the world, only about one percent is accessible freshwater whereas two percent is locked away as ice caps and glaciers at the Polar Regions, far distant from any human habitation and thus is not available for our use virtually. The surface water is renewed by rainfalls and thus becomes available to us on sustainable basis. A break up of the Global water distribution is given in Table 1.

Table 1: The global water distribution[2]

Sr. No	Global Water Distribution	(%)
1	Oceans, Seas, & Bays	**96.5**
2	Ice caps, Glaciers, & Permanent Snow	**1.74**
3	Groundwater	**1.7**
4	Soil Moisture	**0.001**
5	Ground Ice & Permafrost	**0.022**
6	Lakes	**0.013**
7	Atmosphere	**0.001**
8	Swamp Water	**0.0008**
9	River	**0.0002**
10	**Biological water**	**0.0001**

Source: Gleick, P. H., 1996

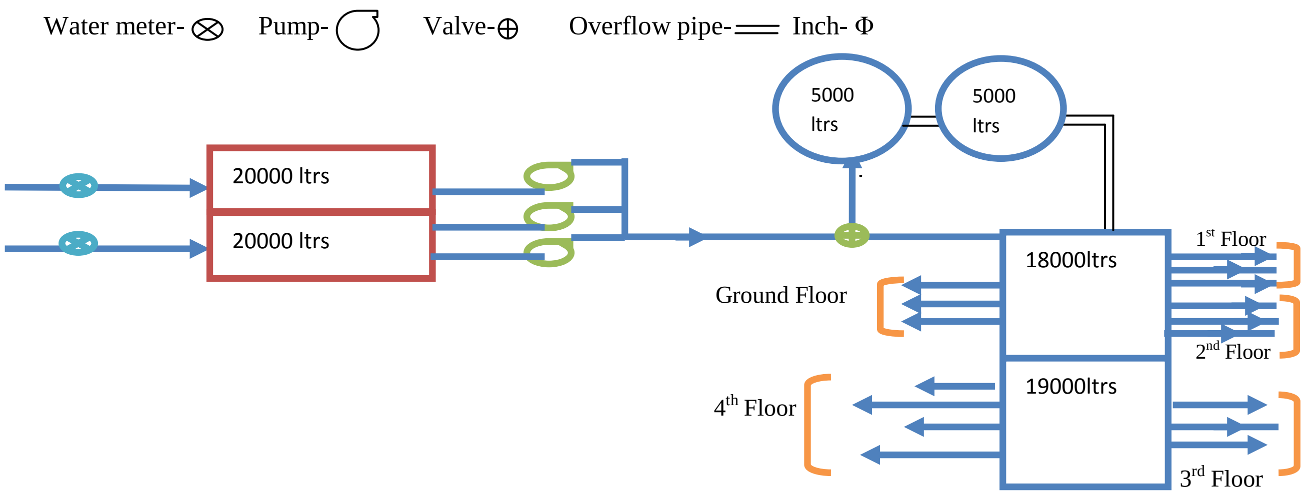
As per a study by Development Alternatives the demand from domestic sector over the next twenty years will increase from 25 billion m^3 to 52 billion m^3. However, this increase in the demand from the domestic sector will not be as much as that from other sectors over the next several years.(Development Alternatives 2002) Currently, only 85% of the urban and 79% of the rural population has access to safe drinking water and fewer still have access to adequate sanitation facilities. Recognizing that the growing demand for water in agriculture and industries sets a pattern of water scarcity even in areas where there is sufficient water for domestic purpose, the national water policy has rightly prioritized drinking water over other uses. However, in giving subsidies to the industrial and agriculture sectors where the water consumption is highest and allowing these sectors to use more water at negligible prices, the government has effectively contradicted its own water policy. This has resulted in mining of ground water leading to a rapidly falling water table.

With the Indian economy on the rise and the large number of people moving to the urban areas, demand for high rise buildings is increasing.[3] The reasons are; the lack of space for construction, ensuring security, maintenance and comparatively cheaper construction costs. Most of the high rise buildings are found in places where space is at a premium. The high rise buildings also come with its own set of problems like for a particular space (i.e. land occupied by high rise buildings) it uses more energy and resources thereby causing a stress for the environment. The height of the building also means that more energy is to be utilized to do this. In addition to that the distribution system is also much more complicated and the chances of leakages are greater than before.

