General Guidelines on Rainwater Harvesting & Artificial Recharge to Ground Water

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INTRODUCTION

Water is a prime life-sustaining natural resource that cannot be created like other commodities. We have about 18% of the total world population and a large number of livestock which require water for their survival while we have only 4% of potable water available. There are many water related problems like frequent floods, soil-salinization, acid rain, water quality, droughts, and sea-water intrusion in coastal aquifers due to over drafting etc. It is estimated that for sustaining the needs of an increasing population and environmental ecological needs of the country we are fast approaching the scarcity situation. We already have situation of relative scarcity if we take into account the affordability of real costs of supplies for purposes of irrigation and domestic use.

To overcome the water scarcity problem considering the serious limitations and the high cost involved in enhancing supply, the viable option is to give priority to conservation of water. India also has a deep historical roots and strong cultural traditions. These are reflected in our social fabric and institutions of community life. One of the important traditions is collecting, storing and preserving water for various uses.

The National Water Mission (NWM) of India focuses on "Conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management". The Goal 2 & Goal 3 under the NWM is 'promotion of citizen and state action for water conservation, augmentation and preservation' and Focused attention to vulnerable areas including over-exploited areas.

Rainwater Harvesting & Artificial Recharge to ground water can be an effective tool for Water conservation, preservation & augmentation.

CONSERVATION OF GROUND WATER

Almost all the natural resources whether replenishable or non – replenishable have to be conserved for sustainable development. Water is important replenishable natural resources. Man has to be careful in the use of water resources viz. "guarding against any willful waste and water conservation means the elimination of waste not the curtailment of use." In other words, the requirement of conservation of ground water is to use the

ground water efficiently and minimize the wastage of ground water so that the draft from the basin is equal to the recharge and no adverse effects like falling/ rising in ground water levels and deterioration in ground water quality is noticed.

RAINWATER HARVESTING

Rainwater Harvesting is the technique of collection and storage of rainwater at surface or in sub-surface water bearing zones before it is lost as run off. Rainwater harvesting in India and elsewhere in world is as old as civilization. This is still being practiced traditionally in some parts of the country, like Rajasthan and north east states. Similarly majority of domestic and drinking water supply in Mizoram is met through harvested rainwater. However use of harvested rain water for artificial ground water recharge is relatively new in India.

NEED FOR RAIN WATER HARVESTING

Ever increasing population of the country and consequent increased use of ground water to meet the domestic, irrigation and industrial requirements, ground water resources were put under tremendous stress. This has resulted in lowering of water levels in large parts of the country, necessitating augmentation of ground water through artificial recharge by means of rainwater harvesting.

MERITS OF RAINWATER HARVESTING

The following are the merits of rainwater harvesting:

a) Rainwater harvesting is an ideal solution to arrest the declining trend of water levels.
b) The surface runoff, which goes waste to storm drains, is utilized.
c) Rainwater is bacteriological free, purest form of water, free from organic matter and soft in nature.
d) It helps in reducing the flooding of roads and roundabouts.
e) The structures required for harvesting the rainwater are simple, economical and eco-friendly.

f) Rainwater can be harnessed at a time when it is surplus and utilized at the time of need.
g) Energy can be saved on account of rise in water level.

SOURCE OF WATER FOR RECHARGE

i. Rainwater

ii. Roof top

Most common source of water within the control of common house owner is roof top water. This rooftop rain water is directly collected in storage tanks and used by the households.

iii. Run off

Most of the rainwater goes as surface runoff into the streams and rivers and drains into the sea. Large proportion of rainwater goes unutilized into the rivers. This water can be tapped in the drain beds by constructing a series of recharge structures at the suitable locations.

In most of the urban areas, drinking water needs are largely met by ground water resources. Because of paved and constructed area, a large volume of runoff water is available. This water can be harvested and recharged to the ground water by constructing artificial recharge structures near the points of flooding and diverting the flood water into these structures.

STRUCTURES SUITABLE FOR RAIN WATER HARVESTING IN DIFFERENT TERRAINS

Primarily India can be divided into two major rock types on the basis of type of sediment deposited as follows:

Alluvial Area: It is suggested that the recharge schemes should only be taken up in those alluvial areas where depth to post monsoon water level is more than 10 meter below ground level (mbgl) with yearly decline of more than 20 cm. in pre monsoon period. In Alluvial Plain the aquifer parameters are primary in nature which are associated with the original depositional texture of the sediment and developed at the time of deposition of sediments.

