Rain water harvesting to ensure drinking water supply in problem areas

The purest form of raw water, rain water could be harvested in a variety of ways to ensure a steady supply of safe drinking water in problem areas. The article describes the various rain water harvesting structures and techniques that are now being put into practice under the National Technology Mission on safe drinking water for villages.

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WATER is essential for human survival. Life without water is unthinkable.

The total quantity of available water in the World is constant. According to a report of the United Nations Environmental Program (UNEP), more than 97% of the available water is in the form of sea water while the quantity of fresh water is less than 3%. Out of this fresh water, 77% is ice locked away in the glaciers and the polar ice caps and 22% is ground water. This leaves less than 1% of fresh water supply to take part in the hydrological cycle, about half of which is found in rivers, lakes and swamps. Yet, on the global scale, availability of fresh water is more than enough to meet the demand in the present and the foreseeable future. But this water is not available every where, all the time or in proper quality and form. As a result, scarcity and pollution of water have led to a situation where at least 20% of the population living in Third World's cities and 75% of its rural population do not have access to reasonably safe supplies of water even for drinking.

Contaminated water is a source of a large number of diseases—cholera, typhoid, hepatitis, etc. Considerable work-hours are lost due to sickness caused by these diseases in most of the Third World countries every year. Such diseases can be eliminated to a large extent by providing potable water to the masses. Recognizing this as a great problem and a basic need for human beings, the United Nations declared the decade 1981-90 as the International Drinking Water Supply & Sanitation Decade. The aim is to provide safe water and proper sanitation for all by 1990.

India has also been facing the problem of short supply of drinking water specially in the rural areas and certain urban pockets. Considerable work has been taken up to mitigate this problem as part of the Water & Sanitation Decade, but this is not enough to make a dent into the problem considering its magnitude. The Government of India, therefore, have started work in a large number of villages in problem areas under its Technology Mission on drinking water supply in villages.

A number of schemes have been designed for fresh water supply from either ground water or river water. These schemes are costly, time consuming and difficult to maintain, specially in rural, hilly and forest areas. For solving the problem of drinking water supply in rural areas, therefore, there is an immediate need to design such water schemes which could be easily and quickly installed

and maintained by local people. These should be inexpensive in terms of initial expenditure and maintenance so that a larger area may be covered within the available budget.

Sources of drinking water

The main sources of water for drinking are ground water, surface water and rain water. Ground water is much favoured as generally it is least contaminated. But in some areas, ground water is very deep and the rate of recharge is poor and therefore it is costly to exploit for human consumption. Besides, in certain places ground water contains high quantities of Fluorides, Nitrites, Iron, Salts, etc, which make it unfit for human consumption.

Surface water is available in rivers, ponds, lakes, streams, etc. This source of water is not available everywhere. Besides, in most cases, it is found contaminated with physical, chemical or bacteriological impurities. Therefore, it can not be used for drinking without treatment—which again would be a costly and difficult affair for rural areas.

Most parts of the country receive enough rainfall. A large portion of rain water flows to rivers, lakes, ponds and seas; some of it gets evaporated or seeps into the ground. During this course rain water gets contaminated with impurities. In most hilly regions there is abundant rainfall, but the people face acute shortage of drinking water as most of the rain water flows down to the plains. If we can tap rain water before it reaches the ground, the problem of providing drinking water in hills can be easily solved with least expenditure. The water so collected can be stored in safe water storage structures like tanks made of ferrocement, reinforced cement concrete, or hy-galvanized iron sheet.

In some parts of the world, rain water harvesting schemes have been developed and used for getting potable water. Some ancient structures in India incorporated rain

Training course-cum-field demonstrations for construction of rain water harvesting structures and ferrocement water storage tanks

The Technology Mission on Drinking Water in Villages and Related Water Management, established by Government of India, has accorded high priority to utilization of rain water for drinking purposes in areas where there is enough rainfall such as the North Eastern States and the islands. The Structural Engineering Research Centre (SERC), Ghaziabad (U.P.) has developed domestic rain water harvesting schemes using roof or micro catchment platforms for collection of rain water. It has developed a method for removing suspended impurities by introducing a strainer system into inflow pipes, a byepass system for removing the initial rainfall bringing atmospheric impurities and surface washings, a filter for the inlet of the storage tank, and ferrocement water storage tank of up to 20,000 litre capacity.

