Design of Artificial Recharge System for Enhancing GroundwaterStorage – Rainwater Harvesting System

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Abstract - *Serious abuse of springs is one of the principle natural issues overall along with different marvels, for example, environmental change, changes in land use, the vanishing of species, etc. Water shortage is intense issue all through the world for both metropolitan and rustic local area. Urbanization, mechanical turn of events and expansion in horticultural field and creation has brought about overexploitation of groundwater and surface water assets and resultant crumbling in water quality. The ordinary water sources like well, waterway and repositories, and so on are deficient to satisfy water interest because of lopsided precipitation. To that regard, the fake groundwater re-energize nearly remains as the arrangement to lessen straightforwardly the impacts of spring misuse. To be accurate, the re-energize of springs is the procedure used to bring water into the ground to meet water shortfalls in springs. This investigation means to improve the information procured on fake groundwater re- energize utilizing water gathering all together for this procedure to be thought about as a substantial alternative when lessening escalated misuse of springs.*

In this examination, the downpour water gathering (RWH) framework is investigated as an elective wellspring of water at PataskarEclat, Opp.to D-store, Kavesar Ghodbunder Street, Thane (west) in the province of Maharashtra, India. The normal result of the investigation is the improvement ofwater reaping framework for complete catchment space of the venture in square meters 8961sq m. The created framework fulfills the social prerequisites and can be executed in both rustic and metropolitan regions by thinking about practically all the specialized viewpoint.

***Key Words*: : Aquifer, Artificial groundwater recharge, Rainwater harvesting, Water scarcity, Urbanization**

1. INTRODUCTION

Groundwater being most dependable source of water supply is under tremendous stress to meet the ever increasing demand of irrigation, industrial and domestic sector. The over exploitation of this resource has resulted in to decline in water levels in many part of the Country and many of the water assessment units are thus categorized as over-exploited Blocks. Immediate remedial measures are therefore required to be taken up for converting areas into Critical / Semi-critical / Safe categories. This can be done through various artificial recharge methods. Artificial recharge is the planned, human activity of augmenting the amount of groundwater available through works designed to increase the natural replenishment or percolation of surface waters into the groundwater aquifers, resulting in a corresponding increase in the amount of groundwater available for abstraction. The artificial recharge to ground water aims at augmentation of ground water reservoir by modifying the natural movement of surface water utilizing suitable civil construction techniques.

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1.1 RAINWATER HARVESTING SYSTEM

Rainwater harvesting (RWH) is a simple method by which rainfall is collected for future usage. The collected rainwater may be stored, utilised in different ways or directly used for recharge purposes. With depleting groundwater levels and fluctuating climate conditions, RWH can go a long way to help mitigate these effects. Capturing the rainwater can help recharge local aquifers, reduce urban flooding and most importantly ensure wateravailability in water-scarce zones.This water conservationmethod can be easily practiced in individual homes, apartments, parks, offices and temples too, across the world. Farmers have recharged their dry borewells, created water banks in drought areas, greened their farms, increased sustainability of their water resources.

The different components for Rain Water Harvesting are:
1. Land Surface Catchments
2. Collection Devices
3. Conveyance Systems

2. SITE DETAILS

The location of our site is PataskarEclat Building (19°15`40``N 72°58`12``E) situated on Ghodbunder road opposite to D-Mart kasarvadavli in Thane (West). Total catchment area of the site which can be used for rainwater harvesting is 3425 sq m(rooftop area & surface area). No. of floors in building - 23 floors (2BHK- 46NO, 3BHK- 46NO).
There is also a shopping complex in present in surrounding of building which also considered for rainwater harvesting.

Fig 2.1: Top view of Pataskar Eclat

3. DATA COLLECTION

3.1 Rainfall Analysis

A lot of rain (rainy season) falls in the months: June, July, August and September. Mumbai has dry periods in January, February, March, April, May, November and December. On average, July is the wettest month.On average, March is the driest month. The average amount of annual precipitation is: 2260.0 mm (88.98 in).

