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Provision and Scope of Rain Water Harvesting at the Elitte College of Engineering

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Abstract. As the population of world increases, the demand for quality drinking water is also increasing. Therefore, the saving of water became very essential. Many nations adopted rainwater harvesting which is an old practice as a viable decentralized water source. The definition of rainwater harvesting is the technique of collection and storage of rainwater at surface or in sub-surface aquifer before it is lost as surface run off. Due to depletion of groundwater resources, the only way to solve the water problem is rainwater harvesting. The rainwater will be not only useful, but also helps to improve the quantity and quality of water. Here our focus is to construct a underground water reservoir to store the rooftop rainwater and use the water for washroom purpose. The methodology includes collection of rainfall data, finding out the area on which rainwater can be harvested for storage, calculating the volume of storage tank, quality analysis of rainwater, treatment for rainwater, how to reuse the water for college purpose.

Keywords. Rainwater; Treatment; Harvesting; Reservoir

1. Introduction

The basic need of life is water. Now days there is a increase in demand for good quality of water in every sector like industries, irrigation, domestic purpose. 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 only 1% of the total water is available as surface water which is flowing in rivers, streams, etc and 22% of the total water locked up as underground water [1]. Due to massive misuse, the quality of water is deteriorating everywhere, particularly of underground water. Every part of the ecosystems is under massive pressure. As per the report by the United Nations Environment Programme (UNEP) that by the year 2050 more than 2000 million people would live under conditions of high-water stress and water would be a limiting factor for all development activities in most of the regions of the world. As per the present trend continues, it is presumed that by the year 2010, more than 50% of the world population will live in the state of urban areas. As the overall global population growth is slowing down, the number of people living under water-stress condition is expected to increase, to nearly 2 billion people by the middle of next century [2]. These reports show that there is increasing pressure on the world's freshwater resources. Because of the increasing water demand, alternative sources such as stormwater and treated

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effluent reuse of water need to be considered. Rainwater harvesting is an old practice that is adopted by many nations. Among many tools, individual rainwater harvesting systems helps to meet the growing water demand. Rainwater harvesting is an environmentally effective solution to address issues brought forth by large projects utilizing centralized water management approaches. Growing population all over the world is causing similar problems and concerns of how to supply quality water to all. rainwater harvesting may be one of the best methods which is available to recovering the natural hydrologic cycle and enabling urban development to become sustainable [3].

2. Site Description

B Block of Elitte College of Engineering was chosen for rooftop rainwater harvesting. Total height of the building is 14.85 meter. Total number of people including students and faculty in the B block is 600. Total per capita demand per day for toilet purpose is 20 liters per capita per day (lpcd). Total rooftop area of block B is 1122.43 square meter.

