Water Audit

For

Centre for Science and Environment (CSE)

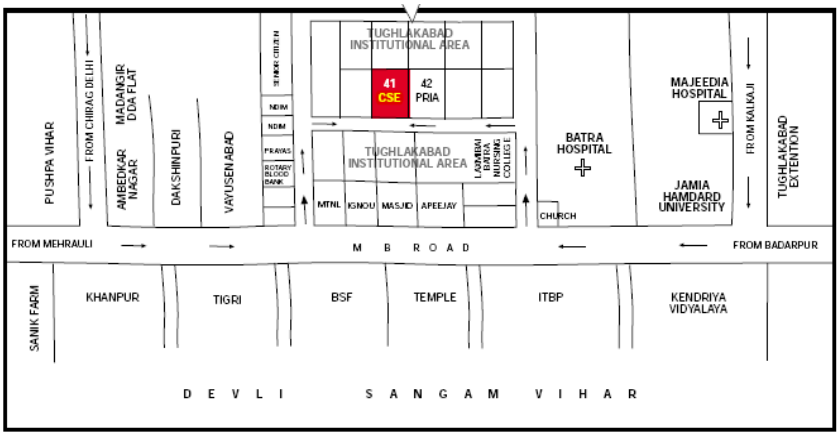
Centre for Science and Environment (CSE)
Centre of Excellence-Sustainable Water Management
Ministry of Urban Development, Government of India

1. Introduction

Centre for Science and Environment (CSE) is located in the South East district in the state of Delhi according to the state administrative boundary. Spread over an area of 1000 sq. m, the office complex is located in the highly exploited groundwater area falling within the South district as per the Central Ground Water Board (CGWB) classification.

CSE located in the Tughlakabad Institutional Area and is surrounded by a variety of land and building uses. Since this area is designated as an institutional area several large office areas including those of Society for Participatory Research in Asia (PRIA), New Delhi Institute of Management (NDIM), Rotary blood bank, Prayas, senior citizen home etc. are located in the neighbourhood.

Figure 1: Location of CSE and its neighbours



*Map not to scale

Slide 1: Site of the CSE building

But the prime landmark is the Batra hospital located on the Mehrauli Badarpur road, which has a capacity of 495 beds, along with laboratories, operation theatres, green spaces, canteen etc. The hospital campus is spread over an area of 48562. sq. m and has 11 rainwater harvesting systems according to a related document[1]. The neighbouring campus of Jamia University is another major water user in the area, which is spread over a massive area of 3.15 sq.m. Based on a CSE water audit the campus uses 3.42 lakh litres of water per day of which 1.26 lakh litres is extracted from groundwater and rest is purchased from tankers or private borewells. Although rainwater system w with a potential of 773 lakh litres annually is installed

[1] Batra Hospital & Medical Reaserch Centre available at http://www.emt-india.net/eca2007/Award2007_CD/35Hotels&Hospital/BatraHospital&MedicalResearchCentreDelhi/Profile.pdf

In addition to these institutional complexes this area includes Sangam Vihar, which is one of the Capital's oldest and amongst Asia's largest unauthorised colony. According to some estimates more than 4 lakh people reside in only 100 sq.m, without adequate infrastructure provision like electricity, roads etc. Since it is unauthorized there is no municipal water supply and poor residents have to pay an average of Rs. 500 per month to private water suppliers for a meagre one-hour supply once in a week. These private suppliers have created a network of private pipelines and draw underground water for the supply. Towards the north eastern direction, the institutional area is surrounded by the Jahanpanah forests, which covers approximately 800 acres and is located between Tughlaqabad and Chirag Delhi and passes through Alaknanda and Greater Kailash Part II. Apart from this there are several defence establishments Vayusenbad, ITBP campus and other dense residential areas like Ambedkar Nagar, Devili gaon etc. Annexure 1 provides a bird's eye view of the area and location of CSE in reference to the landmarks and neighbouring areas discussed above. The pictures taken from *Google Earth* also gives an fair understanding of the nature of density and types of land uses (habitation, vegetation etc.) surrounding CSE's office.

2. Key facts about the Site[2]

Name of project	Water Audit For CSE Building
Address	41, Tughlakabad Institutional Area, New Delhi
Total rooftop and surface area	1000 square metres (sq m)
Annual water harvesting potential	377500 liters
Average annual rainfall in Delhi	755 millimetres (mm)
Rainwater Harvesting System	The RWH system at CSE entails a network of an abandoned borewell, recharge well, 13 soakaways and raised stormwater opening used entirely for recharging
Capacity of wastewater system	10,000 litres/day
Wastewater treatment system	The components involved in treatment are a settler, a baffled reactor, a planted filter and a polishing pond
Total staff strength	Around 157

[2] Support from Mr.Bains, Mr. Suresh Kumar, Mr. J. K Sharma, Mr. Rameshwar (Electrician), Mr. Babulal (housekeeping head), Mr. Ashok (Gardener), Mr. Deepak (Volunteer), Mr. Sandeep (Canteen), Sugandh, Sarandha, Harshita during the audit is greatly appreciated, along with all the CSE staff who contributed in the survey. Guidance from Gitaji and Dr. Suresh Rohilla was also valuable throughout the audit exercise.

Average Visitors per day	25
Underground storage tank capacity	12,000 litres
Average Borewell extraction per day	

3. Rationale for Water Audit

Since the municipal water supply is virtually absent in the entire area including the unauthorized colony of Sangam Vihar, groundwater is the primary water source and thus highly exploited as compared to other parts of the capital and under severe strain.

The paper titled Groundwater Management in NCT Delhi, by Shashank Shekhar, Raja Ram Purohi2 & Y. B. Kaushik highlights the already known facts about the rapidly declining and deteriorating groundwater resources in the capital especially the south district which includes Tughlakabad Institutional Area, where CSE office is located.

It is generally known that the groundwater availability in an area is controlled by the hydro geological situation. CSE's office building is located in an area dominated by hard rock formations; mainly the Alwar quartzites. Unlike this area other parts of Delhi have alluvial cover like the Yamuna flood plains and Eastern, Western Delhi, Chattarpur basin have newer and older alluvial respectively with higher tubewell potential and water levels. While in this area the predominant rocks are quartzites which are pinkish to grey in colour, hard, compact, highly jointed/ fractured and weathered. Quartzites are ferruginous and gritty types on weathering and subsequent disintegration give rise to coarse sand (Badarpur sands). Chemical weathering of deeper horizons is also common, which gives rise to coarse sand which is commonly known as Badarpur sands with their subsequent disintegration.

As a result depth of wells varies in South district from 50-150 mbgl[3] in these quartzite areas covering part of south east amongst others. Bore/tubewells in these areas are referred to as limited yield and have a potential of 100-150 Litres Per Minute (LPM). While the entire Yamuna Flood Plan area and North West, West and South west areas falls under large (800-3200 LPM) and medium yield (400-500 LPM) tubewells area respectively. On an average, Delhi's south district drafts 8,343 million hectares (ha m) of groundwater annually, while the net groundwater availability is only 3,433 ha m per year. According to CGWB, South Delhi has the highest stage of groundwater development at 243%, followed by South west district at 214%. As a result deeper water levels are mostly found in South and South

[3] meters below ground level

west districts. Further, the CGWB data shows that nearly 50% wells of South district show a depth more than 40 mbgl and nearly 35% wells show depth to water level in the range of 20-40 mbgl. This is attributed to excessive water withdrawals leading to rapid drop in the groundwater level in this area ranging from 11.01 - 26.55 meters over the past 10 years.

