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RAINWATER HARVESTING FOR TRACTOR INDUSTRY

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Abstract:

Growing shortage of water especially for commercial enterprises in urban areashas prompted industries to undertake studies on feasibility of runoff and rooftop rainwater harvesting. A tractor industry wanted to study feasibility of harvesting rain water from its rooftop areas, paved areas, unpaved areas and drainage. These were quantified by physical measurements. It was found that i) total rooftop area available was 53061 $m^{2,}$ii) paved area was 54535 $m^{2,}$ and iii) area under plantation was 18750 m^2. Precipitation pattern in Nagpur amid the previous 5 years was used to calculatethe likely recoverable rainfall quantity. Topography,local geology and other area componentswere studied for recommending i) Rainwater harvesting (RWH) structures and ii) aquifers for groundwater recharge.Water harvesting potential for the buildings were calculated. Type and design of suitable and appropriate tanks including material of construction and their capacities have been included in this paper on the basis of hydrological analysis. Suitable location of storage tank has been suggested to the industry. Design details of underground water storage tank for a sample building have been given in order that other tanks suitable to site conditions in other buildings can be calculated to enable rainwater harvesting.

Keywords: Rainwater Harvesting, Rooftop, Surfacerunoff, Conservation, Ground water recharge

1. Introduction:

Populationgrowth, industrialization, urbanization and deforestation is causing significant effect on water assets.These non-renewable assets areutilised morequickly than they can be revived. It has been found that the spatial precipitation pattern over the earth has changed. Investigation of periodicity of monsoon in Vidharbha region is not dependableany more. Precipitation in catchment areas of assets(natural or synthetic) is also unpredictable. In India, with the expanding population and strain on natural assets, particularly water, utilization of RWH system is turning out to be vital. One of the methods to conserve water can be by storing rainwater.

Every civil structure and industrial unit has a potential for collecting RWH system. RWH is being the most conventional strategy for conserving water. It can be performed on large as well as small scale.The Industryunder study manufactures tractors. This industry is divided into eight production units viz., Marketing Building,Transmission plant, Ware House Building, Hydraulic Building,Tractor Transmission, Tractor assembly Engine plant, and PT-CED.

2. Rainwater Harvesting System:

Rainwater Harvesting is a procedure of gathering rainwater from rooftop or runoff and storing it in surface/ subsurface reservoir. Rainwater harvesting is standout amongst the best technique for water administration and water protection.In India, with growing population& strain on natural assets,particularly water, the utilization of rainwater harvesting system is turning out to be very essential. Rainwater harvesting implies conservation of rainwater. Normally, the size of rainwater harvesting is based on the size of catchment area (Thamer et al., 2007). The RWH system relies on the geology, topography, and rainfall pattern and land availability.This requires collection system, storage tank, pump and control system.The feasibility of rainwater harvesting was studied for an industry with a perspective to suggest suitable method for -i) Rooftop Rainwater harvesting and ii) Groundwater Recharge.

In order to arrive at methodology for the above mentioned methods groundwater zone, groundwater table around the industry were measured /drawn and are shown in Fig (1) & (2) respectively.

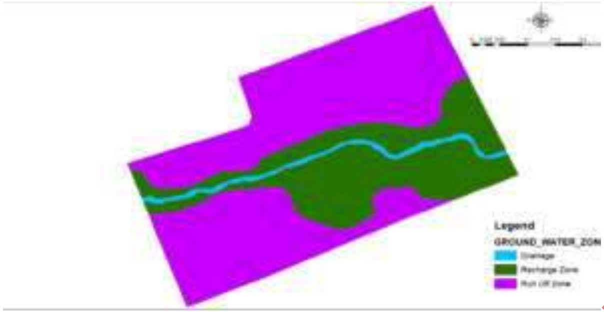


Fig 1: Ground Water Zone Map of Tractor Industry (Courtesy:Enviro Techno Consult, Nagpur)

Fig 2: Ground Water Table Map of Tractor Industry (Courtesy:Enviro Techno Consult, Nagpur)

2.1 Objectives of Rainwater Harvesting System:

1. To increase ground water levels and soil moistures.

2. To diminish the load on treatment plant by preventing the runoff from going into sewer or storm drains.

2.2 Purpose of Rainwater Harvesting System:

1. The venture is essential since a lot of water that goes into waste will be tapped through suitable downpour water catchment.

2. Objective is proportional up the undertaking and make the frameworks not so much less expensive but rather more easily accessible.

3. To fulfil expanding water needs and requests of assembly line labourer.

4. To monitor water.

2.3Need of Rainwater Harvesting System:

1. To supplement water amid deficiency of surface water supply to meet our needs.

2. To capture exhaustion of ground water levels.

3.To expansion openness to ground water at specific place and time and utilize water for feasible improvement.