3.2 Water Supply Data

The primary source of water for the facility is municipal supply (time 05:00pm – 07:00pm), and the secondary sources are borewell and sewage treatment plant(STP). After surveying and monitoring the facility we came to know that, there is 1 borewells present in the building whose yield of working was 2500 liters/hour. On an average 4 hours of pumping water from the borewell. Water meters were installed on tube wells to monitor extraction of groundwater.The facility never called for anywater tanker as the water need was fulfilled by the processes used by the building.

3.3 Available Water Storage

Underground tanks layout:

Drinking tank(7000litres)	Domestic tank (42600 litres)	Fire tank (150000 litres)	Flushing tank (15500 litres)

Overhead tanks layout:

Fire tank (20,000 litres)
Domestic tank (45600 litres)
Drinking tank (11500 litres)
Flushing tank (30250 litres)

Fig3.1 water storage

3.4 Water Requirement data

Reference: As per National building code (NBC 2016)
(a)For communities with population above 100,000 together with full flushing system is 150 to 200 lphd.
(b)Out of the 150 to 200 litre per head per day, 45 litres per head per day may be taken for flushing requirements and the remaining quantity for other domestic purposes. Therefore,
Total requirement for Society per day: = 180 x (506+100) =1,09,080 litres
Considered Average 180litres per head per dayTotal population = (46 x 5) + (46 x 6) = 506
Considering Population for 2bhk is 5No.
Considering Population for 3bhk is 6No
Average 100No. of visitors per day in societyTotal requirement for Drinking per day :
= 6 x (506+100) = 3,636 litres
Considered Average 6 litre per head per day Total requirement for flushing per day :
= 45 x (506+100) = 27,270 litres
Considered Average 45 litre per head per day.

Total requirement for Domestic per day :
=129 x (506+100) = 78174 litres
Considered Average (180-45-6)=137 litre per head perday.

4. DESIGN OF RAINWATER HARVESTING SYSTEM

4.1 Calculation of rainwater harvesting potential:

Rainwater harvesting potential: The total amount of water that is received in the form of rainfall over an area is called the rainwater endowment of that area. Out of this, the amount that can be effectively harvested is called the rainwater harvesting potential.

Data collected:

1. Average annual rainfall of Thane district – 2260.00mm (88.98 inch).
2. Total catchment area that can be effectively used for rainwater harvesting – 3425 sqm
   - Rooftop area – 1245 sq m (Building and shopping complex)
   - Surface area – 2180 sq m
3. Runoff coefficient:

Table 1: Runoff coefficient depending on type of surface

Type of Catchment	Coefficients
Roof catchments: 1.Tiles/concrete 2. Corrugated metal	 0.8-0.9 0.7-0.9
Ground surface catchment: 1.Concrete (urban residential) 2.Brick pavement	 0.6-0.8 0.5-0.6
Untreated ground catchment: 1.Soil on slopes less than 10% 2. Natural rocky catchment	 0.0-0.3 0.2-0.5

- Calculating rooftop rainwater potential (P):

P = Total catchment area (sqm)*Average annual rainfall (mm)*Runoff coefficient

P = 1245 * 2260 * 0.8

P = 22,50,960 liters

- Calculating surface rainwater potential (S):

S = Total catchment area (sqm)*Average annual rainfall (mm)*Runoff coefficient

S = 2180*2260 * 0.6

S = 29,56,080 litres

- Total rainwater that can be harvested = P+S =52,07,040 litres
- This harvested rain water is to be for recharging borewell.

4.2 Design and specifications of components to beused for rainwater harvesting:

1. Coarse mesh: It is to be used at the roof to prevent the passage of debris.

2. Gutters:

Channels all around the edge of a sloping roof to collect and transport rainwater to the storage tank. Gutters can be semi-circular or rectangular and could be made using:Semi-circular gutters of PVC material can be readily prepared by cutting those pipes into two equal semi- circular channels.We will be using PVC half round gutter of180mm diameter.

3. Conduits:

Conduits are pipelines or drains that carry rainwater from the catchment or rooftop area to the harvesting system. Conduits can be of any material like polyvinyl chloride (PVC) or galvanized iron (GI), materials that are commonly available.

