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Rainwater Harvesting- A case study

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ABSTRACT

Water scarcity is serious problem throughout the world for both urban & rural community. urbanization, industrial development & increase in agricultural field & production has resulted in overexploitation of groundwater & surface water resources and resultant deterioration in water quality. At the dawn of 21st century numerous countries including india are facing a growing water crisis. About 80 countries comprising 40%(2.8billion) of world's population suffer from serious water shortages. Rainwater harvesting is defined as process of augmenting the natural infiltration of rainwater or surface water into the ground by some artificial methods. The roof top rainwater harvesting is a system of catching rainwater where it falls. In rooftop harvesting, the roof becomes the catchments, and the rainwater is collected from the roof of the house/building it can either be stored in a tank or diverted to artificial recharge system. This method is less expensive and very effective and if implemented properly helps in augmenting the ground water level of the area. The methods of rooftop rainwater harvesting are recharge pit, recharge trenches, storage tanks, abandoned dugwells, borewell. For disinfection using bleaching powder the general dosage recommended is long of bleaching powder containing 25% of free chlorine per litre of water. This meets the required standard of 2.5 mg of chlorine per litre of water. If water has to be stored for long time, chlorination is advised about 1gm of bleaching powder can be mixed with 200litres of water. The rainwater collected at college hostel building is to be calculated & quantity of water to be stored for domestic use. The quantity of water harvested are 2,89,305.73 litres/year .

Keyword- Catchment, conduit, recharge trench, recharge pit

I. INTRODUCTION

Rainwater is the primary source for all and is one of the purest forms of water. Water is required for human being from birth to death i.e. drinking, bathing, washing, irrigation & industrial requirement. Most of our fresh water is obtained from rainfall. Rain replenishes water in pond, lakes, tanks & reservoirs and seeps into the ground & is stored as groundwater. H.G. Geddes used water harvesting term firstly in Australia(1). Rainwater harvesting is defined as process of augmenting the natural infiltration of rainwater or surface water into the ground by some artificial methods(1). To collect and

store the rainwater which fall on the rooftop of buildings. The rainwater can be stored in tanks or diverted into dugwell or borewells, recharge pit and recharge well trenches.

1.1. History

Rainwater harvesting has been implemented from ancient times in forms of tanks, kunds, bawadis in different part of world. Rooftop catchment & cistern storage have been the basis of domestic water supply in small island in Caribbean. Gordon Brown was setup rooftop rainwater harvesting unit in Moral Armament center building at Panchgani in 1964.(2)

1.2 Water Crisis

Water scarcity is serious problem throughout the world for both urban & rural community. Urbanization, industrial development & increase in agricultural field & production has resulted in overexploitation of groundwater & surface water resources and resultant deterioration in water quality. At the dawn of 21st century numerous countries including India are facing a growing water crisis. About 80 countries comprising 40%(2.8billion) of world's population suffer from serious water shortages(2).Nearly 44 million people in India are affected by water quality problems either due to pollution, prevalence of fluoride, arsenic, iron deposits in groundwater or saline water intrusion in coastal areas(4).Millions do not have enough water particularly during summer months. India has more than250 city dwellers even though the rate of urbanization is among the lowest in the world. So it is necessary to recharge rainwater every year to fulfill our requirements.

1.3 Efforts

In eighties Anna Hazare saved water flowing from a hillock by introducing runoff to the village ponds. Continuous water harvesting put an end to Ralegaon SiddhiVillage woes. The New Delhi Municipal Corporation has marked out all the major parks in the city for water harvesting. Rainwater harvesting has been implemented at chief minister of Delhi Mrs. Shila Dixit's residence and President's residence. Sekar (Hydrogeologist) started his campaign 1995 for rainwater harvesting in Chennai.Sri Aurbindo Ashram implemented rainwater harvesting & representing a net rise of 2.2m water level in July 2003. Tamilnadu state Government has made mandatory for every building owner to setup rainwater harvesting unit(6). It is also compulsory in BMC area where rooftops is greater than 1000sq.m. area. In 1995 rainwater club has constituted by Vishwanath & his wife Chitra (Architect& Engineers) in Banglore (7).

1.4 Availability of water

Globally 12.5- 14 billion cubic meter of water is considered available for human use annually. India receives 400 millions hectare meters (mham) of rain & snowfall. 180 mham water flow in rivers in rainy season and another 0.7 mham is available as groundwater. 20 mham water flow in rivers as surface water coming from outside the country.The total water available in the country up to 247 mham out of which 137 mham water lost as evaporation or becomes as soil moisture. If even 20-30 mham rainwater can captured through rainwater harvesting tremendous pressure can be taken off the country's groundwater & surface water resources.

