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Rain Water Harvesting in VOGCE Campus

Gaurav Bangar[1], Darshan Patil[2], Shweta Patil[3], Pankaj Bagul[4], Prof. Dattatrey Patil[5]
Students, Department of Civil Engineering[1,2,3,4]
Faculty, Department of Civil Engineering[5]
Vishwatmak Om Gurudev College of Engineering Aghai, Thane, Maharashtra, India

Abstract: *At the rate in which India populace is expanding, it is said that India will definitely supplant China from its number 1 position of most thickly populated nation of the world after 20-30. These will prompt high rate of utilization of most profitable regular asset; Water's subsequent in enlargement of weights on the allowed freshwater assets. Old technique for damming waterway and transporting water to urban zone has its own issues of everlasting inconveniences of social and political. Keeping in mind the end goal to save and take care of our day by day demand of water prerequisite, we have to think for elective savvy and generally less demanding mechanical techniques for monitoring water. Rainwater reaping is outstanding amongst other techniques satisfying those necessities. The specialized parts of this paper are water gathering gathered from housetop which is thought to be catchment territories from all lodgings and Institutes departmental working at VISHWATMAK OM GURUDEV COLLEGE OF ENGINEERING AGHAI Campus. As a matter of first importance, required information are gathered i.e. catchment zones and hydrological precipitation information. Water gathering potential for the inns and workforce flats was ascertained, and the tank limit with appropriate plan is being considered. Volume of tank has been ascertained with most suitable strategy for estimation. Ideal area of tank based on hydrological investigation. Over the years, the rising population, growing industries and expanding agricultural practices have raise the demand of water supply. Monsoon is still the main hope and source of our agriculture. Hence water conservation had become need of the time. Rainwater harvesting is a way to capture the rainwater at the time of downpour, store that water above the ground or charge the underground water and use it later. As the groundwater resources are depleting, the rainwater harvesting is the only way to solve the water problem. Rainwater harvesting will not only be helpful to meet the demand of water supply but also be helpful to improve the quantity and quality of water. Here, in this paper our focus is to design a tank to store rainwater from rooftop of the building to cater the need of water requirement for College of Engineering,*

Keywords: Rain Water Harvesting

I. Introduction

Rainwater harvesting is an important environment friendly approach. It is a Green Practice having double benefit of keeping the groundwater level undisturbed and charging the aquifer. This green practice can be encouraged in the form of Community Development Program. Rainwater and run-off water, stored in a planned way, can save the earth from soil erosion and flood and recharge the aquifers to increase the groundwater level. The extensive and unplanned use of groundwater has not only disturbed the natural water level but also has made the groundwater contaminated and unfit for use. Collecting and harvesting rainwater and run-off water would reserve the water for future generation. Rainwater harvesting is ecofriendly and economical. The cost of digging a catchment area can be saved by roof-top collection of rainwater. The catchments and settlement tanks reduce the ground heat and act as a natural cooler. The best part of the practice of rainwater harvesting, is that if unused, this water can be collected in natural ponds or artificial tanks and decanted to the ground thus charging the a aquifer.

1.1. What Is Rain Water Harvesting?

Rainwater harvesting is a simple strategy by which rainfall is gathered and stored for future usage. The process involves collection and storage of rainwater with help of artificially designed systems, that runs off natural or man-made catchment areas e.g. rooftop, compounds, rocky surface, hill slopes or artificially repaired impervious/ semi pervious land surface. The collected rainwater from surfaces on which rain falls may be filtered, stored and utilized in different ways or directly used for recharge purposes. Rainwater Harvesting is unrestricted from any kind of impurity, with relatively less storage cost and no maintenance cost involved except for periodical cleaning.

With depleting groundwater levels and fluctuating climate conditions, this measure can go a long way to help mitigate the adverse effects rising water scarcity. Reserving rainwater can help recharge local aquifers, reduce urban flooding and most notably, ensure water availability in water-scarce zones.

1.2. History

Water collecting and use frameworks have been utilized since antiquated circumstances and confirmation of rooftop catchment frameworks go back to early Roman circumstances. Roman estates and even entire urban communities were intended to exploit water as the chief water hotspot for drinking and residential purposes since no less than 2000 B.C. In the Negev leave in Israel, tanks for putting away overflow from slopes for both local and farming purposes have permitted home and development in zones with as meager as100mm of rain for each year. The most punctual known proof of the utilization of the innovation in Africa originates from northern Egypt, where tanks running from 200-2000m3 have been utilized for no less than 2000 years – numerous are as yet operational today. The innovation likewise has a long history in Asia, where water gathering hones have been followed back right around 2000 years in Thailand. The little scale gathering of water from the overhang of rooftops or by means of straightforward drains into conventional jugs and pots has been polished in Africa and Asia for a huge number of years. In numerous remote provincial regions, this is as yet the technique utilized today. The world's biggest water tank is most likely the Yerebatan Sarayi in Istanbul, Turkey. This was built amid the lead of Caesar Justinian (A.D. 527-565). It quantifies 140m by70m and has a limit of 80,000 cubic meters.

1.3. Methods of Rainwater Harvesting

- Rainwater stored for direct use in above ground or underground sumps / overhead tanks and used directly for Farming, Gardening and Washing etc. (Rainwater Harvesting).
- Recharged to ground through recharge pits, dug wells, bore wells, soak pits, recharge trenches, etc. (Ground water recharge.)

1.4. What are the Factors Affecting Runoff from Catchment?

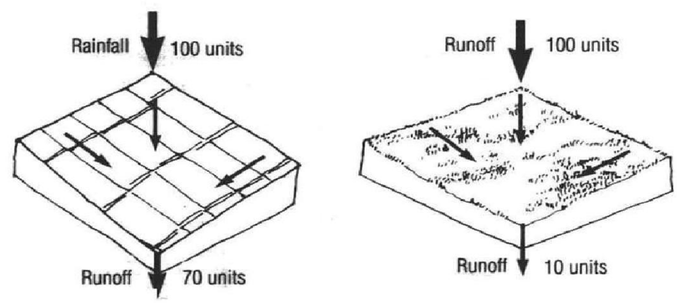
Among the several factors that influence the rainwater harvesting potential of a site, eco climatic conditions and the catchment characteristics are more important.

A. Rainfall

1. Quantity: To determine the potential rainwater supply form a given catchment, rainfall quantity is the most important parameter. For assessing rainfall quantity a reliable rainfall data are required, preferably for a period of at least 10 years. It can be determine by using rainfall data from the nearest rain gauge station with comparable conditions.
2. Pattern: The intensity, duration and aerial distribution of rainfall influences the rate and total volume of runoff. Total runoff from a given intensity rainfall depends on its duration, basically due to decrease in rate of infiltration with the time in the initial stages of rainfall. Therefore, though a rainfall of short duration may not produce any runoff, but the same intensity rainfall of longer duration will result in runoff. Rainfall intensity influences both the rate and the volume of runoff. An intense rainfall, which exceeds the infiltration capacity by a greater margin than a mild rainfall, will result greater total volume of runoff, even when the total rainfall is the same.

B. Catchment Area Characteristics

Runoff depend upon the area, type as well as surface features of the catchment over which it falls. Runoff can be generated from both paved and unpaved catchment areas.