1. ABOUT THE BUILDING

Like any typical high rising building in the capital this building also uses fresh water for its daily activities. Although the water bill paid to NDMC is based on certain average value amounting to about 1100 rupees per month. The Building receives water supply from two NDMC pipe lines which are of 0.5 inch diameter each. The water is usually supplied thrice during a day i.e from 6am to 10am, 1pm to 2 pm and 6pm to 8pm. The water is stored in two inter connected underground tanks of 20000 litres capacity each. The water is then pumped to the highest point of the building to be distributed to the different floors by gravitational distribution. There are three 10 Hp pumps that are used to pump water to the overhead tanks, two of these are standby and only one runs at a time. The schematic of the water distribution system of the building is given in the following fig. 1.

Fig 1: Schematic showing the water flow & storage system in the building



The typical areas of water consumption in this building have been shown below. The areas of water consumption are given in **Table 2**.

S.No.	Area	Location	Remark
1.	Water taps	All floors	No. of taps frequently used by people for hand washing
2.	Toilet	All floors	Intermittent use
3.	Kitchen	3rd floor	Frequently used as no. of seminars/event being organized
4.	Tea room	All floors	For preparation of working tea
5.	Floor cleaning	All floors	Daily
6.	Gardening	Outside the building	Daily in the morning but by using raw water
7.	Drinking	All floors	Intermittent usage
8.	Others		DG cooling sets, make up water, bottled water

It is observed that the water requirement in the above usage areas is not uniform and varies as per the requirement/visitors per day etc. However an attempt has been made to quantify the water usage by various techniques like Ultra Sonic Flow Meter, dip method, bottle filling method. The following calculation shows the Specific Energy Consumption of the building.

Now, the annual run hour of the pump would be;

(a) Working Days (65 min/day 245 days) = 245 hrs

(b) Non working Days (30 min/day 120days) = 60 hrs

Total = <u>310 hrs</u>

Annual Energy Consumption by the Pump

Pump capacity = 10 Horse Power (hp) = 10*0.75 = 7.5 kilo watt (kw)

Considering 90% loading the power consumption would be 7.5*0.9 = 6.75kw

So Annual energy kilo Watt hour (kWh) consumption is 6.75*310 = 2092.5kwh

Specific Energy Consumption (SEC)

As per actual flow measurement, it is found out that the pump delivers at 48m^3/hr of water.

Water pumped annually = Flow * run hour = 48*310 = 14880 m^3

1 m^3 = 1000 ltrs = 14880 kilo litres (kltrs)

Hence SEC = Energy consumption/Water quantity

=2092.5/14880 = 0.140625 kWh

2. OBSERVATIONS

During the field work, the following observations have been made regarding water distribution system and usage in the building.

- There are water flow meters installed for each NDMC supply line. However, it is observed that water meters are not functional. The water billing is done based on an average reading and charged provisionally.
- There is a semi automatic water level controller for the building (i.e. Called as Status) which sets of an alarm if there is any overflow from the over head tanks or the underground tanks and is working fine.
- People usually wash their hands twice while using the washbasins. This means two dispersions of water occur from infra red sensor taps for every usage.
- There are seven toilets with flushing systems on the ground floor, five on the first floor, three on the second floor, four (ladies rest room is under renovation so there are two working) on the third floor and six on the fourth floor.
- An average of eight to nine liters of water is used per flush and some flushing systems don’t work properly.
- Drinking water is treated by aqua guard and then cooled by the water dispensers.
- There are two dispensers on the ground floor with a capacity of 150 and 100 litres respectively.
- There is one water dispenser on the first floor with a capacity of 100 liters.
- There is one water dispenser on the second floor with a capacity of 80 liters.
- There is no water dispenser on the third floor and bottled water (average of 20x6 liters) is usually used.
- There is one water dispenser on the fourth floor with a capacity of 160 liters.
- There is a high amount of water lost by the cooling towers by drift and blow out.
- There are some minor leaks (i.e. 5 drops per minute) seen on the 3 inch pipes and the 2 inch distribution pipes in the building
- Some of the water dispensers also have leaks especially the one close to the canteen.
- Water for gardening is used from a different line (raw water). A hose is used to spray water onto the plants.

