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Quality Assessment of Stored Rainwater

S. Shrihari

Professor of Civil Engineering
N.I.T.K. Surathkal, Mangaluru – 575025.

Abstract—*The scarcity of water is cause of major concern in most parts of the world. A big portion of world is facing the problem of lack of drinking water. Various modern methods are being adopted for converting non drinkable water to drinkable water such as distillation, osmosis, desalination, etc. These methods require high capital and technology. Rain water harvesting is considered to be easier, economical and sustainable method. Irrespective of technology used, rain water harvesting means harvesting and storing the rain water. This water can be used to meet various requirements and water demands. This project includes the study of quality of direct rain water, roof top water and stored water in different storage material type tanks. The analysis of various physico-chemical parameters such as pH, electrical conductivity, total dissolved solids, alkalinity, etc. were carried out using standard methods. These values were compared with the desirable limits set by WHO.*

1. Introduction

The need for sustainable environment is undeniable. Water conservation is becoming inevitable as the demand for water for various needs like toileting, bathing, cleaning, agriculture, drinking water,industrial and ever-changing lifestyles with modernization is leading towards tremendous water wastage [9]. Due to population boom and excessive need of water to suit our ever-expanding modern lifestyle, water scarcity is felt all over the world. In this context, adopting rainwater harvesting and recharging groundwater is one of the simplest and best measures in conserving water globally. This practice can efficiently be implemented in lieu of traditional water supplies.

Good drinking water quality is essential to the health and well-being of all people. Acceptable water quality occurs when here are no bacteria of faecal origin present , there are no chemicals (e.g. heavy metals) or chemical substances, should not have a bad taste or smell. In most municipal water supply systems, water is taken from sources such as borewells, rivers and lakes. These sources are relatively easily contaminated if human waste from sanitation systems (e.g. septic tanks, pit latrines), or animal waste, is discharged onto the land nearby to the water source.[4]

2. Quality of Rainwater

Rainwater is the most reliable source of surface and sub-surface water. Rainwater is widely collected and stored for domestic use due to the increased requirements of water in urban areas. Many of the governments and local bodies have also made it mandatory for large habitations to harvest rain water.

Rainwater collection systems are commonly believed to provide safe drinking water without treatment because the collection surfaces (roofs) are isolated from many of the usual sources of contamination (e.g. sanitation systems). In almost all countries properly collected and stored rainwater is likely to be superior to untreated surface and bore well water supplies but this may not always be the case. Although roofs are higher than the ground, dust and other debris can be blown onto them, leaves can fall from trees, and birds and climbing animals can drop dead animals, half eaten food or defecate upon them. The quality of drinking water can be much improved if this debris is not allowed to enter the storage tank.[6].

The quality of harvested rain water depends on several factors like collection methodology, method of storing. duration of storing etc. The harvested rainwater generally did not meet drinking water standards[1]. The composition of rainwater is dependent on many factors, such as atmospheric pollution (including the presence of dust, pollen, and bioaerosols), the type of catchment, land use (industrial areas and roads and highways), the local microclimate, and the type of the runoff surface (various roof pitches and various roofing materials). Rainwater contamination reaches the highest levels in urban areas, which is mainly linked to the emissions of power plants, local boiler plants, and industry [10]. The source of rainwater pollution is, to a large extent, substances that are washed out of the atmosphere, but the greatest pollution occurs in rainwater that flows down the surface of terrains, roofs, gutters, or pipeline networks. However, the greatest contamination is caused by the entry of microbial pathogens, such as bacteria, viruses, and protozoa [10]. Indicators of microbial contamination of rainwater are E. coli or thermotolerant strains of coliforms. Pathogenic microorganisms are also detected, such as Cryptosporidium, Giardia, Campylobacter, Vibrio, Salmonella, Shigella, and Pseudomonas. Studies reported from different parts of the world reveal the prevalence of microbiological and chemical contaminants such as nitrate, sulphate, chloride, sodium, calcium and zinc in roof-collected rainwater [11]

Table 1 : Quality of Rainwater [11]

