Technical Bulletin No. 91

# Technologies for Artificial Groundwater Recharge

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AICRP on Irrigation Water Management
ICAR - Indian Institute of Water Management
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भाकृअनुप

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Bhubaneswar – 751023, Odisha

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# Preface

Groundwater is one of the most valuable natural resource and contributes major share of freshwater in the earth. Its unique qualities like easily accessible, generally free from pathogens and suspended particles, requires no or little treatment has made it the most preferred source of water for domestic, industrial and irrigation uses. It is estimated that groundwater provides about 50% of the current global domestic water supply, 40% of the industrial supply, and 20% of water use in irrigated agriculture. However, overexploitation of groundwater resources has led to water shortages, increased pollution and degraded ecosystems worldwide. Hence the key concern is how to maintain a long term sustainable yield from underground aquifers in the face of impending climate change and socioeconomic factors.

In India, groundwater accounts for more than 60% of irrigation demands, 85% of rural drinking water demand and 50% of urban water demand. Excessive dependence on groundwater has caused overexploitation of groundwater resources in different parts of the country. It has led to alarming decline in groundwater levels in different states such as Punjab, Haryana, Rajasthan, Delhi, Western UP, Tamil Nadu, Gujarat etc. In recent studies, the analysis of GRACE satellite data revealed that the groundwater reserves in the states of Punjab, Haryana and Rajasthan are being depleted at a very alarming rate. The depletion of groundwater resources has increased the cost of pumping, caused seawater intrusion in coastal areas and has raised questions about sustainable groundwater supply as well as environmental sustainability. Therefore, there is a need to develop technologies on artificial groundwater recharge in which groundwater is augmented at a rate exceeding that under natural condition of replenishment.

The All India Coordinated Research Project on Irrigation Water Management has been working to address the research issues related to irrigation water management in 26 Centres distributed all over the country. In view of the declining groundwater level in different parts of the country, many Centres have developed technologies on artificial groundwater recharge suitable for their region. In this technical bulletin, an effort has been made to compile such technologies on artificial groundwater recharge. We hope that the bulletin will be useful for water resources researchers, planners and other stakeholders of the country.

Authors

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# Use of Abandoned Wells for Artificial Groundwater Recharge

(*Ludhiana centre*)

*R. Aggarwal, S. Satpute, C. Singla and S. Kaur*

## Relevance

In the state of Punjab, many open dugwells earlier used for irrigation have gone dry due to lowering of groundwater levels. Depth of these wells generally varies from 15-35 ft with diameter of 5-6 ft. There are about 3 lakhs such wells in Punjab and these wells can be good options for recharging groundwater. Therefore, efforts were made to develop a technology to artificially recharge groundwater using surplus canal water/ agricultural runoff through these abandoned wells.

## Description of technology

To utilize the abandoned wells, cleaning of the wells is essential. While cleaning the well, there is a chance of poisonous gases being emitted during the monsoon season. Hence, it is advised that cleaning should be completed before arrival of monsoon season. A blanket (3”-6”) of brick flakes is put at the bottom of the well to avoid direct impact of incoming water into the well and reduce the load on the bottom of the well.

A desilting pit is excavated near the well to settle most of the silt that is carried by rainfall runoff/surplus canal water (Fig. 1). Water overflown from the pit is diverted into the well. The desilting pit should have diameter of 1.0-3.0 m depending on the availability of open space with depth ranging from 0.75-1.25 m. To keep the sides of the pit stable, lining should be done with flexi sheets (Fig. 1). Brick flakes are placed at the bottom of the pit to avoid direct impact of the runoff entering the pit. The abandoned well used for recharge should be covered with perforated slab or wire mesh to avoid accidents (Fig. 2). During rainy season, when farmer receives canal water supply but irrigation is not required, surplus canal water can

**Fig. 1. Construction and lining of desilting pit**

be diverted to an abandoned well for recharging the aquifer.

The quality of water to be recharged through the abandoned well is a major concern. So, before allowing agricultural runoff or surplus canal water into the well, all water quality parameters should be carefully examined. Use of abandoned well for recharge should be done only if the water level is over 100 ft deep. Regular cleaning of the desiltation pit during pre-monsoon season is essential. Annual cleaning of the bottom of an abandoned well will increase performance and life of the well.

## Performance evaluation

A maximum recharge rate of 60 L/min can be achieved with the abandoned dugwell recharge structure. The technology showed an average recharge rate of 10 L/min. The structure helped in reducing water stagnation in the surrounding fields. During off-season, surplus canal water was used for groundwater recharge. The structure also helped to improve groundwater quality by allowing recharge of good quality water.

## Extension and adoption

Many farmers in the State of Punjab are facing ponding problem during monsoon season. So, they are using this technology to divert stagnated/surplus water from paddy fields to an abandoned well where water table depth is over 100 ft. Farmers are adopting the technology in consultation with the scientists of AICRP-IWM Ludhiana centre. This technology has been included in the State Irrigation Plan of Punjab.

**Fig. 2. Covering of abandoned well and entry of water into the well for recharge**

# Rooftop Water Harvesting for Groundwater Recharge

(*Ludhiana centre*)

*R. Aggarwal, S. Satpute, S. Kaur and C. Singla*

## Relevance

Due to overexploitation, groundwater level is fast declining in different states of India like Punjab, Haryana, Rajasthan, Tamil Nadu and western Uttar Pradesh. Groundwater depletion is more in urban areas due to higher population concentration and domestic consumption by groundwater withdrawal. Therefore, there is an urgent need to recharge groundwater aquifers in urban areas using rainwater from rooftops. There are about 1.4 million residential houses in urban areas and 2.6 million houses in rural areas of Punjab. Assuming average covered area of each house to be 100 $m^2$, about 140 million $m^3$ of rainwater can be harvested for groundwater recharge every year based on the average rainfall in each district.

## Description of technology

In rooftop rainwater harvesting, the roof of a building acts as the catchment and runoff generated over the roof due to occurrence of rainfall is stored in a tank for recharging groundwater. The schematic diagram of the recharge system depicting all the components is shown in Fig. 1.

Roof of the building should be cleaned of trash/debris. There should not be any chemicals and paints on the roof. The roof should have slope towards the outlet pipe. The collection pipes made of PVC material are used to take the roof water towards the ground surface. Dimension of the structure will vary depending upon the roof area. The pit should be lined with bricks and cement. Side wall of the pit should be strong enough to take the pressure of water collected in the pit and soil along the brick work. Thickness of the bricks should be 9” on all sides. The brick masonry lined pit is further divided into three units: siltation unit, filtration unit and outlet chamber. The siltation unit is useful for collecting water from the roof through outlet pipes. Silt coming along with the water settles in siltation unit and relatively clear water flows towards

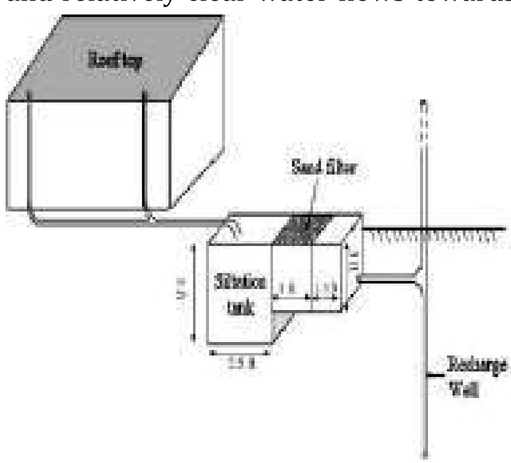



**Fig. 1. Schematic diagram of rooftop rainwater harvesting system**

the unit of the structure. Fig. 2 shows the view of the rooftop water harvesting structure for groundwater recharge.