To make matter worse, most parts of the south east district are completely groundwater fed through private borewells. The public piped water supply is also sources water from the groundwater and there are very few areas perusing conjunctive water use. Thus with underlying hard rock, limited tubewell potential, rapid declining groundwater level, over exploited with stage of groundwater development, limited recharge potential etc. the area under focus is undergoing severe crisis. Therefore it is critical and urgent to asses the current withdrawal, supply and use patterns for various uses (domestic, commercial, institutional etc.) in order to achieve efficiency and realistic water savings.

4. What is water audit?

A water audit is an on-site survey and assessment of water-using hardware, fixtures, equipment, landscaping, and management practices to determine the efficiency of water use and to develop recommendations for improving water-use efficiency (Newcomb P. J 2008[4]). In simple words, a water audit is a systematic review of a site that identifies the quantities and characteristics of all the water uses. The site may vary from a public water utility, facility (institutional or commercial properties like malls, office, schools etc.) or a household. The overall objective of conducting a water audit is to identify opportunities to make system or building water use more efficient.

Since water uses vary greatly from one type of business or institution to another and from site to site, therefore water audit is crucial to determine quantity, nature and quality of water consumption. Water audit for a water utility refers to tracking, assessing and validating all components of flow from the site of withdrawal or treatment through the water distribution system and into the consumer's properties. On the other hand, water audit of an office building would review direction and quantity of water used for domestic, cooling/heating, sanitary and landscaping processes. Whereas, a domestic water use audit examines the major areas in which a facility uses water, including human consumption, personal hygiene & sanitation, washing, cleaning, laundry, gardening etc.

[4] Newcomb P. J, Indoor Water Audits, presentation at the Higher Education Water Workshop, February 6, 2008

Thus, even though the nature and scale of water use varies and differs according to the sites and systems, the underline principle is common, that is, water use audit determines where the water ends up and in what amount. The audit exercise provides decision making tools to the concerned people in the utility, institutions or households by identifying inefficient uses, problem areas wherein water conservation and remedial measures can be undertaken.

Water auditing is an ongoing process and rarely stays consistent in a site or system over time. Therefore in order to gauge progress from adopted water conservation and cutbacks, water audit should be performed on a regular basis. In addition it provides convincing overview of the water use trends, effectiveness of conservation measures and potential cost and water savings.

5. Methodology

The key components in the water audit methodology undertaken for the CSE building included

i. **Pre Audit Information**

- Preliminary literature review of concepts and methodologies related to water audit for utility, facilities and households.
- Walk through the entire building to understand the nature of water uses and the systems installed in the building.
- Discussion with the administrative officers, housekeeping and kitchen employees on the various water uses during the day and the source of water.
- Regular discussions with the administrative department including the electrician, housekeeping and canteen incharge were conducted throughout the exercise on current situation and the past trends in water consumption, current sources, supply amount, source metering, distribution, storage, wastewater generation etc.

ii. **Base-lining and benchmarking**

The water audit for CSE included both primary and secondary data collection for various identified water uses. Primary data collection included the following components

- Development of questionnaire format for individual water use, mopping, gardening etc.

- Sample survey of CSE staff to estimate individual water consumption on sanitary and drinking purposes based on questionnaire format. Of the 157 employees, 34 undertook a week long observation of their personal water use in toilets and for drinking. Thus the per capita average of personal water use was calculated for the audit based on this 20% representative sample.
- For other water uses in kitchen, irrigation, mopping etc. primary data on time, patterns and frequency of water use was recorded over a varying period of time.
- Flow rate calculation from the taps flow rates and number of all water using fixtures/ equipment was also undertaken.
- Secondary data collection included compilation of number of visitors visiting CSE over a period of 10 days, along with their duration of stay.
- Collating records of water pumped to the overhead tanks, average borewell withdrawals, DJB water bills etc. to estimate actual supply.

iii. **Conducting an water audit at the building level**

- The data collection and processing for personal water use including drinking, flushing and face/ handwashing, mopping, irrigation, utensil washing etc. was done on the basis of actual consumption.
- One litre bottle and 10 litres bucket method was used to estimate the flow rate from various taps used for a variety of purposes. This was then calculated with the frequency of use to determine the actual water use.
- As part of the survey, staff members recorded the number of daily visits to, flushes in toilets and urinals, along with daily frequency of hand washing and average time of water flow from the taps.
- The data for all the above uses was calculated for varying time period for e.g personal water use survey was based on a week long observation by the CSE staff to calculate per capita use.

6. Water supply

Slide 2: Borewell Location

The primary source of water for CSE is a private borewell located near the front gate of the building. The office building receives majority of its water supply from groundwater, supplemented by DJB supplied water which is also sourced from groundwater. The current borewell which supplies to CSE's daily water requirement of drinking and non potable uses is the third in the series of borewell. It is located just outside the entry gate near the guard room and was installed in May 2007 after the earlier one became dry. The total depth of the borewell is around 158 meters below the ground level (mbgl) or about 520 feet and during the time of drilling water was found at a depth of 132-137 mbgl (435-450 feet). The submersible pump of 5 Horse Power (HP) was installed at a depth of around 122 mbgl. Of the three borewells, the first is located on the near the present battery room and was about 265 feet or around 81 mbgl and was installed around 1992-93. At present, the bore is used for recharging groundwater within the CSE's rainwater harvesting system. The second bore which was operational till 2007 was deeper by about 110 feet than the 1st borewell. It was around 350 feet or 106 mbgl and is located outside the CSE premise in the middle of the car park area.

Therefore it could be derived that water table has gone down drastically further since the current borewell is at a depth of 520 feet or 158 mbgl from the first bore which was around 265 feet (81 mbgl) deep. The average yield of the borewell is about 4235 litres per hour, which was recorded using the 10 litres bucket test.

The secondary water source for CSE is the DJB supply line fed by a board's borewell, is located a few meters away from the CSE's building. During the time of the survey, there was no additional DJB supply to supplement the borewell water since the motor which draws water from the DJB pipe was not in working condition. Hence DJB source water was not accounted in the audit. On past occasions when this 1 horsepower (HP) motor is operational, about 1000 -1500 litres of water is drawn from the DJB line depending on the need and supply pressure. Records of the DJB bills showed that water is charged on a flat rate at Rs. 375/ month. Besides, there was no mention of water consumption by the consumer, although the bill contained that category. CSE falls under the South East Delhi x 1 (SDEx1) division and SD III sub division of the Delhi Jal Board.

Slide 3: Underground Storage Tank

The pipe from the borewell located near the entry gate is connected to a storage tank of capacity 12,000 litres. This underground tank is located under the table tennis board and is the only storage structure for all the supplied water in CSE (see Figure 2). From this storage tank, water is pumped to the overhead tanks by a 3 HP pump located opposite to the generator battery.

