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Design of Compost Pit and Rain Water Harvesting System at Shivajirao S. Jondhle Knowledge City

[1]Vivek Manyar, [2]Mahima Londhe, [3]Akash Dhirde, [4]Balaji Pawar, [5]Milind Telavane

[1234]Student, [5]Assistant Professor
[12345]Department of Civil Engineering,
[12345]Shivajiaro S. Jondhle College of Engineering and Technology, Asangaon, India

Abstract : ***The project focuses on the design and implementation of sustainable solutions for waste management and water conservation at Shivajirao S. Jondhle Knowledge City, Asangaon. It encompasses a design of compost pit and rainwater harvesting system, aiming to address environmental challenges and promote eco-friendly practices. The project begins with extensive site assessments to identify optimal locations and requirements for both compost pits and rainwater harvesting system. Through detailed design processes, including the design of recharge pit for rainwater harvesting system, the project aims to maximize efficiency and effectiveness while minimizing environmental impact. Utilizing rainfall data collected over the past decade in Asangaon, calculation of the rooftop catchment area of all buildings on campus and determines the rainwater harvesting potential. Further calculations determine the size and depth of recharge pits required to replenish groundwater levels sustainably. Estimation processes are employed to determine the costs associated with the implementation of both composting and rainwater harvesting system. Through meticulous planning and analysis, including the calculation of campus water demand, this project seeks to create a more environmentally conscious and resource-efficient campus, contributing to a greener and more sustainable future.***

Keywords - Composting, Rainwater Harvesting, Sustainable Solutions, Water Scarcity, Eco-friendly Practices, Environmental Responsibility, Waste Disposal, Water Conservation, Design, Estimate.

1. INTRODUCTION

Compost pits are an eco-friendly method of recycling organic waste materials into nutrient-rich compost. Compost pits can be constructed in various sizes and designs, including simple backyard pits, windrow composting systems, and vermicomposting bins. Rainwater harvesting systems capture and store rainwater for various uses, including irrigation, landscaping, and non-potable household purposes. Rainwater harvesting helps reduce reliance on municipal water supplies, conserve water resources, and alleviate stormwater runoff and flooding. In the rainwater harvesting system recharge pits can be constructed for ground water recharge. Rainwater harvesting systems can be customized to suit different climates, building types, and water usage needs, making them a versatile and sustainable water management solution.

1.1 STATEMENT OF PROBLEM

The Shivajirao S. Jondhle Knowledge City faces significant challenges in waste management and water resource management. There is a high volume of organic waste generated within the campus. Inefficient water resource management has resulted in a heavy reliance on external water sources, exacerbating water scarcity concerns. These challenges have direct and indirect consequences, including adverse environmental impacts, increased operational costs, and a lack of sustainable practices.

1.2 OBJECTIVES

- To Design Compost Pit and Rooftop Rainwater Harvesting System for Shivajirao S. Jondhle Knowledge City Asangaon.
- To accurately estimate the costs associated with the construction and implementation of the compost pit and rainwater harvesting system.
- To provide actionable recommendations to the college administration based on the project's findings and analysis.

2. STUDY AREA

The campus of Shivajirao S. Jondhle Knowledge City is located in Asangaon, and is spread in around 27 Acres of land. The campus has a population of around 2500 including students and staff. The trees, bushes, grass and the cafeteria are the sources of generation of waste in the campus. The campus lack in waste management system. Inefficient water resource management in the campus has resulted in a heavy reliance on external water sources, exacerbating water scarcity concerns.

Figure 1: Study Area (Source – Goggle Earth)

3. Review Of Literature

3.1 Mayilsankar B. et. al. underscores the importance of composting as a sustainable solution for organic waste management and highlights the need for comprehensive economic analyses to inform decision-making regarding composting facility design and implementation. By integrating scientific research with economic considerations, policymakers and stakeholders can make informed choices to address the challenges associated with waste management effectively.

3.2 Tesfu Mengistu et. al. underscores the significance of composting as a sustainable waste management strategy and highlights the importance of selecting appropriate methods to ensure efficient waste transformation and pathogen elimination. The findings of this study contribute valuable information to guide decision-making processes aimed at optimizing composting practices for organic waste management.

