RAINWATER HARVESTING FOR RECHARGING GROUNDWATER- A CASE STUDY FOR NURSING COLLEGE, T.M.U. MORADABAD

Dr S Rehan Ali

Associate Professor & Head, Department of Civil Engineering, College of Engineering, Teerthanker Mahaveer University, Moradabad, (India)

ABSTRACT

The technical aspects of this paper are rooftop rainwater harvesting which is considered to be catchment areas of College of Nursing, Teerthanker Mahaveer University, Moradabad. Required data such as catchment areas, rainfall data, runoff, groundwater condition etc was collected and calculated. Then a recharge pit of suitable capacity and design was constructed. Optimum location of recharge pit was done using the hydrological analysis from the available data. The cost of the project was also calculated.

In order to conserve the groundwater, this project was found cost effective and very useful for recharging the groundwater. It is hoped that this paper will also be a useful and valuable resource to other organizations which are planning to promote rainwater harvesting to supplement existing water systems. This paper will also raise awareness of the importance of rainwater harvesting for recharging groundwater.

Keywords*: *Catchment Area, Conserve, Groundwater, Rainwater Harvesting, Rainfall Data, Recharge, Runoff

I INTRODUCTION

This research paper discusses the importance of managing rainwater in order to recharge groundwater sources. The concept of rainwater harvesting involves 'tapping the rainwater where it falls'. A major portion of rainwater that falls on the earth's surface run off into streams and rivers and finally into the sea. An average of 8-12 percent of the total rainfall recharge only is considered to recharge the aquifers.[1] The technique of rainwater harvesting involves collecting the rain water from localized catchment surfaces such as roofs, plain / sloping surfaces etc., either for direct use or to augment the groundwater resources depending on local conditions. Among various techniques of water harvesting, harvesting water from roof tops needs special attention because it is one of the appropriate options for augmenting groundwater recharge/ storage in areas where natural recharge is considerably reduced due to increased urban activities and not much land is available for implementing any other artificial recharge measure. Rooftop rainwater harvesting can supplement the domestic requirements in rural areas as well.[1] Rainwater runoff which otherwise flows through sewers and storm drains and is wasted, can be harvested and utilized. It is bacteriological safe, free from organic matter. It also helps in reducing the frequent drainage congestion and flooding during heavy rains in urban areas where availability of open surfaces is limited and surface runoff is quite high. Overall, it improves the quality of groundwater through dilution and the harnessed rainwater can be utilized at the time of need. The structures required for harvesting rainwater are simple, economical and eco-friendly. Finally, roof catchments are relatively cleaner and free from contamination compared to the ground level catchments.

Today due to rising population & economic growth rate, demands for the surface water is increasing exponentially. Rainwater harvesting is seems to be a perfect replacement for surface & groundwater as later is cost effective and relatively lesser complex way of managing our limited resources ensuring sustained long-term supply of water to the community.

Today, only 2.5 per cent of the entire world's water is fresh, which is fit for human consumption, agriculture and industry [2]. Almost all of it is locked up in ice and in the ground. In several parts of the world, however, water is being used at a much faster rate than can be refilled by rainfall. In India, the per capita water availability is 1545 cubic meters as per the 2011 census which was 1816 cubic meters in 2001. It is reducing progressively from 5000 in 1950.[3] The United Nations warns that this shortage of freshwater could be the most serious obstacle to producing enough food for a growing world population, reducing poverty and protecting the environment.

II OBJECTIVES

The campus is situated at the distance of 12 km from Moradabad city in a large area of about 200 acres with strength of about 14000 students and staff. Water is the most natural resource which is being always in high demands by students and staff. If this demand is not met, then it will lead to water scarcity. Therefore, rainwater harvesting system can be considered as a best solution for fighting against scarcity of water. Moreover, owing to its simple technique, ease of construction & installation and low cost of investment, this technique again suites for implementation inside the campus. It can meet potable and non-potable water demands. It will also help in increasing the soil moisture condition and fertility factor of soil for plantation. This simple technique tends to increase the greenery in and around the campus, increasing aesthetic factor for a proper residential institute to live in. Therefore, keeping in mind all these positive aspects, rainwater harvesting is highly recommended for College of nursing, campus of TMU, Moradabad.

III DATA SOURCES & METHODOLOGY

3.1 Rainfall Data

Table1. Average Annual Rainfall of Moradabad

Year	Average rainfall in mm
2008	64.83
2009	49.73
2010	97.50
2011	85.75
2012	53.50
2013	79.25

Average rainfall = 79 mm

Moradabad has a tropical climate and receives high rainfall during Southwest monsoon (June –Sept.) and retreating Northeast monsoon (Dec.-Jan.). The average monthly rainfall data are being taken from the Metrological and agriculture department, Moradabad. The monthly rainfall data of the Moradabad city is given above in the Table 1, which is assumed to be same for the Campus also.