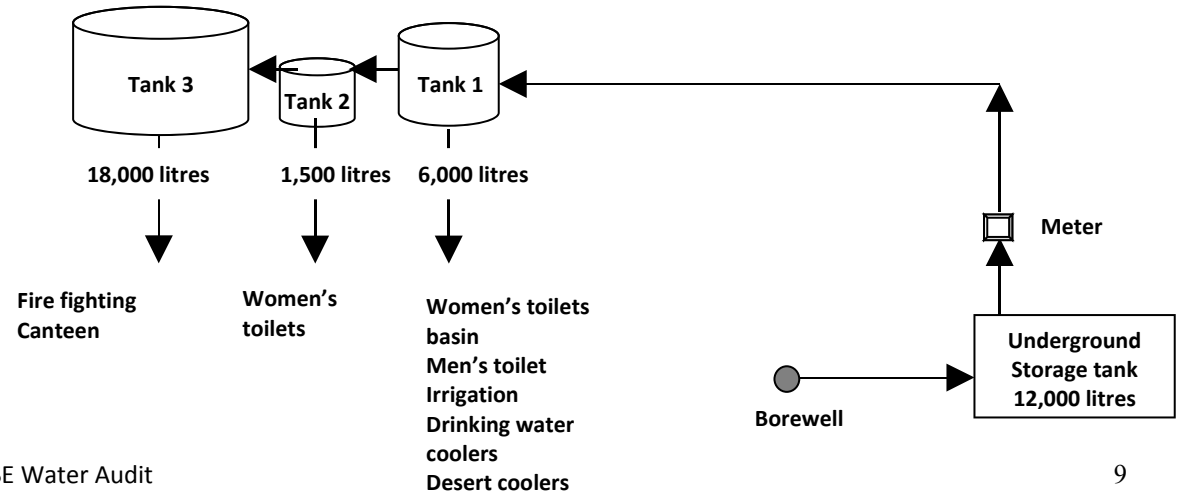
A water meter is installed on this pump and daily readings are noted by the electrician for the records. Based on 21 days reading the average amount of water that is pumped to the overhead tanks is about 6510 litres (see Annexure 4). Although on certain days there is a sudden jump and increase in the amount of water which is generally attributed to weekly offs or increase in certain water uses like gardening etc.

Slide 4: Water meter on the Pump

From the storage tank, the water is pumped to three storage tanks located on the roof of the building. The three cemented tanks are of 6000, 1500 and 18,000 litres capacity and are used for different purposes. The 6000 litres tank (T1) is the first to be filled by the pipeline coming from the storage tank. The water from this tank has connections to the basins in the women's toilets, men's toilets (basins and cisterns), taps used for watering the plants, water coolers and desert coolers. After the water in T1 is topped up, the second tank of 1500 litres (T2) receives its share. This tank is connected to the cisterns in the ladies toilets. Finally, the third tank (T3) is of the biggest capacity i.e. 18,000 litres and receives water once T2 is full. Water in T3 is primarily stored for fire fighting purposes, but has a connection to the three working taps in the canteen.

Slide 5: 6000 litres tank located on the terrace

Figure 2: Schematic diagram of CSE's water supply system



7. Water Usage

Slide 6: Men's urinal (on right) & women's toilet on the ground floor

CSE office building has five floors excluding the basement and each of these five floors has terraces with plants and foliage. Ground, first and second floor have grass cover and unpaved area, with ground floor having the maximum green area circumventing the entire building. The ground floor also has a tank with 6000 litres capacity which is fed by the rainwater or drained water from the above floors. The pond also has small tap which is connected to tank 1 and has floating vegetation, along with a small fish population. The pond is frequently topped with water from the excess drained water from the above terraces, while they are being irrigated.

In total there are 9 toilets in the building, which includes both for men and women. Except for basement and the fifth floor, all the other floors have toilets, while the fourth floor has one toilet which is of single use. Rest all the floors have two toilets each and the ground and third floor toilets are most frequented by the staff. All the toilets have wash basins and men's toilets have two urinals connected to a five litre cistern. While women and men's toilets have single commode connected to cisterns of 10 litre capacity connected to tank 2 and tank 1 respectively.

Similarly only ground and third floors have water coolers of 80 and 50 litres capacity respectively which are connected to the respective filters which sources water from the T1 of 6000 litres capacity.

Slide 7: Dishwashing in the canteen area

The canteen complex has four taps connected to the T3 (otherwise used as storage for fire fighting) and a basin for hand washing. Water for drinking purposes is collected from the third floor cooler daily. The canteen starts operating from about 7.30 am every morning and continues till 7 pm in the evening on most days.

The housekeeping staff initiates cleaning, washing and mopping activities from 7 am in the morning and they generally continue till 7 in the evening in two shifts. Buckets are used for mopping which are generally filled from the toilet or terrace taps.

Slide 8: Watering of plants & floor mopping in action

Therefore, to conduct a building water audit water consumption data for all these uses were required to be monitored and recorded. Toilet water use including for flushing and face/ hand washing along with drinking was clubbed under personal water use. In order to collect primary data and to ensure accuracy, a brief questionnaire format was prepared and survey conducted for the CSE employees (Annexure 2). Of the 70 questionnaires that were distributed amongst the employees, 34 filled questionnaires were received. This formed about 22% of the total employee strength of 157 and was considered adequate as representative sample to calculate per capita per day water use for personal purposes. The questionnaire required the respondents to monitor their daily toilet/urinal visits, hand washing frequency, average water release time from the tap, drinking water consumption etc. for a week. Of the 34 respondents, 12 were female and rest 22 were male and average number of days over which monitoring was carried out was 6.6. The average daily working hours came to about 7.7 hours during which the average toilet and urinals visits were about 2.2 and 3.5 for women and men employees respectively. The capacity of the cisterns in the men's toilet was ascertained by the make of the cisterns, while the cisterns of the women's toilet had a direct connection to the overhead tank 2. Therefore to ascertain its capacity, an exercise of measuring the drop in the water level after a single flush was carried out.

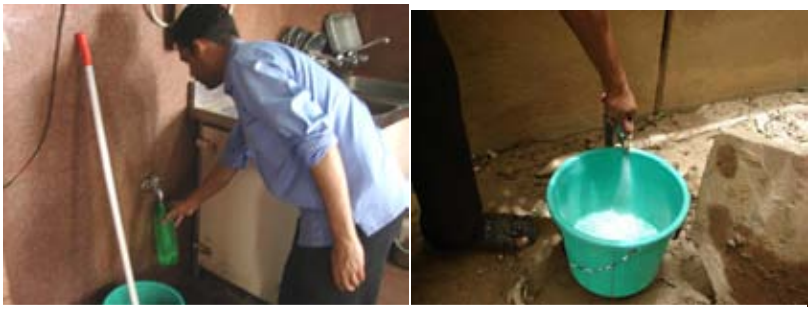
The average number of times women flushed during the day was calculated to 2.9 or 3 times, whereas men used the urinal flushes 2.3 times daily. Similarly on an average the respondents washed their hands 3.9 times daily and each time the tap is usually left opened for about 17.4 seconds. While women washed their hands 3.5 times daily for an average time of 20 seconds, men leave open the tap for about 16 seconds for handwashing about 4.1 times daily. The average daily drinking water consumption for the individual employees was calculated as 1.6 litres. Of the 34 respondents, four

mentioned bringing water from home and not taking any refills from the water coolers. While the rest 30 filled bottles or used glasses for drinking from these water coolers during the day.

On an average 1.5 training programs are organised in CSE in a month and about 20-30 people participate in these programs. During the period 22nd March to 21st May, six trainings were organised at CSE for various units. Although participant's entry is recorded at CSE's entrance gate but the entire program proceedings take place in the AAGC building. Only lunch is taken in the CSE building during the training days. During the training period participants use the toilet and water facilities in AAGC, therefore their water use was not accounted in this audit.

To measure uses like mopping, the housekeeping in-charge was provided with format to record the number of buckets all measuring 10 litres used for mopping and washing daily over a period of five days. Readings of the water coolers were taken daily for five days to record frequency of filling it, which was then utilised to derive the drinking water use as their capacity was already known.

To arrive at total water use from the taps, flow rate was computed using the one litre bottle test by recording the time taken to fill the bottle, which was then used to compute flow at litres per minute. This exercise was repeated for 2-3 days in all the toilet basins and for two days in the canteen to record water flow in the four taps.



