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Government of India - Ministry of Railways

WATER HARVESTING



CAMTECH/2009/C/WH/1.0

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Indian Railways

Centre for Advanced Maintenance Technology

Maharajpur, GWALIOR - 474 005

FOREWORD

An age-old practice/ tradition of collecting, storing and preserving water for various uses is deeply rooted in Indian culture. However, deviating from the old traditions the over extraction of ground water and scanty rainfall in recent years have resulted into alarming drop in water table. The high population growth of urban areas has further increased the gap between availability and requirement of fresh water. To bridge this gap, various techniques are now being practiced. Water harvesting is also one of these techniques, which can be used to bridge this gap.

Civil engineering branch of CAMTECH has made an effort to bring out this handbook to provide elaborate and detailed information on water harvesting.

I am sure that this book will certainly prove to be useful for field engineers and staff of Indian Railways.

(S.C.SINGHAL)
Executive Director
IRCAMTECH/Gwalior

CAMTECH/Gwalior
Date: 04.03.2010

PREFACE

Indian Railway is a big organisation having large assets of civil engineering structures and buildings throughout the country and a large number of customer bases requiring fresh water as a basic survival need almost for 24X7 throughout the year. As compared to its demand, the availability of this resource is limited due to various factors like limited rainfall and over-extraction of ground water which has further worsen the situation more critical specifically in those areas (arid and semi-arid) where water-stressed conditions are prevailing.

The water harvesting system as widely accepted and implemented throughout the world may be the ideal solution to cope up the problem of water scarcity and to make it as an essential activity to harvest the water or 'to catch water where it falls' through implementation of various technologies/methods for using rainfall runoff from rooftops or ground surface as storage for future use or recharging of ground water. Indian Railways with its vast network can play a vital role to mitigate the water problem by adopting and implementing water-harvesting techniques.

This handbook is prepared with the objective to provide informative technical details on *'Water Harvesting'* for the guidance of civil engineering personnel involved in planning, designing, construction and maintenance of buildings. This handbook does not supersede any existing instructions from Railway Board, RDSO & Zonal Railways and the provisions of IRWM, BIS codes & reports on the subject.

This handbook is not statutory and contents are only for the purpose of guidance. Most of the data & information mentioned herein are available in some form or the other in various books and other printed matter. For more in-depth information, the relevant codes and reports on the subject may be referred before final implementation of any technique/ or method described in this handbook.

We welcome any suggestions from our readers for further improvement.

(JAGMOHAN RAM)
Director/Civil
IRCAMTECH/Gwalior

CAMTECH/Gwalior
Date: 04.03.2010

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ISSUE OF CORRECTION SLIPS

The correction slips to be issued in future for this handbook will be numbered as follows:

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Where "XX" is the serial number of the concerned correction slip (starting from 01 onwards).

CORRECTION SLIPS ISSUED

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CHAPTER - 1 INTRODUCTION

'Catch Water Where It Falls' shall be the motto behind the success of this age-old concept of water harvesting through implementation of new technologies/ methods specifically designed to make it as an ideal solution to the problems of water stressed conditions usually occurred in arid and semi-arid areas of the country like India. India with deep historical roots and strong cultural traditions reflecting in our social fabric and institutions of community life has been practicing water harvesting for more than 4,000 years through following one important tradition of collecting, storing and preserving water for various uses. In view of the vital importance of water for human and animal life, for maintaining ecological balance and for economic and developmental activities of all kinds and considering its increasing scarcity, the planning and management of this resource and its optimal, economical and equitable use has become a matter of the utmost urgency.

Indian railway has its own infrastructural setup throughout the country and requires a huge quantity of water for drinking and other purposes and presently, this requirement of water is met through a municipal supply or extraction of ground water. *Alternatively, the water requirement of railway can also be met by capturing the water in the form of rain or surface runoff on railway area for* ***direct storage*** *or* ***recharging ground water*** *thus reducing the dependency on municipal water. By recharging groundwater aquifers railway can also contribute in big way for augmenting ground water storage as a whole, for its own requirement and for the benefit to the nearby locality*.

Excessive ground water extraction has resulted in deterioration of ground water quality, also in coastal areas due to saline water ingress. Ground water development, therefore, needs to be regulated and augmented through suitable measures to provide sustainability and protection. In order to tackle the burgeoning problem of water level decline, it is necessary to take up schemes for **water conservation** and **artificial recharge to ground water** on priority.

Traditional water harvesting methods, which were in vogue in arid and semi-arid areas of the country have either been abandoned or have become defunct in most cases. There is an urgent need to revive these methods. Ground water recharge by water harvesting is simple and effective way. The basic concept of **water harvesting** and the various methods/techniques for its field implementation on Indian Railway have been explained in details in the subsequent chapters of this handbook.

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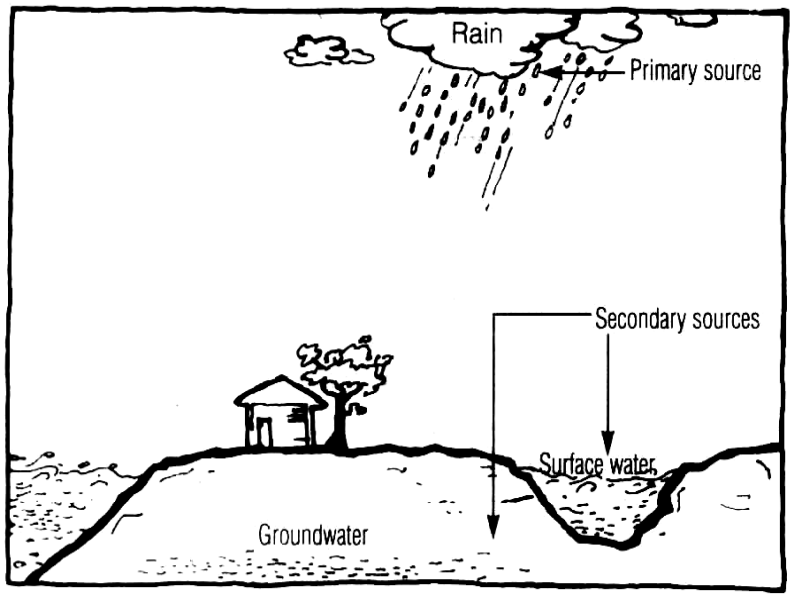
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CHAPTER – 2 GENERAL CONSIDERATIONS

The term 'water harvesting' is understood to encompass a wide range of concerns, including rainwater collection with both rooftop and surface runoff catchment, rainwater storage in small tanks and large-scale artificial reservoirs, groundwater recharge, and also protection of water sources against pollution. It also aims at other activities like prevention of losses through evaporation and seepage, conservation and efficient utilisation of the limited water endowment such as a watershed and all other hydrological studies and engineering interventions.

2.1 DEFINITION

Technically speaking, water harvesting means capturing the rain where it falls and in general, it is the activity of direct collection of rainwater that can be stored for direct use or can be recharged into the groundwater.



2.2 OBJECTIVE

The main objective of water harvesting is to harvest the water as rainfall run-off from rooftop and surface on railway area for direct storage or recharging ground water. Although, emphasis has been given on increasing groundwater recharge and managing storm water in urban areas, while in rural areas, the aim is to provide water for drinking and farming, especially for life-saving irrigation, and to increase groundwater recharge.

2.3 SOURCE OF WATER

The ultimate/prime source of water is the rain that feeds all secondary sources like rivers, lakes and groundwater, through which supply of fresh water for survival of the living creatures is ensured. The source water available for artificial recharge could be of the following types:

- In-situ precipitation in the watershed/area
- Nearby stream/spring/aquifer system
- Surface water (canal) supplies from large reservoirs located within the watershed/basin
- Surface water supplies through trans-basin water transfer
- Treated Municipal/Industrial wastewaters
- Any other specific source

The availability of water for artificial recharge from all these sources may vary considerably from place to place. Rainfall and runoff constitute the major sources of water for artificial

recharge of ground water.

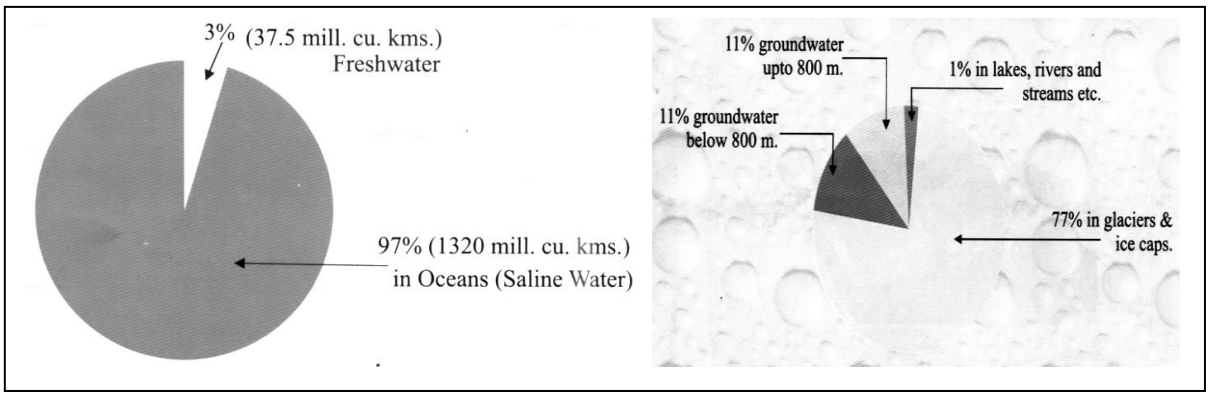
2.4 WATER REQUIREMENT

Over a period, due to increase in population, modern life style and urbanisation the water requirement has increased tremendously whereas the storage in surface bodies and ground water has reduced drastically. The storage in surface bodies and ground water is gradually decreasing due to change in land use pattern and depleting trend of ground water recharge due to increase in impervious surfaces. All this, caused to over extraction of water from ground storage and surface water bodies thus making availability of potable water, an increasingly scare commodity everywhere.

The arid and semi-arid areas where the supply of fresh water is available during a limited monsoon period throughout the year, that too non-uniform in spatial distribution and magnitude face water-stressed conditions due to excessive ground water extraction, which further decline the ground water level. Though, the fresh supply of water is available for a limited period but the water is required for the survival of living beings throughout the year. This imbalance of availability and requirement is met by extracting the water stored in the surface bodies i.e. ponds, lakes etc. or from ground water storage.

2.5 WATER AVAILABILITY ON EARTH

The fresh water as available on earth's surface is about 3% of total water and 97% as saline water. About 77 percent of this fresh water is locked up in glaciers and permanent snow and 11 percent is considered to occur at depths exceeding 800 m below the ground which cannot be extracted economically with the technology available today. About 11 percent of the resources are available as extractable ground water within 800m depth and about 1 percent is available as surface water in lakes and rivers.



2.6 NECESSITY

The successful water harvesting needs a collective community effort to cater the ever-increasing imbalance of water availability and requirement either by capturing the water overflowing the continental regions i.e. river/stream through dams and/or by capturing the available rainwater at the place of supply itself. The captured rainwater may either be stored directly or as ground water through artificial recharge techniques. The need is to be felt to adopt water harvesting as an ideal solution due to following reasons:

- To overcome the inadequacy of waters to meet our demands.

- To arrest decline in ground water levels.
- To enhance availability of ground water at specific place and time and utilize rain water for sustainable development.
- To increase infiltration of rain water in the subsoil that has decreased drastically in urban areas due to paving of open area.
- To improve ground water quality by dilution.
- To increase agriculture production.
- To improve ecology of the area by increase in vegetation cover, etc.

2.7 RAINWATER HARVESTING

The process of capturing and storing rainwater is known as rainwater harvesting. Following are three basic types:

- Roof top rain water harvesting and storage in tanks.
- Roof top rain water harvesting and recharging subsurface aquifer.
- Surface run-off harvesting and recharging subsurface aquifer.

2.8 ADVANTAGES

- Promotes adequacy of underground water.
- Mitigates the effect of drought.
- Reduces soil erosion as surface runoff is reduced.
- Decreases load on storm water disposal system.
- Reduces flood hazards.
- Improves ground quality/decreases salinity (by dilution).
- Prevents ingress of sea water in subsurface aquifers in coastal areas.
- Affects rise in ground water table, thus saving energy (to lift water).
- The cost of recharging subsurface aquifer is lower than surface reservoirs.
- The subsurface aquifer also serves as storage and distribution system.
- No land is wasted for storage purpose and no population displacement is involved.
- Storing water underground is environment friendly.

