Rooftop Rainwater Harvesting – A case study

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Abstract

During the last few years, India has witnessed a decline in surface water effected the use of flow irrigation and the rise of a groundwater drafting through private tube wells increased drastically. During past few years climate change has become as a force multiplier in dropping groundwater levels further. Hence there is a serious need of groundwater recharge in replenishing the aquifer. In some parts of India, due to over-exploitation of groundwater, decline in groundwater levels resulting intrusion of saline water in coastal areas and land subsidence have been observed. Usage of groundwater arose because of dip in normal rainfall and changes in government policies like free supply of electricity to farmers etc. Hence groundwater has become critical and threatened. There is need for artificial recharge of groundwater, conserve rainfall water i.e. water harvesting should be done wherever it is possible. Micro Water harvesting may be adopted by city dwellers, farmers in villages, and institutions level. The choice of a particular method is governed by local topographical, geological and soil conditions; the quantity and quality of water available for recharge; and the technological-economic viability and social acceptability. This paper discusses water harvesting at educational institution level.

Keywords: *groundwater, depletion, land subsidence, groundwater harvesting, recharge, rainfall, drafting.*

1. Introduction

Rain water harvesting (RWH) aims to augment ground water reservoir by modifying the natural movement and directing surface water to a suitable location where RWH pit is constructed. RWH techniques will address enhancing the sustainable yield in areas where over-development has depleted the aquifer. RWH conserves surface water runoff during monsoon, reduce soil erosion, preventing runoff from going into sewer or storm drains and reduce the water load on treatment plants, makes ecological and financial sense not to waste a pure natural resource available in large quantity. The increasing demand for water specifically in urban areas has increased awareness towards the use of RWH to augment ground water supplies. It is stated simply, RWH is a process by which excess surface-water is directed into the ground through a rain water pit interface. The RWH system for collection and reuse has to be constructed with

adequate collection facility in an open area should also be diverted to a percolation pit. These pits must be maintained in order to retain their percolation capacity. Percolation pits have to be constructed with proper layering.

2. Objectives

The main objective of water harvesting is sustainable water management and to accomplish the objectives like effective use of surface water collected from building roof, improvement and restoration of soil quality, maintaining physical health of the population, meet future water demands at reasonable cost, reducing the impact of natural hazards, helps to maintain clean and green environment, helps to increase the ground water levels. In the present study, an institute campus is selected. The specific objective of the study is to identify the locations and assessing the site condition for constructing RWH structures. Studies have been conducted for rain water collection and how effectively collected rain water can be recharged to ground aquifer through recharging pits and benefits drawn out.

3. Material and Methods

The methods of recharge of ground water are divided into two main categories.

1. Natural recharge
2. Artificial recharge i.e. RWH

Rain water collection from roof top of a building is one of the solution to conserve water through water harvesting system in urban areas where there is an inadequate groundwater resources and surface water sources are insignificant quality.

Average annual rainfall in the study area i.e. campus of Chaitanya Bharathi Institute of Technology (CBIT), Hyderabad is around 770 MM. To meet the water demand in the campus and augment the groundwater potential through RWH, eight groundwater recharge structures with a capacity ranging from 32,000 to 94,000 liters have been planned. The total water requirement for the institute is approximately **225,000** liters excluding watering to plants. The study area is located in the capital city of Hyderabad, Telangana State located at Latitude and Longitude of 17.3921° N and 78.3195° E respectively. The areal extent of the study area is 50 Acres (202,343 m^2). Total existing built-up area within the campus is 13,092 m^2 i.e. 11% of total area. The topography of the area is moderately undulating gravel soil, sloppy and well drained.

The data required for construction of water harvesting pits are given below:

1. Map Layout
2. Rainfall data
3. Geological data
4.

Roof top of a building is used as a source of rain water collection.

