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EXPERIMENTAL INVESTIGATION ON ROOF TOP RAIN WATER HARVESTING IN A COLLEGE BUILDING

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Bachelor of Engineering in **School of Building and Environment**

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Abstract: It is high time now to fall for surface water usage instead of going for ground water resources to meet human demand on needs. Considered the main source of surface water, rainwater is deemed more or less as fresh, the cost of collecting rainwater too is very low. Rivers and canals, lakes and wetlands, ponds and dry wells. All are potential catchments to hold direct rainwater and its indirect source, the run-off storm water. The closed tanks also doubly work as settlement tanks to innately clearing the contaminated water to some extent. Pebbles, gravels, sand and charcoal. All available in abundance work great as natural filter for cleaning the rainwater before usage. Hence keeping an eye on the rapidly increasing day-to-day demand for water among fast growing human population, there lies a great opportunity to harvest rainwater to meet a potential scarcity and avoid destruction of the normal groundwater table level. The boon of rainwater harvesting is the unused or extra water which remains after using by the human settlements. It can be sent down to the aquifer to recharge the groundwater level too, so we are going to design an effective plan by collecting of rain water and recharging it, when there is shortage runoff water. Present paper majorly focuses on "ROOF TOP RAIN

WATER HARVESTING" (RRWH) of the study area as "E.S COLLEGE OF NURSING "campus, Villupuram (near Vikravandi). The result analysis shows that the present RWH system is having the storage **32, 53,000** liters per year. The primary objectives are to fulfill the scarcity of the water in campus and then use it for the domestic purpose in college campus.

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Water is the most precious assent on earth. It is one of the five basic elements of nature, the other being our air, soil, fire and space. Water is essential for human's survival and the rainfall is the largest sources for human consumption. The rainwater runs on the surface areas like paved or unpaved land areas and thus gets settled on the surface are called surface water. Some part of rainwater gets trapped in underground and thus forming groundwater table. The saving and utilizing of rainwater for domestic purpose and future uses is otherwise called RAINWATER HARVESTING, (RWH) system is a technique that involves in direct collection of rainwater from the catchment area (rooftop) and then it is transported to the filtration system and later, it is stored in an open well.

1.2 RAINWATER HARVESTING

Rainwater is obtained from the rainfall in a particular place. The runoff portion of a rainwater flows over a land surface reaches to larger water bodies therefore it forms seas, oceans, lakes, ponds and rivers. The rainwater is a major component of water cycle and is responsible for depositing most of the fresh water on the earth. It provides a suitable condition for many types of ecosystems, as well as water for hydroelectric power plants and crop irrigation. The **pH** of rainwater is **5.6**, which contains acidic in nature and it does not directly affect the living being, because the acid in rainwater is too diluted to have adverse effect. Most of the rainwater are clean and fresh which falls directly from clouds and it gets polluted due to air pollution and thus forms yellow dust rain or acid rain (sulphuric and nitric acids), they are called **weak acid**. It contains **vitamin B12** which is a water-soluble vitamin that is involved in the metabolism of every cell of the human body and it is cofactor in DNA synthesis, and in both fatty acid and amino acid metabolism. The rooftops provide the necessary platform for collecting rain water and storing it in a suitable tank or open well. The harvesting of rainwater is otherwise called rain water harvesting system. The rainwater is usually free from harmful chemicals, which makes it ideal for irrigation purpose. Another important. Advantage is that it reduces demand for potable water. The environmental benefits of rainwater harvesting that it can reduce storm water runoff from a property.

RAINWATER HARVESTING is a technology used to collect, convey and store rain for later use from relatively clean surfaces such as a roof, land surface or rock catchment. The water is generally stored in a rainwater tank or directed to recharge groundwater. Rainwater infiltration is another aspect of rainwater harvesting playing an important role in storm water management and in the replenishment of the groundwater levels. Rainwater harvesting has been practiced for over 4,000 years throughout the world, traditionally in arid and semi-arid areas, and has provided drinking water, domestic water and water for livestock and small irrigation. Today, rainwater harvesting has gained much on significance as a modern, water-saving and simple technology. The **pH** of **drinking good water** is **7** (Neutral).

The practice of collecting rainwater from rainfall events can be classified into two broad categories:

- Surface runoff harvesting (Land based)
- Roof top harvesting (Roof based)

1.2.1 SURFACE RUNOFF HARVESTING:

Collection of rainwater from the surface area such as paved areas, unpaved areas. This runoff could be caught and used for recharging aquifer by adopting appropriate methods. The components of surface runoff are direct runoff, Base flow and Ground water runoff.

1.2.2 ROOF TOP HARVESTING:

Roof top rainwater harvesting system refers to collecting rainwater runoff from roof top surfaces like open roof area, open terrace area, which usually provides a much cleaner source of water that can be also used for drinking and domestic purposes. The components of roof top harvesting are direct collection of rainwater from catchment area and transporting to the storage system.

1.3 MAJOR USES OF RAINWATER HARVESTING

- The rainwater can be used for DRINKING and COOKING purpose and therefore rainwater is safe to drink by installing a filtration system, boiling or distilling the water.
- It is even used for BATHING and LAUNDRY. The use of harvested rainwater for this purpose could reduce municipal water use over 40%.
- Another usage of rainwater in FLUSHING TOILETS which will lead to save the metro water. The 27% of metro water is used in flushing toilet purpose. Use collected rain water Instead of metro water to flush toilet by keeping a six-gallon bucket of rainwater. The six gallon of rainwater is equal to 22.7 liters.
- The uses of rainwater will reduce the WATER BILLS.
- The rainwater can be used for WATERING LAWNS, GARDENS and HOUSEPLANTS. Rainwater is used in watering can to water plants in indoor and outdoor gardens or also it can attach rainwater storage tank directly to automatic irrigation system.

1.4 PAVED AND UNPAVED AREA

The PAVED AREA covered in pavements having a hard surface, as of concrete or asphalt such as rooftop paved road, driveway.

The runoff coefficient of paved area = 0.7

The 70% of rainwater can be harvested in the paved area.

The UNPAVED AREA is not covered in pavements which has no hard surface of concrete or asphalt such as green surface area (lawn surface)

The runoff coefficient of unpaved area = 0.2

The 20% of rainwater can be harvested in the unpaved area.

1.5 SURFACE WATER

It is formed above the earth's surface. The surface water can be contaminated by rainwater. The runoff from home (rooftop), roads, driveway and parking lot. Thus, the amount of excessive rainwater gets settled in large water bodies such as rivers, lake, and wetland. The surface water is an important natural resource used for many purposes like drinking water, public uses and irrigation. **pH** of surface water is **6.5** – **8.5** (either good or bad).

1.6 GROUNDWATER

The water present beneath earth's surface in soil pore spaces and in the fractures of rock formations. A unit of rock or an unconsolidated deposit is called an aquifer and can yield a usable quantity of water, and when there is a rainfall the sum of the rainwater gets settled under the soil pores which leads in the formations of underground water table. The **pH** of ground water is **8.5** (very good).

1.7 CATCHMENT AREA

The surface that receives rainfall directly is the catchment of rainwater harvesting system. It may be terrace, courtyard, or paved or unpaved open ground. The terrace may be flat RCC/stone roof or sloping roof. Therefore, the catchment is the area, which actually contributes rainwater to the harvesting system.

1.8 FILTRATION SYSTEM

Filters are used for treatment of water to effectively remove turbidity, color and microorganisms. After first flushing of rainfall, water should pass through filters. A gravel, sand and mesh filter are designed and placed on top of the storage tank. This filter is very important in keeping the rainwater in the storage tank clean. It removes silt, dust, leaves and other organic matter from entering the storage tank. The filter media should be cleaned daily after every rainfall event. Clogged filters prevent rainwater from easily entering the storage tank and the filter may overflow. The sand or gravel media should be taken out and washed before it is replaced in the filter.

1.9 TYPES OF FILTERS

- Mesh filter
- Sand gravel filter
- Charcoal filter
- PVC – pipe filter
- Dual intensity filter

1.10 OBJECTIVES OF THE STUDY

- To prove that rooftop rainwater harvesting system can harvest **80%** of rainwater in rooftop or open terrace.
- To study the types of **filters** used in the rooftop rainwater harvesting system.
- To determine the huge quantity of **32, 53, 000 liters** of rainwater is harvested **per year** in the college building.

1.11 PROPOSED SYSTEM

In this rooftop harvesting system, we have used leaf – shedding rain head (mesh filter) and first flush diverters is used to separate the first flow of contaminate rainwater and after the first flow contaminate rainwater is separated. The continuous flow of freshwater is transported to the main filtration system (Dual intensity filter) from the main filter it is delivered to open well (Storage) by pipes.