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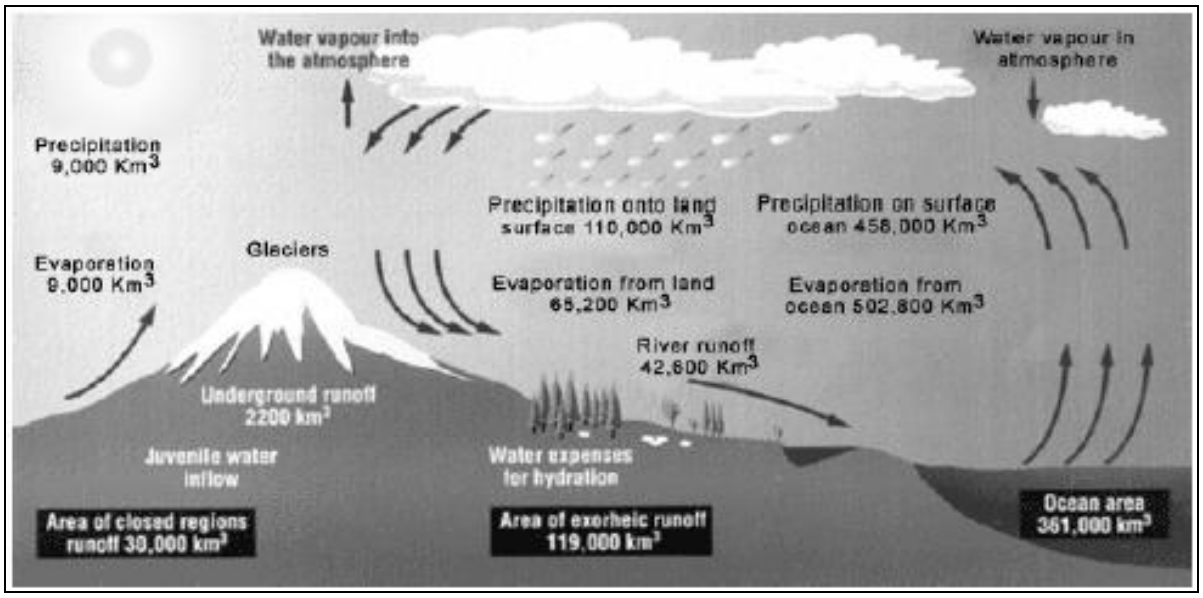
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CHAPTER – 3 HARVESTING WATER AS RAINFALL

Harvesting water as rainfall in India is a tradition which is deeply rooted in its historical background and in broadest sense, it is a technology used for collecting and storing rainwater for human use from rooftops, land surfaces or rock catchments using simple techniques such as jars and pots as well as engineered techniques. Generally known as Rainwater harvesting that has been practiced for more than 4,000 years, owns to the temporal and spatial variability of rainfall. It is an important water source in many areas with significant rainfall but lacking any kind of conventional, centralized supply system. It is also a good option in areas where good quality fresh surface water or groundwater is lacking. The application of appropriate rainwater harvesting technology is important for the utilization of rainwater as a water resource.

3.1 HYDROLOGICAL CYCLE

We all are well aware that the water evaporates from wet ground, from the leaves of the growing plants and from the lakes and reservoirs. It is carried in the air as water vapour, a gas. When water vapour condenses it changes from gas to liquid form and falls as rain. The rain feeds the rivers and lakes. Rivers carry water to the ocean. Evaporation from land and oceans puts water back into the atmosphere and this exchange goes on continuously. Water goes from earth to atmosphere and back to the earth, in a hydro-geological cycle. This way a water balance as shown in figure is maintained through out the year and this process continues without any interruption.



HYDROLOGICAL CYCLE

3.2 RAINFALL IN INDIA

Rainfall occurring on the continental regions (23% of total global rainfall), partially get stored in the surface water bodies, and as ground water through natural percolation, remaining over flows through the continental regions in the form of streams/rivers before merging in oceans i.e. saline water. The annual precipitation including snowfall in India is of

the order of 4000 BCM (billion cubic metres) and the natural runoff in the rivers is computed to be about 1869 BCM. The utilizable surface water and replenishable ground water resources are of the order of 690 BCM and 433 BCM respectively. Thus, the total water resources available for various uses, on an annual basis, are of the order of 1123 BCM.

Rainfall in India is typically monsoonal in nature that means seasonal wind which, on average, carries about 1120 mm of rainfall in the country. Bulk of this rainfall occurs during Southwest monsoon that normally takes a month's time to cover whole of the country (late June or early July). Thus, the entire country is covered by the summer monsoon for two months, July and August, making them the wettest months. The monsoon starts withdrawing gradually by early September and leaves the country by middle of October. Rainfall is confined mainly to the month of October and to a lesser extent up to the middle of November.

3.3 RUNOFF

Runoff is defined as the portion of the precipitation that makes its way towards rivers or oceans as surface or subsurface flow.

- **Surface flows:** The excess rainfall flows out through the small natural channels on the land surface to the main drainage channels after the occurrence of infiltration and other loses from the precipitation (rainfall).
- **Interflows:** A part of the infiltrated rainwater moves parallel to the land surface as subsurface flow, and reappears on the surface at certain other points.
- **Subsurface flow or ground water flow:** Another part of the *infiltrated* water percolates downwards to ground water and moves laterally to emerge in depression and rivers and joins the surface flow.

3.3.1 RUNOFF ESTIMATION

For estimation of runoff, all losses due to spillage, leakage, infiltration, catchment surface wetting and evaporation etc., are accounted for by using runoff coefficient. *Runoff coefficient* for any catchment is the ratio of the volume of water that runs off a surface to the volume of rainfall that falls on the surface. Runoff coefficient for various catchment surfaces are given in table below:

Type of catchment	Coefficient
Roof catchment	
-Tiles	0.8-0.9
-Corrugated metal sheets	0.7-0.9
Ground surface coverings	
-Concrete	0.6-0.8
-Brick pavement	0.5-0.6
Untreated ground catchment	
-Soil on slopes less than 10 percent	0.0-0.3
-Rocky natural catchment	0.2-0.5

The water harvesting potential i.e. runoff, of a catchment is estimated as under:

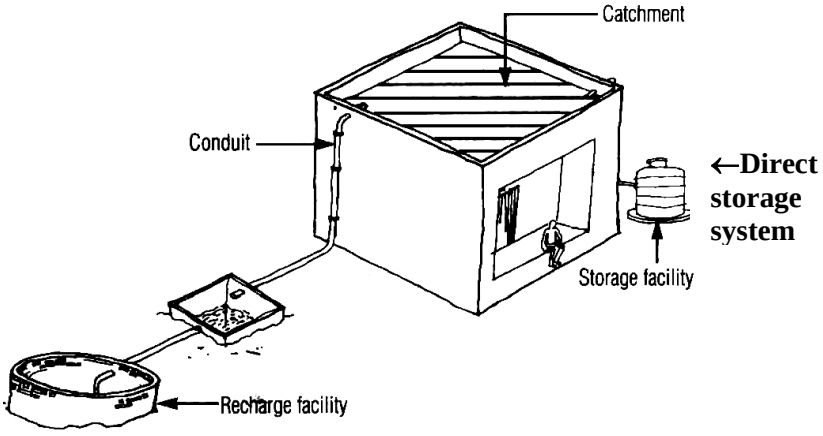
Water harvesting potential = Rainfall X Area of catchment X Runoff coefficient

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3.4 ROOF TOP RAIN WATER HARVESTING

Roof top rain water harvesting is the technique through which rain water is captured from the roof catchment and stored in small tanks and large scale reservoirs to ensure water availability for future use and to meet the household needs. Among others, some of the advantages of rain water harvesting might be as follows.

- It provides self sufficiency to water supply.
- It provides high quality water, soft and low minerals.
- The system is less expensive and can be adopted by individuals.
- In the hilly terrain, rain water harvesting is preferred for adoption.



Artificial recharge system

The system comprises of various components such as roof catchment, gutters to transport water pipes (inlet, overflow, outwash and water tap etc), filter unit, storage tank. Among the above components, storage tank is the most expensive and critical component and the capacity of the storage tank determine the cost of the system.

3.5 SYSTEMS OF RAINWATER HARVESTING

There are two main systems of rainwater harvesting:

3.5.1 STORAGE ON THE SURFACE FOR FUTURE USE

Storage of rainwater on surface is a traditional system and structures used are under/above ground tanks, ponds, check dams, weirs, etc. The collected run off from catchment area is diverted to the storage containers like RCC, masonry or plastic water tank through connecting devices. Generally, runoff from only paved surfaces is used for storing, since it is relatively free of bacteriological contamination. Storage tank is provided with a cover to avoid contamination from external sources. Tank is also provided with outlet, overflow and the drainpipe. Some maintenance measures like cleaning and disinfection are also required to ensure the quality of stored water. For domestic water needs ferro-cement tanks of cylindrical shape are more suitable for the capacity between 4,000 to 15,000 litres. Plain/reinforced cement concrete



RAINWATER CAN BE STORED IN TANKS

tanks are used for capacity more than 50,000 litres, and brick or stone masonry tanks are used for capacity between 15,000 to 50,000 litres.

3.5.2 ARTIFICIAL RECHARGE TO GROUND WATER

It is a relatively new concept of rainwater harvesting through which the ground water reservoir is augmented at a rate much higher than that under natural condition of replenishment. The structures generally used for recharge are: Recharge pit/trench/shaft, recharge dug-well/bore-well, recharge injection wells etc.



In this process, the ground water is augmented at a rate much higher than those under natural condition of replenishment. Various techniques can be used to augment the percolation of rainwater in the ground instead of draining away from the surface. While some structures promote the percolation of water through soil strata at shallower depth (e.g., recharge trenches, permeable pavements), others carry water to greater depths from where it joins the groundwater (e.g., recharge wells) directly. At many locations, existing features like wells, pits and tanks can be modified to use as recharge structures, eliminating the need to construct any structures afresh.

Note: In both the cases, the rain water harvesting system comprises of catchment area, water inflow/conveyance network and the storage tank or ground aquifer recharge facilities.

3.6 COMPONENTS OF RAINWATER HARVESTING

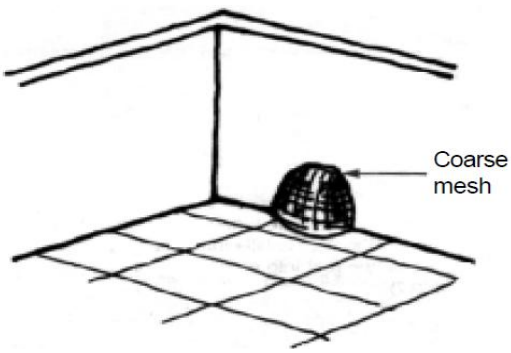
3.6.1 RAIN COLLECTING SURFACES

The rain collecting surface known as catchment area that receives rainfall directly and contributes the water to the system can be paved area like a terrace or courtyard of a building, or an unpaved area like a long or open ground or the roof of the house. The style, construction and material of the roof affect its suitability as a catchment. Roofs made of corrugated iron sheet, asbestos tiles or concrete can be utilised as such for harvesting the rainwater but thatched roofs are not preferred as they give some colour to water and also the water carries large quantity of suspended impurities.

Note: Water to be used for drinking purpose should not be collected from roof with damaged asbestos sheets or from roofs covered with asphalt and lead flashing or lead based paints as the poisonous lead contamination may occur in the collected water.

3.6.2 CONNECTING DEVICES FOR CONVEYANCE OF WATER

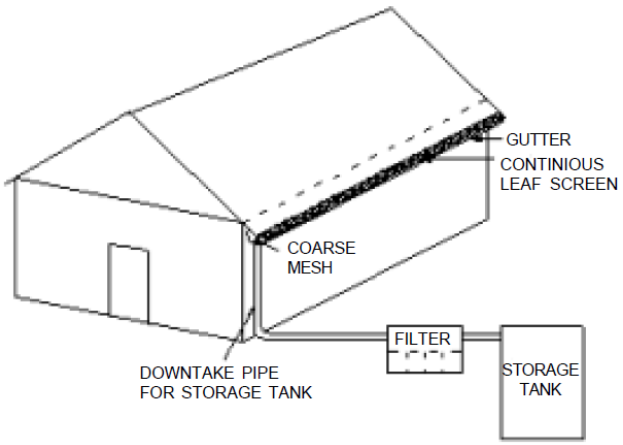
These are inflow-structures usually consisting of coarse mesh/leaf screen, gutter, down spout or conduit, mesh filter, first flush device, water filter, storage / or settlement tank and recharge structure.



