RESEARCH ARTICLE OPEN ACCESS

A Case Study on Rainwater Harvesting For TownHall Kumta, Uttara Kannada District Karnataka.

Mr. Deepak. G. Talekar
Selection Grade Lecturer Dept. of Civil Engineering Government Polytechnic Karwar – 581 301
Email-deepakgtalekar@gmail.com

Abstract-
Rainwater harvesting has been practiced for over 400 years, and it continues to be adopted as a technique to accumulate and store rainwater for various purposes. In ancient times, rainwater harvesting systems were used for drinking and agricultural purposes and have grown increasingly popular in recent years. With the constant increase in the world's population, the demand for clean drinking water has skyrocketed, whilst the available surface and subsurface water sources are unable to meet these demands, further exacerbated by their rapid depletion. Rainwater harvesting is an environmentally sustainable solution to meet the growing demand for clean water, especially in areas of irregular rainfall. Rainwater is collected from rooftops and redirected into recharge tanks or deep pits, helping to replenish the groundwater and providing a renewable source of clean water that is ideal for domestic use and small-scale agriculture. Besides, rainwater harvesting is an affordable solution that can be implemented on a low-cost and easy-maintenance basis, especially at the household level. The temporal and spatial variability of rainfall mitigates the effectiveness of traditional water management systems, leaving many areas with irregular weather patterns. Rainwater harvesting enhances the water supply by utilizing rainwater that may go to waste otherwise and providing clean water for basic human needs and small-scale activities. The local administration is promoting rainwater harvesting systems and has made it mandatory to build such systems to ensure sufficient water is arrested and suitable for recharging the groundwater. Therefore, rainwater harvesting and storage have proved to be an effective and sustainable solution in areas where there is a scarcity of rain, and groundwater exploration expenses are exorbitant.

Keywords - rooftop, recharge, groundwater, filter, runoff,catchment, gravel, sand, recharge pits

I. INTRODUCTION

Rainwater harvesting is an innovative method used to collect and store rainwater for human consumption or agricultural purposes. The technique takes advantage of rooftops, land surfaces, or rock catchments to capture rainwater using simple jars and pots or complex underground check dams. It is an environmentally friendly process as it provides a source of soft and high-quality natural water, without dependence on wells or other sources. This low-cost process is often more economical since it significantly reduces the cost of construction compared to other costly alternatives like wells, canals, dams, and diversions.

The primary aim of rainwater harvesting is to increase crop production, which directly results in a reduction of groundwater usage and an increase in its levels. Rainwater harvesting is the practice of collecting and storing rainwater in underground tanks or reservoirs for later use for domestic or irrigational purposes. There are two primary techniques for accomplishing this: surface runoff rainwater harvesting and rooftop rainwater harvesting.

Surface runoff harvesting is the process of collecting and storing rainwater runoff from land surfaces, while rooftop rainwater harvesting involves collecting and storing rainwater that falls on rooftops. The collected rainwater may be used for various purposes, such as gardening, irrigation, and even drinking, providing a local, renewable, and low-cost alternative water source for households and small farms. Hence, rainwater harvesting is an efficient and cost-effective system that helps reduce the demand on groundwater and ensures the sustainable supply of clean water for different purposes.

II. LITERATURE REVIEW

The process of harvesting rainwater includes using the appropriate methods to gather and store water for various purposes. In urban environments, rainfall has a propensity to evaporate as surface runoff, but it can also be captured and used to restock aquifers. Catching rainwater as it falls on rooftops is a process known as rooftop rainwater collecting. This method involves collecting and storing rainwater on the roofs of houses and other buildings. The collected water can be retained in a tank or utilized to rehydrate an artificial system. Raising the local groundwater table through practical and affordable means is rooftop rainwater collection. The essential components of a rooftop rainwater collection system are shown in Figure 1. The essential components of a rooftop rainwater collection system are shown in Figure 1.

The catchment area, also known as the surface area where rainwater collects from precipitation, might be a terrace, a pitched roof, or any paved or unpaved ground surface. In the event of a pitched roof or terrace, rainwater is conveyed through a well-designed pipe system, gutters, or drains before being collected in subterranean tanks, adequate reservoirs, or occasionally just by charging the ground where the ground water table is kept at a constant level. Overall, rooftop rainwater harvesting is a cost-effective and straightforward solution to collect and store rainwater for various purposes. It can be a useful practice for households and small farms to conserve water and lessen dependency on other sources of water, ensuring a sustainable water supply.