3.3 S Sumiyati et. al. underscores the importance of community-driven waste management initiatives and the adoption of appropriate technologies to address waste challenges effectively. By integrating community participation, technological innovation, and sound waste management practices, initiatives like pit composting can contribute to the creation of environmentally sustainable communities and support the transition towards a circular economy.

3.4 Veluru Sailaja et. al. underscores the economic and environmental benefits of rainwater harvesting. With an average water consumption of 50,000 liters per day in the Siddharth region, implementing this system can result in significant cost savings compared to purchasing water from external sources, with estimates ranging from 7,000/- to 10,000/- per day. Moreover, the rainwater harvesting system is environmentally friendly, improving groundwater resources without adverse effects on the ecosystem. Additionally, the project's affordability is underscored, as it aligns with the economic standards for plumbing costs, constituting approximately 8% of the total building expenses. The aesthetically pleasing design ensures that the functionality of the system does not compromise the architectural integrity of the buildings, making it a viable and visually appealing solution for sustainable water management.

3.5 Dr. S. P. Cholke underscores the effectiveness of rainwater harvesting as a cost-effective solution to mitigate water scarcity. By quantifying the rainwater harvesting potential based on catchment area characteristics and rainfall data, the study provides valuable insights into addressing water supply-demand imbalances. Implementing rainwater harvesting can significantly alleviate water scarcity issues by replenishing groundwater resources and fulfilling various water needs on campus. Overall, the study underscores the importance of proactive measures such as rainwater harvesting in sustainable water management practices to combat water scarcity effectively.

3.6 Mr. Sagar M. Mehetre et. al. underscores the importance of adopting water conservation techniques like RWH at individual, institutional, and community levels to address water scarcity challenges effectively. By harnessing rainwater, the Jaihind campus can contribute to sustainable water management practices, ensuring water availability for various purposes while also replenishing groundwater resources.

3.7 S. Sangita Mishra et. al. underscored the importance of implementing RWH systems as a sustainable solution to water scarcity issues, emphasizing the benefits of rainwater harvesting for both surface and groundwater resources. By effectively harnessing rainwater, the initiative not only addresses immediate water needs but also promotes long-term water sustainability and resilience in the face of changing environmental conditions.

3.8 Abhijeet Keskar et. al. emphasizes the importance of gradually replenishing groundwater tables through the implementation of recharge structures, contributing to the rejuvenation of depleting groundwater resources. By implementing the RWH system at GECA campus, a significant quantity of rainwater can be stored annually, addressing the current water scarcity scenario. This initiative not only helps conserve water but also provides a sustainable solution for water supply, particularly in rural areas, while considering various technical aspects.

3.9 Abhinav Trivedi et. al. underscored that rooftop rainwater harvesting involves collecting, storing, and utilizing rainwater from rooftops, offering an attractive and technically feasible solution for water storage. Sub-surface reservoirs, in particular, are highlighted as viable alternatives for storing surplus monsoon runoff, leveraging geological formations as warehouses for water storage. Favorable lithological conditions and geological structures are essential considerations for creating sub-surface storages, allowing for the retention of significant volumes of water in porous and permeable formations. Overall, the study underscores the potential of rainwater harvesting systems, particularly sub-surface reservoirs, in addressing water scarcity challenges and promoting sustainable water management practices.

4. Compost Pit

4.1 Geometry of Compost Pit

- Internal Dimensions = 3m x 2m x 1m
- External Dimensions = 3.46m x 2.46m x 1m
- Capacity of Compost Pit
  V = 3 x 2 x 1 = 6 cum
- Thickness of Wall
  T = 230mm = 0.23m

4.2 Specifications for Compost Pit

- Soling
  Thickness = 200mm = 0.2m
- PCC
  Cement Concrete Grade = M15
  Ratio = 1:2:4
  Thickness = 100mm = 0.1m
- Brick Masonry
  Thickness = 0.23m
  Height = 1m
  First Class Bricks
  Size of Brick = 190mm x 90mm x 90mm = 0.19m x 0.9m x 0.9m
  CM = 1:6
- Plaster
  Thickness = 12mm = 0.012m
  CM = 1:6