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Hard Rock Terrain: The limit for depth to water level is reduced to 5 mbgl where recharge structures should be constructed because in hard rock areas the aquifer parameter (porosity, permeability) are secondary in nature.

Secondary parameters are those parameters that developed after deposition and burial of the sediment in the sedimentary basin. They may results from dissolving of grains, cracks & fractures in the rocks due to various natural processes like weathering, leaching etc.

The least permeable rocks are un-fractured intrusive igneous and metamorphic rocks, followed by un-fractured mudstone, sandstone, and limestone. The permeability of sandstone can vary widely depending on the degree of sorting and the amount of cement that is present. Fractured igneous and metamorphic rocks, and especially fractured volcanic rocks, can be highly permeable, as can limestone that has been dissolved along fractures and bedding planes to create openings in the rocks.

Table*:* Differentiation of Indian States in different Rock-Types:

Sl. No.	Name of States/UTs	Rock type in the area
1	Andaman and Nicobar Islands	Hard Rock, Alluvial Coastal area
2	Andhra Pradesh	Hard Rock
3	Arunachal Pradesh	Hard Rock, Alluvial Brahmaputra Valley
4	Assam	Alluvial Plain
5	Bihar	Alluvial Plain
6	Chandigarh	Alluvial Plain
7	Chhattisgarh	Hard Rock
8	Dadra and Nagar Haveli	Hard Rock
9	Daman and Diu	Hard Rock
10	Delhi	Alluvial Plain, Hard Rock
11	Goa	Hard Rock
12	Gujarat	Hard Rock, Alluvial Plain
13	Haryana	Alluvial Plain, Hard Rock
14	Himachal Pradesh	Hard Rock
15	Jammu and Kashmir	Hard Rock, Alluvial Plain
16	Jharkhand	Hard Rock
17	Karnataka	Hard Rock
18	Kerala	Alluvial Plain, Western Ghat Hard

		Rock
19	Lakshadweep	Hard Rock
20	Madhya Pradesh	Hard Rock, Alluvial Plain
21	Maharashtra	Hard Rock, Alluvial Plain
22	Manipur	Hard Rock
23	Meghalaya	Hard Rock
24	Mizoram	Hard Rock
25	Nagaland	Hard Rock
26	Odisha	Hard Rock , Alluvial Plain
27	Puducherry	Hard Rock
28	Punjab	Alluvial Plain
29	Rajasthan	Alluvial Plain, Hard Rock,
30	Sikkim	Hard Rock
31	Tamil Nadu	Hard Rock, Alluvial Plain (Valley Areas)
32	Tripura	Alluvial Plain, Hard Rock
33	Telangana	Hard Rock
34	Uttar Pradesh	Alluvial Plain, Hard Rock (Bundelkhand),
35	Uttarakhand	Hard Rock, Alluvial Plain (Tarai Area)
36	West Bengal	Alluvial Plain, Hard Rock (Darjeeling Area)

Rain water harvesting structures in rural areas

In rural areas due to large scale ground water development for irrigation the withdrawal of ground water has far exceeded the natural recharge. This has resulted in declining in water levels at fast rate. In some low lying areas the water remains stagnant for days together during rainy period. Sometimes due to flooding of areas the crops get damaged and farmers are not able to grow Rabi crops. This water can be recharged under gravity.

Following structures may be created for the artificial recharge & RWH in rural areas.

1. Recharge Pit
2. Recharge Trench
3. Recharge Well / Injection Well

4. Recharge Shaft
5. Ponds/ Reservoirs, Farm Ponds
6. Surface Storage
7. Recharge through Dug & defunct bore wells.

Roof Top Rain Water Harvesting in urban areas: Methods/ Techniques:

In Cities large scale ground water development is taking place and water demand is increasing every year due to increase in population and change in living style. In future there will be more stress on pumping of ground water due to expanding urbanization, industrialization, increased floating population and ultimately there will be tremendous pressure on exploitation of ground water.

Following Structures may be created for the artificial recharge & RWH for the recharge from the roof top & paved pavements in urban areas:

1. Recharge Pit
2. Recharge Trench
3. Recharge Well / Injection Well
4. Recharge Shaft
5. Ponds/ Reservoirs
6. Surface Storage

(The benefit of roof top rainwater harvesting can be assessed by the fact that from Roof Top of 100 sq. meter area with annual rainfall of 1000 mm, 80,000 liter rain water may be conserved / recharged every year)

Suggested Methods for Rain Water Harvesting In Industrial Areas

1. Recharge Pits
2. Recharge Trench
3. Surface Storage/Pond

(In any case, 'Recharge Well/ Injection Well' method should not be adopted in the industrial areas).

