Planning and Design of Rooftop rain water harvesting (RT-RWH) system in N.B.K.R.I.S.T. campus-A case study

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***Abstract*— Water scarcity is serious problem throughout the world for both urban & rural community. Urbanization, industrial development & increase in agricultural field & production has resulted in overexploitation of groundwater & surface water resources and resultant deterioration in water quality. The conventional water sources namely well, river and reservoirs, etc. are inadequate to fulfill water demand due to unbalanced rainfall. While the rainwater harvesting system investigate a new water source. The expected outcome of the study is the development of rooftop rainwater harvesting system from all the academic blocks hostels and parking facilities within the campus thereby the scarcity of the water in the campus. The harvesting structure are planned and design to store the rainwater and use the same for domestic purpose within the campus. The result analysis shows that the present RT-RWH system is having the storage 8,21,494litres/year and construction cost of Rs.7.25 lakhs respectively and is reasonably well in comparison with conventional water sources. The developed system satisfies the social requirements and can be implemented in rural areas by considering almost all the technical aspect.**

***Keywords*— Rooftop Rain water harvesting, NBKRIST, Storage, QGIS.**

I. INTRODUCTION

Water is the basic need of life and the increasing demand of good quality water for irrigation, industry and domestic purpose necessitates its judicious use. Of the total water on earth, only 2.7 % constitutes freshwater which is largely (77%) locked up in the polar icecaps and mountain glaciers and 1% is available as surface water flowing in rivers, streams, etc and 22% of it is locked up as underground water. With excessive misuse, the quality of water is deteriorating everywhere, particularly of underground water. All our ecosystems are under tremendous pressure. It is estimated by the United Nations Environment Programme (UNEP) that more than 2000 million people would live under conditions of high water stress by the year 2050 and water would be a limiting factor for all development activities in most of the regions in the world (Bhattacharya and Rane, 2003).

If the present trend continues, it is presumed that by the year 2010, more than 50% of the world population will live in urban areas. While overall global population growth is slowing down, the number of people living under water-stress condition is expected to increase fourfold, to nearly 2 billion people by the middle of next century (Knight, 1998).). These trends show that there is increasing pressure on the world's freshwater resources. Due to the increasing water demand, alternative sources such as stormwater and treated effluent reuse of water need to be considered (Constandopoulos, 2005).

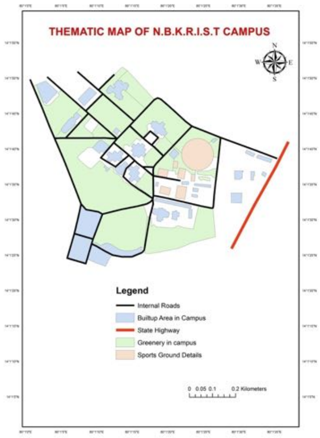
II. OBJECTIVE OF THE PRESENT STUDY

The planning & design of Roof Top -RWH system includes following:

1. Estimating the demand and supply of water within campus.
2. Estimation of total catchment area and amount of rainwater available per year.
3. Finding the best locations for sumps to store the harvested rain water.
4. Design, quantity and cost estimation of storage sumps.

III. SITE DESCRIPTION

The campus of N.B.K.R. Institute of Science & Technology, Vidyanagar,is situated at 14.0258° N, 80.0269° E and is located in SPSR Nellore district of Andhra Pradesh.



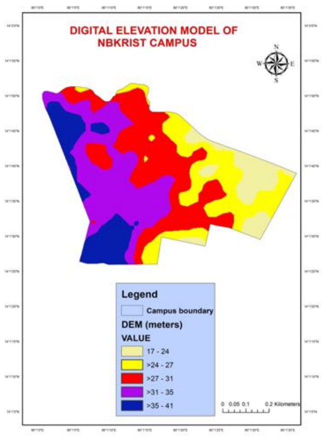


Fig. 1.(a) **Fig. 1.**(b)

Fig. 1. a.Thematic map of N.B.K.R.I.S.T campus, ***Fig.***1. b. Digital Elevation map of the campus

IV. METHODOLOGY

Collection of rainfall data

The rainfall data for 31 years (1989 – 2015) was collected from the Office of Chief Planning Officer, SPSR Nellore. Using the maximum, minimum and average rainfalls, the storage capacity of the rainwater tank can be calculated for these events and thus, can be related to the optimal size of the storage tank based on cost benefit analysis.

Calculation of amount of rainwater that can be harvested over a rooftop of a given area

The amount of rainfall that can be harvested on a given rooftop area can be calculated using the Rational formula (Eq. 1) which is,

$$Q = c*i*A \quad (1)$$

Where, Q = amount of discharge from the roof (in m^3)
A = Area of the rooftop (in m^2)
i = depth of annual rainfall received on the roof (in m)
c = runoff coefficient (no units)

Runoff coefficient plays an important role in assessing the runoff availability and it depends on catchment characteristics. It is the factor, which accounts for the fact that not all rainfall falling on the catchment can be collected. Some rainfall will be lost from the catchment by evaporation and retention on the surface itself (Bhattacharya and Rane, 2003). The value of 'c' depends on the material used to make the roof. This value varies for different materials and is given in Table 1.