Calculation of diameter:

To find out the required diameter of the pipe to be used for draining the rainwater , first we need to calculate the discharge Q given by:- **Q = CIA**

Where, Q= Discharge from roofs due to rainfall in (m3 /s)

C= Coefficient of runoff taken as 0.8 I= Intensity of rainfall i.e.75mm/hr.

A= Area of catchment taken as 1245 m^2Therefore,

Q = 0.8*75/3600000*1245

Q = 0.0208 m^3/sec

Calculation of diameter of conduit:

$V^2 = u^2 + 2aS$

Where;

V= Velocity of water entering the horizontal Discharge pipe

U = Velocity with which Rainwater enters the R.W.P. = 0.1 m/sec.

S= Height of the building = 76 m.

a = Acceleration due to gravity= g = 9.81m^2/sec.

The velocity of water in the mail building was calculated tobe 38.61 m/sec.

The discharge Q of the Building = 0.0208 m^3/sec.

We know that $Q= \pi/4\times d^2\times V$

On putting all the values we get; d = 35.4 mm (36 mmapproximately)

Which will not available in standard sizes. Hence 50 mm diameter discharge
pipes can be used.

The no. of pipes required would be depending on construction. We will take it
approximately 100 nos.

4. Rainwater harvesting filters:

We will be using FL RAINY filters for filter ng rainwater carried from roof top. `RAINY' is Dual Intensity Rainwater Harvesting Filters with self cleaning and auto flush out arrangements.

The characteristic features of FL Series Dual Intensity RWH Filter is its capacity to take up the load up to 10 to 500 square meters of Roof area with variable intensity of rainfall of 5 to 75 mm/ hour with a discharge capacity of 10 To 480 Liters per minute.

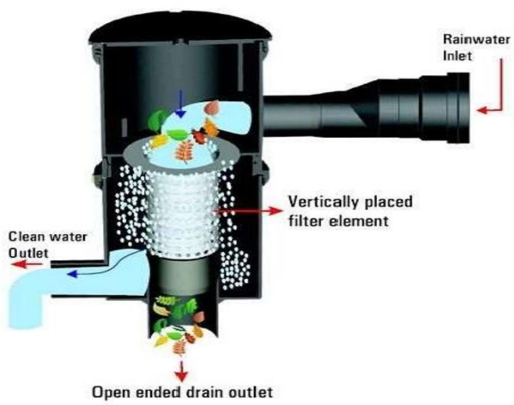


Fig 4.1: FL rainy FIlter

1)

Technical Specifications & Parameters of various models of Rainy FL Series Dual Intensity RWH Filter				
	Rainy FL-100	Rainy FL-200	Rainy FL-300	Rainy FL-500
Suitable up to roof area:	110 SQMTRS	225 SQMTRS	350 SQMTRS	500 SQMTRS
Max: Intensity of Rainfall:	75 mm/hr	75 mm/hr	75 mm/hr	75 mm/hr
Working Principle:	Cohesive Force & Centrifugal force			
Operating Pressure:	Less Than 2 feet of head (0.060kg/cm²)			
Capacity:	105 LPM	225 LPM	340 LPM	480 LPM
Filter Element:	SS-304 Screen	SS-304 Screen	SS-304 Screen	SS-304 Screen
Mesh Size:	250 Microns	250 Microns	250 Microns	250 Microns
Inlet:	90 MM	110 MM	110 MM	110 MM
Clean Water Outlet:	63 MM	75 MM	90 MM	90 MM
Drain Outlet:	90 MM	90 MM	90 MM	110 MM
Housing:	High Density Polyethylene			
Efficiency of Filter:	Above 90 %	Above 90%	Above 90 %	Above 90%
Source of power:	Gravity	Gravity	Gravity	Gravity

Fig 4.2: Comparision between various filters

We will be using total 7 nos of FL 200 type of filter and 2nos of FL 100 type of filter.

5. Recharge Pit with Filter:

Furaat recharge pit: It is precast Modular Step-well(Recharge Pit) for an effective rain water harvesting.

