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RAINWATER HARVESTING AND RE-USE

Satish Kumar[1], Vikas Yadav[2], Nishant Kumar[3]
[1,2,3] *Department of Civil Engineering, IIMT College of Engineering, Greater Noida, (India)*

ABSTRACT
In most of the places of the India we see rapid increase in the population resulting in capability of supplying adequate water demand to the people. Whether it is to fulfill the social needs or to insure equality in the access of water is one of the major issue faced by the authorities. For solving this problem we have only two paths, firstly finding an alternate water resources using conventional methods and secondly utilization of limited amount of water resources in most appropriate way. The better option of the above two seems to be the first one and therefore it has been given more attention. As we see that different people have different degree of requirement of the amount of water for their utilization. So it is difficult to limit the public water demand. The best alternative nowadays to supplement fresh water resources is nothing but Rainwater Harvesting. It is the accumulation and deposition of Rain water for reuse on site rather than allowing it to runoff. It is the environment friendly and decentralized solution. It can help in efficient solution for the scarcity of water.

1. INTRODUCTION

Water is the most common or major substance on the earth, covering more than 70% of its surface. Out of the total volume of water available on the surface of the earth, only 2 percent (over 28,000,000 km^3) is fresh water. The fresh water is used for the purpose of human use, industries and agriculture. In India, the water availability per capita is declining. The per capita availability of water at the national level is reduced from about 5,177 m3 in the year 1951 to the present level of 1,869 m^3. The prominent reasons behind are the increasing demand for water due to the increasing population and extensive use of water by agricultural sector, which continues to be the single largest consumer of water. In fact India is blessed with adequate rainfall as a whole, yet there are large swathes of dry and drought prone area. In many places the quality of groundwater is not good. In such places rainwater harvesting may provide lifeline for survival. The human civilization, entirely depend upon rivers, lakes and ground water to fulfill their water demands. However rain is the ultimate source that feeds all these sources. The implication of rainwater harvesting is to make optimum use of rainwater at the place where it falls i.e. to conserve it without allowing it to drain away. *Rainwater harvesting* is an ancient technique enjoying a revival in popularity due to the inherent quality of rainwater. It broadly refers to the technique for collection and storage of rain water from rooftop, land surfaces, rock catchments for human use with the application of simple as well as engineering technologies. The collected water is saved in natural or artificial reservoirs. They are generally made underground. Another process for Rainwater harvesting is the seepage of rainwater from the ground surface into the aquifer. The water from the aquifer can be abstracted by artificial means .It has been practiced for more than four thousand years owing to the chronological and spatial variability of rainfall. There are many places in India like Cherrapunji, and Pondicherry which have abundant rainfall throughout the year but unfortunately lack in a suitable and decentralized approach for the utilization of water. No proper water supply system is being developed by the government which can avail this resource. The harvested water can be used for gardens, livestock, domestic uses (with proper treatment) and indoor heating for houses. It can also be used for drinking water as well as distilled water and recharge of ground water table. It is a very good option in the areas where there is a scarcity of quality fresh water. Most modern technologies exploit the surface water from river streams and lakes for obtaining pure drinking water. But, falling rain is the cleanest naturally occurring water available anywhere. Therefore, it is apparent that there is most scope for the collection of rain water before the extreme losses from evaporation and transpiration. Generally, the term rain water harvesting is only taken to refer the straightaway collection of Rain water running off surfaces upon which it has fallen directly. Infact, it also means the collection from the runoff of land watershed into streams, rivers and lakes etc. Our paper concerns mainly with the importance as well as advantages of rainwater harvesting and innovative techniques that can be utilized for doing the same.

II ADVANTAGES

Advantages of Rainwater Harvesting Rainwater harvesting systems can provide water at or near the point where water is needed or used. The systems can be both owner and utility operated and managed. Rainwater collected using existing structures (i.e., rooftops, parking lots, playgrounds, parks, ponds, flood plains, etc.), has few negative environmental impacts compared to other technologies for water resources development. Rainwater is relatively clean and the quality is usually acceptable for many purposes with little or even no treatment. The physical and chemical properties of rainwater are usually superior to sources of groundwater that may have been subjected to contamination.