SERC, a CSIR laboratory has been entrusted with the responsibility of training a large number of resource persons, trainers and technicians in the construction techniques of rain water harvesting schemes and ferrocement water storage tanks. The Centre has already organized 8 training courses and trained over 230 engineers, technicians and volunteers from U.P., M.P., Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, West Bengal, Meghalaya, Assam, Manipur, Tripura and Nagaland. Actual construction techniques for cylindrical ferrocement tanks of 2,500, 5,000 and 10,000 litre capacities and rain water harvesting systems have been demonstrated to the course participants. More than 50 ferrocement tanks of various capacities have been constructed during these courses. NRDC has released technologies developed by SERC to many entrepreneurs in Assam, Meghalaya, Manipur, etc, so that an expert core group is available for helping the State Governments taking up these projects.

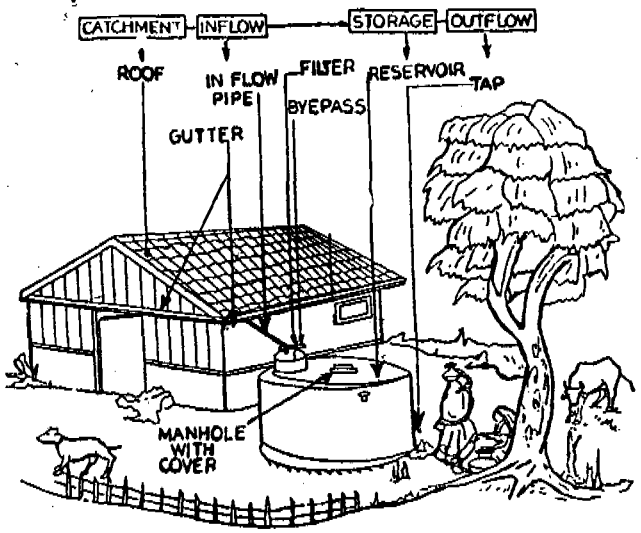

Fig. 1. Rain water collection from roof.

water harvesting systems. Therefore, even today, this good source of water can offer an immediate solution to the problem of potable water supply in rural areas. In hilly and costal areas such a scheme will be particularly useful, because providing piped water and finding a sweet water source is difficult in such places.

Rain water harvesting

Rain water is the purest form of raw water available on earth. Rain water harvesting is the process of collection of rain water from rain receiving surfaces like building roof tops, courtyards, playgrounds, hill slopes, places of worship, or specially made minicatchment surfaces. The water is collected in storage tanks installed above ground, partly above and partly under ground, or fully under ground depending on the local situation. Since the water is collected before it comes in contact with any contaminated surface, it remains free from physical, chemical and faecal contamination. For removing suspended impurities, if any, the water is passed through a filter before it reaches the collection reservoirs.

The Structural Engineering Research Centre at Ghaziabad (U.P.) has been working on development of rain water harvesting systems for domestic and community drinking water schemes. The Centre has developed various components for rain water harvesting structures like treatment lines for catchment surfaces, filters, tanks and byepass systems.

Rain water harvesting schemes for collection of drinking water may be designed at both domestic level and community level. In domestic level schemes, rain water is collected from roofs, courtyards or minicatchment platforms available in the house or in the adjoining areas of the user's premises and stored in individual family tanks (Fig.1).

For community level schemes, the rain water is collected from larger catchment areas in large underground tanks, fenced reservoirs, or artificial lakes/ponds. In this case water may be collected through water shed management or hill slopes. In watershed management, mini check-dams are constructed at suitable locations to divert the natural flow of rain water run-off to suitable reservoirs (Fig. 2).