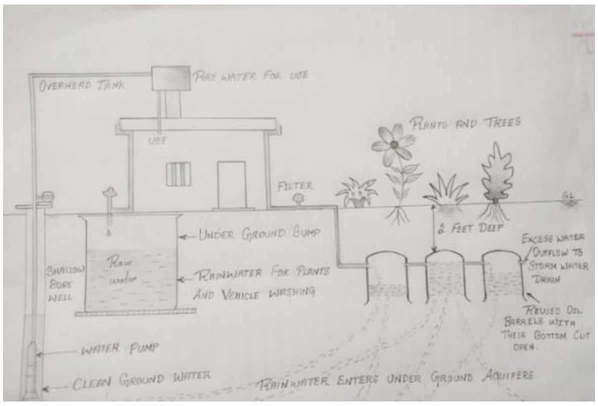

Fig. 1 Typical schematic diagram of Rain Water harvesting

First Flush: The first flush is an essential component of rainwater harvesting systems. The first flush is a critical element in rainwater harvesting systems as it serves to remove initial contaminants from the collected rainwater. These contaminants can include silt, soil, algae, leaves, and other debris that have accumulated on the roof or terrace. To ensure optimal effectiveness, it is recommended to install the First Flush system of separators at the outlet of each pipe.

Filter: There are often concerns about rainwater harvesting from rooftops, as there is a fear that rainwater may contaminate groundwater. This fear can be mitigated by implementing a proper filter mechanism. It is also important to ensure that underground sewer drains are intact without any leaks nearby. Filters are essential for treating water by removing turbidity, colour, and microorganisms. After the first flush of rainfall, the water should pass through filters. A gravel, sand, and "nation" mesh filter is designed to be placed on top of the storage tank. This filter plays a crucial role in maintaining the cleanliness of rainwater inside the storage tank by preventing silt, dust, leaves, and other organic matter from entering. There are various types of filters in use, but their primary function is to purify water. The following section describes different types of filters:

1. Sand and Gravel Filter: The filter media for this system is built using brick masonry and is filled with graded pebbles, gravel, and coarse sand. To prevent clogging and maintain the filter's efficiency, a wire mesh is placed at each layer of the filter media to prevent debris or silt from accumulating.

2. Charcoal Filter: In situations where rainwater carries an unpleasant odour, a charcoal filter is commonly employed. Similar to the sand and gravel filter, this filter consists of a drum constructed using brick masonry. The drum is filled with graded pebbles, gravel, coarse sand, and a layer of charcoal. To ensure the filter operates effectively, a wire mesh is incorporated at each layer of the filter media to prevent clogging caused by debris or silt.

3. PVC Pipe Filter: This filter consists of a polyvinyl chloride (PVC) pipe ranging from 1000 mm to 120 mm in length. The diameter of the pipe is determined based on the roof size. Typically, a 150 mm diameter pipe is sufficient for a roof area of 150 square meters, while a 200 mm diameter pipe is used for roofs larger than 150 square meters. The PVC pipe is divided into three compartments using wire mesh. The filter media is created by alternating layers of gravel and coarse sand in the compartments, with charcoal placed in between. To connect the inlet and outlet of the drain pipes, both ends of the filter pipe are reduced in size. The filter can be installed vertically or horizontally, depending on the desired configuration.

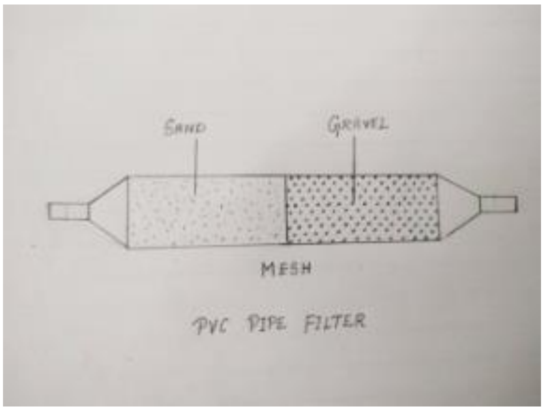

Fig. 2 PVC Filter

4. Sponge Filter: The sponge filter is designed with a PVC drum that includes a central compartment filled with sponge material. This type of filter is suitable for residential use due to its affordability and easy installation. A visual representation of the typical sponge filter is depicted in the figure below.