General Guidelines on Rainwater Harvesting & Artificial Recharge to Ground Water

CALCULATION OF AMOUNT OF RAIN WATER FROM ROOF TOPS FOR RECHARGING

The rain water available for groundwater recharging from the roof top catchment can be computed as follows:

A x R x C
A = Roof Top area
R= Quantum of Rainfall
C = Run-off Co-efficient

Catchment	Run-Off Co-efficient
Pucca Roof	0.80
Roof of Tin/ Asbestos shade	0.85
Surface pavement/ unpaved area	0.60-0.70

For Pucca Roof, following computation is made:

If Roof area is 100 sq. meter and rainfall is 1000 mm, the rain water harvesting potential & available rain water can be computed as follows:-

Total availability of Rain Water = A x R = 100 x 1000 /1000
= 100 cubic meter,
or 1 Lakh Liter

Expected Recharge Potential = A x R x C = 100 x 1000 x 0.80 1000
= 80 cubic meter, or 80,000 Liter

ARTIFICIAL RECHARGE STRUCTURES

The artificial recharge techniques can be broadly categorized as follows:

a. **Direct surface techniques**
   - Flooding
   - Basins or percolation tanks
   - Stream augmentation
   - Ditch and furrow system

- Over irrigation

b. Direct sub surface techniques
- Injection wells or recharge wells
- Recharge pits and shafts
- Dug well recharge
- Bore hole flooding
- Natural openings, cavity fillings

c. Combination surface – sub-surface techniques
- Basin or percolation tanks with pit shaft or wells

d. Indirect Techniques
- Induced recharge from surface water source
- Aquifer modification

Recharge Well

A recharge well is one, which admits water from the surface to aquifer The recharging well may be: (a) Abandoned open wells/tube wells (b) Specially designed wells having vertical or horizontal intake slotted pipes (c) Double purpose which can be used both for pumping and recharging.

Recharge Trench

The recharge trench is suitable for Ephemeral River, drains beds or around a building using harvested rainwater. Recharge trench can be of any dimensions, generally it is 2-3m deep, 3-4m wide and of any length. It can be straight, zigzag, L-shaped, U-shaped and is filled with filter media which can grade from gravel to boulder. The sides of the trench should slope at low angle for stability.

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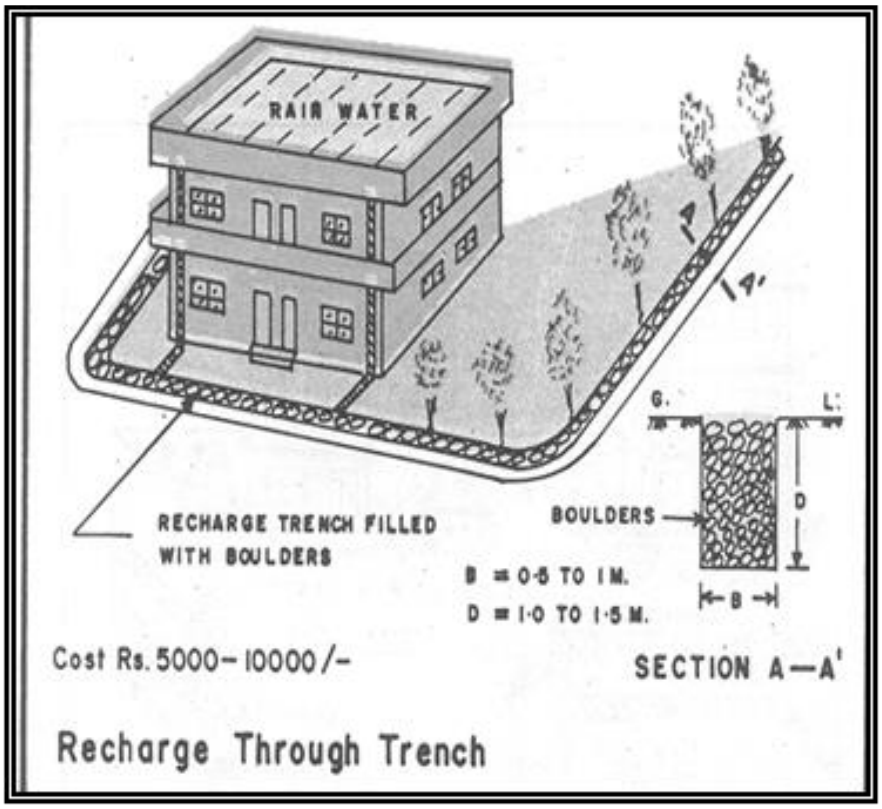


