केंद्रीय भूमि जल बोर्ड
Central Ground Water Board

सत्यमेव जयते

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Government of India

राष्ट्रीय जल मिशन
National Water Mission

SIMPLE AND PRACTICAL METHODS OF ARTIFICIAL RECHARGE FOR GROUNDWATER AUGMENTATION

WHAT
WHY
HOW
WHERE

FARIDABAD
JANUARY 2025

Note to Readers

- *This document serves as a basic guideline for artificial groundwater recharge. It is specifically designed for individuals who may not be experts in groundwater science or artificial recharge techniques.*
- *While readers can refer to specific sections based on their needs, reading the entire document is recommended for a comprehensive understanding and effective planning.*
- *The information provided has been intentionally kept simple and concise to ensure accessibility for all users. However, its applicability may vary depending on local site conditions. Readers are encouraged to consult the referenced manuals and guidelines in this document for additional details.*

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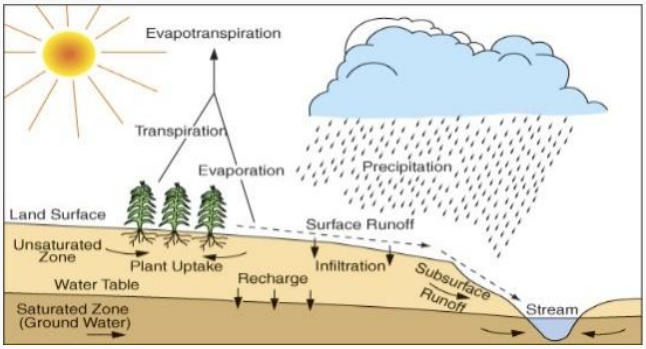
What is Artificial Recharge and why is it required?

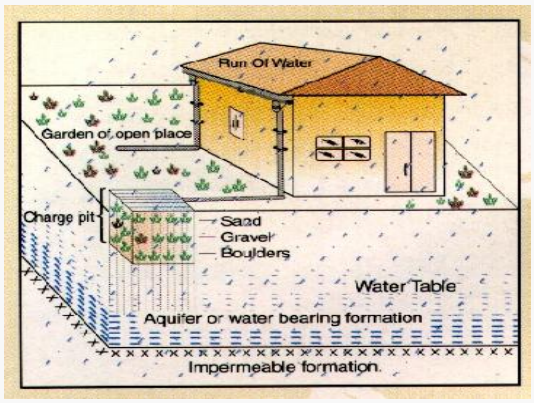
1. What is Artificial Recharge and why is it required?

Natural recharge is the process in which water from rainfall seeps downward from the ground and is stored in aquifers.

The amount of water that can be recharged naturally depends on the slope of the land, the duration of water retention, geographical location, availability of rechargeable area, etc. In many cases, adequate recharge does not occur due to unfavorable natural conditions. Human activities, urbanization and concretisation result in reduction in recharge-worthy area. Further, natural recharge may not be sufficient to compensate the increasing abstraction of groundwater.



Natural recharge



Artificial Recharge

It is possible to increase recharge by constructing suitable structures. This process of increasing recharge is called artificial recharge.

Artificial recharge has the following benefits/advantages:

- Arrest decline in ground water levels.
- Enhance availability of ground water.
- Sustain drinking water sources.
- Improve yields of irrigation wells
- Increase recharge in urban areas which has decreased drastically due to paving.
- Prevent urban flooding
- Improve ground water quality by dilution.
- Restrict sea-water ingress.

2. What are the various techniques or methods of Artificial Recharge?

Artificial recharge techniques can be broadly categorised into three categories surface, sub surface and combination techniques.

i. Surface Techniques:

This is done by restricting surface flow, impounding water on surface or by spreading (also called flooding). Major variants are PercolationTanks, Check Dams, Ditch and furrow system, Flooding and over Irrigation.

Surface Technique-Percolation Tank

ii. Sub Surface Techniques:

This is done by putting water directly to the aquifers and the variants include Recharge pits, Recharge shafts, recharge wells or Injection wells etc.

Sub-Surface Technique: Recharge Pit

iii. Combination of Surface–Sub-Surface Techniques:

The surface and sub-surface techniques described above can also be combined to get more out of the recharge interventions. One such example is a recharge well within a percolation tank.

Combination Technique: Percolation Tank with a recharge pit

3. Are there any detailed guidelines and manual available for artificial recharge?

Yes, CGWB has prepared “Guide on Artificial Recharge to Groundwater” and “Manual on Artificial Recharge to Groundwater” which has been placed in CGWB website. The link of the same is provided below:

https://cgwb.gov.in/cgwbpnm/public/uploads/documents/16799972423395910 60file.pdf
https://cgwb.gov.in/cgwbpnm/public/uploads/documents/16861384061006484074file.pdf

How to do Artificial Recharge in individual houses?