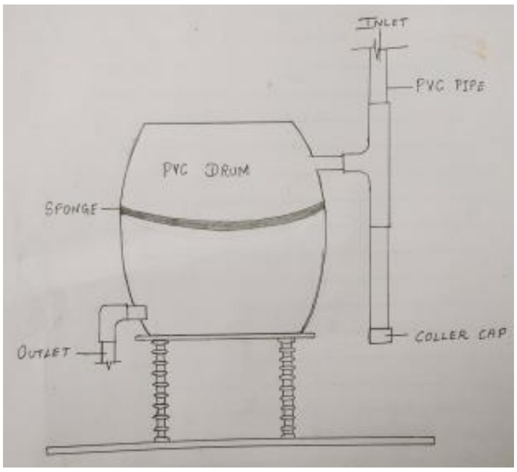

Fig. 3 Sponge Filter

VARIOUS METHODS OF USING ROOFTOP RAINWATER HARVESTING

1. Direct Use: In this system, rainwater is collected from either a pitched or flat roof area and stored in an underground water tank known as a sump tank. The size of the tank is determined by various factors, including the amount of rainwater to be collected, the roof area or catchment area, and the water requirements of the community. Since the stored water is used directly, it must undergo proper water treatment and chlorination. However, in many cases, this water is primarily utilized for washing and gardening purposes, eliminating the need for an extensive water treatment system. To ensure the quality of the collected rainwater, a mesh filter and a first flush mechanism are often incorporated at the inlet. These components work to remove contaminants such as debris and silt before the water flows into the storage tank. This method proves to be cost-effective as it reduces the expenses associated with transportation and distribution systems.

Recharging Groundwater Aquifers: There are various methods employed to recharge groundwater aquifers. The following are commonly used approaches:

1. Bore Wells: Rainwater collected from pitched or flat roofs is directed through drain pipes to a sedimentation tank. In this tank, heavy sediments settle down, and the filtered water is then conveyed to bore wells, effectively recharging them. The size of the sedimentation tank depends on factors such as the amount of rainwater to be collected, the roof area or catchment area, the water requirements of the community, and the need to recharge dried bore wells.
2. Recharge Pits: These pits are small units, usually rectangular or square in shape, constructed with brick or stone masonry walls. Recharge pits have weep holes that allow collected rainwater to pass through, recharging the surrounding ground. These weep holes are regularly spaced and covered with perforated holes. The bottom of the pit is filled with pebbles, gravel, and coarse sand to serve as filter media. The size of the pit is determined by factors such as the amount of rainwater to be collected, the roof area or catchment area, the water requirements of the community, and the soil's percolation capacity. Recharge pits are suitable for recharging shallow aquifers and for small houses.
3. Soakways or Recharge Shafts: Soakways are used in areas with less porous alluvial soils. These are boreholes with a diameter of 300 mm and lengths of 10 to 12 meters. The boreholes are slotted with perforations made of PVC or mild steel. A storage tank is constructed at the top of the shaft or bore well to collect rainwater before it filters through the soakway. The storage tank or sump is filled with pebbles, gravel, and coarse sand as filter media.
4. Recharging Dug Wells: Dug wells can be recharged by conveying rainwater through an appropriate system of filter media. However, this method requires regular cleaning and desalting to prevent clogging and ensure an optimal recharge rate.

CASE STUDY (RAINWATER HARVESTING FOR TOWN HALL KUMTA, UTTARA KANNADA DISTRICT)

Fig. 4 Town Hall Kumta

The Town Hall in Kumta Taluk, Uttara Kannada District is situated at the heart of the city. Spanning approximately 400 square meters, this building has been strategically designed to incorporate roof water harvesting systems. The aim is to collect an ample water supply during the rainy season, which can then be used to replenish the surrounding wells. The scarcity of water is a persistent issue for the city, particularly during the summer months. To address this challenge, three pits with a diameter of 3 meters have been excavated to a depth of 1.50 meters. These pits are equipped with 200 mm thick RCC (reinforced concrete) wall casings to securely hold the surrounding earth in place. Additionally, another pit, measuring 2.00 meters in diameter, has been excavated to a depth of 1.5 meters from the bottom edge of the RCC casing. This central pit serves as a focal point within the previously mentioned excavated pits.

Fig. 5 Recharge Pits

In the depicted setup, a perforated PVC pipe with a diameter of 200 mm was installed at the center of the pit. The pipe was inserted and securely plugged at a depth of 300 mm below the excavated ground surface. To create an effective filtration system, four layers of filter media were established in the lower part of the pit. The bottom layer consisted of coarse gravel measuring 100 mm in size and extended to a depth of 600 mm. Two intermediate layers, each 300 mm in depth, were then filled with gravel ranging from 40 to 80 mm in size. Finally, the top layer, with a depth of 300 mm, was composed of gravel measuring 10 to 20 mm in size. The upper portion of the pit was filled with coarse sand, leveled, and uniformly spread. To ensure safety and prevent debris from entering the pit, the entire structure was covered with an MS grill, as depicted in the figure. The inlet pipe, responsible for collecting rainwater from the roof area, was connected to the central perforated pipe.

