150 YEARS OF CELEBRATING THE MAHATMA

सत्यमेव जयते

स्वच्छ भारत
एक कदम स्वच्छता की ओर

Rain Water Harvesting & Conservation Manual 2019

CPWD

Director General, CPWD, New Delhi

CHAPTER 5

RECHARGE STRUCTURE AND ITS DESIGN

5.1 Recharge structures

The basic purpose of artificial recharge of Ground Water is to restore supplies from aquifers depleted due to excessive Ground Water development and usage.

Detailed knowledge of geological and hydrological features of the area is necessary for adequately selecting the site and type of recharge structures. In particular, the features parameters and data to be considered are: geological boundaries, hydrological boundaries, inflow and outflow of water, storage capacity, porosity, hydraulic conductivity, transmissivity, natural discharge of springs, water resources available for recharge, natural recharge, water balance, lithology, depth of aquifer, tectonic boundaries. "the aquifer best suited for artificial recharge are those aquifers which absorb large quantity of water and do not release the same to quickly.

Wherever CPWD has road infrastructure and drainage system with the buildings like a campus, feasibility of providing road runoff rain water harvesting will be worked out along with rooftop rain water system. The design of rain water harvesting system will be similar to other rain water system. The rain water from the drains will be diverted to a suitable place and discharged to ground aquifer after sedimentation, and filtration arrangement.

In case rooftop runoff is connected to road runoff, overall rain water harvesting system will be designed and constructed to draw maximum advantage of combined system and easy maintainability.

5.2 Factors affecting selection of recharge structure:

There are various factors which affect the choice of recharge structure. Some of them are:

I) Pattern of rainfall in the area

ii) Topography of the area and terrain profile

iii) Land use and vegetation

v) Type of soil and soil depth

v) Hydrological and hydrogeological conditions of the area

vi) Amount of surface runoff available for ground water recharge

vii) Environmental Impact Assessment (EIA) of the proposed groundwater recharge technique

viii) Socio-economic conditions of the habitants in the area

ix) Availability of infrastructure facilities

5.3 Artificial groundwater recharge techniques

Direct methods

i) Surface (spreading) techniques

   a) Flooding

   b) Ditch and furrows

   c) Recharge basins

   d) Stream modification/augementation

ii) Runoff conservation structures

   a) Contour bunds and contour trenches

   b) Gully plugs nallah bunds, check dams

   c) Percolation ponds

   d) Bench terracing

iii) Sub-surface techniques

   a) Recharge wells (or injection wells)

   b) Gravity head recharge wells

   c) Recharge pits and shafts

Indirect methods

I) Induced recharge from surface water

ii) Modification of aquifer

iii) Bore-blasting

iv) Hydro-fracturing

v) Combination methods

   a. Sub-surface dykes (Bandharas)

   b. Fracture sealing cementation technique (to arrest sub-surface flows)

5.4 The various type of recharge structures are:

i) Recharge Through Abandoned Dug Well

ii) Recharge Through Hand Pump

iii) Recharge pit

iv) Recharge Through Trench

v) Gravity Head Recharge Tube Well

vi) Recharge Shaft

5.5 Design Guidelines:

In general the recharge structures are designed with total volume as twice the peak discharge as detailed below:

5.5.1 Abandoned well *(Refer Drawing No. 9 & 10)*

i) A dry/unused dug well can be used as a recharge structure

ii) The recharge water is guided through a pipe to the bottom of well or below the water level to avoid scouring of bottom and entrapment of air bubbles in the aquifer.

iii) Before using the dug well as recharge structure, its bottom should be cleaned and all the fine deposits should be removed

iv) Recharge water should be silt free as far as possible.

v) It should be cleaned annually preferably.

vi) It is suitable for large building having the roof area more than 1000 Sqm

vii) The run off of first rain should not be allowed to percolate to the rainwater harvesting structure and allowed it to go to the drain by making suitable by-pass arrangement in water carrying pipe systems.

