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Water scarcity is a serious problem throughout the world for both urban and rural communities. Existing scarcity and water quality problems experienced practically all over the country make water harvesting a critical issue for sustainable development. More and more water is required for domestic, construction and industrial use. The rate of withdrawal is far in excess of the rate of recharging the water table. Pollution and over-exploitation have shrunk the availability of clean and potable water to a trickle.

Urbanization and industrialization has resulted in over exploitation of ground water, reduction in open soil surface and water infiltration rate and a resultant deterioration in water quality. Apartments and industrial units face acute water shortage forcing them to spend considerable amounts of money to purchase water from municipal and private water suppliers.

An United Nations estimate says that by the year 2025 two thirds of humanity will face a shortage of fresh water. At present one third of the global population is facing water stress.

How are we going to face the problem? How are we going to increase the ground water level? The main source is precipitation, in the form of rain. The annual rainfall in India is 400 million hectare metre (mham.). This rainwater can be used to recharge the ground water, by adopting a simple technique called rainwater harvesting.

The need for rainwater harvesting: even a place like Cherapunji which receives around 11000 mm rain annually (roughly 20 times that of Jaipur), suffers from acute shortage of drinking water as the rainwater is allowed to drain.

Most of the rainfall specially in Western and Northern India is concentrated in a few large but short downpours during the monsoon season which together may add up to about 100-125 hours in a year. The rest of the time is either dry or there may be some light drizzles. Thus the rainwater of the major showers during monsoon has to be caught where it falls and stored for use. This used to be done during the past and now needs to be taken up with renewed vigour and the appropriate technology and peoples movement as part of rainwater harvesting efforts.

In the context of our industrial area, every entrepreneur - allottee in the industrial area, has to become involved in the effort to ensure its success.

With the aim to promote rainwater harvesting among its entrepreneurs, this brief publication has been prepared which contains some relevant information about rainwater harvesting and the techniques involved.

Acknowledgment :

While preparing this booklet following publications were referred to:

- Jal leevan Avam Samrakshan, Rajasthan Groundwater Department, Jaipur
- Rain Water Harvesting Techniques to Augment Ground Water, Central Ground Water Board, Western Region, Jaipur
- A Water Harvesting Manual by Centre for Science and Environment, New Delhi
- Manual on Rain Water Harvesting and Conservation by CPWD,

Government of India, New Delhi

- Making Water Everybody's Business: Practice & Policy of Water Harvesting edited by Anil Agarwal, Sumita Narain and Indira Khurana, Centre for Science and Environment, New Delhi, 2001
- Water Harvesting and Sustainable Supply in India by R.N. Athavale, Rawat Publications, Jaipur and Centre for Environment Education Ahmedabad, 2003.
- Rainwater Harvesting-New Approaches for Sustainable Water Resources Development by P.M. Natarajan and Shambu Kallollikar, Sarma's Pudukkota (Tamil Nadu, 2004)

So what is water harvesting :

The principle of collecting and using precipitation from a catchment surface. It is an old technology which is gaining popularity in a new way. Rainwater harvesting is enjoying a renaissance of sorts in the world, but it traces its history to biblical times. Extensive rainwater harvesting apparatus existed 4000 years ago in Palestine and Greece. In ancient Rome, residences were built with individual cisterns and paved courtyards to capture rainwater to augment water from city's aqueducts. As early as the third millennium BC, farming communities in Baluchistan and Kutch impounded rainwater and used it for irrigation dams.

Definitions :

"Water harvesting" is defined as the process of collecting and concentrating runoff water from a runoff area into a run-on area, where the collected water is either directly applied to the cropping area and stored in the soil profile for immediate use by the crop, i.e. runoff farming, or stored in an on-farm water reservoir for future productive uses, i.e. domestic use, livestock watering, aquaculture irrigation. The collected water can also be used for groundwater recharge and storage into the aquifer, i.e. recharge enhancement, FAO 2003.

"In scientific terms, water harvesting refers to collection and storage of rainwater and also other activities aimed at harvesting surface and groundwater, prevention of losses through evaporation and seepage and all other hydrological studies and engineering interventions, aimed at conservation and efficient utilization of the limited water endowment of physiographic units as watershed", CSE Manual on Water Harvesting.

