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Energy Conservation by Reducing Pumping Efforts Using Roof Top Rain Water Harvesting: A Case Study of Poornima University

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ABSTRACT

It is well known fact that drinking water is in scarcity and it will become a major problem for our society in times to come. Harnessing the drinking water also consume enormous amount of electricity. Rain water harvesting becomes very important because it can not only meet the minimum drinking water requirement of future generation but also saves electricity by reducing pumping efforts through roof top rain water harvesting using storage tanks. This paper includes a case study based on the campus of Poornima University, Jaipur, Rajasthan, India which includes rain water received in the campus, design of settlement tank, storage tank and electrical saving through the proposed model.

Keywords: electrical energy, conservation, storage tanks, rain water, roof top, rain water harvesting, artificial, ground water, recharge

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INTRODUCTION

In some of the developed countries, water is also being synthesized by various means like desalination, artificial rain by cloud seeding. India is also feeling water stress from last many years which made a shift the thrust of policies from water development to sustainable water development.

This shift created a need of water harvesting and artificial ground water recharge.There is a huge increase in carpeted area due to urbanisation like mesh of highways, buildings etc. The ground water recharge passages were blocked by manmade activities. These recharge passages used to transfer rain water from surface into underground water pockets and aquifers. This water was also extracted very heavily during previous decades for irrigation and water consumption for human beings. This is because of increase in population and food demand of human being.

In India annual rain fall occurs in short period and its intensity is high. Because of its high intensity in short time most of the water flow away.There is a little scope of recharging of ground water naturally due to this wastage and lack of effective naturally recharging area. Hydrologic cycle is the most important source of water which collects the water from oceans and gives it to us as a natural phenomenon. In this series we can collect water coming out from rain and can use it with minimum purification processes. So, Rain water can either stored for direct utilisation or it can be directly recharged artificially to the ground water. So accordingly there are two types of systems: settlement tank & storage tank and another one is settlement tank and recharge structure.

In first system, we actually calculate the available rain water and design a storage tank accordingly to utilise the water mainly coming in four months for the whole year.

Although some time due to cost considerations or land considerations it is not possible to create such storage tanks or rain water coming is much higher than the annual water demand of the area. In those cases, we go with second system and prefer to recharge ground water directly after minimum purification so that it can go to ground water table directly without incorporating man- made pollutants. In rural areas it is generally undertaken through such structures as percolation tanks and storage tanks and any other means.

STUDY AREA

The present study is focused on saving in electrical energy through roof top rain water harvesting using storage tank of poornima university, Jaipur. Poornima University (PU) was established in Jaipur in year 2012. In the university more than 2400 students are studying in regular academic courses and around 700 hostellers are residing in hostels. we have 5 nos. bore wells for fulfilling our demand and we are directly using ground water. So to maintain ground water level in long years, we have designed a sustainable roof top rain water harvesting system to save the depletion of water table.

Roof top rain water harvesting is the technique through which rain water is captured from roof catchments and stored in ground water aquifers/reservoirs/tanks.

It requires collecting rain water from roof top through pipes and connects outlet pipes to divert the collected water to existing well/tube well or a specially designed well.

Basic components of roof top rain water harvesting & conserving system:

I) Catchment area/ roof surface area upon which rain falls
II) Transport channels: carry rain water from catchment surface to storage
III) Leaf screens or roof washers: Systems that remove contamination and debris
IV) Storage tanks: where collected water can be stored
V) Conveying: The delivery system for treated water either by gravity or pump
VI) Water treatment: filters and equipment and additives to settle, filter and disinfect

Details of Roof top area available for harvesting

S. No.	Description	Area (Sqm)
1	Admin 1	334.57
2	Admin 2	334.57
3	Academic Block	5576.20
4	Hostel 1	660.38
5	Hostel 2	660.38

We have analysed saving in electrical energy through roof top rain water harvesting system through storage tank for the largest area of academic block under this project.

Assessment of Available Rain Water

The agro climatic zone of proposed roof top harvesting area is III A as per IWMP DPR. The average rain fall of the block is 556 mm. The year wise annual rain fall for the last 15 yr is as follows.

Year wise annual rain fall in mm				
2000	2001	2002	2003	2004
356	406.8	215	639.6	442
19	28	15	36	27
2005	2006	2007	2008	2009
513.4	342.6	577.4	735.4	424
23	29	35	38	29
2010	2011	2012	2013	2014
928	685	640.6	606.3	699

45	40	34	43	35

The average monthly rainfall of the block is as follows

S. No.	Month	Rainfall (mm)
1	June	56 (5 days)
2	July	108 (9 days)
3	August	170 (12 days)
4	September	38 (2 days)

So for current design we have taken the Average annual rain fall as 547 mm per year as per the zone identified for the harvesting area.

A smoother, cleaner and more impervious roofing material contributes to better water quality and greater quantity. As we have cemented neat punning roof, we have taken

1. Coefficient for roof finish as 0.85
2. Coefficient for evaporation, spillage and first flush wastage as 0.80

Total water to be harvested
= rainfall (m) x collection efficiency
=0.547x5576.20x.80x.85 cum
=2074123 litres

So almost 21 lac litres water is available for harvesting from one academic block.