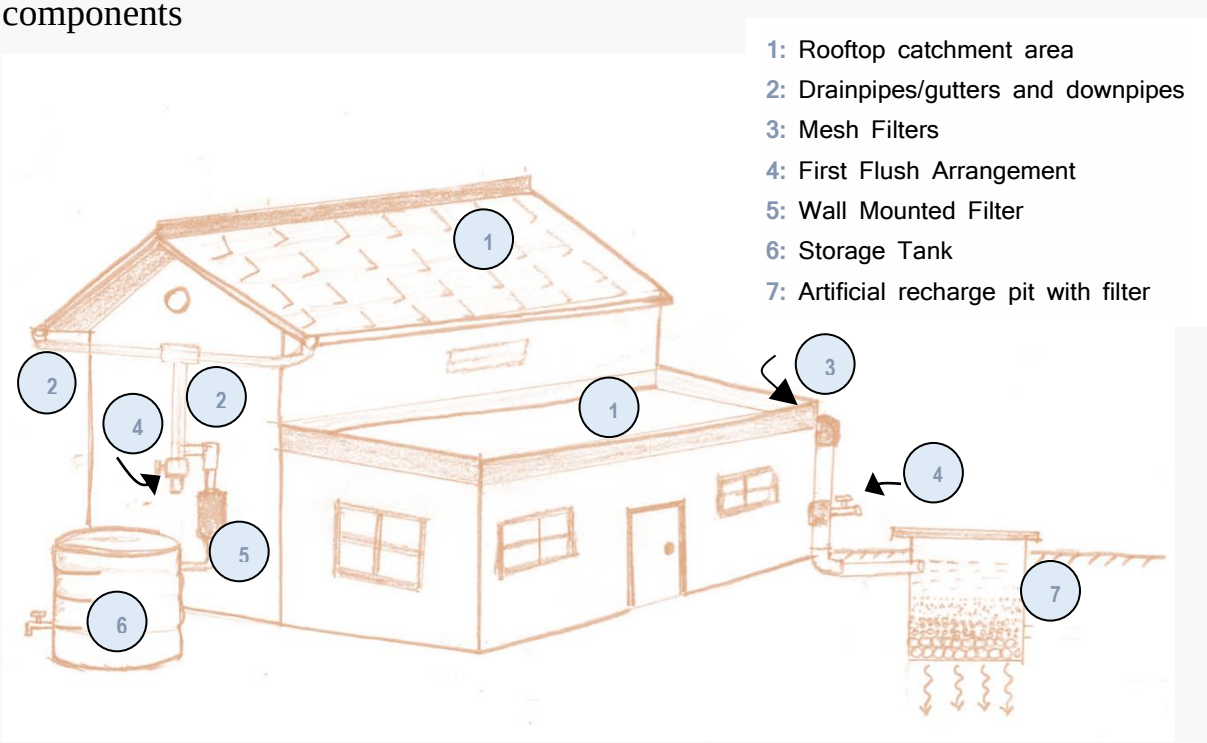
1. What are most suitable structures for individual houses?

Rooftop Rain water harvesting structures are the most suitable structures for the individual houses.

2. What is Rooftop rainwater harvesting?

Roof Top Rainwater Harvesting is a method of harvesting Rain water from roof areas and then directing it via gutters and pipes into storage tanks or recharging the aquifers.

Basically, a rooftop rainwater harvesting system consists of the following components



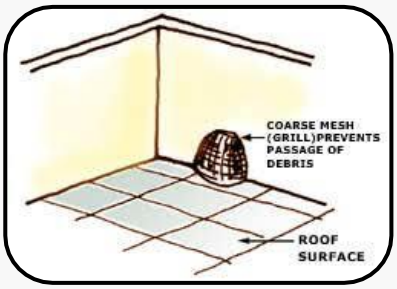
Rooftop rainwater harvesting system

3. Do I need a special type of roof for rainwater harvesting?

All roofs can be used for rainwater harvesting. However, less absorbent and slopy roofs are best for rainwater harvesting as they will generate more runoff. Tin sheds, RCC roofs etc. are best for harvesting. *As a roofing material asbestos is not suitable for Rooftop Rainwater Harvesting.*

4. Why do I need to install a wire mesh filter?

A mesh filter at the entry point of the drainpipe will prevent leaves and other large objects from entering the drainpipe. Avoid using very fine mesh filters as it may cause waterlogging on the roof.



Wire Mesh filter

5. What are arrangements for first flush?

Dust, dry leaves etc may get accumulated on the roof. Thus, the first spell of rain is likely to carry these dust and dry leaves through the pipes. To avoid this from entering the filtration unit, it is recommended to use a first flow diverter. This will facilitate discarding (flushing) the first rain laden with impurities. A simple valve will serve the purpose. By default, the valve should be kept closed and it should be opened after the first spell of rain washes the dust from the roof.