5.5.2 Recharge pit *(Refer Drawing No. 12)*

i) Recharge pits are constructed for recharging the shallow aquifer.

ii) These are constructed generally 1 to 2 m wide and 2 to 3 m deep

iii) After excavation, the pits are refilled with pebbles and boulders

iv) Water to be recharged should be silt free as far as possible.

v) Cleaning of the pit should be done annually preferably.

vi) It is suitable for small buildings having the roof top area upto 100 Sqm

vii) Recharge pit may be of any shape i.e. circular, square or rectangular.

viii) The run off of 1st rain should not be allowed to go percolate to the rain water harvesting structure and allowed it to go to the drain by making suitable by-pass arrangement in water carrying pipe systems.

ix) If the pit is of trapezoidal shape, the side slopes should be steep enough to avoid silt deposition.

5.5.3 Recharge trench *(Refer Drawing No. 13 & 14)*

i) It is constructed when permeable strata of adequate thickness are available at shallow depth.

ii) It is a trench of shallow depth filled with pebbles and boulders.

iii) These are constructed across the land slope.

iv) The trench may be 0.5 to 1 m wide 1 to 1.5 m deep and 10 to 20 m long depending upon the availability of land and roof top area.

v) It is suitable for the buildings having the roof area of 200 to 300 sq.m.

vi) Cleaning of trench should be done periodically.

5.5.4 Gravity head recharge well *(Refer Drawing No. 15 to 19)*

i) Bore wells/tube wells can be used as recharge structure.

ii) This technique is suitable where:

a. Land availability is limited

b. When aquifer is deep and over laid by impermeable strata (clay)

iii) The roof top Rain Water is channelized to the well and recharges under gravity flow condition.

iv) Recharge water should be silt free as far as possible.

v) The well can also be used for pumping.

vi) Most suitable for the areas where Ground Water levels are deep.

vii) The number of recharging structures can be determined in limited area around the buildings depending upon roof top area and aquifer characteristics.

viii) The run off of 1st rain should not be allowed to go percolate to the rain water harvesting structure and allowed it to go to the drain by making suitable by-pass arrangement in water carrying pipe systems.

5.5.5 Recharge shaft *(Refer Drawing No. 20 to 22)*

i) A recharge shaft is dug manually or drilled by the reverse/direct rotary method.

ii) Diameter of recharge shaft varies from 0.5 to 3 m depending upon the availability of water to be recharged.

iii) It is constructed where the shallow aquifer is located below clayey surface.

iv) Recharge shaft is back filled with boulders, gravels and coarse sand.

v) It should end in more permeable strata (sand).

vi) Depth of recharge shaft varies from 10 - 15 m below ground level.

vii) Recharge shaft should be constructed 10 to 15 m away from buildings for the safety of building.

viii) It should be cleaned annually preferably by scraping the top layer of sand and refilling it accordingly.

5.6 Maintenance of recharge structure

Roof Top Rain Water Harvesting for Ground Water recharge involves injection of rain water in to the aquifer through recharge trench cum tube wells under gravity flow. The surface water although treated through the filter bed may cause clogging after comparatively short periods of injection. In this case through the precaution is taken, there is a probability of silt being injected into the recharge wells and may cause clogging. Short periods of pumping quickly remove the clogging particles and improve the recharge capacity. Annual redevelopment of recharge wells by air compressor is recommended for improving the recharge capacity of trench cum recharge wells. Moreover silt deposited on sand bed also reduces the recharge rate. This also needs periodic removal of the finer material by scraping.

The type of Recharge structures to be considered for different areas (Alluvial areas or Hard Rock areas) in Delhi for various roofs are shown in Table No.5. The whole complex/colony can be suitably divided in various clusters and one of the above systems appropriate to roof size and underground characteristics may be selected for use/execution.

5.7 Modular Rain Water Harvesting System:

Modular Tank System is a subsurface water infiltration storage tank for storm water control and management system, and thus, it is also known as the Modular Rainwater Storage / Harvesting System, and Sub-soil Drainage. It is efficient, cost effective and ecologically sustainable. The main function of Modular Tank is to allow on-site natural water infiltration and this prevent surface run-off. This Underground Tank System is best applied for flat ground area for rainwater harvesting and storm water management.

This system can be constructed to hold any volume of water required. These systems are built out of modular plastic cubes. They are arranged to the appropriate size then wrapped in a liner and covered with soil and GI Sheets. This allows the storm water to be managed underground with zero-footprint that easily integrates into landscaping.