The kitchen on the third floor and the canteen consumes lot water for washing of dishes and for cooking.

Following table shows the water consumption in each floor. The flow is calculated by filling method.

Table 3: Water consumption on each floor

Floor	Area of use	Flow/sec	No. of faucets/flushing system	Time (sec)	No. of people per floor	Total lts. (Q)/Day
4th	Kitchen	0.143	2	21600	100	3088
	Toilets(taps)	0.077	14	1800		138
	Flush	1.2	6	1800		2160

	Washbasins	0.077	8	4002		316
	Urinals	0.067	5	2400		160
	Drinking water	0.03	2	2500		75
3rd	Kitchen	0.154	3	11000	60	2772
	Kitchen WM	0.154	3	21600		3326.4
	Toilets(taps)	0.2	6	900		180
	Flush	0.9	2	420		378
	Washbasins	0.09	4	1800		170
	Urinals	0.067	5	1200		80
	Drinking water		Nil			
2nd	Kitchen	0.154	1	9000	80	1386
	Toilets(taps)	0.167	8	900		150
	Flush	0.6	3	900		540
	Washbasins	0.09	5	4000		360
	Urinals	0.058	4	960		55
	Drinking water	0.035	1	2714		95
1st	Kitchen	0.167	3	21600	90	3607
	Toilets(taps)	0.2	10	900		180
	Flush	0.5	5	1800		900
	Washbasins	0.057	5	6360		362
	Urinals	0.038	4	1800		69
	Drinking water	0.033	1	3182		105
GF	Kitchen	0.25	4	3600	100	900
	Toilets(taps)	0.185	14	12600		2331
	Flush	1	7	3600		3600
	Washbasins	0.125	7	3920		490
	Urinals	0.077	7	1680		130
	Drinking water	0.034	2	4706		160
Total Water Consumption						28183

Total water consumption of the whole building per day is 28.183 kl.

Following table shows the water consumption during normal hours. The drop in height in overhead tanks was calculated by dipping method.

Table 4: Water consumption during normal hours

S.No	**Date**	**Days**	**Level controlled Volume of water in the overhead tanks**	**Drop in the height of water(m) at 12pm -1pm**	**Volume of water after usage into overhead tanks**	**Estimated Volume of water used**	**Estimated loss (ltrs)**
1	16-6-08	Monday	26236	.12	2811	2635	176
2	18– 6-08	Wednesday	26236	.11	2570	2420	150

3	20-6-08	Friday	26236	.o6	1405	1238	167
4	24-6-08	Tuesday	26236	.o9	2108	1886	222
5	26-6-08	Thursday	26236	.07	1639	1646	-7
6	28-6-08	Saturday	26236	.04	937	874	63
7	30-6-08	Monday	26236	.08	1874	1734	140
8	2-7-08	Wednesday	26236	.11	2570	2367	203
9	4-7-08	Friday	26236	.10	2342	2278	64
10	7-7-08	Monday	26236	.08	1874	1685	189
11	9-7-08	Wednesday	26236	.07	1639	1700	-61
12	11-7-08	Friday	26236	.06	1405	1289	116
13	12-7-08	Saturday	26236	.04	937	874	63
14	15-7-08	Tuesday	26236	.13	3045	2904	141
15	17-7-08	Thursday	26236	.08	1874	1680	194

The measurements between 12 pm to 1 pm which have been used as an average for water consumed per hour and estimated the actual volume of water used in accordance with the number of people and the water usage areas. There is a fluctuation in the readings because of the difference in the number of people present and the water usage areas at that time. It is observed that there is water lost in most of the days when compared to the estimated water used, this maybe because of excessive use of water for the activities like flushing, the extra dispersion of water that is lost after hand washing as controlled by the infrared sensors, cleaning the utensils in high flow taps, etc.