The construction method for ferrocement mini-checkdams developed at SERC, Ghaziabad is shown in Fig. 3. These dams of up to 1.6 m height can be precast in small lengths and quickly assembled at site. The cost of such dams is quite competitive with solid masonary dams constructed for this purpose in hill areas. Such schemes can also play a

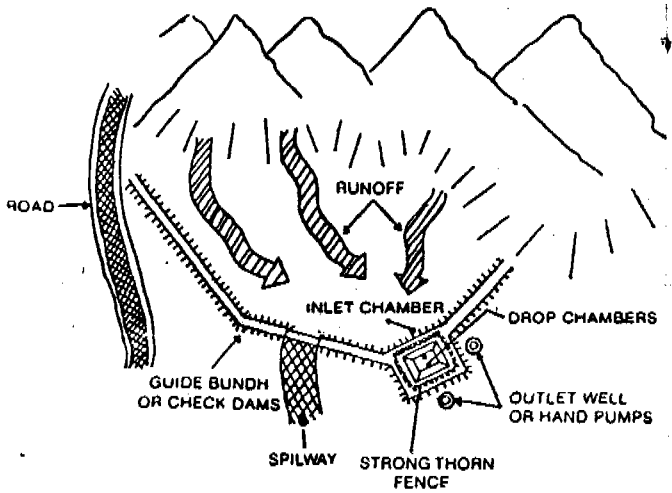

Fig. 2. Rain water collection through water-shed management.

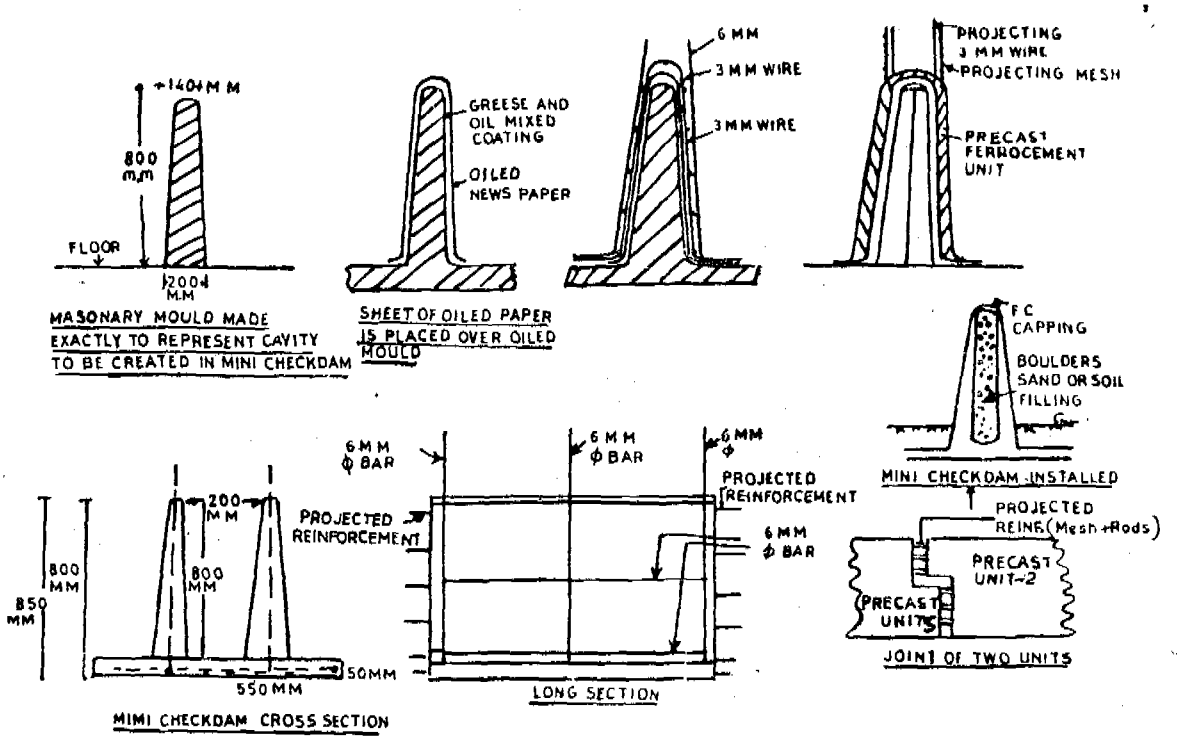

Fig. 3. Ferrocement mini check-dams developed at SERC, Ghaziabad.

vital role in recharging of ground-water strata. For collection of rain water from hill slopes, cross-drains are constructed to direct the rain water into under-ground or above-gronud tanks through pipe-lines or covered masonary drains (Fig. 4). In both the above cases silt traps are required to be installed for removing silt from the water. The stored water may be utilized by a community for domestic and other purposes.

