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Rooftop Rainwater Harvesting: A Case Study on Jnana Nivas Apartment

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Abstract – *The exponentially increasing population and depleting water resources leads to water stress. Water stress is a condition where the demand for water is more than that can be supplied. One such method that can increase the groundwater potential is by harvesting rainwater. This includes both collection and preservation of rainwater for further applications such as, domestic, industrial or recreational etc. In this study, a residential apartment is explored for its rooftop rainwater harvesting potential through recharge pit method. The case study revealed that adoption of rainwater harvesting system is crucial in saving water and increasing ground water table in urban areas. It was found out that the apartment having rooftop area of 1283.92 m² harvested 772 m³ of rainwater resulting in preservation and possible rise of existing groundwater table level of the study area.*

Key Words: groundwater, depletion, recharge, rainwater harvesting and water stress.

1. INTRODUCTION

About 71% of the Earth's component is made up of water, possessing such vast potential only 2.5% of the total water source constitutes to fresh water [1]. Of the 2.5%, groundwater has a share of 30.1% while the remaining exists in the form of glaciers, ice caps and surface water storage such as lakes and rivers [2].

The scarcity of fresh water availability leads to water stress and the primary front factors responsible for water stress are viz., poor resource management, lack of government regulations and the allowance of untreated waste water into the natural water bodies etc. This can be exemplified from the fact that 18% of the world's population that resides in India has an access only to 4% of the useable water sources [3]. Decrease in water stress has become need of the hour and this can be achieved by amplifying the existing groundwater potential through rainwater harvesting.

The rainwater harvesting can be primarily classified under two sections viz., surface runoff harvesting and rooftop harvesting [4]. Surface runoff can be defined as the flow of excess storm water, melt water, or other sources over the earth's surface [5]. Harvesting of such water is called as surface runoff harvesting. Following two methods can be adopted for surface runoff harvesting viz., water pan and rock catchment. The precipitation collected on the rooftop of a building or a house can be harvested for direct domestic use and also to recharge ground water and this method is known as rooftop rainwater harvesting [6]. Rooftop rainwater harvesting is basically localized to urban areas and by proper implementation of this method, groundwater table level can be significantly increased, subsequently reducing the water stress of the area.

1.1 Need for Rainwater Harvesting System

- To complement the existing surface runoff.
- Groundwater recharge amplifies its availability paving way for sustainable development.
- To lift the ground water table level.
- To satisfy the demand and supply equation of surface water.
- To improve ecology of the surrounding environment.

2. METHODOLOGY

2.1 Study Area

The study area Jnana Nivas Apartments is geographically located between 12° 54' 42.64'' N and 77° 30' 48.38'' E. It is a G+4 residential building in RR Nagar, Bengaluru, Karnataka, India.

Fig -1: Jnana Nivas G+4 residential apartments

2.2 Method

Rooftop rainwater harvesting is a vital and effective system to play down the water stress problem in urban areas. In this study area rainwater harvesting through recharge pit method has been adopted. Rainwater accumulated on rooftops of buildings, paved and unpaved areas goes waste unless it is recharged to aquifer and utilized appropriately at the hour of need. The design of this system should be such that it is low in space coverage and highly efficient in collection and recharge of rainwater. More the amount of rainfall, greater is the harvested water from rooftop.

Similarly, larger amount of rooftop rainwater is harvested from roofs with large area.

2.3 Rooftop Rainwater Harvesting through Recharge Pit

a. In alluvial areas where the rocks with interconnected pores i.e., permeable rocks are bare open to the land surface or are present just below the land surface at a shallow depth, then rooftop rainwater harvesting can be done through recharge pits.

b. The recharge pit technique is adaptable for a roof area of 100m² and is an efficient method of recharging the shallow aquifers.

c. Recharge pits may be of any shape and size, generally circular shape is preferred and the diameter of the pit varies between 1.5m to 3 m wide and 2 to 3 m deep which are back filled with boulders (5cm - 20cm), gravels (5mm - 10mm) and coarse sand (1.5mm - 2 mm) in graded form [7]. Boulders are at the bottom, gravels in middle and the coarse sand at the top and for smaller roof area, pit may be filled with broken bricks or cobbles [8].

d. Adoption of mesh results in prevention of leaves and other debris entering the recharge pit and also a de-silting chamber can be provided at the ground level to inhibit the flow of finer particles to the recharge pit.

e. By-pass arrangement is provided before the collection chamber to reject the first showers [7].

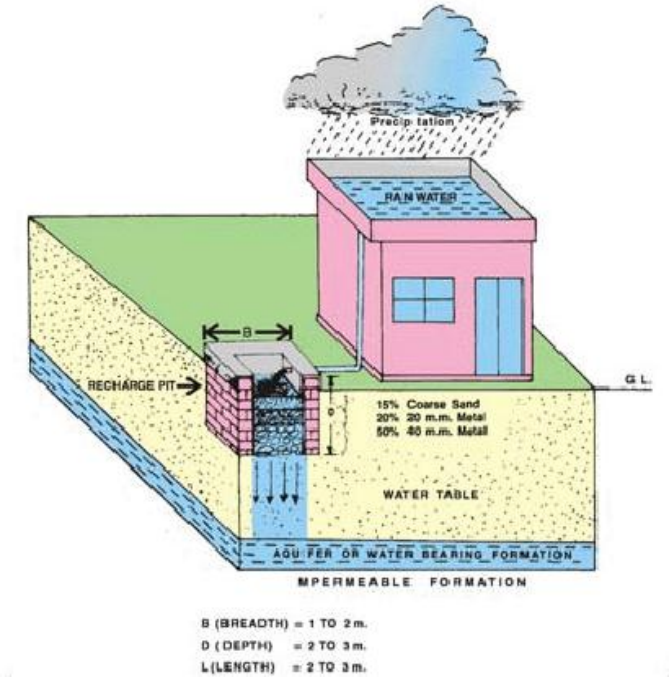

Fig -2: Rooftop rainwater harvesting through recharge pit method [9]

3. DATA

The following data are used in designing the rainwater harvesting unit.