It comes in two types, which are as follows:

Sand Filtration Module (SFM): It is advisable for roof top Rain Water harvesting.

2) Horizontal Filtration Module (HFM): It is advisable forroof and surface run off rain water harvesting.

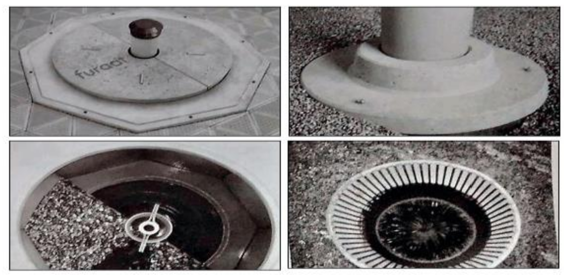


Fig 4.3: SFM recharge pit top view

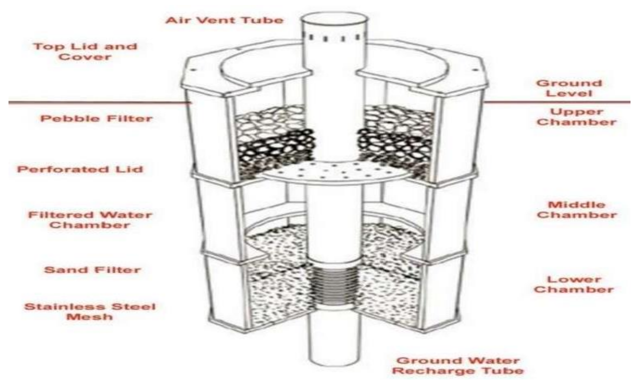


Fig 4.4: SFM recharge pit sectional view

We will be using 2 nos of SFM type of recharge pit.

Furaat Sand Filtration Module will be of diameter 2500mm and 3475mm height.

The system should be of octagonal in shape and each slab should have 1075mm x 550mmx 40mm thick. Eight vertical pre cast slabs held together between two horizontal pre cast octagonal slabs (with 590mm edge length, 50mm thick and hole of 100mm diameter in the center).

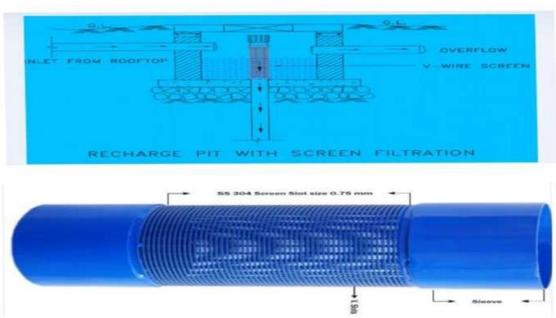
The top surface of well can be flushed with ground level or can be maximum 300/600 mm above ground level.

Bottom module holds another type of filter media in the form of sand bed around a continuous slot fine aperture stainless screen (420 mm diameter and 300 or 450 mm length).
Screen is fixed to the bottom slab and is fully covered by filtration sand. Screen creates entry points for the filtered water.
All precast concrete slabs are of M-25 grade filtration capacity & testing up to 30m3 per hour with Storage capacity 5.1 Cu.mtr. from modular systems and only.

Filtration rate is high i.e. 30000 liters/ hr.
The filtered water is finally connected with the existing tube well/recharge borewell/ UG water storage tank or artificial reservoir.

6. V- wire screen:
We will be using V wire screen is of stainless steel material, grade SS-304, cage type trapezoidal wire wound screen.
Screen is evenly distributed continuous slot opening of 0.75mm.The diameter of screen is 150mm and length is

Excavating the earth.



Providing RCC walls in the excavatedthere after providing the filter materials portion and Covering the tank made with a RCC or stone slab provided
with a manhole. In our project borewell should be drilled nearly upto 200 ft Total water that can be recharged is 52,07,040 litres.