Rain water harvesting scheme

A rain water harvesting system (RWHS) consists of the following components :

1. *Catchment area* : The surface used for collection of rain water is known as catchment area. For domestic rain water harvesting, this may be the roof, courtyard, elevated platforms adjoining the house, or specially made microcatchments. For community schemes, catchment areas available in the form of play-grounds, fields, hill slopes or water-sheds can be used. However, it is essential that the catchment surface is free from faecal and chemical contamination; and the surface itself should be made of materials that will not contaminate the water, in either suspended or soluble form.

(i) Roof: For collection of water the roof may be made of corrugated galvanized iron or aluminium sheet, ferrocement, plaster, flat roof (tiled top or cement concrete surface), wood (covered with plastic sheet), thatch (covered with plastic sheet or non-erodable mud), or canvas (e.g. tent-roof). Roofs made of asbestos (loosing asbestos fibres), bituminous sheets or corroded MS

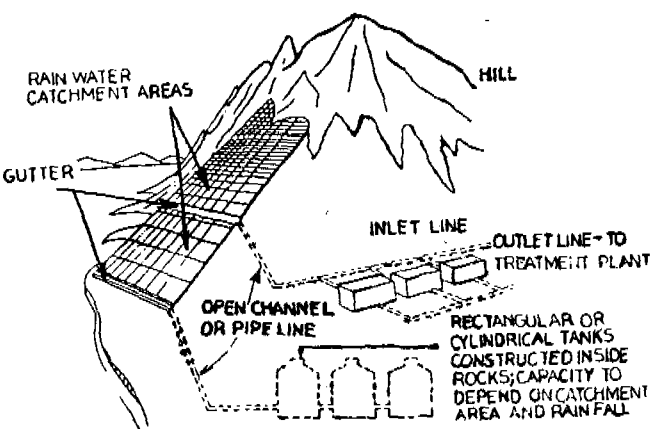

Fig. 4. Rain watercollection through hill slopes.

sheets, or sheets painted with lead based paints should be avoided as they can contaminate the water. Thatched roofs with damaged surfaces loosing thatch fibre in the rain should be used only after repairing and covering them with plastic sheet.

In view of the relatively small individual roofing area, the construction of roof in a single slope is recommended to achieve savings in the cost of the gutter system. This slope should be directed towards the entrance of the house so that the storage tank can be placed in front of the house to prevent theft of water. Tree branches or such other obstacles should not overhang the roof so that the entire roof area could receive the rain fall.

The main advantage of collection of rain water from the roof is that it eliminates additional investment on construction of a catchment area and minimizes contamination with faecal matter or animal droppings.

(ii) Micro-catchment platform: Raised platforms (natural or man-made) or ground surfaces prepared and protected against contamination may be used for collection of rain water. High level earth deposits sloping to one side or artificially constructed raised platforms (Fig. 5) can be utilized for this purpose. Ground surfaces like courtyards, play-grounds, meeting places or tennis/badminton/basket-ball courts can also be used for this purposes. In all such cases, precautions should be taken to reduce chances of water contamination.

Platform surfaces should be provided with some lining—soil-cement, brick, grit/coarse sand, masonry, plastic sheet, etc—to avoid turbidity in the collected water. The surface should be made compact and smooth mechanically to reduce infiltration of water and achieve maximum run-off. The area should be cleaned regularly and vagetation, if any should be removed. To eliminate faecal contamination, the approach and easing of animals and human beings in the catchment area is to be prohibited. Silt traps and filters are to be provided to remove turbidity and suspended impurities.

Micro-catchment areas are developed around storage tanks like the traditional tanka system, which is popular in Rajasthan (Fig. 6).

(iii) Hill slopes: The rain water flowing down hill slopes is collected by constructing cross-drains in the slopy areas (Fig. 4). The water so diverted is taken to under-ground or above-ground water storage tanks/reservoirs after filtration. This water is consumed in no-rain periods after treatment, involving filtration and chlorination with chlorine tablets.