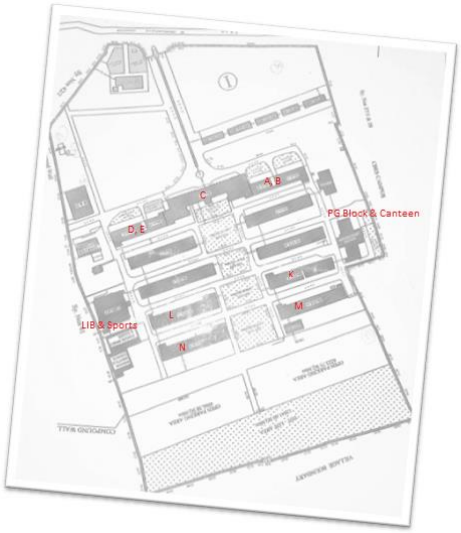

Figure 1. Building Blocks

*Black shade represents Building blocks

Monthly rainfall data has been collected for three years 2010, 2012, and 2014, tabulated as follows:

Table 1. Total monthly rainfall over three years

Rain fall in mm				
S. No	**Month**	**2010**	**2012**	**2014**
1	January	18	0	0
2	February	0	0	0
3	March	0	0	0
4	April	0	0	5
5	May	34	12	0
6	**June**	**185**	**38**	**179**
7	**July**	**261**	**157**	**294**
8	**August**	**243**	**119**	**122**
9	**September**	**171**	**69**	**76**
10	**October**	**70**	**75**	**64**
11	November	53	10	36
12	December	0	0	0
Total annual Rainfall		**1035**	**480**	**776**

The above table shows the monthly average rainfall for three years. It is observed that there was a more rainfall from June to October i.e. during monsoon season. Therefore it has been considered that the average rainfall in monsoon period was taken for design purpose.

Table 2. Rainfall data during monsoon – monthly rain fall in mm

S. No	Month	2010	2012	2014
1	June	185	38	179
2	July	261	157	294
3	August	243	119	122
4	September	171	69	76
5	October	70	75	64

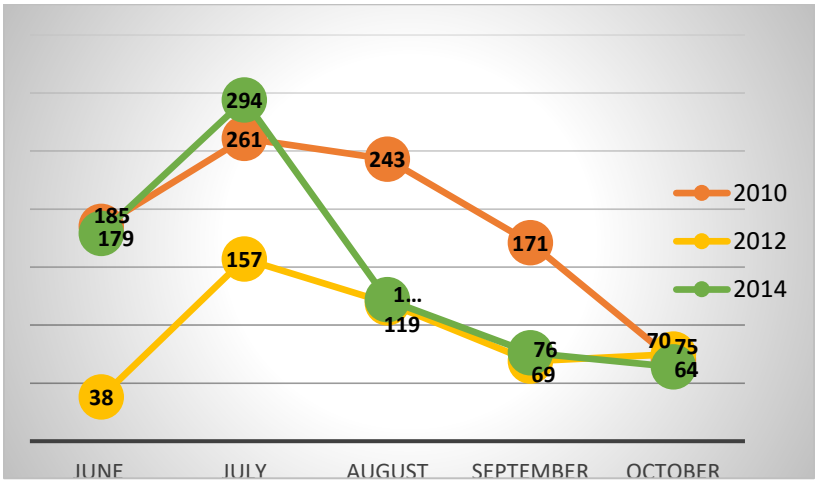

Figure 2. Variation of monthly monsoon rainfall for the year 2010, 2012 and 2014.

Table 3. Total annual rainfall for the period 2010, 2012, and 2014

S.No	Year	Annual Rainfall in mm
1	2010	1035
2	2012	480
3	2014	776

Average annual Rain fall = 764 mm

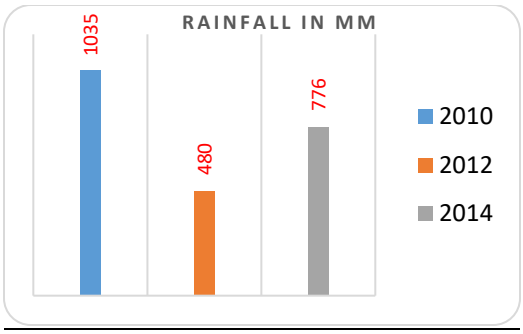

Figure 3. Variation of total annual rainfall for the year 2010, 2012 and 2014

Table 4. Maximum and minimum rainfall in a day for the period 2010, 2012 and 2014