Frazier and Myers Handbook of Water Harvesting (1983) has defined water harvesting as the process of collecting and storing water from an area that has been treated to increase precipitation runoff. A water harvesting system is the complete facility for collecting and storing precipitation runoff. It is composed of a catchment or water collecting area, a water storage structure, and various other components such as piping etc.

In general, water harvesting is the activity of direct collection of rainwater. The rainwater collected can be stored for direct use or can be recharged into the groundwater.

The term rainwater harvesting refers to direct collection of precipitation falling over the roof or onto the ground without passing through the stage of surface

runoff on land. Sometimes people commonly use the words "rainwater harvesting" to describe the entire gamut of water harvesting, which also includes rainwater harvesting. Rainwater harvesting is primarily of two types (i) roof water harvesting, or (ii) 'in situ' water harvesting.

Roof water harvesting has traditionally comprised of collection of precipitation falling on the roof or terrace of a building and storing it in a water proof sump at ground level for year round use.


'In situ' water harvesting is a type of rainwater harvesting in which the rainfall on a plot of land is harvested themselves by storing it in a pit or trench. In modern times the rainwater from roof top on plot of land may either be stored in a sump, pit, or trench, or discharged into the immediate local aquifer through an existing open well or tube well, or a recharge shaft or recharge well.

The preparation of the roof surface or the ground level land area within the plot involves using suitable material to coat the surface from which rainwater is to be collected (CAZRI Jodhpur and Bhoruka Charitable Trust Rajgarh, Churu have tested various materials like emulsions for preparing the surface), and taking steps to ensure that the water is directed towards the sump or the percolation pit/ recharge well.

For small individual factories or individual houses it is better to construct percolation pits. For a group of factories or a colony of houses recharge trenches may be suitable. For huge buildings or large industries recharge wells may prove better.

Groundwater status in Rajasthan (2001) :

Total water recharge	: 11159 M cum
Water used for irrigation	: 10454 M cum
Water used for industrial and residential use	: 1181 M cum
Total use	: 11635 M cum
Excess withdrawal	: (-)476 M cum

 The above table clearly implies that there is a constant depletion in groundwater table and thus indicates the need for water harvesting.

Why rainwater harvesting ?

Rainwater harvesting is essential because :-

- Surface water is inadequate to meet our demand and we have to depend on ground water.
- Due to rapid urbanization, infiltration of rainwater into the sub-soil has decreased drastically and recharging of ground water has diminished. Rainwater harvesting can help in local recharge of ground water and such water can also directly be used and stored.

Rainwater harvesting techniques :

There are two main techniques of rainwater harvesting.

- Storage of rainwater on surface for future use.
- Artificial recharge to ground water.

The storage of rainwater on surface is based upon traditional techniques using structures such as underground tanks, ponds, check dams, weirs etc.

The basic purpose of artificial recharge of ground water is to restore supplies from aquifers depleted due to excessive ground water development and usage. It is a relatively new concept of rainwater harvesting and the structures generally used are :-

Pits :- Recharge pits are constructed for recharging the shallow aquifer. These are constructed 1 to 2 m wide and to 3 m deep which are back filled with boulders, gravels, coarse sand.

Trenches:- These are constructed when the permeable strata is available at shallow depth. Trench may be 0.5 to 1 m wide, 1 to 1.5 m deep and 10 to 20 m long depending up availability of water. These are back filled with filter materials.

Dug wells:- Existing dug wells may be utilised as recharge structure and water should pass through filter media before putting into dug well.

Hand pumps:- The existing hand pumps may be used for recharging the shallow/deep aquifers, if the availability of water is limited. Water should pass through filter media before diverting it into hand pumps.

Recharge wells:- Recharge wells of 100 to 300 mm diameter are generally constructed for recharging the deeper aquifers and water is passed through filter media to avoid choking of recharge wells.

Recharge Shafts :- For recharging the shallow aquifer which are located below clayey surface, recharge shafts of 0.5 to 3 m diameter and 10 to 15 m deep are constructed and back filled with boulders, gravels & coarse sand.

Lateral shafts with bore wells :- For recharging the upper as well as deeper aquifers lateral shafts of 1.5 to 2 m wide & 10 to 30 m long depending upon availability of water with one or two bore wells are constructed. The lateral shafts is back filled with boulders, gravels & coarse sand.