(iv) Water-shed management: This technique is useful where large areas with natural gradients to one side are available and the water requirement is high. Here, the

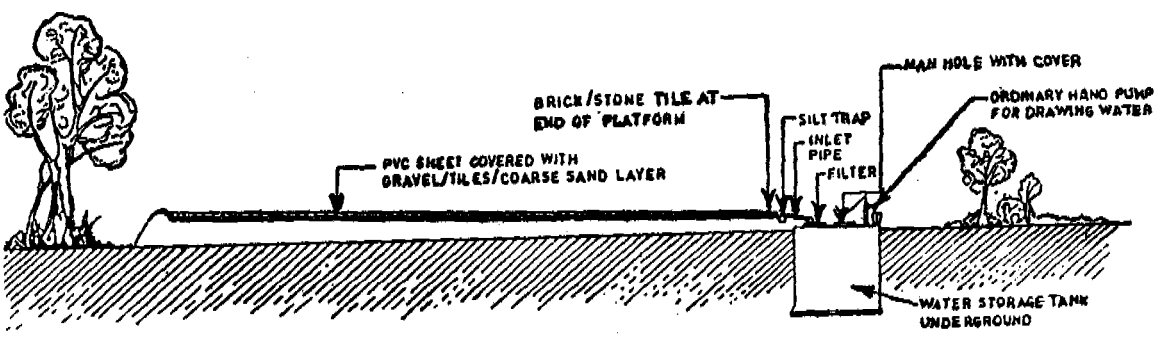

Fig. 5. Platform catchment system for rain water collection (collection platforms can be lined with brick, stone, tiles or even with non-erodable mud-plaster. Tank capacity depends on area of catchment).

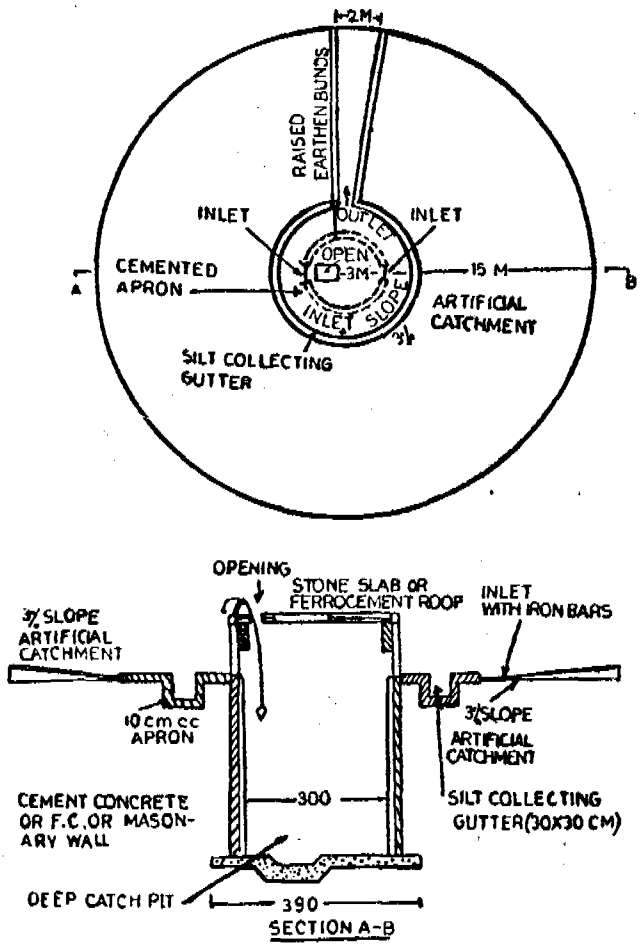

Fig. 6. Construction of a family size water Tunka of 21 cm³.

large volume of run off rain water is diverted to the desired location of storage by constructing small check-dams. The diverted water flow is collected in large capacity underground tanks or reservoirs. These check-dams or bunds are made of masonary, earthen embankments, RCC or ferrocement. The height of these structures is generally upto 1.5 m as these act as stopper/diversion walls for the run off water.

