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Design & Estimation of Rain Water Harvesting System for a college campus in Solapur City

A.A. Sangave, S . J. Mohite, H.R. Pawar, V.V. Kulkarni, C.R. Abhangrao

Abstract: Millions of people in every part of the world do not have means of approach to pure water for household purposes. In many parts of the world typical piped water is either not present, irregular or too costly. One of the greatest dares of the 21st century is to control the increasing water scarcity. Rainwater harvesting has thus retrieved its significance as a precious substitute or additional water resource, in addition to other typical water supply technologies. Much undeniable or possible water scarcity can be pleased if rainwater harvesting is exercised more widely. This project deals with provision of different options for economical water storage tank in college campus situated in Solapur city. The most economical option is of water bank whose payback period is of 4 to 5 years. The other 2 options are costly as payback period is more. The main objective is to create efficient Rainwater harvesting system for big institutes and housing societies. This project will be useful to fulfil the water demands in dry period and to make sustainable use of water resource. This stored water can fulfil the demands for different uses like washing purpose in toilets, gardening, washing vehicles etc.

Index Terms**:** ***Circular water tank, Rainwater Harvesting, Solapur city, water bank.***

I. INTRODUCTION

The present scenario of water is very bad especially in countries those located in arid and semi-arid regions. These countries have started to face crisis, although the magnitude, intensity and extent of the crisis vary from country to country. There is huge increase in demand of water for drinking, irrigation and industrial purposes. Presently demands are satisfied either by over utilization of ground water or Pipelines from rivers and reservoirs. Sources of water becoming insufficient and distant. Ground water sources are reducing rapidly or getting polluted. Surface storages are becoming dry early. 50% population of third world is suffering from water contamination problem. 97% of total water on earth is salty and only 3% is freshwater. Out of 3% freshwater, 22% is groundwater and 1% is surface water.

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* Correspondence Author
Prof. A. A. Sangave*, Assistant Professor, SVERI's College of Engineering, Pandharpur.
Prof. S. J. Mohite,Assistant Professor in JSPM's Imperial College of Engineering & Research, Wagholi, Pune.
Prof. H. R. Pawar, Assistant Professor in SVERI's College of Engineering, Pandharpur.
Prof. V. V. Kulkarni, Assistant Professor in SVERI's College of Engineering, Pandharpur
Miss. C.R. Abhangrao, PG Student in SVERI's College of Engineering, Pandharpur.

1% groundwater is available up to 800 m and remaining 11% available below 800 m.

This paper outlines rainwater harvesting, which is being regularly utilized now a days; though, the concept of water harvesting is not new for India. Water harvesting ideas had been advanced and evolved centuries ago. In spite of having an appreciable evaluate for water, we seem to have failed to address this sector thoughtfully.

Rainwater harvesting is the action of supplementing the natural filtration of Rainwater into the subterranean development by some unnatural methods. Responsive gathering and storage of rainwater to serve demands of water, for drinking, household purpose & irrigation is also known as Rainwater Harvesting.

Rainwater is proportionately unsecured from contamination excluding those collected from the atmosphere**.** But the quality of rainwater may fall during harvesting, storage. Utilization of contaminated water from storage tanks may causes health risks. Imperfect hygiene in storing water in and withdrawing water from tanks or at the point of utilization can also represent a health concern. Apart from these, risks from these hazards can be lowered by adequate design and practice. Adequately designed rainwater harvesting system with clean catchments and storage tanks assisted by good hygiene at point of utilization can provide drinking water with very minimal health risk. On other side, an improperly designed and managed system can produce high health risks.