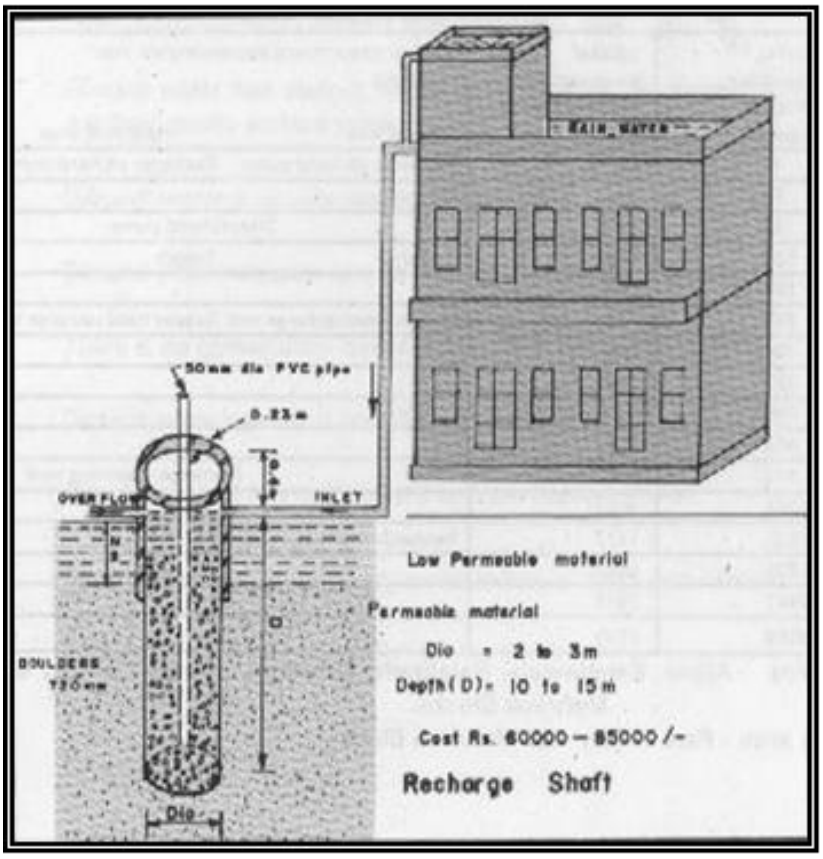
Important points for construction of Recharge Trench**:**

i) It is constructed when a permeable stratum of adequate thickness is available at shallow depth.
ii) Recharge trench should be filled with gravel, pebbles and boulder for filtration of water.
iii) These are constructed across the land slope.
iv) The trench may be 1.5 to 4m wide , 1 to 3m deep and 5 to 300m long depending upon the availability of land , roof area and length of river / drain bed.
v) It is suitable for the buildings having the roof area of 200 to 300 sq.m
vi) It is not constructed in the areas where water levels are very deep.
vii) Cleaning of trench should be done periodically.

Recharge shaft

This is like an open well but filled with filter media (graded boulder, coarse gravel, fine gravel). These are of 1m to 3m diameter circular, rectangular or square in shape and depth varies from 2m to 12m depending on the sub-surface lithology of the area and water level. These are filled with filter material to remove silt and other suspended particles.

General Guidelines on Rainwater Harvesting & Artificial Recharge to Ground Water



The following points are important while constructing recharge shaft:

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

ii) Diameter of recharge shaft generally varies from 1 to 3m depending upon the availability of water to be recharged.

iii) It is constructed where the aquifer to be recharged is located at shallow depth

iv) Recharge shaft is back filled with boulders, coarse gravel and fine gravel for filtration.

v) The recharge shaft should end in permeable strata (sand) to be recharged.

vi) Depth of recharge shaft varies from 2 to 12 m below ground level as construction of deeper shafts is difficult and is not economical.