2.1 GENERAL

CHAPTER 2 LITERATURE SURVEY

The various literatures related to the roof top rainwater harvesting system were reviewed to get an idea about experimental study. And methodology spells out the sequential order and ways to execute the experimental study

Sekhar Raghavan, Director, rain center **(2006)** has conducted "RAINWATER HARVESTING" – Need, Relevance and Importance of Groundwater Recharge in Urban Areas with Particular Reference to Coastal Cities. And published Paper on "INTERNATIONAL WORKSHOP ON RAINWATER HARVESTING" held in Kandy, Srilanka. Rainwater Harvesting (RWH) is the only way to sustain both our surface and sub-soil sources in a large portion of the earth. RWH has two broad aspects collection of rainwater for immediate use and groundwater recharge (GWR). This paper deals mostly with the need, relevance and importance of GWR, particularly in urban areas where, due to urbanization rainwater can be harvested only as groundwater. To sustain and improve the exploitable quantity and quality of groundwater source. Most of the cities not only in India but the world over depends on the groundwater source to meet their potable and/or non-potable needs and is therefore necessary to sustain them. To mitigate urban floods. Most of us are aware that urban flooding is of a recent origin. The two important reasons for it are shrinking of open spaces and indiscriminate paving activity carried out in urban areas by both the state and the society. Rainfall, remaining the same over time, does not find a place either above the soil or below to get collected and hence floods the locality. Only making use of all the floodwaters to recharge the groundwater source can solve this. GWR is an important aspect of Rainwater Harvesting and will have to be preached and practiced in every city around the world for more than one reason. The groundwater source, good or bad, whether it is being exploited or not should be sustained and improved as a source for the future by practicing GWR. Secondly, large quantities of rainwater could be saved through GWR in the bank called Groundwater source, instead of allowing it to runoff and get wasted. Cities, which are not rain starved, could be prevented from becoming concrete deserts by practicing GWR.

Muqeem ahmed.et.al **(2012)** has investigated on "THE ANALYSIS OF GROUNDWATER QUALITY IMPROVEMENT USING RAINWATER HARVESTIN". "A JOURNAL OF AGRICULTURAL RESEARCH". The study was aimed to evaluate the ground water quality technique using the rainwater harvesting which is located in new Delhi. To achieve the main objectives of the study. Groundwater Quality Test Results of February 2011 are arranged and analyzed. Groundwater Samples were collected in the month of November, 2011 (Post-Monsoon period) and analyzed. Groundwater Samples were collected in the month of April 2012, in order to know the changes in the groundwater quality since the rainwater recharge. All the three groundwater quality test results of the JMI were compiled and comparative study was done to reveal the overall impact of rainwater harvesting on groundwater quality of the JMI campus. Analysis of rainwater sample and groundwater sample of the JMI Campus in order to check the impact of rainwater harvesting. Study of the impact of rainwater harvesting on groundwater quality potential of the JMI. The groundwater quality analysis data at pre-installation period of the rainwater harvesting structures at the JMI is collected. Groundwater samples in the Post Monsoon period covering the entire JMI campus area is collected in order to analyses the impact of rainwater harvesting on groundwater quality. Groundwater samples after few months is to know the changes in the groundwater quality since the post-monsoon times. Comparative Study is done of quality of all the three groundwater quality test results in order to ascertain the overall impact of Rainwater Harvesting on groundwater quality of the campus area. It can be concluded that the rainwater recharge improves the quality of groundwater and its quality depends upon the amount of rainwater recharged and the environment of rainwater collection and recharging.

Vikrant a. Patel. et.al **(2013)** have proposed on the "ROOF TOP RAINWATER HARVESTING" (RRWH) at SPSV campus, Visnagar: Gujarat published journal on "INTERNATIONAL JOURNAL OF RESEARCH IN ENGINEERING AND TECHNOLOGY". The method carried out in this project by capturing the rainwater on the rooftop campus building and determination of the use of captured water and determination of collection surface from which the rainwater is collected which is to be used for rainwater harvesting and hence it was finally concluded that the implementation of "Rainwater Harvesting Project" to the campus of S.P.S.V will be best. Approach to fight with present scenario of water scarcity in all aspects, whether it is form financial point of view or from optimum utilization of land surface. By implementation in water harvesting project in S.P.S.V campus we make little noble cause for rainwater conservation which will be beneficial to the student of campus. It may also helpful to campus.

Sagar p. Mali. et.al **(2013)** has studied "POTENTIAL ROOF RAIN WATER HARVESTING". In pirwadi Village of Kolhapur District, Maharashtra and published "JOURNAL OF RESEARCH IN HUMANITIES AND SOCIAL SCIENCE". This research paper include comparison between conventional procedure for adopting the rainwater harvesting method and using geospatial technique. In pirwadi village, the water deficiency situation in hot season can be change in to water adequate situation by adopting the roof rainwater harvesting techniques. The total potential of roof rainwater harvesting is more than enough to satisfy the total annual drinking and cooking requirement of the people in this village. The afore said discussion emphasizes that the rainwater harvesting techniques are proficiently useful to tackle down the water scarcity problem in rural areas.

James madalitsotembo.et.al **(2013)** have investigated "POTENTIAL OF RAINWATER HARVESTING" in urban Zambia. The study was aimed to evaluate the applicability of rainwater harvesting in Zambia. Pilot stations (five) were selected in Lusaka based mainly on catchment/collecting area material (roof), number of users, alternative water sources and affluence or density of residential area. The RWH system that was used in the research for the pilot system was the roof harvesting system. His comprised a collection surface (roof), guttering, storage tanks and first flush. The gutters were designed using the Rational and Manning's formulas. Design of the storage tanks was based on the mass curve analysis. Author have made conclusion that the water which would be harvested from the pilot stations could be used for drinking purposes.

Angelineprabhavath et.al **(2013)** have proposed “RAINWATER HARVESTING” (RWH) and published “INTERNATIONAL JOURNAL OF SCIENTIFIC & ENGINEERING RESEARCH”. Rainwater stored for direct use in above ground or underground sumps / overhead tanks and used directly for flushing, gardening, washing etc. (Rainwater Harvesting) Recharged to ground through recharge pits, dug wells, bore wells, soak pits, recharge trenches, etc. (Ground water recharge) It is no denying 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.

Patil s.s. et.al **(2014)** have investigated on “ROOF TOP HARVESTING (RWH) of Renavi village in Sangli district in Maharashtra”. Published journal on “AFRICAN JOURNAL OF AGRICULTURAL RESEARCH”. A general village survey was carried out to assess the rooftop area of houses; number of houses were collected through personal discussion with beneficiaries and Gram panchayat records. The information related to the geographical location of SANGLI district and monsoon collected from socio- economic review of SANGLI District respectively. For the sake of reliability, the quantitative data was collected from a focus group discussion. Rooftop rainwater harvesting is one of the optimistic and economically viable methods of rainwater harvesting. Rooftop rainwater is allowed to percolate in the ground and become helpful to increase ground water recharging groundwater aquifers. Rainfall data was collected from the Jalja Report. The Renavi village is situated in the Khanapur block in the eastern part of Sangli District, whose annual rainfall is 558 mm (Jalja, 2005). For the present research, the annual rainfall of the year 2005 which was 527 mm have been considered for carrying out potential assessment. The village survey revealed that the Renavi village has 231 houses and total population is 1300.In this 70 Houses are selected for rainwater harvesting purpose. In this study coefficient of runoff and potential of rainwater is calculated Roof top area is measured using the tape used for surveying After that estimated rainwater harvested in liters is calculated using the roof top area. Roof top rain water harvesting measures need to be given priority in the drought prone areas and should be incorporated in the watershed development programs. As illustrated by this case, roof top rain water harvesting measures helps in fulfilling the domestic water need as well improving the ground water level by few meters.

Rudrappashetahalli.et.al **(2015)** have proposed “DESIGN OF ROOFTOP RAINWATER HARVESTING SYSTEM” for The Administrative Block of V.V.C.E, Mysore and published “ENGINEERING JOURNAL VOLUME”. Primarily the current consumption of water in the administrative block of VVCE was studied. This was achieved by taking into account the count of individuals residing in the study area alongside with the per capita consumption. The assessment of the rainfall receptive area was next undertaken. Further, the quality of rainwater collected on the roof top area of the administrative block was analyzed for physio-chemical and biological parameters, by referring to ‘Standard Methods’. Then by applying empirical relationships in the field of rainfall analysis and hydrology. This was then subjected to ascertain cost estimation and eventually the cost benefit was analyzed for the rooftop rainwater harvesting system. The harvested rainwater can be used for non- potable purposes after employing filtration from the designed composite rainwater harvesting unit. When the quality aspects of main source of drinking water is looked into, rainwater harvesting is an economical option to overcome dependency on water supply. Also, the rainwater quality assessment indicates its relatively pollution free, indicating considerably economical treatment. The cost benefit ratio of 1.53 indicates the research as a favorable and viable proposition.