COARSE MESH: At the mouth of inflow-pipe a

mesh filter i.e. grills should be fixed to prevent the entries of debris leaves etc. into drain pipe with the water collected from roofs.

LEAF SCREEN: For slope in roofs where gutters are provided to collect and divert the rain water to downspout or conduits, the gutters should have a continuous leaf screen, made of ¼ inch wire mesh in a metal frame, installed along their entire length, and a screen or wire basket at the head of the downspout.



GUTTERS: Gutters provided in the system collects rain water from the tapered/ sloppy roof and transport it to the inflow-pipe. The gutters could be of various shapes, size and material. To keep leaves and other debris away from entering the system, the gutter should be covered with wire mesh (jali) along the entire length.

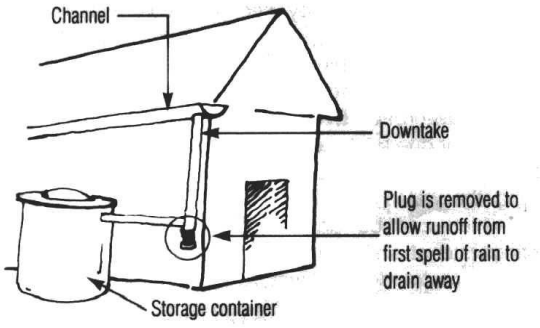
- Shape of gutter can be semicircular or rectangular.
- Material of the gutter could be: Aluminium or G. I. sheet, half cut PVC rigid pipe, half cut large diameter bamboo trunk.
- Size of the gutter should be according to the flow during the highest intensity rain. It is advisable to make them 10 to 15 percent over size.

CONDUITS: Conduits made of any material like PVC, asbestos or galvanised iron etc. that are commonly available are the pipelines or drains that carry rainwater from the rooftop to the harvesting system. The following table gives an idea about the diameter of pipe required for draining out rainwater based on rainfall intensity and roof area:

Dia meter of pipe (mm)	***Average rate of rainfall in mm/h(millimetre per hour)***					
	50	**75**	**100**	**125**	**150**	**200**
	Roof area in square metre					
50	13.4	8.9	6.6	5.3	4.4	3.3
65	24.1	16.0	12.0	9.6	8.0	6.0
75	40.8	27.0	20.4	16.3	13.6	10.2
100	85.4	57.0	42.7	34.2	28.5	21.3
125	-	-	80.5	64.3	53.5	40.0
150	-	-	-	-	83.6	62.7

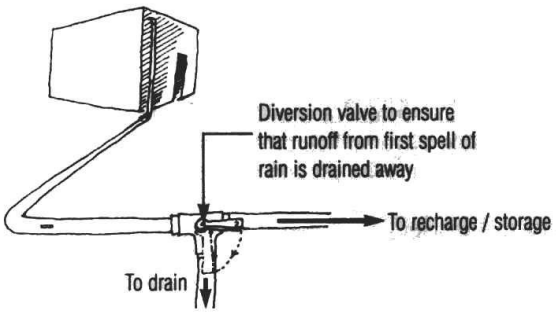
(Source = National Building Code)

FIRST FLUSH DEVICE: The device gets importance in the system due to its ability to dispose off the first spell of water which normally contains debris, dirt and dust collected on the roofs during non-rainy periods. Following systems are normally used:



- In manual system, the down pipe is manually moved away from the tank inlet and replaced again once the first spell of rain water has been disposed off.

A manual first-flush device



- In semi-automatic system, a separate vertical pipe is fixed to the down pipe with a valve provided below the T-junction as shown in figure. After the first rain is washed out through first flush pipe the valve is closed to allow the water to enter the down pipe and reach the storage tank.

Semi-automatic type first flush device

Note: The manual/semi automatic systems are simple and widely recommended however they rely on the user both being at home and prepared to go out into the rain to operate the device.

FILTER UNIT: A filter unit is a container or chamber filled with filter media such as coarse sand, charcoal, coconut fibre, pebbles and gravels, to remove the debris and dirt from water. The container is provided with a perforated bottom to allow the passage of filtered water. The height of filter chamber is kept at least one foot above the filter media to provide hydro-static head for filtration. It should also be provided if the water is used for recharging ground water aquifer through functional well/bore-well/ hand-pump/ tube-well. The filter unit consists of three parts:

- Container: Made of concrete, brick masonry, PVC, galvanised iron sheet or ferro-cement etc.
- Perforated plate: Made from a non-corroding material i.e. steel, PVC etc., with 1 cm diameter holes.
- Filter Media: It normally comprises of following layers :

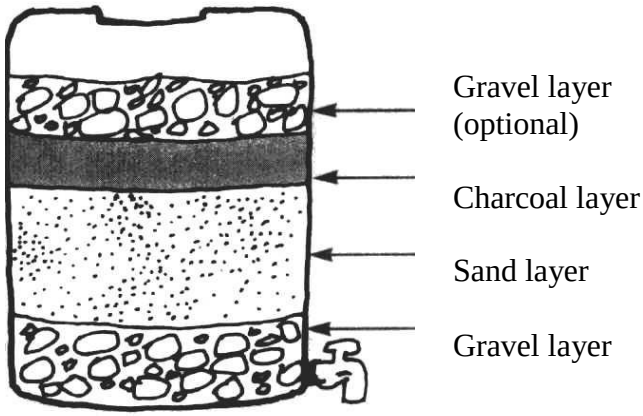
Layer 1:	Sand	- fine to medium
Layer 2:	Gravel	- 4 to l6 mm
Layer 3:	Gravel/pebbles bed	- 16 mm to 50 mm

3.7 FILTERS

When the water is stored human consumption, filtration and disinfection of water are necessary to remove suspended pollutants from collected rainwater by providing a filter unit in the conduit system before water is stored and shall be placed after first flush device. Another simple way of filtering the debris and dust particles that came from the roof along with rainwater is to use a fine cloth as filter media. The cloth, in 2 or 3 layers, can be tied to the top of a bucket or vessel with perforations at the bottom. Depending upon the filter media used and its arrangements, filters commonly used in rain water harvesting system are as under:

3.7.1 CHARCOAL WATER FILTER

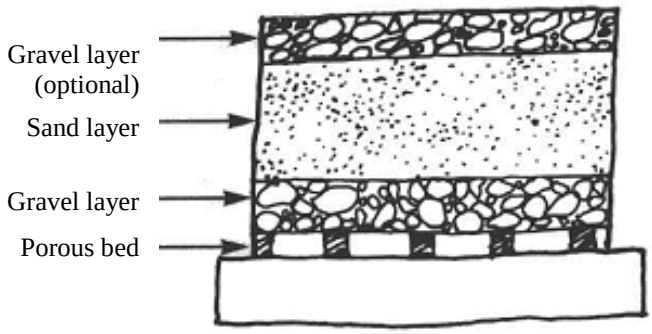
A simple charcoal filter can be made in a drum or an earthen pot. The filter media comprises of gravel, sand and charcoal. This filter is more suitable for roof top rainwater harvesting system for direct storage from individual houses.



Composition of a charcoal filter

3.7.2 SAND FILTERS

In these filters commonly available sand is used as filter media. Sand filters are easy and less expensive to construct. These filters are quite effective for removal of micro-organisms and turbidity (suspended particles like silt and clay). The container of sand filters can be either PVC, concrete, ferro-cement tanks or it can be provided underground in a pit lined with masonry. In these filter, filter media are placed as shown in figure below:



3.7.2.1 THE DESIGN OF FILTER BED AND THE SPECIFICATION OF GRAVEL AND SAND: The filter media of inverted sand filter basically consists of a gravel bed overlain by a sand layer. The specifications for gravel bed and the sand layer are as under:

A) Gravel bed: It consists of 4 to 5 layers of gravel of various sizes as below:

Layer number from top	Size of gravel (mm)	Thickness of layer (cms)
1	2 – 5	7.5 – 10.0
2	5 – 12	7.5 – 10.0
3	15 – 20	10.0
4	20 – 38	10.0
5	38 – 65	10.0

- Gravel shall be non flaky free from clay, organic impurities, shells etc.

- Naturally available rounded gravels are more preferred.
- Specific gravity shall be more than 2.5.

B) Sand layer: Over a gravel bed a coarse sand layer of 50 to 75 cm thick is provided.

- Sand should be hard free from clay, dust, roots, organic materials etc.
- Effective size = 0.45 to 0.70 mm
- Silica content > 90%
- Lime content < 2%
- Specific gravity – 2.55 to 2.65

3.7.2.2 DESIGN OF SAND FILTER

A) Filter bed area: Area of sand filter bed is designed to cater the critical runoff flow rate. Normally the rate of filtration of filter bed is considered 4 to 5 m^3/m^2/hour. The typical design of filter is enumerated as under:

Suppose filter is to be designed for a catchment area of 200 sq.m. Peak rainfall intensity of area is 80 mm/hour. Runoff coefficient of the catchment is 1.0.

First calculate the peak runoff rate from the catchment
Peak runoff rate = peak intensity of rain fall x catchment area x runoff coefficient

Therefore, Peak runoff rate	= 200 x 0.08 x 1.0 = 16 m^3/hour
Assuming, Rate of filtration	= 5 m^3/hour
Area of filter bed required	= Peak runoff ÷ Rate of filtration
	= 16 ÷ 5 = 3.2 m^2

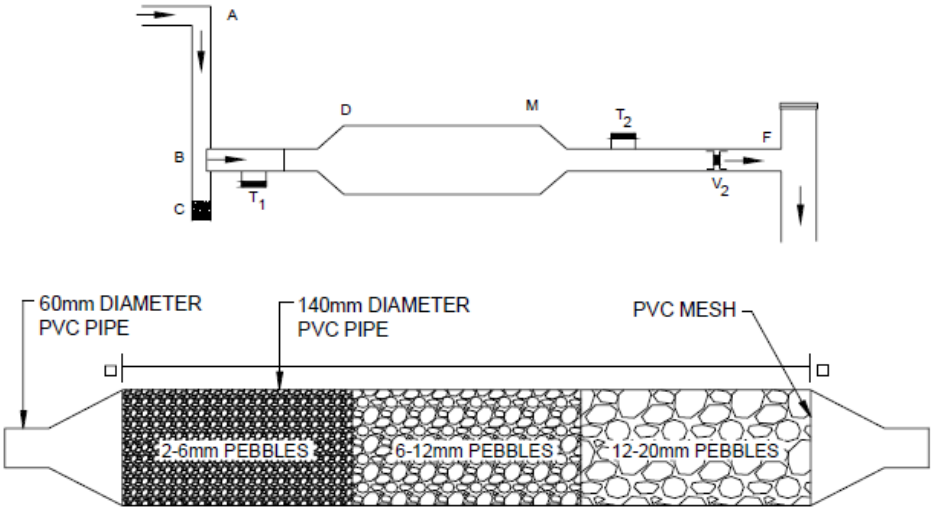
Provide filter bed of 2 m x 1.6 m size
Normally, ratio of length to width of filter bed is kept as 1.25.

B) Height/Depth of filter unit: The depth of the container is normally kept at least one foot above the top of the filter media to provide the required hydro-static head for filtration.

Note: These filters are commonly used for recharging ground water. Sand filters are also used for removing silt from the harvested water for recharging functional tube-well/hand pump/ dug-well.

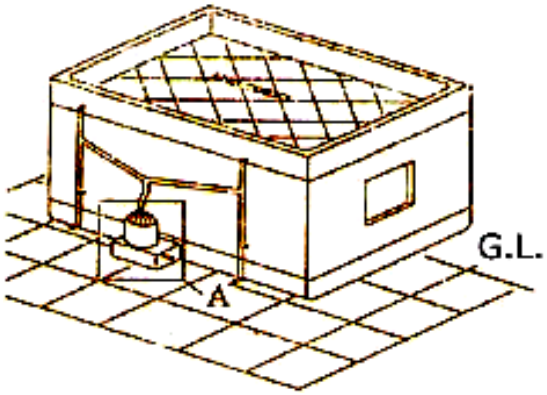
3.7.3 DEWAS FILTERS

These are the filters design and widely used for filtering roof top rain water in the Dewas area of Madhya Pradesh for recharging service wells. The filter consists of a PVC pipe 140 mm dia and 1.2 m long. There are three chambers, the 1st purification chamber has pebbles varying between 2 to 6 mm, the second chamber has slightly larger pebbles between 6 to 12 mm, and the third chamber has the largest 12 to 20 mm pebbles. There is a mesh at the out flow site through which clean water flows out after passing through the three chambers.