First flush setup

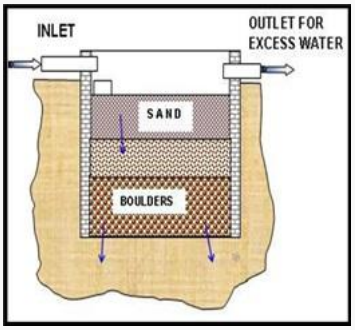
6. What is a Filter and What should be the design and dimensions of the filter?

A filter is a device or structure that removes impurities, debris, and contaminants from collected rainwater, ensuring clean water enters storage or recharge structures, thereby preventing blockages and maintaining water quality.

Filters are mainly of two types

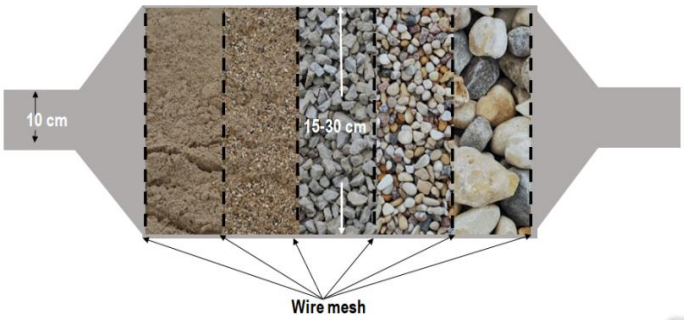
i) In situ Filter: An inverted filter, constructed on site is a pit dug and filled with three layers: Pebbles (at bottom), followed by Gravel (in middle) and then coarse/ fine sand (at top) Water enters from top of filter media and percolate down.

One can also install a screen to keep out pests and mosquitoes.



In situ Filter

ii) Wall Mounted filters: Filters can also be made with PVC pipes, where the filtration material like pebbles, gravel and sand are placed within the PVC pipe. Such filters can be placed horizontally as well as vertically. These can be of different types and of different capacity, depending on the roof area. Various types of filters are available in the market.



Wall Mounted filters

Accurate designs and assessment of accurate dimensions of the various components of the recharge system will depend on local rainfall intensity and local hydrogeological conditions. For the purpose of simplicity, following broad dimensions are recommended

Size of the filtration unit can be of around 2 cubic m (2 m (length) X 1 m (width) X 1 m (depth)). This size of a filtration unit is expected to be sufficient for a roof area of 100 sq.m (1000 sq. feet).

7. Can I recharge using a borewell?

Both functional and abandoned borewell/tubewell/dugwell can be utilised for artificial recharge to ground water. For recharging of wells which are in use, only rooftop rainwater should be used after filtration and overland flow should not be used for recharging these wells.

Abandoned wells can also be used for artificial recharge. However, while using abandoned wells for recharging the following points may be taken into consideration

- Wells that were initially productive, but have become **defunct due to decline in water level** are the most suitable for artificial recharge
- Wells that are **collapsed**, but are partially filled can also act as recharge structures
- Wells that are abandoned due to **poor ground water quality** should be avoided
- A well that **does not tap a potential aquifer** cannot act as a recharge structure
- Dug wells can be converted into recharge shafts by providing an inverted filter at the bottom to arrest silt and improve the recharge rate.
- Even for recharging the abandoned borewells, the source water should be clean and filtered before diverting to the borewell

8. Does this system require maintenance?

Yes, you should maintain the rooftop rainwater harvesting system by cleaning its filter media once or twice in a year. If you have inverted filter media in pit then remove top sand layer before every monsoon. Also, the roof area should also be kept clean.

You can also refer and follow the Standard Operating Procedure (SOP) developed by Government of Haryana on maintenance of Rooftop Rainwater Harvesting Structure.

(https://hwra.org.in/Content/Images/Guidelines%20for%20construction%20and%20maintenance%20of%20Rooftop%20Rainwater%20Harvesting%20Structure-English.pdf)

12. How much rainwater can I collect from my roof?

The volume of water that can be harvested depends on amount of rainfall and the catchment type. Entire rain falling on the roof cannot be harvested as some might get lost due to processes like evaporation. Typically, 80% of the water falling on a roof can be harvested.

Total water that can be harvested in a season or the entire year, can be estimated using the formula given below.

