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# Study of Rainwater Harvesting for S.G.S. Govt. P.G. College Campus Sidhi (M.P.) India

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**Abstract:** *This research paper deals with the assessment of the rainwater harvesting within the college campus comprising various buildings. The study focused on the rainwater harvesting on rooftop area of the various building. As the rainfall profile indicates about the dry days, incensement in temperature etc. which interns makes necessary to harvest rainfall, water and utilize it during dry days for irrigation, washings, drinking and for many other application.*
**Keywords:** *Dry days, Irrigation; Harvesting, Rainwater.*

## I. Introduction

Rainwater Harvesting is the collection of rainwater using the rooftop of the building which in turn leads to a storage container for further consumption. The collected rainwater can be used for a variety of applications which include toilet flushing, washing cloths and irrigation of garden etc. and when treated properly, it can be used for drinking too.

The concept of harvesting rainwater in the event of scarcity is not new idea. It had been in use in ancient time, in the country such as Egypt, Jordan[1, 2] thereafter; it has been in practices in the country like, Japan Singapore, Malaysia, Australia and China[3, 5]. In Malaysia with the rise in population and new research began in the 1980s due to water scarcity, and that resulted in improved farming practices and that were immensely benefited by he locals. Thereafter research was initiated by an experiment conducted with only 16 green houses, which in later time due to its success progressed to 2.00 lacs farmers by 1994, with the increase in participation from the locals within the province the rainwater harvesting projects proved to be sustainable with 70 % of the investments coming from the locals themselves[6-8].

## II. Objective Of The Study

The main objectives of this study are (1) to estimate the potential of rooftop rainwater harvesting within the college campus comprising of various buildings (2) to assess that upto what extent the collected water could be used for, other useful applications like in gardening, toilet and in sport field etc. in the event of scarcity of water in college campus.

## III. Methodology

For the study of the Rainfall harvesting system for S.G.S. Govt. P.G. College, Sidhi Campus, the calculation of whole Rooftop area of all the campus building taken, quantity of rainfall for Sidhi has been taken from Indian meteorological Deptt., Govt. of India and its regional offices, the average monthly data of rainfall, rainy days, dry days, relative humidity and percentage of evaporation rate taken. Thereafter, statistical formulas were also used in order to obtain result regarding the daily capacity that could be gathered.

Table-1 shows average monthly data for rainfall, rainy days and dry days, while table 6 shows humidity and rate of evaporation for Sidhi district. Area of rooftop was manually measured along with Google earth was also taken for further help and comparison in order to indentify the measure of accuracy. The result came to contain a minor error with the original rooftop length/area being is 7427559 sq. ft. and the Google earth result coming to a close 73922 sq. ft. This resulted in an error of 0.78 % which was very low (table 1).

**Table 1.**

| Sr. No. | Building | Rooftop Area (Sq.ft.) |
|---|---|---|
| 1. | Composite building (New) | 45000 sq. ft. |
| 2. | Old Building | 21875 sq. ft. |
| 3. | Annexure of old building | 1800 sq. ft. |
| 4. | Hostel building | 5600 sq. ft. |
| | Total | 7427559 sq. ft. |

The amount of rainwater that is to be collected (V) can be calculated by the catchment surface which used as given in equation 1.

$$V = A. \left[ \frac{Y}{1000} \right] \times Rc \qquad - (1)$$

Where V is total rainwater collection ($m^3$), A is surface area ($m^2$), Y is rainfall (mm), and RC is runoff coefficient. RC depends upon the catchment surface. A is the total area of the catchment surface and Y is the rainfall daily. Table 2 shows that all the building having concrete surface area in the college campus.

**Table 2.** Type of roof surface along with Run off coefficient

| Type of roof surface | Rain off coefficient |
|---|---|
| All building having concrete surface and steepness is flat | 0.6- 0.8 |

For the storage of collected rain waterfall the tank was selected, based on the requirement of water for sport field irrigation, garden irrigation and toilet flushing etc. of the college compass.