4.3 Plan of Compost Pit

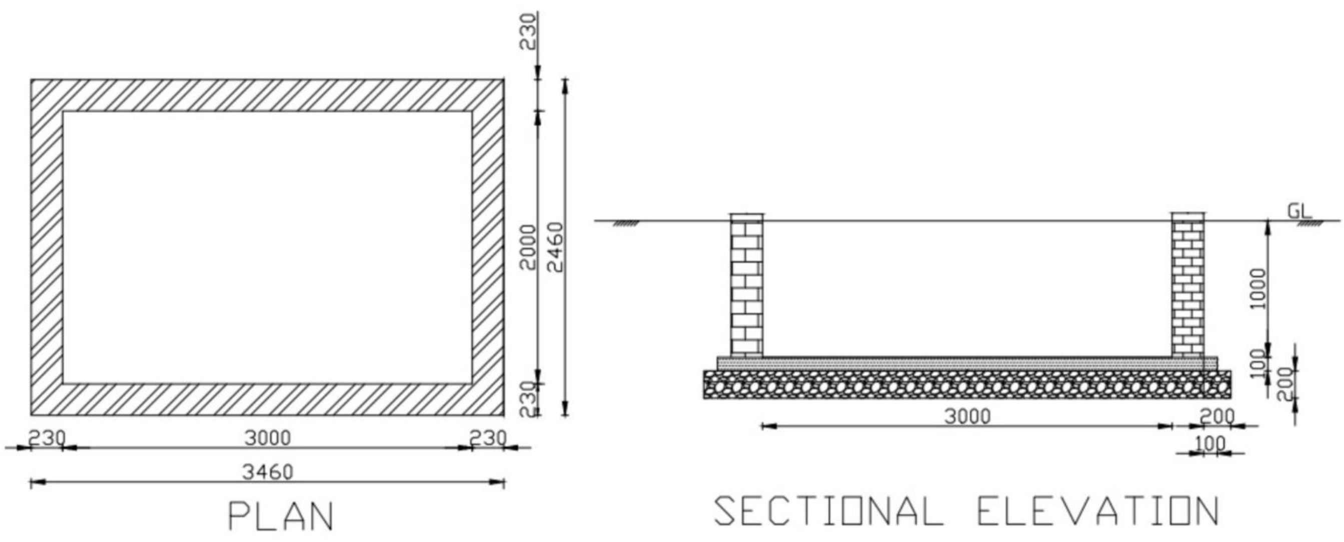

Figure 2: Plan and Sectional Elevation of Compost Pit

4.4 Estimation of Compost Pit

Abstract sheet contains the quantities of all the items of work their rate and the total amount required to complete the project. The quantities of all items of work are taken from measurement sheet, The unit rate of all the items of work were taken from PWD SSR 2022 -2023. The total estimated cost of construction of compost pit is Rs. 158,458.15

Table 2: Abstract Sheet of Compost Pit

Sr. No	Item Description	Quantity	Unit	Rate	Amount
1	Excavation	8.42	cum	Rs. 207.00	Rs. 1,742.94
2	Soling	6.92	cum	Rs. 1,382.00	Rs. 9,563.44
3	PCC	6.42	cum	Rs. 5,830.00	Rs. 37,428.60
4	Brickwork	12.15	cum	Rs. 7,750.00	Rs. 94,162.50
5	Plaster	24.35	sqm	Rs. 639.00	Rs. 15,560.67
				Total	**Rs. 158,458.15**

5. Rainwater Harvesting System

5.1 Rooftop Catchment Area of Buildings

The rooftop catchment area of all the buildings in the campus are measured using tape. The total rooftop catchment area is calculated as 17157 sqm.