HYDROMET DIVISION
INDIA METEOROLOGICAL DEPARTMENT
DISTRICT RAINFALL (MM.) FOR LAST FIVE YEARS

District : MORADABAD

Note : (1) The District Rainfall(mm.)(R/F) shown below are the arithmatic averages of Rainfall of Stations under the District.
(2) % Dep. are the Departures of rainfall from the long period averages of rainfall for the District.
(3) Blank Spaces show non-availability of Data.

YEAR	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.
2008					0.0	-100	0.0	-100	13.4	-16	365.2	358	173.1	-44	315.6	4	58.8	-63	2.0	-96	7.4	118	0.0	-100
2009	0.0	-100	10.8	-47	4.0	-71	39.6	529	5.7	-64	13.3	-83	145.6	-53	195.9	-35	171.2	8	103.5	117	4.6	35	0.0	-100
2010	0.2	-99	13.0	-36	1.3	-90	0.0	-100	45.7	187	18.7	-77	555.1	81	450.9	49	436.1	176	0.5	-99	0.2	-94	8.7	-2
2011	2.1	-91	22.4	3	6.2	-52	5.9	26	43.4	175	193.6	113	242.7	-17	518.6	65	134.3	-14	0.6	-99	0.0	-100	0.0	-100
2012	19.3	-14	1.4	-94	3.0	-77	6.4	36	1.1	-93	4.2	-95	190.4	-35	288.6	-8	137.2	-12	0.0	-100	0.2	-94	3.7	-58

Table 2 Rainfall data of Moradabad district for last five years

3.2 Determination of catchment area

The catchment area of college of nursing building is measured with the help of following plan. (Fig.1). It is 27000 sq. ft.

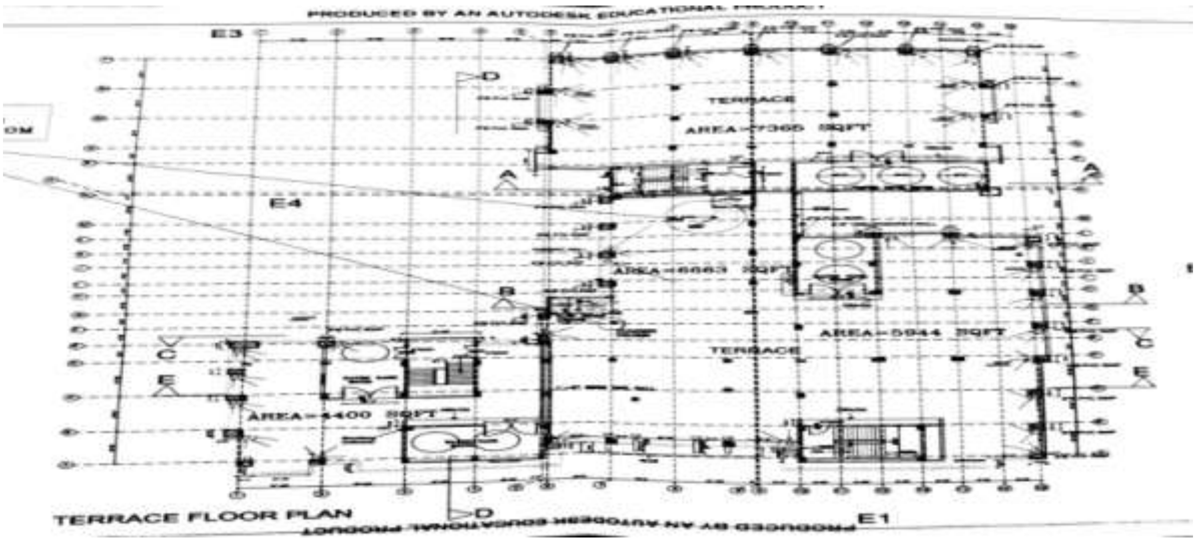

Fig.1 Terrace Plan of college of nursing

3.3 Hydrological Analysis

The total amount of water that is received from rainfall over an area is called the rainwater legacy of that area and the amount that can be harvested effectively is called the water harvesting potential. The formula for calculation is given as

Harvesting potential or Volume of water received (m^3)

Coefficient = Area of Catchment (m^2) x Amount of rainfall (mm) Runoff

Runoff coefficient for any catchment is the ratios of the volume of water that runoff a surface to the volume of rainfall that falls on the surface. Runoff coefficient accounts for losses due to spillage, leakage, infiltration, catchment surface wetting and evaporation, which will all contribute to reducing the amount of runoff. Runoff coefficient varies from 0.5 to 1.0[4]. In present problem statement, runoff coefficient is equal to 0.8 as the rooftop area is impervious. Eco-Climatic condition (i.e. Rainfall quantity & Rainfall pattern) and the catchment characteristics are considered to be most important factors affecting rainwater Potential.