Spreading techniques :- When permeable strata starts from top then this technique is used. Spread the water in streams/Nala by making check dams, nala bunds, cement plugs, gabion structures or a percolation pond may be constructed.

Collection techniques of rainwater :

- Rooftop collection of rainwater
- Road-top/pavement collection of rainwater
- Open area runoff collection
- Integrated roof top plus plot of land collection

Roof water harvesting and storage systems are the common feature of old buildings in North Gujarat, Saurashtra and Western Rajasthan.

Often an integrated approach is adopted for storing all the rainwater received by the building and the open ground of the plot of land in which the building stands. Some of the roof water is stored in a sump and the rest is discharged into the ground. The surface runoff from the open ground within the compound wall of a building is diverted towards discharge facility and is transferred underground. A sediment trap or filter bed or de-silting tank is used to remove suspended particles and organic debris before water enters the recharge well or percolation pit. Similarly, for a sump a small filter box is placed to clean the water entering the sump.

If roof water harvesting is used for spot recharge by large number of units located close to each other then it will help in restoring / raising the water table and also improving the water quality. It also reduces demand on the existing water supply which often today has started proving inadequate to meet the needs of industrial units.

Effects of industrialization on groundwater hydrology:

- Increase in water demand
- More dependence on ground water use
- Over exploitation of ground water
- Increase in runoff, decline in well yields and fall in water levels
- Reduction in open soil surface area
- Reduction in infiltration and deterioration in water quality

How much rainwater can be harvested ?

The total amount of water that is received in the form of rainfall over an area is called the rainwater endowment of the area. Out of this the amount that can be effectively harvested is called the rainwater harvesting potential.

Rainwater harvesting potential = Rainfall (mm) x collection efficiency
Roof top area 100 sq m of tiled roof

Collection efficiency depends on the product of two factors:

Runoff coefficient (refer Table 1)

Table 1. Runoff coefficients for various surfaces

Type of Catchments	Coefficient
Roof Catchment	
- Tiles/Cement concrete	0.8-0.9
- Corrugated metal sheet	0.7-0.9
Ground surface coverings	
- Concrete	0.6-0.8
- Brick pavement	0.5-0.6
Ground catchments	
- Unimproved land areas	0.1-0.3
- Parks	0.1-0.25

Coefficient for evaporation, spillage, first flush etc usually assumed as 0.85.
 Average annual rainfall at Jaipur: -523mm. (refer Table 2)
 Effective annual rainfall contributing to recharge for: $100 \times 523 \times 0.85 \times 0.85$, i.e.
 Water available for harvesting/recharge per annum: 37780 litre

A roof area of 100 sq.m. (roughly 1000 sq.ft) is sufficient to meet the daily water requirement of two families of five persons each for one whole year. As per IS 1172, the average daily water requirement per person is 10 litres.

Table 2. Average Normal Annual Rainfall in Rajasthan *

S.No.	Name of District	Average Normal
1	Ajmer	439.1
2	Alwar	534.7
3	Banswara	892.4
4	Baran	828.8
5	Barmer	235.1
6	Bharapur	598.9
7	Bhiliwara	649.0
8	Bikaner	233.8
9	Bundi	728.6
10	Chittorgarh	772.6
11	Churu	323.4
12	Dausa	584.1
13	Dholpur	649.7
14	Dungarpur	698.9
15	Hanumangarh	253.9
16	Jaipur	523.1

S.No.	Name of District	Average Normal
17	Jaisalmer	146.9
18	Jalore	406.7
19	Jhalawar	910.5
20	Jhunjhunu	399.0
21	Jodhpur	287.7
22	Karauli	635.9
23	Kota	732.3
24	Nagaur	354.8
25	Pali	453.4
26	Rajsamand	494.2
27	Sawai Madhopur	720.9
28	Sikar	427.0
29	Sirohi	859.1
30	Sri Ganganagar	185.9
31	Tonk	574.4
32	Udaipur	575.0

* Data from Irrigation Department

Benefits of rainwater harvesting:

- Saves water.
- Improves soil moisture.
- Improves the quality of water.
- Allows drought proofing.
- Prevents flooding of storm water drains.
- Saves energy required to lift water.
- Reduces flooding of roads.
- Reduces soil erosion.
- An ideal solution for water problem in areas having inadequate water resources.