4. To enhance ground water quality.

2.4 Components of Rainwater Harvesting System:

The system mainly consist of the following components -

1. Catchment: It is the surface that receives rainfall directly. It can be rooftop, paved or unpaved area.
2. Transportation: Rooftop rainwater should be carried through drains to storage tanks. Water pipes should be UV resistant and anti corrosive. At rooftop, mouth of each drain should be covered with wire mesh to restrict floating material.
3. First Flush: It is the device used to flush off the initial surface runoff a rainstorm.

4. Filter: It is used to expel suspended contaminations from rainwater collected from roof. Filter consist of filtering media which is filled with fibre, coarse sand and gravel layers to remove dirt and debris.
5. Storage facilities: The collected rainfall can be stored anywhere depending on the shape, size and material of tank.
6. Recharge structures: Rainwater can be recharged through any appropriate structures like constructed wetland, dug wells, overland system etc.

3. Methodology:

3.1 Geographical Location: The tractor industry has a total area of 179,966 sq.mt. Complete premises is divided into 8 production units namely Marketing Building, Ware House Building, Tractor Transmission, Transmission Plant, Engine Plant, Hydraulic Building, Tractor Assembly and PT-CED. A Satellite picture demonstrating majority of the buildings in the industry is given below in Fig. 3.

Fig. 3: Satellite picture of Industry (Source:Google Earth)

3.2 Data Collection:

During field visit general observations as well as resource mapping to indicate the location and distribution of any available resources such as wells, nalas and trees were conducted. This was essential with a specific end goal to recognize whether there was any current in site RWH system being executed. Rooftop areas were measured and calculated manually. Rainfall data was gathered from Regional Meteorological Centre, India Meteorological Department (IMD), Nagpur.

3.2.1 Rainfall Data Collection:

Tractor Industry is situated at 79°5'24"E longitude and 21°9'0"N latitude in Nagpur district of Maharashtra of 310.5 meters above sea level.Nagpur has tropical wet and dry atmosphere with dry conditions prevailing for most of the year. Summers are greatly hot, enduring from March to June, with May being the most sweltering month. Winter lasts from November to January, during which temperatures drop beneath 10 °C. Average annual rainfall at Nagpur is1000 mm.

The average monthly rainfall data was taken from Regional Meteorological Centre, India Meteorological Department (IMD), Nagpur. The monthly rainfall data of Nagpur city is given in Table 1 which is assumed to be same for the Tractor Industry in Hingna area.

Table 1 :Monthly Average Rainfall Data Of Hingna Area, Nagpur

MONTH	RAINFALL(mm)
January	0.12
February	-
March	6.26
April	5.76
May	7.06
June	151.06
July	274.76
August	168.72
September	150.42
October	29.78
November	3.20
December	-

3.2.2 Calculation of Rooftop Area:

The rooftop area is nothing but the catchment area which receives rainfall. Rooftop areas of the buildings, paved areas and unpaved areas within the industry was measured. The measurement was done manually with the help of engineering tape which is the common technique known as "Tape survey". Before using the tape, tape was checked for any error and for its precision the length of tape was checked precisely. Those places which are difficult to reach were measured by using the ruler from "Google Earth" toolbox. The calculated rooftop areas and drain details of all the buildings within the premises are given below in Table no. 2.

Table2 :Calculation Of Rooftop Area And Drain Details Of All Buildings

SERIAL NO.	BUILDING NAME	ROOFTOP AREA (m^2)	NO. OF DRAINS	DRAIN SPACING (m)	DRAIN DIAMETERS (mm)
1	Transmission Assembly	7910	37	8	150
2	Engine Assembly	11850	30	12	150
3	Hydraulic	4969	20	8	150
4	Marketing	4424	8	6	150
5	Transmission Machine	5086	34	8	150
6	Ware House	4134	20	8	150
7	Tractor Assembly	7146	26	12	150
8	PT-CED	7542	24	12	150

3.3 Hydrological Analysis:

On the premise of trial results Henry Darcy (1865), established a law overseeing the rate of flow (i.e. the discharge) through the soils and contented that discharge is directly proportional to head loss (H) and the cross sectional area (A) of the soil, and inversely proportional to the length of the soil sample (L). In other words,

$$Q \propto \frac{H}{L} \cdot A$$

where, $\frac{H}{L}$ = Hydraulic gradient (I)

Q = Runoff

$$Q = C \cdot I \cdot A \qquad (1)$$

where, C = Co-efficient of permeability

Similarly, based on the above principle, water harvesting potential of the catchment area was calculated.