Modular cisterns are much more versatile than traditional rain tanks. This technology allows us to create load-bearing void space for underground water storage. Modules (boxes) are manufactured recycled plastics. These modules are 95 percent void space and are strong enough for vehicle traffic and parking.

Runoff water from open surface as well as from rooftops would be channelized to filtration unit. Filtration unit should consist of the following units in chronological order:

i) Sedimentation tank

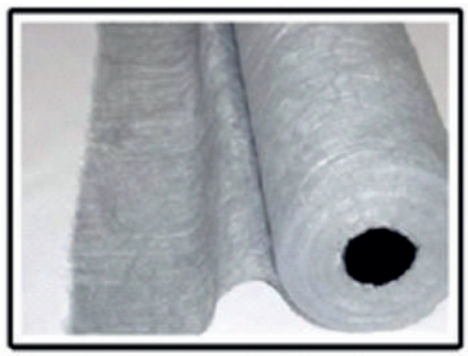
ii) Filtration through micro-filter of FRP tank or similar arrangement

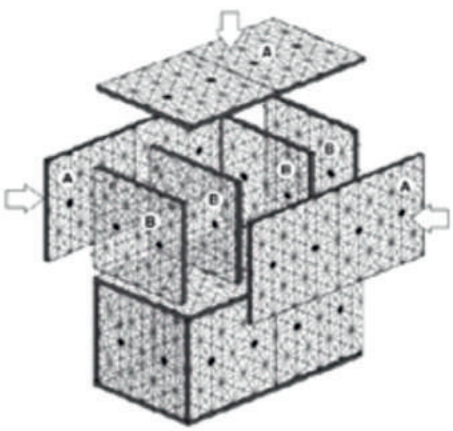
iii) Sand filter with geotextile layer at the top

Water then would be taken to the modular Modular Rainwater Storage or similar arrangement as per site feasibility.

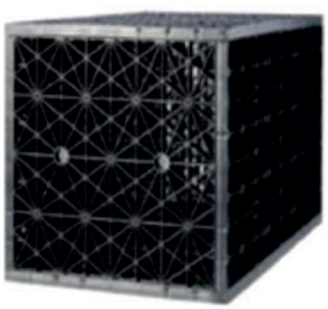
FRP (or similar materials) Tank with micro-filter (Geotextile)

Geotextile





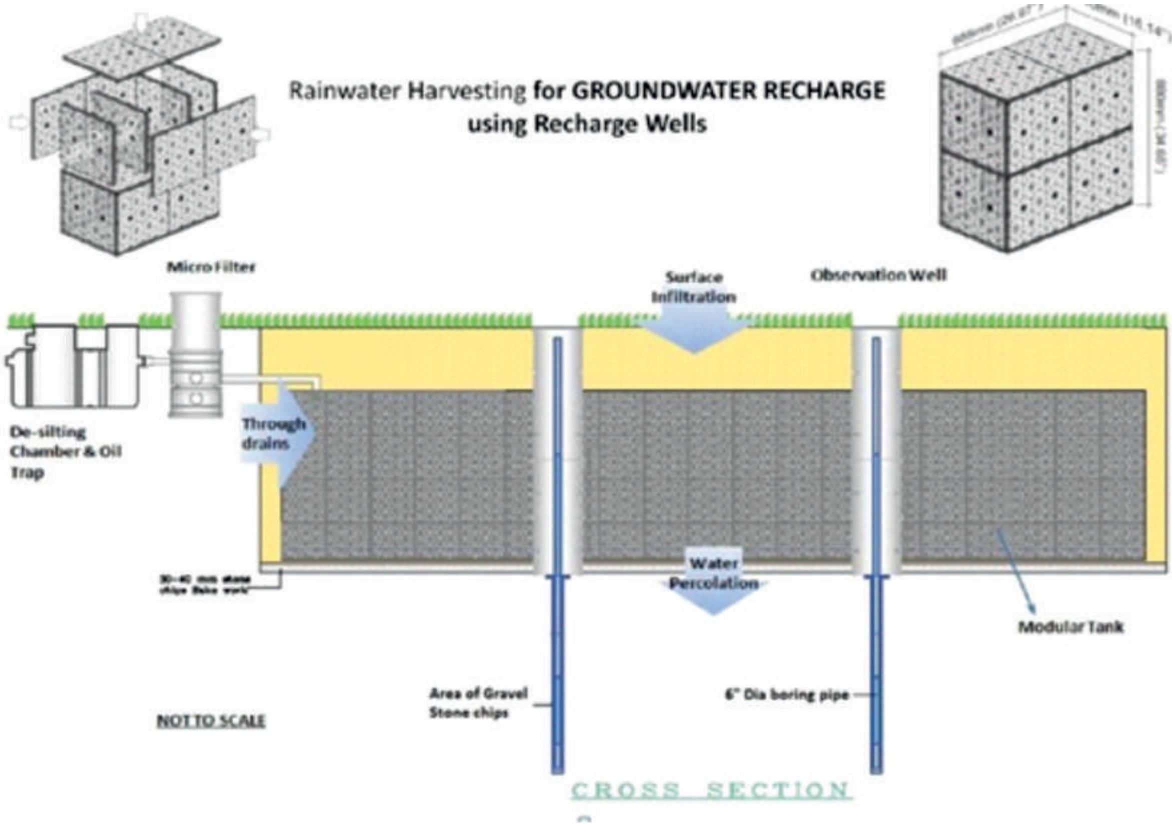
Waterproof Liner (for Storage and reuse only)