Runoff from a smooth tiled surface. **Runoff from a surface covered with grass.**

Fig.1.4.1.Runoff

For example, about 70% of the rainfall that occurs over surface of a terrace would flow as runoff while only 10% of the rainfall on a wooded or grassy area would flow, and the rest is retained on the surface and gets percolated into the ground. Unpaved surfaces have a greater capacity of retaining rainwater on the surface. A patch of grass would retain a large proportion of the rainwater falling on it, yielding only 10 to 15percent as run off. A considerable amount of water retained on such a surface naturally percolates in the ground contributing to the natural recharge of groundwater. Therefore, if paving of ground surface is unavoidable, one may use pavements, which retain rainwater and allows it to percolate into the ground.

1.5. Rainwater Harvesting at VOGCE Campus

In the VOGCE campus rainwater harvesting system has been installed in School Building. The roof runoff water is collected through network of pipe lines and stored in the wells. There is one wells in the campus where the roof runoff water is stored & also increase the ground water level. The total capacity of storage is 900 m^3. The remaining roof runoff water is allowed to infiltrate in the ground for recharge. The stored water is used for Farming, Gardening and Washing of vehicles. The orientation of each building is such that it maximizes the chances of collection of water. The open area of main playground will serve as the location for the storage Recharge Well for water collected in buildings mentioned above.

1.6. Components of Rainwater Harvesting System

A water gathering framework includes parts for - transporting water through funnels or depletes, filtration, and tanks for capacity of reaped water. The regular parts of a water collecting framework are:-

1. Catchments: The surface which straightforwardly gets the precipitation and gives water to the framework is called catchment zone. It can be a cleared region like a patio or yard of a building, or an unpaved zone like a garden or open ground. A rooftop made of fortified bond concrete. (RCC), excited iron or layered sheets can likewise be utilized for water gathering.
2. Coarse Mesh: It keeps the section of flotsam and jetsam, gave in the rooftop.
3. Drains: Channels which encompasses edge of a slanting rooftop to gather and transport water to the capacity tank. Canals can be semi-round or rectangular and for the most part made locally from plain aroused iron sheet. Drains should be upheld so they don't hang or tumble off when stacked with water. The manner by which canals are settled basically relies upon the development of the house, for the most part iron or timber sections are settled into the dividers.
4. Channels: Conduits are pipelines or channels that convey water from the catchment or housetop zone to the collecting framework. Generally accessible courses are comprised of material like polyvinyl chloride (PVC) or electrifies press (GI).

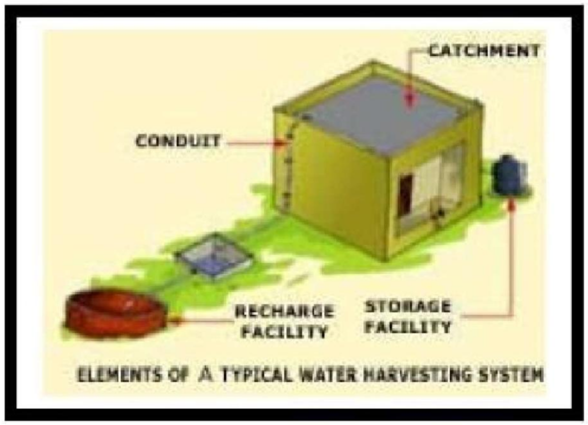


Fig.1.6.1. Components of Rainwater Harvesting system

5. To begin with flushing: A first flush gadget is a valve which guarantees flushing out of first spell of rain far from the capacity tank that conveys a moderately bigger measure of contaminations from the air and catchment surface.
6. Channels: The channel is utilized to expel suspended poisons from water gathered from housetop water. The Various sorts of channels for the most part utilized for business design are Charcoal water channel, Sand channels, Horizontal roughing channel and moderate sand channel.
7. Storeroom: There are different alternatives accessible for the development of these tanks regarding the shape, estimate, material of development and the situation of tank and they are:-Shape: Cylindrical, square and rectangular. Material of development: Reinforced bond concrete (RCC), stone work, Ferro concrete and so forth.
8. Position of tank: Depending ashore space accessibility these tanks could be built over the ground, somewhat underground or completely underground. Some support measures like purification and cleaning are required to guarantee the nature of water put away in the holder. In the event that collected water is chosen to energize the underground aquifer/store, at that point a portion of the structures specified underneath are utilized.
9. Revive structures: Rainwater Harvested can likewise be utilized for charging the groundwater aquifers through reasonable structures like burrowed wells, bore wells, energize trenches and energize pits. Different energize structures are conceivable - some which advance the permeation of water through soil strata at shallower profundity (e.g., revive trenches, penetrable asphalts) while others lead water to more prominent profundities from where it joins the groundwater (e.g. revive wells). At numerous areas, existing structures like wells, pits and tanks can be adjusted as revive structures, killing the need to build any new structures. A portion of the few regularly utilized reviving techniques are energizing of burrowed wells and surrendered tube wells, Settlement tank, Recharging of administration tube wells, Recharge pits, Soak ways/ Percolation pit, Recharge troughs, Recharge trenches, Modified infusion well.

1.7. Rain Water Harvesting Techniques

There are two fundamental procedures of rain water harvestings:

- Storage of water on surface for some time later.
- Revive to ground water.

The capacity of rain water on surface is a customary procedures and structures utilized were underground tanks, lakes, check dams, weirs and so on. Energize to ground water is another idea of rain water collecting and the structures for the most part utilized are:-

1. **Pits:-** Recharge pits are built for energizing the shallow aquifer. These are built 1 to 2 m, wide and to 3 m. profound which are inlayed with stones, rock, and coarse sand.
2. **Trenches:-** These are built when the penetrable strata is accessible at shallow profundity. Trench might be 0.5 to 1 m. wide, 1 to 1.5m. Profound and 10 to 20 m. long depending up accessibility of water. These are refilled with channel. Materials.

3. Dug wells:- Existing burrowed wells might be used as revive structure and water should go through channel media before putting into burrowed well.
4. Hand pumps:- The current hand pumps might be utilized for reviving the shallow/profound aquifers, if the accessibility of water is constrained. Water should go through channel media before redirecting it into hand pumps.
5. Recharge wells :- Recharge wells of 100 to 300 mm. distance across are by and large built for energizing the more profound aquifers and water is gone through channel media to abstain from gagging of revive wells.
6. Recharge Shafts:- For energizing the shallow aquifer which are situated beneath clayey surface, revive shafts of 0.5 to 3 m. distance across and 10 to 15 m. profound are developed and refilled with stones, rock and coarse sand.
7. Lateral shafts with bore wells:- For energizing the upper and additionally more profound aquifers sidelong shafts of 1.5 to 2 m. wide and 10 to 30 m. long contingent on accessibility of water with maybe a couple bore wells are developed. The sidelong shafts is inlayed with rocks, rock and coarse sand.
8. Spreading procedures:- When penetrable strata begins from top then this strategy is utilized. Spread the water in streams/Nasal by making check dams, Nala bunds, bond plugs, gabion structures or a permeation lake might be built.