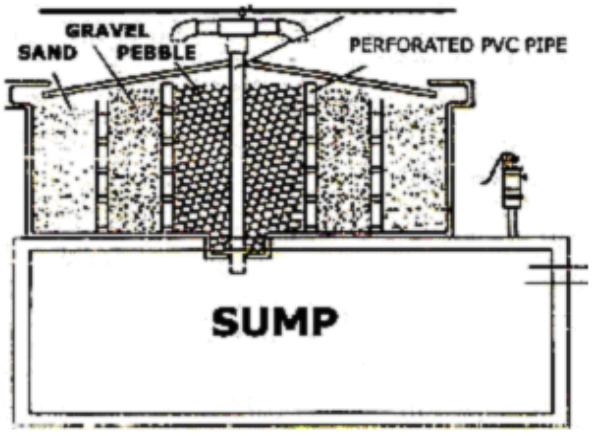
Note: These filters are the suitable for recharging ground water through functional bore-well/hand pump in the roof top rainwater harvesting systems, where the quantity of harvested water is limited.

3.7.4 FILTER FOR LARGE ROOFTOPS



When the rainwater is harvested from a large rooftop area for direct storage, filtering unit with high filtration rate is required particularly for high intensity rainfall. A system is designed with three concentric circular chambers in which the outer chamber is filled with sand, the middle one with coarse aggregate the inner-most layer with pebbles. This way the area of filtration is increased for sand, in relation to coarse aggregate and pebbles to achieve overall higher rate of filtration. Rainwater reaches the centre core and is collected in the storage tank/sump.

Note: These filters are mainly used in the roof top rainwater harvesting systems with direct storage, where the roof area is large with heavy intensity rainfall of short duration.



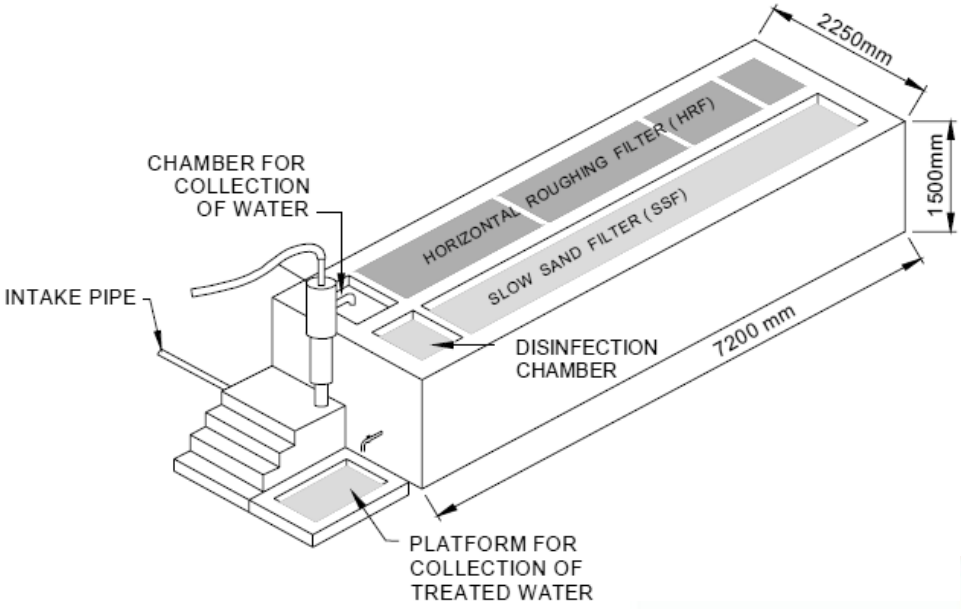
Details of filter for large rooftops

3.7.5 HORIZONTAL ROUGHENING FILTER AND SLOW SAND FILTER

This is one of the most effective filters used for purification of water in coastal areas of Orissa. It consists of two filters – (a) horizontal roughening filter (HRF) and (b) slow sand filter (SSF). The water is first passed through the HRF and then through SSF.

(a) HRF acts as a physical filter and is applied to retain solid matter through filter material like gravel and coarse sand that successively decrease in size from 25mm to 4mm. The bulk of solids in the incoming water are separated by this coarse filter media or HRF. The filter channel consists of three uniform compartments, the first packed with broken bricks, the second with coarse sand followed by fine sand in the third compartment. At every outlet and inlet point of the channel, fine graded mesh is implanted to prevent entry of finer material into the sump. The length of each channel varies accordingly to the nature of the site selected for the sump.

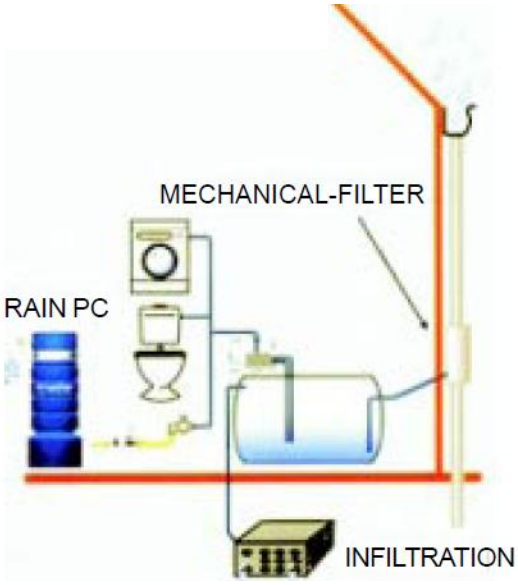
(b) SSF is primarily a biological filter used to kill microbes in the water through filter material fine sand in a channel of size one sqm in cross section and eight metre in length, laid across the tank embankment. The water after passing through SSF is stored in a sump from which water can be supplied through pipe line or can be extracted through hand pump.



3.7.6 RAIN WATER PURIFICATION CENTRE

This filter popularly known as Rain PC developed by three Netherlands based companies is used for conversion of rain water to drinking water. It is made of ultra violet resistant poly-ethylene housing and cover, stainless steel rods and bolts, a nickel-brass valve and an adapter for maintaining constant volume.

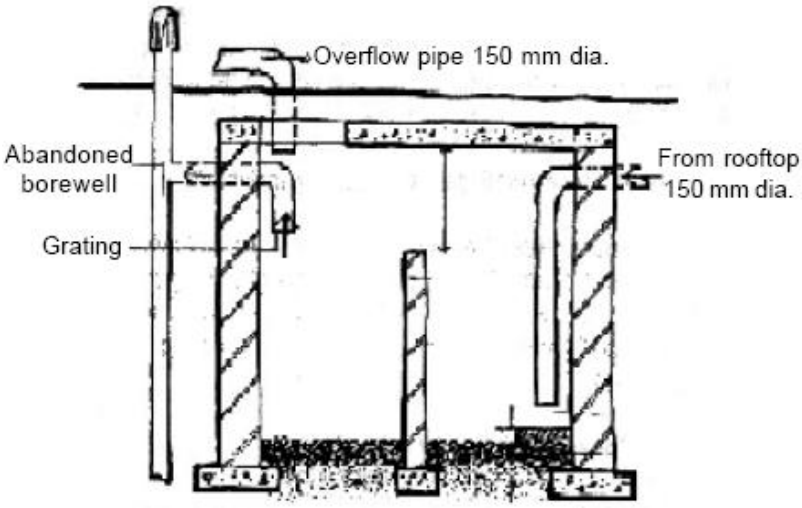
This filter can effectively remove E-coli and other bacteria from water using Xenotex-A and active carbon cartridges along with ultra membrane filtration



modules. This filter is easy to operate and maintain and needs no power. This operates at low gravity pressure and maintains nearly constant volume irrespective of water pressure. The system is capable of providing a constant flow of about 40 litre of rain water per hour. The Xenotex- A and activated carbon cartridges processes up to 20,000 liters of water and can be regenerated up to 10 times.

3.8 STORAGE/ OR SETTLEMENT TANK

If the collected rainwater is used for recharging ground water reserve, it should be passed through a retention/ settlement tank before it enters the aquifer. The passage of water through settlement tank is essential firstly to remove suspended material i.e. silt and other floating impurities from the water and to also act as a buffer in the system. In case of excess rainfall, the rate of recharge, especially of bore wells, may not match the rate of rainfall. In such situations, settlement tank holds the excess amount of water till it is soaked up by the recharge structure.



A settlement tank is like an ordinary storage container having provisions for in flow (bringing water from the catchment), outflow (carrying water to the recharge well) and overflow. Any container with adequate capacity of storage can be used as settlement tank. It can be either underground or over ground type.

- Over ground tanks, beside masonry and concrete tanks, pre-fabricated, PVC or ferro-cement tanks can be used. Pre-fabricated tanks are easy to install, compared to masonry and concrete tanks.
- Underground tank, are normally masonry and concrete tanks. These tanks may have an unpaved bottom surface to allow standing water to percolate through soil.

3.8.1 DESIGN OF STORAGE TANK

The quantity of water stored in a water harvesting system depends on the size of the catchment area and the size of the storage tank. The storage tank has to be designed according to the water requirements, rain fall and catchment availability. Design parameters for storage tanks are:

- Average annual rainfall
- Size of the catchment
- Drinking water requirement

Suppose, the system has to be designed for meeting drinking water requirement of a 5 member family living in a building with a roof top area of 100 sq.m. Average annual rainfall in the region is 611 mm. Daily drinking water requirement per person is 10 litres.

First calculate the max. amount of rain fall that can be harvested from the roof top :

Area of the catchment (A)	= 100 sq.m
Average annual rainfall are (R)	= 611 mm
Run of co-efficient (C)	= 0.85
Annual water harvesting from 100 sq. m roof	= A x R x C
	= 100 x 0.6 x 0.85
	= 51 m^3 (51000 litres)

The tank capacity has to be designed for the dry period, i.e. the period between the two consecutive rainy seasons. With a monsoon extending over 4 months, the dry season is of 245 days.

Drinking water requirement for the family (dry season) = 245 x 5 x 10 = 12250 litres

As a safety factor the tank should be built 20% larger than the required i.e. 14,700 litres. This tank can meet the basic drinking water requirement of a small family for the dry period.

3.8.2 DESIGN OF SETTLEMENT TANKS

The de-silting tank also acts as buffer tank. Therefore, it is designed to retain a certain amount of rainfall for percolation through recharge facilities. This minimum capacity is mainly required due to rate of recharge may not be comparable with the rate of runoff. The capacity of the tank should be enough to retain the runoff occurring during peak rainfall intensity. Normally, the settlement tank is designed to retain runoff from at least 15 minutes rainfall of peak intensity. For designing the optimum capacity of the tank, following aspects are considered

- Size of the catchment
- Intensity of rain fall
- Settlement/detention tank
- Rate of recharge

Suppose the following data is available:

Area of rooftop catchment (A)	= 100 sq.m
Peak rainfall in 15 min. (r)	= 25 mm (0.025 m)
Runoff coefficient (C)	= 0.85
Then, capacity of settlement tank	= A x r x C
	= 100 x 0.025 x 0.85
	= 2.125 cu. m. (2,125 litres)

3.9 HARVESTING WATER AS SURFACE RUNOFF

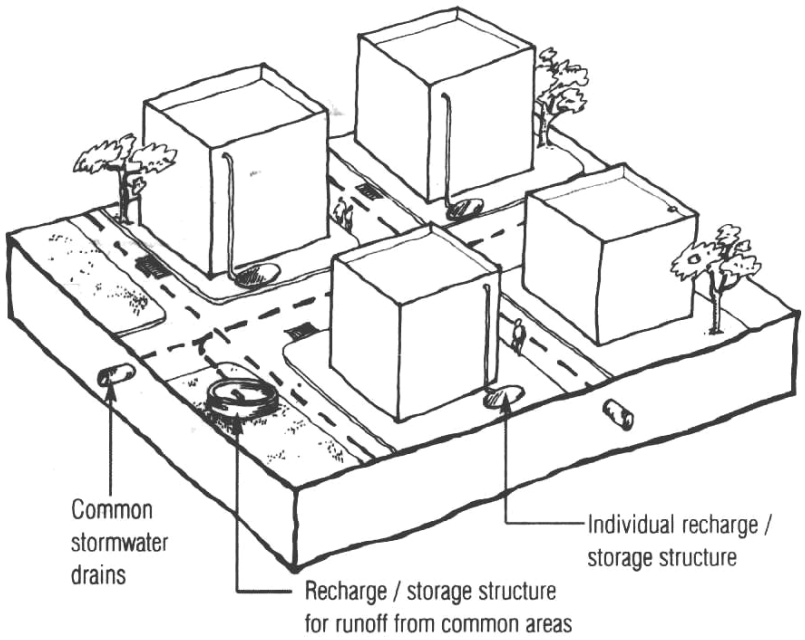
During heavy rainfall, it is very difficult to collect, store and preserve the excess water that goes waste or unutilized in absence of suitable pre-installed mechanism for its effective use.The rainfall runoff flowing from the roads and open grounds is substantial during rains and often creates the water logging and the drainage system under stress in the urban areas.