What can entrepreneurs do ?

As availability of water for all users including industrial use is becoming more and more problematic from year to year and in many industrial areas, it is becoming difficult to provide required quantities of water, all entrepreneurs particularly within industrial estates need to undertake rainwater harvesting. Some of the water so harvested can be directly used by the unit undertaking rainwater harvesting. Such harvesting and injecting underground would result in water table rising at entrepreneurs unit, enabling easier access to such ground water.

If all the entrepreneurs in an industrial area take up rainwater harvesting then the overall water table would rise in the entire industrial estate.

Many industrialists as part of their social responsibility undertake developmental work in rural areas or near their industrial units. They could take up rainwater harvesting in public building like schools, colleges, hospitals, dispensaries etc. as part of their developmental works.

Rainwater harvesting techniques suitable for industrial complexes/industrial buildings/industrial sheds:

As mentioned above, option of recharge to ground water is the most suitable technique for industrial complexes/buildings. This includes settlement/filtration tank and a trench/shaft/perforated pipe depending upon the type of strata, availability of land and volume of runoff for delivering the water to the aquifer.

Recharge trench (refer FIG. 1):

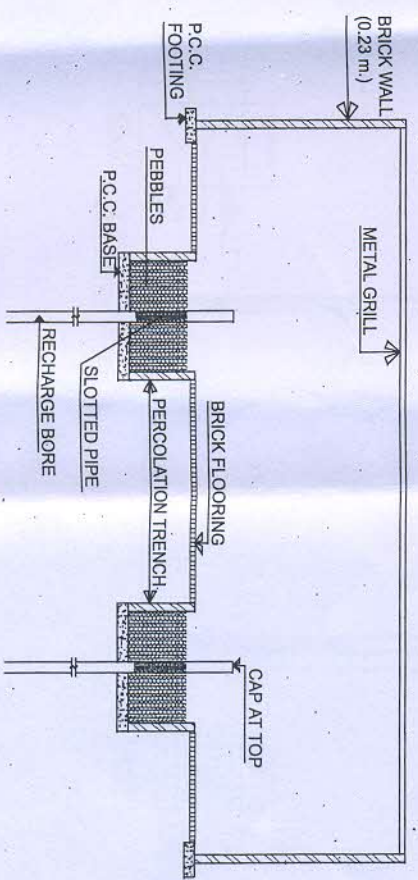


FIG. 1 : DETAIL OF RECHARGE TRENCH

- It is constructed when permeable strata of adequate thickness is available at shallow depth.
- It is a trench of shallow depth filled with pebbles and boulders.
- The trench may be 0.5 to 1 m wide, 1 to 1.5 m deep and 10 to 20 m long depending on the availability of land and runoff.
- Cleaning of trench should be done periodically.

Gravity head recharge well (refer FIG. 2) :