Fig.1.7.1. Under Ground Well

Strategies for manufactured revive in urban territories: Water spreading

- Recharge through pits, trenches, wells, shafts
- Roof best gathering of water
- Road best gathering of water
- Initiated energize from surface water bodies

1.8. Components of Consideration

The catchment zone and capacity limit of a framework are generally little. There is an awesome variety in climate. Amid a drawn out dry spell, the capacity tank may become scarce.

- Maintenance of water gathering frameworks, and the nature of gathered water, can be troublesome for clients.
- Extensive improvement of water reaping frameworks may decrease the wage of open water frameworks.
- Rainwater collecting frameworks are frequently not some portion of the construction regulation and need clear rules for clients/engineers to take after.
- Rainwater use has not been perceived as an option of water supply framework by the general population segment. Governments regularly do exclude water use in their water administration arrangements, and residents don't request water usage in their groups.
- Rainwater capacity tanks might be a risk to kids who play around it.
- Rainwater capacity tanks may consume up profitable room.
- Some improvement expenses of bigger water catchment framework might be too high if the expenses are not imparted to different frameworks as a feature of a multi-purpose arrange Learning from these favorable circumstances and hindrances, the choice to utilize water as another water source ought to be talked about among

national/client gatherings and government water authorities.

1.9. Need for Rainwater Harvesting

- Increasing water demand
- Variations in water availability
- Responsibilities towards protecting Nature
- Advantage of collection and storage near the place of use
- Quality of water supplies
- As water is becoming scarce, it is the need of the day to attain self-sufficiency to fulfill the water needs.
- As urban water supply system is under tremendous pressure for supplying water to ever increasing population.
- Groundwater is getting depleted and polluted.
- Soil erosion resulting from the unchecked runoff.
- Health hazards due to consumption of polluted water.

1.10. Context of Rainwater Harvesting

- The soil in the college campus has a good infiltration rate.
- For the gardening purpose, water is required daily.
- For the washing of vehicles large quantity of water is required.
- This requirement is satisfied by the water stored by rainwater harvesting.

1.11. Benefits of Rain Water Harvesting System

Rainwater is a comparatively clean and totally free source of water.
Rainwater is improved for scenery plants and gardens because it is not chlorinated.
It can supplement other sources of water supply such as groundwater or municipal water connections.
It lower the water supply cost.
It can provide an excellent back-up source of water for emergencies.
It is socially acceptable and environmentally responsible.
It uses simple technologies that are inexpensive and easy to maintain.
Reduced flood flows and topsoil loss.
It is free; the only cost is for collection and use.
It reduces the contamination of surface water with sediments, fertilizers and pesticides from rainwater run-off resulting in cleaner lakes, rivers, oceans and other receivers of storm water.
It is used in those areas which face insufficient water resources.
It is good for laundry use as rainwater is soft and lowers the need for detergents.
It can be used to recharge groundwater.
It minimizes the runoff which blocks the storm water drains.

II. Literature Review

As water harvesting is a very old tradition and has been used for years, several techniques have been developed so far. Extensive literature is available on RWH with respect to various methods, its impacts on groundwater quantity, quality and its modelling. Literature related to the various methods of recharge estimation, applications of remote sensing and GIS in artificial recharge, studies on groundwater modeling, RWH implementation and its impact studies was collected and a critical review was carried out, as shown in the following sections.

Mishra & Tembhurkar (2018) discussed the application of filters such as sand and foam filter in combination for rooftop RWHS in buildings such that the water shortage and scarcity can be minimized with sustainable approach in storing and collection of water for the needs of future. The area selected was a girl's hostel building in VNIT Nagpur campus covering 4980 m2. The per capita consumption of water in a day was calculated in liter/day for all activities washing, cleaning and flushing. According to the experiments, it was found that the dual media filter combination is acceptable for treating rainwater with addition of little disinfectant like chlorine during its utilization. From experiments it was found that in this dual media filter single layer of foam works better than double layers.

Patel et al (2014) defined the process of collecting and storing the rainwater and use it for domestic use in the S.P.S.V. campus and analyzed the problems with current distribution system and water use at campus. The average monthly rainfall data was stipulated in tabular form to generate the data for hydrological analysis, volume of runoff per year, rainfall potential & catchment area of building. It was found that the RWH project on the campus can fight water scarcity and can reap benefits from financial point of view.

Rahman et al (2010) examined the sustainability of rainwater collection by harvesting in multi store apartments taking a hypothetical approach to create various scenarios related to site area and floor arrangement. The water demand was assumed that it would be only used for flushing laundry and irrigation. The life cycle costing was developed assuming material cost, maintenance and operation cost. The operation cost was estimated following pump running time and pump operating cost. It was possible to achieve “payback” under most favorable financial condition and the benefit to cost ratio is smaller with the BASIX approach than non BASIX approach.

Shrivastava et al (2019) purposed design of the rooftop harvesting system in a sea coast high rainfall zone of south Gujarat, due to nearness to the sea the area suffers ingress water supply and overexploitation of the groundwater. The study is a four year extensive and the water studied is stored for more than 2 years for physical chemical and micro bacterial quality assurance. The roof water was collected from 6 rooftops of the campus measuring around 3085m2 in total. In the first year of study it was concluded that the water’s physically had peculiar rotten smell and black residue carbon from atmosphere. The chemical quality of harvested water using RBD methods showed that the quality of water in terms of TDS is far better than ground water i.e. 1440tds. The micro bacterial quality of the water in terms of MPN of fecal coliform/100ml was observed to be less than municipal water supply however it increased with the first year of storage and then decreased extensively due to enclosed conditions of the tanks. The efficiency of different bacterial removal methods was also studied with an achievement where E.coli bacteria was not found out in any treatment.

III. Aim & Objective

3.1. Aim

To increase recharge of groundwater by capturing and storing rainwater, by rainwater harvesting from rooftop run-offs.

3.2. Objective

- To store the water for Farming, Gardening and Washing purpose.
- To increase recharge of groundwater by capturing and storing rainwater, by rainwater harvesting from rooftop run-offs.
- To meet the rising demand of water needs.
- To reduce soil erosion.
- To raise the water table underground.

IV. Study Areas and Data Collection

4.1. Study Area

As discussed earlier in the section of introduction – importance of rainwater harvesting at VOGCE CAMPUS, we clearly came to know that all the advantages which we can draw out by implementing this small but highly efficient technique in the campus. Thus to increase the potential, benefits of this system and draw maximum advantages from it, we need to have large rooftop areas which will be going to act as catchment areas. More the catchment areas more will be the surface runoff and thus more will be the amount of harvested water.

Therefore as much as possible, we have included and considered all the major buildings having large rooftop areas. Hence, study areas includes Block B (School Building) & (School Ground). Given below a satellite picture, showing majority of the buildings considered for rainwater harvesting system at VOGCE CAMPUS.