The second unit i.e. the filtration unit consists of pea gravel (2-4 mm in size) placed between MS wire mesh frames. The wire mesh frame is covered with nylon filter mesh to keep the pea gravel confined within the two frames. Thickness of the filtration unit is 1.0 ft. Depth of filtration unit from the ground surface is 3.0 ft. The filtration unit helps to filter the water coming through siltation unit. The filtered water then flows to the outlet chamber. Depth of outlet chamber is same as the depth of filtration unit. At the base of the outlet chamber, a PVC outlet is provided, that is connected to the recharge well so that the filtered water is diverted to recharge groundwater. A recharge well of 10-15 cm diameter is drilled upto the dry aquifer. Depth of the recharge well depends on the groundwater level of the area. The recharge well should not meet the actual groundwater table. It should be upto dry sand level so that natural filtration also takes place beneath the ground surface before water fills up the aquifer.

**Evaluation and adoption**

More than 200 rooftop rainwater harvesting structures have been constructed at different locations in the State of Punjab in consultation with the University. Many urban colonies are consulting scientists of AICRP on IWM for guidance and installation of the same. The decline of groundwater level has been considerably checked due to the rooftop rainwater harvesting structures. The technology is working very well in the urban localities where ponding of water is the main concern. The technology can be used at all places and slowly it is becoming mandatory in all residential buildings in most of the states.

**Fig. 2. Rooftop water harvesting unit for groundwater recharge**

# Horizontal Flow Sediment Filter for Aquifer Recharge through Open Wells and Borewells

(*Coimbatore centre*)

*V. Ravikumar, S. Selvakumar and S. Pazhanivelan*

## Relevance

Artificial recharge through open wells and borewells is a viable option which is promoted by both central and state governments. Clogging of wells remains a major operational issue in well recharging because of the sediments from the recharging water. Clogging can limit the quantity of water that can be stored within the aquifer and may necessitate regular well redevelopment or even lead to site abandonment in extreme cases. Therefore, during recharge of groundwater through wells using sediment laden water, the latter must be filtered before letting into the wells. Efforts have been made to develop a horizontal flow filter which has simple working principle and can be easily managed by farmers.

## Description of technology

In the horizontal flow sediment filter, water flows horizontally through the filter media consisting of crushed stones. The sediments get deposited over the surface of the stones. As the deposited sediments grow in size gradually, they tend to drift down to the bottom. Hence, these filters need not be cleaned often and last for at least few years with very less maintenance. The sectional elevation of horizontal flow sediment filter is shown in Fig. 1 and a field installed view of the filter is presented in Fig. 2.

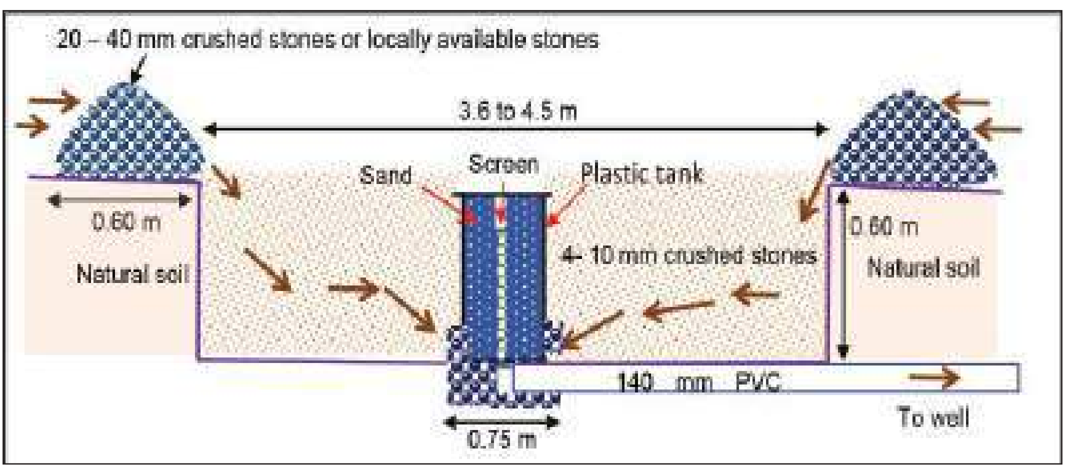



**Fig. 1. Sectional elevation of horizontal flow sediment filter**

For construction of the filter, a pit of diameter 3.6 to 4.5 m, most preferably 4.5 m diameter with 0.6 m depth is dug. At the periphery of the pit on the ground, either crushed stones of size 20 to 40 mm or locally available larger stones are placed. Inside the pit, 4 to 10 mm crushed stones are placed. At the center of the filter, a plastic tank of approximately 0.60 m diameter and around 0.90 m height is placed. In the plastic tank, a provision for flow through the bottom of the tank is provided. A screen is placed at the center of the plastic tank which collects filtered water, which is then conveyed to either borewell or open well through a PVC pipe. It is to be noted that this horizontal flow filter can be used for recharging groundwater through borewell or open well. Fig. 3 and Fig. 4 show views of the filter during construction process. Approximate cost of one unit of horizontal flow filter is Rs. 40,000**.**

**Fig. 2. Field view of installed horizontal flow filter**

**Fig. 3. PVC T-s covered with screen inside plastic tank**

**Fig. 4. Filling of 20-40 mm crushed stones around the central tank**

## Performance evaluation

The filter was evaluated in the field and the maximum filtration rate was 2 litres per second. Water samples were collected at three stages. Stage 1 is upstream of 20 to 40 mm crushed stones. Stage 2 is just before entering the plastic tank (i.e. after passing through crushed stones of size 4 mm to 10 mm). Stage 3 is after passing through sand. Turbidity levels measured at Stage 1, Stage 2 and Stage 3 are 600, 300 and 60 NTU, respectively. Overall efficiency of the filter was 90%.