Some Other Advantages of Rainwater Harvesting Include:

- It can co-exist with and provide a good supplement to other water sources and utility systems, thus relieving pressure on other water sources.
- It provides a water supply buffer for use in times of emergency or breakdown of the public water supply systems, particularly during natural disasters.
- It can reduce storm drainage load and flooding in city streets.
- Users of rainwater are usually the owners who operate and manage the catchment system, hence, they are more likely to exercise water conservation because they know how much water is in storage and they will try to prevent the storage tank from drying up.
- Rainwater harvesting technologies are flexible and can be built to meet almost any requirements. Construction, operation, and maintenance are not labour intensive.
- Relatively cheap materials can be used for construction of containers and collecting surfaces
- Construction methods are relatively straightforward

- Low maintenance costs and requirements
- Collected rainwater can be consumed without treatment, if a clean collecting surface has been used
- Provides a supply of safe water close to homes, schools or clinics, encourages increased consumption, reduces the time women and children spend collecting water, reduces back strain or injuries from carrying heavy water containers

III WORKING METHODS

Rainwater can be collected from most forms of roof. Tiled roofs, or roofs sheeted with corrugated mild steel etc. are preferable, since they are the easiest to use and give the cleanest water. Thatched or palm leafed surfaces are also feasible, although they are difficult to clean and can often taint the run-off. Asbestos sheeting or lead-painted surfaces should be avoided. The rainwater is collected in guttering placed around the eaves of the building. Low cost guttering can be made up from galvanized mild steel sheeting (a thickness of around 22 gauge), bent to form a 'V' and suspended by galvanized wire stitched through the thatch or sheeting, as shown in Figure 1.

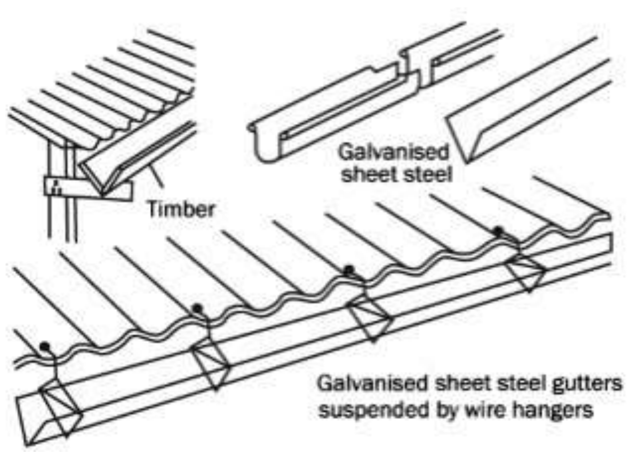

Fig 1: Guttering materials

The guttering drains to a down-pipe, which discharges into a storage tank. The down-pipe should be made to swivel so that the collection of the first run-off can be run to waste (the first foul flush), preventing accumulated bird droppings, leaves, twigs and other vegetable matter, as well as dust and debris, from entering the storage tank. Sometimes a collecting box with a mesh strainer (and sometimes with additional filter media) is used to prevent the ingress of potential pollutants.Alternatively, a foul flush box, which can be drained separately, may be fitted between the down-pipe and the storage tank. The run-off from a roof is directly proportional to the quantity of rainfall and the plan area of the roof. For every one millimeter of rain, a square meter of roof area will yield one litre of water (disregarding evaporation, spillage losses and wind effects). The guttering and down-pipes should be sized so as to be capable of carrying peak volume of run-off; in the tropics this can occur during high intensity storms.

IV STORAGE TANKS

The capacity of the storage tank is based upon several design criteria: rainfall patterns and volume, the duration of the dry period and the estimate of demand. Sometimes sophisticated calculations are involved, but these tend not to take into account human behavior and the willingness to use water if it is available and not conserve it for future use, in the hope that the dry spell will soon be over. The following simple calculation can be used to approximate the potential supply of rainwater from a collecting surface. This can help to determine the capacity of storage tanks:

S = R x A x Cr

S = Mean rainwater supply in m^3

R = Mean annual rainfall in mm/year

A = Surface area of catchment in m^2

4.1. Domestic storage tanks

Tanks for household use can be made cheaply in a variety of ways. ‘Basket tanks’ are baskets made of bamboo, originally intended for carrying or storing maize, which have been plastered internally and externally, in two stages, with sand/cement mortar. Storage of up to two cubic meters can be provided by such baskets. Corrugated galvanized mild steel sheeting, bent and welded or bolted into a circular plan, and often coated with sand/cement mortar, can provide similar storage capacity, but at a greater cost.

4.2. Ferro cement tanks

Larger tanks can be made of fibrocement, which substitute chicken wire for the bamboo reinforcement of the basket tank. These are cheaper to construct than tanks made of masonry, block work, reinforced concrete etc., and do not require the rendering with waterproof cement mortar that masonry and block work often need.
The run-off coefficient accounts for losses due to splashing, evaporation, leakage and overflow and is normally taken to be 0.8 (80%). The provision of the storage tank is the most costly element of a rainwater harvesting project, usually about 90% of the total cost. Storage can range from small containers made for other purposes, for example oil drums, food cans etc., up to large tanks of 150 cubic meters or more, at ground level, or sometimes beneath it.