Fig.4.1.1.VOGCE Campus

School Dimensions

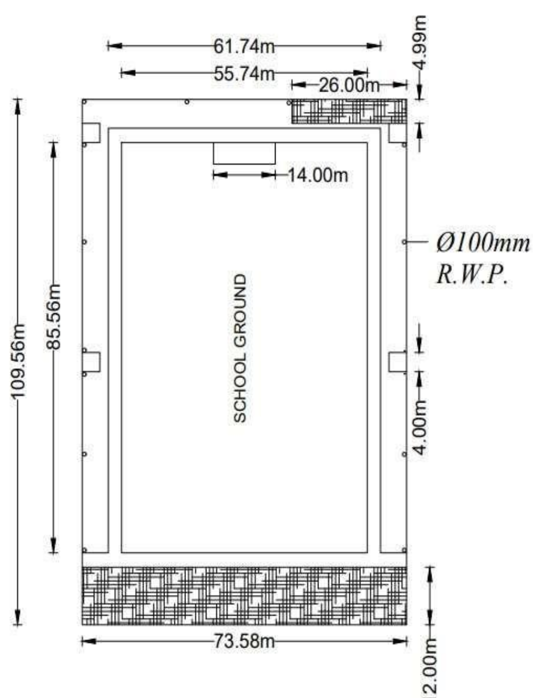


Fig.4.1.2. Dimension of School

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School Building

3d Views

Fig.4.1.3. Front View of School

Fig.4.1.3. 3d View of School

4.2. Data Collection

Statement Showing Month-Wise Average Rainfall (mm) for the last 13 Years in the SHAHAPUR TALUKA

MONTHS	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
JAN	-	0.4	-	-	0.1	0.44	0.82	-	-	-	0.3	0.4	28.7
FEB	-	-	1.21	-	1	3.2	10	0.5	-	-	-	-	-
MAR	0.4	1.7	1.3	-	-	2.12	27.55	3.6	0.3	0.2	0.5	1.5	-
APR	0.6	0.5	0.1	7.3	-	0.1	0.92	0.41	0.2	1.13	2.4	-	0.9
MAY	13.7	2.9	10.7	1.8	6.9	1	3.9	9.73	21.5	2.2	1	2.1	31.3
JUN	331.6	537.1	774.9 6	251.5 6	713.6	149.8 8	638.4 1	402. 89	596. 9	563. 09	330. 8	270. 6	602. 3

JUL	1808. 1	981.6	1020. 76	769.4 2	1112. 6	949.1 4	683.8 6	1286 .25	1083 .3	980. 4	1319 .3	640	999. 3
AUG	535.9	655.5	866.9 2	674.1 7	487.4 6	497.6 5	375.9 2	920. 73	600. 6	845. 3	956. 6	1214 .6	173. 8
SEP	289	383.1 4	370.6	255.8 1	226.3	188.9 3	199.2 4	374. 8	283. 2	144. 29	604. 9	539. 8	242. 82
OCT	229	155.3	103.6	148.3	37.6	15.8	94.1	45.7	247. 4	35.8	330. 3	183. 7	38.9
NOV	177.6	225.1 5	1.6	1	7.8	20.2	33.8	-	0.1	22.1	40.1	-	19.3
DEC	0.2												
TOTAL	3386. 10	09	75	96	96	42	53	.91	.60	.51	.70	.40	.30

TABLE.4.2.1: Average Rainfall (mm) for the last 13 Years

4.3 Rainfall and Climate

The climate of Shahapur Taluka can be classified as tropical rainforest, semiarid and hot which is mainly characterized by the extreme Humidity of the Air except during summer months. During three months of monsoon from last week of May to September, the moist air of oceanic penetrate into the Shahapur and causes high humidity, cloudiness and monsoon rainfall. The period from October to December constitutes post monsoon season. The cold weather season prevails from January to the beginning of March and followed by the hot weather or summer season which prevails up to the last week of May. The normal annual rainfall in Shahapur Taluka is about 2151.30 mm spread over 90 days. The south west monsoon sets in the last week of June and withdraws towards the end of September and contributes about 85% of the annual rainfall. July and August are the wettest months and 15% of the annual rainfall occurs during the non-monsoon months in the wake of thunder storms and western disturbances.

Normal Annual Rainfall: 2151.30 mm

Normal Monsoon Rainfall: 2018.22mm Temperature:-

Mean Maximum: 380 C (April & May)

Mean Minimum: 180 C (January)

Normal Rainy days: 90

Intensity of Rainfall: 40mm/hour.

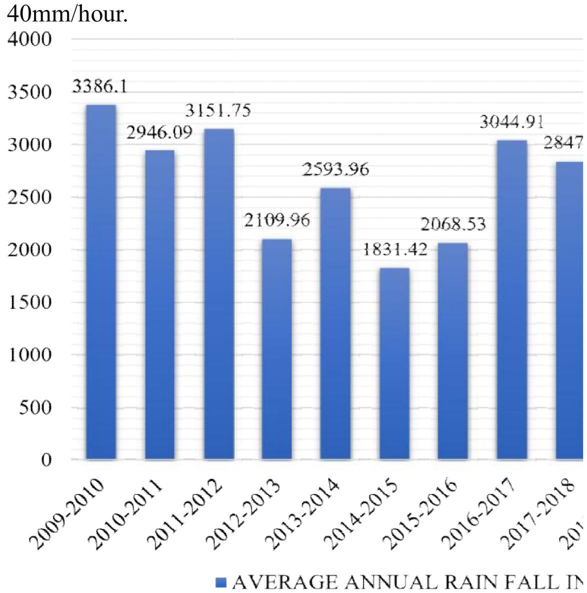

CHART NO.4.2.1.: Average Annual Rain Fall in Shahapur.

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CHART NO.4.2.2. Monthly Average Rainfall Days In Shahapur

