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Planning And Designing an Environmentally Sustainable College Campus of DVR & Dr. HS MIC College of Technology

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Abstract- Proactive efforts for sustainability help to protect the environment and leave a more promising future for the next generations. The general awareness in sustainability issues has improved in the recent years through mass media coverage. However, this knowledge is not always translated into the actual sustainable practices. The main aim of this project is to improve environmentally sustainable practices in DVR & Dr. HS MIC College of Technology. The major environmentally sustainable elements like Rainwater harvesting, Roof top rain water storage, Recycling of waste water, Composting of leaves of plants, Production of Biogas by using canteen food waste. Are identified in our efforts to design sustainable college campus. Sustainable practices in college campus educate the students and other stakeholders on the usage of resources efficiently. All the sustainable practices mentioned above are useful to protect the environment besides improving the reuse of natural resources. In this project we are planning to design a sustainable college campus by using available natural resources. The feasibility and scope for implementation of different sustainable elements are discussed here.

Key words: Sustainability, Sustainable campus, Rainwater Harvesting, Biogas, Composting

1. INTRODUCTION

Sustainability is the ability to exist and develop without depleting natural resources for the future. Sustainability consists of fulfilling the needs of current generations without compromising the needs of future generations, while ensuring a balance between economic growth, environmental and social well-being. Sustainable development goal is "conserve and sustainably use natural resources for sustainable development". Therefore, it is important to use the environment and its resources rationally and protect it for the good of the earth, our environment, humanity, and all living things. So, to make MIC college campus environmentally sustainable, we have chosen 5 sustainable elements.

The environmentally sustainable elements are as follows:

- Rainwater harvesting
- Roof top rainwater storage
- Recycling of wastewater
- Composting of leaves of plants
- Production of Biogas by using canteen food waste

The importance and benefits of the above environmentally sustainable elements are described below.

1.1 Rainwater Harvesting: The process of rainwater harvesting involves the collection and the storage of rainwater with the help of artificially designed systems that run off naturally or man-made catchment areas like- the rooftop, compounds, rock surface, hill slopes, artificially repaired impervious or semi-pervious land surface. The rainwater harvesting system is one of the best methods practiced and followed to support the conservation of water. Today, scarcity of good quality water has become a significant cause of concern. However, rainwater, which is pure and of good quality, can be used for irrigation, washing, cleaning, bathing, cooking and also for other livestock requirements.

1.2 Roof Top Rainwater Storage: Rooftop Rain Water Harvesting is the technique through which rain water is captured from the roof catchments and stored in reservoirs. Harvested rainwater can be stored in sub-surface ground water reservoir by adopting artificial recharge techniques to meet the household needs through storage in tanks.

1.3 Recycling of Waste Water: Recycling of wastewater is done to treat the wastewater to a level suitable for various purposes. Water recycling is reusing treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing and replenishing a ground water basin. The term water recycling is generally used synonymously with water reclamation and water reuse.

1.4 Composting of Leaves of Plants: Composting leaves is a very good way to recycle and create a nutrient rich garden soil amendment at the same time. The benefits of leaf compost are numerous. The compost increases the porosity of the soil, raises the fertility, diminishes the strain on landfills, and creates a living "blanket" over your plants. Learning how to compost leaves just requires a little knowledge of the balance of nitrogen and carbon.

1.5 Production of Biogas By Using Canteen Food Waste: Biogas is a type of natural gas. It's created by breaking down the bacteria in organic waste (such as plant and animal products) in 'anaerobic digestion' – a digestive process in a purpose-built vessel, and an oxygen-free environment. When creating biogas from food waste, the biogas is created by anaerobic digestion, recycling the organic material fed into the vessel which releases biogas. But that's not all: the biogas from the food waste process separates the energy created – the biogas itself – and any other solid run-off ('digestate'), which can also be used for sustainable living.

2. LITERATURE REVIEW

Linda Too, Bhishna Bajracharya, (2015) "Sustainable campus: engaging the community in sustainability", They have developed the 6-P community engagement framework for developing a sustainable campus and has illustrated its application through a case study method to review the current sustainability programs adopted by two university campuses. These case examples clearly illustrate the need for a holistic approach to engage any community in sustainable development.