Water required for per person 135 litres per day; when India's population was 1 billion then water required to us $49{,}275 \times 10^{12}$ litres per year. India's projected use of water is 105 mham in 2025. Of the 105 mham, some 70 mham water is expected to come from surface water & about 35 mham from groundwater.This exclusively reliance on river water and groundwater is already leading to a number of problems. It is necessary to implement rooftop rainwater harvesting in rural & urban areas as we may face acute water crisis in future.

II. COMPONENTS OF RAINWATER HARVESTING SYSTEM

The system mainly constitutes of following sub components:

- Catchment
- Transportation
- First flush
- Filter

The surface that receives rainfall directly is the catchment of rainwater harvesting system. It may be terrace, courtyard, or paved or unpaved open ground.The terrace may be flat RCC/stone roof or sloping roof. Therefore the catchment is the area, which actually contributes rainwater to the harvesting system(7).

2.1. Transportation

Rainwater from rooftop should be carried through down take water pipes or drains to storage/harvesting system. Water pipes should be UV resistant PVC pipes of required capacity. Water from sloping roofs could be caught through gutters and down take pipe. At terraces, mouth of the each drain should have wire mesh to restrict floating material.

2.2.First Flush

First flush is a device used to flush off the water received in first shower. The first shower of rains needs to be flushed-off to avoid contaminating storable/rechargeable water by the probable contaminants of the atmosphere and the catchment roof. It will also help in cleaning of silt and other material deposited on roof during dry seasons Provisions of first rain separator should be made at outlet of each drainpipe.

2.3.Filter

There is always some skepticism regarding Roof Top Rainwater Harvesting since doubts are raised that rainwater may contaminate groundwater. There is remote possibility of this fear coming true if proper filter mechanism is not adopted. Secondly all care must be taken to see that underground sewer drains are not punctured and no leakage is taking place in close vicinity. Filters are used for treatment of water to effectively remove turbidity, colour and microorganisms. After first flushing of rainfall, water should pass through filters. There are different types of filters in practice, but basic function is to purify water.

2.4. Sand gravel filter

These are commonly used filters, constructed by brick masonry and filleted by pebbles, gravel, and sand. Each layer should be separated by wire mesh.

2.5. Charcoal Filter

Charcoal filter can be made in-situ or in a drum. Pebbles, gravel, sand and charcoal as shown in the figure should fill the drum or chamber. Each layer should be separated by wire mesh. Thin layer of charcoal is used to absorb odor if any.

2.6. PVC- Pipe filter

This filter can be made by PVC pipe of 1 to 1.20 m length; Diameter of pipe depends on the area of roof. Six inches dia. pipe is enough for a 1500 Sq. Ft. roof and 8 inches dia. pipe should be used for roofs more then 1500 Sq. Ft. Pipe is divided into three compartments by wire mesh. Each component should be filled with gravel and sand alternatively. A layer of charcoal could also be inserted between two layers. Both ends of filter should have reduce of required size to connect inlet and outlet. This filter could be placed horizontally or vertically in the system.

Sponge Filter

It is a simple filter made from PVC drum having a layer of sponge in the middle of drum. It is the easiest and cheapest form filter, suitable for residential units.

2.7. Methods of Rooftop Rainwater Harvesting

1. Recharge pit
2. Recharge shaft
3. Recharge trenches
4. Storage tanks
5. Abandoned Dugwells
6. Borewell

a) Recharge pit:- Recharge pits are constructed for recharging the shallow aquifers.These pits are suitable for recharging of shallow aquifers, and small houses.These are constructed1-3m wide & 2-3m deep depending on the depth of pervious strata. which are back filledwith boulders , gravels and coarse sand. The size of filter material is generallytaken as below:

Coarse sand- 1.5-2mm
Gravels- 5-10mm
Boulders- 50-200mm

b)Recharge shafts

Recharge shafts are provided where upper layer of soil is alluvial or less pervious. These are bored hole of 30 cm dia. up to 10 to 15 m deep, depending on depth of pervious layer. Bore should be lined with slotted/perforated PVC/MS pipe to prevent collapse of the vertical sides. At the top of soak away required size sump is constructed to retain runoff before the filters through soak away. Sump should be filled with filter media.

c) Recharge Trenches :- Recharge trench in provided where upper impervious layer of soil is shallow. It is a trench excavated on the ground and refilled with porous media like pebbles, boulder or brickbats. it is usually made for harvesting the surface runoff. Bore wells can also be provided inside the trench as recharge shafts to enhance percolation. The length of the trench is decided as per the amount of runoff expected. This method is suitable for small houses, playgrounds, parks and roadside drains. The recharge trench can be of size 0.50 to 1.0 m wide and 1.0 to 1.5 m deep.

d) Storage tanks :- These tanks may construct on the surface as well as underground by utilizing local material. The size of tank depends upon availability of runoff & water demand. The stored water may be used for drinking after proper chlorination and boiling.

e) Abandoned Dugwells :- This pit is excavated 6m X 6m. In this pit in which coarse sand at top (200mm) thick layer underlain by gravels (200mm) thick layer & at bottom boulders 75mm(200mm thick)near dugwell then water is to be drain by pipe to abandoned dugwell.

f) Borewells:- The rainwater drained from terrace through filter (Dewas filter)& joined to handpump. The length of Dewas filter is 1.2m, diam.140mm & 140x 75mm reducer is used for joining. T is provided for to pour sodium hypochloride or chlorine tablet.