DESIGN

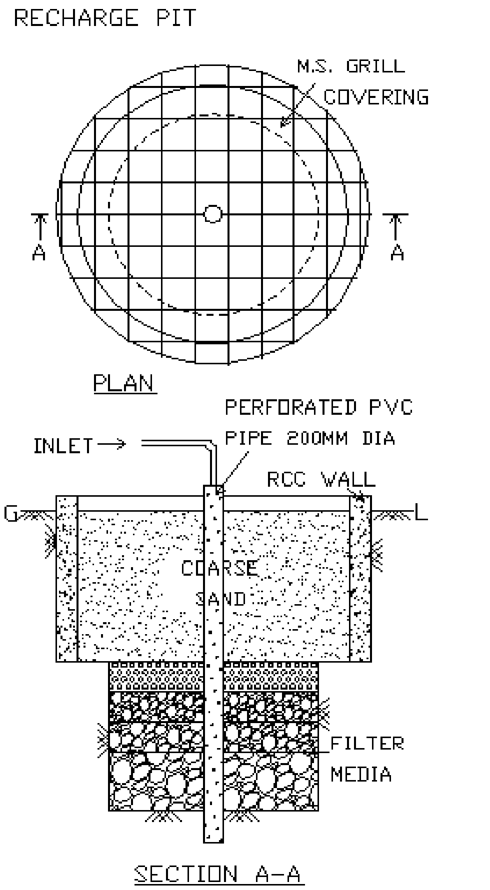

Fig. 6 Plan and Cross section of Water Harvesting Tanks

Fig. 7 Roof-Water Harvesting for Town Hall Kumta

APPROXIMATE QUANTITY OF WATER AVAILABLE:

The roof area of the Town Hall (A),
=16.00 m x 25.00 m
= 400.00 m2
Average rainfall R, = 1000 mm
= 1.00 m
The volume of rainfall,
= A x R

= 400 x 1.00 = 400 m^3

Considering the loss of water, 70% of effective collection,
Volume of water,
= 400 x 70%
= 280 m^3
= 2,80,000 Liters
Therefore average water per day available,
= 280000 L / 365 Days
=767 LPD.

III. CONCLUSIONS

1. Rainwater harvesting systems have been employed since ancient times for domestic and agricultural purposes.
2. The key advantages of rainwater harvesting systems include their accessibility, low construction costs, and ease of maintenance, making them suitable for household-level implementation.
3. Rainwater harvesting and storage have proven to be cost-effective and sustainable solutions, particularly in regions with limited rainfall and high groundwater exploration costs.
4. Concerns about potential groundwater contamination from rooftop rainwater harvesting exist, but these can be mitigated through the use of proper filter mechanisms.
5. In the case of the Town Hall in Kumta, Uttara Kannada District, a Rooftop Rainwater Harvesting system has been installed, featuring three recharging pits.
6. The anticipated daily collection from the rooftop rainwater harvesting system at the Town Hall is approximately 767 LPD.

REFERENCES

[1]. Jyotiba B.Gurav and D.G. Regulwar (2013) “Rainwater Harvesting – A Case Study”, Sustainable Water Resources Development and Management, pp. 179-pp183
[2]. Mati, B. M., Malesu, M. and Oduor, A. 2005. Promoting rainwater harvesting in Eastern and Southern Africa: The RELMA experience, Working Paper- 24: pp17-pp 22.
[3]. S.N. Kalia (2013) “Rainwater Harvesting – A Case Study Catch Water where it Falls”, Sustainable Water Resources Development and Management, pp. 153-pp159
[4]. Biazin B., Sterk G., Temesgen M., Abdulkedir A., Stroosnijder L., Rainwater harvesting and management in rainfed agricultural systems in sub-Saharan African-A review. Physics and chemistry of the Earth, 2012, pp 47-48, pp 139-151
[5]. Padmanabhan G, “Methods of Rainwater Harvesting, published in https://theconstructor.org/water-resources/methods-rainwaterharvesting/5420/
[6]. Amha R., Impact Assessment of Rainwater Harvesting Ponds: The Case of Alaba Woreda, Ethiopia. M.Sc. Thesis, Addis Ababa University, 2006.