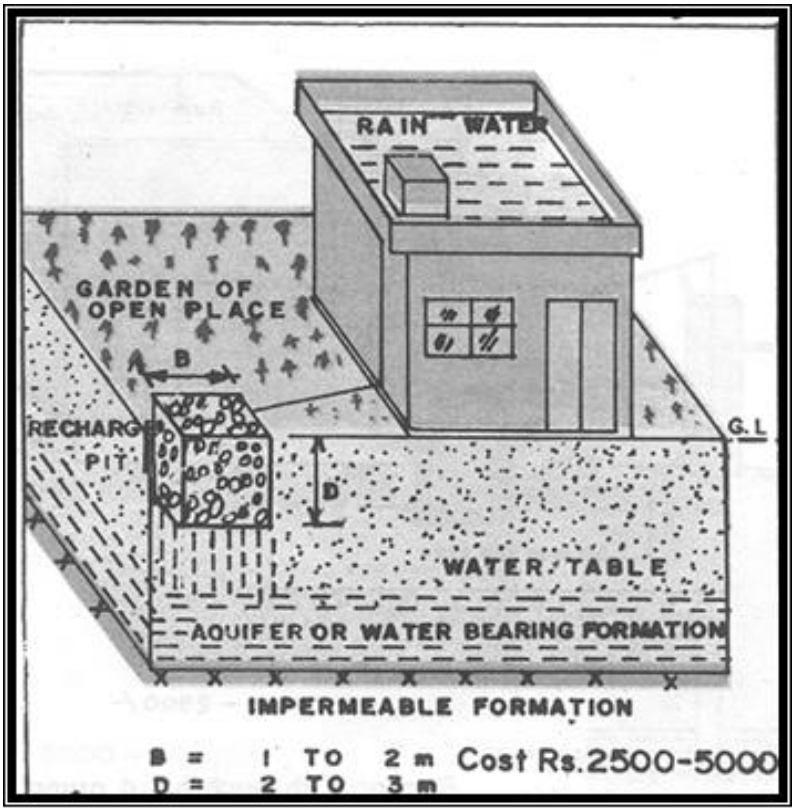
viii) Recharge shaft should be constructed 10 to 15m away from buildings for the safety of the building.

ix) The shaft should be cleaned periodically by scraping the top layer of fine sediments deposited.

General Guidelines on Rainwater Harvesting & Artificial Recharge to Ground Water

Recharge Pit:

Recharge pit is constructed in areas where sandy formations occur within 1-2 m from ground surface. It can be circular, square or rectangular in shape.



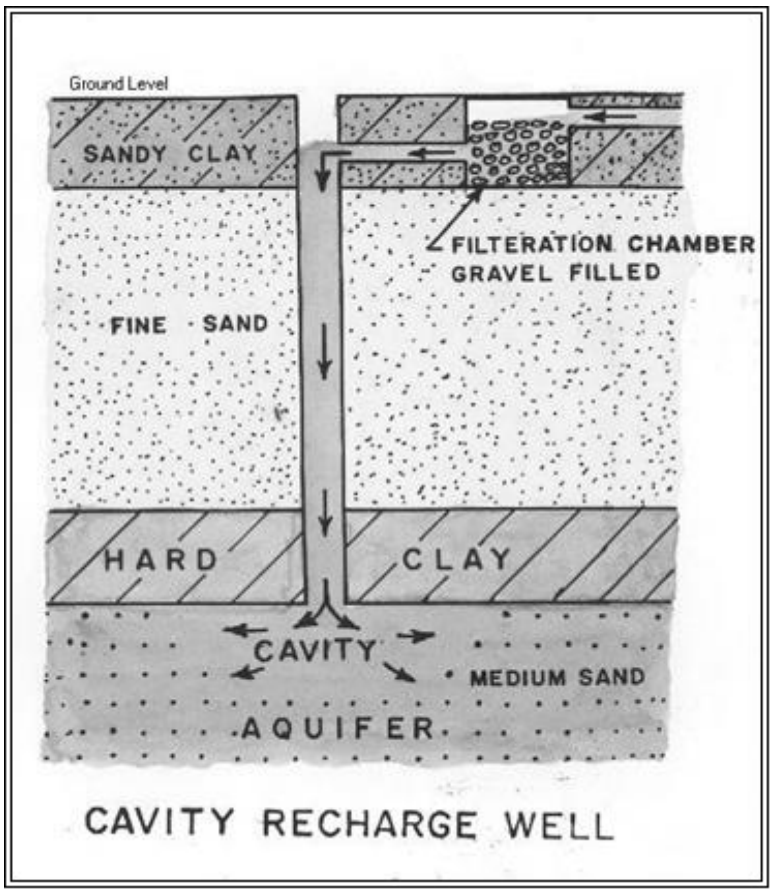
The following points are important while constructing Recharge Pit:

i) Recharge pits are suitable for recharging very shallow aquifer.
ii) These are constructed generally 1 to 2 m wide and 2 to 3m deep.
iii) After excavation, the pits are refilled with pebbles and boulders.
iv) Water to be recharged should be silt free.
v) Cleaning of the pit should be done periodically.
vi) It is suitable for small buildings having the roof top area upto 100 sq. meters.