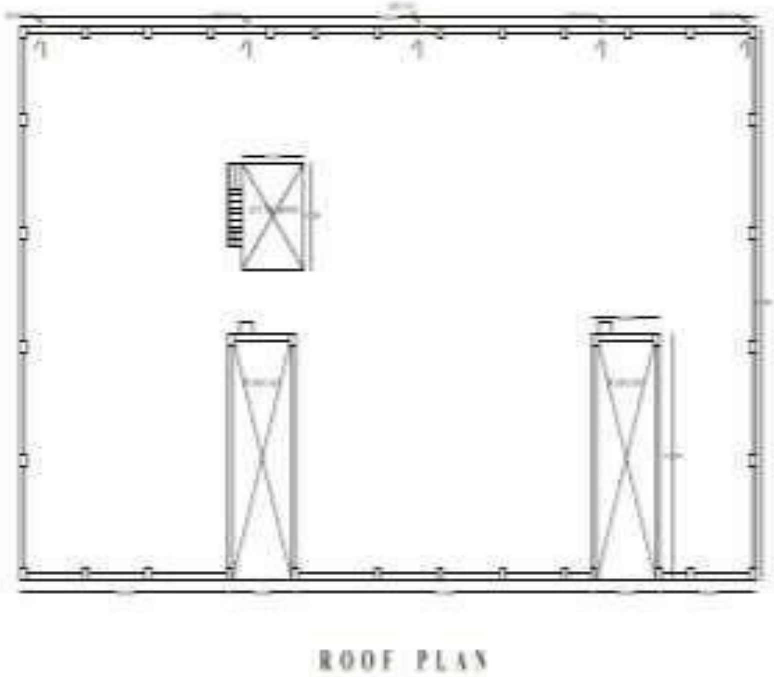

Figure 1. Roof plan of block B ECE Campus

3. Methodology

3.1. Climate

The annual temperature is about 27^{0}C, monthly mean temperature ranges from 19^{0}C to 30^{0}C. Sodepur, that is the area, is dominated by three seasons, summer, monsoon and winter. In summer the area is hot and humid with mean temperatures about 30 ℃ but during dry spells the maximum temperatures often exceeds 40 ℃, during April-May there is a frequent event of severe thunderstorm/thunder during afternoon/evening hours that causes relief from the humid heat.

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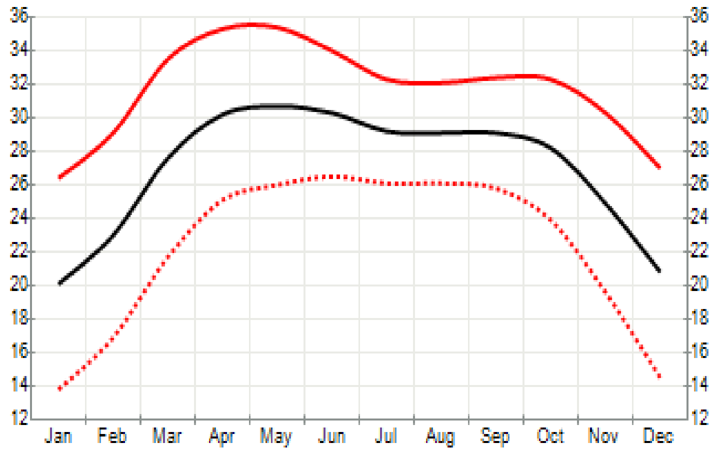

Figure 2. Average temperature per month in ^{0}C

3.2. Collection of rainfall data

The rainfall data for 11 years (2009– 2019) was collected from IMD. The storage capacity of the tank can be calculated for these events using the maximum, minimum and average rainfalls, and it can be related to the optimal size of the storage tank which is based on cost benefit analysis.

3.3. Calculation of amount of rainwater

The amount of rainfall which can be harvested on a given rooftop area can be calculated using by the Rational formula which is,

$$Q = c*i*A$$

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

Runoff coefficient plays an important role in assessing the runoff availability. This coefficient depends on catchment characteristics. It is the fact, which accounts for the fact that total rainfall falling on the catchment cannot be collected or stored. Some of the part of rainfall will be lost from the catchment by evaporation and retention on the surface itself. 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**
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
Natural rocky catchments	0.2-0.5
Green area	0.05-0.1

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4. Observation and Analysis

4.1. Analysis of rainfall data

Table 2 shows the average annual rainfall at the study area.

Table 2. 11 years average annual rainfall data

ANNUAL DATA IN cm												
MONTH	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	10 YRS AVG
JAN	0	0.1	0.6	42	0.3	0	48	0.6	0.3	0	0	8.4
FEB	0	8.1	1	7.8	11	38	3	104	0	0	156	29.9
MAR	36	4	23.2	0	1.1	16.2	42.2	15	34	0	100.3	24.7
APR	0	17	56.2	58.2	70.7	0.2	108.5	0	13	180.1	26.8	42.6
MAY	302.7	181	177	63	155.6	131	30.9	126	72.7	143.6	94	134.3
JUNE	8304	175.7	366.4	44.7	298.7	297.7	181.6	122.2	185.4	151.3	71.7	179.9
JULY	221.5	216.4	295.1	369.1	294.1	235.6	938	403.2	592.2	488.8	87.2	367.4
AUG	377.3	177.9	518.2	220	392.9	231.1	244.5	130.8	300.4	146.1	367.7	308.7
SEP	298.7	281.7	233.2	185.2	222.7	233.6	170.3	196.1	269.7	180.3	303.1	234.1
OCT	80.2	74	47.1	43	309.5	42.1	21.1	69.7	289.6	46.2	154.2	107
NOV	41.8	0.3	0	43.2	0	0	0	25	67.5	0	113.2	26.5
DEC	0.7	20.2	0	25	0	1	5	0	15	6	6	7.2
YEARLY AVG	120.16	96.37	147.17	83.43	146.38	101.79	149.43	99.38	153.32	111.87	123.35	
MONTH	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
JUNE	83.4	175.7	366.4	44.7	298.7	297.7	181.6	122.2	185.4	151.3	71.7	
JULY	221.5	216.4	295.1	269.1	294.1	235.6	938	403.2	592.2	488.8	87.2	
AUG	377.3	177.9	518.2	220	392.9	231.1	244.5	130.8	300.4	146.1	367.7	
SEP	298.7	281.7	233.2	185.2	222.7	233.6	170.3	196.1	269.7	180.3	303.1	
YEARLY AVG	245.23	212.93	353.23	179.75	302.1	249.5	383.6	213.08	336.93	241.63	207.43	