**Extension and adoption**

Functioning of the filter is under demonstration in TNAU. During the year 2022, demonstration of this filter was done in two State-level exhibitions in Coimbatore and Trichy. The step-by-step procedure of construction of this filter is available in YouTube and keywords for the search is 'tnautv' and 'sediment filter'. ITC limited has implemented these filters in more than 200 farmers' fields in Coimbatore district through its corporate social responsibility funds. Another organization namely, World Wide Fund for Nature has implemented this in 12 locations in Noyyal river basin. The Department of Agricultural Engineering, Government of Tamil Nadu has implemented these structures at 32 locations across various districts of Tamil Nadu. Installation of the filter by Department of Agricultural Engineering, Government of Tamil Nadu is shown in Fig. 5. Two non-governmental organizations namely MYRADA, Hosur and National Agro foundation, Chennai have evinced interest in implementing this technology in farmers' fields during the year 2025.


**Fig. 5. Installation of horizontal flow sediment filter by Department of Agricultural Engineering, Government of Tamil Nadu**

# Vertical Flow Sediment Filter for Aquifer Recharge through Borewells

(*Coimbatore centre*)

*V. Ravikumar, S. Selvakumar and S. Pazhanivelan*

## Relevance

In the conventional way of developing a borewell recharge filter, at first a square or circular deep pit is dug, where many layers of stones are placed one above the other. At the bottom layer, big boulders of 300 to 400 mm size are placed, followed by a layer of stones of 150 to 200 mm placed over the bottom layer. Over that, a layer of pebbles or crushed stones of 30 to 40 mm is placed. The top of the filter consists of a sand layer, that is separated by a nylon mesh to avoid downward movement of sand. A small brick wall is constructed around the pit to guide the runoff water into the filter. But there are certain constraints of this filter: (1) Digging of pit is a costly work, (2) Top sand layer being the only filtering layer, the stone layers beneath sand layer are not useful for filtering, (3) Sediment laden water that is first exposed to the sand layer clogs the latter rapidly, thereby demanding frequent cleaning of the sand layer, (4) Construction of brick wall around the structure to arrest erosion of sand is a cost intensive job, (5) Filtered water is not visible because it enters the borewell at a lower elevation in the casing pipe. Most of the above shortcomings can be minimized with vertical flow filtration technology.

## Description of technology

For the construction of vertical flow filter, a pit of diameter of 2.10 m is dug upto a depth of 1.20 to 1.50 m. In the pit, reinforced cement concrete rings are placed and all the joints between the cement rings are plastered with cement mortar on both inner and outer sides. In the annular space between the cement rings and inner wall of the pit, 4 to 10 mm crushed stones are placed. On the ground, surrounding the pit, 20 to 40 mm crushed stones are placed. Inside the RCC rings, a layer of reticulated polyurethane foam is placed. On the casing pipe, a minimum of 20 holes are drilled each having 20 mm diameter. LDPE pipes of diameter 16 mm are inserted in minimum four holes upto a depth of 5 to 10 m. These LDPE pipes have the ability to accelerate flow rate into the well due to development of increased pressure head in the pipes. Fig. 1 shows the sectional elevation of vertical flow sediment filter. Sequence of construction of vertical flow sediment filter is shown in Fig. 2.

Reticulated polyurethane foam is tied over an aluminum framework. Foams are available in different densities ranging from 10 to 500 kg/m$^3$. Foam of 90 cm width is commonly available. Higher the foam density, lower the size of flow passage. Foams of density around 40 to 50 kg/m$^3$ can be used for this filter. Depending on the quality of filtration needed, more than one layer of foam can also be used. Quality of filtration improves with the number of foam layers. After the foam framework is placed over the casing pipe, at the bottom of the foam, soil is firmly pressed to prevent water leakage. Sand can also be placed around the foam for a depth of 30 to 45 cm. A cover slab made of RCC or mild steel can be used to close the central concrete rings.

After rainfall, the runoff water passes vertically through 20 to 40 mm crushed stones, then 4 to 10 mm crushed stones and gets into the annular space between the foam, and inner wall of RCC rings. Finally, the filtered water gets into the borewell through the holes and LDPE pipes in the casing. Approximate cost of one unit of vertical flow filter is Rs. 50,000.

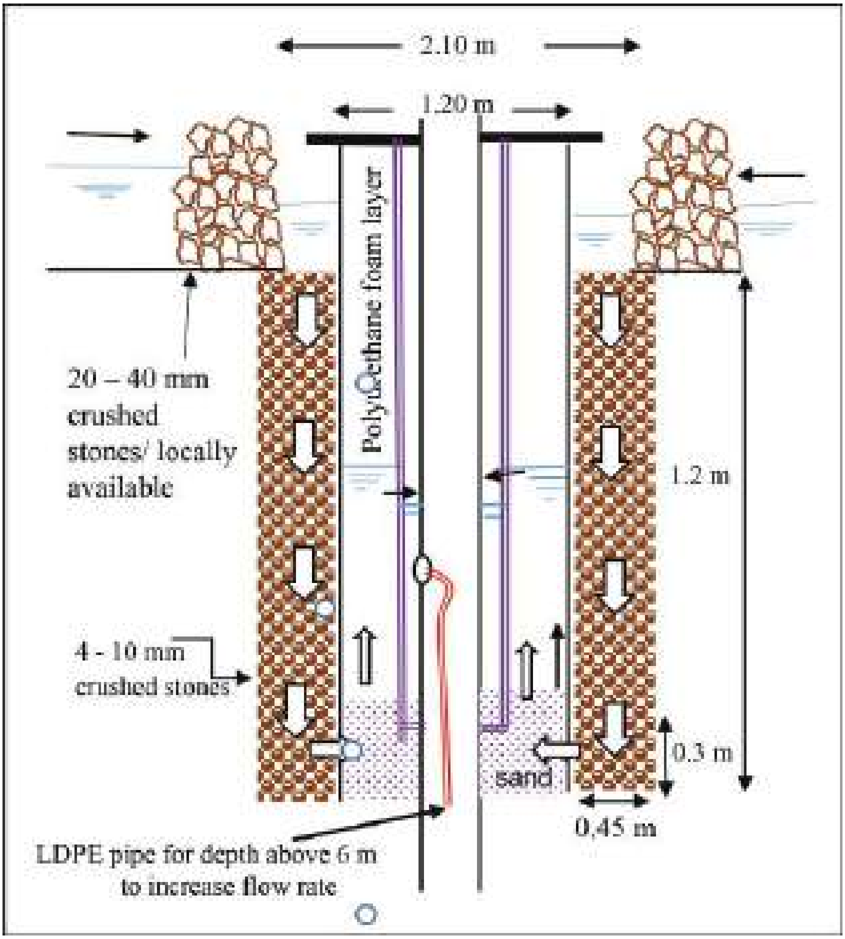



**Fig. 1. Sectional elevation of vertical flow sediment filter**

**Fig. 2. Construction sequences of vertical flow sediment filter**

## Performance evaluation

Polyurethane foam of thickness of 2.5 cm and density of 450 kg/m$^3$ was used for the study. Height of the foam is 90 cm and perimeter of the foam is 80 cm. For 30 cm height of water around the foam, filtration rate was evaluated to be 2 L/s. Hydraulic conductivity of the foam was 2 cm/h. Testing of the sediment filtration was also done by winding more layers of polyurethane foam around the aluminum framework. Filtration efficiencies for passing of sediment laden water through crushed stones and polyurethane foam are shown in Table 1. Filtration efficiency of 95% was achieved with three layers of polyurethane foam.

