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Opportunities in Rainwater Harvesting

Uspendra Kumar, Assistant Professor,
Department of Mechanical Engineering, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email Id- ushpendrachauhan@gmail.com

ABSTRACT: In many developing nations, water shortage is a significant issue. Rainwater may be used as a source of drinking water depending on the amount of precipitation. Furthermore, effective management may help alleviate water and food shortages in some of these areas. Rainwater harvesting (RWH) is a technique for efficiently collecting surface runoff during rainy seasons. RWH systems should be built on local talents, resources, and equipment to support such innovations. The majority of developing nations are categorized as water-scarce, with low irregular rainfall, resulting in a high risk of droughts, intra-seasonal dry spells, and frequent food insecurity. The majority of rain occurrences are intense, typically convective storms with very high rain intensity and significant spatial and temporal rainfall variability. The rainfall-to-evaporation ratio is often poor. Rainwater harvesting may then be utilized for rain fed agriculture or domestic water supply. Rainwater, however, may be contaminated with germs and dangerous substances, necessitating treatment before to use. Pollution may be reduced using slow sand filtering and solar technologies. Membrane technology may potentially be used to purify water to ensure that it is safe to consume.

KEYWORDS: Agriculture, Evaporation, Harvesting, Rainwater, Technology.

1. INTRODUCTION

One of the UN Millennium Development Goals is to cut the number of people without access to clean drinking water in half. Another aim is to cut the percentage of individuals who are hungry in half. Both objectives are unlikely to be met until 2015 in certain nations. A billion people lack access to clean drinking water. 840 million people are still malnourished, according to the Food and Agriculture Organization (FAO). Rainfall in dry and semi-arid regions typically ranges between 200 and 600 mm per year. Evaporative potential ranges between 1500 and 2300 mm. Crops suffer as a consequence of this [1]–[3]. In semi-arid zones, the relationship between rainfall and potential evapotranspiration defines the growth phase, which lasts approximately 2.5–4 months. Only 2–4.5 months of the year do rainfall in semi-arid regions surpass potential evapotranspiration?

The partitioning of rainfall into various water flow components. Soil evaporation accounts for 30–50% of rainfall in semi-arid areas, a figure that may reach 50% in thinly planted agricultural systems. Surface runoff is said to account for ten to twenty-five percent of rainfall. In arid areas, the features of frequent, big, and intense rainfall events result in substantial drainage, accounting for 10–30% of rainfall [4]–[7].

Plant transpiration accounts for just 15–30% of rainfall, according to reports. The remainder of the rainfall is lost to the agricultural system through soil evaporation, deep percolation, and surface runoff, accounting for 70 to 85 percent of total rainfall. Regardless of the geographical and temporal variability in rainfall, there is a significant danger of soil water shortage in crop production. It is essential to raise the quantity of water accessible for agricultural uses beyond the actual amount of direct rainfall in such a scenario. Rainwater harvesting (RWH) may be a way to alleviate water shortages in certain areas.

1.1 Techniques for collecting rainwater:

For thousands of years, rainwater collecting has been practiced. It's a method of collecting and storing rainwater from roofs, land surfaces, and rock catchments utilizing basic methods like natural and/or constructed ponds and reservoirs. One litre of water per square metre is equal to one millimeter of collected rainwater [8]. Rainwater is a supply in homes for drinking, cooking, sanitation, and other uses, as well as for productive use in agriculture, once it has been collected and stored.

RWH is divided into three types:

- In situation RWH, which collects rain on the surface where it falls and stores it in the soil; external water harvesting,
- which collects runoff originating from rain falling on another surface and stores it offsite; both are used for agricultural RWH.
- which collects water from roofs and street and courtyard runoffs and stores it offsite.

1.2 Agricultural RWH:

Rainfed agricultural irrigation using RWH is a probable feasible alternative for increasing water productivity and therefore crop production. Rainfed agriculture accounts for up to 90% of total grain output in arid and semi-arid areas [9]. However, owing to less than ideal rainfall characteristics, unfavorable land conditions, and a lack of effective management of these resources, productivity in many nations remains low. Increased rainfed area production may boost food security, enhance livelihoods, and decrease irrigation frequency. The terrain, in addition to the climate, must be suitable for RWH agriculture. The following basic criteria must be met:

- Rainfall must be able to easily produce runoff on the landscape surface, and there must be differences in elevation in the landscape surface. Rainfall runoff must be permitted to flow and concentrate in specifically prepared areas of the landscape.
- The runoff receiving area must have adequate deep soils with appropriate texture and structure to hold and store the received runoff water. Various kinds of surface and sub-surface storage systems may be used to store items. The process of application varies depending on the financial status of the applicant. To enhance runoff from catchment regions, land modifications, soil compaction, and other methods may be used. The following systems are widely used:
- Micro-catchment systems: These are specifically shaped regions with slopes and berms that are intended to enhance rain runoff and concentrate it in a planting basin, where it infiltrates the soil profile and is effectively ‘‘stored." Plants have access to water that is shielded from evaporation. Micro catchments are easy and cheap to build, and they may be done quickly using local materials and labor. Contour bench terraces, runoff strips, and micro-watersheds are the three kinds of micro-catchments.

