© November 2017 | IJIRT | Volume 4 Issue 6 | ISSN: 2349-6002

Design of Rain Water Harvesting Unit: A Case Study in Jain University, SET, Jakkasandra, Ramanagara District

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***Abstract*- Rain water harvesting is an accumulation and deposition of rain water for reuse before it reaches the aquifer. The main uses include water for gardening, water for livestock and water for irrigation etc.[1] Presently this water is used for gardening in SET JU is been pumped from bore well. Rain water harvesting unit has been designed for SET JU (Main building, hostel and canteen). The unit consists of 3 sand beds for filtering the collected rain water from each individual building. The water is then redirected to the designed underground water storage tank. The water collected in the water tank can be used efficiently for multiple purpose. The overflow water, if any may be diverted for the ground water recharge by using efficient method like recharge trench with bore. The overall cost for the rain water harvesting unit for SET, JU is estimated. The rain water harvesting unit is cost effective compared to the cost involved in pumping ground water for multiple purpose. As large quantity of water is used for gardening. The rain water harvesting is a good alternative.**

***Index Terms*- Rain water, harvesting, ground water, ground water recharge etc**

I. INTRODUCTION

Water, one of the main natural resources is taken for granted keep by all humans, of whom not many put thought into usage and rejuvenate the water. Rain water harvesting is the process of collection of rain water from land to the rain falling, filters and save it to be used for various multiple purposes. With water, harvesting provides the supply back to the normal levels. It is the collection and storage of water from the surfaces that is like rain. [2]

Need for rain water harvesting:

i. to overcome the inadequacy of surface water to meet our demands.

ii. to arrest decline in ground water levels.

iii. To enhance availability of ground water at specific place and time and utilize rain water for sustainable development.

iv. To increase infiltration of rain water in the subsoil this has decreased drastically in urban areas due to paving of open area.

v. To improve ground water quality by dilution.

vi. To increase agriculture production.

vii. To improve ecology of the area by increase in vegetation cover etc. [3]

Advantages of rain water harvesting:

i. the cost of recharge to sub-surface reservoir is lower than surface reservoirs.

ii. The aquifer serves as a distribution system also.

iii. No land is wasted for storage purpose and no population displacement is involved.

iv. Ground water is not directly exposed to evaporation and pollution.

v. Storing water under ground is environment friendly.

vi. It increases the productivity of aquifer.

vii. It reduces flood hazards.

viii. Effects rise in ground water levels.

ix. Mitigates effects of drought.

x. Reduces soil erosion. [3]

Materials and Methods:

Study Area: The study area, Jain University, geographically lies between12° 55´4.8" N and 77° 35´27.6"E, situated in jakkasandra, kanakapura taluk. A total area of 5200 sq.m was surveyed and studied for this work.

The following is the sample satellite image of the above mentioned study area:

Materials: The present work aims at designing a rain water harvesting unit in the SET-JU campus. The following materials are used in designing the rain water harvesting unit.

1. Land survey details.
2. Collection and prediction of rainfall data.
3. Catchment area
4. Coarse mesh/ leaf screens
5.Gutters
6.Down spout/Conduit
7.Filters
8.Storage tanks
9.Estimation details

Land survey details: The land survey was carried out in the SET-JU covering an area of almost 51,720 sq.m. This was carried out in order to determine the topography of the ground of above mentioned area in SET-JU campus.

The following equipment were used in the land survey:-

1. Dumpy level with stand
2. Leveling staff
3. Tape
4. Cross staff
5. Arrows
6. Chain

Table: 1 the survey details of the college to canteen are shown below

BS	IS	FS	BM	RL	REMARKS
1			101	100	
	1.81			99.19	Zero end
	1.71			99.29	
	1.685			99.315	
	1.78			99.22	
	1.765			99.235	
	1.795			99.205	
	1.68			99.32	
	1.635			99.365	
	1.635			99.365	
	1.595			99.405	
	1.1			99.9	
	0.795			100.205	
	0.725			100.275	
	0.71			100.29	
	0.705			100.295	
	0.67			100.33	
	0.62			100.38	
	0.55			100.45	
		0.53		100.47	

Graph: 1 The ground profile from college to canteen is as shown in the below drawing