Slide 9: One litre bottle and 10 litres bucket test (on left)

To estimate the water use in irrigating plants, 10 litres bucket was used to record flow rate and duration for irrigation was recorded on each floor. Plants are irrigated using a hose pipe, except on the fifth floor where buckets are used to water plants. Generally plants on the ground floor are watered after 4.30 pm in the evening to reduce evaporation losses. Similarly, terrace plants are irrigated early morning before 9 am for the similar reasons. The same technique of 10 litres bucket was used in measuring the hourly yield of the borewell. Since the borewell lid is sealed on the entrance gate, therefore yield measurement was done in the AAGC, where the line from the borewell is extended and can be accessed.

8. Data processing

The total staff strength at CSE is estimated at 157, which includes regular, on contract, interns, canteen/office boys, guards and housekeeping personnel.

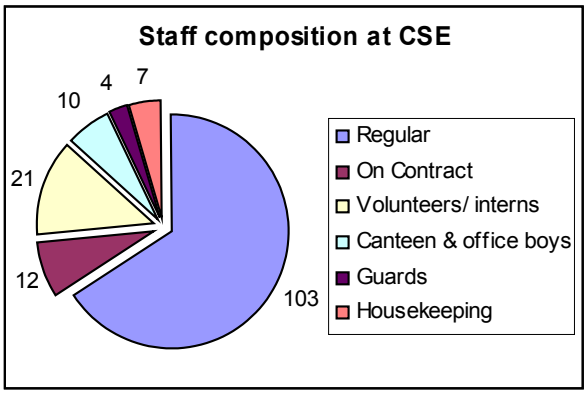
Table 1: Staff composition at CSE's office

S. No	Staff	Number	Male	Female
1.	Regular	103	60	43
2.	On Contract	12	7	5
3.	Volunteers/ interns	21	5	16
4.	Canteen & office boys	10	10	-
5.	Guards	4	4	-
6.	Housekeeping	7	7	-
Total		**157**	**93**	**64**

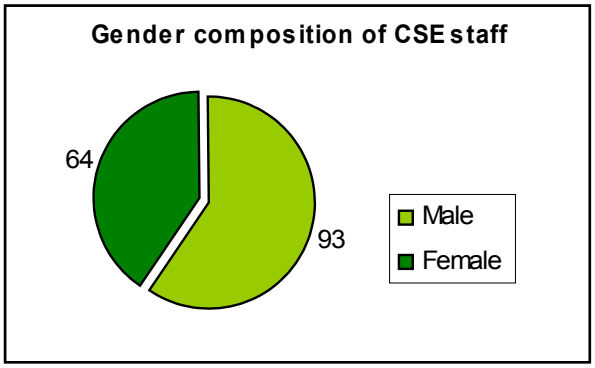
Source: HR department, CSE

It is estimated that usually on a regular working day of the week around 100 people are usually present in the premises, which is around 65% of the total staff strength of CSE. This assumption is similar to one that was taken while designing the wastewater treatment system and its capacity.

Graph 1: Staff Composition at CSE



Graph 2: Gender Composition of CSE staff



Thus, the toilet, drinking and hand washing water use have been calculated using this assumption. The per capita water use has been calculated based on the averages from the sample survey which has a representative sample of 25%.

9. Calculation of water consumption pattern

A. Water consumption data

1. Potable water consumption (daily)

   a. Drinking

   Total[5] water use for drinking is 220 litres/ day*

   i. Daily Drinking water use for canteen purposes= 50 litres

   - *Based on capacity of the drum used to fill water from the water coolers*

   ii. Daily Drinking water consumption by CSE staff: 1.6 x 100 = 160 litres

   - *Per capita per day drinking water is 1.6 lpcd[6] & assuming presence of 100 employees on an average day*

   iii. Daily Drinking water consumption by Visitors: 25 x 1.6/7.7 x 1.9 =9.9 litres

   - *Average daily duration of CSE staff in office is about 7.7 hours and during this period they consume about 1.6 liters of water. Therefore based on this premise, drinking water consumption of visitors has been calculated. Average daily visitors in CSE are around 25 & there duration of stay at CSE is around 1.9 hours or 112 minutes.*

   b. Cooking

   Total water use in cooking 250 litres/ day**

   *** This is a total of i & iv items, since ii & iii are already accounted in the drinking water use category.*

   i. *Total water used in the preparation of tea/ coffee daily: 150 x 0.2 = 30 litres*

   - On an average 150 tea/coffees are served during the day in cups with a capacity of about 200 ml or 0.2 litres.

   ii. *Total water used to prepare drinks daily: 40 x 0.3 = 12 litres**

   - On an average 40 drinks (lassi, lemonade etc.) tea/coffees are served during the day in glasses with a capacity of about 300 ml or 0.3 litres.

   iii. *Total water used to serve water & make ice during the day time in the canteen daily: 40 litres**

[5] Total water consumed by all users/ day

[6] litres/ capita /day (LPCD) and is calculated from the sample survey

- On an average 40 are served during the day in glasses with a capacity of about 300 ml or 0.3 litres. this adds up to 40 x 0.3 = 12 litres
- Rest 28 litres rest is used in making ice or other purposes

iv. *Total water used to prepare lunch and breakfast daily: 55 x 4 = 220 litres*

- On an average 55 people have their food (including lunch, breakfast & snacks) daily and it takes on an average 4 litres of water to prepare these meals.

2. Non- potable water requirements (daily)

a. Toilet Flush

Total flush water use in toilets (for men and women) is 2171 litres/day & 17.3 lpcd

Total flush water use in toilets (for men and women) excluding for visitors is 2045 litres & 20.4 lpcd

Total flush water use in men's toilets (toilets and urinals) is 855.5 litres & 14.5 lpcd for men in the office

i. Total water used for flushing in men's toilets daily : 0.3 x 10 x 59= 177 litres

- *The average daily flush in men's toilets is 0.3 & capacity of the urinal cistern is 10 litres.*
- *Of the total 157 employees 93 are male, therefore based on this premise around 59 employees would be male from the assumed figure of 100 staff members.*

ii. Total water used for flushing in men's urinals daily : 2.3 x 5 x 59= 678.5 litres

- *The average daily flush in* men's *urinals is 2.3 & capacity of the urinal cistern is 5 litres.*
- *Of the total 157 employees 93 are male, therefore based on this premise around 59 employees would be male from the assumed figure of 100 staff members.*

Total flush water use in women's toilets is 1189 litres & 29 lpcd for women in the office

i. Total water used for flushing in *women'* toilets daily : 2.9 x 10 x 41= 1189 litres
   - *The average daily flush in women's toilets is 2.9 & capacity of the toilet cistern is 10 litres.*
   - *Of the total 157 employees 64 are female, therefore based on this premise around 41 employees would be male from the assumed figure of 100 staff members.*

Total flush water use in toilets by visitors is 126 litres & 5.04 lpcd

ı. Total water used for flushing by visitors daily: 20.4/7.7 x 1.9 x 25= 126 litres
   - *Average daily duration of CSE staff in office is about 7.7 hours and during this period they flush about 20.4 litres of water in the toilet. Therefore based on this premise, drinking water consumption of visitors has been calculated. Average daily visitors in CSE are around 25 & there duration of stay at CSE is around 1.9 hours or 112 minutes*

b. Basin water use

Total water use in basins for face/hand washing 733 litres/ day & 5.8 lpcd

i. Total water **use** in basins for hand washing is 113.1*5.2 = 588.1 litres and 5.9 lpcd
   - The average flow rate in all the basins is around 5.2 litres per minute, which was calculated using one litre bottle test.