4.4 RAINWATER HARVESTING LAYOUT OF THE SITE

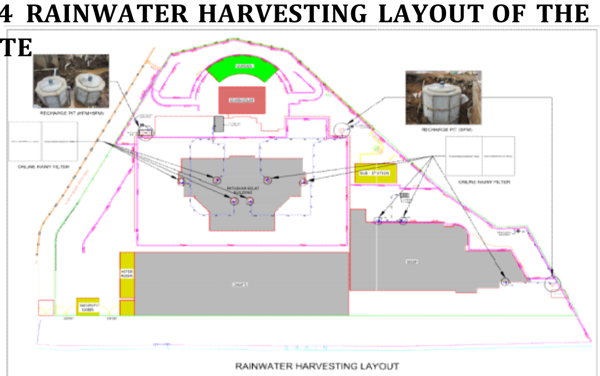


Fig 4.6 : V Wire screen

500mm.

4.3 Recharging of borewell

In alluvial and hard rock areas, the borewell can be drilled.These can be recharged directly with rooftop run-off.

Rainwater that is collected on the rooftop of the building is diverted by drainpipes to a settlement or filtration tank, from which it flows into the recharge well.

If a borewell is used for recharging, then the casing (outer pipe) should preferably be a slotted or perforated pipe so that more surface area is available for the water to percolate.

Steps for constructing borewell:

Making a borehole to facilitate groundwater recharging.

5. COST ESTIMATE

Table 2: Total expenditure constructing RWH system

Sr. No.	Description	Approx Quantity	Unit	Rate (Rs)/unit	Amount
1)	FEASIBILITY STUDY				
A	Borewell Drilling upto 200 ft		No	55000	55000
	Pumping Machinery for Borewell		No	70000	70000
2)	PROJECT EXECUTION				
	Harvesting Rain Water				
A	RWH Material				
	Rainy Filter FL 100	2	No	9853	19706
	Rainy Filter FL 200	7	No	13581	95067
B	Providing and Installing Modular Rechrge pit	2	No	124000	248000
C	Collection System				
	50 mm PVC SWR Pipe of Pressure 4kg/sq.cm.	100	Rmt	350	30000
	PVC Half Roud Gutter 180 mm		Rmt	1500	7500
	Excavation for Underground pipeline	5	Rmt	450	2250
D	Contingencies (Debris Removal, dewatering etc)	1	No	22250	22250
		Total			549773

6. RESULT AND DISCUSSION

1. Rainwater harvesting system almost cover catchment area of **3425** Sq.m
2. The total rainwater potential is around **52,07,040** liters and it is use for recharging borewells effectively with proper purification and disinfection arrangements.
3. Components used in RWH:
   3.1. Coarse mesh:
      3.1.1. It is to be used at the roof to prevent the passage of debris.
   3.2. Gutters:
      3.2.1. Semi-circular gutters of PVC material with 180mm diameter will be used.
   3.3. Conduits:
      3.3.1. We will be using polyvinyl chloride conduits (PVC) of 50mm diameter.
   3.4. Rainwater harvesting filters:
      3.4.1. FL RAINY Filter
      We will be using 7 nos of FL 200 type of filter and 2 nos of FL 100 type of filter.
   3.5. Recharge pit with filters:
      3.5.1. We will be using Furrat recharge pit of sand filteration module (SFM) type.
      SFM should have diameter 2500mm and 3475mm height.
      The system should be of octagonal in shape having various layers of filter medias like sand, small aggregates etc.
   3.6. V-wire screen:
      3.6.1. V wire screen is of stainless steel material, grade SS-304, cage type trapezoidal wire wound screen.
4. Recharge pit will be connected to borewell for borewell recharge.
5. The borewell is to be drilled upto 200 ft.
6. The cost total estimate of the entire set-up will be of ₹5,49,773.