Okareh O.T. et.al **(2015)** has studied "DEVELOPMENT OFRAINWATER HARVESTINGTECHNOLOGY FOR SECURING DOMESTIC WATER SUPPLY" in Ibadan, Nigeria published the journal on "INTERNATIONAL RESEARCH JOURNAL OF ENGINEERING SCIENCE, TECHNOLOGY AND INNOVATION" (IRJESTI). The first stage of the research consisted of planning a research approach in order to develop an idea of rainwater harvesting systems and the methods being adopted in the collection, storage, and usage. Primary and secondary data were collected from relevant sources. Rainfall data for a period of ten (10) year between the periods 1995-2004 was obtained from the Argo climatology, Department of the International Institute of Tropical Agriculture IITA Ibadan. Rainwater harvest system has proven to be an effective intervention for the perennial water shortage at household level in Ibadan city.

Chiemeka onyeka Okoye. et.al **(2015)** has investigated in "OPTIMAL SIZING OF STORAGE TANKS IN DOMESTIC RAINWATER HARVESTING SYSTEMS". And published journal on "SCIENCE DIRECT". This paper proposes an optimization model to determine the optimal tank size of a single residential housing unit for rainwater harvesting and storage First of all mathematical model based on linear programming has been proposed and it is used in the optimal sizing of rainwater storage tank for domestic rainwater harvesting and storage. Then this optimization model can be used to determine the rainwater tank. This model was applied to the case study from Northern Cyprus. Then the experiment of sensitivity analysis was taken. The sensitivity analysis is used to determine the optimum size of tank which is required the drinking purpose. The sensitivity analysis reveals that the optimal tank size increases with the roof area, but decreases with an increase in the discount rate and the unit cost of building the tank. As shown by the case study application, the proposed optimization model is an effective tool that can be used by public authorities or individuals to make feasibility analysis of RWH systems at residential housing units.

3.1 GENERAL CHAPTER 3

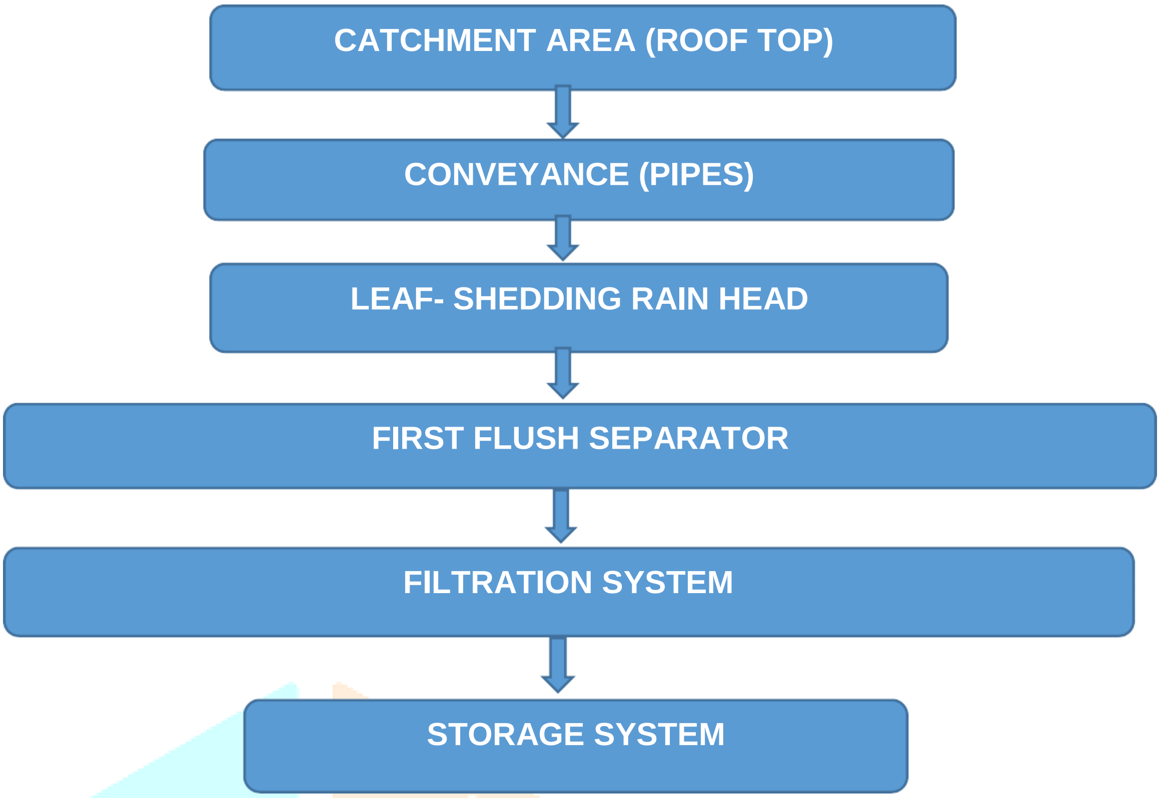
METHODOLOGY

In this roof top rain water harvesting system, the rainwater is collected from the catchment and filtered by using mesh filtration and sand gravel filtration system, later it is stored in open well.

3.2 FILTERS USED

The filters used in this project are leaf-shedding rain head, first flush separators and Dual intensity filter (Rainy filter). The property of these filters is notified below. The following flow chart will be used to explain brief about this project.

3.3 COMPONENTS OF ROOF TOP RAIN WATER HARVESTING SYSTEM



3.3.1 CATCHMENT AREA

The surface that receives rainfall directly is the catchment of rainwater harvesting system. It may be terrace, courtyard, or paved or unpaved open ground. The terrace may be flat RCC/stone roof or sloping roof. Therefore, the catchment is the area, which actually contributes rainwater to the harvesting system. The catchment of water harvesting system is the surface that receives rainfall directly and drains the water system. Any roofing material is acceptable for collecting of water. The effective catchment area and the material used in constructing the catchment surface influence the collection efficiency and water quality. Catchment surfaces and collection devices should be cleaned regularly to remove dust, leaves and bird droppings so as to minimize bacterial contamination and maintain the quality of collected water.

One of the most important components of RWH system is catchment, which is used for holding rainwater. Roof provide an ideal catchment surface for harvesting rainwater. The roof surface may be constructed of many different materials, which include but are not limited to concrete, tiles, galvanized corrugated iron sheets and corrugated plastic. If a building or house with an impermeable roof, which will not allow water to pass through and are resistant to rainwater, if it is installed in the catchment area then it is catchment is available free of charge. Painted roofs are not often used for collecting rainwater but has a nontoxic content and does not cause water pollution. An impermeable roof will yield a high runoff of good quality water that can be used for all domestic purposes.

Fig: 3.3.1 Catchment area

3.3.2 RUNOFF COEFFICIENT

The collection of rainwater is usually represented by runoff coefficient (RC). The runoff coefficient for any catchment is the ratio of the volume of the water that runs off a surface to the volume of rainfall that falls on the surface. A runoff coefficient of 0.8 that the 80% of rainwater will be collected, so the higher the runoff coefficient, the more the rainwater will be collected.

3.3.2.1 PAVED AREA

Area covered in pavements having a hard surface, as of concrete or asphalt such as Roof top paved road, driveway. The runoff coefficient of paved area is **0.7** that 70% of rainwater can be harvested in the paved area.

3.3.2.2 UNPAVED AREA

Area that are not covered in pavements which has no hard surface of concrete or asphalt such as green surface area. The runoff coefficient of unpaved area is **0.2** that 20% of rainwater can be harvested in the unpaved area.

Table 3.3.2 Runoff Coefficient

TYPE	RUNOFF COEFFICIENT
Galvanized iron sheets	0.9
Corrugated metal sheet	0.7 – 0.9
Tiles	0.8 – 0.9
concrete	0.6 – 0.8
Brick pavement	0.5 – 0.6
Rocky natural catchment	0.2 – 0.3
Soil with slope	0.0 – 0.3
Green area	0.05 – 0.2

3.3.2.3 ROOF TOP AREA

Roofed area where catchment area covered with tiles, concrete surface can hold the rainwater of 80% of harvested water in required place. The runoff coefficient of roof top area is 0.8

3.3.3 CONVEYANCE

Rainwater from rooftop should be carried through down take water pipes or drains to storage/harvesting system. Water pipes should be UV resistant (ISI HDPE/PVC pipes) of required capacity. Water from sloping roofs could be caught through gutters and down take pipe. At terraces, mouth of each drain should have wire mesh to restrict floating material. The roof top water collection through delivery system from the roof top catchment usually consists of gutters hanging from the side of the roof sloping towards a down pipe and tank. This delivery system issued to transport the rain water from the rainwater from to the storage reservoir. As much as 90 percent of or more of the rain water collected on the roof will be drained to the storage tank if the gutter and down pipe system is properly fitted and maintained. The water from storage tank is delivered to the treatment unit through delivery pipe system. In delivery system there are uses of pumps to take out water from tank and deliver for many purposes. Again, transportation system is used to deliver the water for the needs. Water are delivered by pumps.