3.4 Roof top rain water harvesting through recharge pit

In alluvial areas where permeable rocks are exposed on the land surface or at very shallow depth, roof top rain water harvesting can be done through recharge pits. The technique is suitable for buildings having a roof area of 100 sq. m. or more and is constructed for recharging the shallow aquifers. Recharge pits may be of any shape and size and are generally constructed 1 to 2 meter wide and 2 to 3meter deep which are back filled with boulders (5-20 cm), gravels (5-10mm) and coarse sand (1.5 to 2mm) in graded form, boulders at the bottom, gravels 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 coarse sand layer and can easily be removed. A mesh should be provided at the roof so that leaves or any other solid waste / debris is prevented from entering the pit and a desalting / collection chamber may also be provided at the ground to arrest the flow of finer particles to the recharge pit [5]. The top layer of sand should be cleaned periodically to maintain the recharge rate.

3.5 Process for constructing a suitable Recharge Pit

Different types of catchments are to be marked on the site plan. The collection efficiency of a particular catchment will be determined by the fact whether the catchment will be paved, unpaved or roof.

3.6 Area of the catchments

The amount of rainfall that will be collected will depend directly on the area of the catchment. And the quality of water that will be collected from the catchment will depend on the location of the catchment. Roof catchment provides the best quality of water. In areas where the catchments are open to contamination or are chemically treated then the water must be treated before being used for any purpose.

3.7 Rainfall

The annual average rainfall will give an overall picture of the total amount of water that can be collected.

3.8 Geological and hydrogeological data

For systems where the harvested rainwater will be used to recharge the aquifer, selection of site is important. Information must be collected on the basis shown in Table.3 given below .

Parameter	Type	Description
Soil	Poor or well sorted sand or gravel, fine sand, silt, loam, layered or weathered clay	Sand, sandy loam and loamy sand soils have high infiltration rates. Silty loam or loam has moderate infiltration rates and clayey soils or consolidated rocks have low infiltration rates.
Rocks	Fractured or massive rocks, sandstone, limestone	Hard massive rocks are conducive to recharge
Aquifers	Confined or unconfined, perched, thickness of aquifer	The aquifer should be unconfined and must have good hydraulic conductivity as well as transmissivity so that the water that is recharged is quickly spread horizontally to prevent a water mound forming below the surface.
Depth of Water table	Shallow or deep water table zones	The aquifer must not be at shallow depths and should be at least 8-10 meters below the ground level.

3.9 Site Study plan

From the site plan we find the space available for water harvesting structures. This will determine the size and location of the structures. Note the number and location of existing rain water pipes, outlets/spouts. Find out if there are any defunct or existing bore wells, swimming pool, water storage tanks that can be used for storing the harvested water. Determine the natural drainage, slope and location of storm water drains. This will help to lay out the conveyance pipes along the natural drainage patterns. This is particularly important while planning for a large complex or colony. Mark the location of plumbing (water and sewage) and electrical lines in the site. Care must be taken to avoid plumbing and electrical lines while constructing the water harvesting structures. In case of project in public places this becomes even more important that underground sewer, water supply and other such cables and lines are not inadvertently destroyed. Other information such as the existence and location of generator room, compost pit, waste dump etc. also need to be taken into account.

3.10 Optimum location of recharging pit

In this section, we need to find out the optimum location for recharging point if harvested water decided to recharge the underground reservoir. As we already calculated the groundwater level of the campus. From above calculation we can easily determine the amount of water which is used to recharge the groundwater level through recharge pit. We choose a suitable area where slope can easily provide for making suitable flow of water to the recharge pit, and for this reason we have to choose a suitable area near the college of nursing building. So we have to design the pit where slope is more than as compare to other side of the building.

Hence, the best locations for artificial recharging point will be the land in between the college of nursing and college of architecture.

IV CALCULATIONS

Height of building = 98 ft.

Total area of structure = 27000 sq.ft.