S.No	Month	maximum and minimum day rainfall (in mm) for the period 2010, 2012, and 2014					
		2010		2012		2014	
		Max	Min	Max	Min	Max	Min
1	January	9	0	0	0	0	0
2	Feb	0	0	0	0	0	0
3	March	0	0	0	0	0	0
4	April	0	0	0	0	3	2
5	May	25	1	12	2	0	0
6	June	84	6	14	2	86	4
7	July	35	2	45	2	30	2
8	August	80	2	43	2	63	1
9	September	30	2	32	14	26	3
10	October	28	1	31	2	24	2
11	November	42	2	10	0	28	8
12	December	0	0	0	0	0	0
Average Rain fall in mm		27.75	1.33	15.58	1.83	21.67	1.83

***Data source**: HMWS & SB, Bojagutta, Hyderabad

An average rainfall of **21.67 mm** in a day was taken from the latest available data for the year 2014. Based on this average rainfall per day, the quantity of rain water is calculated. RWH structures are designed for the computed water quantity.

The rain water storage structure usually represents the biggest capital investment component of a RWH system. It requires a careful design – to provide optimum storage capacity and structural strength while keeping the costs as low as possible. In general, the size varies from 10 to 30 cubic meters for a domestic system at household level and 50 to 100 cubic meters for a community or education institute level.

5. Design of RWH Structure:

The total area of campus is 50 acres (202,343 square meters). Total existing built up area in campus is 13,092 m^2 i.e. **about 11% of total campus area**. The campus is underlain by gravel type of soil. Occasional fractures occur down to depth of 100 m below ground level. The climate in the study area is semi-arid with an average annual rainfall of 770 mm.

Design details of RWH structure (Block no. A, B):

Annual rainfall (year 2014) = 0.776 m

Average of "maximum rainfall in a day" (as per year 2014 rain fall) = 0.02167 m (approximated to 0.02 M)

A Rain fall of 0.02167 m per day is assured for six months in a year.

Maximum rainfall in a day is considered for design of harvesting structure.

Sample Design:

RWH1 for A and B blocks:

Roof Area of A and B blocks =702.23m^2

Volume of rain water available on roof top of A and B block = 0.02 m x702.23 m^2

=14.03 cum

RWH dimension = 3m x 2m x 2.5m

Model RWH structure (not to scale):

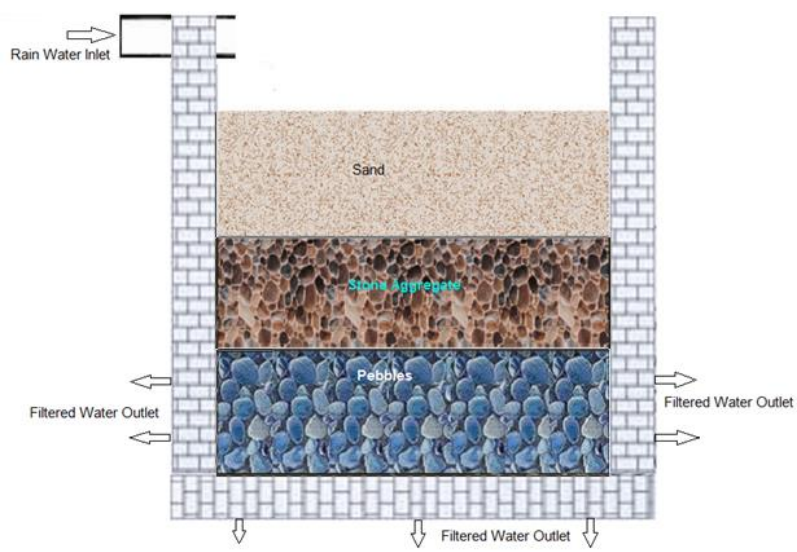

Figure 4. RWH structure (not to scale)

Institute water requirement is **2, 25,000** liters (5000 students, *45 liters per head) excluding watering to plants.
*Day schools 45 liters per head as per Bureau of Indian Standards IS: 1172-1993

Table 5. RWH structure details

S. No	**Block**	**Rainfall volume in a day (m^3)**	**RWH in meters (LxBxD)**	***RWH cost in rupees**	**RWH in liters**
1	A&B	14.03	3x2x2.5	35,175	15,000
2	C	34.23	4x4x2.2	82,544	35,200
3	D&E	13.6	3x2x2.3	32,361	13,800
4	PG block	19.52	3.2x2.5x2.3	47,193	18,400
5	K&M	28.8	3.5x3x2.75	67,712	28,875
6	L	19.8	3.5x2.5x2.3	47,193	20,125
7	N	19.8	3.5x2.5x2.3	47,193	20,125
8	Lib& Sports	40	5x4x2	93,800	40,000
Total Cost(Rs)				**453,171**	**191,525**

*RWH cost: Cost for construction of one cubic meter of RWH (inclusive of pipes and fittings) is Rs 2345. The above table shows that about **191,525 liters** of rain water can be collected during the months June to November i.e. for 6 months in a year.