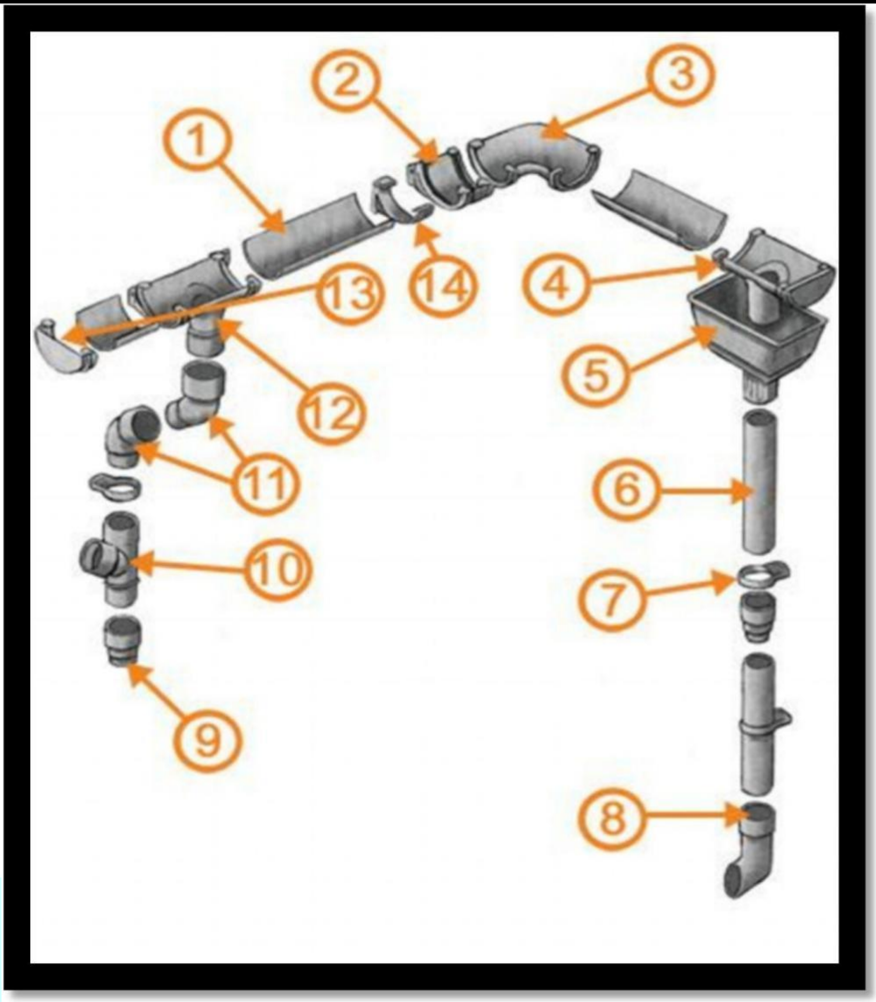


Fig: 3.3.3 Pipes

1. Gutter Available in up to 3m lengths, the guttering must slope gently downwards at least 12mm every 3m towards the RUNNING OUTLET in order to provide effective drainage. It should be fixed at 1m intervals with a GUTTER SUPPORT BRACKET

2. Gutter Union Bracket Connects two GUTTER pieces; some guttering ranges have joints ready incorporated in the design

3. 90° Gutter Angle allows a run of guttering to continue around a corner. A GUTTER SUPPORT BRACKET must be fixed within 150mm on both sides of the angle.

4. Stop End Outlet Sits at the end of a run of guttering to close the pipeline, and let's water out by connecting to the DOWNPIPE. Usually supplied as a 'right' or 'left end', depending on the layout.

5. Hopper Funnel shaped rainwater collector that diverts to a DOWNPIPE. Elaborate cast iron and lead versions are of great significance on many facades of historical buildings. On some old houses, hoppers took out Grey water, but this is not permitted now

6. Downpipe Available in lengths up to 2.5m, it lets water run down to the SHOE. Fixed to the wall with a DOWNPIPE BRACKET

7. Downpipe Bracket Secures a DOWNPIPE to the wall there should be one positioned near the top of the first pipe and then around every meter after that. Two sorts are generally available: the saddle bracket and the barrel clip (shown). The saddle bracket just holds the pipe away from the wall while the barrel clip gives a firmer grip to the pipe and prevents it moving up and down.

8. Shoe Fitted at the base of the DOWNPIPE to change the direction of the flow of water, discharging it horizontally, clear of the wall, into a drain or hard standing which it should be positioned around 40mm above. Cast iron shoes may be decoratively branded with dates or crests.

9. Downpipe Connector allows more than one DOWNPIPE to be connected in series. Cast iron connectors are sometimes decoratively branded. Plastic down pipes may, however, just join by sitting the upper pipe inside the lower, without connectors, which creates a watertight seal.

10. Branch Single branch for joining two DOWNPIPES together, to divert the water from another roof section into the same drain

11. Offset Bends At either a 112.5° (as here) or 92.5° angle, these bends bring the DOWNPIPE close to the wall, ensuring water runs vertically, thus reducing debris build up

12. Running Outlet Provides an outlet to the DOWNPIPE for rainwater along the length of guttering. Unlike a STOP END OUTLET, it connects to a guttering run at both ends

13. External Stop End Closes off a run of guttering.

14. Gutter Support Bracket Attaches the guttering to the facia at 1m intervals.

3.3.3.1 Supporting Collection System.

The harvested water from a catchment area needs to be transported to the storage reservoir or tank through a system of gutters and pipes. The rule of thumb of designing gutter is that 1cm^2 gutter cross section would be constructed for 1m^2 roof surface. Even though several types of delivery systems exist for guttering, commonly used materials for gutters down pipes are galvanized metal and plastic (PVC) pipes, which are readily available in local shops. Apart from that, split bamboo, which is an indigenous product, can also be used for this purpose. A well-designed gutter system can increase the longevity of a house. In this study, PVC pipe was used for making gutter and flushing system while metal net was used as screen, which was placed at the entrance of the water collection system.

LEAF-SHEDDING RAIN HEAD

The rain heads are also known as leaf eaters are a head piece designed to fit at the top of vertical PVC piping. The rain head forms the screened entry point to the top of the pipe work that leads water in to your tank. The rain head at the top of this pipe work is therefore normally used below an open downpipe from your gutter. As water flows onto the head piece, leaves, sticks, insects and the like are deflected allowing only fresh rainwater to pass through. If there are trees in your surroundings or roof capture area, then leaves with no doubt fall or be blown on the area. When there is rainfall the rainwater washes these leaves and sticks as wells as the insects and other matter in area to the down pipes and which potentially end up in tank, so by installing of rain head system in your RWH system can save fresh water to storage tank.

Fig: 3.3.4 Rain head

3.3.3.2 BENEFITS OF RAIN HEAD FILTER

There are many benefits that rain heads provide:

- **Higher Quality Tank Water:** An obvious benefit is that water in your tank will be of a higher quality. This is especially important if you wish to use your rainwater as a potable water supply, in cooking, drinking or watering stock.

- **First-Level Filtration:** Mesh screens on rain heads come with an aperture size of less than 1mm. This means that while they mainly guard against leaves, they also

- work to prevent mosquitoes, insects, vermin and smaller debris from entering your rainwater pipework. This is especially important if your pipework runs underground (in a "wet system" setup), which is prone to sediment build-up.

- **Cost-Effective & Time-Efficient:** Screening water at the entry point to your pipework is a simple and low-cost way to keep leaves and debris out of your water. Gutter guards, which are mesh screens attached to the top of gutters, will also work to keep out leaves and debris. Yet, many aren't as effective and would be much more expensive and time-consuming to implement compared to rain heads.

- **Reduced Tank Maintenance:** Every 2-3 years, you should be inspected your water storage tank for sludge build-up which will need pumping out periodically. Since rain heads filter debris out from your rainwater, this means you won't need to clean your tank as regularly. In this summary, installing rain heads are a simple, inexpensive and effective method to screen your rainwater before it even enters your pipework system. The enormous benefit they bring makes them a valuable addition to have with any rainwater tank purchase.

3.3.4 FIRST FLUSH

First flush is a device used to flush off the water received in first shower. The first shower of rains needs to be flushed-off to avoid contaminating storable/rechargeable water by the probable contaminants of the atmosphere and the catchment roof. It will also help in cleaning of silt and other material deposited on roof during dry seasons Provisions of first rain separator should be made at outlet of each drainpipe.