These larger tanks are made of concrete or fibrocement and are used as storage for schools, clinics or other institutions with large areas of roof.

Fig 2: Rainwater Harvesting in a Domestic Storage Tank

Above ground level, tanks are constructed with a plain or reinforced concrete base, cylindrical walls of fibrocement and a roof of fibrocement, or sometimes mild steel sheeting. The construction of fibrocement walls is carried out by first assembling a cylindrical mesh of chicken wire and/ or fence wire reinforcement, with or without the aid of formwork. On to this, a cement-rich mortar of 3:1 sand: cement is applied by trowel and built up in layers of about 15 millimeters to a finished thickness of between 30 to 100 millimeters, depending on wall height and tank diameter. Thicker walls may have two layers of mesh. The mesh helps to control local cracking and the higher walls may call for the provision of small diameter vertical steel reinforcing bars for bending resistance. Sometimes barbed fence wire is wound spirally up the wall to assist with resistance to ring tension and stress distribution.

V ROCK CATCHMENTS

Rock catchments just as the roofs of buildings can be used for the collection of rainwater, rock outcrops can also be used as collecting surfaces. Indeed, if access to the catchment area by animals, children etc. can be prevented, a protected catchment can collect water of high quality, as long as its surfaces are well flushed and cleaned before storage takes place. A significant proportion of Gibraltar's water is obtained from sloping rock catchments on the Rock. At the foot of the slopes, collecting channels drain into pipes that lead to tanks excavated inside the rock. Some artificial collection surfaces have also been formed; cracks and voids in rock surfaces have been filled in and a large, soil covered, sloping area has been covered in corrugated mild steel sheeting supported on short piles driven into the subsoil. This is an example of what may be possible on a smaller domestic or village scale. Sometimes it proves difficult to prevent the collected water from being polluted. If so, it is sensible to use this water for purposes that do not require a potable water supply, such as house cleaning, laundry, horticulture etc., and reserve for drinking water, cooking and personal hygiene the better quality water that has been collected from a clean roof. Use can also be made of other forms of ground catchment where, although the collection coefficient can be as low as 30%, useful volumes of water can be collected and used for agriculture and animals.

VI WHAT MUST BE CONSIDERED TO DESIGN AND MAINTAIN FACILITIES FOR RAINWATER UTILIZATION?

Catchment Surface the effective catchment area and the material used in constructing the catchment surface influence the collection efficiency and water quality. Materials commonly used for roof catchment are corrugated aluminum and galvanized iron, concrete, fiberglass shingles, tiles, slates, etc. Mud is used primarily in rural areas. Bamboo roofs are least suitable because of possible health hazards. The materials of catchment surfaces must be non-toxic and not contain substances which impair water quality. For example, asbestos roofs should be avoided; also, painting or coating of catchment surfaces should be avoided if possible. If the use of paint or coating is unavoidable, only non-toxic paint or coating should be used; lead, chromium, and zinc-based paints/coatings should be avoided. Similarly, roofs with metallic paint or other coatings are not recommended as they may impart tastes or colour to the collected water. Catchment surfaces and collection devices should be cleaned regularly to remove dust, leaves and bird droppings so as to minimize bacterial contamination and maintain the quality of collected water. Roofs should also be free from over-hanging trees since birds and animals in the trees may defecate on the roof.

When land surfaces are used as catchment areas, various techniques are available to increase runoff capacity, including: i) clearing or altering vegetation cover, ii) increasing the land slope with artificial ground cover, and iii) reducing soil permeability by soil compaction. Specially constructed ground surfaces (concrete, paving stones, or some kind of liner) or paved runways can also be used to collect and convey rainwater to storage tanks or reservoirs. In the case of land surface catchments, care is required to avoid damage and contamination by people and animals. If required, these surfaces should be fenced to prevent the entry of people and animals. Large cracks in the paved catchment due to soil movement, earthquakes or exposure to the elements should be repaired immediately. Maintenance typically consists of the removal of dirt, leaves and other accumulated materials. Such cleaning should take place annually before the start of the major rainfall season.