Since these catchment areas are quite large and the water may flow in even from outside the managed area, the water collected may carry a number of impurities. Hence, proper purification of the collected water is necessary before supplying it for human consumption. This water may also be used for livestock and irrigation purposes.

Any of the four types of catchment areas described above may be used for rain water harvesting schemes depending on the available conditions and needs. For individual families, water collection from roofs and micro-catchments may be sufficient. For community schemes, rain water collection from platforms, water-shed management or hill slopes has been found to be more suitable.

2. *Inflow structures:* These structures transfer the rain water collected from the harvesting surface to storage tank/reservoir. The main components of inflow structures are gutter, inflow pipe with byepass arrangement, and filter.

(i) Gutter: This is a type of hanging or supported open drain through which the water flowing from the catchment area goes to the inflow pipe connected to the filter of the storage tank. The number and size of the gutter will depend on the slope and surface area of the roof. In single slope roof system one gutter may be needed. The size of the gutter will depend on the area of catchment and intensity of rain. Depending on discharge, the gutter may be made of GI sheet, half-cut PVC rigid pipe, or half-cut large size bamboo. MS sheet is not used for gutters to avoid any rust contaminating the water. The gutter is provided with GI wire edging and is supported with properly designed bracket system to prevent it from deflecting when it is full of water.

(ii) Inflow pipe: Inflow pipe connects the gutter to the filter of the water tank/reservoir. Use of GI pipe is preferred but rigid PVC or bamboo pipes can also be used. The size of the pipe is selected according to the amount of water to be carried. Generally 10 cm and 15 cm dia inflow pipes are used, depending on the quantity of flowing water. There is bye-pass arrangement to divert the rain water collected in the first few minutes (15-20 minutes), before it reaches the inlet of the filter. Thus the initial flow of water from the catchment area, carrying dust and