S. Sangita Mishra, Shruthi B. K., H. Jeevan Rao, their study was aimed to designing a rooftop rainwater harvesting structure for the Amity University Mumbai, located in Maharashtra state of India. Out of the possible catchment areas, the main building was selected as the required catchment area for rainwater harvesting considering the water demand in university campus and the supply. Further, different parts of the RWH system were designed based on standard guidelines.

Abhijeet Keskar, Satish Taji, Rushikesh Ambhore, Sonali Potdar, Prerana Ikhar, Regulwar D.G. The rainwater harvesting (RWH) system is analyzed as an alternative source of water at campus of Government College of Engineering, Aurangabad (GECA) in the state of Maharashtra, India. The expected outcome of the study is the development of rainwater harvesting system for catchment area of campus from parking area, workshop area, some of the electronics department area up to Hostel 'A'. The result analysis shows that the present RWH system is having the storage 53,96,816 liters/year and construction cost of Rs.5 lakhs respectively and is reasonably well in comparison with conventional water sources.

Ram Karan Singh, Nitin Jakhar, the technique of rainwater harvesting through rooftops in an urban scenario was looked into. The basic requirements, like the kind of data needed for doing such analysis and the challenges faced while employing the technique, were gathered by reviewing literature on the topic and the experiences from other case studies and success stories. The different aspects from which the problem can be viewed (modeling, law and policy, economic, etc.) were also studied. The study is extended for the study of effectiveness of rooftop rainwater harvesting in decreasing the gap between demand and supply with the help of two case studies carried out in Delhi. The methodology employed includes collection of rainfall data, finding out the area on which rainwater can be harvested for storage and subsequent reuse and calculating the volume of water that can be substituted with rainwater.

3. DATA COLLECTED.

To design the rain water harvesting and roof top rain water storage we need to collect the data required and is mentioned below:

3.1 ANNUAL RAIN FALL DATA

Annual rainfall data of Kanchikacherla village is collected through NASA website and is as follows:

Table: -1 Annual Rainfall data of Kanchikacherla village

Year	Annual rainfall in mm
2005	1117.97
2006	1276.17
2007	996.68
2008	1091.6
2009	791.02
2010	1545.12
2011	696.09
2012	1139.06
2013	1223.44

Year	Annual rainfall in mm
2014	701.37
2015	769.92
2016	907.03
2017	922.85
2018	885.94
2019	949.22
2020	1408.01
2021	1209.78

3.2 ROOF TOP AREAS OF BUILDINGS IN CAMPUS

The Roof top areas of buildings in a campus are calculated and mentioned in table 2

Table: - 2 Roof top areas of buildings in campus

S. No.	Harvesting pit	Size (L x B x D) in m
1	Playground	5 x 3.5 x 4
2	Bus parking area	6 x 3 x 3

3.3 CATCHMENT AREA OF GROUNDS

The catchment areas of grounds are also mentioned in table 3

Table: -3 Catchment area of grounds

S. No.	Ground	Catchment area of ground (sq.m)
1	Playground	20092.38
2	Bus parking ground	15596.09

4. DESIGN

4.1 DESIGN OF RAINWATER HARVESTING PIT

This rainwater harvesting system will not only maintain the water level of the ground water of the region but also save our water resources and power consumption for future use. In this project we are designing the rainwater harvesting pits for MIC college grounds to increase the water level of the ground water in that region to conserve the natural resource for future use.

<u>Calculation:</u>

1. Based on the annual rainfall data:

The average rain fall of past 17 years is 1037.13 mm

Therefore, intensity of rainfall is 3 mm/day

Intensity of rainfall per year =1037.13 mm

2. As per the rain water harvesting guidelines runoff coefficient for unpaved grounds shall be taken as 0.3

3.Volume of water acquired from the playground = area x 0.3 x intensity

Assume effective rainfall season for 90 days then, volume/90 = 69.452 m^3/day

Assuming that a pit of 200 mm and 130 mm long has taken a time of 1 hour to percolate 2.5-liter water. Here diameter 200 mm, radius = 100 mm = 0.1 m

Rate of percolation in terms of volume = $2.5/(\pi \times 0.1^2 \times 0.13)$

Volume of pit = daily volume/percolation rate.