**Table 1. Filtration characteristics of polyurethane foam**

| SN | Number of foam layers | Turbidity upstream of 20 to 40 mm crushed stones (NTU) (Stage 1) | Turbidity before entry into foam (NTU) (Stage 2) | Turbidity after passing through Foam (NTU) (Stage 3) | Efficiency between (Stage 1) & (Stage 2) (%) | Overall efficiency between (Stage 1) & (Stage 3) (%) |
|---|---|---|---|---|---|---|
| 1 | 1 | 892 | 175 | 102 | 80 | 88 |
| 2 | 2 | 892 | 163 | 85 | 81 | 90 |
| 3 | 3 | 892 | 111 | 44 | 88 | 95 |

## Extension and adoption

Working of the vertical sediment flow filter is under demonstration in TNAU. During the year 2022, demonstration of this filter was done in two State level exhibitions in Coimbatore and Trichy. Step-by-step procedure of construction of the filter is available on YouTube and keywords for the search is tnautv and sediment filter. World Wide Fund for Nature has implemented this in 2 locations in Bhavani river basin. The Department of Agricultural Engineering, Government of Tamil Nadu has implemented these structures in 218 locations in various districts of Tamil Nadu. Two non-governmental organizations namely MYRADA, Hosur and National Agro foundation, Chennai have evinced interest in implementing this technology in farmers' fields during the year 2025.

# Siphon Filter for Sediment Removal and Groundwater Recharge

(*Coimbatore centre*)

*V. Ravikumar, S. Selvakumar and S. Pazhanivelan*

## Relevance

Sediment filtration is an essential process wherever Aquifer Storage and Recovery (ASR) is adopted. A sediment removal filter for recharging through borewells using runoff water has been developed and tested. The siphon principle is used in which the filter is placed at a higher elevation than the level of runoff water collected, which helps in convenient operation and maintenance of the filter. No external energy is needed for the operation of the filter. Sediment filtration efficiency can be controlled by adjusting filtration rate easily while operating the filter. This filter can be a value addition for any sediment filter setup.

## Description of the technology

The difference in elevation between the groundwater table and the surface runoff provides ample scope for filtering the water by using gravitational energy through siphoning process. Fig. 1 shows the scematic diagram of a siphon filter that is used for purifying drinking water in low income countries. A siphon tube has a rising limb through which water flows upwards and a falling limb through which water flows downwards. To use the siphon filter, at first, priming of the siphon pipe is done by removing the air inside the pipe using a rubber bulb. By pressing the rubber bulb, air inside the pipe is removed. Rubber bulb is designed to prevent the reverse entry of air into the bulb. After few pressings of the rubber bulb, the pipe gets fully primed and water gets filled inside the siphon pipe. After priming is completed, when the tap at the outlet is opened, water from the upper container passes through filter element and the filtered water is obtained at the lower container.

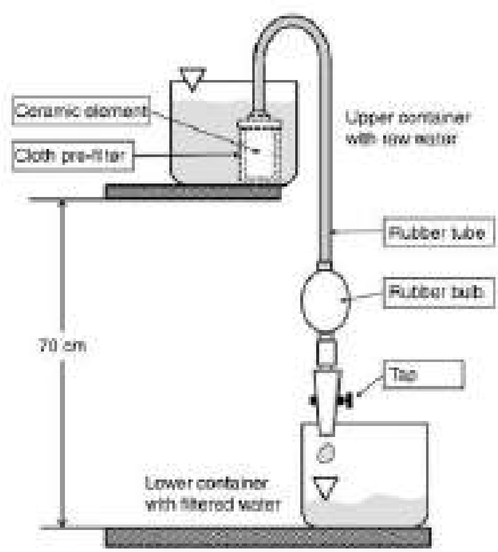



**Fig. 1. Siphon filter (SF) for purifying drinking water**

The major difference between the Siphon Filter (SF) for purifying drinking water discussed above and Siphon Filter for Groundwater Recharge (SFGR) developed in this work lies in the way of priming. As the outlet of the siphon tube is to be placed inside the borewell in SFGR (Fig. 2), it is very difficult to operate the rubber bulb inside the borewell. Hence, rubber bulb is not used in SFGR. During priming, the outlet valve is in closed state and while starting the siphoning process, the outlet valve is opened in the case of SF. In the case of SFGR, the outlet valve always remains open. The priming in SFGR is done by filling water in the rising limb of the tube by providing a non-return valve at the inlet of the siphon tube. Here, a simple air release valve in the inverted mode is used to perform as non-return valve. These air release valves use a simple float mechanism to release the air. The float in the valve gets closed when the water from the priming tank flows into the rising limb of siphon tube (dotted arrows from the priming tank in Fig. 2). The water for priming can easily be collected during rainfall from any available roof nearby. The volume of water needed is little more than the water needed to fill the siphon tube and the filter. A volume of 10 to 20 litres is sufficient.

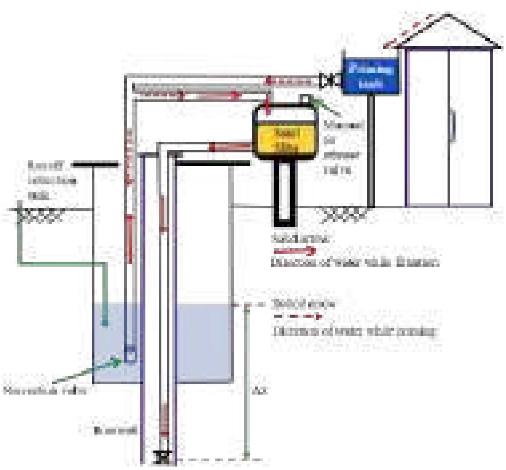


**Fig. 2. Siphon filter for groundwater recharge (SFGR)**

After filling water in the rising limb, the water gets filled in the sand filter. Air inside the filter gets collected at the top inside of sand filter. Removal of this air is done by providing a manually operated valve. Here, a flush valve has been used which is normally used in drip irrigation. This accessory has been found to be useful for this work because this valve has a provision of rubber O-ring. This O-ring provides airtightness when the valve is closed and it must be noted that air tightness is essential for operation of siphon. When priming is done, the manual air release valve has to be in open state to release air. While priming, the water flows through the falling limb of siphon after passing through the filter media. When water flows through the falling limb, the flow must be a full pipe flow. If the flow in the falling limb is not full-pipe flow, the siphon flow cannot be initiated.