Table 3: Rooftop Catchment Area of Buildings

Building	Total Catchment Area (sqm)
Law	1880
School	2526
Pharmacy	1846
Canteen	2098
Polytechnic	2603
Engineering A-wing	2635
Engineering B-wing	2603
Auditorium	966
Total	**17157**

5.2 Monthly Rainfall Date of Last 10 Years

The rainfall data is obtained from ‘Rainfall Recording and Analysis, Department of Agriculture Maharashtra State’. The monthly rainfall data of last 10 years is collected. The annual average rainfall in Asangaon is 2677.2 mm per year.

Table 4: Monthly Rainfall of Last 10 Years

Month	Monthly Rainfall										Average Monthly Rainfall in mm
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	
Jan	0	0	0	0	0	0	0.4	3.2	1.7	0	0.5
Feb	0	0	0	0	0	0	0.7	1.8	0.0	0	0.3
Mar	0	14.6	0	0	0	0	0	0.2	2.3	6.6	2.4
April	0	0	0	0	0	0	0.6	1.4	1.0	0	0.3
May	0	0	0	0	0.6	0	10.5	55.2	0	0.1	6.6
June	62.0	500.7	207.8	752.6	556.2	392.8	229.5	543.1	191.3	406.3	384.2
July	1240.8	802.2	1129.6	1233.0	1250.2	1586.8	416.4	890.1	1400.6	1247.0	1119.7
Aug	909.3	269.7	157.3	871.0	459.4	972.9	1148.0	301.6	565.6	336.4	599.1
Sept	438.1	290.0	393.5	346.6	101.4	623.6	301.0	806.6	678.0	541.2	452.0
Oct	36.0	111.2	46.8	172.9	18.2	102.5	95.0	108.2	132.4	12.9	83.6
Nov	0	43.1	0	0	0	40.1	0.9	87.3	0	36.4	20.8
Dec	0	0	0	11.3	0	0.9	2.3	62.0	0	0	7.7
Total	**2686.2**	**2031.5**	**1935.0**	**3387.4**	**2386.0**	**3719.6**	**2205.3**	**2860.7**	**2972.9**	**2586.9**	**2677.2**

5.3 Water Demand in Campus

The total water demand is 14052.5 cum per annum (14052500 liter), out of that 182.5 cum for gardening and 182.5 cum for cleaning, and 13687.5 cum for students and working staff in college campus.

Table 5: Water Demand in Campus

Block	Consumption	Water Demand Per Day (cum)	Total Water Demand Per Year (cum)
Students and Staff	2500 Students and Staff x 15 Liter	37.5	13687.5
Cleaning	500 Liter	0.5	182.5
Gardening	500 Liter	0.5	182.5
Total		**38.5**	**14052.5**

5.4 Annual Rainwater Harvesting Potential

The quantity of water that is received from rainfall over an area is called the rainwater potential of that area. And the quantity that can be effectively harvested is called the rain water harvesting potential. Rain water harvesting potential can be calculated using the following formula.

Rainwater Harvesting Potential (cum) = Area of Catchment (sqm) X Amount of rainfall (mm) X Runoff coefficient.

The rainwater harvesting potential is found to be 32152.304 cum per year (32152304 liter).

Table 6: RWH Potential Per Year

Building	Catchment Area (sqm)	Run-off Coefficient	Average Rainfall Per Year (mm)	RWH Potential Per Year (cum)
Law	1880	0.7	2677.15	3523.129
School	2526	0.7	2677.15	4733.737
Pharmacy	1846	0.7	2677.15	3459.413
Canteen	2098	0.7	2677.15	3931.662
Polytechnic	2603	0.7	2677.15	4878.035
Engineering A-wing	2635	0.7	2677.15	4938.003
Engineering B-wing	2603	0.7	2677.15	4878.035
Auditorium	966	0.7	2677.15	1810.289
Total	**17157**			**32152.304**

5.5 Rainwater Harvesting Potential Per Day (June – October)

Rainwater Harvesting potential(cum) = Area of Catchment (sqm) X Amount of rainfall (mm) X Runoff coefficient.

The daily rainwater harvesting potential in rainy season (June to October) is found to be 207.171 cum (207171 liter).