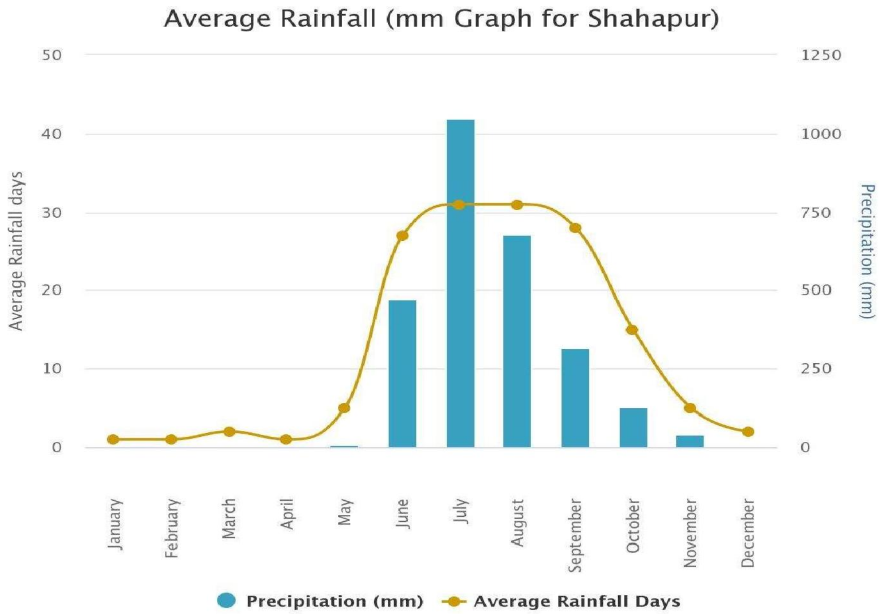


CHART NO.4.2.3. Yearly Average Rain Fall & Rainy Days In Shahapur

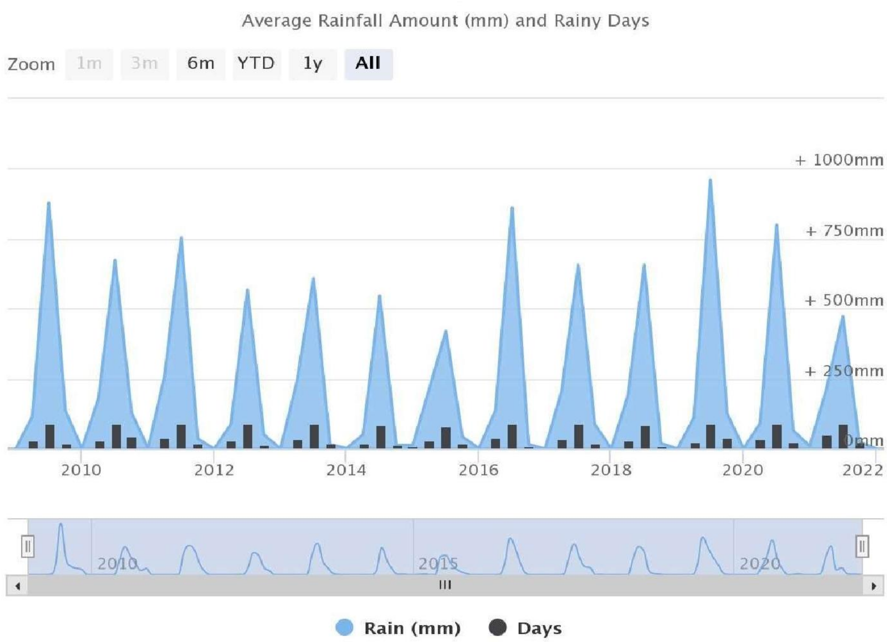


CHART NO.4.2.4.: Yearly Average Rainy Days In Shahapur.

CHART NO.4.2.5: Monthly Average Rainy Days In Shahapur.

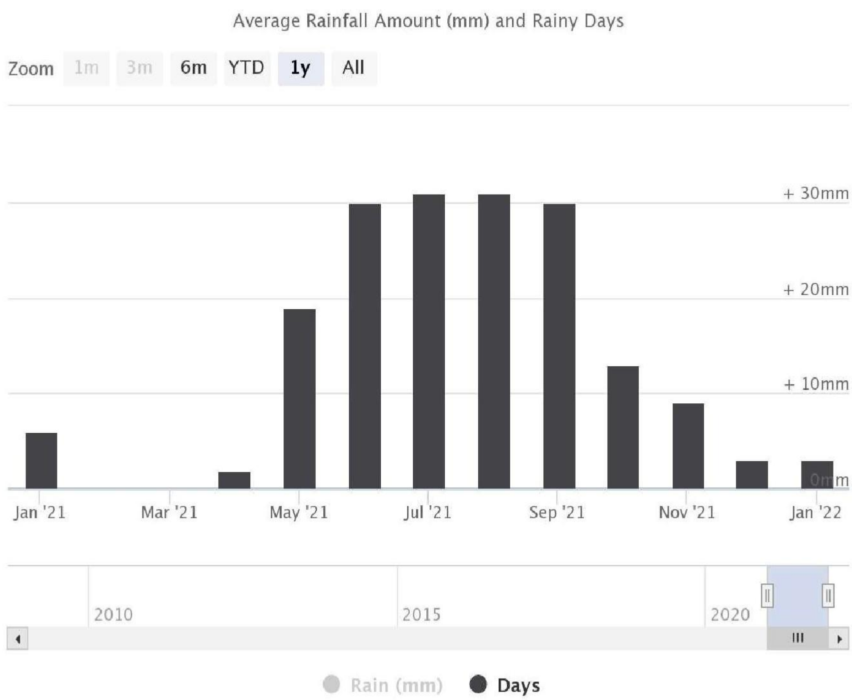


CHART NO.4.2.6: Yearly Average & Max Wind Speed In Shahapur.

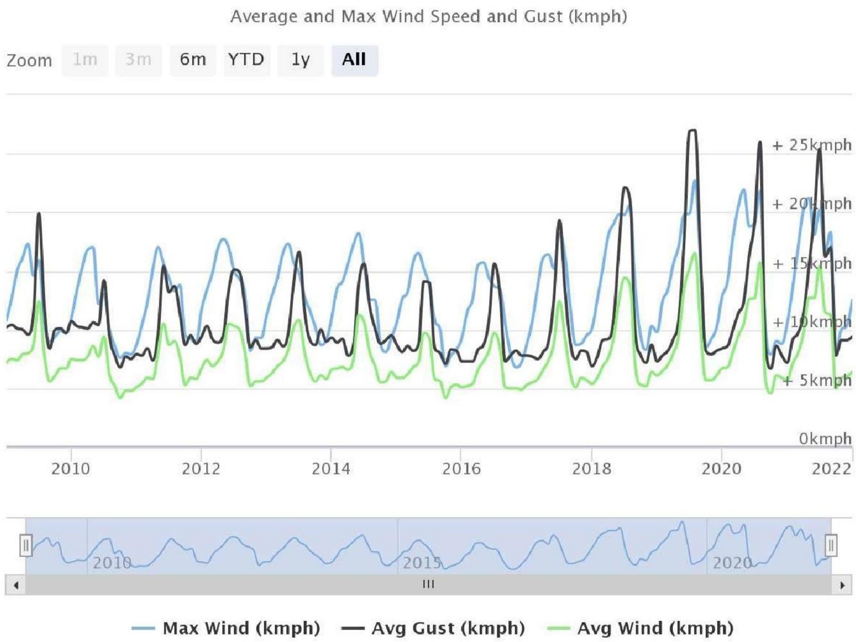
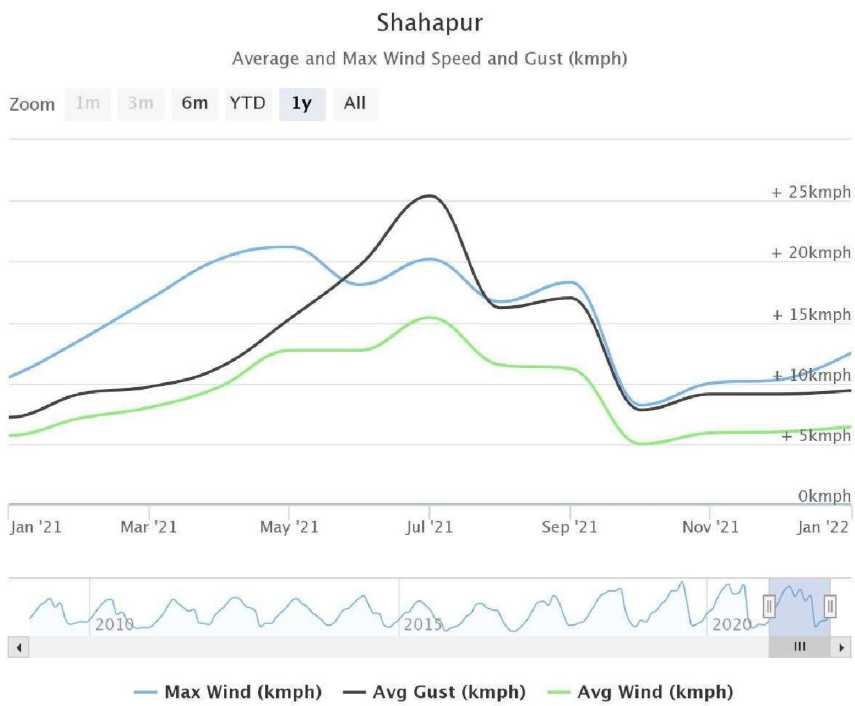


CHART NO.4.2.7. Monthly Average & Max Wind Speed In Shahapur.