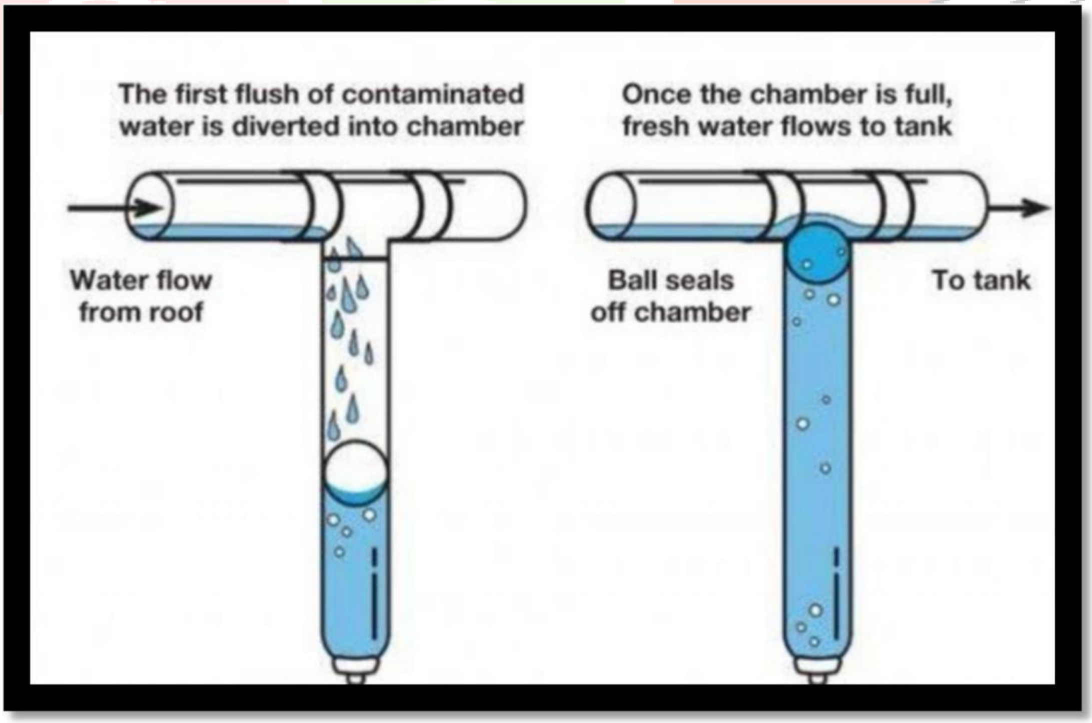


Fig: 3.3.5 First flush

3.3.4.1 FIRST FLUSH MECHANISM

First flush mechanism is shown in the figure. Due to long dry period, the catchment area generally gets dirty. Hence in order to prevent entry of excess dirt from the catchment area from entry into tank and polluting the water, first flush mechanism is designed. And the order of this mechanism becomes highly important when water preserved is utilized for drinking purpose. Turbidity factor was also considered while design first flush mechanism. After studying our requirement and prevailing condition, the design value of this mechanism was fixed to be 8litres/10 m^2. And finally, Ball-Valve

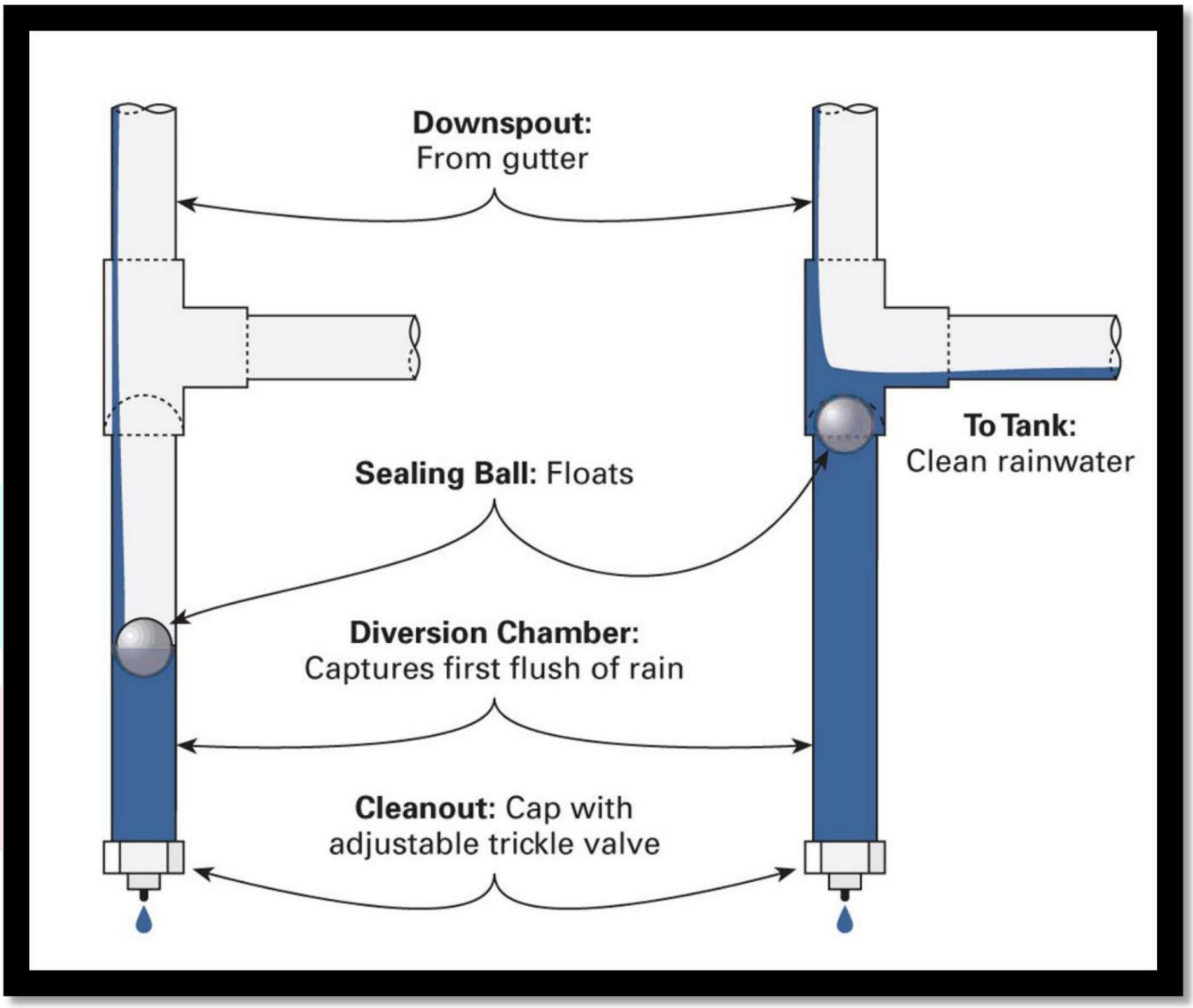


Fig: 3.3.5.1 First flush mechanism

Design was chosen. Ball-Valve design has a unique mechanism for controlling the flow of water into and outside of the tank. Ball-Valve design is shown in the figure. This system consists of ball inside the specially designed pipe which opens and closes the opening of outlet to the storage tank and diversion chamber according the level of water. When the water fills up to the brim, the water is diverted to the main tank from the side outlet. And when the water needs to be rejected is sent to the small diversion chamber where it fills the inlet pipe. Hence total volume of the diversion chamber and the pipe up to the Ball-Valve are carefully designed to match the diversion volume that is calculated. The connection between the terrace water and storage tank rebuilds when water reaches the level of the ball making the ball to float and block the connection between the terrace water and diversion chamber,thus, sending the water back again to main storage tank. In this way, Small diversion chambers are designed for the down pipes from each terrace. The diversion tank can have a tap which may be operated.

3.3.5 FILTERATION SYSTEM

The filter is used to remove suspended pollutants from rainwater collected over the roof. Filter units consists of a chamber filled with filtering media such as fiber, coarse sand and gravel layers to remove debris and dirt from water before it enters the storage tank or recharge structure. Filters are used for treatment of water to effectively remove turbidity, colour and microorganisms. After first flushing of rainfall, water should pass through filters. There are different types of filters in practice, but basic function is to purify water

3.3.6 .1 SAND GRAVEL FILTER

Sand filters have commonly available sand as filter media. Sand filters are easy and inexpensive to construct. These filters can be employed for treatment of water to effectively remove turbidity (suspended particles like silt and clay), colour and microorganisms. In a simple sand filter that can be constructed domestically, the top layer comprises coarse sand followed by a 5-10 mm effective size gravel layer followed by another layer of gravel and pebbles.