By using above formulas, the size of the harvesting pits for both grounds are mentioned in table

Table: - 4 Size of harvesting pit

S. No.	Name of the Building in Campus	Rooftop area of building (sq.m)
1	BED block	1050.025
2	Boys hostel	624.260
3	Main block	5070.115

Diagrams:

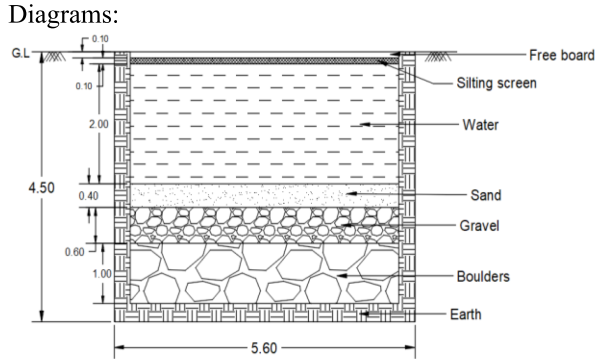

Fig: - 1 Rain water Harvesting for playground area

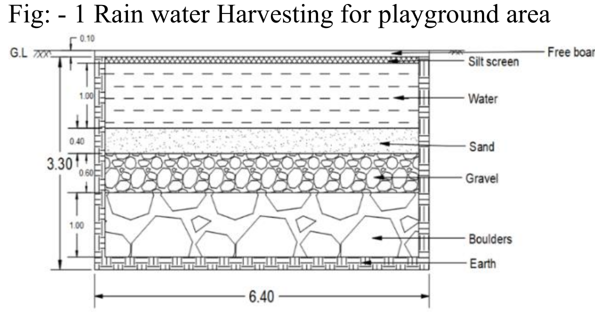

Fig: - 2 Rain water Harvesting pit for bus parking area

4.2 ROOF TOP RAINWATER STORAGE

Roof top rainwater storage is a collection of roof top rain water through pipes and then is stored into tanks. The stored water can be used for Gardening, cleaning and flushing. This helps the college to save the power consumption and also the water scarcity. The roof top rainwater storage can be used for different purposes. In this project we are designing the storage tanks to store the rainwater from the roof tops of buildings in campus.

Design of Roof top rainwater storage tanks:

1. Based on the annual rainfall data:
The average rain fall of past 17 years is 1037.13 mm
Therefore, intensity of rainfall i = 3 mm/day
2. As per guidelines of roof top rainwater harvesting (IS 15797:2008) runoff coefficient for flat concrete roof top C = 0.95
3. Formula to calculate total discharge,

$Q = C \times i \times A$

Where, C = runoff coefficient
i = rainfall intensity
A = area of roof top

Based on this the size of the storage tanks are determined and as follows.

Table: - 5 Size of Roof top rainwater storage tanks

S. No	Building	Tank size in m (L x B x D)
1	Main block	24.19 x 12.09 x 4
2	BED block	9 x 9 x 3
3	Boys hostel	9 x 8 x 2

Diagrams:

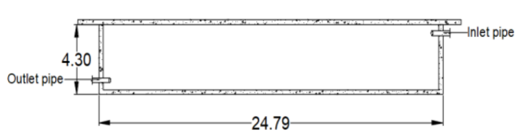

Fig: - 3 Rain water storage tank for Main block

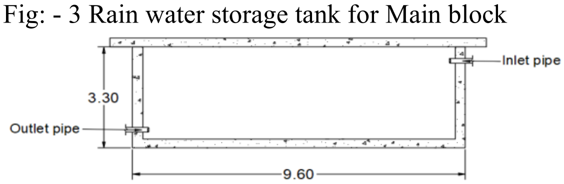

Fig: - 4 Rain water storage tank for BED block

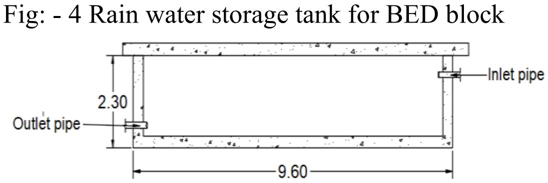

Fig: - 5 Rain water storage tank for boys hostel

Design of pipes:

Discharge = Area x Velocity

$Q = A \times V$

Where, Q = discharge
A = area
V = velocity

Assume velocity of flow V = 0.6 m/sec

$A = Q/V$

We know that, Area = $\frac{\pi}{4}D^2 = 2.78\text{x}10^{-4}$

D = 0.0188 m

D = 18.22 mm

As per design calculations pipe diameter is very small and not available in market.