V. Methodology

In the VOGCE campus rainwater harvesting system has been installed in Block B (School Building). The roof runoff water is collected through network of pipe lines and stored in the wells. There are three wells in the campus where the roof runoff water is stored. The total capacity of storage is 900 m³. The remaining roof runoff water is allowed to infiltrate in the ground for recharge. The stored water is used for Farming, Gardening and Washing of vehicles.

The methodology that will be followed for the economic social as well as long term benefits of rainwater harvesting in the VOGCE campus are as followed:-

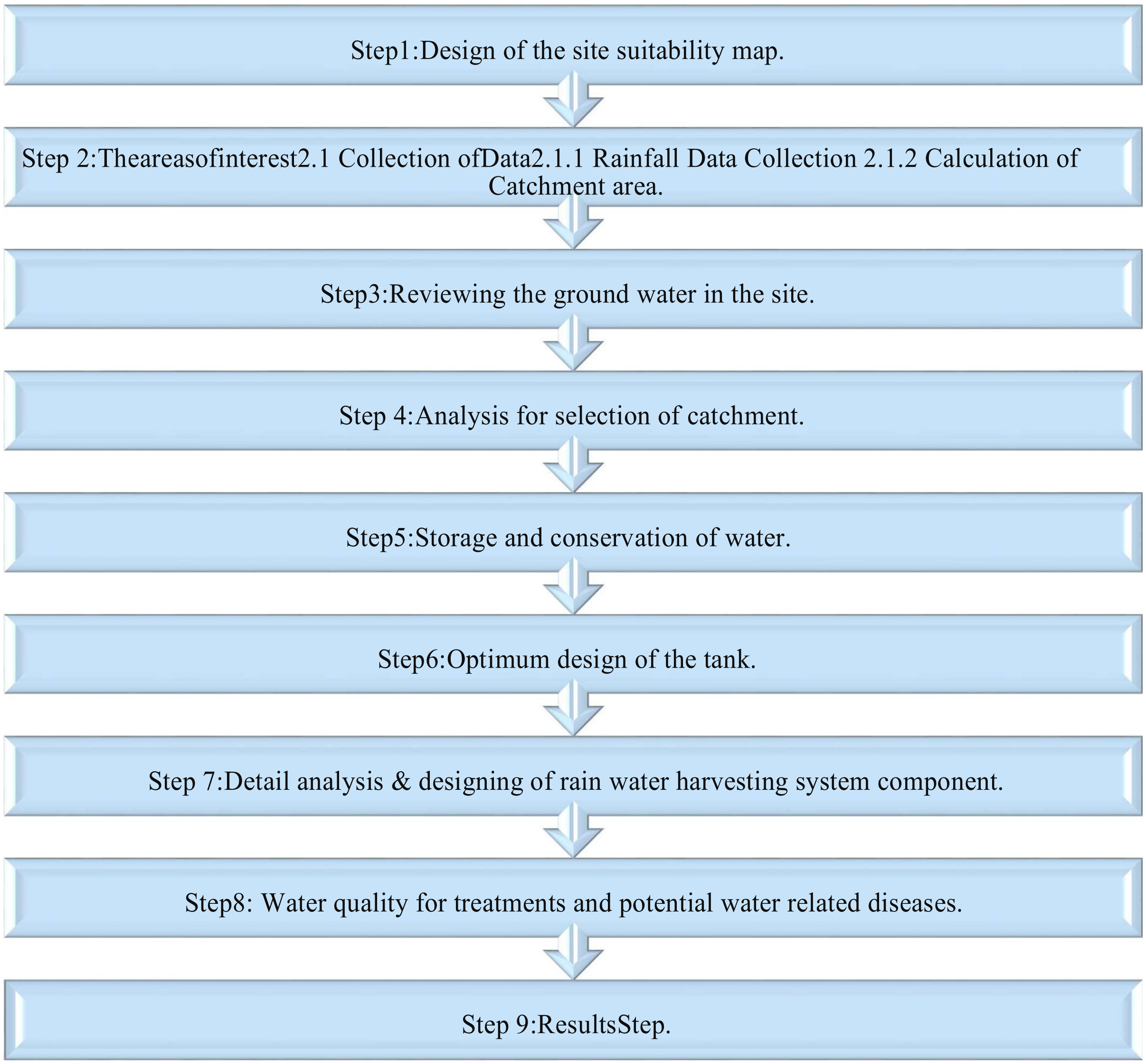


CHART NO.5.1. METHODOLOGY

5.1 Determination Of Catchment Area

The rooftop surface area is nothing but the catchment area which receives rainfall. Catchment areas of the different hostels and Institutional departments are measured. This measurement was done manually with the help of "reinforced fiber tape" which is the simplest technique known as "tape survey". Before using the tape, tape was checked for any zero error and also length of the tape was also carefully checked for its accuracy. Those places which area not accessible to land on, are measured by using the ruler from tool box of Google Earth. Given below the table no.2 for calculated the rooftop areas of all the buildings suited inside the campus:-

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SR.NO.	NAME	AREA (m^2)
1.	School Building	2233.61
2.	School Ground	4769.11

TABLE NO.5.1.CATCHMENT AREA

5.2 Hydrological Analysis

On the basis of experimental evidence, Mr. H. Darcy, a French scientist enunciated in 1865, a law governing the rate of flow (i.e. the discharge) through the soils. According to him, this discharge was directly proportional to head loss (H) and the area of cross-section (A) of the soil, and inversely proportional to the length of the soil sample (L). In other words,

$$Q \propto \frac{H}{l} A$$

Here, H/L represents the head loss or hydraulic gradient (I), K is the co-efficient of permeability. Hence, finally,

Q = K. I. A.

Similarly, based on the above principle, water harvesting potential of the catchment area was calculated.

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

(m3)= Area of Catchment (m2) X Amount of rainfall (mm) X Runoff coefficient

5.3 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. As per manual of artificial recharge of ground water, Government of India Ministry of Water Resource Central Ground Water Board. Given below the table showing the value of runoff coefficient with respect to types of surface areas:-

TYPE OF AREA	RUNOFF COEFFICIENT (K)
Residential	0.3-0.5
Forests	0.5-0.2
Commercial & industrial	0.9
Parks & Farms	0.05-0.3
Asphalt or Concrete Paving	0.85
Road Surfaces	0.8-0.9

TABLE NO.5.2.RUNOFF COEFFICIENT

Runoff Coefficients of Different Surfaces:

DIFFERENT SURFACES	RUNOFF COEFFICIENT (K)
Roof Conventional	0.7-0.8
Roof Inclined	0.85-0.95
Concrete / Kota paving	0.6-0.7
Gravel	0.5-0.7
Brick Paving	0.7

TABLE NO.5.3. Runoff Coefficients of Different Surfaces

5.4 Annual Rainwater Harvesting Potential

Annual rainwater harvesting potential is given by

$V = K \times I \times A$

Where, V =Volume of water that can be harvested annually in m3.