According to department of sport of the college the present sport filed requires an irrigation amount of 1000 liter per day for dry days when there in no rainfall means for summer days specially. The sizing of the tank decided by running a simulation using MS Excel, where economical and meteorological factors are considered in the final selection of tank size. Also an important relation used was the reliability factor which signifies the efficiency of rainwater harvesting system as whole it can be defined as in equitation 2.

$$\text{Reliability } \% = \frac{\text{Days Tank irrigates field as garden and other use}}{\text{Total Number of Dry days}} \qquad - (2)$$

To calculate the tank capacity, an equation was subsequently formulated based on the pattern of rainfall and consumption of water by sport filed and garden. Accordingly, constant were also placed within the equation to keep the utilization of the tank as realistic as possible. The equation no. 3 is as follows -

$$\text{Tank capacity} = X - A\ (\text{Sin } \Theta.\ \text{Sing } \phi)\ y - \text{Cos } \phi \quad \propto \ \text{Cos } \ \Theta.\ Z$$

Where x is previous day capacity, A = 0 if tank is full. B = 0 if tank < 1, Y is total rainfall received. Z is daily consumption and equal to $1m^3$, $\propto$ is volume needed for the full capacity = tank size – X. $\Theta = 90^0$ when there is RF and $\Theta = 0^0$ if $y > \propto$

Payback period for harvesting rainwater system can be calculated as in equation 4.

$$\text{Payback Period} = \frac{\text{Total Cost}}{\text{Volume of water saved}} \qquad - (4)$$

The volume of water saved can be defined as in equation 5.

$$\text{Volume of water saved} = \text{Cost of water} \times \text{total water saved} \qquad - (5)$$

$$\text{Total water saved} \quad \frac{\text{Total days irrigated by tank}}{1m^3/\text{Day}} \qquad - (6)$$

## IV. Result and Discussion

The concrete based rooftops (as shown in table 2) are only suitable for irrigation purpose, with the help of this roof catchment area (Shown in table 1) an overall potential of rainwater collection volume can be calculated with the help of the average monthly rainfall (As shown in table 5) multiplying with runoff coefficient of 0.8 (as shown in table 2) due to concrete surface area we get a potential of $905.6m^3$.

From the meteorological date (table 6) it is apparent that the evaporation rate is highly affected by the temperature, humidity and daily total solar radiation. The lower the humidity levels the higher the evaporation rate because of the tiny amount of water present within the air. This fact shows that more irrigation work is required with days with less humidity level due to the increase evaporation.

Looking the campus in a more geographical perspective, it is quite clear that there is a no considerable variation between the elevations of the building with respect to the sport filed and garden area hence, the collected rain water could be delivered from storage to the sport filed and garden by gravity very easily without help of pumping set and electricity. The placement of tank (for storage) was chosen next to building serving adequate space and height for water delivery to the filed and garden by gravity through pipe.

Fig. 1 shows the route from tank to the sport field/garden field. The route utilizes the rain water drain system within campus therefore no excavation of any kind is required. With the elevation of tank water flow can be achieved in order to irrigate the filed and this could minimize the expenditure on pumps and electricity.

Table 3 shows the piping details for the route from the tank to the filed, the dimension were calculated using a pipe flow calculator known as the pipe flow wizard, this programmes help in calculating desired flow, pressure, diameter and length of a piping system.

**Table 3:** Piping details

| | |
|---|---|
| Pipe material | Rigid PVC |
| Internal diameter | 0.0005 mm |
| Length | 400 m |
| Pipe fittings | 16 |
| $90^o$ bend | 12 |
| 45° Elbow | 6 |
| Gate Valve | 8 |
| Elevation Chang | 10 fit fall |
| Fluid | Water at 20°C |
| Flow | 16.400 $m^3$/hr |
| Flow Type | Turbulant |

Finally much more detailed analysis was conducted as to how much water would actually be saved. The Year (Table 5) 2014 was taken as a sample to conduct the analysis due to its elongated dry days which can be seen from table as 276.5 days, which is 75 % of the entire year. The flow chart for the simulation of the tank is also shown in fig. 2.

Table 4 also shows the tank size with reliability and payback period. The list of tank size along with their prices was compared to the amount of water that was being saved this helped calculating the payback period of the tank.

By looking at high number of dry days it would be easy to assume that the 10 $m^3$ tank would irrigate much more days due to its much larger volume. Therefore the right size of the tank should serve the purpose of irrigation well enough and also payback its investment at the quickest time.

**Table 4:** Tank Sizes with Reliability and Payback Period

| Tank Sixe ($m^3$) | Reliability | Saving Rm | Tank Cost (Rs) | P. B. Period (Years) |
|---|---|---|---|---|
| 1.5 | 30 % | Rm 83.10 | Rm 1900.00 | 22 |
| 2.5 | 50 % | Rm 132.60 | Rm 2100.00 | 15 |
| 3.5 | 60 % | Rm 165.00 | Rm 2500.00 | 14 |
| 5 | 75 % | Rm 200.00 | Rm 2900.00 | 13 |
| 10 | 90 % | Rm 235.7 | Rm 4000.00 | 17 |

## V. Conclusion

The assessment of the rainwater harvesting within the college campus as a case study carried out based on the sport filed and garden, irrigation and for other application. The sport filed and garden irrigation consumes more than 1$m^3$ of water every non rainy day according to the result so obtained reveal that the catchment surface area of all building rooftop is adequate for collection of rainwater and to meet the requirement during dry days. The sizing of the tank at 5 $m^3$ is most beneficial in term of its cost and payback, reliability.

