RAINWATER HARVESTING SYSTEM FOR JAIHIND CAMPUS

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Abstract:
Rain water harvesting (RWH) is an excellent technique of water conservation of future needs and also to recharge ground water. Due to alarming population burden, climate change, uneven distribution of rainfall and abrupt variation of metrological parameters, the surface and ground water resource are continuously depleting in India. Hence adoption of different water conservation techniques at individual, institute and community level has become imperative to cater to the needs. The study was aimed at designing a rooftop and surface runoff rainwater harvesting structure for the Jaihind campus, Kuran, Located in Maharashtra state of India. All possible catchment areas are considering for rain water harvesting. Further, different parts of RWH system where designed based on standard guidelines it was observed from the analysis that implementation of RWH system in Jaihind Campus, Kuran can resolve the water scarcity during non monsoon seasonby recharging the huge quantity of 18614.22 m^3 in a year in the Jaihind campus. This initiative can increase the water supply for gardening purpose and will help in artificial recharge of ground water thus enriching both surface and ground water resources.

Keywords: Rooftop and surface runoff rainwater harvesting, Jaihind Campus, Kuran, Water Scarcity.

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INTRODUCTION

Water plays a very important role in the growth & development of all types of habitats on the planet. Rain is the primary source of water. [1] Water is a must for all life forms to survive and it is perhaps the most important natural resource on planet earth because it helps in performing several important activities agricultural, industrial, household etc. and essentially all these activities require fresh water leading to the situation of water crisis which can be explained as the lack of fresh water resources to meet the increasing water demand. [3] There are several reasons for the water crisis.

Few of the broad factors are listed below:

1. Mismanagement of water
2. Climate change leading to irregular rainfall
3. Unequal distribution of freshwater resources
4. Increasing fresh water demand due to the Growing population.

The best way for rainwater harvesting is to recharge the ground water and also, if rain water collected in natural ponds or artificial tanks is unused, the same can be used to charge the natural aquifer thus boosting the ground water level. [2] The technique by which the rain water is collected from rooftop catchments is termed as roof top rain harvesting. In order to cater the domestic needs, harvested rain water can be stored in sub-surface ground water reservoir by using artificial recharge techniques by storing in tanks. Though harvesting rain water is vital for sustainable water saving system for both rural and urban regions, the major challenge in the design is to estimate the area for storing water. The required catchment area should be designed effectively to collect rainfall for required purpose. [4]

PROBLEM STATEMENT & AIM

A. Problem Statement

Due to increasing use of water there are numbers of bore wells or amount of ground water to be pumped is increased which affects the level of ground water table and day by day the level of ground water table get decreases. In Jaihind campus there are 2 existing bore wells but due to low ground water table there are no use of bore wells and in dry season scarcity occurs. With the rainwater harvesting system we are able to recharge ground water with bore well which helps to increase level of ground water table in surrounding area.[5-7]

B. Aim of the Project

To design a Rainwater Harvesting System components for Jaihind campus and to increase level of ground water table by recharging existing bore well.

OBJECTIVES & SCOPE

A. Objectives of the Project

- To study the rainwater harvesting potential of Jaihind Campus.
- To identify suitable designing rainwater harvesting system.
- To study the design of water tank and filter unit.
- To raise the underground water table by recharging the collected rooftop water.
- Reducing the loss of water by its running – off.

B. Scope of the Project

- Rainwater can be used for irrigation purposes, indoor facilities of campus.
- For Recharging Groundwater.
- Reduce the wastage of rainwater and use it for increasing ground water level.
- Conserve and Preserve rain water without wastage of rainwater.

STUDY AREA

Jaihind campus is located in the district of Pune in Maharashtra in Pune Division. During monsoon in the months of June, July, August and September, the weather conditions are generally humid and wet. This area receives heavy rainfall during this season. The weather is pleasant and comfortable in the months of October and November. Jaihind campus is located near the Junnar city and the weather conditions in the College campus are mainly characterized by high rainfall in the monsoon season and a prolonged dry period during rest months of a year. This leads to water scarcity in the campus during the summer months which can be taken care using roof top rain water harvesting techniques in the campus. The Campus is at Kuran, Tal-Junnar, Dist-Pune. The campus is lies latitude of 19.163125937420155, and the longitude is 73.91451191005889 Junnar, Maharashtra, India. Approx area of campus is 58695.20 sq.m.