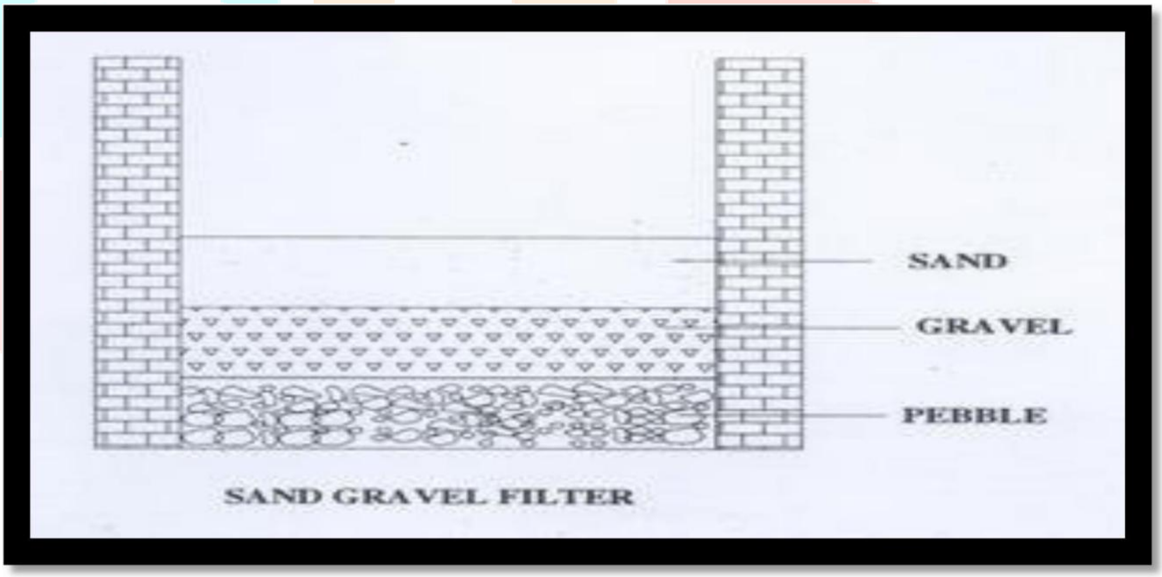


Fig: 3.3.6 .1 Sand Gravel Filter

3.3.6.2 PVC - PIPE FILTER

This filter can be made by PVC pipe of 1 to 1.20 m length; Diameter of pipe depends on the area of roof. Six inches diameter. pipe is enough for a 1500 Sq. Ft. roof and 8 inches diameter. pipe should be used for roofs more than 1500 Sq. Ft. Pipe is divided into three compartments by wire mesh. Each component should be filled with gravel and sand alternatively. A layer of charcoal could also be inserted between two layers. Both ends of filter should have reduce of required size to connect inlet and outlet. This filter could be placed horizontally or vertically in the system.

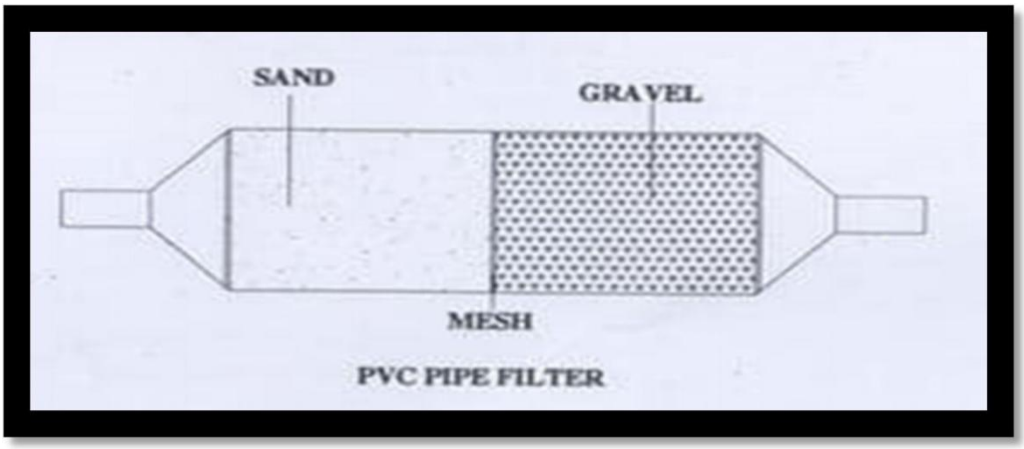


Fig: 3.3.6.2 Pvc - Pipe Filter

3.3.6.3 Charcoal Filter:

Charcoal filter can be made in-situ or in a drum. Pebbles, gravel, sand and charcoal as shown in the figure should fill the drum or chamber. Each layer should be separated by wire mesh. Thin layer of charcoal is used to absorb odor if any. A schematic diagram of Charcoal filter. A simple charcoal filter can be made in a drum or an earthen pot. The filter is made of gravel, sand and charcoal, all of which are easily available.

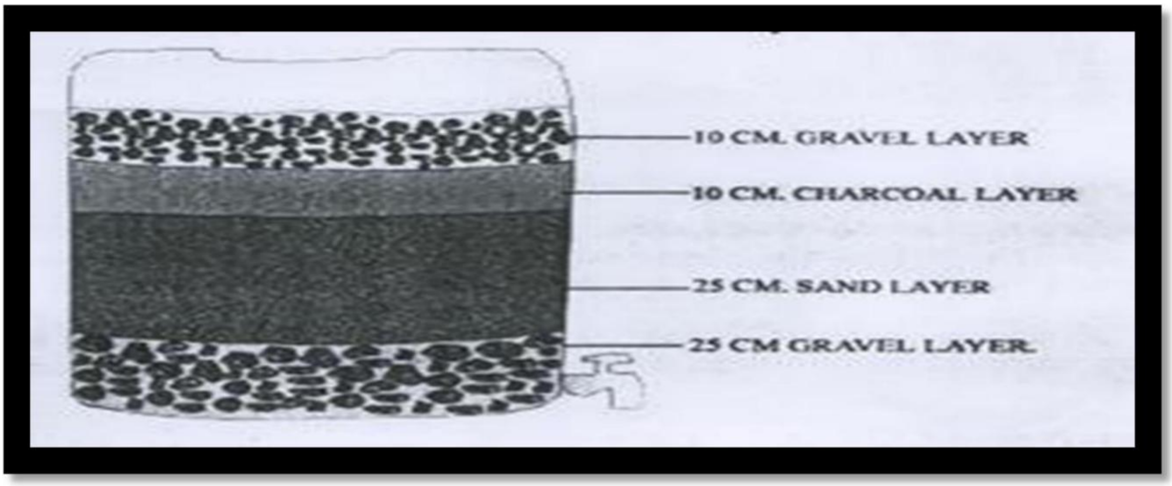


Fig: 3.3.6.3 Charcoal Filter

3.3.6.4 DUAL INTENSITY RWH FILTER

Rainy filters are designed with self-cleaning mechanism and can be fixed to the wall by connecting Rooftop rainwater drain pipes. The rainwater along with dirt particles enters into the inlet of filter through the hollow pipe tangentially to the filter housing and rotating slowly along the periphery of upper housing so as to flow into the **SS 304 FILTER** element placed in lower housing of the filter unit in angular motion at specific velocity, which creates cohesive force and segregates dirt particles and clean water individually. However, when the intensity of rainfall increases the high volume of water moves in circular motion with high velocity in the upper housing and creates a centrifugal force. In both situations, involving low and high intensity of rainfall, the working principle of the filter based on cohesive and centrifugal force respectively, aids the filter element to divert clean water into the cistern/ recharging well and simultaneously flushes out automatically sand, debris, and dirt particles through the drain outlet. Rain Water is purest form of water. And if we keep our roof tops clean. the only things which can mix with this pure rain water upon falling on our roof are solid particles. This heavy-duty dual intensity rainwater harvesting filter shall filter out those sediments using a SS 304 mesh-based filter and provide clean water for storage. The basic premise is to filter out the roof top water and divert the clean water into the sump/bore well/open well/external storage tanks and reuse the rain water as much as possible Self-Cleaning (not required to clean after each rainfall), No Filter change, Simple to Maintain, grab your filter model as per your rooftop size and start saving precious amounts of free water.

Fig: 3.3.6.4 Rainy Filter

Fig: 3.3.6.4.1 SS - 304 mesh filter

3.3.6.4.1 SPECIAL FEATURES ON RAINY FILTER

- The Rainy filter has open drain outlet in order to avoid stagnation of water and dirt particles inside the Filters
- No consumables required
- Filter inlet and outlet connections can be rotated 360 degrees to suit to the pipe line direction.

- Bypass valve is provided in the filter to divert the sudden summer rains into the drain
- The filter efficiency remains unchanged even with the variation of intensity of rainfall
- Fully enclosed and compact in size, so minimum space is sufficient to install
- The versatility of these filters is such that they can even be fitted inside the ducts.
- Tough high-density UV treated High density polyethylene Housing is built to last long
- filter element is made out of SS-304 Steel and it is food graded
- The Filter being wall mounting can be fitted with wall bracket and flexible rubber straps with hooks
- Inlet, outlet and drain outlets can be connected easily through the rubber bushes and bellows to the existing pipes.
- Various models are available to suit various dimension of Roof areas as per the requirements of consumers
- Since the filters do not have any moving parts, there is no wear & tear of the filter hence it enables long life span
- Due to simplicity in connection, local plumbers, technicians, can easily install the filter
- The technology of filter components is of food grade, environment friendly, and recyclable
- If the filter element is clogged it can be easily removed, washed and Re- inserted

3.3.6.4.2 ADVANTAGES OF RAINY FILTER

- By storing of water in the sump & re utilizing, around 35% of the annual requirement of a household can be met. Thereby a considerable amount on the water and power bill can be saved.
- Dependency on water tankers, ground water and corporation water can also be much reduced
- Recharge of Groundwater, replenishes the deeper layers of the earth's crust which in turn insulates the earth from rise in temperature, reducing global warming
- Reduces loss of top soil, surface runoff, thereby avoids silting of ponds and lakes
- Reduces hardness, salinity and TDS contents in the bore well
- Seawater ingression can be checked in costal line
- All materials used in this Technology are eco-friendly and recyclable
- Reduces significant carbon foot prints
    - Technology works on the Gravitational Principle
    - Reducing the Pumping of water from distant places, deeper depths & Movement of Water Tankers
- Checks over-exploitation of groundwater source.
- Prevents water logging in low lying areas.