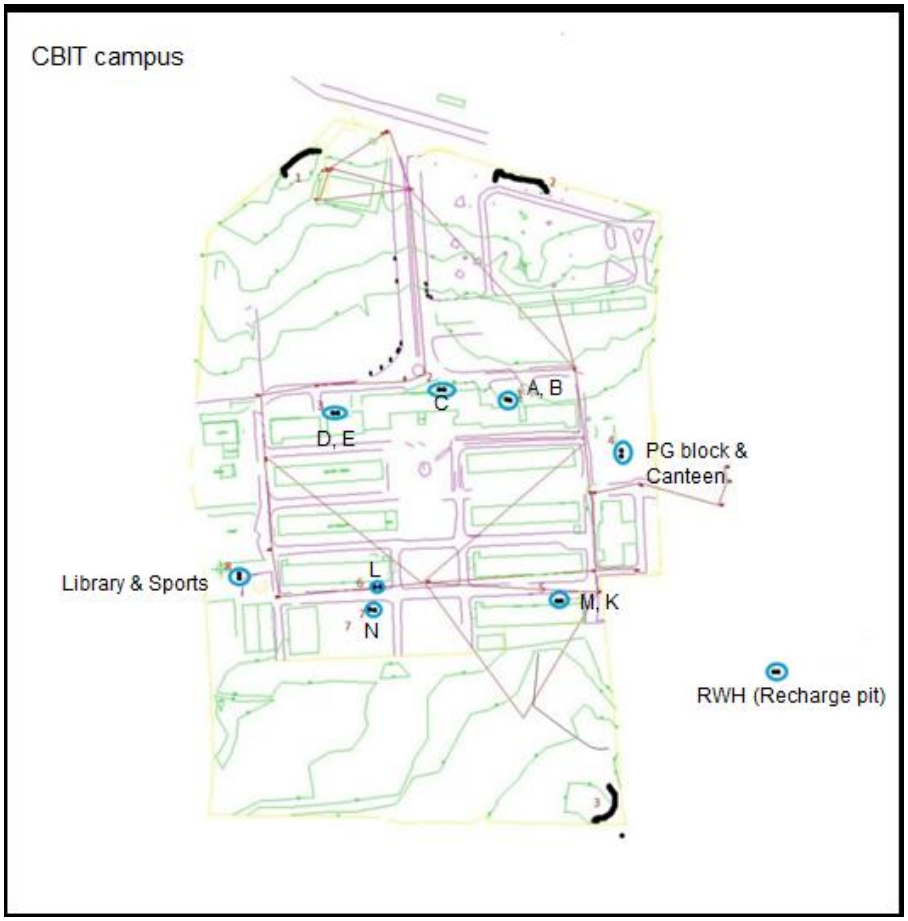

Figure 5. RWH locations

6. Conclusion:

The reality, water crisis cannot be ignored. India has been notorious of being poor in management of water resources. The demand of water is already outstripping the supply. Extraction of ground water is being done unplanned and uncontrolled resulting in hydrological imbalance. This study dealt with all aspects of improving the water scarcity problem in CBIT campus by implementing RWH to augment the ground water table. The aquifer is recharged through RWH during rain fall i.e. in monsoon period.

Present groundwater table level for Hyderabad is 9.39 meters below ground level (mbgl) as per data obtained from Telangana State Ground Water Department (TSGWD), May 2018.

The areal extent of study area is 50 acres (202,343 m^2). Considering groundwater recharge of 191,525 liters per day for 6 months in a year, there will be a rise of water table about 17 cm in a year. This will alter the present groundwater table level 9.39 meters below ground level (mgbl). It will have an effect on pumping head and it reduces the consumption of electrical energy.

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