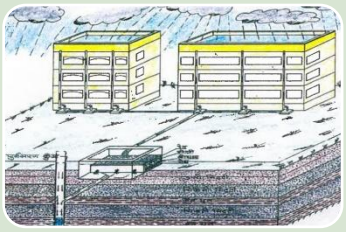
Water available from roof (liters) *= Rainfall (in mm) X Area of roof (in sq.m) X 0.8 (runoff coefficient)*

Rainfall measurements provided by India Meteorological Department (IMD) can be used (https://mausam.imd.gov.in/imd_latest/contents/rainfall_statistics_3.php)

Can artificial recharge be done in schools, offices, commercial and residential complexes?

1. What would be the most suitable structures for offices, schools, residential and commercial complexes?

The following three types of artificial recharge structures are most suitable for offices, schools, residential complexes and commercial establishments.



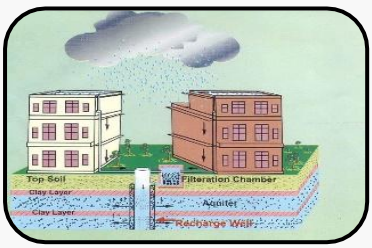
Artificial recharge by rooftop rain water harvesting

Artificial recharge by harvesting overland flow

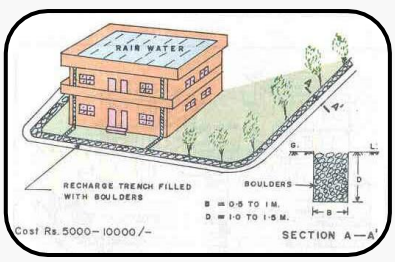
Harvesting of roof water in tanks

Artificial recharge through Roof top Rain water Harvesting

1. As per details given in the previous section.
2. The dimensions of the recharge structure will be defined according to the size of the roofs.
3. Water collected from multiple rooftops can be connected to a single recharge system.
4. As described in the previous section, mesh filters and inverted filters can be used.
5. Generally, recharge structures are of following types:



Recharge Borewell/Shaft

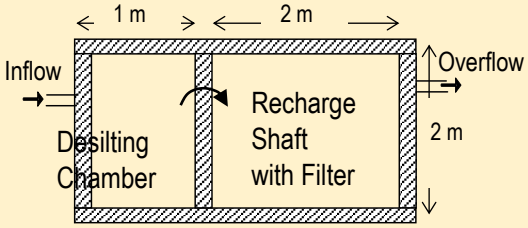


Rechage Trench

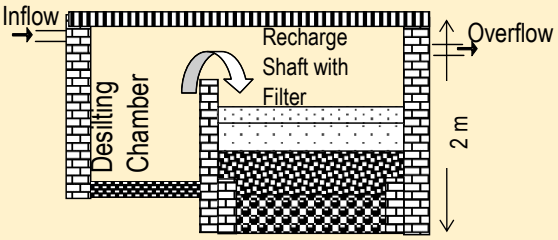
Trench with Borewell

Artificial Recharge by harvesting overland flow

- Water flowing over open areas including paved areas, lawns etc can be diverted through drains to the recharge structure
- A filter (as described in the previous section) must be used before putting the harvested water to the recharge structure.
- Water collected from the open area is likely to have large silt load so it is advisable to use a silt trap or a desilting chamber before water is allowed to enter the filter. An indicate design is given below



Desiltation Chamber and Recharge Shaft with Filter - Plan View



Desiltation Chamber and Recharge Shaft with Filter – Cross Section

- Recharge shafts, trenches, shallow recharge wells or their combinations can be constructed
- Since overland flow is likely to contain contaminants, it is advisable that the depth of the recharge structure should not go below local ground water level. For Example: if the ground water level is at 10 m below ground, the depth of the recharge structure (shaft or borewell) should be 3 to 5 m above the ground water level.

An Artificial Recharge System (Desilting Chamber, Filters and Recharge Borewell) in Faridabad

Roof top rainwater harvesting for building premises in hilly area

- Artificial Recharge may not feasible or an effective option in hilly areas where slope is high and where aquifers may not be able to retain recharge.
- In such areas, it may be more effective to filter and store the rainwater and use it for the purposes it is suitable for.
- Ready-made filters and Storage tanks available in the market can also be used.

Roof Top Rainwater Harvesting

2. Whether artificial recharge will have an adverse impact on the foundations of nearby structures?

Artificial Recharge to Groundwater is advisable in areas where the depth to groundwater level after the rainy season (post monsoon) is more than 3 m bgl. Otherwise, there will be a rise in the groundwater levels and may lead to water logged situation which is likely to damage foundations.

How to do artificial recharge at Village and Panchayat Level?

1. Which are the most suitable artificial recharge structures for my village?

Suitability of recharge structures depend mostly on the slope and geology of an area. Ideally, a watershed approach should be followed for a village or a group of villages.

Watershed

At different slope levels, the following recharge structures and their variants are recommended

- In high slope areas, embankments like gully plugs, gabion structures, rock fill dams etc. can be constructed with narrow drainage channels

- In areas with intermediate slopes, check dams etc. can be constructed with drainage
- Percolation tanks can also be constructed where water can be spread over a larger area.