This water if conserved and utilized properly for recharging the ground water reservoir may bring much needed relief to the water scarcity areas of the city.

A scheme suitable for artificial recharge in urban area is prepared by CGWB and is successfully implemented and operated at Nagpur Municipal Corporation ground. In this scheme about 15000 sq. m of residential catchment was intercepted and runoff generated was diverted into the specially constructed recharge well in the public garden. The runoff water was filtered silt free by providing a filter pit. Number of such locations can be identified within city areas where such structure may be constructed to provide a sustainable ground water based water supply in the city. This will also ensure sustainability of ground water during the peak demand period of summer.

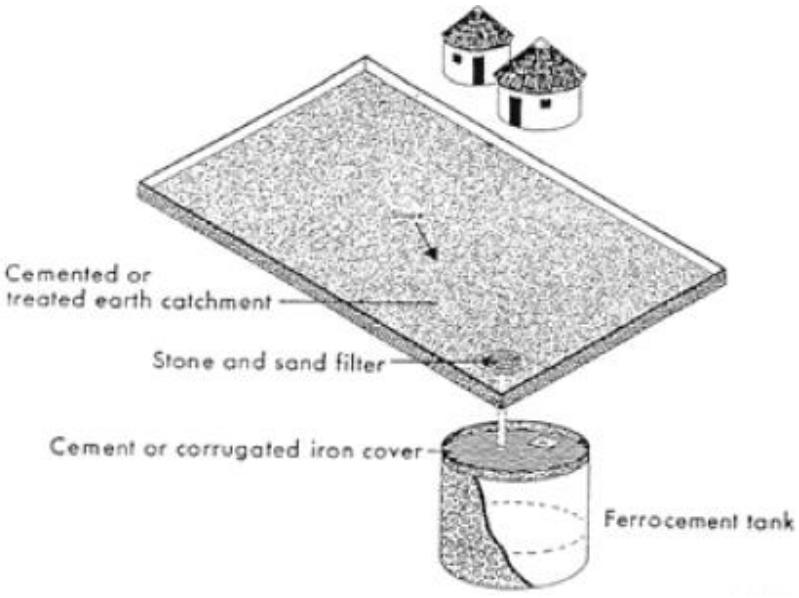
3.9.1 COMMUNITY LEVEL WATER HARVESTING SCHEME

To control the total amount of runoff received by a large-scale system, the catchment can be subdivided into smaller parts. A community level water harvesting schemes illustrated in figure shows how the runoff from individual houses can be dealt with at the building-level itself, while remaining runoff from the storm water drain (which drains water from roads and open areas) can be harvested by constructing recharge structures in common areas.



3.9.2 LAND SURFACE CATCHMENTS

Rainwater harvesting using ground or land surface catchment areas can be a simple way of collecting rainwater. Compared to rooftop catchment techniques, ground catchment techniques provide more opportunity for collecting water from a larger surface area. By retaining the flows (including flood flows) of small creeks and streams in small storage reservoirs (on surface or underground)



created by low cost (e.g., earthen) dams, this technology can meet water demands during dry periods. There is a possibility of high rates of water loss due to infiltration into the ground, and because of the often marginal quality of the water collected, this technique is mainly suitable for storing water for agricultural purposes.

3.9.3 COLLECTION OF STORMWATER IN URBANISED CATCHMENTS

The surface runoff collected in storm water ponds/reservoirs from urban areas is subject to a wide variety of contaminants. Keeping these catchments clean is of primary importance, and hence the cost of water pollution control can be considerable.

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CHAPTER – 4 GROUND WATER RECHARGE

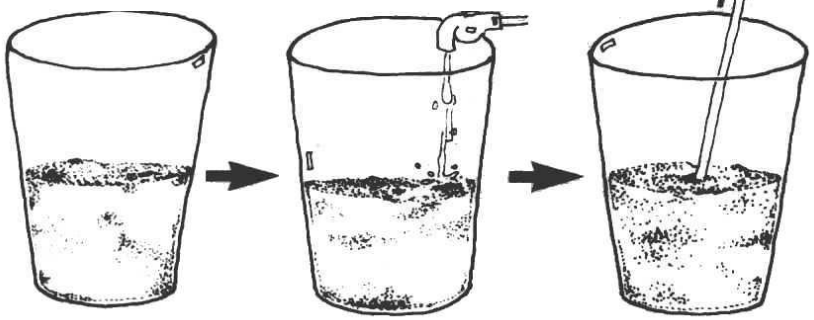
Contrary to the popular belief, ground water reserves are not in the form of lakes or streams of water inside the ground. Water in the ground is stored in the interstices of soil or rock that forms the earth, which are called ground water aquifers. Below a certain depth in the ground, the earth is saturated and this is referred as ground water level, the depth of which varies from few meters to hundreds of meter from place to place. The ground water extracted is replenished by the annual monsoon rain.

4.1 GENERAL

When rain falls on the earth surface, some amount of water is absorbed by the ground surface. Absorbed water percolates through the soil and moves downwards under the effect of gravity. When this percolated water reaches the permeable layers (aquifers) in the zone of saturation, it gets stored in the interstices of the soil/rock and constitutes groundwater source. Groundwater aquifers are formed over many years, as percolation from successive rains joins the existing groundwater. The soil or rock formations in earth that contain water are called ground water aquifers. Below a certain depth in the ground, the earth is saturated (saturation is a state in which all the free spaces or interstices are filled with water). This level is referred as the groundwater level. This level may be just below the ground level or may be hundred metres below ground level.

When water moves through the soil, it is said to be infiltrating, i.e. it gets filtered in the process of passing through the pores of the soil. Therefore, ground water is normally free from suspended impurities, bacterial contamination and organic impurities.

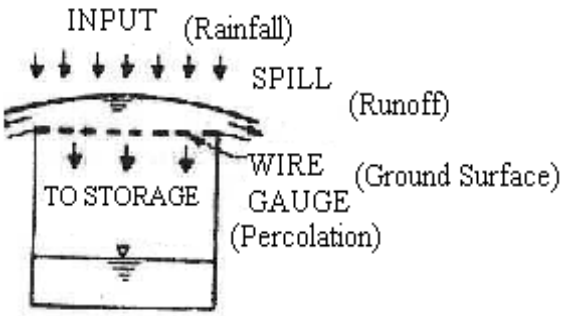
Nature of the ground water is illustrated as:



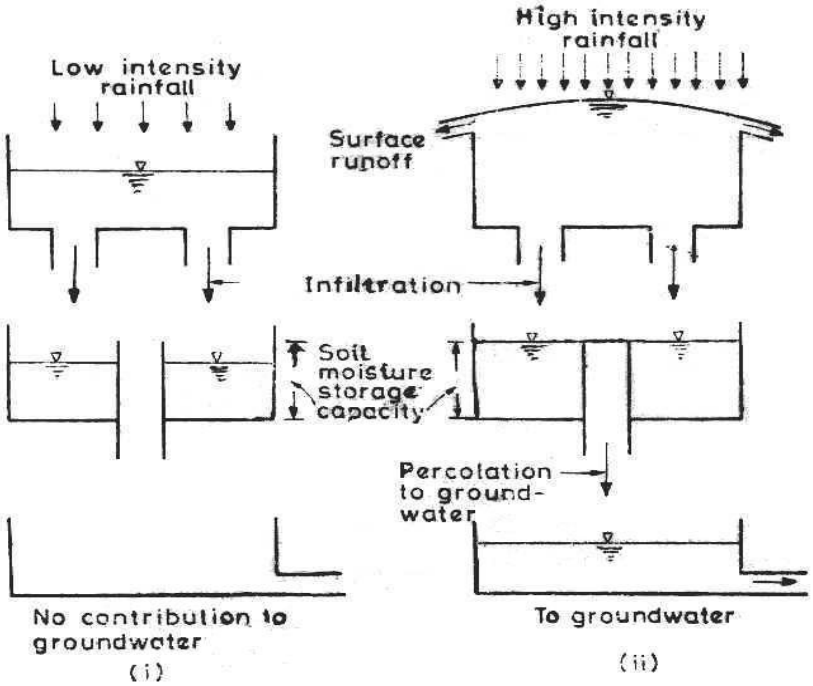
Sand filled in a glass… ..holds water … .. and yields it too.

4.2 NATURAL RECHARGE OF GROUND WATER

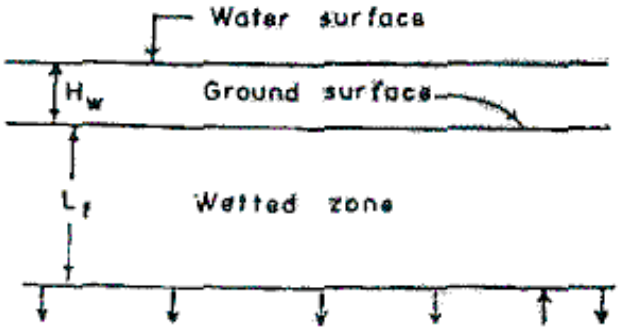
When the water is applied to the surface of the soil, a part of it seeps in to the soil. This movement of water through the soil is known as infiltration, and is a primary process of natural recharge of ground water. This process can be easily understood through a simple analogy. Consider a small container covered with wire gauze. When water is poured over the gauze, a part of it will go into the container and part overflows.



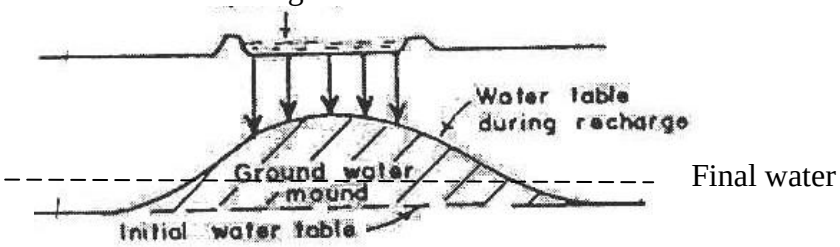
Infiltrated water may contribute to increase in soil moisture only or may also contribute for charging the ground water reserve. It depends upon the intensity and duration of the rainfall as illustrated in a self-explanatory figure.



When the rainfall of adequate intensity and duration occurs, as soon as the top surface gets wetted, the wetted front moves downward under the effect of gravity and joins the existing ground water reserve. With continuous percolation of water, *a ground water mound* is formed in the water table, which grows with time, causing rise in water table. With cessation of percolation/infiltration, water mound levels out giving rise to final water table. This recharge process is illustrated in the figures below:

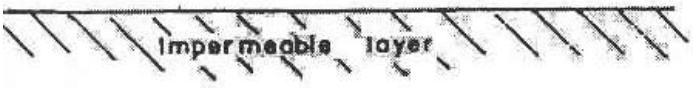


Recharge area



Final water

Unconfined aquifer



Note: Percolation will cause recharge of ground water reserve only when the rainfall is of adequate duration and intensity i.e. infiltrated/ percolated water is more than that required for wetting of soil in the zone of aeration.

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4.3 FACTORS AFFECTING NATURAL RECHARGE

The natural recharge of unconfined aquifer takes place through infiltration of the rainwater through a topsoil surface and then its downward movement i.e. percolation, through the soil in the zone of aeration, till it joins existing ground water table.

For the unconfined aquifer having pervious soil in the zone of aeration, rate of recharge will depend on the following factors provided rainfall is of adequate intensity and duration:

- The type of top surface soil, i.e. sand, silt or clay, its texture, structure & permeability affect the infiltration rate i.e. a maximum rate at which a given formation can absorb water. Loose permeable, sandy soils have higher infiltration capacity than well-compacted sand. Sandy soil is having higher infiltration capacity compare to silty or clayey soil.

  The infiltration capacity of a formation/soil is high when it is dry i.e. at the beginning of rainfall and then it decreases with time as the soil saturates, till it attains final steady rate.

- Surface at entry, i.e. top surface of the soil at entry point, if the pores are open the infiltration rate will be higher compare to when top pores are clogged with fines particles.

- Presence of porous and highly permeable formation in the zone of aeration will permit higher percolation rate i.e. the rate at which the water is able to move downward through the soil. When the soil occurs in the layers the overall permeability of the soil layers will determine the effective rate of percolation.