In many regions of the world, fresh drinking water is not regularly accessible and this is only achievable with huge investment costs and expenditure. Rainwater is a free source and comparatively clean and with genuine treatment it can be even utilized as a potable water source. Rainwater harvesting rescue good quality drinking water sources and reduce the pressure on sewers and the environment by reducing floods, soil erosions and refilling groundwater levels.

a) Objectives

- To create simple and economical rainwater harvesting system for big campuses like educational institutes.
- To store rain water for water scarcity period.
- To design and provide economical, strong and specious water tank with minimum dimensions.
- To minimize cost on Municipal corporation water by reducing its demand.

b) Components of rainwater harvesting system

- Catchment surface
- Delivery system
- Storage reservoirs
- PVC gutters
- Downpipes
- Filter
- Storage tank
- Overflow pipe

II. STUDY AREA

Solapur lies in the rain shadow region of western Maharashtra and receives rain from the returning monsoon in September-November. The standard precipitation in Solapur is abruptly 488mm (June to September). In 2015-16 the standard rainfall has been 186mm (June to September) and if we consider the rainfall up to November, it goes to 252mm. Solapur district has one of the biggest areas enclosed under drought prone area program in Maharashtra. On the basis of National Agricultural Research Project (NARP) categorization of agro-climatic zones of the country, Solapur drops under the MH-6 scarcity zone.

In semi-arid district of Solapur, reservoirs, sugarcanes and sugar mills have produced a brutal circle of unscientific farming practices. These may lead to catastrophic results of water management, which has provided extremely to the present-day calamity of reduction and non-availability of water. Therefore, it is critical to understand the steps taken in both short-term, in terms of inadequacy management for the current year, and long-term in terms of executing soil and water conservation measures in the district.

Fig. (1): Google map Image of study area

III. METHODOLOGY

Following steps were followed in designing a rainwater harvesting system

STEP 1: Determination of catchment area.

STEP 2: Determination of total amount, volume of water required and available rainwater.

STEP 3: Design of filter units.

STEP 4: Cost Estimation for filter units.

STEP 5: Design of storage tanks and cost estimation

a) Area Calculation of roof catchment:

The area calculation of all the buildings are shown in following table.

I. Area calculations for college buildings

Particular (Building name)	Number	Area (m^2)
Engineering	4	8030.96
MBA/MCA	2	4228.96
School	3	1458.41
Hostel	2	2853.24
Canteen	1	550.56
Estate office	1	333.19
Library	1	1426.8
Quarters	6	1318.298
Miscellaneous	4	3152.12
Total		23352.53 m^2

b) Total roof top storage:

Volume of water collected

= Area * rainfall * runoff coefficient

= 23352.53 * 0.400 * 0.70

=6538.70 m^3

=65.38 lakh liters

c) Design of Filter unit for rainwater:

The collected rainwater is passed through a suitable filter unit before it is stored or sends to charging unit. The filter that we are designing consists of Gravel, Sand, Small brick pieces and 'netlon' mesh is designed and placed on top of the Storage tank. This filter is very important in keeping the rainwater in storage tank clean. It removes silt, dust, leaves and other organic matter from entering the storage tank. Dimensions of filter we proposed are as follows:

- 2m *2m * 1.2m
- Wall thickness of the filtration tank is 0.230 m
- Thickness of different filter materials are:
- Sand layer = 5 cm
- Gravels

  -Top layer =15cm

  -Intermediate layer 15cm

  -Bottom layer = 15cm

  -Small pieces of bricks 10cm

d) Cost Estimation for filter:

- one brick wall = 2m*2m *0.23m = 0.92 m^3
- volume of 4 walls = 4*0.92 = 3.68 m^3
- Rate of brickwork = 5103/ m^3
- Brickwork cost = 5103 * 3.68 = Rs 18,780
- Sand layer = 2m * 2m* 0.05m = 0.2 m^3
- Rate of sand layer = 1274/ m^3
- Sand layer cost = 1274 * 0.2 =Rs 255
- Gravel layer = 2m * 2m * 0.45 = 1.8 m^3
- Rate of gravel layer = 180/ m^3
- Gravel layer cost = 180 * 1.8 = Rs 324
- Total cost of construction = Rs 19,360
- Add 2.5 % as contingencies =Rs 19,845
- Add 5% as water charges =Rs 20,840