- As mentioned in the previous section, recharge pits, recharge shafts etc. can be constructed in office/school premises and private houses.

- Towards the mouth of the watershed, sub-surface dams can be constructed to conserve baseflow.

Gully plugs: Built within eroded channels or gullies to slow down or stop water flow, prevent further erosion, and encourage water infiltration. Gully plugs can be made of locally available materials like rocks, sandbags or soil.

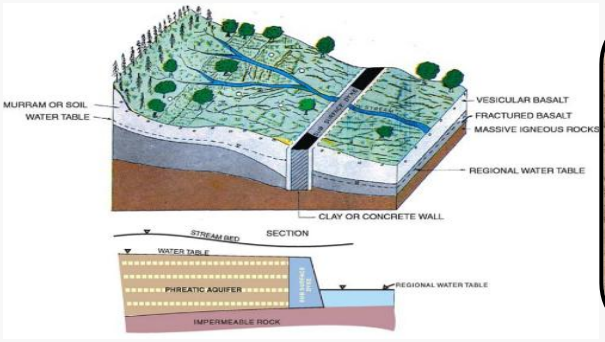
Gabion Structures: Boulders held together with steel wire are placed across small streams to serve as a bund.

Rockfill Dams (RFD)/Earthen Dams: Small barriers across small nalas using rock or earth materials.

Check Dams: Small, low-height masonry/concrete dams built across streams having gentle slope. Check dam with recharge shafts and wells can also be constructed with certain modification to recharge deeper aquifers where shallow formations are impermeable or clayey.

Percolation Tanks and Ponds: are designed for water conservation and groundwater recharge. They capture rainwater/run off/storm water, allowing it to percolate into the soil and recharge groundwater. Percolation tanks with recharge shafts and wells can also be constructed where shallow formations are impermeable or clayey.

Sub-Surface Dykes/Barriers (SSD/SSB): Similar to a bund constructed on surface to restrict surface flow, sub-surface dykes (or subsurface dams or sub-surface barriers) are constructed below the ground surface to restrict sub-surface flow or baseflow.



Sub-Surface Dyke Illustration

Sub-Surface Dyke

2. What are the combination Techniques and what are their advantages?

The combination techniques include employing both surface and sub surface methods of artificial recharge. For example, recharge shafts can be constructed within a check dam/percolation tank. Such combinations help in increasing rate of recharge and also in recharging deeper aquifers.

Percolation tank with Recharge shaft

3. How to convert a Village Tanks to a Recharge Structures

Existing village tanks, often silted and damaged, can be modified for groundwater recharge. By desilting and constructing recharge shafts within the tanks, these tanks can serve as effective recharge structures. It is to be kept in mind that the tanks should be kept clean to avoid contamination of groundwater.

4. What measures are essential for effective Operation and Maintenance (O & M) of Artificial Recharge structures?

Regular desilting, cleaning and repairs are required to prevent clogging and deterioration of the structures and to maintain recharge efficiency. Ensure that the source water is of adequate quality to prevent contamination of the aquifers. Recharge structures including ponds and tanks are to be kept clean, filters are to be cleaned periodically to prevent contamination of groundwater

5. Which areas are not suitable for Artificial Recharge?

Following areas may not be suitable for artificial recharge:

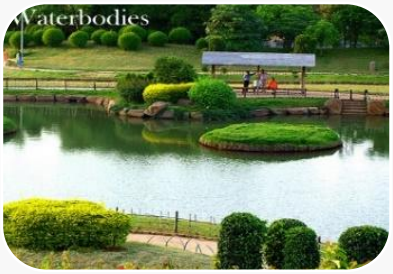
- Areas with depth to water levels less than 3 m (in post monsoon Period) below ground level should be avoided as it may cause water logging. However, harvested rainwater in these areas can be stored in storage tanks, if required.
- Artificial Recharge through techniques other than surface spreading should be avoided in regions with industrial, chemical, or hazardous waste as they may contaminate the aquifers.
- Artificial Recharge through techniques other than surface spreading should be avoided in regions covered with limestones. Because of the presence of solution cavities, contaminated water may get directly (without moving through the intervening soil layer) added to groundwater. This may result in contamination.

Which artificial recharge systems are suitable for Cities/Urban areas?

1. What types of artificial recharge systems are useful for cities/urban areas?

- **Pervious/perforated pavements** can be used in pathways, parking areas etc.
- **Rooftop Rainwater Harvesting in households** is the most effective way for water conservation/artificial recharge in the urban areas. Please refer details in the previous chapters
- Techniques recommended for **building premises of residential societies, schools** etc as described in the previous sections are also suitable for urban areas.
- Artificial Recharge in urban area can also help in mitigating **urban flooding**
- **Following variants** can also be considered.