Table 5: Water consumption during peak hours

S.No	Date	Days	Level controlled Volume of water in the overhead tanks	Drop in the height of water(m) at 1.40pm - 2.40pm (peak hour)	Volume of water after usage into overhead tanks
1	09-6-08	Monday	26236	.15	3513
2	11– 6-08	Wednesday	26236	.18	4216
3	13-6-08	Friday	26236	.19	4450
4	17-6-08	Tuesday	26236	.26	6090
5	19-6-08	Thursday	26236	.22	5153
6	21-6-08	Saturday	26236	.06	1405
7	23-6-08	Monday	26236	.20	4685
8	25-6-08	Wednesday	26236	.20	4685
9	27-6-08	Friday	26236	.19	4450
10	01-7-08	Tuesday	26236	.17	3982
11	03-7-08	Thursday	26236	.18	4216
12	05-7-08	Saturday	26236	.07	1639
13	07-7-08	Monday	26236	.19	4450
14	09-7-08	Wednesday	26236	.21	4919
15	11-7-08	Friday	26236	.25	5856

The measurements between 1.40 pm to 2.40 pm which have been used as the amount of water consumed during peak hour. The volume of water used during peak hours is much more than the volume of water that is used during normal hours which was taken as 12 pm to 1 pm. The peak hours are after lunch time so the water used in kitchen and the flushing systems in the toilets accounts for the increase in the amount of water consumed should be taken to reduce the water bill by efficient activities.

From Table 4 and 5 it is seen that the quantity of water used is much more during the peak hours (1.40 pm to 2.40 pm). This is because more water is used to clean the dishes in kitchens, in toilets and washing hands. It is seen that non working days have a comparatively lesser amount of water consumption as there is lesser number of people

Table 6. Total quantity of water used in working and non working days

Working days	Usage Time	Quantity used(ltrs)	Waste (ltrs)
	Peak hrs	4216.6	397.8
	Non peak hrs	1939.52	149.6
Non working days	Peak hrs	1317	223
	Non peak hrs	93	62.5

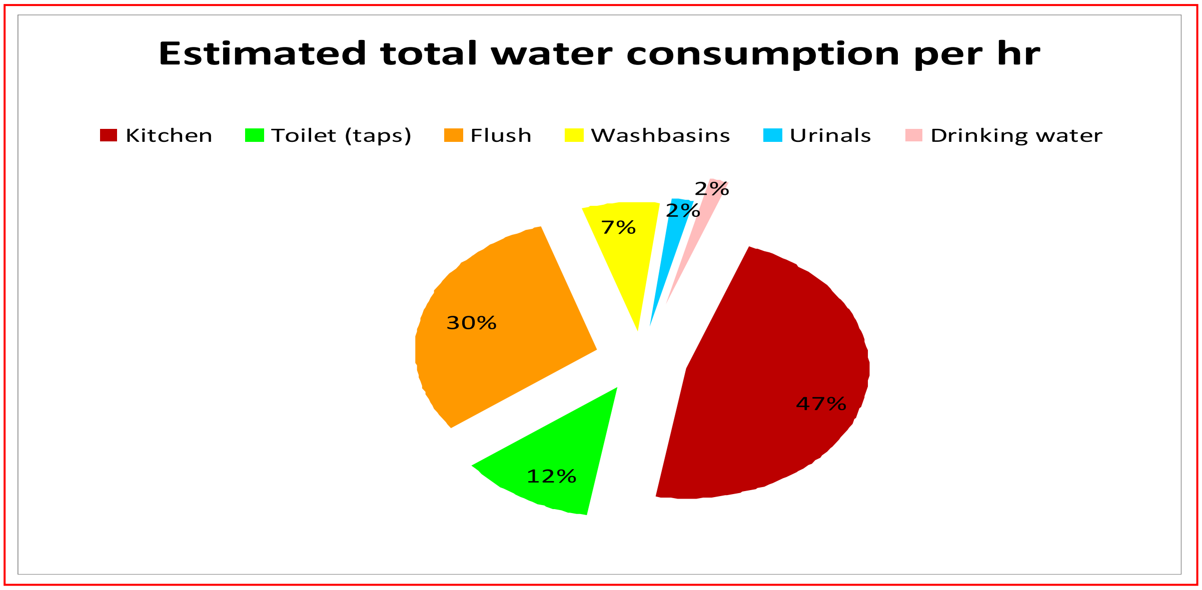
It can be seen that the largest water consumer is the kitchen (47% of total) but if we put together all the components in the toilets that is, the taps, the flushing systems, the washbasins and the urinals we can see water consumed is comparatively more than in the kitchen (i.e. 51% of the total). Water use in kitchen is 11.735 kl/day whereas total water used in toilets is 12.749 kl/day.