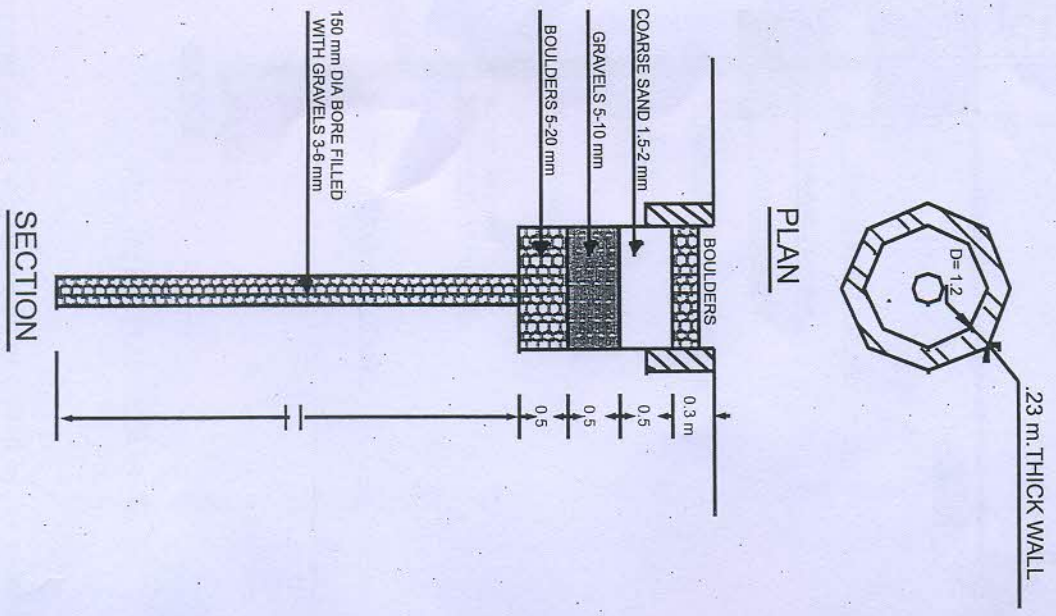


FIG. 2 : GRAVITY HEAD RECHARGE WELL

- Bore wells/ tube wells can be used as recharge structure
- This technique is suitable where:
 - * land availability is limited
 - * when aquifer is deep and overlaid by impermeable strata (clay)
- The rainwater is channelised to the well and recharges under gravity flow condition.
- Recharge should be silt free as far as possible. This can be achieved by passing the runoff through a series of settlement tank and filtering media as illustrated at FIG. 3 & FIG. 4.

Recharge Shaft (refer FIG. 3 & FIG. 4) :