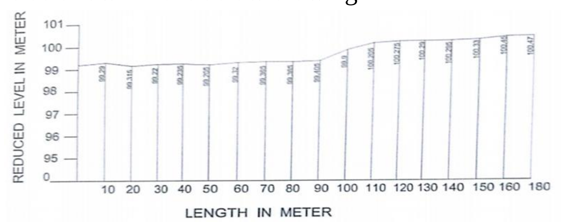
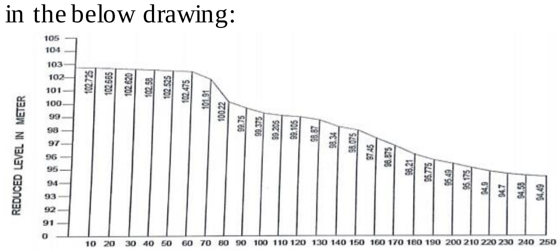


Table: 2 The survey details from hostel to canteen are as shown in the below table:

BS	IS	FS	BM	RL	REMARKS
1			101	100	
2.96		0.21	103.75	100.79	
	0.995			102.755	Zero point
	1.025			102.725	
	1.085			102.665	
	1.13			102.62	
	1.17			102.58	
	1.225			102.525	
	1.275			102.475	
	1.585			101.91	
	3.53			100.22	
0.31		4	100.06	99.75	
	0.685			99.375	
	0.885			99.205	
	0.995			99.105	
	1.19			99.87	
	1.72			98.34	
	1.985			98.075	
	2.61			97.45	
	3.185			96.875	
0.89		3.85	97.1	96.21	
	1.325			95.775	
	1.61			95.49	
	1.925			95.175	
1.645		2.2	96.545	94.9	
	1.845			94.58	
	2.015			94.49	

The ground profile from hostel to college is as shown in the below drawing:

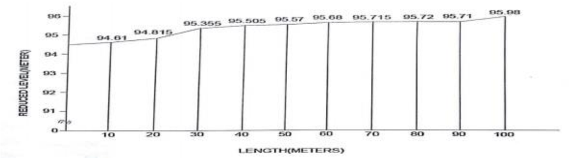


The survey detail from college parking to KEB junction is as shownin the table below:

BS	IS	FS	BM	RL	REMARKS
2.055			96.545	94.49	Zero point
	1.935			94.61	
	1.73			94.815	
	1.19			95.355	

	1.04			95.505	
	0.975			95.57	
	0.865			95.68	
	0.83			95.715	
	0.825			95.72	
	0.835			95.71	
	0.565			95.98	

The ground profile from college parking to KEB junction is as shown in drawing below:



Collection and prediction of rain fall data: The rainfall data was collected from "KARNATAKA GOVT BUREAU OF ECONOMICS AND STATISTICS DEPARTMENT" taluk office, Kanakapura. The monthly rainfall data collected for the year 2005 to 2012 from the department is tabulated below in the table.

MONTH	RAINFALL(mm)								
	2005	2006	2007	2008	2009	2010	2011	2012	PMP
Jan	0	1.2	0	0	0	0	0	0	2.29
Feb	14.2	0	0	0	0	0	16.2	0	39.08
Mar	13	18.8	0	40.4	25.6	0	0	0	91.125
Apr	48.6	58.2	60.2	27.2	17.2	49.2	67.6	21.4	148.525
May	109.2	81.8	30.2	29	170.4	123.0	164.6	90.6	367.69
Jun	150.8	30	50	2.2	105.6	11.6	17.8	0	329.471
Jul	38.4	25.2	53.6	90.6	41.4	110.6	75.8	57.4	205.475
Aug	90.8	20.4	115.2	392.2	151	82.6	122.8	62.4	696.07
Sep	25.6	49.4	198.6	90.6	229.6	115.8	5.2	3.4	522.47
Oct	10.4	59.8	91.04	65	22.6	112.2	130.4	111.4	293.17
Nov	20.2	40.2	23.8	74.6	15.2	113.8	37.4	64.4	216.75
Dec	1.2	9.4	29	0	0	0	0	3.2	55.775

Calculation of probable maximum precipitation: from the available data the PMP is calculated using below formulas:

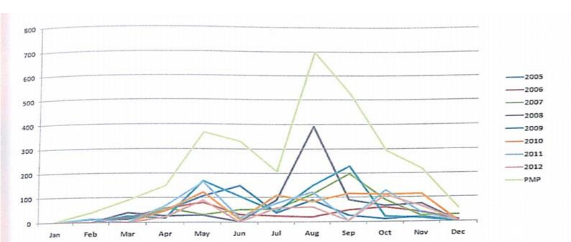
PMP=

$$\bar{P} = \frac{\sum_{i=1}^{m} Pi}{m}$$

$$\sigma = \sqrt{\frac{\sum_{i=1}^{m}\{Pi-\bar{P}\}^2}{\{m-1\}}}$$

$$PMP = \bar{P} + k\sigma,$$

Where k is constant



Graph of PMP

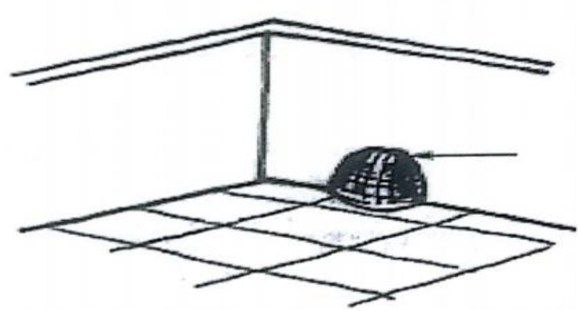
The above graph of PMP shows the different values of PMP against the twelve months of the year and the data represented is of 2005-2012.This graph gives the maximum value of PMP which is at 700 in the month of august. The water storage tank to be used for the collection of rain water has to be designed for maximum value of PMP in the last ten years.

Catchment Area: It is the surface on which the rain water falls. This may be a roof top or open area around the building. The quality of water collected from roof top is comparatively much better than the collection from the ground. The rain water yield varies with the size and texture of the catchment area. This contributes to the better water quality and greater quantity with higher value of runoff coefficient.

The following table shows the standard run off coefficient values: [4]

Type of Catchment	Coefficients
Roof Catchments	
Tiles	0.8 – 0.9
Corrugated metal sheets	0.7- 0.9
Ground surface coverings	
Concrete	0.6 – 0.8
Brick pavement	0.5- 0.6
Untreated ground catchments	
Soil on slopes less than 10	0.0 – 0.3
Rocky natural catchments	0.2 – 0.5

4. Coarse mesh/ leaf screen: to prevent the entry of leaves and other debris in the system, the coarse mesh should be provided at the mouth of inflow pipe for flat roofs as shown in the figure below.



5. Gutter: it is required to be used for collecting water from sloping roof and to divert it to downspout. These are the channels all around the edge of a sloping roof to collect and transport the rain water to the storage tank.

6. Downspout/ conduit: the rain water collected on the roof top is transported down to storage facility

through down spouts or conduits. These can be of any materials like PVC, GI or cast iron.

7. Filter: If the collected water from roof top is to be used for human consumption directly, a filter unit is required to be installed in RWH system before storage tank. This filter is used to remove suspended pollutants from rain water collected over roof. It is basically a chamber filled with filtering media such as fiber, coarse sand and gravel layers to remove the debris and dirt from water before it enters the storage tank.

8. Estimation Details: This consists of the overall cost of pipe line, filter, storage tank and ground water recharge.

Cost of PCC work for 1 cum =Rs.1542/-

Cost of 1st class brick work for per cum= Rs.248582.1/-

cost of RCC work for 1 cum with 2% steel = Rs. 130173.265/-

cost of pipe installation=Rs 243846

cost of installation of sand filter= Rs 331905.45/-

Cost of installation of storage tank =Rs 371538.545/-

cost of steel work= Rs 230727.88/-

Total cost for the completion of the design of unit estimated = Rs.12, 00,000/-

Methods

The method of ground water recharge used in SET JU:

Roof Top Rain Water Harvesting through Recharge Trench:

a. Recharge trenches are suitable for buildings having roof area of 200-300 sq.m and where permeable strata are available at shallow depths.

b. Trench may be 0.5 to 1 m wide, 1 to 1.5 m deep and 10 to 20 m long depending upon availability of water to be recharged.