4.2. Analysis of data collected on sites

The total area available for rainwater harvesting is 1122.43 square meter (rooftop area). The total amount of rainfall that can be harvested in the area is calculated by using Rational formula where the average annual rainfall in the area was taken as 1533.2 mm and the value of c was taken to be 0.85. After analysis, it is found that in the entire campus a lot of water is used, which cannot be substituted entirely with harvested rainwater. If a rainwater structure is made at the campus, then its capacity can be calculated by using Rational formula and it can also be used for calculating the storage volume of the tank[5].

Thus, Q comes out to be 0.027 m^3/s

The dimensions of the storage tank of this capacity, if the depth is kept 4.5 m, length 20 m and breadth 8m, and then structural design and economic aspects can be worked out as a civil work by appropriate consulting organizations. 8 numbers of rainwater pipe of diameter 100 mm should be provided at the rooftop.

4.3. Quality analysis of Rainwater

Rainwater was collected at ECE campus, and the quality was analyzed at Environmental Engineering Lab of ECE. Table-3 shows the quality of the rainwater collected at ECE campus:

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Table 3. Quality of Rainwater

NAME OF THE TEST	TEST VALUE
HARDNESS Total hardness Calcium hardness	244mg/ltr121mg/ltr
TURBIDITY	7.2 NTU
pH VALUE	7.75

5. Rainwater Harvesting Structure

The rainwater harvesting structure proposed, is a very simple underground structure having basic components. The rain tank contains an inlet from a first-flush pit through a mesh filter; a low water level monitor, and there is also water supply outlet and a pipe-conveying overflow to the sewage drainage pipe. Rainwater collected from roofs flows via stormwater pipes through a "first-flush" pit into the rainwater storage tank. If the capacity of rain water tank is exceeded, overflow is occurred directly through a pipe, which joins with the sewage pipe[6]. If a more sensitive structure is required, then dual strategy could be adopted. In it, there are two water tanks, one for the supply water tank and other for rainwatertank. These two water tanks will be separate units but they will be inter-connected by a simple DMS such that when the rainwater tank is empty, potable water will be pumped into it to a pre-determined level and the water will be used for non-potable uses. The operation of both these tanks will ensure that potable and non-potable requirements are fully satisfied. The inflow pipe from the distribution tank should be at least 15 cm above the top water level of the rainwater tank so that no black flow can take place.

6. Conclusions

In our study, we have collected rainwater, analyzed the quality of rainwater and suggested to construct a storage tank and use the water as sanitary purpose in the college campus. For sustainability, rainwater harvesting technique is highly recommended. The harvested rainwater would only substitute only a small portion of the demand but still it is essential. One more point that was noticed was, if the campus is big, then more water is harvested as compared to the needs but, if the campus is highly commercialized and must provide to people of higher living standard then, even the comparatively more harvested water will substitute less percentage of the total demand [7].

During the study, the biggest problem was the time. As we had to collect the rainfall during the rain to analyze the quality. Water harvesting is a very simple way to ensure availability of water in water stressed areas and seasons but it not the only solution to the problem. It is needed for a more comprehensive integrated approach for water management with traditional structural approaches that combine construction of dams and reservoirs, and rainwater projects for multipurpose use elements of a non- structural approach, along with suitable changes in other sectors like law, policy, governance and astress on monitoring and modeling of the existing structures and techniques. Water harvesting is not applicable in all situations for example, in extremely low rainfall areas. Prevention of local and downstream pollution of water bodies has also emerged as a big area of concern and steps must be taken to ensure that.

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