- Quality of water, i.e. impurities in the infiltrating water, particularly in suspension form, affects the rate of infiltration. The turbidity of water, especially the clay and colloid content blocks the fine pores in the soil thus reducing infiltration capacity.

4.4 GROUNDWATER DEPLETION

When the extraction of groundwater is *excessive* compared to natural replenishment it leads to an imbalance in the groundwater reserves, causing depletion/lowering of the existing groundwater level with time. Depth of water table from the surface increases, and wells becomes dry.

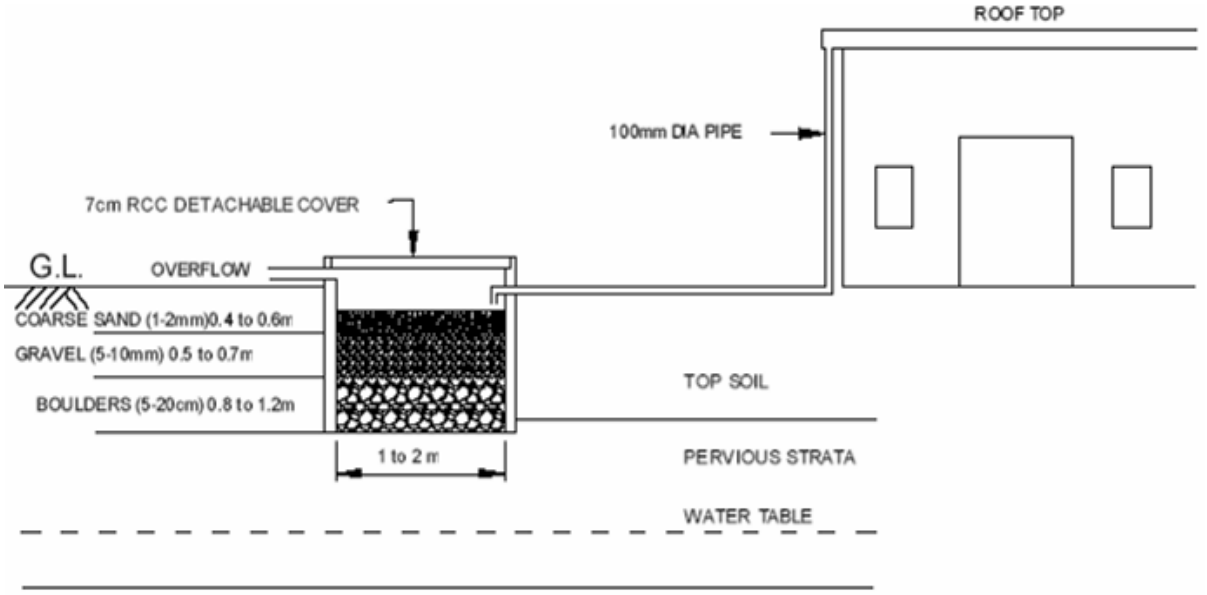
4.5 ARTIFICIAL RECHARGE OF GROUND WATER

The term artificial recharge refers to transfer of surface water to the aquifer by human interference. The natural process of recharging the aquifers is accelerated through percolation of stored or flowing surface water, which otherwise does not percolate into the aquifers. Artificial recharge is also defined as the process by which ground water is augmented at a rate exceeding that under natural condition of replenishment. Therefore, any man- made facility that adds water to an aquifer may be considered as artificial recharge. Natural replenishment of ground water reservoir is a slow process and is often unable to keep pace with the excessive and continued exploitation of ground water resources in various parts of the country. This has resulted in declining ground water levels and depletion of ground water resources in such areas. Artificial recharge efforts are basically aimed at augmentation of the

natural movement of surface water into ground water reservoir through suitable civil construction techniques. Such techniques interrelate and integrate the source water to ground water reservoir and are dependent on the hydro-geological situation of the area concerned. The Various methods of recharging subsurface aquifers are:

4.5.1 THROUGH RECHARGE PIT

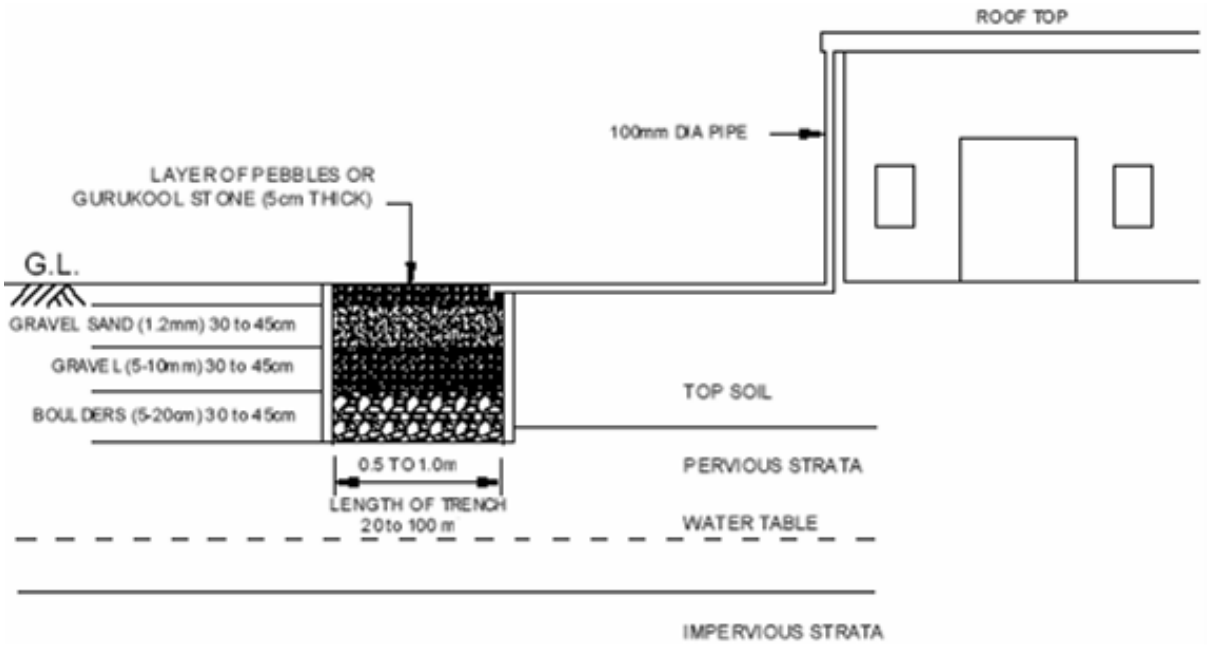
This method is suitable where permeable strata are available at shallow depth. It is adopted for buildings having roof area up to 100 Sq m. Recharge pit of any shape is constructed generally 1- 2 M wide and 2- 3 M deep. The pit is filled with boulders, gravel and sand for filtration of rain water. Water entering in to RWH Structure should be silt free. Top layer of sand filter should be cleaned periodically for better ingression of rain water in to the sub soil. Details are shown in figure below.



Observations: This surface technique is used for recharging shallow aquifers, with thin impervious layer at top. In this technique, collected water, after bypassing impervious layer is applied over a pervious surface in pit/trench to percolate for recharging ground water. However, bottom of these structures is kept above the ground water level to drive the advantages of infiltration. In this technique, few precautions are required to maintain the quality of rainfall run off. For these structures, there is no restriction on the type of catchment from which water is to be harvested that is, both paved and unpaved catchment can be tapped.

4.5.2 THROUGH RECHARGE TRENCH

This method is used where permeable strata is available at shallow depth. It is suitable for buildings having roof top area between 200 To 300 sq. m. In this, trench of 0.5-1.0 m wide, 1-1.5 m deep and of adequate length depending upon roof top area and soil characteristics should be constructed and filled with boulders, gravel and sand as shown in the figure below. Cleaning of filter media should be done periodically.



Observations: It is a continuous trench constructed when permeable strata of adequate thickness are available at shallow depth. The length of the recharge trench is decided as per the amount of runoff expected. The collected water from the rooftop is diverted into the trench through a drainpipe. Water to be recharged, should be silt free. For recharging silt-laden water it should be either pass through the separate settlement chamber or by providing inverted filter in the trench. For providing inverted filter, trench is filled with boulders and pebbles at the bottom followed by gravel and then sand at the top. The top of the trench may be cover with perforated cover. The sand layer in the trench should be removed and replaced every year after rainy season. The recharge trench without filter media should be periodically cleaned of accumulated debris to maintain the intake capacity. In surface runoff methods, these are constructed across the land slope.

4.5.3 DESIGN OF RECHARGE PIT/ TRENCH

The methodology of design of a recharge pit/trench is similar to that for designing a settlement tank. The difference is that the water holding capacity of a recharge pit/trench is less than its gross volume when it is filled with porous material for providing inverted filter. A factor of loose density (voids ratio) of the media has to be applied to the equation.

Using the same method as used for design of settlement tank:

Area of rooftop catchment (A)	= 100 sq.m.
Peak rainfall in 15 min. (r)	= 25 mm (0.025 m)
Runoff coefficient (C)	= 0.85
Voids ratio (D)	= 0.5 (assumed)
Required capacity of recharge tank	= A x r x C/D
	= (100 x 0.025 x 0.85)/0.5
	= 4.25 cu. m. (4,250 litres)

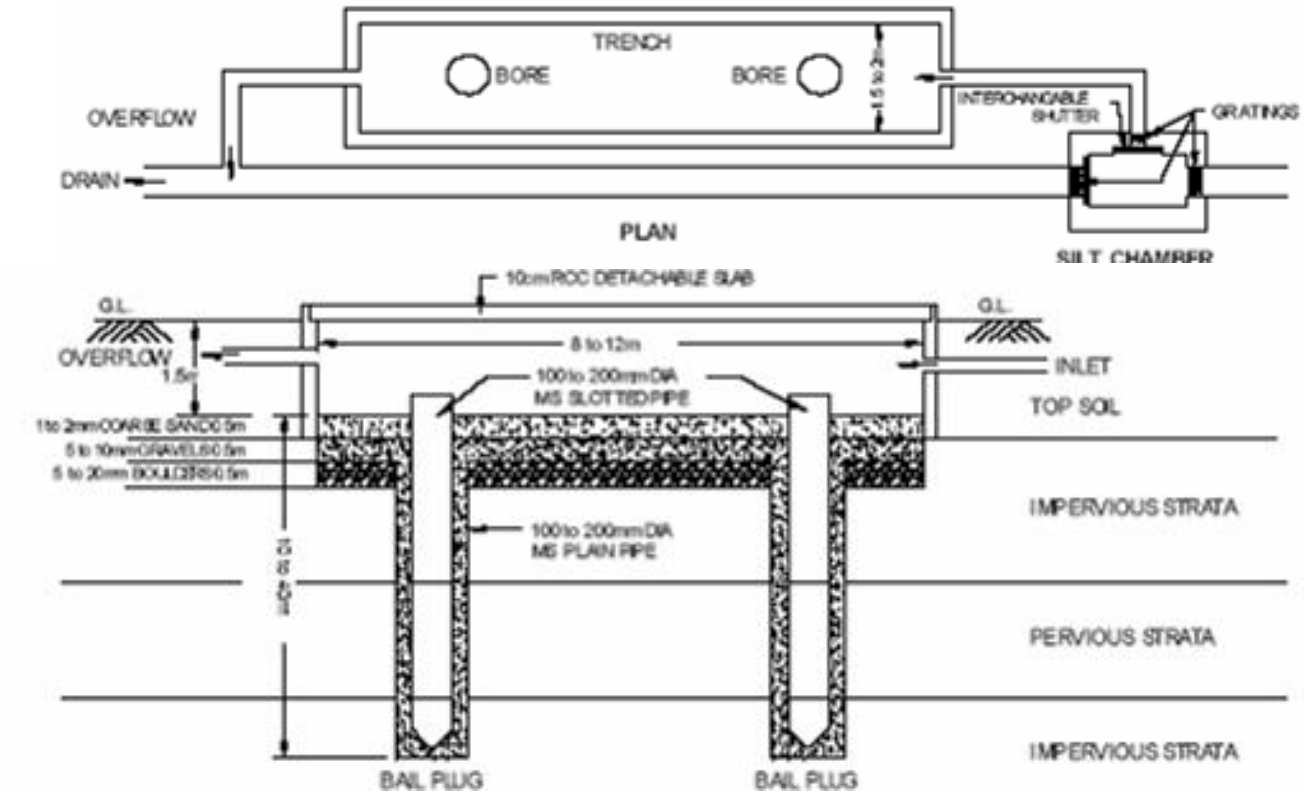
The voids ratio of the filler material varies with the kind of material used, but for the commonly used materials like brickbats, pebbles and gravel, a voids ratio of 0.5 may be assumed.