After the priming process is completed, the valve in the priming tank is closed. As soon as the valve is closed, the runoff water with sediments gets sucked through the valve at the inlet of siphon tube, passes through filter media, gets filtered, and flows into the borewell through the falling limb of the siphon.

Filtering process would continue as long as runoff water is available in the collection tank. The valve at the outlet of falling limb of SFGR is provided not to operate during the priming process. That valve is provided to control the filtration rate through the filter. By restricting the flow through this outlet valve, filtration efficiency can be improved. The filtration rate must be decided by the user. The level of opening of the outlet valve is to be finalized before installation of the siphon filter.

## Performance evaluation

A sand filter consisting of 35 cm depth of sand and 25 cm diameter was used in the study. Uniform sand of mean size 0.65 mm with an uniformity coefficient of 1.5 was used. The hydraulic conductivity of the sand was 0.002 m/s. Raw water turbidity of 900 NTU was used. For a filtration rate of 1200 L/h, the filtration efficiency was found to be around 50%. It was decided to have the minimum expected filtration rate to be 275 L/h (97.5% efficient filtration rate) and maximum expected filtration rate of 1200 L/h (50% efficient filtration rate). Field installation view of the SFGR is presented in Fig. 3.

## Extension and adoption

Working of the filter is under demonstration in TNAU (Fig. 3). During the year 2022, demonstration of this filter was done in two state level exhibitions in Coimbatore and Trichy. Two non-governmental organizations namely MYRADA, Hosur and National Agro foundation, Chennai have evinced interest in implementing the technology in farmers' fields during the year 2025.

**Fig. 3. View of field installation of sediment filter for groundwater recharge**

# Artificial Groundwater Recharge through Borewells

(*Rahuri centre*)

*P. G. Popale, A. G. Durgude and P. S. Bodake*

## Relevance

The percolation tanks, check structures such as nala bund, cement nala bund, *Bandhara*, etc. are some the effective measures to recharge groundwater in watershed based system. However, recharge through these structures is very slow. Artificial groundwater recharge through borewells can achieve higher rate of groundwater recharge. Surface water which is sufficiently available during rainy season in the form of runoff can be used for augmenting the wells. The runoff water contains impurities of physical, biological and chemical nature. Hence, great care needs to be taken before injecting the water into borewells to prevent pollution of groundwater reserves and blocking of fractures. In this study, effort has been made to develop a borewell recharge technology with a robust filtration unit.

## Description of technology

The borewell recharge technology for filtration of runoff/surface water was developed with the use of locally available material i.e. sand and gravel. The four layer filter comprising of brick flakes (BF-I) of size 24-28 mm, sand (SG-I) of size 0.6-2.0 mm, angular gravel (AG-I) of grade 9.5-15.5 mm and pea gravel (PG-I) of size 20-24 mm with each layer having thickness of 25 cm, with total thickness of 100 cm. The layer-wise specifications of the filter unit is given in Table 1. Schematic diagram of the four-layer filter for groundwater recharge through borewells is shown in Fig. 1. Construction process of the borewell recharge structure with filter material in each layer is displayed in Fig. 2.

**Table 1. Layer-wise specification of the four-layer filtration unit**

| Filter layer no. | Filter layer thickness (top to bottom) | Filter material and its size |
|---|---|---|
| 1 | 25 cm | Brick flakes (24 to 28 mm) |
| 2 | 25 cm | Sand grade I (0.6 to 2.0 mm) |
| 3 | 25 cm | Angular gravel grade I (9.5 to 15.5 mm) |
| 4 | 25 cm | Pea gravel grade I (20 to 24 mm) |

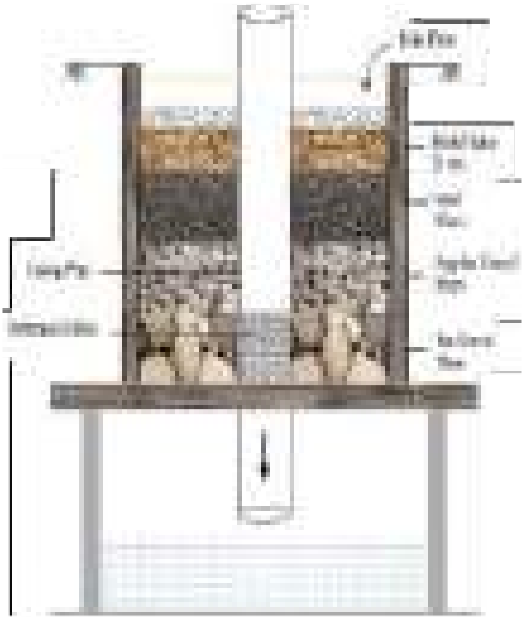


**Fig. 1. Schematic diagram of four layer filter for groundwater recharge structure**

## Performance evaluation

Performance evaluation of the filter unit for artificial groundwater recharge through borewell was done on farm/field to study its effectiveness. Overall filtration efficiency of the four-layer filter was found to be 84.5% which is considered satisfactory. Average recharge volume of 1512 $m^3$ was observed during a year.

## Extension and adoption

The developed borewell recharge filtration technology was accepted by Maharashtra government. A project entitled "Enhancement of groundwater recharge through open and bore well" was sanctioned to MPKV Rahuri under RKVY grants. Under this project, borewell recharge technology was adopted at various locations and training and demonstration was conducted.

**First layer of pea gravels**

**Second layer of angular gravels**

**Third layer of fine sand**

**Fourth layer of brick flakes**

**Fig. 2. Construction of borewell recharge structure showing filter material in different layers**

# Groundwater Recharge cum Drainage Structure

(*Pusa centre*)

*R. Chandra, S. K. Jain and A. K. Singh*

## Relevance

Bihar, despite being rich in water bodies and having waterlogging scenario in several parts during rainy season, faces a paradoxical situation of severe droughts in some years. Accelerated groundwater depletion has been observed in the last few decades, primarily due to excessive groundwater extraction for irrigation. This is further exacerbated by inadequate drainage facilities in agricultural areas, which delay sowing of *rabi* crops and lead to poor crop performance. Hence, effort was made to develop a groundwater recharge cum drainage unit to address these challenges. The technology can recharge aquifers with surplus runoff during the monsoon season as well as provide drainage to waterlogged fields, thereby enabling timely agricultural activities. Farmers in waterlogged areas, particularly in the *chaur*/*taal* lands and regions with declining groundwater levels will benefit significantly from this technology.