The picture shown below shows the majority of the buildings for rain water harvesting system under study at Jaihind Campus, Junnar. (Fig. 1)

Fig 1: Jaihind Campus, Kuran

METHODOLOGY

In this study, the Engineering Building, Polytechnic Building, Boy's Hostels, Auditorium, Canteen, Entrancement, Parking Shed, School entrance, workshop's, Paving block area, Concrete streets are selected as catchment areas. The total area and height of the buildings were calculated by using Total station. The total rainwater harvesting potential was estimated using rational formula and total water demand was calculated.[8-10]

The step wise procedure adopted to design rainwater harvesting structure is mentioned here (Fig. 2)

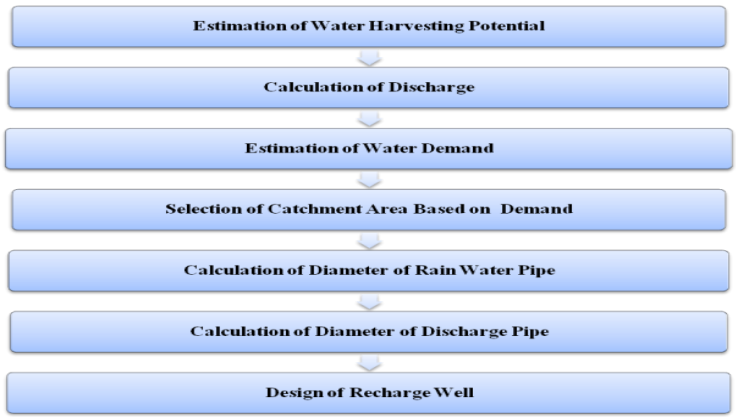

Fig 2: Methodology Flow Chart

Layout of Campus The position of various building in the campus is mentioned inthe layout which helps to plan rain water harvesting system. The layout of campus is mentioned below as (Fig.3)

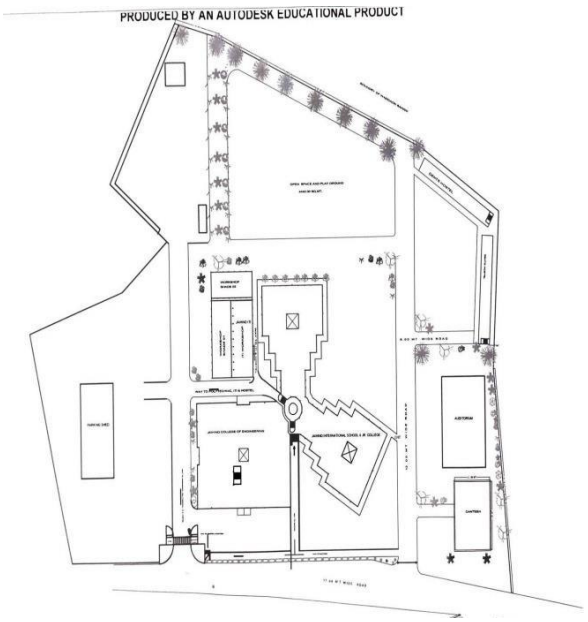

Fig 3: Layout of Campus

A. Rainfall Data

For this study, rainfall data for a period of (2013-2022) of the study area was collected from Tahasil Office, Junnar and analyzed in table 1:

Table 1: Rainfall Data

Sr. No.	Years	Annual Rainfall in mm
1.	2013-2014	706.77
2.	2014-2015	752
3.	2015-2016	706
4.	2016-2017	738
5.	2017-2018	1111
6.	2018-2019	459
7.	2019-2020	1066
8.	2020-2021	607
9.	2021-2022	552
10.	2022	1367

B. Existing Structures In Campus For Storage and Supply of Water

Building Name	Structure Available
Engineering College(R.O)	2000 liter Tank
Engineering College	5000 liter Tank
Polytechnic College	10000 liters Tank (2 Tanks)
Boys Hostel	35000 liters (2 Tanks)
Boys Hostel Underground Tank	10000 liters Tank
Boys Hostel (R.O)	3000liters Tank
Auditorium	30000liters Tank
Bore Wells	3 bore wells , out of that 1 in working condition

VI. RESULTS & DISCUSSIONS

A. Determination of Catchment Area

The rooftop surface area is the catchment area that receives the incident rainfall. The rooftop areas of 7 buildings and Concrete paving, pavement block area are selected as catchment areas in the study. The rooftop area and heights of the selected buildings are mentioned in table 2.