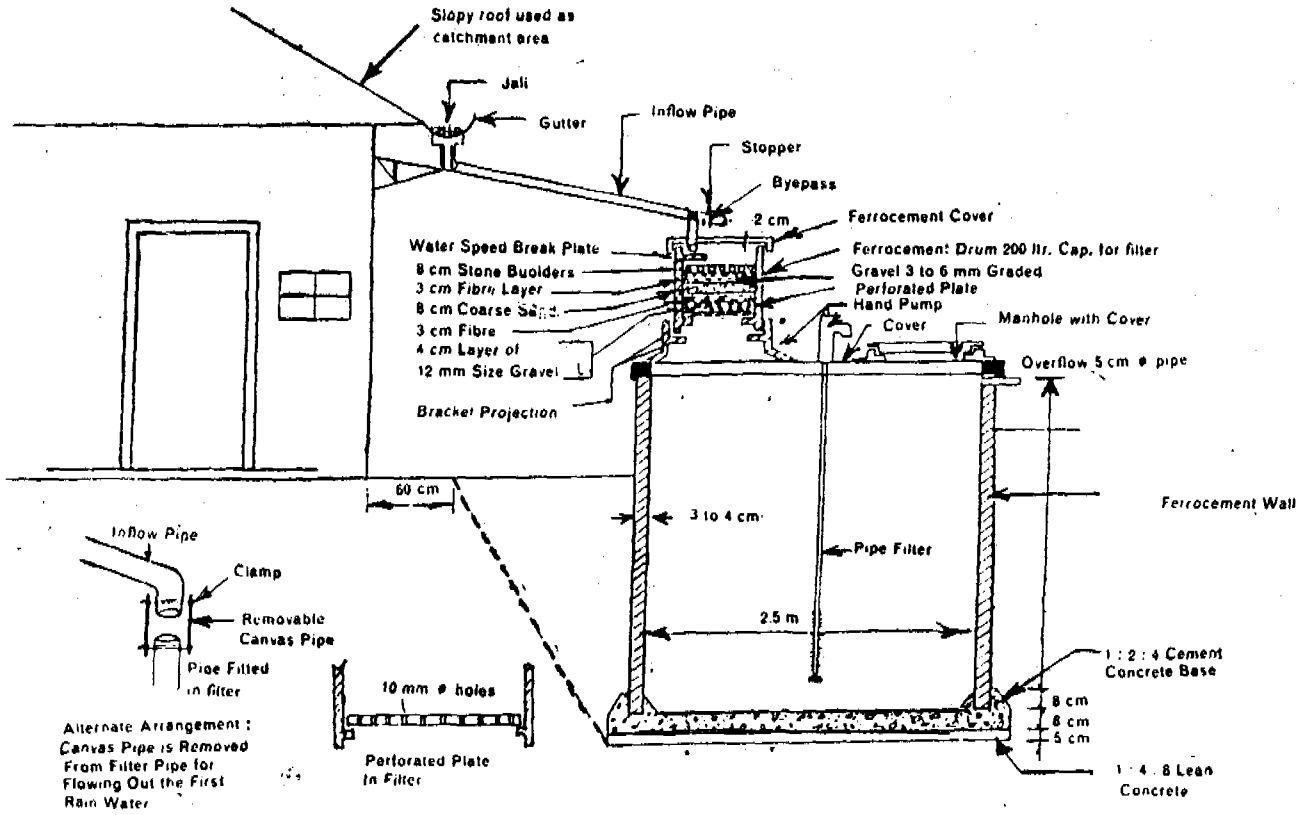

Fig. 7. Byepass system for removing initial rain water carrying surface wash.

other washouts from the collection surface, are removed from the system. Two stoppers one each at the inlet pipe near the entry point of the filter and at the bye-pass pipe are provided for this purpose. To bye-pass the initial flow of water, the stopper at the filter and is closed and the stopper at bye-pass end is opened. After a few minutes of rain, the bye-pass stopper is closed and stopper at filter end is opened (Fig. 7).

(iii) **Filter**: An important part of the inflow structure, the filter removes suspended impurities from the collected water. It basically consists of a filter container, a perforated plate and filtering media. The filter container can be made of GI sheet, ferrocement or RCC in circular or rectangular shape. It rests over an opening provided in the roof of the tank. Ferrocement filter containers are better as they could be locally made and repaired and do not require any maintenance. The perforated plate having 1 cm dia holes is fitted over brackets at the bottom of the filter container. It may be made of non-corroding material like GI sheet or ferrocement. Over this perforated plate are layers of sand, gravel, natural fibres (of coconut, palm or betalnut) and stones, which serve as the filtering media. The filter is kept free from contamination and is cleaned and washed at least twice a year. For this purpose the filtering media are removed, washed and dried before repacking. Experience has shown that such filtration system is quite effective in filtering water.

3. *Storage tank/reservoir*: Proper storage of the collected rain water in closed and safe storage tanks is important. The stored water

can be used in the dry season or no-rain period. The capacity of a tank is decided according to the requirement of water during the dry period, available catchment area, average rainfall, etc.

The major part of expenditure on the installation of rain water harvesting system is accounted for by the storage tanks—but this is a one time investment. Tanks should therefore be cheap, durable, and easily repairable; and they should be locally cast or fabricated without depending on outside labour, sophisticated machinery or costly raw materials. Tanks generally used are made of GI sheet, masonary, MS plate, brick/stone/concrete reinforced blocks, HDPE plastic, or ferrocement. Except GI, MS and plastic tanks, other tanks can be installed above ground, under ground or partly under ground and partly above ground, depending on location, type of catchment area, height of roof, etc. Construction of GI, MS and RCC tanks needs skilled labour and equipment for rivetting, welding or form work. Repair and maintenance of steel tanks is expensive, and they have a short life. Factory made tanks are light in weight, thus easy to carry and instal. But they are costly and difficult to repair; and they can get easily damaged during transportation or, in rural areas, by miscreants. Brick masonary/stone masonary tanks have a large number of joints and making them leak-proof is quite difficult. An uneven ground settlement is enough to cause cracks in them. These tanks should be carefully constructed with the help of skilled masons.