## Description of technology

The alluvial plains of eastern India have potential aquifers with ample source of water for recharge, and are witnessing accelerated groundwater draft over the last couple of decades. Groundwater recharge can be done using surplus runoff water available during monsoon season. Keeping the importance of groundwater recharge and drainage of excess water, a recharge cum drainage unit was designed and developed. The recharge unit incorporates PVC pipes, elbows, and filtration units to create an efficient system for directing runoff water into aquifers (Fig. 1). Sediment is trapped in siltation tanks and filtration units, ensuring the recharge water is clean and effective. The steps involved in development of groundwater recharge cum drainage unit are as follows:

1. Design, development and fabrication of filter unit
2. Performance of different filter combinations having different filter length/thickness in lab and field
3. Identification of suitable recharging point and depth using well litholog of different locations of the study area
4. Study related to clogging of filter
5. Installation of the groundwater recharge cum drainage unit
6. Evaluation of the installed groundwater recharge cum drainage unit

***Major components:***

1. **Stilling basin:** Facilitates initial sediment settling
2. **Siltation tank:** Reduces suspended solids in water
3. **Recharge filter:** Removes fine impurities to prevent clogging
4. **Boring unit:** Directs water to the target aquifer.

**Fig. 1. Groundwater recharge cum drainage unit installed in university campus**

## Performance evaluation

The technology was rigorously tested under laboratory and field conditions. The unit helped in successful drainage of waterlogged fields after the monsoons, preventing delayed agricultural operations. The system has a recharge capacity of 22,000–24,000 litres/hour, thereby mitigating groundwater depletion. Farmers reported early field drainage, allowing timely sowing of *rabi* crops, which significantly improved crop yields. Solid removal efficiency was consistently recorded between 80-85%, demonstrating the effectiveness of the filtration unit.

## Extension and adoption

More than seven groundwater recharge units have been installed in the university campus and five recharge units have been installed in farmers' field (Fig. 2). Field trials were conducted in Sukhet village, Madhubani district, where recurrent flooding and waterlogging had long impeded *rabi* cultivation. Installation of the recharge unit showed early drainage of the waterlogged fields, enabling timely sowing of wheat for the first time in over two decades. More than 15 hectares of land and 10 farmers directly benefitted from this intervention. Farmers noted significant reduction in waterlogging duration and enhanced land productivity. With government support and farmers' participation, this technology can play a pivotal role in ensuring sustainable water management and enhancing agricultural productivity.

**Fig. 2. Groundwater recharge cum drainage unit draining waterlogged land after monsoon**

# Twin Rings Technique of Tubewell Recharge

(*Arabhavi centre*)

*P. S. Kanannavar, S. N. Honnali and Kumara B. H.*

## Relevance

Karnataka is largely dependent on groundwater to meet industrial, municipal, domestic, and irrigation needs. Groundwater resources in Karnataka have been under severe stress for years owing to increasing demand and unplanned exploitation of groundwater resources. Karnataka is the second most drought-prone state in the country. The groundwater table is very deep and saline. With steady increase in withdrawal of groundwater, the water table is declining further. There is a need for artificial groundwater recharge as natural groundwater recharge is very slow. Therefore, indigenous suitable technologies for borewell/tubewell/ groundwater recharge were explored and installed to rejuvenate borewells with low yield and saline groundwater.

## Description of technology

Twin rings technology for borewell/ tubewell recharge through rainwater harvesting was developed and installed

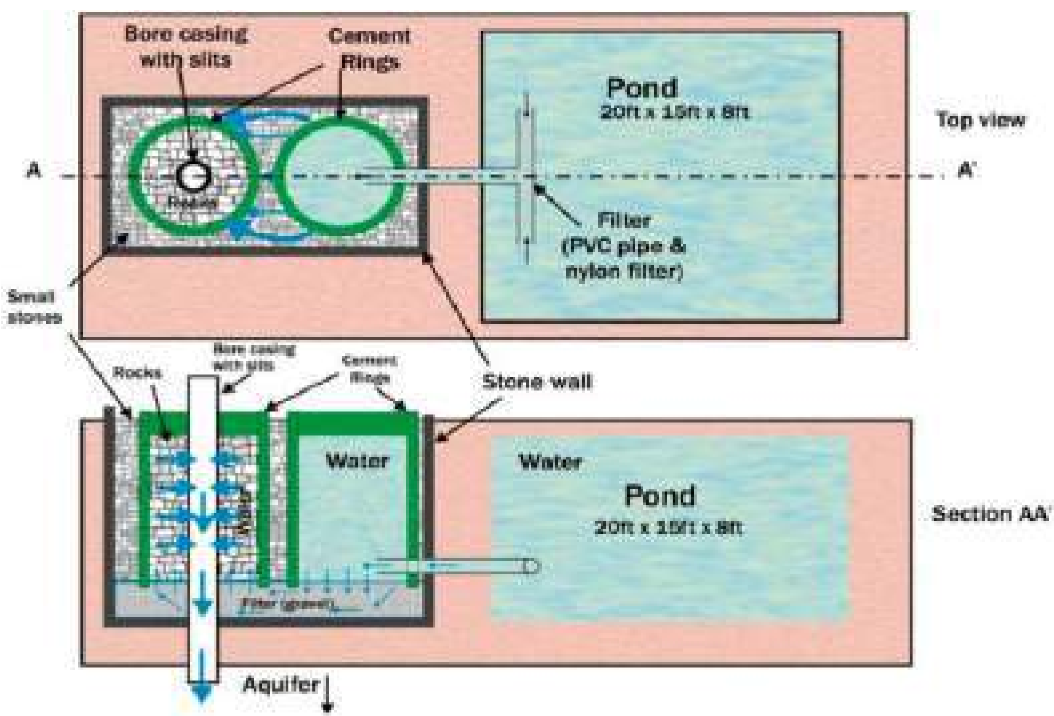



**Fig. 1. Schematic diagram of twin rings technique of tubewell recharge**

at Irrigation Water Management Research Center, Belvatagi, UAS Dharwad, Karnataka. The recharge unit has a pit, a farm pond for collecting harvested rainwater, and a silt trap. Storage of excess runoff is done by rainwater harvesting and point recharge by diverting the harvested water to an existing tubewell in a recharge pit of 12 feet length, 5 feet width and 8 feet depth. A schematic diagram of recharge unit is shown in Fig. 1.

After digging a trench/recharge pit of depth 8 feet, cement concrete is put around casing pipe for a depth of 1 foot to support it. Next, 3 feet of the pit is filled with boulders of 100 mm size, crushed stones of 40 mm size and crushed stones of 20 mm size arranged from bottom to top, respectively. Then about 1 m height of the casing pipe of the borewell is drilled with 40-50 slits of 2-3 mm width. Nylon mesh of 4-5 layers is wrapped around the casing pipe and tightened with plastic string/metallic wire. Remaining 5 feet depth of the recharge pit is filled with 20 mm crushed stones (Fig. 2).

Another set of rings is placed adjacent to rings around the casing pipe. First 3 feet of this set of rings (ring without borewell casing) is filled with filter materials of different sizes *viz*., boulders of around 100 mm size, and crushed stones of 40 mm, 20 mm & 6 mm size arranged from bottom to top, respectively. Broken bricks and charcoal are laid for a depth

**Fig. 2. Visit of farmers/trainees to groundwater recharge structure site**

of half feet. Remaining depth of set of rings is kept empty to allow harvested rainwater to enter the recharge unit. Harvested rainwater from farm pond enters this ring, percolates down to the recharge pit, and the recharge water rises in the set of rings around the casing pipe. Thus, rise of water to slits in the borewell casing gets point recharged to the aquifer/groundwater. The size of filter materials and their depth may vary as per the local conditions. Excess rainwater through runoff from the adjoining fields is diverted to a tubewell, and later runoff water collected through rainwater harvesting in nearby farm ponds is transferred to the double ring filter for recharge (Fig. 2).