As per CPHEEO (Central Public Health and Environmental Engineering Organization) manual the minimum pipe diameter should not be less than 150 mm.

Hence, provide 150 mm diameter pipes for conveyance to all cisterns and for all 3 buildings.

4.3 RECYCLING OF WASTEWATER

In this project we have taken recycling of wastewater as an environmentally sustainable element.so, we are planning to design the method for recycling of wastewater.

Taking domestic wastewater coming from the Hostels, Main block and BED block in campus into account we designed the slow sand filter for recycling the wastewater from the campus. The slow sand is economic, and the recycled water can be used for gardening and toilet flushing. This technique helps the college campus to save the water and it makes sustainable college campus.

Design of Slow Sand Filters:

The calculation is based on water demand as per standards for educational institution water demand considered as 45 lit/day

And for Hostels, water demand for bathing and washing considered as 55 lit and 20 lit.

Quantity of wastewater = Population x Water demand

Rate of filtration of slow sand filters considered as 100 to 200 lit/hr/m^2

Total surface area of filter required = Quantity of wastewater / filtration rate

Table: - 6 Student Population

S. NO.	Building	Population
1	Main block	3000
2	BED block	1000
3	Girls hostel	250
4	Boys hostel	250

Therefore, the size of the filter is determined by using the data mentioned in table and design. The size of the slow sand filters is mentioned in table:

Table: - 7 Size of the Slow Sand Filters

S. NO.	Building	Size of filter in m (L x B x D)
1	Main block	2 x 2 x 2.2
2	BED block	2 x 1 x 2.2
3	Girls hostel	2 x 2 x 2.1
4	Boys hostel	2 x 2 x 2.1

Diagram:

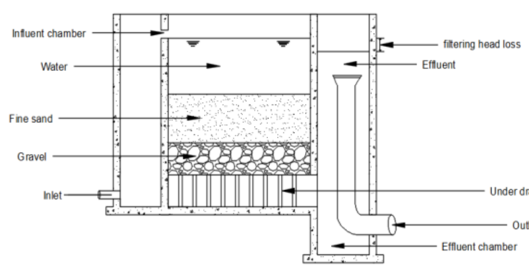

Fig: - 6 Slow Sand Filter

5. EXPERIMENTAL PROCEDURE

5.1 Production of Biogas by Canteen Food Waste

The produced biogas can be used for fuel vehicles, turbines, can be converted to various types of energy and replacement of natural gas. The biogas can be used instead of LPG gas for cooking. This helps economically in saving the LPG gas cylinders by biogas. Biogas typically consists of 50-75% methane, 20-50% carbon dioxide and smaller amounts of nitrogen 2-8%.

5.1.1 Biogas setup:

We have made a biogas setup in college campus and the procedure and estimation is as follows:

Based on this we have estimated the gas yield.

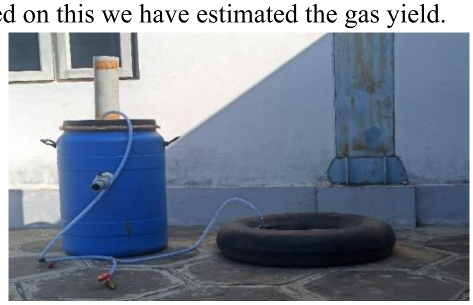

Fig: - 7 Biogas setup

5.1.2 Estimation of biogas production

For any one feedstock, daily biogas production can be estimated using the following equation:

$$G = C \text{ x } V_d \text{ x } S \text{ x } \left(\frac{k}{1+kR}\right)$$

Where:

- G is the biogas production (in m^3/day)
- C is the biogas potential, which is the maximum amount of gas that can be produced from 1 kg of volatile solids in a feedstock (in m^3/kg)
- V_d is the digester volume (in m^3)
- S is the initial concentration of volatile solids in the slurry (in kg/m^3)
- R is the feedstock retention time (in days)
- k is a constant indicating the rate of gas production at a given temperature.