Therefore, the total cost of the filter unit is Rs. 20,840

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IV. STORAGE TANK DESIGN

Due to following merits circular RCC tank was adopted for design over rectangular RCC tank:

a) As the stresses at the corners are more which is reduced in circular tank and cost will be reduced.

b) Thickness of wall is also reduced in RCC circular tank

a) Option-1: Water tank for individual building

- Per capita demand for school /colleges (15-25) lpcd
- Taking it to be 15 lpcd
- Total Users of the building 400
- Total demand = 15 * 400 = 6000 lits/day
- For dry period of 4 months = 6000 * 120 = 7,20,000 lits = 720 m^3
- Excluding drinking purpose, only 70% of above value is for washing = 0.7 * 720 = 504 m^3

In this option we are providing separate storage tanks for all different buildings. The water stored in this case will be utilized by separate respective buildings for a dry period of 4 months.

- Area of a building = 86.84 * 23.12 =2007.74 sq.m
- Average Rainfall for Solapur = 400mm
- Runoff coefficient for Plaster on bricks floor = 0.7
- Volume of water collected =2007.74*0.4*0.7=570 m^3
- Provision of RCC circular tank:
  Volume = Area * Height
  $600 = (0.785 * D^2) * H$
  $D^2 = 600 / (0.785*H)$
  D =14m
- The tank is designed as per IS code method.

II. Estimation for individual tank

Particulars	Diameter m	Height m	Quantity m^3	Cost
Excavation	16	4.2	834	58,666
Concreting	-	-	169	1012.44 0
UCR work	15.84	4.2	121	3,53,511
Steel work	10 mm & 12 mm bars	-	5.5 Tons	2,50,250

- Hence Total cost for installation including contingencies and water charges is = Rs. 22,00,000
- Capacity of tank = 600 m^3
- Depth of tank = 4 m (with freeboard of 0.3m)
- Dimension of the tank = 14 m
- Total cost for construction of tank = Rs 22,00,000
- Cost of construction for per Sq.m = Rs 14,290
- Corporation charges for water per person per month= Rs. 76.4
- Out of this 30% is drinking water bill and 70% is washing water bill.
- Water bill for washing water per person per month = 0.7 * 76.4 = Rs. 54
- Water bill for washing water per person for 4 months = Rs 216
- Therefore, we can save in 4 months for one particular building = (216 * 400) = Rs 86,400
- i.e. In a year we can save nearly Rs 86,400
- For this the payback period is 30 years.

From above calculation it is observed that for single building only cost of construction is too much on higher side and payback period is also not feasible. Therefore, we go for 2nd option.

b) Option-2: Combined R.C.C. circular tank for some feasible buildings in the campus

- Per capita demand for school /colleges (15-25) lpcd
- Taking it to be 15 lpcd
- Total Strength of college campus = 3000
- Total demand =15 * 3000 = 45,000 lit/day
- For dry period of 4 months = 45,000 * 120 = 5400 m^3
- If we exclude drinking purpose, then taking only 70% of above value is equals to (0.7 * 5400) = 3780 m3

We are providing a common R.C.C. circular tank for rainwater from some feasible buildings of campus. This stored water will be used by whole campus for 4 months dry period.

- Total catchment area of feasible buildings = 14,892 Sq.m
- Average Rainfall for Solapur 400 mm
- Runoff coefficient for Plaster on bricks floor 0.7
- Volume of water collected = 14892 * 0.4 * 0.7 = 4169.75 m^3
- Capacity of tank = 3960 m3
- Dimension of the tank = 29 m
- After following the same design steps for RCC circular tank as in 1st option, we got total cost for construction of tank is Rs 1.65 crores
- Cost of construction for per sq.m = Rs 25,000
- Corporation charges for water per month = Rs 2,29,000
- Out of this 30% is drinking water bill and 70% is washing water bill.
- Bill paid for washing water per month = Rs. (0.7 * 2,29,000) = Rs. 1,60,300
- Water bill saved per person per month = 1,60,300/3000 = Rs 54
- Water bill saved in 4 months dry period = 4 * 54 * 3000 = 6,48,000
- i.e. In a year we can save nearly Rs. 6,48,000
- In this type of storage tank payback period is 25 years.