### Performance evaluation

Three years of performance analysis of the borewell recharge unit showed that salinity of groundwater extracted through borewell decreased from over 10 to 1.6 dS/m, static groundwater table increased from 100 to 26 feet below ground level and borewell yield increased from 0.50 to 2.52 lps. After installation of the recharge unit, total 10.44 lakhs litre of borewell water has been withdrawn in three years. The technology is helpful in harnessing runoff water generated from rainfall events and using it for groundwater recharge. Farmers having low performing or defunct borewells can adopt this technology. Energy consumption to pump groundwater for irrigation has reduced due to rise in the water table.

### Extension and adoption

Demonstration of technology for ground water recharge in *Krishi Mela* of UAS Dharwad has been done and 15 field trainings have been given by centre. More than 2900 farmers/trainees have been briefed about this technology (Fig. 3). Technical assistance is also given to farmers to adopt the borewell recharge technology.

**Fig. 3. Visit of farmers/trainees to groundwater recharge structure site**

# Groundwater Recharge through Pit Filtration Technique using Borewells

(*Raipur centre*)

*D. Khalkho, M. P. Tripathi, B. L. Sinha and Y. Rathore*

## Relevance

Use of groundwater for water supply has created a situation where natural replenishment cannot keep up with exploitation rates, resulting in declining groundwater levels. Artificial groundwater recharge is a process by which groundwater reservoir is augmented at a rate exceeding the augmentation rate under natural conditions of replenishment. In some parts of India, due to over-exploitation of groundwater, decline in groundwater levels has resulted in shortage of water supply and intrusion of saline water in coastal areas. In such areas, there is need for artificial recharge of groundwater by augmenting natural infiltration of precipitation or surface water into underground formations by methods such as water spreading, recharge through pits, shafts, wells, etc. The choice of a particular method is governed by local topographical, geological and soil conditions; the quantity and quality of water available for recharge; and the technological-economic viability and social acceptability of such schemes. Aquifers need to be artificially recharged by introducing excess surface water deep into the groundwater tables.

## Description of technology

In this study, the groundwater has been recharged artificially through borewell with minor modification of casing pipe and a suitable filtration system. There were two filtration units in the borewell recharging system *viz.*, primary filter and secondary filter. The primary filter unit traps the sediments from the surface runoff water. The water is directed vertically downwards to the secondary filter under the effect of gravity. The secondary filter acts as a barrier to prevent filtered materials from entering the borewell and also serve as an envelope for the casing pipe. The filtered water is directly percolated into the deeper strata through the casing pipe that contributes to groundwater storage. Details of the developed recharge model is described as below.

- A 10 × 10 × 12 feet pit is excavated around an existing borewell such that its casing pipe is at the center of the borewell. Size of the pit depends on availability of rainwater. Concrete bed or foundation is constructed around the casing pipe to prevent it from slipping down. In the bottom 5 feet of the casing pipe, 150 holes of 5 mm diameter are drilled randomly around the circumference of the casing pipe. Usually, 3 inches gap is considered sufficient between two adjacent holes.

- The designed filter system is installed to filter the incoming water and making it free from any debris or silt from the source water. For achieving this goal, two filter systems are being used in the recharging unit: primary filter and secondary filter.
- Primary filter (Fig. 1) consists of layers of boulders (30-45 cm), medium size gravel (40 mm), small size gravel (20 mm), charcoal, alum, coarse sand (2 mm) and fine sand (0.2 mm). The pit is filled with boulders of 30 to 45 cm size from bottom upto the height of 5 feet. Above these, a layer of medium size gravel of size 4 cm is filled upto the height of 0.5 feet. After this, small size gravel of 2 cm size is filled upto 0.5 feet height, a layer of HDPE net is put above the gravel to avoid any entry of sand and soil in the lower layers. After this a layer of charcoal is provided for better filtration of source water. Over this, layers of medium and fine sand are placed till the ground level.
- Secondary filter (Fig. 2) consists of coconut rope, fine sand and good quality agro shade net. Coconut rope is swathed around the casing pipe covering each drilled hole. This blinds the pipe so that no silt will enter through these holes polluting the water in aquifer. Over this, an agro shade net (green net) is stitched in a tube-like structure and bound with a nylon rope loosely, leaving a space of about 4 cm between the agro shade net and the coconut rope cover. In between these two layers, fine sand layer is filled. This system restricts muddy water to enter the borewell.
- Parapet wall of 2 feet height is constructed around the pit with a single entry point of source water to prevent entry of muddy water from all

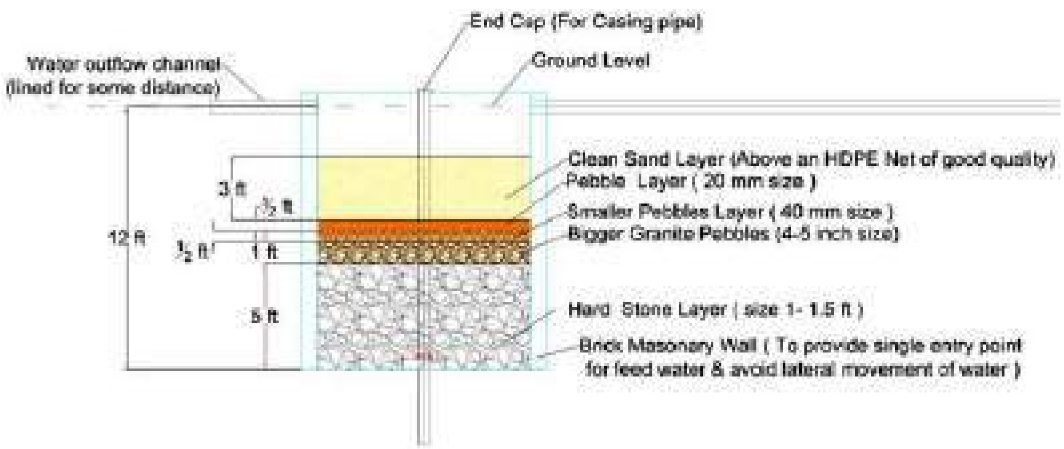
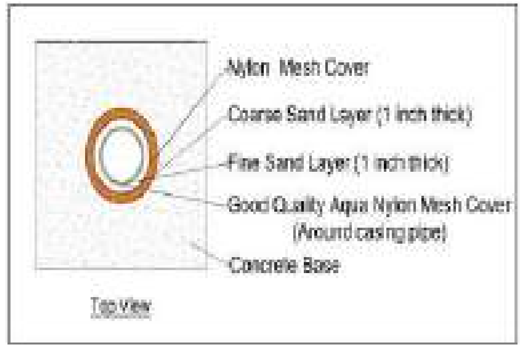



**Fig. 1. Cross-sectional view of primary filter of pit filtration technique**

sides in the percolation pit. Rainwater gets collected in the percolation pit and percolate slowly into the borewell via holes drilled on the casing pipe. An outlet is provided for the condition where inflow is greater than the filtration capacity/rate.