ii. Total time tap is opened on average day for hand washing is 17.4*3.9*100/60= 113 minutes
   - Based on the survey conducted amongst the CSE staff, average daily frequency of hand washing per person is 3.9 and average time the tap is opened while hand washing is 17.4 seconds.
   - Assuming presence of 100 employees on an average day, the average time (in seconds) tap is opened during the day is 17.4*3.9*100

iii. Total water use in basins for hand washing by visitors is 27.88*5.2 = 145 litres and 5.7 lpcd

- Average daily duration of CSE staff in office is about 7.7 hours and during this period the tap is open for 113.1 minutes. Therefore based on this premise, water consumption for hand washing by the visitors has been calculated. Average daily visitors in CSE are around 25 & there duration of stay at CSE is around 1.9 hours.
- Average time tap opened by the visitors is 113/7.7*1.9 = 27.88 minutes
- The average flow rate in all the basins is around 5.2 litres per minute, which was calculated using one litre bottle test.

c. Washing utensils

Total water use in washing utensils/vegetables etc. is 711 litres/ day

i. Total water use in washing utensils/vegetables etc is 76.7 + 71.4 = 148.1 x 4.8 = 711 litres

- The average flow rate for all the four taps in the canteen is 4.8 litres/ minute.
- During the peak use time of 10 am-4 pm which is 6 hours, the average time the four taps are opened for use is about 76.7 minutes.
- During 8-10 am & 4-6 pm, which is 5 hours, the average time tap is opened is 71.4 minutes.

d. Washing & cleaning (floor mopping, toilet cleaning)

Total water use in floor mopping is 280 litres/ day

i. Total water use in floor mopping is 1400/5 = 280 litres

- Number of 10 litters buckets used for mopping and washing were recorded on all the floors during a period of five days.
- Total water used during these five days was 1400 litres.

e. Gardening

Total water use in watering plants is 2143 litres/ day

i. Total water use in watering the plants is 1780.6 + 81.5 + 112.1 + 34.9 + 24 + 110 = 2143 litres

- Individual flow rate (litres per minute) for the taps on various floors was recorded based on 10 litres bucket test.
- On the fifth floor buckets are used to water plants therefore water use was calculated accordingly
- Time taken to water the plants on the ground floor and all the four terraces were recorded to calculated total water use on each floor for watering the plants
  - ground floor: 22.50 (flow rate litres/min) x 78.5 (mins) = 1780.6 litres
  - First floor: 13.6 x 6 = 81.5 litres
  - Second floor: 14.02 x 8 = 112.1 litres
  - Third floor : 17.45 x 2 =34.9 litres
  - Fourth floor: 11.99 x 2 = 24 litres
  - fifth floor : 11 (buckets) x 10 (no. of buckets) = 110 litres

f. Water for Cooling/ Desert Coolers

Total water use in desert coolers is 100 litres

ı. Total water use in desert coolers is 50 + 50 = 100 litres

- Capacity of the two water coolers is 50 litres each
- They are daily filled once during the day to their maximum capacity

The detailed questionnaire developed to monitor and calculate components of the above water use heads was prepared. This was based on literature review and observations and discussions during the pre audit phase (see Annexure 3).

Overall Water Consumption

Therefore based on the above recordings, monitoring and calculation the **total water consumption for CSE is 6608 litres per day** and the **per capita use is 66.08 lpcd**, based on the assumed staff strength per day of 100.

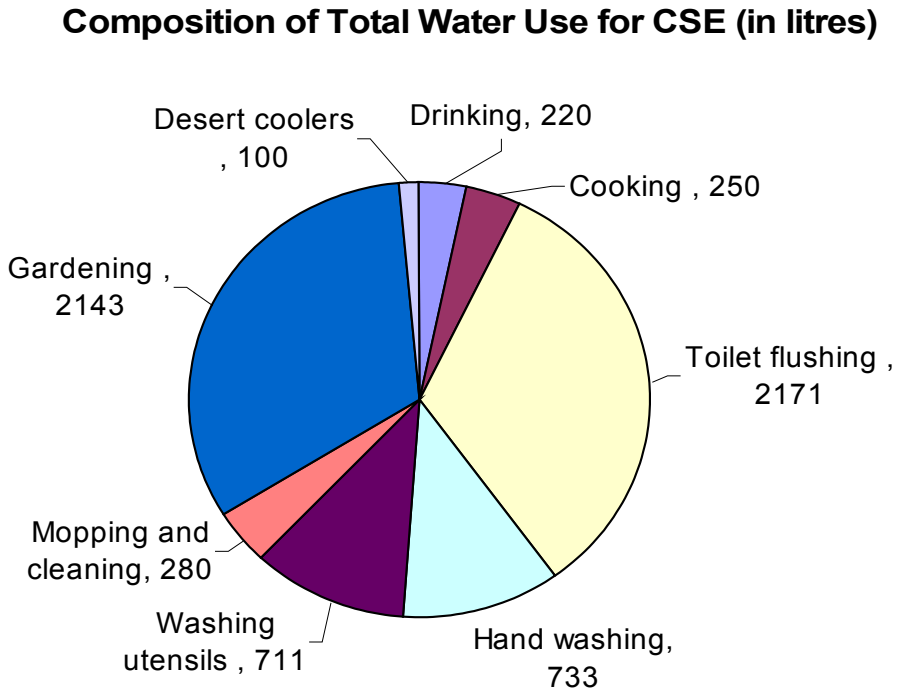
The potable water consumption is 470 litres which includes water for drinking and cooking purposes. The per capita consumption of potable water is therefore 4.7 lpcd. On the other hand the total water consumption for non potable uses like toilet, hand washing, mopping, gardening, cooling and utensils cleaning is 6138 litres. Therefore the average per capita consumption for non potable uses comes to 61.38 lpcd. If gardening is excluded, then the per capita use for non potable water is around 50 lpcd.

Table 2: Activity wise water use composition

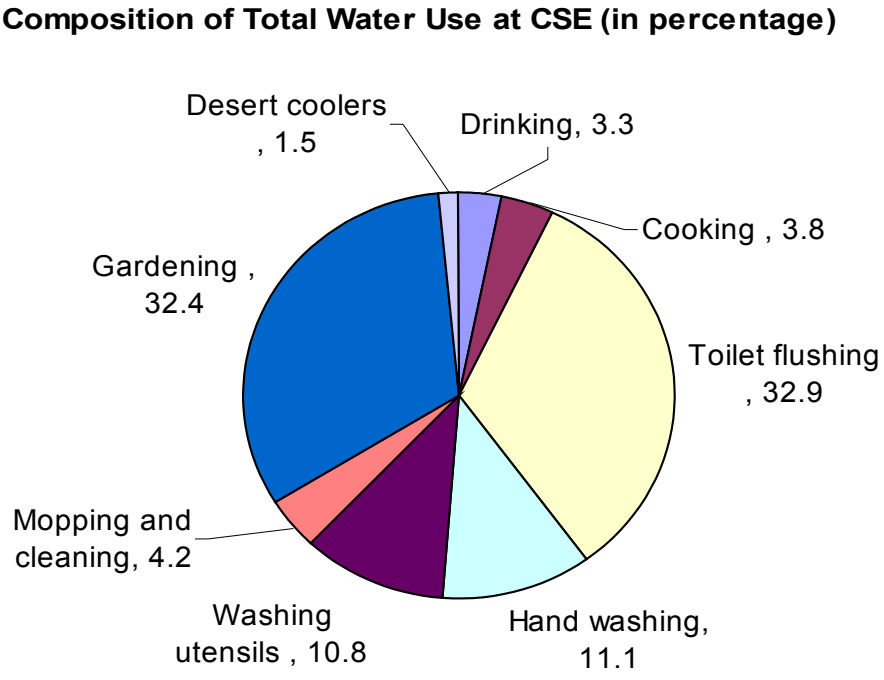
S.No	Activity	Water use in litres/ day	Percentage of total use	Litres Per Capita Per Day (lpcd)
1.	Drinking	220	3.3	2.2
2.	Cooking	250	3.8	2.5
3.	Toilet flushing	2171	32.9	21.71
4.	Hand washing	733	11.1	7.33
5.	Washing utensils	711	10.8	7.11
6.	Mopping and cleaning	280	4.2	2.8
7.	Gardening	2143	32.4	21.43
8.	Desert coolers	100	1.5	1
9.	Total	6608	100	66.08