Cavity Wells

Cavity wells are constructed by drilling boreholes with hand boring and pipes are derived up to the bottom of clay beds. Cavity is formed within

the underlying sand bed with the help of high capacity pump. Filter /screen is not used in these wells and the bottom of the pipe is not closed but kept open for entering water. The filtered water is recharged under gravity through these wells.



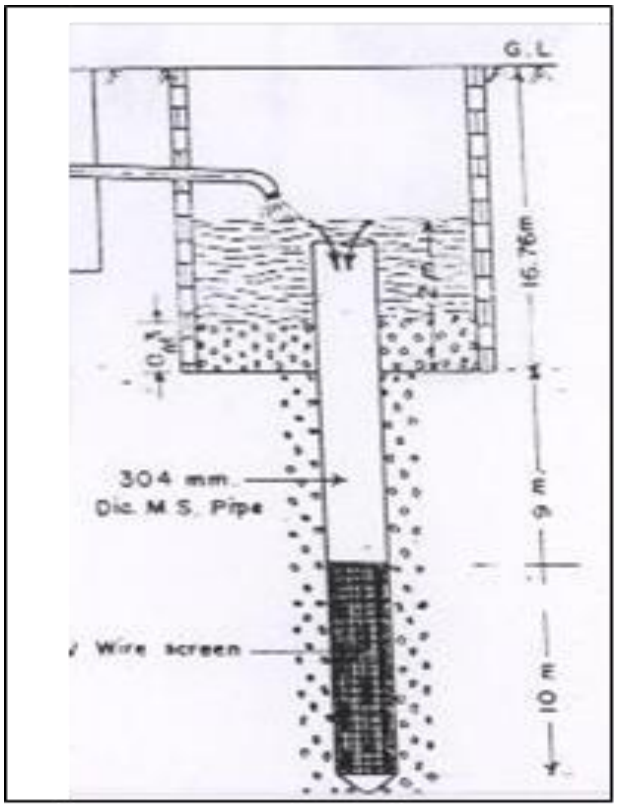
The following points are important while constructing:

i) The cavity well can be constructed in the area where overlying aquifer layer to be charged is hard and plastic in nature.
ii) The recharge capacity of cavity well is generally 5-10 liters per second.
iii) It is cheap structure as compared to recharge well.
iv) It can also be used as pumping well.
v) The water to be recharged should be silt free.
vi) The cavity should be developed periodically whenever it is found that its recharge capacity is reduced.

General Guidelines on Rainwater Harvesting & Artificial Recharge to Ground Water

Dug cum Bore Well

There are number of abandoned dug wells all over the country which have gone dry or covered with concrete slab for protection. These can be used as artificial recharge structures after modifying them by constructing a recharge well at the bottom. A filtration chamber may be constructed so that water can be made free from silt before water enters into the dug well.



Dug cum Recharge Well

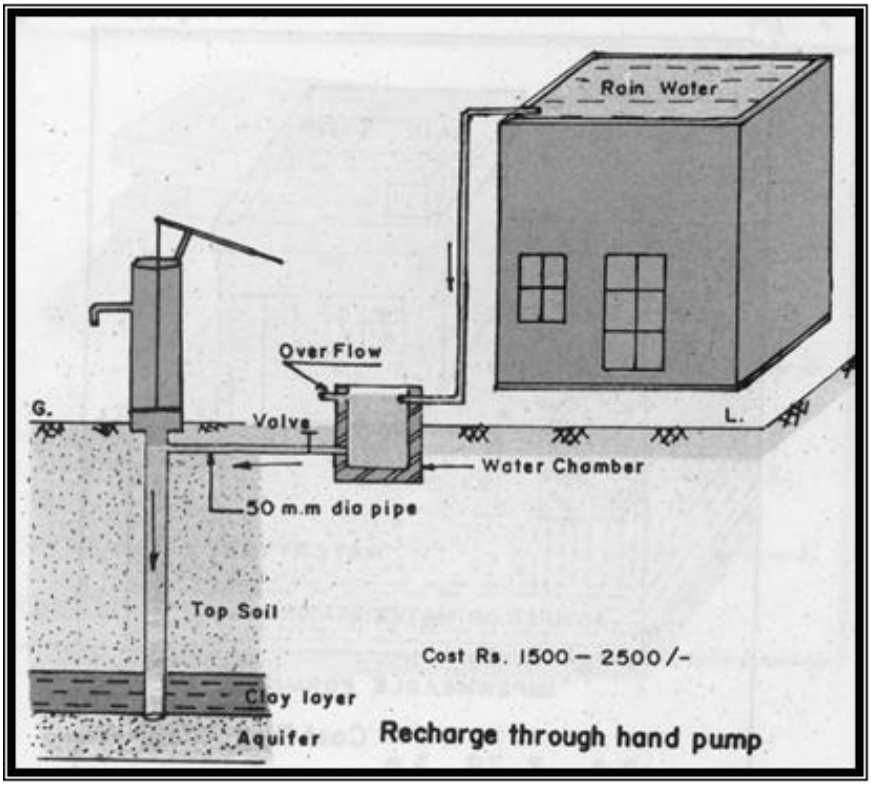
The following points are important for Dug cum Recharge Well:

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 to avoid scouring of bottom.
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.
v) The well should be cleaned regularly.
vi) In order to enhance the rate of recharge, a borehole is drilled at the bottom of the dug well and it is converted in to dug-cum bore well.

vii) It is suitable for large buildings preferably having the roof area more than 1000 sq. meters from where rainwater can be diverted and recharged.

Abandoned Dug Wells/ Tube wells/ Running Hand Pump

These ground water abstraction structures (abandoned) act as good recharge structures.



The following points are important for recharge through Abandoned Dug Wells/ Tube wells/ Running Hand Pump:

i) An abandoned hand pump can also be used for recharge.
ii) The hand pump is suitable for the small buildings having the roof area up to 150 Sq. meters.
iii) Water is diverted from roof top to the hand pump through pipe of 100mm dia.
iv) Recharge water should be silt free.

General Guidelines on Rainwater Harvesting & Artificial Recharge to Ground Water

IMPORTANT ASPECTS OF ARTIFICIAL RECHARGE

- Artificial Recharge should be taken up in only those areas where water level is more than 10 m below land surface.
- Long term post-monsoon trend should be declining
- The aquifer to be recharged should be moderately thick and extensive.
- It is essential to drill a 75mm (3") dia test borehole with hand boring to know the sub-surface lithology of the site for construction of recharge structures. The borehole should be drilled down to at least water level. This will give an idea of thickness of unsaturated zone to be recharged.
- In case of recharging of confined aquifer, the aquifers to be recharged should be identified on the basis of strata chart of nearest borehole drilled
- In some of the areas, the water levels in unconfined shallow aquifer are showing rising trend but in deeper confined aquifers these are receding at fast rate. These are falling at alarming rates. In such areas unconfined shallow aquifer should not be recharged. The recharge wells should be constructed tapping only deeper water bearing zones.
- The sand filter media should not be used at the top of trench as it does not allow water to pass through it because it contains more percentage of finer material, Hence fine gravel (Zeera Bajri) be filled at the top surface. In case of roof top rain water harvesting the size of gravel should be 2mm-4mm. If surface runoff is tapped, then it may be kept 1.5mm-3mm to remove the silt from the water to be recharged.
- The uncased recharge wells (i.e. borehole filled with gravel) are not very effective recharge structures as intake capacity is much less as compared to cased recharge wells. In case of uncased wells, the hydrostatic pressure is not built up.
- The recharge well will accept water if the water level in the well stands at least below 32 feet i.e. one atmospheric pressure
- The slotted pipes should not be wrapped with nylon net which is in practice in case of pumping wells. It reduces the effective open area, thus the intake capacity of the recharge well decreases considerably.
- The Galvanized 'V' wire screen is more effective as compared to conventional slotted pipes because 30% open area is available against 10% in M.S. slotted pipes.
- The boreholes for construction of deep recharge wells should be drilled with reverse circulation rotary method. However in case of shallow recharge well drilling can be carried out with mechanized hand boring.