c. These are back filled with boulders (5-20 cm), gravels (5-10 mm) and coarse sand (1.5-2 mm) in graded form—boulders at the bottom, gravel in between and coarse sand at the top so that the silt content that will come with runoff will be deposited on the top of the sand layer and can easily be removed.

d. A mesh should be provided at the roof so that leaves or any other solid waste/debris is prevented from entering the trench and a desilting/collection chamber may also be provided on ground to arrest the flow of finer particles to the trench.

e. By-pass arrangement is provided before the collection chamber to reject the first showers.

f. The top layer of sand should be cleaned periodically to maintain the recharge rate.

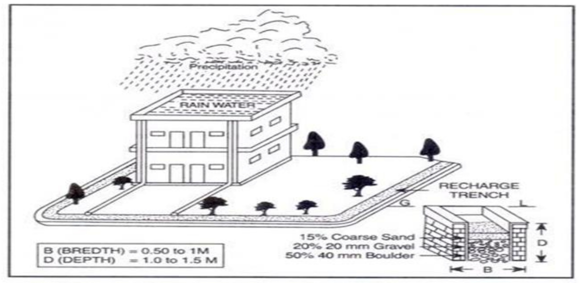


FIG. 16.8. Roof top rain water harvesting through recharge trench

The above mentioned method can be used if there is any over flow of rain fall. [5]

Rain water harvesting potential:

The rain water harvesting potential can be estimated using the following equation:

Rain water harvest potential = amount of rainfall*area of coefficient*runoff Coefficient this potential can be illustrated using the following example:

Consider a building with a flat roof terrace area (A) of 100 sq.m located in Bangalore.

The average rainfall in Bangalore(R) = 859 mm.

The run off coefficient for a flat terrace may be taken between 0.7-0.9.

Therefore let C =0.85

Therefore rain water harvesting potential = A*R*C = 100*0.859*0.85=73.015cu.m= 73015 litres. [6]

Precautions to be considered while harvesting rain water:

1.Keep the roof or the water collection area clean before the rains.

2. Flush the rainwater collected in the first few minutes.

3. Store the collected rainwater in a closed container (avoid sunlight).

4. The quality of water deteriorates in the presence of sunlight and air.

5. Water can be kept clean over a period of five to six months in a clean container stored in an enclosed area protected from sunlight. [7]

Results and Discussions

The study area selected is located at SET JU campus and it includes green belt area of almost 60% of the study area. The survey was conducted in the study area of 52000 sq.m. For our work we considered roof area of college, hostel and canteen. The total roof area calculated and adopted for the study is 11,874sq.m.

Designing of filter and storage tank is made for the filtration and storage of rain water on the basis of volume of rain water predicted per day. The designed parameters of different components of RWH unit are

Designed dimensions of the sand bed filter to filter the collected water from the roof of:

1.college is (L*B*D) = 5.61m*2.8*2.5m

2.hostel is (L*B*D) = 4.3m*2.2m*2.5m

3. Canteen is (L*B*D) = 3.55m*1.77m*2.5m

Underground storage water tank for collecting the rain water:

The dimension of storage tank for collecting 200 cu.m of water =10*5*5 m

the overall cost for the completion of work is estimated to be =Rs 12, 00,000/-

The initial cost of the proposed rain water harvesting unit appears to be more, but if compared with the overall cost of pumping and storage , the rain water harvesting will prove to be more beneficial, never the less it also reduces the use of natural ground water.

CONCLUSION

1. Rain water collected in the tank can be used for different purposes on the quality.
2. In our study area large quantity of water is used for gardening. Hence collected rain water can be used for gardening.
3. By adopting RWH method, we can reduce pumping of natural water. Hence the pumping cost will also reduce.
4. When the rain fall is of large duration the collected water can also be used for ground water recharge by using different methods. Recharge trench with bore method being cost effective has been recommended for recharging the ground water.
5. By adopting RWH, surface runoff can be reduced. Hence in return erosion also reduces.
6. For total RWH Operation, the maintenance cost is expected to be less when compared to ground water pumping.
7. By using the collected rain water, we can reduce the consumption of the natural ground water, hence can reduce ground water table depletion.

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