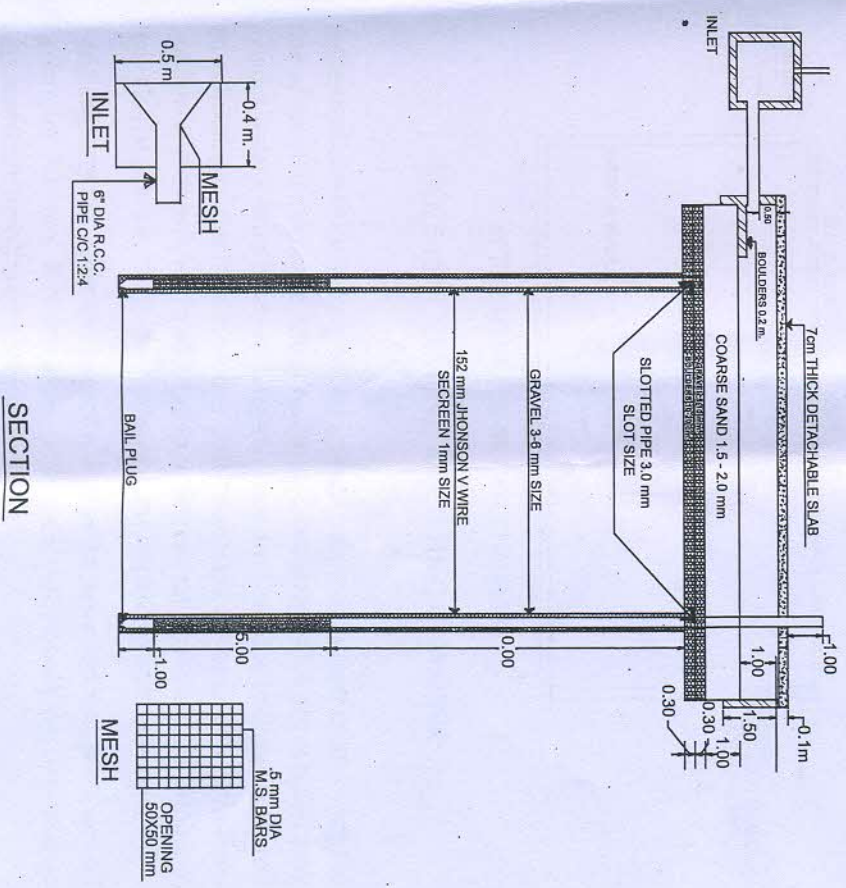


FIG. 3 : RECHARGE SHAFT

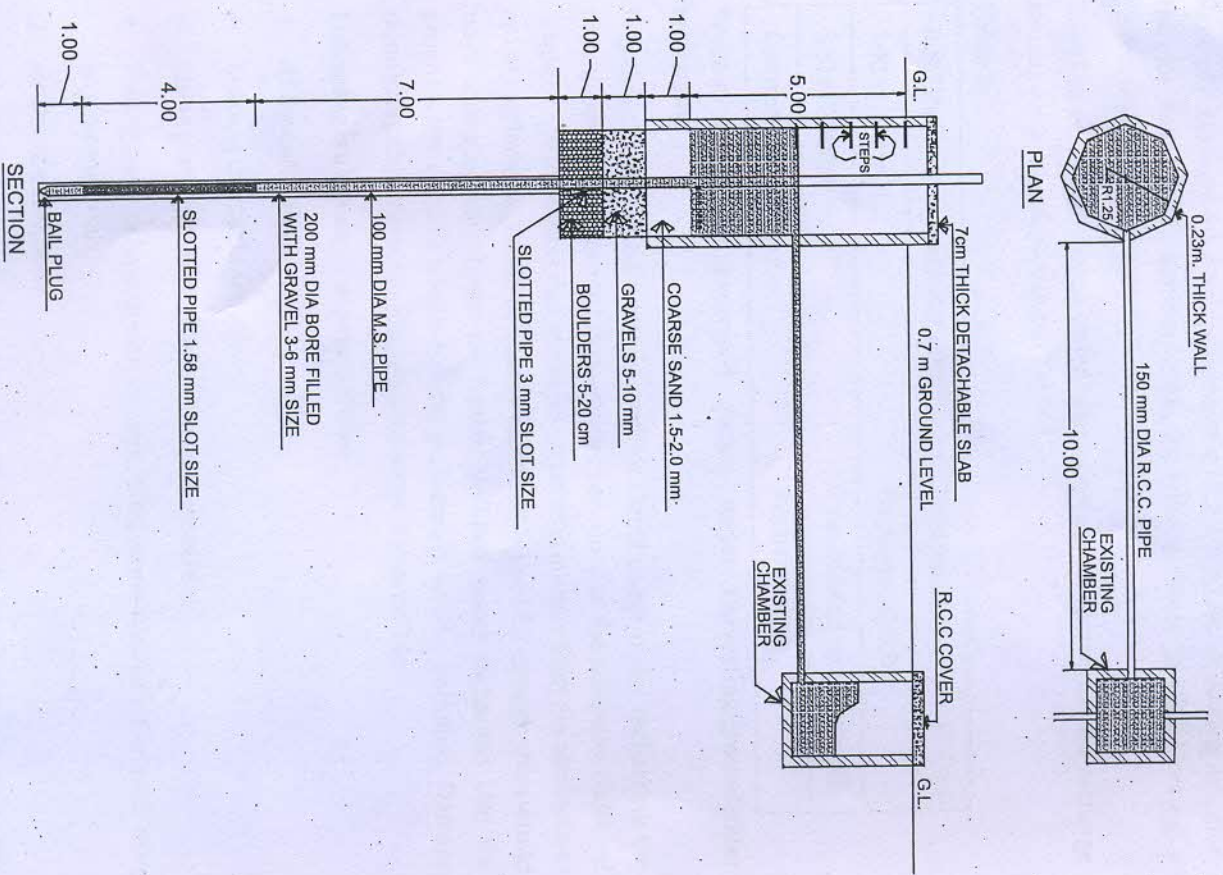


FIG. 4 : RECHARGE SHAFT

- A recharge shaft is dug manually or drilled by the reverse/direct rotary method (alternatively an abandoned dug well may be used for the same)

- diameter of recharge shaft varies from 0.5 m to 3 m depending upon water to be recharged.
- It is constructed where the shallow aquifer isolated below clayey surface.
- Recharge shaft is back filled with boulders, gravel and coarse sand.
- Depth of recharge shaft varies from 10-15 m below ground level.
- It should be constructed 10-15 m away from the main buildings for structural safety
- It should be cleaned annually preferable by scrapping the top layer of sand and refilling it accordingly.