3.3.7 STORAGE SYSTEM OF RRWH

Rain water storage tank is device for collecting and maintaining harvested water Rain water has to be collected and stored in well manner for future use and storing should be in effective way so that the consumption of rain water will be maximum Storage system of rain water tank is otherwise called Rain barrel. Mostly rain water is collected from roof top via pipes i.e., transportation system. In E.S. college of nursing has open well near

(RRWH) system building. In this principle rainwater is collected from the catchment area of a building in campus through rain head filter. The mechanisms of rain head filter to filter trees leaves, sticks and other contaminant particles and then transported to the pipes of the first flush separator the first flow of rainwater is captured separately and continuous flow of rainwater is collected and transported to dual intensity filter (Rainy filter). After this process the filtered water is transported to the open well storage system. The required open well storage is about 30 m deep. Another important advantage is when there is heavy rainfall the runoff of rainwater in the surface area percolate in underground and thus reaches the main storage well of the campus and forming maximum quantity of water source.

Fig: 3.3.7 Storage System of RRWH

CHAPTER 4

STUDY AREA & DATA COLLECTION

4.1 LOCATION OF STUDY AREA

Fig: 4.1 Location of Study Area

E.S COLLEGE OF NURSING
CHENNAI – TRICHY HIGHWAY (NH – 45)
E. S NAGAR, V. SALAI-605-652
VILLUPURAM (NEAR VIKRAVANDI)

The campus of E. S college of nursing, Villupuram is situated at 12.08047ºN latitudes and 79.55683ºE longitude. The minimum amount of ground water is only available in this Rocky region. The campus is surrounded by lawn area. The total strength of campus including students and staff peoples is more 1000. Thus, with this present strength and also with the expansion, campus should also increase its facilities and maintenance requirements. Thus, water is most natural resource being always in high demands by human beings and is indispensable part of the life. Hence, keeping in view all the above problems and status of campus, Villupuram, and administrative body focused on water scarcity problem. Therefore, in this situation, rain water harvesting system can be considered as a best solution for fighting against water scarcity in this campus.

4.2 FORMULAE TO DERIVE RAINWATER HARVESTING SYSTEM

The total amount of water that is received from rainfall over an area is called the rainwater legacy of that area. And the amount that can be effectively harvested is called the water harvesting potential. The formula for calculation for harvesting potential or volume of water received or runoff produced or harvesting capacity is given as:

Harvesting potential or Volume of water Received (m^3)
= Area of Catchment (m^2) X Amount of rainfall (mm) X 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 accounts for losses due to spillage, leakage, infiltration, catchment surface wetting and evaporation, which will all contribute to reducing the amount of runoff. Runoff coefficient varies from 0.5 to 1.0. In present problem statement, runoff coefficient is equal to 1 as the rooftop area is totally impervious. Eco-Climatic condition (i.e.) Rainfall quantity & Rainfall pattern) and the catchment characteristics are considered to be most important factors affecting rainwater Potential.

4.3 RAINFALL DATA ACQUISITION

VILLUPURAM has a tropical climate. In winter there is much less rainfall in Villupuram than in summer. This climate is considered to be **AW** According to the Köppen-Geiger climate classification. The average annual temperature is 28.4ºC in Villupuram. The average annual rainfall is **1046** mm. The direst month, with 6mm of rainfall. With an average of 222 mm, the most precipitation falls in October. The warmest month of the year is May with an average temperature of 32.0 ºC. January has the lowest average temperature of the year. It is 24.6 ºC. The difference in precipitation between the driest month and the wettest month is 216 mm. During the year, the average temperature varies by 7.4ºC.

4.4 YEARLY RAINFALL DATA – VILLUPURAM DISTRICT

Table: 4.4 Yearly Rainfall Data - Villupuram

Year	Yearly-Rainfall(mm)
2006	808
2007	754
2008	700
2009	568
2010	783
2011	972
2012	1082
2013	811
2014	621
2015	525

Average yearly rainfall data in VILLUPURAM district from **2006** to **2015.** For ten years (2006 – 2015) rainfall data of VILLUPURAM is tabulated and listed above. In the year of 2012 the rainfall is about 1082 mm have highest rainfall for past seven years.

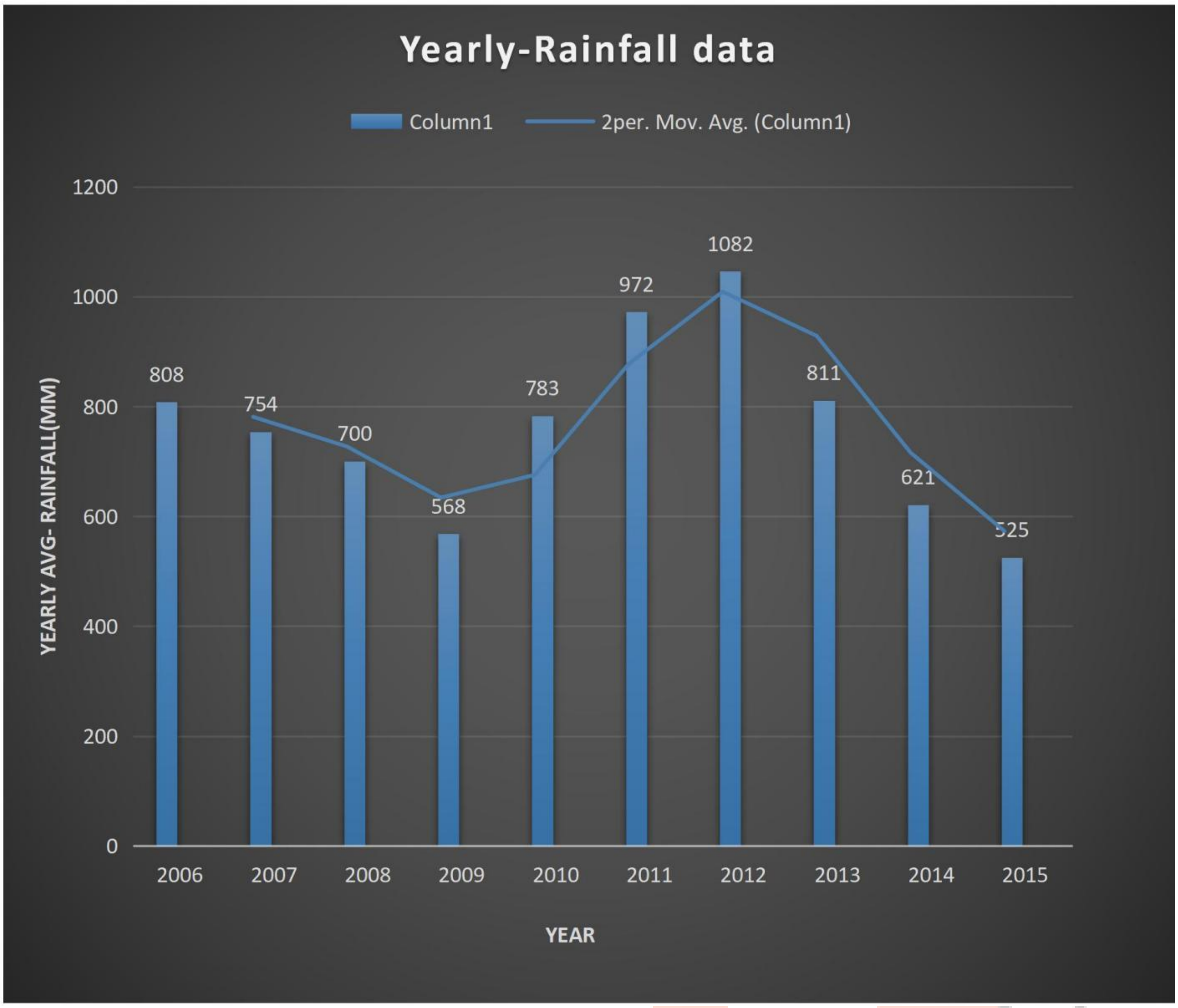


Fig: 4.4 Yearly Rainfall Data – Villupuram

MONTHLY RAINFALL – VILLUPURAM DISTRICT

Table: 4.5 Monthly Rainfall - Villupuram

Month	Monthly-Rainfall(mm)
Jan	20
Feb	7
Mar	6
Apr	16
May	40
Jun	45
July	80
Aug	149
Sep	135
Oct	222
Nov	216
Dec	110
Total	**1046**