Conveyance Systems Conveyance systems are required to transfer the rainwater collected on catchment surfaces (e.g. rooftops) to the storage tanks. This is usually accomplished by making connections to one or more down-pipes connected to collection devices (e.g. rooftop gutters). The pipes used for conveying rainwater, wherever possible, should be made of plastic, PVC or other inert substance, as the pH of rainwater can be low (acidic) and may cause corrosion and mobilization of metals in metal pipes.

When selecting a conveyance system, consideration should be given to the fact that when it first starts to rain, dirt and debris from catchment surfaces and collection devices will be washed into the conveyance systems (e.g. down-pipes). Relatively clean water will only be available sometime later in the storm. The first part of each rainfall should be diverted from the storage tank. There are several possible options for selectively collecting clean water for the storage tanks. The common method is a sediment trap, which uses a tipping bucket to prevent the entry of debris from the catchment surface into the tank. Installing a first flush (or foul flush) device is also useful to divert the initial batch of rainwater away from the tank.

Gutters and down-pipes need to be periodically inspected and carefully cleaned. A good time to inspect gutters and down-pipes is while it is raining, so that leaks can be easily detected. Regular cleaning is necessary to avoid contamination.

VII HOW CAN RAINWATER HARVESTING AND UTILIZATION CONTRIBUTE TO A SUSTAINABLE WATER STRATEGY?

Fig 3: Self-Sufficiency in Water Supply, Without Being Dependent on Remote Water Sources

Many cities around the world obtain their water from great distances - often over 100km away.

But this practice of increasing dependence on the upper streams of the water resource supply area is not sustainable.

Building dams in the upper watershed often means submerging houses, fields and wooded areas. It can also cause si gnificant socio-economic and cultural impacts in the affected communities. In addition, some existing dams have be en gradually filling with silt. If not properly maintained by removing these sediments, the quantity of water collected may be significantly reduced.

Decentralized "Life-Points", Versus the Conventional "Life-Line" Approach

When the city increases the degree of its dependence on a remote water resource, and there is a long period without rainfall in the upstream dam sites, the ability of the city to function effectively is seriously compromised. The same can be said about a city's reliance on a pipeline for drawing water from a water resource area to the city. A city which is totally reliant on a large, centralized water supply pipeline (or "lifeline") is vulnerable in the face of alargescale natural disaster. A shift from "life-line" to decentralized "lifepoints" should be encouraged. Numerous scattered water resource "life-points" within a city are more resilient and can draw on rainwater and groundwater, providing the city with greater flexibility in the face of water shortages and earthquakes. Restoring the Hydrological Cycle Due to the rapid pace of urbanization, many of the world's large cities are facing problems with urban floods. The natural hydrological cycle manifests itself at different scales, depending upon climatic, geographic and biological factors. As rain falls over time and seeps underground to become groundwater, it feeds submerged springs and rivers. The concrete and asphalt structures of cities have tended to disrupt the natural hydrological cycle, and reduce the amount of rainwater permeating underground. A decrease in the area where water can penetrate speeds up the surface flow of rainwater, causing water to accumulate in drains and streams within a short time. Every time there is concentrated heavy rain, there is an overflow of water from drains, and small and medium sized rivers and streams repeatedly flood. These conditions can often lead to an outpouring of sewage into rivers and streams from sewer outlets and sewer pumping stations, thus contaminating the quality of urban streams and rivers.

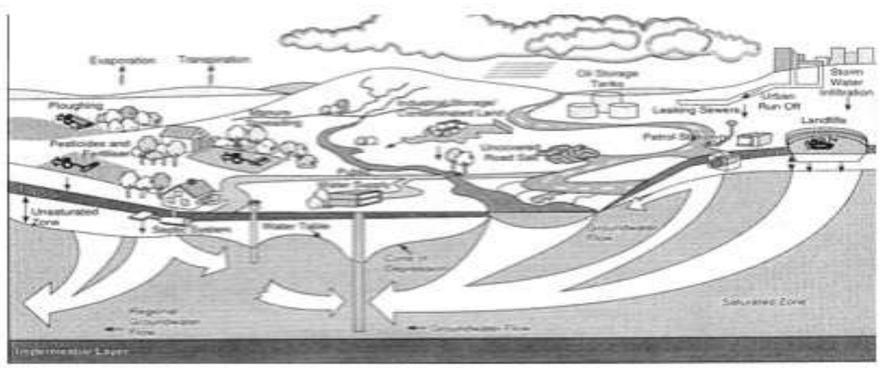

Diagram of the Hydrological Cycle (detail)

Fig 4. Diagram of Hydrological Cycle

Concrete and asphalt have a profound impact on the ecology of the city. These include:

• Drying of the city-

This happens as rivers and watercourses are covered, natural springs dry up, and greenery is cut down.