Table 1: Value of 'c' for different catchments

Type of roof catchments	**Runoff coefficient (c)**
Roof catchments	
Tiles	0.8-0.9
Corrugated metal sheets	0.7-0.9
Ground surface coverings	
Concrete	0.6-0.8
Brick pavement	0.5-0.6
Untreated ground catchments	
Soil on slopes less than 10%	0.0 -0.3
Rocky natural catchments	0.2-0.5
Green area	0.05-0.1

Source: Bhattacharya & Rane, 2003

V. Observations and Analysis

Analysis of rainfall data

The time series of rainfall data is shown in following Fig.2. which shows the trend of rainfall in 26 years. It can be seen that rainfall in vidyanagar is moderately variable. Maximum and minimum rainfalls recorded in the region for the given period is 1745.8 mm and 681 mm, respectively. The average comes out to be 1193.63 mm.

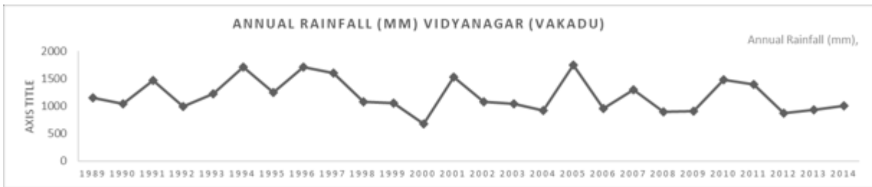


Fig.2: Time series of rainfall data of Vakadu rain gauge station

However, if a rainwater storage tank is constructed, its capacity will depend on the maximum amount of rainfall that occurs in that area in consecutive events, with the assumption that the stored water is not used immediately and the entire volume from the consecutive events is stored. According to data, in the past 26 years, the maximum amount of rainfall recorded in consecutive events is 912.32 mm. Since, all the rainwater stored is used simultaneously; we can safely assume that the rain tank meant for storing 912.32 mm of rainwater will store the entire volume and somewhat more and that there will be no overflow.

Analysis of demand of water supply in the campus

The demand for water in this campus is extremely high i.e. 45,684 m3 of water is pumped every day from groundwater source.

Table 2. Water Demand in the campus

Building	Demand (m^3)
Civil Block	866.700
EEE & ECE Block	332.100
CSE Block	545.400
Mechanical Block	614.250
Academic Block	1499.850
Mercury Hostel	174.150
Jupiter Hostel	267.300
Narmada Hostel	268.650

The purpose of the study is to know whether harvested rainwater can substitute for some amount of water used in horticultural and flushing purposes. The total rooftop area of all blocks under consideration are shown Table 3.

Table 3: Roof areas of various buildings

Name of the Building	Roof area in m^2
Civil Engineering Block	1883.55
Electrical and Electronics Block	2257.9
Computer Science Block	2015.43
Mechanical Block	1883.55
Academic Block	1829.46
Mercury Hostel	1810.13
Jupiter Hostel	1654.46
Narmada Hostel	1547.67

Thus, the total area available for rainwater harvesting is 10,740.7 m^2 (rooftop area). On analysis, it is seen that in the entire campus a lot of water is used, which cannot be substituted entirely with harvested rainwater. The figures obtained show that more than half of the water used in horticultural activities can be substituted by harvested rainwater, which makes only 5% of the total demand every day. However, if a rainwater structure is made in the campus then its capacity can be calculated using Rational formula, which can also be applied for calculating the storage volume of the tank.

VI. Planning and Design of Sumps to Store the Rainwater

Every building (as mentioned earlier) is planned to provide a sump to store the harvested rain water, the following figures and tables provides details of each sump.

Table 4: Cross-sectional details of the sumps

S.No.	Name of the building	Dimensions of the R.C.C. Sump
1	CIVIL BLOCK	8.9 m x 4.4 m x 2.65 m
2	EEE BLOCK	9.7 m x 4.8 m x 2.65 m
3	CSE BLOCK	9.2 m x 4.6 m x 2.65 m
4	MECHANICAL BLOCK	8.9 m x 4.4 m x 2.65
5	ACADEMIC BLOCK	8.8 m x 4.4 m x 2.6 m
6	MERCURY HOSTEL	8.8 m x 4.4 m x 2.6 m
7	JUPITER HOSTEL	8.7 m x 4.4 m x 2.4 m
8	NARMADA HOSTEL	8.4 m x 4.2 m x 2.4 m

VII. Conclusion

In the present study, the potential of rooftop rainwater harvesting has been estimated. Planning and Design of RCC sumps for eight rooftops has been carried out according to the Indian Standards code. The total volume of rainwater that can be stored by all the sumps is 8,21,494 litre/year at a cost of Rs. 7.25 Lakhs. Further the surface water can also be diverted into the sumps by extending and coupling the tapping points.

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