3.1 Groundwater Table

In this particular site, water was found to be at 650 feet below the ground surface. On the whole, a drop of 4 m can be seen in the ground water table of Bangalore south region.

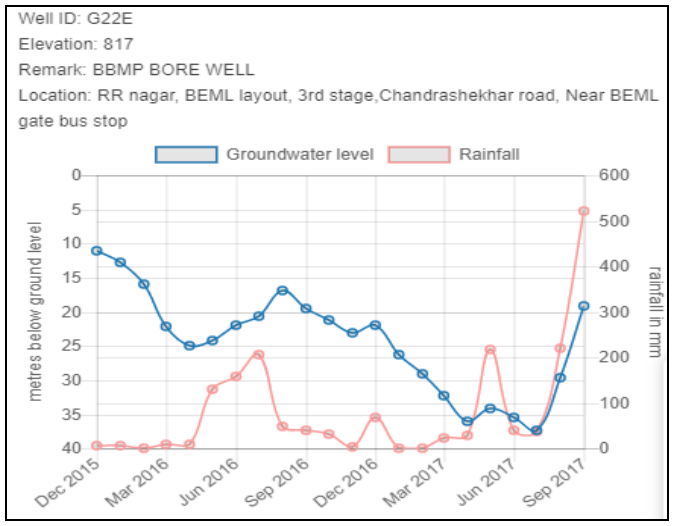

Chart -1: Groundwater and rainfall data [10]

3.2 Rainfall

Comparing normal to the actual rainfall it can be noticed that the rainfall is in excess but it fails to increase the ground water table as stated above.

Table -1: Rainfall data for Bengaluru South region [10]

Taluk	RAINFALL		% DEP	PERIOD	Classification
	Normal	Actual			
Bengaluru South	179	237	32	Jan to May 2017	E*
Bengaluru South	550	862	57	June to Sept 2017	E
Bengaluru South	249	256	3	Sept to Dec 2017	N*
Bengaluru South	977	1355	39	Jan to Dec 2017	E

Note: *E- Excess Rainfall and *N- Normal Rainfall.

3.3 Catchment Area

Catchment area can be defined as the area over which the rainfall is accumulated. In most of the urban dwellings rooftop is taken as the catchment area. The apartment has a

concrete rooftop area of 13,820 sq. ft with a runoff coefficient of 0.6 - 0.8. The quality of the rainwater collected varies with the type and maintenance quality of the catchment area. When rooftop harvesting is compared to the surface runoff harvesting, the former yields better water quality.

3.4 Mesh

It is equipment used to filter out the coarser materials along with leaves, debris etc. the provision of mesh does not alter the quality of the collected water. Secondary water filters have to be adopted, If the water has to be used for domestic purposes such as drinking.

3.5 Down Spout (Conduit)

Rooftop and the storage tank are connected through a 4" PVC pipe which allows the transfer of accumulated water over the rooftop to the recharge pit or storage tank.

Fig -3: PVC conduit

3.6 Storage Tank

The storage tank has been constructed in the form of pit wherein 10 rings, each of 1 ft depth and 3 ft diameter are placed one above the other to form the pit. The gaps are then filled using aggregate. The pit is covered with a concrete covering plate. The collected water is used as and when required.

4. COST ANALYSIS

a. Cost of pit excavation = Rs 4000

b. Cost of one ring = Rs 650

c. Cost of ten rings = 650x10= Rs 6500

d. Cost of cover plate = Rs 1000

e. Cost of 60 feet PVC pipe = Rs 3480

f. Cost of labour = Rs 3000

g. Total cost = Rs 18,879 (including 5% contingencies).

5. RAINWATER HARVESTING POTENTIAL

The rainwater harvesting potential can be estimated using the following equation:

Rainwater harvesting potential = (Amount of rainfall) * (Area of coefficient) * (Runoff coefficient)

a. The Jnana Nivas building has a flat roof terrace of area (A), 1283.92 m^2.

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

c. The run off coefficient for a flat terrace may be taken between0.6-0.8. Therefore, let C =0.7

d. Rainwater harvesting potential = A*R*C = 1283.92 * 0.859 * 0.7 = 772.0210996 m^3 = 772021.096 litres.

6. CONCLUSIONS

a. The rainwater harvesting increases ground water table of the study area, thus providing easy water access to its residents.

b. There is considerable reduce in the water bill for residents since they have opted for usage of harvested water.

c. The harvested rainwater in the study area is used for resident's car wash and also for gardening. This would prevent groundwater depletion and acts as groundwater table supplement.

d. The collected water flows into the recharge pit through gravity, hence there is no pumping action required, and thus pumping cost is nullified.

e. By adapting the rainwater harvesting, the groundwater conditions of the area will be significantly improved and the water resources of area is saved for the future.

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