K = Runoff coefficient

I = Annual rainfall in (mm)

A = Catchment area in (mm)

For School Building

Total catchment area = 2233.61m2.

Out of this A1 =1350.65m2 area of the school classroom & girls hostel & A2 = 882.96m2 area of office.

$I_1 = 2151.30$mm	$I_2 = 2018.22$mm
$I_1 = 2.15$m (annual)	$I_2 = 2.02$m (monsoon)
$K_1 = 0.8$	$K_1 = 0.8$
$K_2 = 0.95$	$K_2 = 0.95$

$V = (K_1*I_1*A_1) + (K_2*I_1*A_2)$

$= (0.8*2.15*1350.65) + (0.95*2.15*882.96)$

$V = 4126.56m^3$ (annual)

For School Ground

$A = 4769.11m^2$

$I_1 = 2151.30$mm

$I_1 = 2.15$m

$K = 0.3$

$V = K*I_1*A$

$= 0.3*2.15*4769.11$

$V = 3076.08m^3$ (annual)

$V = (K_1*I_2*A_1) + (K_2*I_2*A_2)$

$= (0.8*2.02*1350.65) + (0.95*2.02*882.96)$

$V = 3877.05m^3$ (monsoon)

$I_2 = 2018.22$mm

$I_2 = 2.02$m (monsoon) $K = 0.3$

$V = K*I_2*A$

$= 0.3*2.02*4769.11$

$V = 2890.08m^3$ (monsoon)

V = (K1*I1*A1) + (K2*I1*A2)

= (0.8*2.15*1350.65) + (0.95*2.15*882.96)

V = 4126.56m3 (annual)

Annual Rainwater Harvesting Potential Is In Tabular Form:-

SR.NO.	NAME	K	I_1	I_2	AREA (m^2)	V(annual) (m^3)	V(monsoon) (m^3)
1.	School Building	0.8 & 0.95	2.15	2.02	2233.61	4126.56	3877.05
2.	School Ground	0.3	2.15	2.02	5652.91	3076.08	2890.08

TABLE NO.5.4. Annual Rainwater Harvesting Potential.

SR.NO. NAME K I1 I2 AREA

5.5 Discharge Calculation

To find out the required diameter of the pipe to be used for draining the rainwater down from the roof first we need to calculate the discharge Q i.e. given by:

$Q = C \times I \times A$

Where, Q= Discharge from roofs due to rainfall in (m3 /s).
C= Coefficient of runoff by rational method taken as 0.8 for this case.
I= Intensity of rainfall i.e.40mm/hr.
A= Area of catchment.

For School Building

DISCHARGE Q is given by:-

Area (A) m2 = 2233.61 m^2 Intensity (I) = 40mm/hr.

Coefficient (C) = 0.8

$Q = C*I*A$

$= 0.8*(40/3600000)*2233.61$

Q = 0.02m3/s

For School Ground

DISCHARGE Q is given by:-

Area (A) m2 = 4769.11m2Intensity (I) = 40mm/hr.

Coefficient (C) = 0.8

$Q = C*I*A$

$= 0.8*(40/3600000)* 4769.11$

Q = 0.04m3/s

SR.NO.	NAME	C(constant)	I(mm/hr.)	A(m^2)	Q(m^3/s)
1.	School Building	0.8	40	2233.61	0.02
2.	School Ground	0.8	40	4769.11	0.04

TABLE NO .5.5:. DISCHARGE

5.6 Calculations for Number of Rainwater Pipes (R.W.P.) to be Installed

Let us consider the R.W.P. to be provided are of diameter 100mm. So calculations will be as follows:

Formulae Used

$Q = CIA = n \times \pi/4 \times d2 \times v$

Where; Q = Discharge calculated
I = Intensity of rainfall A = Area of catchment n = Minimum no. of pipes d = Diameter of rainwater pipe i.e. R.W.P.
v = Velocity of water on the roof when it is at the verge of entering in the pipe due to the slope available at the roof. As the roofs are flat or having 0-2% slope so; v=0.1m/s.
So, no. of pipes are calculated as: $n = Q / (0.785d2 \times v)$

For School Building:

Q = 0.02 d = 0.1 v = 0.1
$n = Q / (0.785d2 \times v) = 0.02/(0.785 \times 0.12 \times 0.1)$ n = 25.48 pipes
Therefore approximate no. of pipes installed for convenience and it include no. of pipes connected from school ground water drainage = 30 pipes.

5.7 Calculation for the Diameter of the Discharge Pipe

For this we need height of the building studied under the project. The height of School Building is 15m&11m. The highest building in the campus is School building with 15 & 11 meters of height from the ground, and this also carries the maximum discharge per second which is 0.02m3/sec. Now we will design the discharge pipe for the maximum condition that can occur in the main building and then rest of the buildings will be provided with the same data of the discharge pipe. Now as mentioned earlier the initial velocity of Rainwater entering in the R.W.P. was taken as = 0.15m/sec. Now from the Newton's law of motion taking water to flow under the action of gravity only with an acceleration of 9.81m2/sec.

We know that,

$V2 = U2 + 2aS$

Where; V= Velocity of water entering the horizontal Discharge pipe = ?

U = Velocity with which Rainwater enters the R.W.P. = 0.15m/sec.

S= Height of the building = 15m&11m.

a = Acceleration due to gravity = g = 9.81m2/sec.

On putting all the values in above equation we get,

$V2 = U2 + 2aS$

$= (0.15)2 + 2*9.81*23.15$ $V = 21.31$m/sec.

Now as we know the Discharge pipe have to be designed for worse condition taking the fact that it has to carry all the discharge of building collected from even starting of collection

The discharge Q of the Building = 0.02m3/sec.

The velocity of water = 21.31m/sec.

We know that,

$Q = \pi/4 \times d2 \times V$

On putting all the values we get;

$Q = \pi/4 \times d2 \times V$

$0.02 = (3.14/4)*d2*21.31$

d = 34.5mm

Which will no available in standard sizes. We will provide Discharge pipes also of 100mm diameter. We will provide P.V.C. pipes of 100 mm diameter for both Discharge as well as for R.W.P. Both of them will be connected by the "T" joints and Discharge pipes will be provide "S" joints at required corners.

The diagrams of various buildings showing the exact location of the Rain Water Pipes has been shown below block wise:-

5.8 Design of Recharge Well

The design of recharge well is done on the basis of two criteria

Time of Concentration.

Maximum water to be stored at the longest rainfall with chocked filters.