Parameter	Min	Max.	Units
pH	4.76	7.5	
Co	0.0007	0.0029	mg/L
Ni	0.0009	0.024	mg/L
Nitrates	0.6	1.76	mg/L
EC	2.4	88	(µS/ cm)
Pb	0.0044	0.172	mg/L
Cd	0.0012	0.0131	mg/L
Cr	0.00027	0.045	mg/L

3. Rainwater Harvesting

Rainwater harvesting is a simple strategy by which rainfall is gathered and stored for future usage.The process involves collection and storage of rainwater with help of artificially designed systems,that runs off natural or man-made catchment areas e.g. rooftop, compounds, rocky surface, hillslopes or artificially repaired impervious/semi-pervious land surface. The collected rainwater from surfaces on which rain falls may be filtered, stored and utilized in different ways or directly used for recharge purposes. Rainwater Harvesting is unrestricted from any kind of impurity, with relatively less storage cost and no maintenance cost involved except for periodical cleaning.With depleting groundwater levels and fluctuating climate conditions, this measure can go a long way to help mitigate the adverse effects of rising water scarcity. Reserving rainwater can help recharge local aquifers, reduce urban flooding and most notably, ensure water availability in water-scarce zones.[9]

Rainwater harvesting systems are cost-effective, provide high-quality water, lessens dependence on wells and are considerably easy to maintain since they are not utilized for drinking, cooking or other sensitive uses. The all-around expenditures used in setting up harvesting methods are much cheaper compared to other purifying or pumping means. The cost of recharge to the subsurface reservoir is also lower than the surface reservoirs[2,3].

Storing water underground is environment-friendly. The ecological benefits of rainwater harvesting are immense. It minimizes the impacts of flooding by funneling the off water into large tanks for recycling and helps reduce the load placed upon drainage systems. No land is wasted for storage purpose and no population displacement is implicated therefore, groundwater is not directly exposed to evaporation and pollution. Additionally, it helps minimize the possibility of rivers drying up [5].

It reduces soil erosion and flood hazards by collecting rainwater and reducing the flow of stormwater to prevent urban flooding. Most buildings that utilize rainwater harvesting systems have a built-in catchment area on top of the roof, which has a capacity of collecting large volumes of water in case of rainstorms.

Harvesting rainwater allows the collection of large amounts of water and mitigates the effects of drought. Most rooftops provide the necessary platform for collecting water. Rainwater is mostly free from harmful chemicals, which makes it suitable for irrigation purposes [7].

Another vital benefit is that it increases the productivity of aquifer resulting in the rise of groundwater levels and reduces the need for potable water. It is extremely essential, particularly in areas with low water levels [9].

4. Rainwater Harvesting Techniques

The objective of water harvesting in India differs between urban and rural areas. In urban areas, emphasis is put on increasing groundwater recharge and managing storm water. On the other hand, in rural areas securing water is more crucial. There the aim is to provide water for drinking and farming, especially for lifesaving irrigation, and to increase groundwater recharge [13]

There are two major techniques of rainwater harvesting.

a) Surface runoff harvesting : In this method, rainwater flows away as surface runoff and can be stored for future use. Surface water can be stored by diverting the flow of small creeks and streams into reservoirs on the surface or underground. It can provide water for farming, for cattle and also for general domestic use. Surface runoff harvesting is most suitable in urban areas. Rooftop rainwater/storm runoff can be harvested in urban areas through: Recharge Pit, Recharge Trench, Tubewell or Recharge Wells [5,8]

b) Groundwater recharge: Groundwater recharge is a hydrologic process where water moves downward from surface water to groundwater. Recharge is the primary method through which water enters an aquifer. The aquifer also serves as a distribution system. The surplus rainwater can then be used to recharge groundwater aquifer through artificial recharge techniques.Rainwater in rural areas can be harvested through Gully Plugs, Contour Bunds, Dugwell Recharge, Percolation Tanks, Check Dam, etc. Different regions of the country practice a variety of rainwater harvesting and artificial recharge methods. Some ancient rainwater harvesting methods followed in India includes Madakas, Ahar Pynes, Surangas, Taankas, etc. [9]. Kattas, Madakas and surangas were very popular in south India.