2.8. Purification of Harvested Rainwater

For disinfection using bleaching powder the general dosage recommended is long of bleaching powder containing 25% of free chlorine per litre of water. This meets the required standard of 2.5 mg of chlorine per litre of water. The water shall be stirred thoroughly for even distribution of the disinfection agent. The water should be kept without use for about 30 minutes after adding bleaching powder. If water has to be stored for long, chlorination is advised about 1gm of bleaching powder can be mixed with 200litres of water.

2.9. Precautions

1. Always keep the surrounding of tank clean & hygienic.
2. Remove algae from roof & asbestos sheets before the monsoon rains.
3. Drain the tank completely & clean from inside thoroughly before monsoon rain.
4. Clean the water channel during rainy season & definitely before the first monsoon rain.
5. Avoid first 15-20 minutes rainfall depending on the intensity of rain use the first flush arrangement to drain off this rainwater.
6. Change the filter media every rainy season.

2.10. Advantage

1.Provides self- sufficiency to water supply.

2.Reduces the cost of pumping of groundwater.

3.Provides high quality water, soft & low in minerals.

4.Rainwater is purest in quality of groundwater through dilution when recharge to groundwater.

III. Result & Discussion

Assessment of Harvested Rainwater at **SNJB's S.P.M.L hostel building, Chandwad**,
Dist.- Nashik (M.S.)
Runoff = Catchment X Runoff coefficient X Rainfall
Runoff Coefficient- It plays important role in assessing the runoff availability
& catchment characteristics.
Average Annual Rainfall of Chandwad – 518.3 mm
Maximum daily rainfall of Chandwad – 40mm
Maximum intensity of rainfall - 40mm/20minute per day quantity of rainfall
Rooftop of S.P.M.L. hostel bldg. – 734.45m^2
Runoff Coefficient of rooftop of bldg. – 0.95

3.1. Quantity of Water Harvested:-

Reliable annual rainfall – It is 80% of average annual rainfall.
Average Annual Rainfall of Chandwad – 518.3 mm
Reliable annual rainfall – 0.41464m
Water demand = Per capita day x total strength of the hostel
= 135 X 150
= 20250 litres/day
= 20250 X 365
= 73,91,250 litres/year
Annual Recharge = Runoff coefficient x Reliable annual rainfall x rooftop area
= 0.95X 0.41464 X 734.45m^2

$= 289.305m^3$
$= 2,89305.73$ litre/year

3.2. Design of storage tank:

To design a tank of 2,89305.73 litre/year capacity volume of tank required to be design
$= 2,89305.73/1000$

$= 289.305\ m^3$

Assume 1) Depth of tank = 2.5- 3.0m

2) Breadth of length ratio – 1:1.5

therefore Area = 289.305/2.5 (considering 2.5m depth)

$= 115.722$

approxim. 115^{m2} (approximation for free board)

B:L = 1:1.5

Therefore length = 15m

Breadth = 10m

Size of tank = 15x10x2.5m

3.3. Design of filter :-

Filter material is sand. The size of sand varies from 0.35- .060mm.
Maxm. Intensity of rainfall = 40mm/hour (from rainfall records in Chandwad)
Maxm. Runoff of the roof = Maxm. Intensity of rainfall x roof area x 0.95
= 40/1000 X 734.45X 0.95

$= 27.90\ m^3/hr.$
= 27909.1 litres/hr.

Area of filter tank required = runoff/ infiltration rate required of sand
= 27909/6000
$= 4.65\ m^2$

therefore L X B = 0.75X 0.75 (0.56^{m2})

Provide a depth of 0.75m even more depth can be provided depending upon the roof area (large), then freeboard increases therefore recommended size of filter
= 0.75 X 0.75 X 0.75m

3.4. Cost-

The cost of recharge structure varies from place to place. It ranges for recharge pit Rs.2500- 5000 and maximum up to 50,000-80,000 for recharge well. The total cost of rooftop rainwater harvesting unit is estimated Rs.2,50,000/- only.

IV CONCLUSION

The rainwater collected at college hostel building is to be calculated & quantity of water to be stored for domestic use.
Tank capacity & Quantity of water harvested = 2,89,305.73 litres/year

Size of tank = 15x 10x 2.5m
Size of filter = 0.75 x 0.75x 0.75m

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