7. Conclusion

This investigation targets planning a roof water gathering structure for Pataskar Eclat Opp.to D-shop, Kavesar Ghodbunder Street, Thane (west). Further, various pieces of the RWH framework were planned dependent on standard rules which can resolve the water shortage issues during non-rainstorm season by putting away a tremendous amount in a year in the general public. Re-energize of ground water table is a progressive cycle, we can not out of nowhere increment the ground water table subsequent to developing re- energize structures, by building any kind of re-energize design, and we can give our commitment in spring re-energize. This will assist with restoring the draining ground water assets. Additionally help to save the little measure of downpour water which used to empty away out of numerous years. Accordingly it is inferred that execution of RWH arrangement of Pataskar Eclat society would bring about the type of the best way to deal with manage present situation of water shortage. What's more, this water can be used for different purposes like drinking, flushing, homegrown prerequisites and puttingout fires necessities.

REFERENCES

[1] Kanak N. Moharir, Chaitanya B. Pande, Sudhir Kumar Singh and Rodrigo Abarca Del Rio , "Evaluation of Analytical Methods to Study Aquifer Properties with Pumping Test in Deccan Basalt Region of the Morna River Basin in Akola District of Maharashtra in India".-2020

[2] S.Sangita Mishra, Shruti B.K., H. Jeevan Rao, "Design of rooftop rainwater Harvesting structure in university campus.", 2020

[3] Rajasekhar MSudarsana Raju GImran Basha Siddi Raju R.Pradeep Kumar B.Ramachandra M, "Identification of suitable sites of artificial groundwater recharge in semi arid regions ofAnantpur district: AHP Process", 2019

[4] A.S. BhaskarD.M. Hogan, J.R. Nimmo, K.S. Perkins, "Groundwater recharge amidst focussed stormwater infiltration", 2018

[5] Abhijeet Keskar, Rushikesh Ambhore, Satish Taiji, Sonali Potdar, "Rainwater harvesting – A campus study", 2016

[6] Silvie Heviánková, Marian Marschalko, Jitka Chromíková, Miroslav Kyncl, Michal Korabík, "Artificial Ground Water Recharge with Surface Water", 2016

[7] Manisha Yadava, Baldev Setiab, " Conceptualization and Design of an Efficient Groundwater Recharge system for NIT Kurukshetra ", . Global Colloquium in Recent Advancement and Effectual Researches in Engineering, Science and Technology (RAEREST 2016) .

[8] Jayantbabu Vithalrao Khanapurkar, Suryawanshi Ravindranath Anandrao, " Analysis of Groundwater Quality Parameters of Part of Nanded City,Maharashtra State(India) " -December 2016.

[9] Vijay Bhusari, P. kundal, Yashwant Katpal , " An innovative artificial recharge system to enhance groundwater storage in basaltic terrain: example from Maharashtra ", India, Hydrogeology Journal - March 2016.

[10] Avinash kadam, "Determination Of infiltration rate for site selection of artificial water recharge: An experimental study", International journal of science and research (IJSR)- July 2015.

[11] Chaitraa, Mysooru R.Yadupathi Puttyb and Prasanna H Sb, "Subsurface Drainage and Storage Properties in the Western Ghats - A Study in the Basin of Netravati ",
. International Conference on Water Resources, Costal and Ocean Engineering (ICWRCOE 2015).

[12] REA, Raji Pushpalata, "Rainfall-runoff analysis of a compacted area", Article in Agricultural Engineering International : The CIGR e-journal-March 2011.

[13] Amartya Kumar Bhattacharya, "Artificial groundwater recharge with a special reference to India", 2010

[14] G.K.ViswanadhM. Vidyadhar, M.V.S.S.Giridhar, "Rainfall analysis in Rangareddy district.",2004

[15] K.C Tyagi, O.P Singh, "Artificial recharge system in semi-arid basin.", 2001

[16] Kruseman and N.A. de Ridder, " Analysis of aquifer tests.", 2001

- **Bibliography:**
  - Rainwater harvesting information:
    http://www.rainwaterharvesting.org
  - Rainfall Data: https://weather-and-climate.com
  - Modular recharge pit (SFM):
    www.kanonwaterexpert.com

- **Manual :**

1.) Manual for artificial groundwater recharge by
Central Ground Water Board (CGWB), India.
Website: http://cgwb.gov.in

- **Consultancy and Guidance:**

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Website: https://waterfieldindia.com