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- Direct Rotary method should not be deployed for drilling as it chokes the formation with mud cake and thereby reduces the recharge capacity of the structure.
- The water should be made silt free before it enters into the recharge well. For this purpose water should be allowed to pass through the inverted filter media. The water loaded with silt, chokes the gravel shrouded around the well and enters the sandy formations, thus reducing the permeability of the formations.
- The slot openings of the slotted pipes or 'V' wire screen used for construction of recharging wells should be 1.5mm or 2mm as percentage of open area is more as compared to pipes having finer slot openings.
- The gravel used for filling the annular space around the well should be 3mm –6mm. The finer gravel reduces the intake capacity of the well and there are more chances of getting it choked with silt.
- The recharge wells should not be constructed closely spaced as cone of impression starts interfering with passage of time, Hence the recharge capacity of the wells reduces gradually. However in case of confined aquifers these can be constructed tapping different aquifers.
- In areas where thin water bearing zones occurs, alternating with thick clay beds the zones to be tapped should be deciphered with electric logging. In case screen is not properly placed against the aquifers, the intake capacity of the recharge well is likely to reduce considerably
- The trench can be brick lined or it can be R.C.C. The walls of brick lined trench sometimes collapse due to earth pressure. The life span of R.C.C. trench is more as compared to brick lined trench.
- The circular recharge structure can withstand more earth pressure. So, it should be preferred where ever possible. The trench can be brick lined or it can be R.C.C. The walls of brick lined trench sometimes collapse due to earth pressure. The life span of R.C.C. trench is more as compared to brick lined trench.
- The recharge well should be pumped now and then but preferably during the non-recharge times to maintain the efficiency of the well.
- In case recharge well is not pumped the clay particles choke the screen of the recharge well and surrounding formation material.

MAINTENANCE OF ARTIFICIAL RECHARGE STRUCTURES

Roof top rain water harvesting

The recharge structures tapping roof top rainwater does not require much maintenance as it is silt free. However it has been experienced from the studies that weed growth start spreading on the filter media and with passage of time resulting reduction in the intake capacity of the structure. In order to maintain the structures, periodic cleaning is required. In case it is not cleared from weeds the recharge structures will not remain effective and its recharge capacity will get reduced. This can result in making the structure redundant and all the funds and efforts made on the construction of the structure will go waste.

Surface Run off

It has been experienced that monsoon runoff during heavy rains carries lot of silt and clay in colloidal form which gets deposited on the filer media forming a thick layer obstructing the infiltration of water. This results in reduction in efficiency of the structure. The growths of weeds and wild grass also start growing on the silt layer with time, which further reduces the intake capacity of the structure. Due to above factors, the runoff cannot be fully utilized for recharge.

Drain Beds

The scheme in recharging ground water by drain beds will be effective only if the drains are periodically cleaned and are kept free from deposition of silt and weed growth. The trenches and shafts need periodic cleaning before the onset of monsoon, during the monsoon period and after the withdrawal of monsoon.

Run off from grassy land

The runoff generated from grassy lands does not carry much silt and the filter system of the recharge structure does not get choked too frequently. However, it has been experienced that runoff carrying dry grass gets deposited on the filter media but it does not reduce the infiltration rate. Nonetheless, it needs removal from the filter media now and then to maintain the structure.

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Paved / Unpaved area

The runoff generated from the paved area can also be used for recharging ground water by collecting that water in ponds or tanks & then by artificial recharge. The runoff generated from the paved area carries filth like tree foliage, used polythene bags, waste papers and other waste material while the runoff generated from the unpaved area carries lot of silt and other waste material, which chokes filter media thereby by reducing the infiltration rate. So, filter media needs to be cleaned periodically for efficient maintenance of the system.

Pond Water based schemes

Almost in all villages have ponds and they had been serving all these years a very useful purpose by way of washing of cattle, drinking water for cattle and other uses except human consumption. Monsoon runoff used to be collected in these ponds. These ponds can be rejuvenated and can be used for ground water recharge.

RECOMMENDATION FOR TYPE OF RWH FOR STATES

Template for the State wise data information for suggesting RWH, AR & Water Conservations Methods

Name of Region: Northern Region

Name of State: Uttar Pradesh

Number of Districts: 75

No. of overexploited Blocks: 91

General Geology of the Area:

The state consists of two geomorphic units (i) Ganga plains (ii) Bundelkhand plateau. The Ganga plain covers nearly 85% area and is underlain by a thick pile of unconsolidated alluvial sediments of Quaternary age overlying the Precambrian basement. These sediments consist of sands of different grades with clay, silt and occasional gravel and kankar. The southern part of the state comprises of hard rocks of

Bijawar and Vindhyan groups. The alluvium forms a very rich reservoir of ground water.

Agro-climatic zones:

Average Rain Fall: From an annual average of 170 cm in hilly areas to 84 cm in Western U.P.

Ground Water Level: 3.5 mbgl to 100 mbgl approx.

No. of Bore wells & Tube wells (if available):

Water conservation structures suitable for the area: Recharge Pit, Recharge Trench, Recharge Well / Injection Well, Recharge Shaft, Ponds/ Reservoirs, Surface Storage

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****The State wise information in the above format is likely to be received shortly from CGWB (under compilation) which will be incorporated in the above report ****