In addition to this, an attempt was made to find out the quantity of water usage in a working day. Field work was conducted on 11th July 2008. Quantification by dip method established that about 29.28 kl of water is consumed per day. This amount exceeds the estimated water consumption (24.937 kl) by approximately 4343 litres. This maybe because of some unaccounted water consumption in few of the areas and assumptions adopted for estimations.

Table 7: Area wise water consumption

Area of use	Estimated total water consumption per day
Kitchen	11753
Flush	7578
Toilet (taps)	2979
Washbasins	1698
Urinals	494
Drinking water	435
Total	24.937 kl

The share of water usage in different usage area of building is shown in **figure 2.**

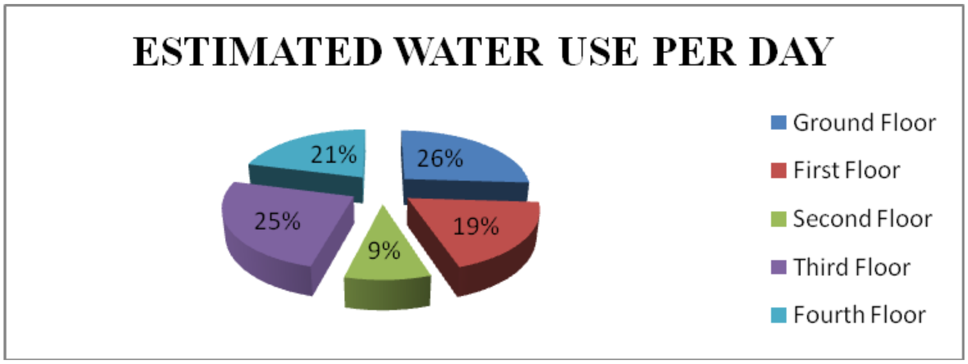


Similarly, it is estimated that the largest water consuming floor is the ground floor. This is because of the comparatively higher flow rates. The third floor comes in second because of the water that is used in the kitchen for its various uses. The water consumption in the third floor can fluctuate from the being the highest to the lowest depending on the number of conferences/meetings that are held there. It seems that the second floor consumes the least amount of water this may be because of the lesser number of faucets and flushing systems.

Table 8: Estimated water use of each floor

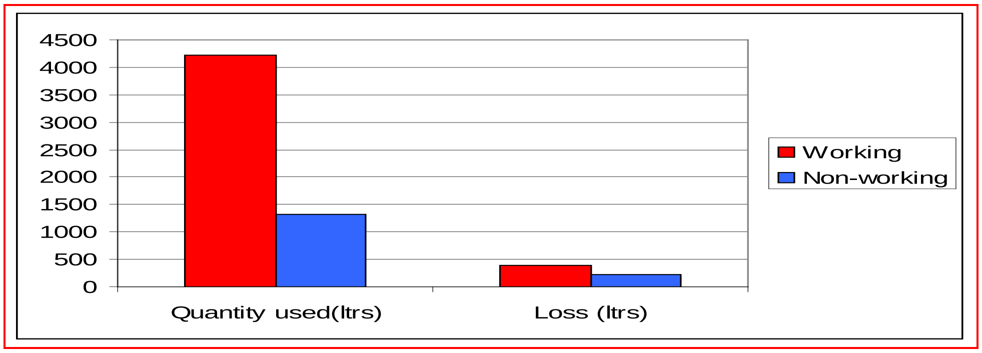
FLOOR	ESTIMATED WATER USE (litre/day)
GROUND FLOOR	7611
1ST	5223
2ND	2586
3RD	6906.4
4TH	5857

Figure 3. Estimated water use per day (floor wise)