In designing a recharge trench, the length of the trench is an important factor. Once the required capacity is calculated as illustrated above, length can be calculated by considering a fixed depth and width.

Note: In terms of the recharge rates, recharge pit/trenches are relatively less effective since the soil strata at depth of about 1.5 metres is less permeable. To enhance the recharge rate soak-aways (borehole) can be provided at the bottom of the pit/trench.

4.5.4 RECHARGE TRENCH WITH BORE

This method is used where sub-soil is impervious and large quantity of roof water/ surface run off is available. In this, trench is made 1.5-3 M wide and 10-30 M length depending upon water availability. Wells Of 150- 300 mm. dia meter and 3-5 M deep (Below pervious layer) are constructed in the trench. No. of wells to be dug are decided in accordance to water availability and rate of ingression. Trench Is filled with filtration media as shown in figure below. A suitable silt chamber is also inserted with grating for water diverting arrangements as shown in the figure.

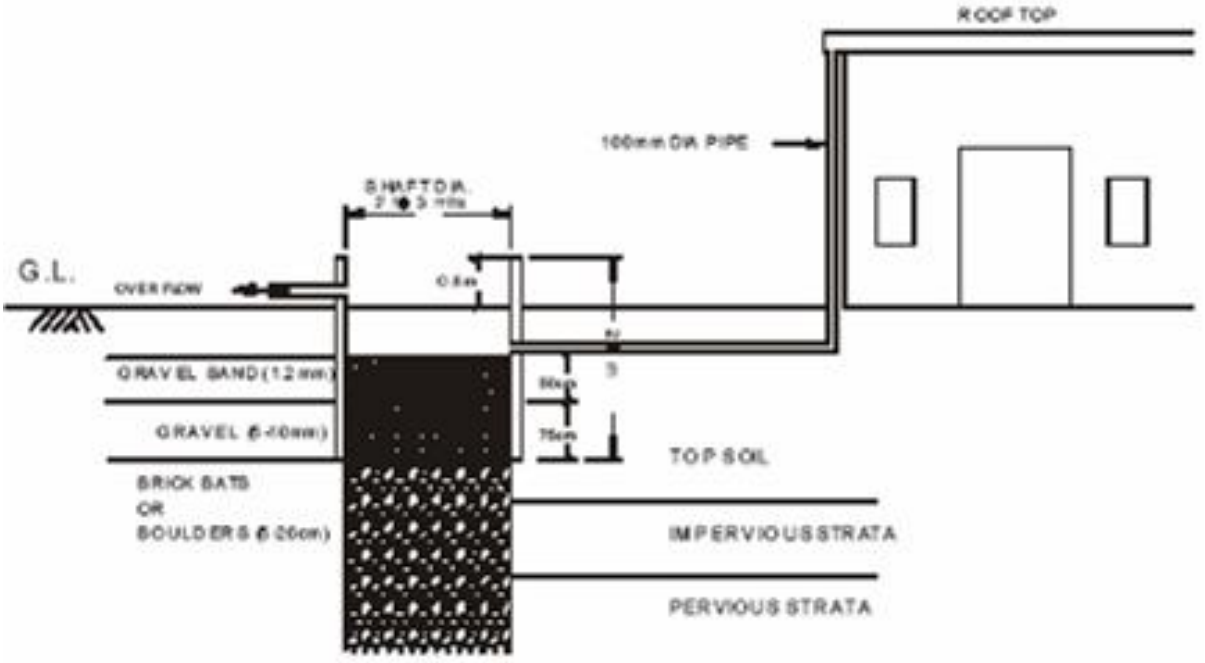


Observations: This sub-surface technique is used where permeable sandy strata exists within 3 to 5 meter below ground level and up to the water level under unconfined conditions, and when the large quantity of runoff water is available within a short period of heavy rainfall for recharge. In this technique, sump i.e. pit/trough is used to store the runoff water in the filter media for subsequent recharge to ground water through a specially constructed boreholes i.e. soak-aways. A soak-away is a bored hole of up to 30 cm diameter drilled in the ground to a depth of 3 to 10 metres depending upon the nature of soil. If the soil is clayey, the bore should be dug to a depth till a reasonably sandy stratum is reached. The depth of the bore is kept at least 3 to 5 meters above/below the water level as required.

The borehole can be left unlined if a stable soil formation like clay is present. In unstable formations like sand, the soak-away should be lined with a perforated PVC/MS pipe to prevent collapse of the vertical sides. In both the cases, the soak-away are filled up with a filter media like brickbats. Depending upon the size of catchment area and quantity of runoff sump provided at the top of soak-away can be either a small pit or a trough and accordingly recharging technique are known as recharge pit with soak-away or recharge trough with soak-away. ***In this technique a sump provided at the top of the soak-away acts as a buffer. For removing suspended impurities inverted filter is provided at the bottom of a sump.***

4.5.2 RECHARGE THROUGH SHAFTS

This method is suitable where shallow aquifer is located below clayey surface. It is used for buildings having roof top area between 2000-5000 sq.m. Recharge shaft of diameter, 0.5-3 M and 10-15 M deep is excavated mechanically. The shaft should end in impermeable strata. The shaft should be filled with boulders, gravel and sand for filtration of recharge water. Top sand layer should be cleaned periodically. Recharge shaft should be constructed 10-15 M away from the buildings for the safety of the buildings. The details are given in figure below.

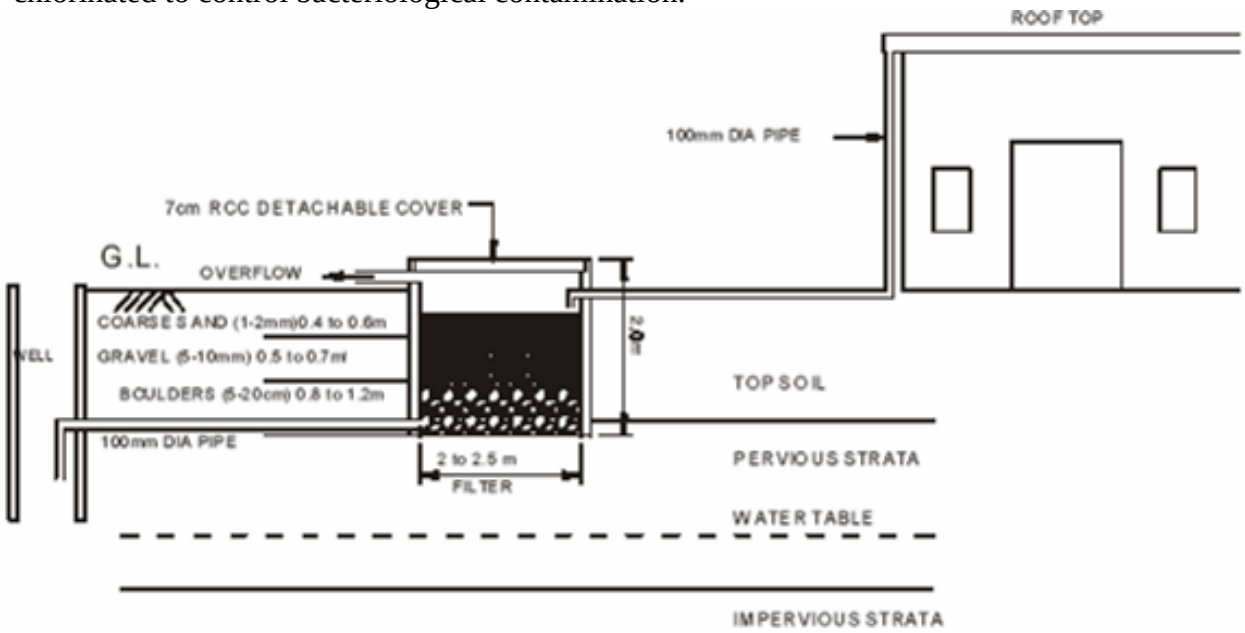


Observations: It is a surface technique used for recharging shallow aquifers, located below clayey surface at a depth of 10 to 15 m. In upper portion of 1 or 2 m depth, the brick masonry work is carried out for the stability of the structure. Diameter of shaft varies depending upon the availability of water to be recharged. Shaft is dug to a depth so that it ends in permeable strata i.e. sand. Bottom of the shaft shall be kept above the water table. It should be cleaned regularly by scraping top sand layer and refilling it periodically. In this technique, shaft itself acts as buffer tank and the suspended/floating impurities are removed through inverted filter action of filled porous material.

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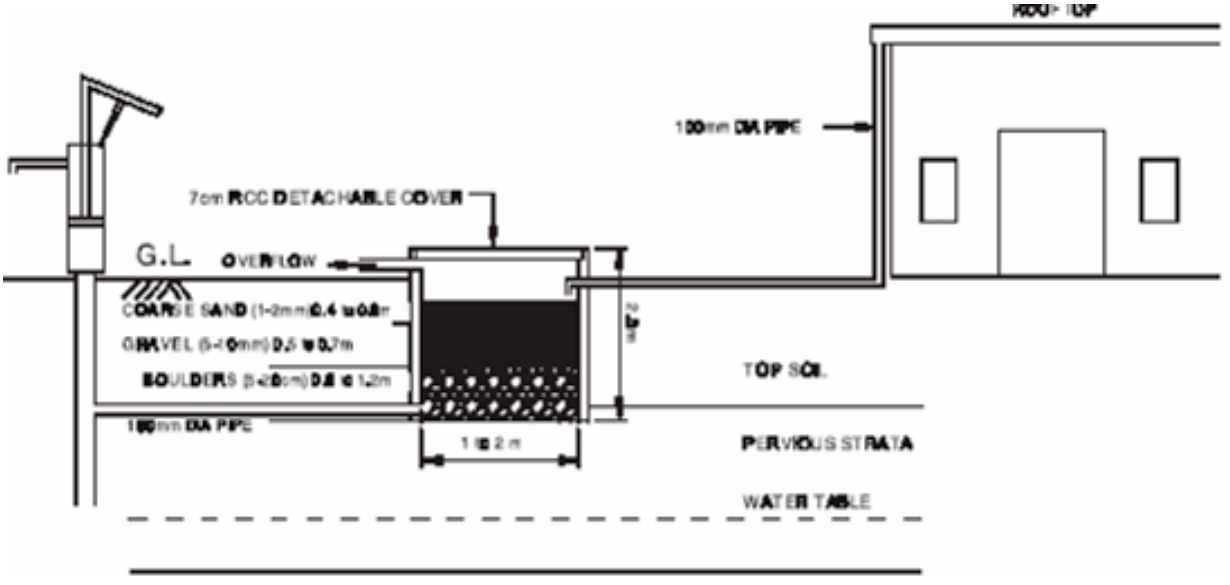
4.5.3 RECHARGE THROUGH ABANDONED DUG-WELL/OPEN WELL

In this method, a dry/ unused dug well can be used as a recharge structure. It is suitable for buildings having a roof top area more then 100 sq. m. Recharge water is guided through a pipe of 100 mm to the bottom of the well as shown in figure below. Well cleaning and de-silting is imperative before using it. Recharge water guided should be silt free, otherwise filter should be provided as shown in the figure. Well should be cleaned periodically and chlorinated to control bacteriological contamination.



4.5.4 RECHARGE THROUGH ABANDONED HAND PUMP

In this, an abandoned hand pump is used for as recharge structure. It is suitable for building having roof top area up to 150 Sq m. Roof top rain water is fed to the hand pump through 100 mm dia. pipe as shown in figure below. Water fed in the Rain Water Harvesting Structure should be silt free. Water from first rain should be diverted to drain through suitable arrangement. If Water is not clear then filter should be provided.