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**Table 5:** Average Monthly Rainfall, Rainy days, for last twenty years of Sidhi District of M. P. (India)

| Month | Average rainfall (MM) | Number of Rainy days | Number of dry days (Year 2014) |
|---|---|---|---|
| January | 27.0 | 2.0 | 24.0 |
| February | 18.4 | 1.7 | 26.0 |
| March | 13.2 | 1.0 | 28.0 |
| April | 3.4 | 0.5 | 30.0 |
| May | 8.8 | 0.8 | 29.0 |
| June | 133.5 | 6.3 | 18.6 |
| July | 338.2 | 15.0 | 14.3 |
| August | 325.2 | 14.9 | 15.7 |
| September | 211.8 | 9.2 | 13.9 |
| October | 33.4 | 2.2 | 22.0 |
| November | 12.1 | 0.7 | 27.0 |
| December | 7.7 | 0.7 | 28.0 |
| Total | 1132.7 | 55.0 | 276.5 |

*Source: Climatological Table (IMD) Indian Meteorological Department, Govt. of India*

**Table 6:** Average Monthly Relative Humidity of Sidhi District of M. P. (India) (for 20 Years)

| Month | Relative Humidity % | | Evaporation (mg/(m$^2$s)) |
|---|---|---|---|
| | 08:30 Hrs. | 17:30 Hrs. | |
| January | 76 | 50 | 2.6 |
| February | 68 | 40 | 2.3 |
| March | 51 | 29 | 5.6 |
| April | 38 | 24 | 7.3 |
| May | 35 | 23 | 7.5 |
| June | 58 | 46 | 6.7 |
| July | 83 | 74 | 2.0 |
| August | 85 | 79 | 2.1 |
| September | 82 | 72 | 2.0 |
| October | 73 | 53 | 3.0 |
| November | 69 | 47 | 3.1 |
| December | 74 | 51 | 2.7 |
| Average | 66 | 49 | 3.9 |

*Source: Climatological Table (IMD) Indian Meteorological Department, Govt. of India*

**Fig. 1:** College Campus

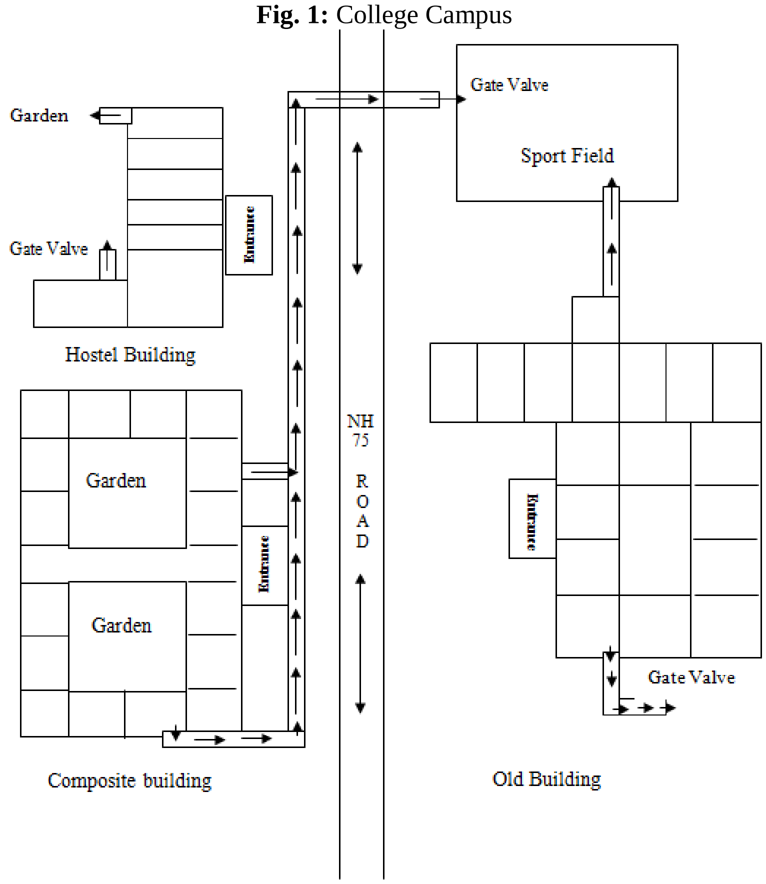

**Fig. 2.** Flow Chart for Simulation of Tank