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- Sub-surface dams, sand dams, or check dams: Water is held underground in a sub-surface reservoir or an artificially elevated water table.
- Tanks constructed of plastic, cement, clay, dirt, and other materials: Depending on space, technology, and financial capacity, they may be constructed underground or above ground.

1.1 Rainwater collection in the home:

Rainwater is collected from roofs, courtyards, and low-traffic areas for DRWH and stored near them. Underground or aboveground storage tanks are possible. The amount of storage required is determined by the needs. Cuboid, cylindrical, and doubly curved tanks are the most common tank shapes. Smaller storage tanks constructed of bricks, stabilized soil, rammed earth, plastic sheets, and mortar jars are often used for storage. Rainwater containers constructed of earthenware, Ferro cement, or polyethylene may hold greater amounts of water. The polyethylene tanks are small, yet they hold a lot of stuff. Rainwater may be collected and stored in underground or above-ground tanks[3], [4], [10].

Provision of an appropriate enclosure to minimize contamination by human, animal, or other environmental pollutants, as well as a tight cover to avoid algae development and mosquito breeding, are all precautions that must be taken while using storage tanks. Collecting water for drinking purposes in open containers is not advised. The water is utilized for household uses, garden irrigation, and small-scale economic enterprises.

The primary benefit of DRWH is that it provides water close to the home, reducing the strain of long distance water collection journeys. The cost of DRWH is determined by the needs on-site. Although capital expenditures are considerable, operating and maintenance costs are seldom significant. The cost of the investment is determined by the tank's size, material, and whether it must be built underground or above ground. Smaller tanks have minimal storage costs, such as 20–40 pounds for a 2 m3 jar constructed of earthenware or cement. A ferromagnetic tank with a capacity of approximately 20 m3 costs between 120 and 140 pounds.

Figure 4 depicts the water demand met by a tank in relation to its size. The advantage of a tank is not proportionate to its size. The reason for this is that a smaller tank will be filled and emptied often, while a bigger tank will be cycled just once in a while.

1.4 Rainwater harvesting quality:

Depending on the condition of the atmosphere, pure rainwater is usually unpolluted. Particles, bacteria, heavy metals, and organic compounds build as dry deposition on catchment regions and are flushed out of the atmosphere during rainstorm events. Except for certain dissolved gases, rainwater in rural regions is relatively pure due to the lack of contamination from the atmosphere and industry. Urban regions, on the other hand, have a significant traffic and industrial effect and are therefore polluted by particles, heavy metals, and organic air pollution. Furthermore, heavy metals and organic compounds may be present on the catchment surfaces. Roofs made of tiles, slates, and aluminum sheets may collect dirty or unpolluted rainfall.

Because of the potential for health risks, roofs with bamboo gutters are the least appropriate. Due to excessive heavy metal concentrations, zinc and copper roofs, as well as roofs with

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metallic paint or other coatings, are not advised. The measured inorganic compounds in rainwater collected from most roof yard catchment systems generally matched the WHO drinking water standards, while the concentrations of some inorganic compounds in rainwater collected from road surfaces appeared to be higher than the drinking water guideline values, but not beyond the maximum permissible concentrations.

If the catchment regions include highways, heavy metals from brakes and tires, as well as organic chemicals such as polycyclic aromatic hydrocarbons (PAH) and aliphatic hydrocarbons from incomplete combustion processes, may contaminate the rainfall.

To apply drinking water quality, these harmful substances must be removed.

Faecal pollution by birds, animals, and reptiles with access to catchments and rainwater storage tanks may be the source of bacteria, viruses, and protozoa. The presence of microbiological markers and pathogens has been shown to vary considerably, with reported numbers ranging from thousands CFU/100 mL to tens of thousands CFU/100 mL.

Sazakli looked at three commonly used bacterial markers. Coliforms were identified in 80.3 percent of rainwater samples, whereas Escherichia coli and enterococci were discovered in 40.9 percent and 28.8%, respectively. As a result, rainwater collected without treatment is often unfit for human consumption. Then, to enhance microbiological quality, disinfection should be used.

1.5 DRWH rainwater treatment:

The most fundamental need for underdeveloped nations is a cost-effective treatment technique. Cut off the initial flush of a rain event, e.g. via first flush water diverters, to produce a first improvement in rainfall quality. They are simple to install, run automatically, and come in a variety of sizes to meet a variety of needs. They minimize tank maintenance in addition to improving the quality of rainwater.