Time of Concentration:

It is a fundamental hydrology parameter and used to compute the peak discharge for catchments. The peak discharge is a function of the rainfall intensity of particular return period and duration. Time of concentration is the longest time required for the water to travel in catchments and reach to outlet point (in our case, roof top and length of drain to recharge pit). The mathematical equation used for calculation of time of concentration requires inputs for the longest watercourse length in the watershed (catchments area (L), the average slope of that watercourse (S). The average value of slope will be different for different surfaces e.g. Roof, road, lawn, drain etc. Usually L and S can be obtained from architectural drawing of the building and if drawings are not available then by assessment.

The (Tc)is generally defined as the time required for a drop of water to travel from the most hydro- logically remote point in the sub-catchments to the point of collection. A time of concentration value is essential to determine critical intensity of rainfall because maximum discharge will occur for rainfall intensity of duration equal to the time of concentration. Time of concentration can be calculated by using following formula, Tc=0.0195L0.77S-0.385

Where; Tc = Time of concentration in minutes.

L = overland flow length in m.

S = average slope of the overland area.

This equation has been adopted from Kirpich 1940 (Soil and water conservation Engineering by Glenn O. Schwab John Wiley). If the slope of overland flow surface is different for different portion of overland flow then we can use the following formula

Tc = 0.0195Li0.77Si-0.385

Where; Tc = Time of concentration in minutes.

Li = overland flow length of i stretch in m.

Si = avg. slope of i stretch of overland flow. N = no. of different stretches.

Calculation Of Critical Rainfall Duration:-

SR.NO.	NAME	L(m)	S(slope)	Tc(minutes.)	Tc(hours.)
1.	School Building	0.8	0.005	50.11	0.835125

TABLE NO.5.6.: Calculation Of Critical Rainfall Duration

As we are going to design only one recharge well for the whole of the building so we will use the overall time which is values of TC. So the total time of concentration will be the submission of all the values of TC which comes out to be approximately0.92 hour.

Total discharge of the campus through rainwater = 0.02m3/s.

Discharge Q in m3/hr. = 72m3/hr.

Volume of the Recharge Well = Q*TC

= 72*0.92

= 66.24m3

But we will design the Recharge Well 1.5 times larger than the data we calculated so the minimum Volume (V) of recharge well = 1.5*66.24 m3.

V = 99.36m3.

The possible dimensions of which can be of 10m in diameter (d) and 12m in depth (h).

Which gives the volume of = π/4×d2×h

V = 0.79*102*12 m3.

V = 948m3 Maximum water to be stored at the longest rainfall.

For this we first need to calculate the maximum duration of the rainfall. The calculation for the same are done below

Maximum No. of days of Rain fall in Shahapur = 90 Days Average Annual Rainfall in Shahapur = 2151.30mm.

So Average Rainfall a day = 2151.30/90 = 23.90mm.

Now Intensity of Rainfall= 40mm/hr.

So maximum duration of rain a day= 23.90/40 = 0.60hrs. For design purpose let us take it as T = 2 hr./day.

5.9 Now Designing The Recharge Well For The Same

Discharge of whole building in m3/hr. = 72m3/hr.

Volume of the Recharge Well = Q*T = 72*2m3.

= 144m3.

So the Recharge Well designed by us of capacity 948m3 will serve the purpose without any difficulty. The inlet of the Recharge Well will have to be kept deep down 1m below the ground level and will be built in the Farming part of the campus.

5.10 Cost Estimation Of Project

We have to spend money on various components of the project. The major components are as follows:

- R.W.P pipes.

- Discharge pipes
- Recharge well cost.
- Fixer and cost of Joints.
- Excavation cost.
- Maintenance charges.

So we first calculate the total amount of above work:
TOTAL LENGTH OF 100MM R.W.P. TO BE PROVIDED:

SR.NO.	NAME	HEIGHT(m)	No. of R.W.P.	Total Length (m)
1.	School Building	23.15	35	805

TOTAL LENTH OF DISCHARGE PIPE:

TABLE NO.5.7. Total Length of 100mm R.W.P.

SR.NO.	NAME	Distance covered by Discharge pipe till Recharge well
1.	School Building	900m

TABLE NO.5.8. TOTAL LENTH OF DISCHARGE PIPE

Volume of the Recharge well = 144 m3.
Fixer and cost of Joints involves fitting of the "T" and "S" while connecting R.W.P and discharge pipe with each other.
Total no. of "T" required = total no. of R.W.P = 98 = Iron mesh at entry point.
Total no. of "S" required = total no. of Corners discharge pipes have to go through=80.
Let us suppose we have clamped R.W.P. at every three meters so no. of clamp required= 805/3= 268.33 or say 300.
Now let us suppose we have provided one couple joint at every five meters of the pipes; So no. of such joints required =(805+900)/5 =341 or say 400.
Excavation cost will cover the total excavation we have done to layout the discharge pipe.
As in this case of laying Discharge pipe we are laying in tapered fashion so we will have to take the slope consideration in mind before actually calculations. Slope provided (S=0.005).
Let us suppose we have excavated a box of 0.5*0.5m2 at the starting of laying of pipes.
Let us do the calculation for total excavation bringing Discharge pipe from opp. side to recharge well.
Length of pipe L =350m.
As mentioned before we have taken' a' of 0.5*0.5m2 at the starting of laying of pipes.
So initial depth a = 0.5m.
Final depth b = 350*0.005= 1.75m
So total excavation = (0.5*(a +b)*L*W) m3.
= [0.5*(0.5+1.75)*350*0.5] m3.
=196.875 m3.

VI. Result & Discussion

After Installing this Rainwater Harvesting System that much amount of water can be harvested and it also help to increase recharge of groundwater by capturing and storing rainwater, by rainwater harvesting from rooftop run-offs.to store the water for farming, gardening and washing purpose.

2022-2023	2.946	9869.29
2023-2024	3.151	10556.06
2024-2025	2.109	7065.29
2025-2026	2.593	8686.72

2026-2027	1.831	6133.97
2027-2028	2.068	6927.94
2028-2029	3.044	10197.60
2029-2030	2.847	9537.64

TABLE NO.6.1: RWH IN FUTURE

VII. Conclusion

This study concluded that roof water harvesting should be recommended for potable water requirements in areas suffering from acute water scarcity after monsoon. The storage tank should be of capacity 900 m³, constructed in such a way that no light or air enters inside the tank to prevent bacterial growth, and the tank should be at least 0.5 m above ground level to stop direct entry of runoff water. First flush of rainwater should be allowed to bypass the storage tank, as well as rainwater should be flushed through the system after long gaps between two rainy events. Calcium carbonate powder kept in earthen pots, tied with muslin cloth on the mouth may be submerged into the storage tank to keep the water disinfected. The study shows that despite all precautions, with the passage of time, anaerobic bacteria (E. Coli) develops in the stored water which could be removed by pumping the water out of storage tank and keeping the same in a copper vessel of 5L to 10L, capacity for 8-10 h, to fully disinfect rainwater and make it potable.

In the VOGCE campus rainwater harvesting system has been installed in School Building. The roof runoff water is collected through network of pipe lines and stored in the wells. There is one wells in the campus where the roof runoff water is stored & also increase the ground water level. The total capacity of storage is 900 m³. The remaining roof runoff water is allowed to infiltrate in the ground for recharge. The stored water is used for Farming, Gardening and Washing of vehicles.

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IMAGE GALLERY