Source: Actual monitoring and primary survey

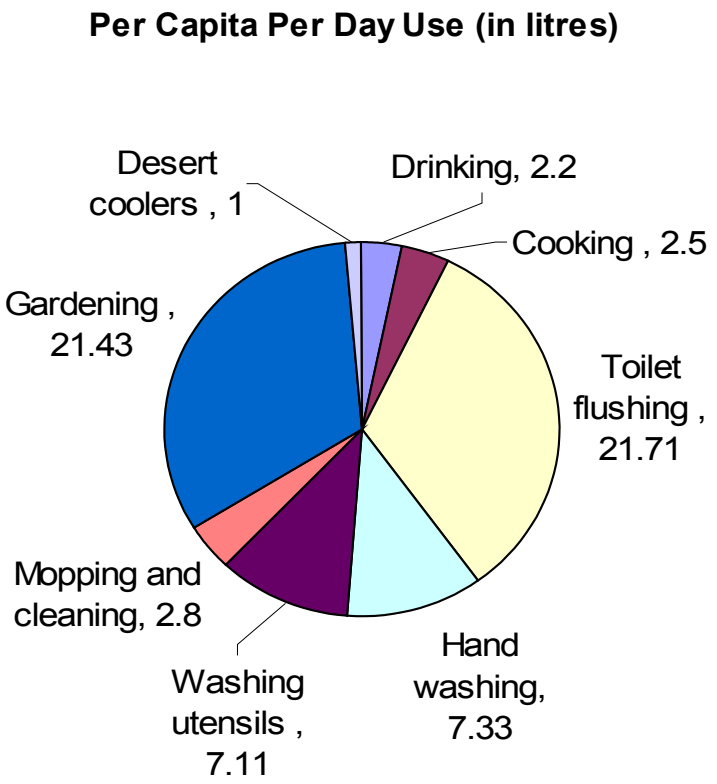
Graph 3: Composition of Total Water Use for CSE (in litres)



Graph 4: Composition of Total Water Use at CSE (in percentage)



Graph 5: Litres Per Capita Per Day Use at CSE



B. Water losses

There were no visible leakages that were observed during the audit exercise at CSE.

10. Data comparison and analysis

There is a slight variation in the average amount of water that is pumped to the three overhead tanks everyday for various purposes and the average water consumption calculation. The average water supply was based on 21 days of records was about 6510 litres per day, while the average consumption is calculated to be 6608. This difference of 98 litres could be attributed to the fact that certain assumptions were taken while calculating water consumption. For example, the staff present per day in the office was assumed to be 100, the sample for personal water use was a representative sample and not a complete sample, average water used per meal (4 litres) was an assumed figure etc. In addition, lawns are not always watered daily. On occasions when the there is rain or weather is not very dry, plants are irrigated on alternate days or sometimes one side of the ground floor is watered. Also, this

supply figure is not inclusive of the water from DJB, since the motor was not working during the time audit was conducted.

Table 3: Total Water Supply and Use at CSE

S. No	Heads	Water use (in litres)
1.	Average daily water supply, to the overhead tanks from the underground tank	6510
2.	Total calculated water consumption from the water audit	6608
3.	Difference between water consumption from overhead tanks and actual water use for various purposes	98

11. Rainwater Harvesting & Wastewater recycling System at CSE

The rainwater system in CSE was installed in 1999 and all the rainwater is recharged into the groundwater aquifers. RWH potential is about 3,77,500 litres per annum, while the annual rainfall recorded in Delhi is on an average 755 mm. The total area of CSE is about 1000 sq.m and has several areas which are unpaved for increased recharge. Earlier the rainwater storage tank with the capacity of 8,500 litres was used for low quality uses like watering plants etc. But, presently storage has been replaced and all the water is recharged into the ground. The entire system was installed at a cost Rs. 36,000 in 1999 and is regularly maintained to ensure quality and efficiency. The system recharges water through network of abandoned borewell (45 meters depth), 13 soakways (9.1 meters depth) raised storm water drainage and recharge troughs etc.

The wastewater recycling system at CSE has been designed to treat 10,000 litres per day based on the assumption that at any given moment at least a 100 people would be occupying the premises. The components involved in treatment are a settler, a baffled reactor, a planted filter and a polishing pond. A biosanitiser, which is an additive, is used to enhance the treatment process. The treated wastewater is stored in the polishing pond and in an underground sump. This water is used for irrigation and recharge purposes but in AAGC building. Although the kitchen waste water from CSE contributes to the system, but all the treated water is used for water plants at AAGC.

12. Potential for water savings

Based on the information collected and observations, the following can be recommended to reduce water use and increase its efficiency.

- Replacement of single flush cisterns with dual flush cisterns, in both men and women's toilets. At present the toilet commodes have 10 litre flush which can be replaced with 3/6 litres or 2/4 litres dual flush cisterns. Dual flush WCs operate on a split button with the user having the option of which one to use. Usually the smaller button operates the shorter flush of 3 litres which is adequate for flushing liquid waste, while the larger button is for 6 litres flush for more substantial waste. This can reduce water use by around 30-40% and save 870 litres per day (if water use reduction is by 40%).
- The urinals in the men's toilets, which at present use about 5 litres of water per flush could be, replaced with water-efficient urinals use 2.8 litres per flush. Waterless urinals could also be installed in the toilets, but there are some concerns with its maintenance and effectiveness.
- Flow fixtures could be installed on the taps on the terraces that are used for watering the plants on all floors (except 5th floor), since their flow rate is between 11-22 litres per minute. Flow fixtures typically controls, deliver a precise volume of water at faucets, showerheads, and hose outlets, typically 5.6 – 8.3 liters per minute, irrespective of varying line pressure. Other technology is aerators which are generally installed or taps fitted with aerators are available, which can cut the water usage of faucets by as much as 40% from 15 litres per minute to 9.4 litres per minute. Rest of the taps in the toilets and kitchen operate at a much lower flow rate. An aerator spreads the water flow into many small droplets. Conventional faucet aerators don't compensate for changes in inlet pressure, so the greater the water pressure, the more water you use.
- It is recommended that flushing should be avoided for disposing toilet paper or other rubbish and e of rubbish, use a rubbish bin and avert unnecessary flushing.
- Installation of water meter on the borewell to measure daily withdrawal and on the motor drawing water from the DJB line. At present on the water pumped to the overhead tank is metered. Metering the bore and DJB line would ensure records of the supply balance from borewell/ DJB pipe to the storage tank and overhead tanks thereafter.