To simplify this equation, IRENA(International Renewable Energy Ageny) has calculated gas production across a wide range of temperatures and retention times, so that biogas production can be calculated as follows:

$$G = \frac{Y \times V_d \times S}{1000}$$

Where G, Vd and S are the same as before and Y is a yield factor based on temperature and the feedstock retention time.

As per the reference from IRENA,

- Yield factor is taken as 4.45 based on the temperature and feedstock retention time. The retention time is taken as 45 days.
- S concentration of volatile solids is determined by weight of volatile solids added each day and the daily feedstock volume is 0.08 m3 /day, the initial concentration of volatile solids (S) is 10/0.08 = 125 kg/m^3.

$$G = 0.055625 \text{ m}^{3/}\text{day}$$

This is the biogas production for the setup we made for 10 kg of waste.

The waste from the canteen is 100 kg per day, then 0.55625 m^3/day

Therefore, yearly biogas production by canteen food waste is 0.55625 x 365 = 203.03 m^3 of gas

Standard equivalent volume of biogas to LPG is 1 kg of biogas = 2.5 m^3 of biogas.

1 cylinder of LPG = 14.2 kg of gas

Therefore, 81.21/14.2 = 5.71 cylinders / year

Based on this calculation we can save 5.71 cylinders per year by using the biogas which can be produced by canteen food waste.

5.2 COMPOSTING OF LEAVES OF PLANTS

5.2.1 Composting Process

The compost bin doesn't have to be a complex structure and you can even compost in a pile. Here we took a clay pot to compost. The basic idea is to add air occasionally for the aerobic microbes that are in the pile decomposing the material. You also need to keep the compost warm, around 60 degrees Fahrenheit (15 C.) or warmer, and moist but not soggy.

Estimation for yield of composting

For estimation of composting, we have to know the total weight of leaves shredded in a college.

To know this we made a process,

Approximately the total leaf weight is taken as 1200kg per month in MIC college.

From the reference from Quora, source sustainable management in India

Organic waste generally loses about 60%of its weight in water during composting and some more in carbon dioxide. The yield is 6-7%.

Which means, 1 tonne of waste gives 60-70 kg of compost.

From this reference the total yield from 1200 kg of waste from college is,

Total yield of compost = 6% of 1200 kg

= 72 kg

Therefore, the total yield of compost from leaves is 72 kg /month.

6. CONCLUSION

The main objective of this project is to make the MIC college campus environmentally sustainable. In this project we have designed and planned the elements like Rainwater harvesting pits, Roof top rainwater storage, Recycling of waste water, Production of biogas from canteen food waste and Composting of leaves.

- We have designed the rainwater harvesting pits for playground and bus parking area. The size of the harvesting pits of playground and bus parking area are (5 x 3.5 x 4 m) and (6 x 3 x 3 m) respectively.
- We have also designed the roof top rainwater storage tanks for storing the roof top rain water. The size of the storage tanks of Main block, BED block and Hostel are (24.19 x 12.09 x 4 m) , (9 x 9 3 m) and (9 x 8 x 2 m) respectively. And we have also determined the diameter of conveyance pipe and is 150 mm.
- We have also designed the wastewater recycling filter for the recycling of waste water from college campus. For that we have designed the slow sand filter for main block, girls and boys hostel and BED block and the sizes are (2 x 2 x2.2 m), (2 x 2 x 2.1 m) and (2 x 1 x 2.2 m) respectively.
- We have made an experimental procedure for the production of biogas from canteen food waste. And we have estimated the production of biogas. Based on this estimation approximately the college can save the 5.7 cylinders per year.
- We have also made a composting of leaves of plants in a clay pot and also estimated the yield of compost from leaves is approximately 72 kg/month.
- So, these are the 5 sustainable elements that makes the DVR & Dr.HS MIC College of Technology environmentally sustainable.

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