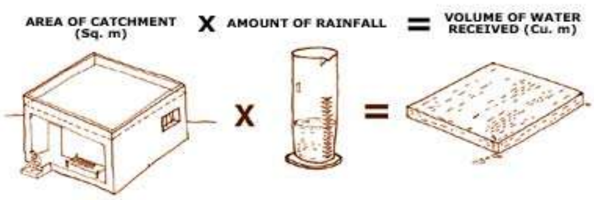
The formula for calculation for harvesting potential or volume of water received or runoff produced or harvesting capacity is diagrammatically shown in Fig. 4& given as follows:

Volume of water Received (m^3) = Area of Catchment (m^2) X Amount of rainfall (mm) X Runoff coefficient (2)

The runoff coefficient (C) is a dimensionless coefficient relating the measure of runoff to the amount of precipitation received. It is a larger value for areas with low infiltration and high runoff (pavement, steep gradient), and lower for permeable, well vegetated areas (forest, flat land). Runoff coefficient represents misfortunes because of spillage, spillage, penetration, catchment surface wetting and vanishing, which all will contribute to reduce in the amount of runoff. Runoff coefficient varies from 0.5 - 1. Runoff coefficients for various catchment surfaces are given in Table 3.

Table 3: Value of Runoff Coefficient (C)
(Source: Rainwater Harvesting and Conservation Manual)

Ground Cover	C Low	C High
Lawns	0.05	0.35
Forest	0.05	0.25
Cultivated land	0.08	0.41
Meadow	0.10	0.50
Parks, cemeteries	0.10	0.25
Unimproved areas	0.10	0.30
Pasture	0.12	0.62
Residential areas	0.30	0.75
Business areas	0.50	0.95
Industrial areas	0.50	0.90
Streets		
bricks	0.70	0.85
asphalt	0.70	0.95
concrete	0.70	0.95
Roofs	0.75	0.95



. Fig 4: Volume of water received (m^3)

3.4Rapid Depletion Method (RDM) For Storage of Harvested Rainwater inTank:

The obtained rainwater from the rooftop areas of the different buildings need to be stored in the tanks. The volume of tank which stores the collected water will be directly proportional to the total volume of water harvested.

In Rapid Depletion method, harvested rainwater use is not confined by consumer. Consumer is allowed to use the preserved rainwater up to their maximum requirement, which results in less number of days of use of preserved water.

Assume, Per capita water demand = 135 lt/day = 0.135 m^3/day

Number of staff at Engine Building = 590

∴ Total amount of water consumption per day = 0.135 x 590 = 79.65 m^3/day

Rooftop area of Engine Building = 11850 m^2

Average annual rainfall = 1000 mm = 1m

∴ Total volume of water received = 11850 x 1 x 0.85 = 10072.5 m^3(From Eq. 1)

Total number of days of utilization of preserved water = $\frac{\text{water received}}{\text{water consumption}}$ = $\frac{10072.5}{79.65}$

= 126 days (4 months)

3.5 Determination of Size & Types OfTank:

3.5.1 General:

In this paper one building (EngineBuilding)has been considered fordetailed calculation of storage tank. Similar approach will be suitable for storage tanks for other buildings. Engine Building has capacity of 590 staff. The total rooftop area of Engine Building is 11850 m^2. Cumulative rainfall runoff was 10072.5 m^3.

3.5.2 Calculation of Volume of Runoff perYear:

From equation 2, Volume of water Received (m^3) or runoff discharge = Catchment Area (m^2) X Rainfall Intensity (mm) X Coefficient of runoff

Total rooftop area of Engine Building = 11850 m^2

Average yearly rainfall = 1000mm = 1m

Coefficient of runoff for rooftop = 0.85
(From Table 3)

Total volume of surface runoff = 11850 x 1 x 0.85 = 10072.5 m^3

The monthly rainfall and volume obtained from the rooftop area of Engine Building is given in Table (4) and corresponding graphs are also plotted in Fig. 5 and Fig. 6.