Annexures

Annexure 1


Tughlakabad Map | India Google Satellite Maps - Mozilla Firefox
Jamia Hamdard University
Batra Hospital
Mehrauli Badarpur Rd


Tughlakabad Map | India Google Satellite Maps - Mozilla Firefox
Annamalai University
Mehar Hospital
Faculty of Pharmacy
Batra Hospital
Mehrauli Badarpur Rd


Tughlakabad Map | India Google Satellite Maps - Mozilla Firefox
AACC
Senior Citizens Home
NIHM
CSE
PRIA
Rotary Blood Bank

Annexure 2

CSE Water Audit Questionnaire: Personal Water Use

1. Name: .....
2. Gender: .....
3. Floor: .....
4. Duration of Monitoring: …/…./2010 to ….//….2010

Table 1: Toilet Water Use

- *Every time you use the toilet, please fill in information the box provided.*
- *In case you are also using urinal, please mention the related information.*
- *Please mark NA for the day there was no data collection*

Week 1	Day of the Week	Duration in office (timings)	Visit to the Toilet during the day **(mention number)**		Number of times you **FLUSHED** in a day for any purpose (toilet paper disposal, waste cleaning, pre use etc.) **(Mention Number)**		Number of times you used the mug **(mention number)**	Number of times you have **WASHED** your hands in a day **(Mention Number)**	**Average time** the tap is running while you are washing hands **(in seconds)** ***Please be Very Precise***
			Toilet	Urinal	Toilet FLUSEHS	Urinal (FLUSHES)			
DAY 1									
DAY 2									
DAY 3									
DAY 4									
DAY 5									
DAY 6									
DAY 7									

Table 2: Drinking Water Consumption

- *Do you use a bottle to drink water?.....Yes……No*
- *Capacity of the water bottle…… (in litres)*
-

Week 1	Day of the Week	Duration in office (timings)	Number of times you filled the bottle during the day
DAY 1			
DAY 2			
DAY 3			
DAY 4			
DAY 5			
DAY 6			
DAY 7			

Please provide as PRECISE information as possible and REMEMBER to fill it up DAILY!

Annexure 3

Water Audit Questionnaire *for Center for Science and Environment*

C. Baseline Information

1. Facility Name .....
2. Address .....
3. Period of surveying .....from ..... to .....
4. Total catchment area of the project/campus in square metres/feet: .....
5. Area of rooftops / terraces .....
   a. Area of unpaved surfaces .....
   b. Area of paved surfaces .....

D. Water user profile

Water users includes staff, visitors etc.

a. Total number of water users.....
b. Number of office staff .....
c. Number of visitors (daily) .....
d. Average water use timing[7] .....
e. Average working days .....
f. Office timings .....

E. Water supply data

What is total daily water supply in the building (litres per day)? .....

a. What are main source of water for the facility?

Source	Primary	Secondary
Municipal supply		
Groundwater (Borewells)		
Tankers (Private or Public)		
Rainwater		
Others		

b. For the municipal supply, are the water bills based on meter reading (actual consumption) or flat rate ? .....
c. Municipal supply time.....
d. Average Flow rate..... lts/min & Pressure..... (PSI)
e. *Monthly water bill (if based on actual meter reading) and divide it by number of days/ billing period. You will get average water consumption per day.*
   .....
f. Number of working tube wells on the site .....
g. Yield of working bore well/ tube well (litres per hour) .....
h. Average hours of pumping the tube well x yield[8] of tube well (per hour)
   .....

[7] Average calculated on the basis of XX days/week monitring

[8] Yield of the tube well can be calculated by a simple method. Take a bucket or any other container of known capacity/volume, ideally 20 litres. Keep it under tube well's out let, switch on the pump and note the total time taken to completely fill up the bucket in seconds/minutes. If time taken is 30 seconds, yield of the tube well will be 40 litres/ minute or 2400 litres/hour.

Source	Daily Water Supply	Monthly water Supply	Water Quality (Comments)	Specify its use* (drinking /cleaning/ washing/gardening etc)	Monthly expenses incurred
Municipal Supply					
Ground water					
Tanker supply					
Rainwater harvesting					
Other source (Pls specify)					
Total :					

i. Have flow-meters installed on tube wells to monitor extraction of groundwater?....

j. Number of water tankers called in a month or week x capacity of each tanker

Total quantity and proportions of water supply

*If both sources are used, please mention total quantity used per day or proportion of both (e.g. 50:50/ 70:30)

F. Water Storage

Details of the storage structures

Storage tanks	Numbers	Capacity	Number of times it is topped (or filled) daily	Time of operation
Overhead				
O1				
O2				
O3				
Underground				
U1				
U1				

G. Water consumption data

3. Potable water consumption (daily)

c. Drinking

- Total[9] water use for drinking ……litres ……lpcd[10]
- Staff Total..... litres ……lpcd
- Visitors Total..... litres ……lpcd

d. Cooking

- Total water use in cooking ..... litres ……lpcd
- Staff Total..... ……lpcd

[9] Total water consumed by all users/ day

[10] Water consumption is generally provided as litres/ capita /day (LPCD)

- Visitors Total..…… ……lpcd
- Number of peoples using canteen for tea & snacks..…
- Average water used in making tea & snacks per person ……
- Average water used in offering tea, snacks and lunch per person ……
- Number of kitchen sinks/ faucets: _____ Faucet flow rate: _____ gpm

4. Non- potable water requirements

g. Toilet Flush

Total flush water use (both toilets and urinals) Total..……litres ……lpcd

i. *Total toilet flush water use Total..……litres ……lpcd*
ii. What is the capacity of cistern..……
iii. Do you have single flushing or dual flushing system ……
iv. Average number of times people visit toilets daily ……
v. Total number of flushes daily ……
vi. How many times flushing is done (on average) ……daily
vii. Number of toilets..……
viii. Do flush valve (tankless) toilets have water-saving diaphragms? Yes… No
ix. Are toilets equipped with automatic water-flushing systems? Yes… No…
x. If so, what is the timing cycle? _____
xi. Are the sensors/timers coordinated with regular work hours? Yes… No…

h. Urinal Flush

i. *Total urinal flush water use Total..……litres ……lpcd*
ii. Number of urinals ……
iii. What type of flushing system does it have? ……
- Cistern based……if yes, capacity of cistern..……..…
- Gate valve/ tap based……..If yes, average time used… flow rate?.....
- Automatic sensors..…… water released per flushing.....
- How many peoples using urinals (on average) ……

i. Basin water use

- *Total water use in basins..……litres ……lpcd*
- Number of basins ……
- What types of tap are installed on basins?
  - Normal taps (threading type) ……
    - If yes, average time of tap used……..
    - Average flow rate ……..
    - Average quantity of water used each time……
  - Automatic taps (with sensors)..…… water released per use.……
  - Push button taps …….. If yes, average time of use…….
  - Are faucets equipped with aerators? Yes… No…

j. Washing utensils

- *Total water use in utensils..……litres*

- Running tap- (What is flow rate[11] of the tap) ……& running time ……
- Sink- Capacity…… & number of times it is filled ……
- Number of kitchen sinks/ faucets: _____ Faucet flow rate: _____ gpm

k. Washing & cleaning (floor mopping, car washing etc)

i. Floor mopping

- *Total water used daily in mopping total……litres*
- Water used for each mopping ……
- Number of times of mopping…… daily
- Total area where mopping is done ……

ii. Floor washing

- *Total water used daily in floor washing Total……litres*
  - Do you use running hose ……
  - Average time of using hose…… Flow rate of hose ……
  - Do you use bucket & broom ……
  - Average numbers of buckets used…… capacity of bucket.....
- Number of times of washing……daily/weekly
- Total area where washing is done ……

iii. Car washing

- *Total water used daily in car washing Total……litres*
- Total number of vehicles washed……
- Number of times of washing……daily
  - Do you use running hose ……
  - Average time of using hose…… Flow rate of hose……
  - Do you use bucket & duster ……
  - Average numbers of buckets used…… capacity of bucket.....

l. Gardening

- Total water use in gardening *Total……litres*
- Total green area or under plantation Yes… No…
  - Watering is done by running hose / sprinkler……
  - Flow rate of hose/ sprinkler……
  - Average time taken to water plants daily……mins
  - Number of times watering……per day/week
- Watering is done during what time of the day……
  ....Morning ....Noon ....Afternoon ..
  ..Evening ....Night

[11] Flow rate can be simply measure like the yield of the tube well. Take a jar or one litre water bottle. Keep it under the running tap and note the total time taken to completely fill up the bottle (in seconds/minutes).