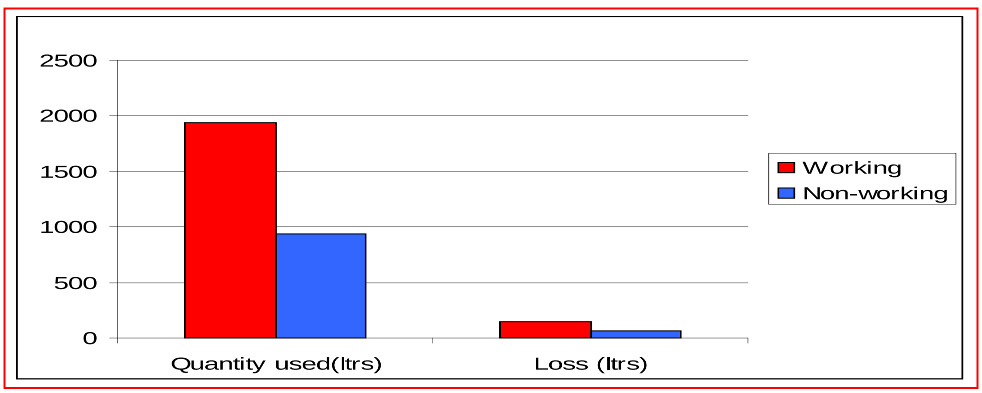
It is observed that during peak hours of working days more water is consumed (4216 litres); hence more water is lost (397 litres).

Graph 1: Quantity of water used during peak hours



On working days the quantity used maybe more than 40000 litres per day because more people will use water for various activities. On non working days the water consumed during the peak hours is around 1317 litres and since the water consumed is less the loss is lesser (149 litres).

Graph 2: Quantity of water used during non peak hours



Now during non peak hours of working days the water consumed is around 1940 Liters is lesser than that of peak hours. This is probably because the employees hardly ever use the rest rooms at around the non peak hours and water consumed in the kitchens is comparatively lesser. The water loss is around 149 Liters which is also lesser than that of peak hours.

3. SUGGESTIONS

The following suggestions and recommendations are made based on the field study and subsequent observations:

Investment Attached Recommendations

- Exploring the possibility of installing waterless urinals working on Eco trap principle maybe done which would save at least 148.2 kl annually. Similarly installation of low flush systems would save more than 1138.2 kl annually.
- It is suggested to use an aerator and/or a water flow-reducer attachment in sink faucets, to reduce water usage. These are readily available in the local hardware stores.
- Building of such kind can conserve significant amount of water by rainwater harvesting system. The implementation of rainwater harvesting system can be easily implemented. Conduits should be made available all around the building that can transfer the collected water from the roof to the pit. This collected water can be used for gardening processes, car and floor washing and etc. For design of rainwater harvesting system a detailed study is required.

Monitoring Related suggestions

- The specific energy consumption is o.14625 kwh/kl which is very satisfactory. However, this estimation is based on a few assumptions. To find out exact SEC a detailed study is required.
- It is observed that there is no proper water distribution diagram available in administration department. The same maybe developed and displayed at concerned places along with the water consumption charts to bring about awareness. Water monitoring and accounting could be done every month so that we can get the exact information about the water bill and then measures should be taken to reduce the water bill by efficient activities.

Low or No Cost Solution:

- It is recommended to use a watering can to water the plants instead of pressurized hose pipes.
- It is recommended to raise the level of the infra red sensors in the wash basins to prevent approximately 0.150 litres of unused water to be dispersed. This comes to a waste of 154.7 kl annually.
- It is observed that about 95 kl of water is lost due to minor leakages. It is suggested to arrest the leakage as soon as it is visible.
- It is observed that the personnel involved in operations and maintenance of water distribution system in the building are not updated with various water conservation approaches. Periodical training is required so that they can conserve water in best and efficient way.
- It is suggested to check the water meters for its functionality at the earliest. It maybe replaced with a new water meter if required.
- Since the use of infrared taps consumes a considerable amount of water, this water can be recycled by connecting the used water to a common conduit. This water can be stored and treated for further use. This estimates to be about 1700 litres/day. This water can be used for floor cleaning, flushing and car washing.

4. REFERENCES

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