From above calculation it is observed that after combining some feasible buildings for collection of rainwater, cost of construction is again too much on higher side and payback period is also not feasible. Therefore, we go for 3rd option.

c) Option 3: Provision of common water bank for whole campus

- Total volume of water that we get from all buildings of campus is 65.38 lakh lits.
- Therefore, capacity of tank be nearly 6538 m^3
- Water requirement of all buildings in campus for 6.6 months for washing = (3000*15*200*0.7) = 6300 m^3
- Diameter of bank at bottom = 41 m
- Diameter at the top = 45 m
- Cost excavation of water bank= Rs.43,74,150
- Cost of Geo membrane = Rs. 1,22,598
- Cost of Shed net = Rs. 46,900
- Therefore, total cost of construction Rs. 50,00,000
- Corporation charges for water per month = Rs 2,29,000
- Out of this 30% is drinking water bill and 70% is washing water bill.
- Bill paid for washing water per month = Rs (0.7 * 2,29,000) = Rs. 1,60,300
- Water charges saved per person per month = Rs. 54
- Therefore, we can save in 6 months and 20 days = (6.6 * 160300) = Rs 10,58,000
- i.e. In a year we can save nearly Rs 10,58,000
- In this proposal the payback period is 4 to 5 years.

In this option the cost of construction and payback period is within feasible region and acceptable. Therefore, we suggest 3rd option.

V. RESULT

On the basis of economy option third i.e. the Water bank is most suitable option for the storage of rainwater. The comparison table of all the three options is given below.

III. Cost and payback period comparison

TANK OPTION	INITIAL INVESTMENT (Rs.)	PAYBACK PERIOD (YEARS)
Individual circular tank for single building	22 Lakhs	30
Combined RCC circular storage tank	1.65 Crores	25
Water bank for whole campus	50 Lakhs	4 to 5

VI. CONCLUSION

It has been observed that by implementation of water harvesting in big institutions large amount of water can be stored. For large built up areas construction of common water bank is most economical option for storing rain water. In long run, strategy of harvesting and storing of rain water becomes much more profitable.

VII. FUTURE SCOPE

1. To develop more economical storage units by using lightweight materials.
2. To develop water treatment plant, to treat water and utilize for drinking purpose.
3. To develop the top layer of the road so as to collect maximum amount of Rainfall.

REFERENCES

1. AFARM Institute Pune - "Action For Agricultural Renewal in Maharashtra". [1]
2. "Water power and Hydrology" by B. C. Punmia, Ashok Jain, Arun Jain, Laxmi publication. [2]
3. "AGRODOK 43" A hand manual on rainwater harvesting by Janette Worm and Tim van Hattum. [3]
4. Design of Reinforced concrete structures by S. Ramamrutham, Dhanpat Rai Publications [4]
5. Advanced Reinforced Concrete Design by P.C. Varghese, PHI Publication. [5]

AUTHORS PROFILE

Prof. A. A. Sangave, M.Tech. (Hydraulic) and Working as Assistant Professor in SVERI's College of Engineering, Pandharpur & Having 3 years' experience in teaching.

Prof. S. J. Mohite, M.Tech. (Remote Sensing) and Working as Assistant Professor in JSPM's Imperial College of Engineering & Research, Wagholi, Pune & Having 4 years' experience in teaching & 1.5 years in industry.

Prof. H. R. Pawar, M.E. (Water Resources Engineering) and Working as Assistant Professor in SVERI's College of Engineering, Pandharpur & Having 7.5 years' experience in teaching & 2 years in industry.

Prof. V. V. Kulkarni, M.E. (Construction Management) and Working as Assistant Professor in SVERI's College of Engineering, Pandharpur & Having 5 years' experience in teaching.

Miss. C.R. Abhangrao, PG Student in SVERI's College of Engineering, Pandharpur.