Table 2: Determination of Catchment Area & Height[11-13]

Sr.No.	Buildings Name	A(m^2)	Height (m)
1.	Engineering College	2835	14
2.	Polytechnic Building		
3.	School & Junior College	3216	14
4.	Boys Hostel-1	343.18	10
5.	Boys Hostel-2	343.18	14
6.	Entrancement	131	6
7.	Canteen	848	5
8.	Workshop-1	590	5
9.	Workshop-2	590	5
10.	Workshop-3	408	6
11.	Parking Shed	1960	4.5
12.	Auditorium	1412	11
13.	School Entrance	244	4
14.	Concrete street	3104	-
15.	Paving Blocks	1926	-
	Total Area	17950.36	

B. Estimation of Water Harvesting Potential

The quantity of water that is received from rainfall over an area is called the rainwater potential of that area. And the quantity that can be effectively harvested is called the rain water harvesting potential. Rain water harvesting potential can be calculated using the following formula. Rainwater Harvesting potential (m3) =

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

C. Runoff Coefficient

In this study, runoff coefficient value was taken from the manual of artificial recharge of ground water, Government of India Ministry of Water Resource Central Ground Water Board, the table 3 represents the runoff coefficient values to be adopted for design purpose.

Table 3: Runoff Coefficient Values[11-13]

Different Surfaces	Runoff Coefficient (k)
Roof Conventional	0.7-0.8
Concrete Roof	0.7
Roof Inclined (Asbestos)	0.8
Roof Inclined (G.I Sheet)	0.9
Concrete Paving	0.7
Brick Paving	0.7

Rainwater harvesting potential of various catchment areas are summarized in table 4.

Table 4: Annual Rainwater Harvesting Potential [11-13]

Buildings Name	A (m^2)	I (m)	k	V (m^3)
Engineering College	2835	1.367	0.7	2712.81
Polytechnic Building School & Junior College	3216	1.367	0.7	3077.39
Boys Hostel-1	343.18	1.367	0.7	328.39
Boys Hostel-2	343.18	1.367	0.7	328.39
Entrancement	131	1.367	0.7	125.35
Canteen	848	1.367	0.9	1043.29
Workshop-1	590	1.367	0.8	645.22
Workshop-2	590	1.367	0.8	645.22
Workshop-3	408	1.367	0.8	446.19
Parking Shed	1960	1.367	0.9	2411.39
Auditorium	1412	1.367	0.9	1737.18
School Entrance	244	1.367	0.9	300.19
Concrete street	3104	1.367	0.7	2970.22
Paving Blocks	1926	1.367	0.7	1842.99
Total Volume				18614.22

D. Estimation of Water Demand

The Total water demand of the Campus was estimated considering the per sq. Meter consumption of water for gardening use as per the IS: 1172-1963 mentioned in table 5.

Table 5: Water Demand for public building

Types of Building	Water demand in liters per Day
Offices	45 per head
Hostels	135 per head
Garden	3.5 m^2
Cinema & Theaters	15 per seat
Restaurants	70 per seat
Day School	45 per head
Boarding School	135 per head

Demographic data of the campus was collected to estimate the total water demand by gardening and considering their daily requirement as per the norms. The information collected regarding the same is mentioned below:

Area under gardening = 14997 m^2

Water demand for gardening = 3.5 liters / m^2 / day

Water Demand = Area X Water Demand

= 14997 X 3.5 = 52489.5 liters / m^2 / day

Daily water Demand = 52.489 m^3 / day

The total water demand was calculated for gardening use. The total water demand of the campus was estimated to be 52.489 m^3 /d.