- A siltation trap is provided in the path of the recharge water upto inlet of the pit in order to remove accumulated silt and sediments from the water.

Fig. 3 shows the constructed groundwater recharge structure in IGKV research farm.



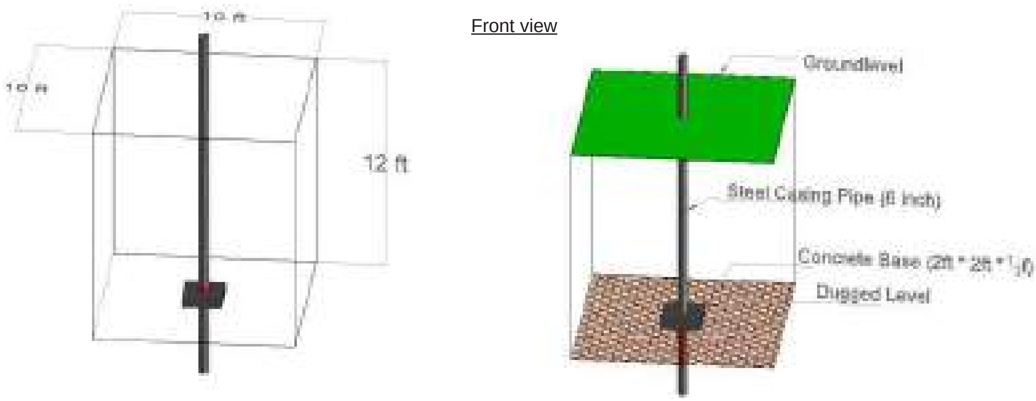




**Fig. 2. Cross-sectional view of the secondary filter of the pit filtration technique**

## Performance evaluation

Total volume of water which was percolated from the casing of borewell and contributed to groundwater reservoir was estimated to be 530.47 m$^3$ in a year. There was a rise in water level of about 1.34 m in recharged borewell compared to the unrecharged borewells in the monsoon season. The water quality parameters in recharged borewell were almost similar to unrecharged borewells, which indicated successful filtration of water for recharge of groundwater.

**Fig. 3. Constructed recharge structure in IGKV research farm**

# On-line Screen Gravel Filter for Groundwater Recharge

(*Junagadh centre*)

*P. B. Vekariya and H. D. Rank*

## Relevance

Groundwater recharge is the need of the hour due to overexploitation of groundwater resources in different regions of the country. Traditional groundwater recharge filters require deep excavation and large construction which is costly and inconvenient to execute. Therefore, effort has been made to develop an on-line screen gravel filter which can be cost effective and convenient to use.

## Description of technology

In on-line screen gravel filter, base materials are avoided by providing support of metallic screens to the filter layer of fine sand. In the construction of screen gravel filter, fine sand used as filter media should have 15% particles finer than 1 mm. The supporting frame is made of 18 gauge non-corrosive GI sheets having round perforation holes of 12 mm diameter. The micro screen is made of stainless steel net having mesh size 0.75 mm. Continuous on-line flow through the filter prevents clogging of the filtration system. After filtration, water is allowed to enter a tubewell or open well for groundwater recharge. Fig. 1 shows the schematic diagram of the on-line screen gravel filter.

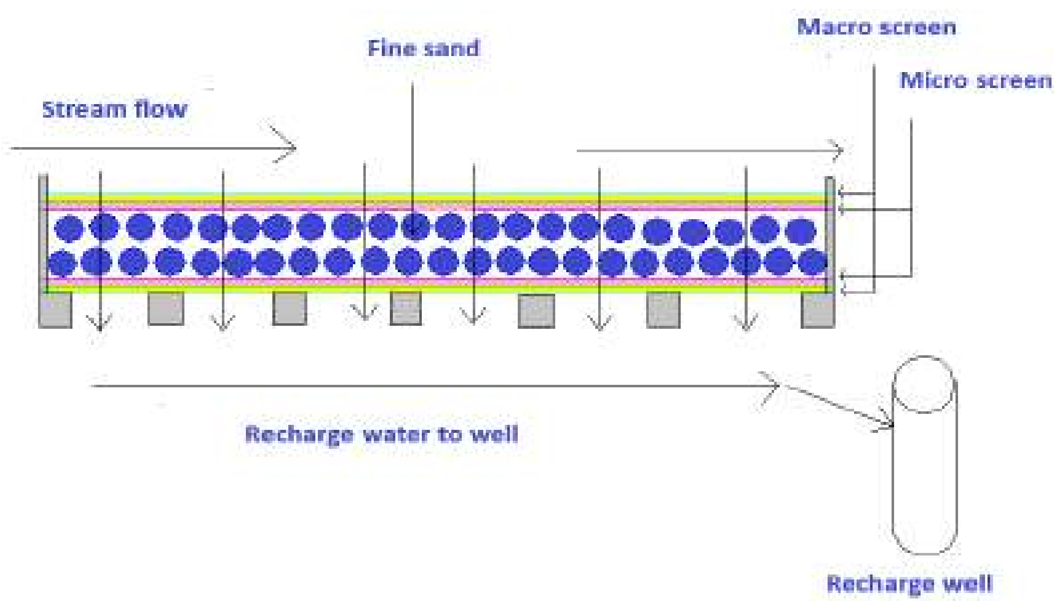



**Fig. 1. Conceptual details of on-line screen gravel filter**

## Performance evaluation

Filtration efficiency increases with thickness of the sand bed. With 10 cm, 15 cm and 20 cm thick sand beds, filtration efficiency was found to be 63%, 85% and 89%, respectively. But recharge flow rate decreased when thickness of sand bed was increased. When thickness of sand bed was kept 10 cm, 15 cm and 20 cm, recharge flow rate was 80%, 59% and 34% of inflow, respectively. With long duration and varying silt load trial, optimum thickness was standardized as 15 cm (Fig. 2).

## Extension and adoption

Technology has been disseminated to stakeholders/end users through extension machineries of university, government departments, NGOs, KVKs, radio talks, demonstrations, farmers' meets, trainings and agri-fair.

**Fig. 2. On-line screen gravel filter functioning with layer of sand filter**

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**ICAR - Indian Institute of Water Management**

(An ISO 9001:2015 Certified Organization)

**Bhubaneswar – 751 023, Odisha**

Web : https://iiwm.icar.gov.in

E-mail : director.iiwm@icar.gov.in