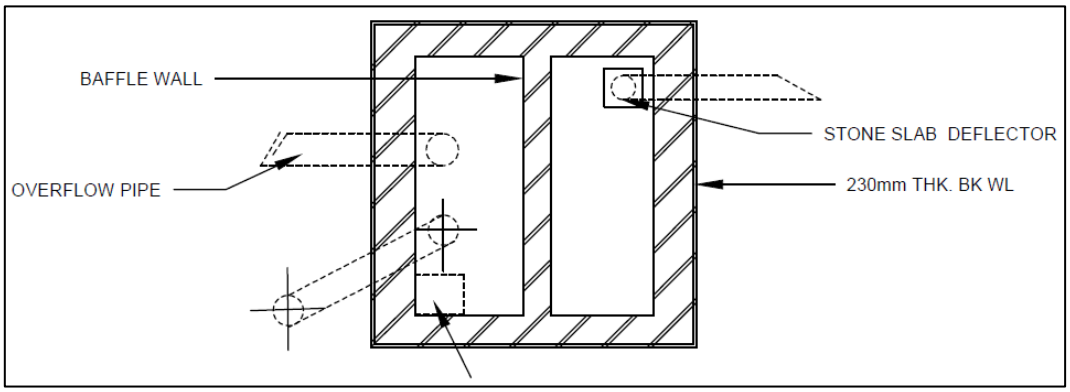
Design of Settlement Tank

The capacity of recharge tank is designed to retain runoff for at least 15 minutes of rainfall of peak intensityBasic data required for settlement tank are as follows

1. Surface area (A) of roof top catchment 5576.20 m^2
2. Peak rainfall in 15 m (r) as 25 mm (assumed)
3. Run off coefficient (C) – 0.85

So capacity of settlement tank =
A x r x C = 5576.20x0.025x0.85x1000 = 118494 litreor 120 m^3.

So settlement tank can be designed as following way by providing proper combination of baffle wall, gravity head flow, Rooftop pipe, Manhole etc. Proposed size of tank can be taken as 10m (L) x 4 m (B) x 3 m (H) with proper baffle walls.



Designing of Storage Tank

The capacity of storage tank can be designed to retain runoff for at least 15 minutes of rainfall of peak intensity Basic data required for settlement tank are as follows

1. Surface area (A) of roof top catchment 5576.20 m^2
2. Rainfall in mm

Day	2nd AUG	4th AUG	5th AUG	6th AUG	7th AUG	8th AUG
Rainfall (mm)	15	36	37	27	29	8
Day	9th AUG	10th AUG	11th AUG	12th AUG	13th AUG	31st AUG
Rainfall (mm)	36	140	15	5	30	22

Frequency analysis of rainfall:-
1- 9 mm – 2 days, 10-19 mm – 1 day, 20-29 mm – 3 days, 30 – 39 mm – 4 days, >40 mm – 1 days
Daily Peak rainfall group having maximum frequency among rainy days in august month of maximum rainfall as per rain fall data of year 2014 (30mm-40mm) so let say 40mm
3. Run off coefficient (C) – 0.85
So capacity of storage tank =
A x r x C = 5576.20x0.040x0.85x1000 = 189591 litre or 190 m^3.
So storage tank can be designed with the following proposed size of tank as 10m (L) x 10 m (B) x 2 m (H) with 5% free float of 200 m^3 capacity.
7.0 Water harvested through this proposed system
According to rainfall data of year 2014 this capacity of tank can able to handle the water out of 699.00 mm approx. 599.00 mm. by using the water for daily operation. So 85.69 ≈85% can be
Total water to be harvested with proposed system
= Average annual water to be harvested (cum) x storage efficiency
=2074.123 x 0.85 cum
=176300 litres (Approximate)

Electrical Energy Saving Through Storage of Water

The daily water demand in Poornima University is satisfied by 5 tube wells for raw water and water tankers supplied by outside for drinking water. The supply of water through tube wells is done by three (3 HP motor) and two (5 HP motor) motors. The details of motors used are as follows.

Calculation of water supplied by bore wells for raw water

The arrangement of bore wells is as follows.

No.	location	Power(HP)	Approximate Discharging capacity as per actual reading by flow valve in litre/hour
1.	Outside college gate campus	3 HP motor	2000
2.	Backside of proctor office	3 HP motor	2000
3.	Near Himalaya-3	5 HP motor	4200
4.	Volleyball ground	3 HP motor	2000
5.	Near boundary wall (labourer)	5 HP motor	4200
Total power consumed per hour and discharge per hour		19 HP motor	14400

* Pipe diameter used for bore well = 1.5 inch
Total Hours required for lifting the water from ground using 19 HP motors
=(Total water to be harvested by the proposed system/ Approximate Discharging capacity as per actual reading by flow valve in litre/hour)
= 1763400/14400
=122.46 Hours

As power required per hour =19 HP or 14.174 KW

Total Power consumed to lift the water from ground = 14.174 x 122.46 = 1735.72 KWH
Total Electrical energy saved with the proposed system in terms of cost

= Cost per unit of electricity x total units saved
= Rs. 8 x 1735.72
= Rs. 13,886/-

So, through the roof top rain water harvesting, approximately Rs. 13,886/- can be saved directly apart from the monitory profit by the saved ground water.

CONCLUSION

1. As pipes coming from roof top are open in garden area which collects minerals with it before going to chamber, reduces the quality of rain water to be recharged. So, there is a need of connecting network for all roof top pipes into the chambers.
2. Settlement tank of 120 $m^3$of size (10mx4mx3m) is required for academic block only.
3. Storage tank of 200 m^3 is required for storing the water to be harvested coming from academic block.
4. Through the roof top rain water harvesting, approximately Rs. 13,886/- can be saved directly apart from the monitory profit by the saved ground water

REFERENCES

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