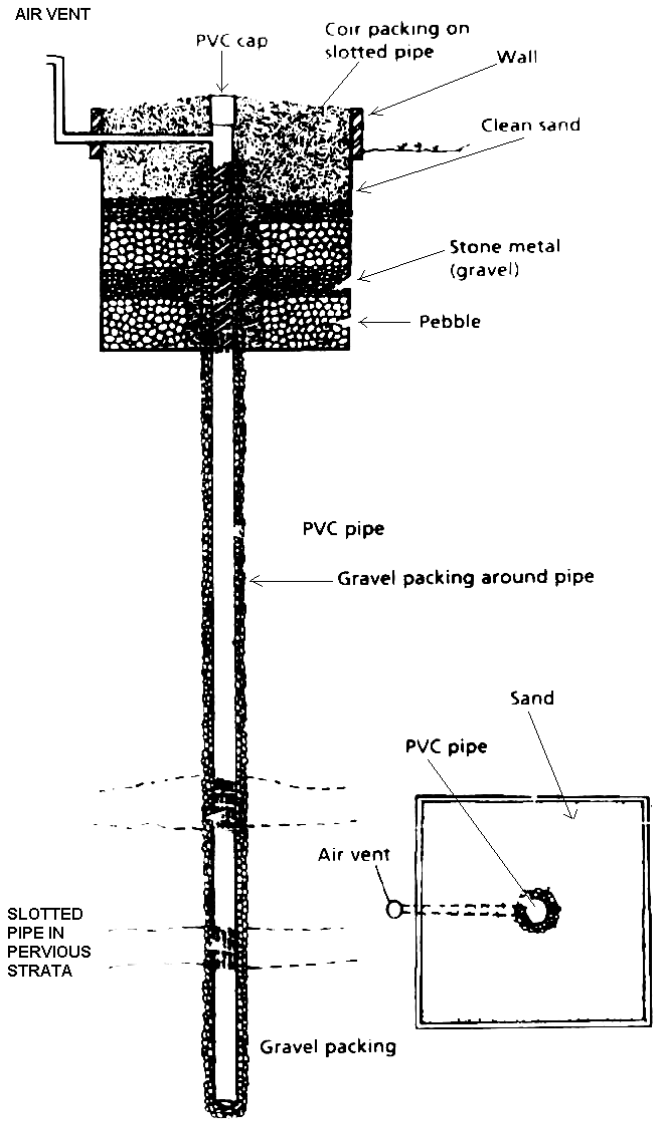


4.5.5 RECHARGE TUBE-WELL (INJECTION WELL)

This sub-surface technique is used in the area where aquifer is very deep i.e. more than 20 meters and/or when an impervious layer is present in the zone of aeration or where confined aquifer is to be recharged. In this method collected rainwater is diverted to a recharge well for recharging the ground water source directly under gravity flow. Due to direct charging of surface water, the recharge is fast and the absorption and transit losses are less.

For injection well, a tube-well of *50 cm* diameter is drilled, to the depth about 5-15 m below the water table in the area. A 20 cm dia perforated/ slotted casing is provided against the aquifers in the tube-well. The annular space between the tube-well and the casing pipe is filled with the good gravel and developed with a compressor till it gives clear water. To provide adequate percolation time and to stop the suspended solids from entering recharge tube well, a chamber with filter mechanism is provided at the top as under.

- A chamber equivalent to settlement tank capacity is constructed with the tube well at the centre.
- This chamber is fitted with small, rounded boulders, stone chips and sand in layers with boulders at the bottom and sand at the top.
- The top 1 m of the casing assembly in this chamber is filled with the sand. The top of the casing pipe is provided with a cap, which is kept about 600 mm below in the sand bed to prevent suspended material from entering the well.



Recharge tube well (injection well)

In order to release the air present in the casing assembly during the percolation process, the air vent is provided through a 50-75 mm diameter pipe connected to the recharging tube-well within the top 600 mm through a reducer Tee. The air-releasing pipe is extended above the ground.

Most of the suspended materials are filtered out when rainwater passes through the sand. The second sand filter surrounding the slotted section of the well and at the top prevents the

remaining suspended material entering the well. Beyond this, there is coir wrapping as a final protective filter before water enters the well. The recharge rate gradually decreases due to settling of silt at the top. Every year, after the rainy season, about 1 m of the sand of the filter bed shall be replaced, and the well is developed with a compressor. The chamber is designed similar to settlement tank with taking into account, porosity of filter material.

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CHAPTER – 5 WATER QUALITY CONTROL

This is the most important task to ensure that the water collected for direct storage or for recharging the groundwater shall be free from any pollutants/toxic substances that might be added to rainwater from the atmosphere or the catchment. The polluted water, if directly used for consumption, would have an immediate impact on health and if recharged into the ground-water, would cause long-term problems of aquifer pollution. The water collected from roof top after filtration can be used directly for lawn watering, washing etc. But if this water has to be used directly for drinking purpose, then quality of water must be ascertained before use. The water used for drinking should comply with the provisions of IS-10500:1991 i.e. Indian Standard "DRINKING WATER–SPECIFICATION (First Revision)".

5.1 QUALITY OF RAINWAER

Rainwater is often used for drinking and cooking and hence it is vital that the highest possible quality standards are maintained. Rainwater, unfortunately, often does not meet the World Health Organization (WHO) water quality guidelines. This does not mean that the water is unsafe to drink. It has been found that a favourable user perception of rainwater quality (not necessarily perfect water quality) makes an enormous difference to the acceptance of RWH as a water supply option. Generally, the chemical quality of rainwater will fall within the WHO guidelines and rarely presents problems. There are two main issues when looking at the quality and health aspects of domestic rainwater harvesting systems.

5.2 BACTERIOLOGICAL WATER QUALITY

Rainwater can become contaminated by faeces entering the tank from the catchment area. It is advised that

- The catchment surface should always be kept clean.
- Storage tanks should be designed to protect the water from contamination by leaves, dust, insects, vermin and other industrial or agricultural pollutants.
- Incoming water should be filtered or screened, or allowed to settle to take out foreign matter.
- Water, which is relatively clean, on entry to the tank, will usually improve in quality if allowed to be inside the tank for some time.
- Bacteria entering the tank will die off rapidly if the water is relatively clean.
- Algae will grow inside a tank if sufficient sunlight is available for photosynthesis. Keeping a tank dark and in a shady spot will prevent algae growth and also keep the water cool.
- As already mentioned, there are a number of ways of diverting the dirty 'first flush' water away from the storage tank.
- The area surrounding a RWH structure should be kept in good sanitary condition, fenced off to prevent animals fouling the area or children playing around the tank. Any pools of water gathering around the tank should be drained and filled.

5.3 INSECT VECTORS

There is a need to prevent insect vectors from breeding inside the tank. In areas where malaria is prevalent, providing water tanks without any care for preventing insect breeding can cause more problems than it solves. All tanks should be sealed to prevent insects from entering. Mosquito-proof screens should be fitted to all openings. Some practitioners recommend the use of 1 to 2 teaspoons of household kerosene in a tank of water, which provides a film to prevent mosquitoes settling on the water.

5.4 QUALITY CONTROL REQUIREMENT OF HARVESTED WATER

Irrespective of harvesting method, certain quality control measures are required for ensuring the quality of harvested water. Harvesting contaminated water may make the stored water unsuitable for drinking purpose or may cause irreversible contamination of ground water aquifer. To ensure the quality of harvested water following measures are generally adopted.

□ **For recharge of ground water through surface technique**, no elaborate or special quality measures are required since, infiltration through soil itself causes:

- Removal of suspended particles
- Removal of pathogenic bacteria
- Retention to large extent of heavy metals, pesticides and radio-nuclides by absorption and ion exchange on the surface of clay materials.
- Decomposition of organic matters.
- Conversion of soluble inorganic compounds to insoluble compound.

Note: It shall be ensured that the collection surface does not cause chemical contamination of harvested water.

□ **For direct storage or recharge of ground water through sub surface techniques**, it is essential to ensure that the water is free from air pollutions and surface contaminations i.e. dust, silt, debris, organic impurities etc. Rainwater collected from *rooftops* contains air pollutants and surface contaminations, which can be prevented to a large extent by:

- Flushing off runoff from the first 10-20 minutes of rainfall
- Arresting debris carried by the water from the rooftop like leaves, plastic bags and paper pieces by the grill at the terrace outlet
- Removing remaining contaminants like silt and dirt by sedimentation (settlement) and filtration.

Note: Water to be used for drinking purpose should not be collected from roof with damaged asbestos sheets or from roofs covered with asphalt and lead flashing or lead based paints as the poisonous lead contamination may occur in the collected water.

5.4.1 FOR RAINWATER COLLECTED FROM GROUND SURFACE

Following actions are usually taken:

- Cleaning of surface of vegetation, organic and loose materials.
- Improving the vegetation management by changing ground cover if required.

- Making the surface smooth by mechanical compaction or surface binding treatment.
- Checking that the surface is free from all such chemical and organic material, which may cause chemical/bacterial contamination of harvested water.

5.5 DISINFECTING WATER

This is the process of killing the disease-causing micro organisms present in the water through disinfecting water either by boiling the water in a vessel before consuming it or by dissolving bleaching power in required quantity to the water stored in the tank. For disinfection, the general dosage recommended is 10 milligrams of bleaching powder containing 25% of free chlorine per litre of water. This meets the required standard of ***2.5 milligrams of chlorine per litre of water***. After Adding the bleaching power, the water shall be stirred thoroughly for even distribution of the disinfectant. The water should be kept for about 30 minutes after adding bleaching powder before it is ready for use. The quantity of bleaching power to be added for disinfecting water for different water depths in the storage tank is shown as:

Storage capacity of tank (L)	**Recommended Dosage of bleaching powder (in grams)**			
	Full Tank	**Tank three fourth(3/4) full**	**Tank half (1/2) full**	**Tank one fourth(1/4) full**
5000	50	37.5	25	12.5
6000	60	45	30	15
7000	70	52.5	35	17.5
8000	80	60	40	20
9000	90	67.5	45	22.5
10000	100	75	50	25

Note: Slow sand filtration will remove any harmful organisms. Also a recently developed technique called SODIS (Solar Disinfections) utilizes plastic bottles, which are filled with water and placed in the sun for one full day. The back of the bottle is painted black.

5.6 PRECAUTIONS TO BE TAKEN

The rain water is one of purest form of water and does not contain suspended/dissolved impurities. However when this water is collected through rain water harvesting, it gets contaminated because of contact with roof surface/ground and some of the impurities get mixed in it. These impurities are required to be removed before collecting the harvested rain water in storage tank or diverting it or recharging of ground water aquifers. Following precautions should be taken to ensure quality of harvested water:

S. No.	**Surface through which rainwater falls/passes**	**Precautions for ensuring water quality**
1	At the catchment level	• Keeping the catchment clean • Using gratings to trap debris at the catchment itself • Paving the catchment with ceramic tiles, stone tiles or other such non-erosive materials
2	At the conduit level	• Provision of first-flush to drain runoff from initial spell of rain for 10 to 15 minutes
3	Before recharging	• Allowing for sedimentation of the water • Filtering the water

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CONCLUSION

In the past, it was believed that rainwater was pure and could be consumed without pre-treatment. While this may be true in some areas that are relatively unpolluted, rainwater collected in many locations contains impurities. Particularly during the last three decades, "acid rain" has affected the quality of the collected water, to the point where it now usually requires treatment.

Given due treatment to such kind of impurities reaching at ground surface in the form of rainfall, which further establishes this fact that sustaining and recharging the groundwater along with judicious use of the limited fresh water resources is the need of the hour. If sufficient measures are not taken up immediately, we will face a crisis which will be detrimental to the very survival of mankind. Efficient management of water resources and education about judicious utilization of water resources along with measures of harnessing, recharging and maintaining the quality of water and water bodies has to be taken up on war footing. One of the most logical steps towards this goal would be acknowledging the importance of rainwater harvesting. This should not only encompass rooftop rainwater harvesting but also storm-water harvesting systems. Storm water harvesting is yet to be acknowledged as a better alternative over rooftop water harvesting. One of the major hurdles in storm water harvesting is the poor state of storm water drain systems in India.

There is another school of thought arguing against Water Harvesting despite the growing awareness about the benefits of water harvesting that roof water harvesting systems (RWHS) are not alternative to public systems in urban and rural areas of regions receiving low rainfall. It says that very little empirical work has been done to assess the impact of roof water harvesting on urban and rural water supply situation. Experts point out that the scope of water harvesting is tremendous. An improvement in water conservation can also provide the foundation for a multitude of other problems. However, they opine that there needs to be a change in the governance of water systems - *a decentralized system of water management is required*.

A planned approach is hence needed in order to fully utilize the potential of rainwater to adequately meet our water requirements. Hence, an equal and positive thrust is needed in developing and encouraging both the types of water harvesting systems. We have to catch water in every possible way and every possible place it falls.

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QUALITY POLICY

To develop safe, modern and cost effective Railway technology complying with Statutory and Regulatory requirements, through excellence in Research, Designs & Standards and Continual improvements in Quality Management System to cater to growing demand of passenger and freight traffic on the Railways.

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OUR OBJECTIVE

To upgrade Maintenance
Technologies and Methodologies
and achieve improvement in
productivity and performance
of all Railway assets and manpower
which inter-alia would cover
Reliability, Availability,
and Utilisation.

If you have any suggestion & comments on content of handbook, please write to us :

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