Average monthly rainfall data of VILLUPURAM district is listed above tabular column. The month of May to July there is average precipitation/rainfall of about 40 – 80 and in the month of August rainfall is about 149 mm per annum. Over all the highest precipitation/rainfall falls on October of about 222 mm. The total monthly rainfall data of per annum is **1046 mm.**

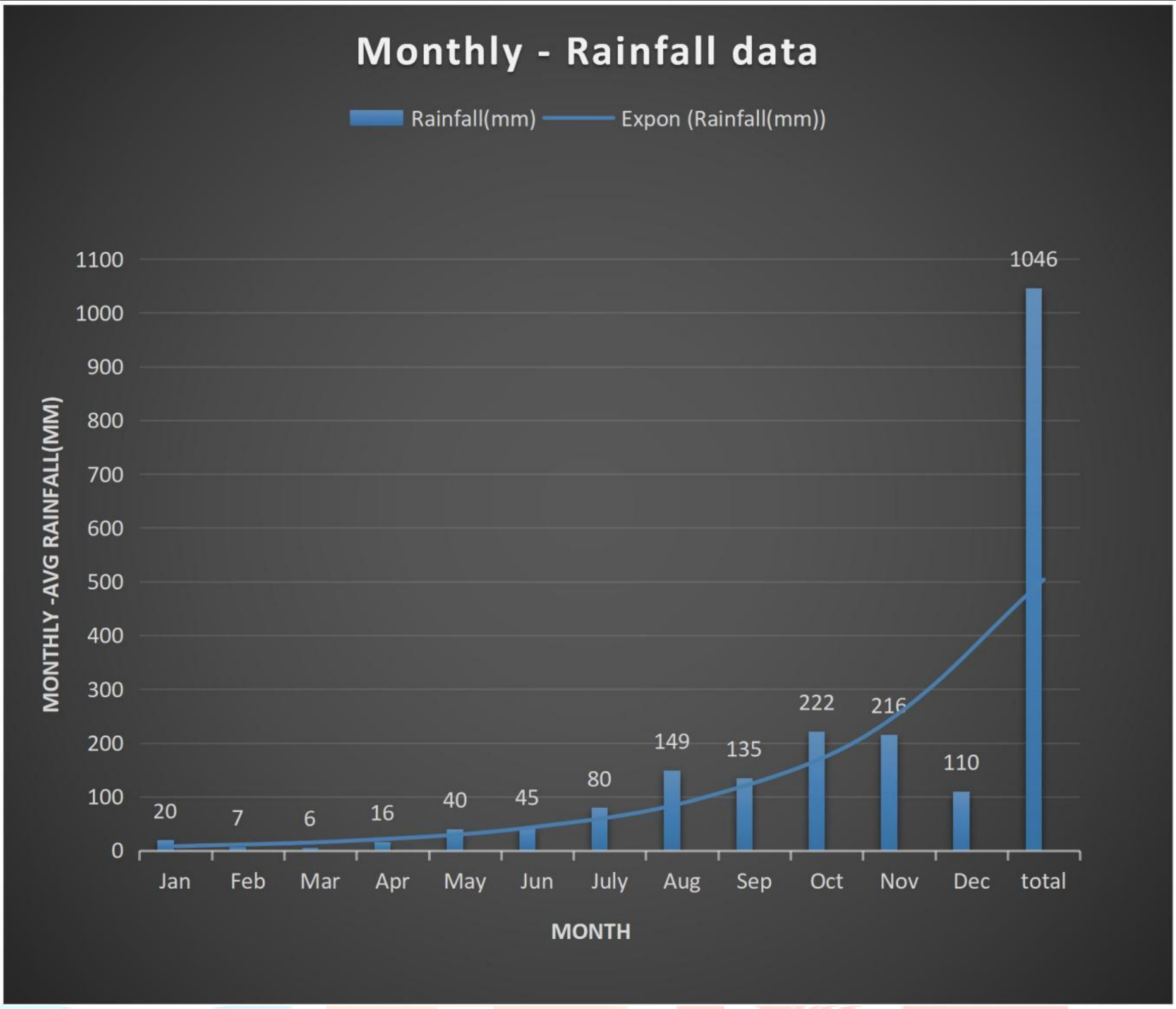


Fig: 4.5 Monthly Rainfall - Villupuram

4.5 CATCHMENT OF A STUDY AREA

Fig: 4.6 Catchment of a Study Area

Catchment area = 43768 square feet

= 43768 / 10.764 (standard method to convert in to square meter)

= **4067 m^2**

4.6 RUNOFF COEFFICIENT OF STUDY AREA

Hence the catchment of the study area is roofed surface (open area/ terrace)

80% of rainwater can be harvested in **Roof top area**

Runoff coefficient of open area = **0.8**

4.7 TOTAL DATA COLLECTED

Table: 4.8 Total Data Collected

CATCHMENT DATA	RAINFALL DATA	RUNOFF DATA
4067 m^2	1060 mm	0.8

4.8 CALCULATION

Volume of water Received (m^3) = Area of Catchment (m^2) X Amount of rainfall (mm) X Runoff coefficient

= 4067 X 1.0 X 0.8

Volume of water Received (m^3) = 3253 cubic. Meters or 32, 53,000 liters per annum.

Thus, total volume of rain water is harvested in open area (Roof top) is **32, 53,000 liters per year** in campus.

Daily usage of harvested rainwater for per day = Volume of water received / 365

= 32, 53,000/ 365

Daily usage of harvested rainwater for per day = 8,912 liters per day

Daily consumption of harvested rainwater for per day usage is **8,912** liters per day.

CHAPTER 5

RESULTS & DISCUSSION

5.1 RESULT

1) The total area under project is calculated as **4067 m^2**
2) The water which will be collected by rainwater harvesting system is of **drinking quality** and **domestic purpose.**
3) This will help to rejuvenate the depleting ground water resources. Also help to save the little amount of rain water which used to drain away from many years
4) Total rainwater harvested per annum in the campus is **32, 53,000** liters per annum.
5) Harvested rainwater for per year and the usage of harvested rainwater for every day consumption is **8,913** liters per day.
6) From the experiment work carried out the following results data are listed below

Table: 5.1 Result

DESCRIPTION	VALUE
Catchment area	4067 m^2
Daily usage of rainwater for per day	8,912 liters per day
Rainwater harvested for per year	32,53,000 liters per year

5.2 DISCUSSION

1) From the experiment work carried out, if we provide rainwater harvesting system at E.S COLLEGE OF NURSING, the total amount of rainwater to be saved and equal to **32,53,000** liters for per annum.

2) This is one-time investment in the work of rainwater harvesting though it's costly but the requirement of the drinking purpose is fulfilled by the 66% only through rain.

3) Nowadays cost of the water per liter is quite high compared to the water collected in this system, it

gives reliable quantity of water. In project area there are two bore wells are provided, one bore wells are placed near the open well (storage) which operates the flow of water to the storage tank (5000 liters) and other bore wells is provided to function the groundwater.

4) In future where there is surface runoff of rainwater in the campus area, the water gets stored in an underground water table, which leads to the open well storage and which will serve the purpose of recharging aquifer and fulfil the increasing demand of water.

5) As the rainwater is free and clean sources of water, the initial cost is zero, we only structure which control the wastage of water in the form of rainwater harvesting.

6) Nowadays water cost is rapidly rising as the population increasing at enormous rate, so rainwater harvesting is beneficial to save money.

7) Daily consumption of harvested rainwater for per day usage is **8,912** liters per day in the campus

CHAPTER 6

CONCLUSION

It can be concluded that the rainwater recharge improves the quality of groundwater and its quality depends upon the amount of rainwater recharged and the environment of rainwater collection and recharging. Hence it was finally concluded that implementation of RAINWATER HARVESTING PROJECT to the campus of E.S college of nursing will be the best approach to fight with present scenario of water scarcity in all aspects, whether it is from financial point of view or from optimum utilization of land surface. By implementation in water harvesting project in E.S College of nursing campus we can make little noble cause for rain water conservation which will be beneficial to the students of campus. The rooftop water collection can be used to fulfil the daily drinking demand. By installing rainwater harvesting system, every year huge amount of water will be saved and huge expenditures on procurement of water will be reduced the huge amount of precipitation occurring on the ground can be harvested and utilized for different purposed, if proper collection system is provided. As so many parts of the world facing the problems of water crises, one must understand the importance of water, and should made optimum use of water and adopt efficient methods of collecting and saving the rainwater. The procedure adopted in this study is proven to be costly as per the cost analysis, very easy as per methodology and very efficient as per the discharge calculated. Thus, it is concluded that implementation of RWH system of ES College of nursing campus would result in the form of the best approach to deal with present scenario of water scarcity and storing huge quantity of **32,53,000 liters** in a year. And daily consumption of harvested rainwater for per day is **8,912** liters in college campus. This harvested water helps their daily needs.

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