Table4:Monthly Rainfall And Volume Of Engine Building

SR. NO.	MONTH	RAINFALL (mm)	VOLUME (m^3)
1	January	0.12	1.42
2	February	-	-
3	March	6.26	74.18
4	April	5.76	68.26
5	May	7.06	83.66
6	June	151.06	1790.06
7	July	274.76	3255.91
8	August	168.72	1999.33
9	September	150.42	1782.48
10	October	29.78	352.89
11	November	3.20	37.92
12	December	-	-

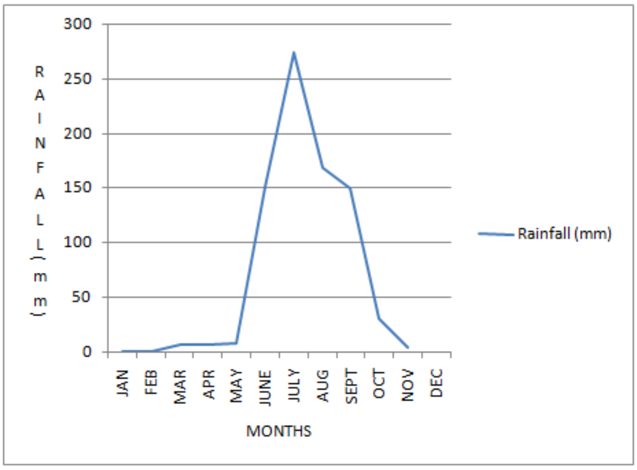


Fig. 5: Amount of annual rainfall collected

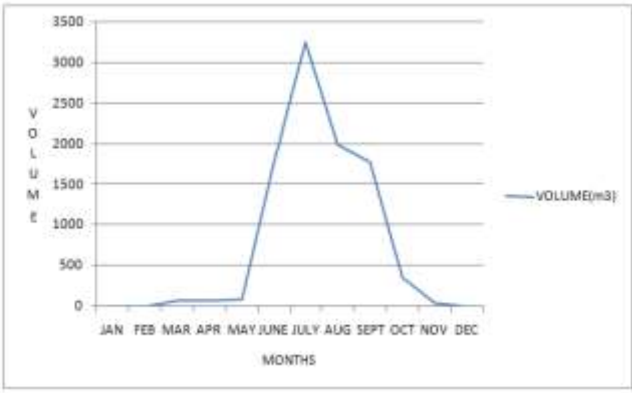


Fig. 6: Volume of water collected from annual rainfall

3.5.3 Optimum dimension of tank:

For Engine Building,

Total amount of water collection in one year = Size of tank = 10072.5 m^3

Taking height of tank = 4m

∴ Area of base = 2518.12 m^2

We can take square base each of side = 50m or rectangular base as per land availability.

So our tank will be of dimension 50 x 50 x 4 m (taking square tank) which is not economical.

As water is stored on monthly basis, size of tank will be equivalent to the excess amount of water left over after utilization. Hence, mostly excess amount of water assumed to be collected during the period of maximum rainfall- June, July & August.

Amount of water collected during June, July & August = 1790 + 3255.91 + 1999.33= 7045.24 m^3

Amount of water consumed/month = 590 x 0.135 x 30 = 2389.5 m^3

Amount of water consumed for 3 months = 2389.5 x 3 = 7168.5 m^3

∴ Total amount of water to be stored = Size of tank = (7168.5 - 7045.24) = 123.26 m^3= 124 m^3

Assuming height of tank = 4m

∴ Area of base = 124/4 = 31 m^2

∴ Dimension of tank = 8.5 x 4 x 4 m (taking rectangular tank) which is feasible.

3.5.4Types of Tank:

Two types of storage tank can be used for storing rainwaterreleased from the roof viz. a lined tank or an unlined tank. Requirements will be

- Lined storage tank: Earthwork viz. excavation andwater retaining underground RCC water storage tank. It will be completely covered from the top. Advantage will be that its top of the tank can be utilized for serving as playground or parking slot, etc.
- Unlined storage tank: After excavation is completed water will be allowed to fall directly in that pit and be stored. There are two advantages. Firstly, natural water gets recharged leading to augmentation of water level and recharge of local aquifer. Secondly, underground water can be abstracted fromanywhere within some restricted areas from that pit and can be utilized to fulfill daily water demand.

4. Result:

Essentialrequirements of any site for feasibility were studied for Tractor Industry.These were availability of land for storage tanks, quantity of harvested water and its utility.Selection criteria for a site was availability of land, convenient transmission of roof-top collected water and mode of its utilization. A specimen for Engine building was worked out and required storage tank (underground) was designed which could be located near the Engine building itself. Dimensions of the tank worked out to be 8.5 x 4 x 4 m.Proper ventilation ducts were designed to ensure inter play of air with stored water, thus to maintain healthy aseptic conditions. Accessibility to the bottom of the tank by stairs through a manhole has been ensured.

5. Conclusion:

It has been concluded that the RWH system is found feasible for Tractor Industryand if applied then water can be stored for 4 months without restricting water demand ensuring water conservation. Collected rainwater would not need any treatment except its safe hygienic storage which is included in the design. This conserved water can be utilised for drinking and gardening purpose. Cost of construction of underground water retaining R.C.C. structure as per prevailing rates was around Rs. 9,00,000/-

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