E. Calculation of Discharge

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 I A

Where,

Q = Discharge in (m^3/sec)

I = Rainfall Intensity i.e 20mm/hr

C =Coefficient of Runoff by Rational Method it taken 0.8 for this case

A = Area of Catchment (m) [5-9]

Discharge from different catchment areas were estimated to calculate the required diameter of rainwater harvesting pipes and summarized in table 6.

Table 6: Calculation of Discharge

Buildings Name	**A (m^2)**	**I (m/sec)**	**C**	**Q (m^3/sec)**
Engineering College	2835	20/3600000	0.8	0.013
Polytechnic Building School & Junior College	3216	20/3600000	0.8	0.014
Boys Hostel-1	343.18	20/3600000	0.8	0.002
Boys Hostel-2	343.18	20/3600000	0.8	0.002
Entrancement	131	20/3600000	0.8	0.0006
Canteen	848	20/3600000	0.8	0.004
Workshop-1	590	20/3600000	0.8	0.003
Workshop-2	590	20/3600000	0.8	0.003
Workshop-3	408	20/3600000	0.8	0.002
Parking Shed	1960	20/3600000	0.8	0.009
Auditorium	1412	20/3600000	0.8	0.006
School Entrance	244	20/3600000	0.8	0.001
Concrete street	3104	20/3600000	0.8	0.014
Paving Blocks	1926	20/3600000	0.8	0.009
Total Discharge				0.0796

F. Calculation of Numbers of Rainwater Pipe (R.W.P)

Assuming the diameter of pipe as 10 cm, the total number of required pipes was calculated in this study.

Q = C I A

$$\textbf{No. of Pipes} = \frac{\mathbf{Q}}{(\frac{\pi}{4}) \times \mathbf{d^2} \times \mathbf{v}}$$

Where,

Q = Discharge in m^3/sec

d = Diameter of RWP

(Assume100 mm diameter of pipe)

v = Velocity of water while entering in pipe due to slope of roof

(As per CGWB roofs are flat or having 0-2% slope)

v= 0.1m/sec [3-8]

Using the above formulae the total number of required RWP were calculated and summarized in table 7.

Table 7: Calculation of No. of R.W.P

Buildings Name	**d (m)**	**V (m/sec)**	**Q (m^3/sec)**	**N**
Engineering College	0.1	0.1	0.013	16
Polytechnic Building School & Junior College	0.1	0.1	0.014	18
Boys Hostel-1	0.1	0.1	0.002	2
Boys Hostel-2	0.1	0.1	0.002	2
Entrancement	0.1	0.1	0.0006	2
Canteen	0.1	0.69	0.004	1 (gutter)
Workshop-1	0.1	3.386	0.003	1 (gutter)
Workshop-2	0.1	1.112	0.003	1 (gutter)
Workshop-3	0.1	3.667	0.002	1 (gutter)
Parking Shed	0.1	1.576	0.009	1 (gutter)
Auditorium	0.1	1.72	0.006	1 (gutter)
School Entrance	0.1	0.69	0.001	1 (gutter)
Concrete street	0.350	0.1	0.014	2
Paving Blocks	0.350	0.1	0.009	2
Total No. of Pipes				70

G. Calculation of the Diameter of the Discharge Pipe

The discharge pipe was designed considering the selected catchment area i.e. the main building. Initially the velocity of water entering the horizontal discharge pipe is calculated using the formula

$$V^2 = U^2 + 2aS$$

Where,

V = Velocity of water entering the horizontal pipe

U = velocity with which rainwater enters the R.W.P

= 0.1m/sec

a = Acceleration Due to Gravity = g= 9.81 m^2/sec

S= Height of Building = 14 m

Q = Discharge of Polytechnic Building = 0.0143 m^3/sec

The velocity of water in the mail building was calculated to be 16.57 m/sec.

The discharge Q of the Building = 0.0143 /sec.

We know that

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

On putting all the values we get;

d = 33.1 mm (34 mm approximately) which will not available in standard sizes. Hence 50 mm diameter discharge pipes can be used.

H. Ground Water Table Measurement

Table 8: Water Table Measurements [1-3]

Dates of Measurement Taken	Water Level Below G.L of Bore well
18 March 2023	5.30 m
24 March 2023	6.45 m
8 April 2023	7.60 m
20 April 2023	9.3 m
28 April 2023	11.2 m

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