• Pervious pavements can be used in open spaces or paths



• Construction of new ponds or restoration/rejuevnation of old ponds

• Construction of shallow recharge pits with filters in parks.

• Recharge borewells with filters within the shaft in parks.

• Small barriers to restrict water flow and recharge in parks.

• Flood water can be used for recharge

Simultaneous solution to waterlogging and decline in water level – Case Study from Faridabad

Following are the Findings of a DST sponsored research project for co-solving urban flooding and ground water decline implemented by Water Centre of Manav Rachna International Institute for Research and Studies

- Nearly 20 square kilometers along both sides of National Highway 19 in Faridabad City Area was found to be vulnerable to urban waterlogging.
- Four sites were selected for a pilot study within this area to construct and test the aquifer storage and recovery system.
- Local newspapers and resident welfare associations have reported that water logging is no longer persistent and their domestic reverse osmosis water filters are working more effectively due to the improvements in groundwater quality.
- Analysis of groundwater samples of nearby production wells found no presence of heavy metals or toxic constituents.

------Source: Mukherjee, A (2024), Down To Earth, October 2024 issue

What are the suitable methods for water conservation and artificial recharge in agricultural fields?

1. What are the most appropriate methods to recharge/conserve groundwater in farms/agricultural areas?

- Rainfed agricultural fields are one of the most effective sources of natural recharge.

- If it is not harmful to the crops, raising the heights of the levees by a few inches will allow impounding of more amount of water there by increasing the volume of water being recharged.

- Since water in agriculture fields may contain fertiliser and pesticide residues, artificial recharge techniques like recharge pits, recharge shafts or recharge borewells should not be used in agriculture fields.

Farm Pond

- Water Conservation structures like farm ponds are small water bodies built in or near agricultural fields to store rainwater for various uses like irrigation, aquaculture etc.

- Laser Levelling and Water efficient techniques like drip irrigation, sprinkler irrigation etc. should be used to reduce water use in irrigation.

Sprinkler Irrigation

Can Artificial Recharge be done in hilly areas?

1. What measures should be adopted for artificial recharge/rainwater harvesting in hilly areas?

Following are the most suitable interventions in high slope hilly regions

Bench Terrace is a structure built on sloped terrains. Benches are levelled "steps" or "benches" carved into the slope. This design effectively slows down water movement, increases water retention, conserves soil moisture and retards erosion.

Contour Trenches are shallow excavations dug along contour lines and raised embankments along contour of a slope respectively. They hold the run off for longer periods, retard erosion of slope, stabilize slopes, increase soil moisture and vegetation along the slopes.

Roof top rainwater harvesting and storge for direct uses are most suitable in hilly region. Rainwater can be collected from rooftops of buildings and channeled to storage tanks for domestic use.

Spring Management requires identifying the recharge areas of a spring, and constructing structures like gully plugs, contour trenches, recharge pits, etc to capture runoff and allow it to percolate into the ground, effectively replenishing the spring source.

What are some low-cost interventions for artificial recharge?

1. Can functional and defunct borewells/dug wells be used for groundwater recharge?

Functional and defunct wells can be effectively utilized for artificial recharge, without the need for additional investment in new structures.

While using operational wells for artificial recharge only rooftop rainwater should be used after filtration. Overland flow should not be put into wells that are currently in use.

Abandoned wells can also be used for artificial recharge. However, while using abandoned wells for recharging the following points may be taken into consideration

- Wells that were initially productive, but have become **defunct due to decline in water level** are the most suitable for artificial recharge
- Wells that are **collapsed**, but are partially filled can also act as recharge structures
- Wells that are abandoned due to **poor ground water quality** should be avoided
- A well that **does not tap a potential aquifer** cannot act as a recharge structure
- Dug wells can be converted into recharge structure by providing an inverted filter at the bottom.
- While using abandoned borewells for recharge source water should be clean and should be filtered before diverting to the borewell

Use of unused borewells for groundwater recharge

2. How to make low-cost filters for artificial recharge structures?

- Locally available sand and stone chips can be used to fill the filter pit.
- Drums/Barrels can be used instead of constructing masonry walls within the recharge pits.

Use of drums in recharge pits

What are the possible impacts of artificial recharge on groundwater quality?

1. Can artificial recharge cause groundwater contamination?

Yes, if proper precautions are not taken, artificial recharge can cause ground water contamination.