H. Water losses

1. Leakages
    - Number of fixtures
        - Faucets……. Toilets……. Hoses…….
    - Number of leaking Fixtures …….
        - Faucets……. Toilets……. Hoses……. Pipes…….
    - Number/locations of leaky pipes and other fittings …….
    - Average water lost as leakage[12] from the building …….
    - How often do you get it repaired …….
2. Over flow from storage tank
    - Average time of water overflowing from the water tank …….
    - Flow rate of water inlet/overflow of the tank …….
    -

F. Water Conservation practices

What water conservation techniques are practiced in building to minimise water use and cut down wastage of water:

a. Rainwater harvesting system

Do you have a Rainwater Harvesting system? Yes/No ……

i. The year of commissioning ……
ii. Estimated harvesting area ……
iii. Capacity……
iv. Potential……Have you noticed an improvement in:
    - Yield of the tube well?……comments? ……
    - Quality of tube well water? Yes/No……comments? ……
    - Reduced water logging? Yes/No……comments? ……
    - Any other benefit noticed? ……comments? ……

a. Waste water recycling system

i. Do you have a waste water recycling system? .....
ii. What is the quantity of waste water generated?
iii. How much water is recycled per day? .....

[12]

Annexure 4

Table 1: Details of amount of water being pumped daily from the storage tank to the overhead tank

S.No	Date	Meter reading	Water Amount (liters)
1	04/12//2010	14936	
2	04/13//2010	14941.9	5900
3	04/14//2010	14946.9	5900
4	04/15//2010	14952	6000
5	04/16//2010	14958.1	6100
6	04/17//2010	14962.9	4900
7	04/19//2010	14970.7	8900
8	04/20//2010	14976.5	6500
9	04/21//2010	14982.1	6100
10	04/22//2010	14990.2	8200
11	04/23//2010	15003	10300
12	04/26//2010	15010.1	7100
13	04/27//2010	15015.2	5200
14	04/28//2010	15020.1	5100
15	04/29//2010	15026	6000
16	04/30//2010	15035.1	9000
17	05/01//2010	15040	5100
18	05/03//2010	15045	5000
19	05/04//2010	15053.2	8200
20	05/05//2010	15059.1	6100
21	05/06//2010	15064.9	5900
22	05/07//2010	15070	5200
Total			**136700.0**
Average water consumption			**6509.5**

Table 2: Details of water consumption in floor mopping and cleaning

Date:- 4/5/2010					
S.no	**Floor**	**No. of buckets**	**Record Timing**	**Capacity (liters)**	**Amount (liters)**
1	basement	3	7 am to 7 pm	10	30
2	Ground	6	7 am to 7 pm	10	60
3	1st	4	7 am to 7 pm	10	40
4	2nd	5	7 am to 7 pm	10	50
5	3rd	5	7 am to 7 pm	10	50
6	4th	3	7 am to 7 pm	10	30
7	5th	8	7 am to 7 pm	10	80
Total					**340**
Date:- 5/5/2010					
1	basement	3	7 am to 7 pm	10	30
2	Ground	6	7 am to 7 pm	10	60
3	1st	4	7 am to 7 pm	10	40
4	2nd	5	7 am to 7 pm	10	50
5	3rd	4	7 am to 7 pm	10	40
6	4th	3	7 am to 7 pm	10	30
7	5th	8	7 am to 7 pm	10	80
Total					**330**
Date:- 6/5/2010					
1	basement	3	7 am to 7 pm	10	30
2	Ground	4	7 am to 7 pm	10	40
3	1st	2	7 am to 7 pm	10	20
4	2nd	2	7 am to 7 pm	10	20
5	3rd	2	7 am to 7 pm	10	20
6	4th	2	7 am to 7 pm	10	20
7	5th	5	7 am to 7 pm	10	50
Total					**200**
Date:- 7/5/2010					
1	basement	3	7 am to 7 pm	10	30
2	Ground	6	7 am to 7 pm	10	60
3	1st	2	7 am to 7 pm	10	20
4	2nd	2	7 am to 7 pm	10	20
5	3rd	2	7 am to 7 pm	10	20
6	4th	2	7 am to 7 pm	10	20
7	5th	3	7 am to 7 pm	10	30
Total					**200**
Date:- 8/5/2010					
1	basement	3	7am to 1:30 pm	10	30
2	Ground	6	7 am to 7 pm	10	60
3	1st	4	7 am to 7 pm	10	40
4	2nd	5	7 am to 7 pm	10	50
5	3rd	4	7 am to 7 pm	10	40

6	4th	3	7 am to 1 pm	10	30
7	5th	8	10 am to 4 pm	10	80
Total					**330**
Grand Total					**1400**

Table 3: Details of Drinking water Consumption from Water Cooler

5/5/2010					
S.no	**Floor**	**Cooler capacity (liters)**	**Record Timing**	**Refills**	**Amount (liters)**
1	Ground	80	9am to 1 pm	2	160
2	3rd	50	9am to 1 pm	2	100
Total					**260**
6/5/2010					
1	Ground	80	9am to 1 pm	2	160
2	3rd	50	9am to 1 pm	2	100
Total					**260**
7/5/2010					
1	Ground	80	9am to 1 pm	2	160
2	3rd	50	9am to 1 pm	2	100
Total					**260**
10/5/2010					
1	Ground	80	9am to 1 pm	2	160
2	3rd	50	9am to 1 pm	2	100
Total					**260**
11/5/2010					
1	Ground	80	9am to 1 pm	2	160
2	3rd	50	9am to 1 pm	2	100
Total					**260**
Grand Total					**1300**

Table 4: Time record for irrigating plants in CSE

04/05/10					
S. no	**Floor**	**Flow Time in seconds (10 liters bucket)**	**Record Time**	**Minutes**	**Seconds**
1..	1st	44.16	9.34 to 9.40 am	6.00	360.00
2.	2nd	42.81	9.47 to 9.55 am	8.00	480.00
3.	3rd	34.39	9.58 to 10.00 am	2.00	120.00
4.	4th	50.05	10.02 to 10.04 am	2.00	120.00
5.	5th	63	110 liters *		
TOTAL				**18.00**	**1080.00**

**Plants on the fifth floor are watered using buckets*

S. no	**Floor**	**Flow Time (10 liters bucket)**	**Record Time**	**Minutes**	**Seconds**
4/05/10					
1	Ground	24.28	16.10 to 17.15	65.00	3900.00
12/05/10					
2	Ground	29.05	16.02 to 17.34	92.00	5520.00

Table 5: Time record for Wash basin's tap water flow

DATE:- 6/5/20			
S.No	**Floor**	**Flow Time (1 litre Bottle)**	
		Gents Toilet Baisn	**Gents Toilet Baisn**
1	Ground	11	7
2	1st	20	15
3	2nd	11	13
4	3rd	10	10
Total		52	45
Average		**13**	**11.25**
DATE:- 7/5/10			
1	Ground	10	8
2	1st	19	12
3	2nd	11	11
4	3rd	10	9
Total		50	40
Average		**12.5**	**10**
DATE:- 10/5/2010			
1	Ground	10	8
2	1st	20	12
3	2nd	12	10
4	3rd	9	10
Total		51	40
Average		**12.75**	**10**
Grand Total		38.3	31.3
Grand Average		**12.8**	**10.4**