Chlorination is the most frequent and straightforward method of disinfection. Most bacteria can be deactivated using chlorine, and it is very inexpensive. Because chlorine may react with organic debris that has fallen to the bottom of the tanks and produce undesirable by-products, chlorination must be administered after the gathered rainwater has been removed from the storage tank. Chlorination should achieve a free chlorine concentration of 0.4–0.5 mg/L and may be accomplished using chlorine tablets or chlorine gas. Some parasite species have demonstrated resilience to low concentrations of chlorine, which is a limitation of chlorination disinfection.

Slow sand filtration is a low-cost technique of improving water's bacteriological purity. For effective performance, slow sand filters depend on biological treatment rather than physical filtering procedures. The filters are made using graded sand layers, with the coarsest fraction on top and the finest at the bottom. The formation of a thin biological layer, i.e. a biofilm, on the filter surface determines filtration performance. If the pretreatment is properly constructed, an efficient slow sand filter may last for weeks or even months, producing water with a very low nutrient content accessible, which physical treatment techniques seldom accomplish. A continuous flow of water through the filters is required for effectiveness. In underdeveloped

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nations, slow sand filters are already in use. Slow sand filters have a limitation in that they can only decrease bacteria.

Solar pasteurization is also recognized as a low-cost disinfection technique. Combining UV-A light with heat may do this.

This approach seems to be a dependable and efficient low-cost treatment method for collected rainwater, since the sun is a free natural source of energy abundant in most poor nations. Solar pasteurization may take place in batch (plastic bottles or bags) or continuous flow (SODIS) reactors. It is most effective when the water temperature is at least 50 degrees Celsius, which may be readily achieved using solar energy. Sun inactivation of E. coli over time in several bottle systems with and without reflectors, as well as a unique reflector system created by Solar Cookers International (SCI) dubbed Cookit. A Cookit is made up of three sections: the vertical reflecting part, the center piece, which contains the black jar (ideal volume: 1– 5 L, costs about 15£), and the front section, which is adjustable to reflect the most amount of sunlight onto the jar.

Candida sp., Geotrichum sp., and Aspergillus flavus spores required 2.4 times as much solar energy to inactivate as E. coli, while Penicillium spores took 6.4 times as much solar energy to inactivate.

Solar batch technique is enough for modest homes, while solar water pasteurization as a continuous flow system (SODIS reactor) may generate approximately 100 L of sterilized water per square metre of solar collector each day. When suspended particles concentrations exceed 10 mg/L, solar technology is restricted. Other methods for removing particulate matter, such as filtering, may be used in this situation.

Filtration methods are often used to remove harmful chemicals from rainwater. Particle-bound compounds make up a portion of these chemicals. Filtration may be used to remove these suspended particles. A fast sand filter is the most popular kind of filter. Water flows vertically through sand, which is often coated with anthracite coal or activated carbon. Organic molecules that contribute to flavor and odor are removed by the top layer. Because the pore space between sand particles is greater than the pore space between the tiniest suspended particles, basic filtration is usually insufficient. On their passage through the filter, most particles pass through the surface layers but get stuck in pore gaps or attach to sand particles and biofilms. As a result, the depth of the filter improves the effectiveness of filtering. This is a unique property.

2. DISCUSSION

The author has discussed about the opportunities in rainwater harvesting, Rainwater collecting seems to be an effective way for poor nations to reduce water shortages. Local resources and labor must be utilized to identify catchment areas and construct harvesting systems. The majority of collected water for agricultural use may be retained underground in natural systems, preventing evaporation. Rainwater collected for household use, on the other hand, may be contaminated with germs and dangerous chemicals, necessitating careful selection of the catchment region. There are a variety of disinfection methods available, some of which use natural sources such as sun energy. GIS technologies may help locate prospective RWH sites.

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3. CONCLUSION

The author has concluded about the opportunities in rainwater harvesting, DRWH collects rainwater from rooftops, courtyards, and low-traffic areas and stores it nearby. It is feasible to construct underground or aboveground storage tanks. The quantity of storage needed depends on the requirements. The most frequent tank forms are cuboid, cylindrical, and doubly curved tanks. For storage, smaller storage tanks made of bricks, stabilized soil, rammed earth, plastic sheets, and mortar jars are often utilized. Rainwater containers made of earthenware, Ferro cement, or polyethylene have the potential to retain more water. Although the polyethylene tanks are tiny, they can contain a lot of material. Rainwater may be collected and stored in tanks that are either underground or above ground. All measures must be taken while utilizing storage tanks, including providing an adequate enclosure to limit contamination by human, animal, or other environmental contaminants, as well as a tight cover to prevent algae growth and mosquito breeding.

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