- **What measures should be considered to prevent contamination of groundwater during recharge?**
  - The poor-quality water as source water should not be used for artificial recharge.
  - Asbestos as a roofing material is not suitable for rooftop rain water harvesting.
  - In case of rooftop rainwater harvesting systems, run-off generated from the first spell of rain should be avoided as it is likely to contain impurities.
  - Filters should be used and it should be cleaned periodically.
  - Artificial recharge system should be cleaned regularly.
  - Since overland flow is likely to contain contaminants, it is advisable that the depth of the recharge structure should not go below local ground water level. For Example: if the ground water level is at 10 m below ground, the depth of the recharge structure (shaft or borewell) should be 3 to 5 m above the ground water level.
  - Except surface spreading technique, no other artificial recharge techniques should be used in areas with industrial, chemical or hazardous waste as they may contaminate the aquifers.
  - In areas underlain by limestones, artificial recharge should not be done through techniques other than surface spreading. Due to the presence of soluble cavities, contaminated water may seep directly into groundwater (without moving through the soil layer). This may result in contamination of groundwater.

- Since water from agricultural fields may contain fertilizer and pesticide residues, artificial recharge techniques such as recharge pits, recharge shafts or recharge borewells should not be used in agricultural fields.

2. Can kitchen/toilet wastewater be used for groundwater recharge?

No, because it will lead to groundwater contamination, pose risks to health and environment, reduce the inherent recharge capacity and pose challenges for regulatory measures.

3. Can artificial recharge help in improving groundwater quality?

Yes, artificial recharge can dilute concentrations of existing contaminants in the aquifer, leading to improved water quality.

4. Can treated water be used for artificial recharge?

Treated waste water can be used for artificial recharge provided, it meets the quality standards. In general, treated waste water is not recommended for recharge using methods other than surface spreading.

- South Western Region, CGWB.
- The study found that the treated water is most probably not contributing to any contamination of surface and ground water in HN Valley Project. However, in KC Valley Project are, treated water is the likely source of bacteriological contamination of surface water and ground water in the area.

What should be considered in the design and maintenance of recharge systems?

1. What points should be kept in mind during design and maintenance of recharge system?

Following points are required to be considered for designing, construction and maintenance of rainwater harvesting and artificial recharge structures:

- **Capacity Calculation:** Design the recharge pit or well based on roof catchment area, average rainfall. This ensures that the system can store the volume of water generated during peak rainfall. For details the users can refer to the manual on artificial recharge of ground water: https://cgwb.gov.in/cgwbpnm/public/uploads/documents/16799972423395910 60file.pdf

- **Depth and Diameter:** For recharge wells or shafts, the depth should be sufficient to reach permeable layers, while the diameter should be based on volume of water and site conditions.

- **Multiple Structures (if required):** In areas with heavy rainfall or large rooftops, consider constructing multiple recharge structures to distribute the water load and maximize efficiency.

- **Gutters and Pipes:** Use durable, corrosion-resistant materials (e.g., PVC or galvanized iron) for gutters and downpipes to channel water from the roof to the storage tank/harvesting pit.

- **Prevent Water Logging:** Artificial Recharge Structures are not recommended in areas where water levels are shallower than 3m (below ground level) in post-monsoon period. Rainwater storage structures can be constructed in these areas.

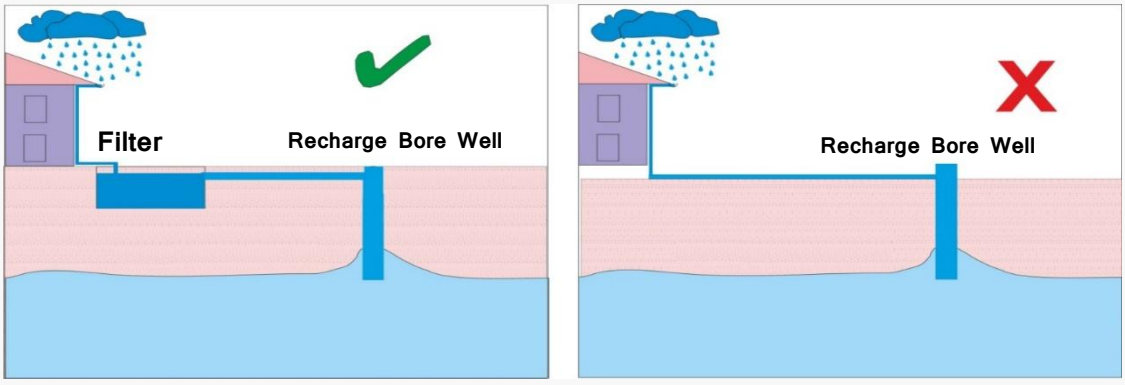
- **Roof Material:** Ensure the rooftop material is non-toxic and suitable for water collection. Avoid roofs with hazardous materials like asbestos.

- **Periodic Inspection:** Regularly inspect the entire system, including the rooftop, gutters, filters, and storage tank, for damage or clogging.

- **First Flush Device:** Install a first flush system to divert the initial rainwater from rooftops, which may contain impurities.