Design parameters for settlement / de-silting tank (refer FIG. 5) :

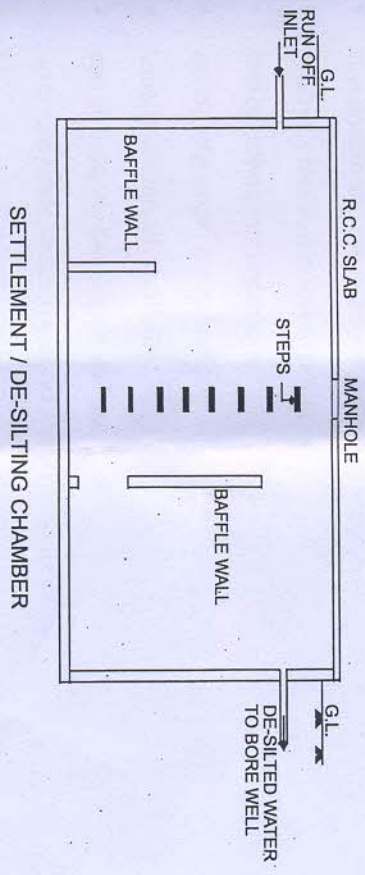


FIG. 5 : SETTLEMENT/ DE-SILTING CHAMBER

Settlement/de-silting tanks are used for dual purpose. In most cases, since the rate of runoff exceeds the rate of recharge, a settlement tank act as buffer tank to store water before it gets recharged. They are also used to remove silt and other floating matter from the water. Settlement tank has provision for in-flow, out-flow and over-flow. In addition to settlement tank a separate filtering unit may also be provided for further removing any impurities from the water.

For designing the optimum capacity, it may be assumed that peak rainfall occurs for 30 min. and therefore settlement tank should be designed to accommodate runoff during 30 min duration.

Assuming a peak rainfall of 12.5 mm in 30 min., the volume of tank (in litres) is calculated as follows:

Area of catchment (roof top/ pavement) x 12.5 x 0.85 for following equation thus for 400 sq m of catchment area , the volume comes to 4240 litres e.g. a tank of 6'x6'x5' (deep) with 20% overhead space.

Based on roof top and/or pavement area/ open area of compound, the recharge structure may be adopted as per Table 3.

Table 3:

Roof top and/or pavement area	Structure
100 to 300 sq.m.	Recharge trench
300 to 2000 sqm	Gravity head recharge well
Greater than 2000 sqm	Recharge shaft

Precautions to be exercised during water harvesting/groundwater recharging :

Whether the harvested water is used for direct usage or for recharging the groundwater, it is of utmost importance to ensure that the rainwater collected is free of any pollutants that might be added to rainwater from the atmosphere or the catchments. While polluted water directly used for consumption would have a immediate impact on health, polluted water recharged into the groundwater would cause long-term problems of aquifer pollution. Damage done to aquifers by recharging polluted water is irreversible.

Following is a summary of precautions :

1. At the catchment level

- Keeping the catchment clean
- Using gratings to trap debris at the catchment itself
- Paving the catchment with ceramic tiles, stone tiles or other such non-erosive materials.

2. At the conduit level

- Provision for first-flush to drain runoff from initial spell of rain in each year

3. For storage in sump

- Avoid penetration of sunlight into sump.
- Permit minimum exposure of water in sump to atmosphere.
- Provide filter at entry point.

4. Before recharging

- Allowing for sedimentation of the water
- Filtering the water

In establishment like industries, it is very necessary to ensure that the catchment surfaces are free of chemical wastes, fuels, lubricants etc. While physical and biological impurities in water can be easily removed by desedimentation and filtration, it is difficult to remove chemical impurities and therefore apart from using first flush, the surface contributing to runoff should be cleaned regularly.

Attributes of Groundwater :

- less expensive and economic resource.
- sustainable and reliable source of water supply.
- relatively less vulnerable to pollution
- free of pathogenic organisms.
- needs little treatment before use.
- usually universally available.
- can be instantly developed and used.
- no conveyance losses in ground water based supplies.
- low vulnerability to drought.

What is RIICO trying to do ?

RIICO has decided to propagate the benefits of rainwater harvesting and to provide knowledge about its techniques to industrial entrepreneurs. For that it is bringing out booklets and planning to organize orientation workshops regarding water harvesting where some industrialists who have already installed water harvesting systems are being encouraged to share their experiences.

For new industrial units constructed in RIICO industrial areas, rainwater harvesting has been made mandatory and this condition is specified in RIICO's allotment letter. A similar condition is proposed to be attached to RIICO loans for construction of industrial units.

All regional offices of RIICO have been directed to motivate all industrialists in RIICO industrial areas to undertake rainwater harvesting. RIICO has requested