The rain water harvesting system mainly consists of the surface that receives rainfall directly (terrace, courtyard, or paved or unpaved open ground), transportation- rainwater from rooftop should be carried through down take water pipes or drains to harvesting system, a coarse Mesh to provide passage for debris at the roof but prevent leaves and other larger material, conduits or drains that carry rainwater from the catchment or rooftop area to the harvesting system, first flush - 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) and a Filter at the end [8,13].

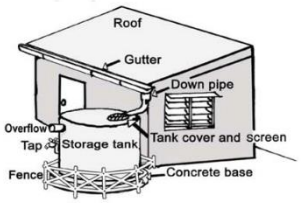

Figure 1: A typical Roof top Rainwater Harvesting System [6] .

5. Quality of harvested rainwater

Table 2 shows the standard prescribed by the Rain Water Harvesting Implementation Network (RAIN) [12]. The harvested rainwater can be stored in stora or in natural storages. Storing of harvested water under ground through aquifer recharge is popular and very beneficial method. Storage tanks above can be of reinforced concrete, masonry, other materials like GI/HDPE/ Ferrocement [13]. Storage can also be sub-surface in earthen tanks lined with materials that prevent leakage. The harvested water can also be used for recharging aquifers and augmenting depleting ground water sources [13].

Table 2: Standards for Harvested Rainwater [12]

RAINs water quality criteria based on WHO			
	Roofwater harvesting	Surface Runoff	Sand dams
E-Coli	< 10 cfu/100 ml	<10 cfu/100 ml	<10 cfu/100 ml
Ammonia	< 1.5 mg/l	< 1.5 mg/l	< 1.5 mg/l
Chlorine[5]	> 0.2 – 0.5 and < 5 mg/l	> 0.2 – 0.5 and < 5 mg/l	> 0.2 – 0.5 and < 5 mg/l
Aluminium[5]	Not relevant	< 0.2 mg /l	< 0.2 mg /l
pH	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5
Turbidity	Not relevant	< 15 NTU	< 5 NTU
Nitrate / Nitrite	Not relevant	< 50 mg/l and < 3 mg/l	< 50 mg/l and < 3 mg/l

Figure 2 shows a recharging mechanism through a bore well.

The water quality of the stored water is expected to deteriorate with time. Though sufficient care is taken as prescribed by the BIS:15797 while charvesting the water and storage, water quality will undergo changes gradually, depending on the material used for storage. RCC slowly leaches its alkalinity into the water, and the pH of the water could rise. This could be beneficial in cases where the pH of rain water was lower, but could be harmful in the longer run. Other material like HDPE tend to assist in the growth of slime layers on its inside, which may lead to bacterial contamination. All storage units irrespective of the material used need periodical cleaning.

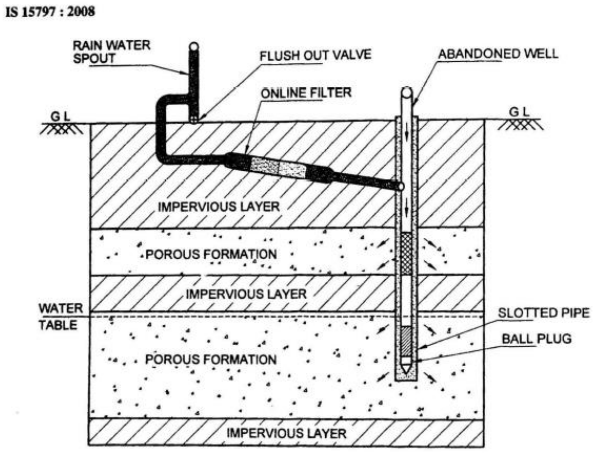

Figure 2: Aquifer Recharge through borewell [13]

When the harvested water is stored in natural aquifers, the water quality depends on the aquifer. While artificial tanks or sub-surface storage units are constructed, proper care to prevent leakage of stored water, as well as leaching of sub-surface water from surroundings into the storage units is very essential. Liners may be used like clay, to provide impervious surfaces. However, the quality and characteristics of the liners themselves need to be very carefully investigated and prescribed.

6. Conclusion

Rainwater harvesting is very beneficial to rural as well as urban areas. Many local governments have made rainwater harvesting mandatory. The harvesting is possible in many ways. The quality of the harvested water depends on the quality of the rain water and the mechanism of storage. The type of storage can enhance or deteriorate the quality of stored water.

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