Amount of average rainfall in last 4 years = 79 mm

Recall Harvested water = catchment area x rainfall depth (mm) x rainfall coefficient (0.8)

As we know that 1 sq.ft = 0.0929 m^2

Therefore, 27000 sq.ft = 2508.3821 m^2

Then, Harvested water = 2508.3821 x 79 x 0.8 = 158529.74 litre

After calculating total runoff we know that we have to design a recharge pit of this capacity

Step 1: We have to calculate no. of pipes use for discharging water from catchment area into the recharge pit

6 no. of pipes are used for this purpose having diameter of 6 inch

Cost of pipes @ Rs 40 /- per feet = 40 x 98 x 6 = **Rs 23520**

Step 2: After calculating total cost of pipes we have to design pit

We know that 1 cubic meter = 1000 litre

For 158529.74 litre we have to design a pit of area = 158.5297 m^3

Using above area we have decide ideal size of pit

= 6m x 6m x 4.5mm = 162 m^3

As per PWD schedule rates of excavation of soil is 70 Rs per cubic m

Hence cost of excavation of area 162 m^3 = 162 x 70 = **Rs 11340**

Step 3: cost of brick work

According to harvested water, we select a suitable size of pit: (6 x 6 x 4.5)

Table 4 Estimation of brick work

No.	Length	Height	Width	Quantity
2	4.5	6	0.23	12.42 m^3
	5.77	6	0.23	15.92m^3
Total volume of brick =28.34m^3				

We know that 1m^3 contains 649.77 (approx. 650) number of bricks of standards size (190mm x 90mm x 90mm).

Hence 28.34m3 contains **18421** number of bricks

We know that cost of **1000** bricks according to **PWD** rates is **Rs. 6107** in this area**.**

Therefore, the cost of 18421 bricks **= Rs 112497.05**

Step 4: cost of filters

- Gravel -10 cm
- Charcoal- 10 cm
- Sand – 25 cm
- Gravel- 25 cm

Cost of different materials in market

- Gravel = Rs. 500 Rs per cum
- Charcoal = Rs 750 qtr.
- Sand = Rs. 400 per cum

Calculation of cost using above specification

- Gravel = 6 x 4.5 x 0.25 = 6.75 x 500 = Rs. 3375
- Charcoal = 6 x 4.5 x 0.10 = 2.7 x 725 = Rs. 1960
- Sand = 6 x 4.5 x 0.25 = 6.75 x 400 = Rs. 2700

Total cost of filters = Rs 11410.00

Detailed Estimated Cost = Rs (23520+11340+112497+11410) = Rs 158767=00

In order to ensure that the scheme runs efficiently, regular inspection is being made to ensure the smooth flow of rainwater from roof to collection drains, main drain and of recharge pit and check that there is no clogging in the pipes thereby ensuring collection of water in the recharge pit without any interruption.

V RESULTS & CONCLUSION

Based on the calculations and results, it is concluded that

1) the average rainfall in the season is around 80 mm per year
2) After calculating catchment area and the water harvested, the pit of size 6m x 6m x 4.5 m was suggested to construct.
3) By the use of this pit, we can harvest a huge amount of water, i.e. 158529 liters per year.
4) Total cost of project including pipes and cost for design is about Rs.1, 58,767.
5) The maintenance cost of this type of system is negligible, i.e. very economical.

REFERENCES

[1] http://www.tn.gov.in/dtp/rainwater.htm.

[2] Peter H Gleick, *Water in Crisis: a guide to the World Water Resources*, Oxford University Press, Inc. New York, USA, 1993.

[3] http://www.rainwaterharvesting.org/People/innovators-urban.htm#svis

[4] http://as.ori.nic/balangir/rainfall/pubNormaldtl.asp

[5] Pacey, Arnold and Cullis, Adrian, *Rainwater Harvesting: The collection of rainfall and run off in rural areas*, Intermediate Technology publications, London,1989

[6] http://www.rainwaterharvesting.org

BIOGRAPHY

Dr S Rehan Ali, working as Associate Professor & Head, Department of Civil Engineering, Teerthanker Mahaveer University since last five years, completed graduation to PhD from AMU, Aligarh, India. He has been awarded JRF & SRF during PhD and having about 18 years of rich experience of research, teaching, and industry. During this period, worked in several organizations, viz., National Institute of Science, Technology and Development Studies (CSIR), New Delhi as Project Scientist, Co-ordinates Solution Pvt Ltd, Saket, Delhi as General Manager (Technical), Aligarh Muslim University as Research Associate, Guest Faculty & Assistant Professor, School of Planning & Architecture, New Delhi as Guest Lecture & presently in TMU as Associate Professor & Head. He has worked in 5 projects as project Scientist, 2 as GM (Technical) and one as Research Associate. He has attended 8 training programmes and 9 international, 8 national conferences/Seminars etc in India & abroad. He has 24 publications to his credit. Presently life member of 5 reputed scientific/ institutional societies (ISTE, IIT Delhi; ISCA, Kolkata; INCA, Survey of India, Hyderabad; ISRS, IIRS, DehraDun; SAAEG, Bhopal) and reviewer of two reputed international Journals. Three scholars are working under his supervision. His field of interest includes Remote Sensing, GIS, Engineering Geology and Environmental Engineering.