- **Mesh Filters:** Install mesh filters on the gutter ends to prevent debris like leaves, twigs, and dirt from entering the pipes.

- **Desilting and Filtration:** Install desilting and filter system to remove suspended solids and debris from rain water before entering the recharge structure. Use materials like sand, pebble, and gravel as filtration layers. Ready-made filters available in the market can also be used.

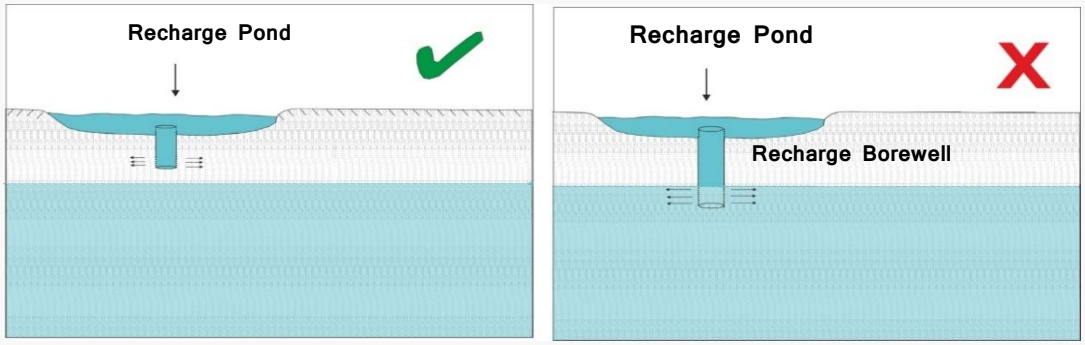


- **Avoiding Contamination:** Ensure the recharge pit or well is located away from septic tanks, soak pits, and contaminated areas. Ensure that contaminated water does not flow into the structure. Refer to the guidelines for prevention of contamination given in the previous section.

- **Cleaning:** Clean storage tanks and pipes annually before the monsoon season to ensure water quality is not compromised. Clean the roof (or the

lawn, paved area etc as the case may be) regularly to remove dust, leaves, and other contaminants that can affect water quality. Clean and replace filter materials periodically to prevent clogging and maintain percolation efficiency.

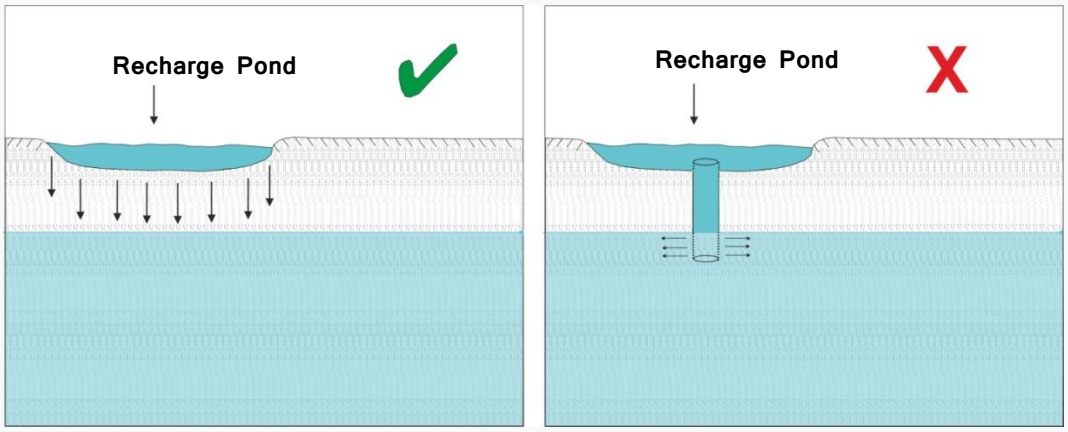
- **Depth of recharge structure when overland flow is used as recharge source:** Since overland flow is likely to contain contaminants, it is advisable that the depth of the recharge structure should not go below local ground water level. For Example: if the ground water level is at 10 m below ground, the depth of the recharge structure (shaft or borewell) should be 3 to 5 m above the ground water level.



- **Use of only surface flooding Technique in industrial areas, areas covered with limestone, and agricultural areas:**

  - Artificial Recharge through techniques other than surface spreading should be avoided in regions with industrial, chemical, or hazardous waste as they may contaminate the aquifers.
  - Artificial Recharge through other than surface spreading technique should be avoided in regions covered with limestones. Because of the presence of solution cavities, contaminated water may get directly (without moving through the intervening soil layer) added to groundwater. This may result in contamination.

- Since water in agriculture fields may contain fertiliser and pesticide residues, artificial recharge techniques like recharge pits, recharge shafts or recharge borewells should not be used in agriculture fields.



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