Matrix® tank module

Materials used In Modular Tank

Installation Process Overview



Flexible Applications of Modular Technology

Step – 1

De-silting Chamber/Oil Filter

- Designed for any flow situations
- Pre-manufactured, short time of installation
- Designed for **easy and low cost maintenance**

Step – 2

Patented Micro-Filter

Easy Maintenance

- Removes particles up **to 180microns** in size
- Suitable for flow situations of 72 cum/hr
- Pre-manufactured, short time of installation
- **Extremely easy to maintain – at little or no cost**

Dual step External Filtration For Easy and Inexpensive maintenance, Clog-free performance

Time for cleaning: 1 to 3 days by 2 or more workers
Maintenance Cost: INR 30,000 to 1,45,000 or more every year

Time for cleaning: 2-3 hours by 1 person
Maintenance Cost: INR 0 to 5,000 per year

Picture: Conventional maintenance vs Modular System maintenance
Clogging Issue Addressed- using Modular Technology

Comparison Modular RWH vs. Conventional RWH System from a case study during 2014

S. No.	Criteria	Modular RWH	Conventional (Concrete Tank)
1	Initial Cost of tank	INR 41,84,654	INR 64,80,000
2	Cost of filtration	External filtration unit:- INR 2,00,000	Cost of de-silting chamber:- INR 2,80,000
3	Total initial cost	INR **43,84,654**	INR **67,60,000**
4	Construction Time	12 days after recharge well	3 months
5	Maintenance cost	INR **7,000** per year	INR **1,50,000** per year
6	Maintenance Time	30 - 45 minutes	2-3 days
7	Size of tank	31.51m * 4.08m * 2.17m	30m * 4m * 6m
8	Top Surface	Infiltration from top surface	No infiltration from top

5.8 Shortcomings of Conventional Rain Water Harvesting System

i) Accumulation of poisonous gases

ii) Accident prone due to hollow structure

iii) De-silting chamber does not perform the function properly

iv) Cleaning the whole structure is tedious and expensive

v) Requires maintenance every year after three year of commissioning

vi) Alteration is very challenging

vii) Not possible to relocate

viii) Because of no movement water quality reduces

ix) Unskilled manpower is used and that reduces the quality of work

Advantages:

i) High compressive strength allows use under trafficable areas

ii) Interlocks vertically and horizontally for maximum stability

iii) Less costly than concrete and metal storage systems

iv) Time saving in installation

v) Low storage and transportation cost

vi) Caters for all volume requirements

vii) Easy assembly of panels and insallation of units

viii) Less maintenance cost than civil pit

ix) No surface water storage hazards

Challenges:

i) Requires specified excavation and burial preparation to ensure longevity of product

ii) Internal cleaning is not possible so the inlet filtration component of the rainwater collection system is extremely vital.