• Heat pollution In some cities during the hot summer, an asphalt road at midday can reach temperatures of over 60° C. The heat expelled from air conditioners can further aggravate this. This dramatically alters the city's natural hydrological cycle and ecological environment.

Introducing the Concept of "Cycle Capacity"

In thinking about sustainable development, one must view environmental capacity from a dynamic perspective and consider the time required for the restoration of the hydrological cycle. "Cycle capacity" refers to the time that nature needs revive the hydrological cycle. The use of groundwater should be considered from the point of view of cycle capacity. Rain seeps underground and over time becomes shallow stratum groundwater. Then, over a very long period of time, it becomes deep stratum groundwater. For sustainable use of groundwater, it is necessary to consider the storage capacity for groundwater over time. If this is neglected and groundwater is extracted too quickly, it will disappear within a short time.

Demand Side Management of Water Supply

In establishing their water supply plans, cities have usually assumed that the future demand for water will continue to increase. Typically, city waterworks departments have made excessive estimates of the demand for water and have built waterworks infrastructure based on the assumption of continued development of water resources and strategies to enlarge the area of water supply. The cost of development is usually recovered through water rates, and when there is plenty of water in the resource area, conservation of the resource is not promoted. This tends to create a conflict when drought occurs, due to the lack of policies and programmes to encourage water conservation. It has even been suggested that the lack of promotion of water conservation and rainwater harvesting is due to the need to recover infrastructure development costs through sales of piped water. The exaggerated projection of water demand leads to the over-development of water resources, which in turn encourages denser population and more consumption of water.

Sustainability of urban water supply requires a change from coping with water supply without controlling demand, to coping with supply by controlling demand. The introduction of demand side management encourages all citizens to adopt a water conservation approaches, including the use of freely available, locally supplied rainwater.

VIII WHAT MUST BE CONSIDERED WHEN SELECTING RAINWATER AS A WATER SUPPLY SOURCE?

The disadvantages of the rainwater harvesting and utilisation systems are:

• The catchment area and storage capacity of a system are relatively small. There is a great variation in weather. Dur ing a prolonged drought, the storage tank may dry up.

• Maintenance of rainwater harvesting systems, and the quality of collected water, can be difficult for users.

• Extensive development of rainwater harvesting systems may reduce the income of public water systems.

• Rainwater harvesting systems are often not part of the building code and lack clear

Guidelines for Users/Developers to Follow

• Rainwater utilisation has not been recognized as an alternative of water supply system by the public sector. Govern ments typically do not include rainwater utilisation in their water management policies, and citizens do not demand rainwater utilization in their communities.

• Rainwater storage tanks may be a hazard to children who play around it.

• Rainwater storage tanks may take up valuable space.

• Some development costs of larger rainwater catchment system may be too high if the costs are not shared with oth er systems as part of a multi-purpose network

learning from these advantages and disadvantages, the decision to use rainwater as a new water source should be di scussed among citizen/user groups and government water officials. Topics of such discussion might include:

- what are the alternatives for new water supply sources?
- What are the advantages and disadvantages of each alternative of new water source?
- How is rainwater utilisation ranked among the alternatives of new water supply sources, taking into account the vi ewpoints of private citizens and governmental officials?
- What are the responsibilities of users and communities for the participation in new water source development?

After these discussions, if rainwater utilisation is selected for development, then a detailed engineering feasibility st udy can be undertaken.

IX CONCLUSION

Rainwater utilization, together with water conservation and wastewater reclamation, should be incorporated into municipal ordinances and regulations. Some standardization of materials, at least at regional level, may be desirable from a maintenance and replacement point of view. It may be also appropriate to standardize the design of the rainwater utilization system, at least at the regional level. Various implementation policies should be established to make rainwater utilization and other measures a part of the social system. Leadership is very important and local governments must take the initiative to promote the concept of water resource independence and restoration of the natural hydrological cycle. Consideration should be given to subsidizing facilities for rainwater utilization. Technology and human resources development to support rainwater utilization is very important. It is also important to promote the development of efficient and affordable devices to conserve water, facilities to use rainwater and devices to enhance the underground seepage of rainwater. Together with this, there is a need to train specialists with a thorough grasp of these technologies and devices. To promote rainwater harvesting and utilization as an environmentally sound approach for sustainable urban water management, a network should be established involving government administrators, citizens, architects, plumbers and representatives of equipment manufacturers. It is essential to encourage regional exchanges amongst public servants, citizens and industry representatives involved in rainwater storage, seepage and use, as well as the conservation and reclamation of water.

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