Ferrocement tanks (Fig. 8) are fabricated using ordinary portland cement, woven or welded wire meshes, medium coarse graded sand, and pore-sealing and plasticizing chemicals. Various methods of their construction, suitable for adaptation in rural areas, are (i) skeletal cage system, (ii) SERC segmental tank construction, (iii) tempformer system and (iv) SERC semi-mechanized process. The second and fourth are patented processes developed at SERC(G) and are available from NRDC for commercial exploitation. The main advantages of ferrocement water storage tank are: (a) it costs less than RCC, MS plastic or even masonary tanks; (b) it can be installed under ground, partly under ground or above ground without chnage in design; (c) it can be quickly produced using local semi-skilled masons and helpers; (d) it does not need any maintenance and can be easily repaired locally if accidentally damaged; (e) its production process does not need electricity, fuel oil or highly skilled technicians; and (f) it provides much better thermal insulation than plastic or steel tank.

Masonary under ground structures, popularly known as Tankas in Rajasthan (Fig. 6), have been in use since long. Their performance can be greatly improved by providing an inner lining of ferrocement. This will solve the problem of plaster cracking and make the surface more impervious to water.

Reservoirs for community schemes

Use of a battery of closed type tanks is the safest method of storing drinking water for

Fig. 8. A ferrocement tank for rain water harvesting installed by SERC, Ghaziabad.

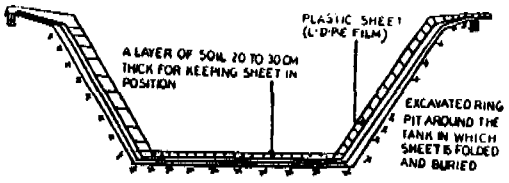

Fig. 9. Plastic sheet lined excavated tanks.

small community schemes. Open reservoirs are generally used when larger communities are to be served.

Some of the structures used for storage of rain water are: (a) excavated tanks lined with plastic sheet covered with brick tiles laid in cement sand mortar (Fig. 9); (b) masonary open-top reservoirs tanks; and (c) a battery of ferrocement under ground or semi-under ground tanks.

All open-top reservoirs used for storage of rain water need strong fencing all around to prevent entry of animals or humans, who are the main cause of water pollution. The sides of the reservoir should be raised above the ground level. For drawing of water, draw wells may be constructed outside the reservoir and connected to the reservoir through a draw pipe. However, open-top reservoirs have the disadvantage of loosing water by evaporating from the open surface. Efforts are being made to reduce this loss by spraying chemicals over the surface. The National Chemical Laboratory, Pune has taken up a project for developing a chemical spray (mixed monomers) which is expected to form a suitable film to withstand wind speeds of about 39 km per hour.

Water treatment system

The water stored in open tanks may have to be treated before consumption as there are chances of bacteriological contamination due to dust. Two types of low cost water treatment systems may be used for this purposes:

1. *Filtration*: Low cost filter candels developed by CSIR Laboratories are available for this purpose. These may be fixed in a set of two plastic buckets or even earthen pitcher pots, placed one above the other. Filter candles work on the principle of micropore filtration to remove suspended impurities from water, including microorganisms deposited around suspended particles.

2. *Chlorination*: The National Environmental Engineering Research Institute (NEERI), Nagpur, a CSIR laboratory, has developed a very simple method of chlorination of water by chlorine tablets. The water is transferred from the tank to a covered plastic bucket of known capacity and the required dose of chlorine tablets is added to it. The water is left undisturbed for about an hour before use.

Summing up

The National Technology Mission on Drinking Water for Villages has taken up the work of solving the problem of safe drinking water in villages. The Mission has accorded due importance to rain water harvesting for solving this problem in areas blessed with sufficient rainfall.

The SERC, Ghaziabad has been working on development of rain water harvesting structures in the recent past. It has organized six training courses on 'Construction techniques for rain water harvesting structures and ferrocement water storage tanks'. More courses have been planned in the North-Eastern region and in the islands like Lakshdeep.

The NRDC has released a large number of licences to entrepreneurs in the North-Eastern States of Manipur, Meghalaya and Assam for construction of ferrocement water tanks and filters, which are essentially required for rain water harvesting schemes (RWHS).

What are the main advantages of these schemes? Construction of piped water supply is very costly. Construction of RWHS, on the other hand, involves low, initial expenditure and the system could be easily maintained by the house owner. There is no dependence on electricity or other energy. And the water collected is free from fluorides, salts or iron.

Acknowledgement

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