Table 7: RWH Potential Per Day (June to October)

Building	Catchment Area (sqm)	Run-off Coefficient	Average Rainfall Per Day (mm)	RWH Potential Per Day (cum)
Law	1880	0.7	17.25	22.701
School	2526	0.7	17.25	30.501
Pharmacy	1846	0.7	17.25	22.290
Canteen	2098	0.7	17.25	25.333
Polytechnic	2603	0.7	17.25	31.431
Engineering A-wing	2635	0.7	17.25	31.818
Engineering B-wing	2603	0.7	17.25	31.431
Auditorium	966	0.7	17.25	11.664
Total	**17157.000**			**207.171**

5.6 Design of Recharge Pits

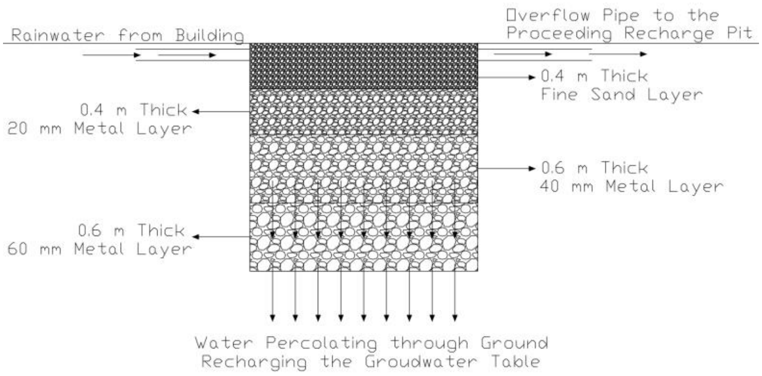

Figure 3: Schematic Representation of Recharge Pit

5.6.1 Size and Capacity of Recharge Pits

Volume recharge pit = Length X Width X Depth
The total volume of recharge pits calculated as is 101 cum.
Each recharge pit is to be filled with metals of 60mm, 40mm, 20mm and fine sand. Coarser material to be filled at the bottom and finest on the top.

Table 8: Size and Capacity of Recharge Pits

Building	RWH Potential Per Day (cum)	Size of Recharge Pit			Volume of Recharge Pit (cum)
		Length (m)	Width (m)	Depth (m)	
Law	12.920	2.50	2.00	2.00	10.00
School	30.501	4.00	2.50	2.00	20.00
Pharmacy	13.186	2.50	2.00	2.00	10.00
Canteen	16.356	3.00	2.00	2.00	12.00
Polytechnic	18.324	3.25	2.00	2.00	13.00
Engineering A-wing	18.170	3.25	2.00	2.00	13.00
Engineering B-wing	18.324	3.25	2.00	2.00	13.00
Auditorium	11.664	2.50	2.00	2.00	10.00
Total	**139.45**				**101.00**

5.6.2 Depth of Metals to be Filled in Recharge Pits

The recharge pit should be filled with the metal, to recharge silt free water. Hence the materials to be filled in the pit are 60 mm metal, 40 mm metal, 20 mm metal, fine sand. The material should be filled depth wise in the pit. The coarser material to be filled at the bottom and finest on the top. The uppermost fine sand layer can be separated from the 20 mm metal layer by using non corrosive wire mesh. It will help for the yearly maintenance.

Table 9: Depth of Materials to be Filled in Recharge Pits

Building	Depth of Recharge Pit (m)	Depth of 60mm Metal (m)	Depth of 40mm Metal (m)	Depth of 20mm Metal (m)	Depth of Fine Sand (m)
Law	2	0.6	0.6	0.4	0.4
School	2	0.6	0.6	0.4	0.4
Pharmacy	2	0.6	0.6	0.4	0.4
Canteen	2	0.6	0.6	0.4	0.4
Polytechnic	2	0.6	0.6	0.4	0.4
Engineering A-wing	2	0.6	0.6	0.4	0.4
Engineering B-wing	2	0.6	0.6	0.4	0.4
Auditorium	2	0.6	0.6	0.4	0.4

5.7 Schematic Representation of Rainwater Harvesting System

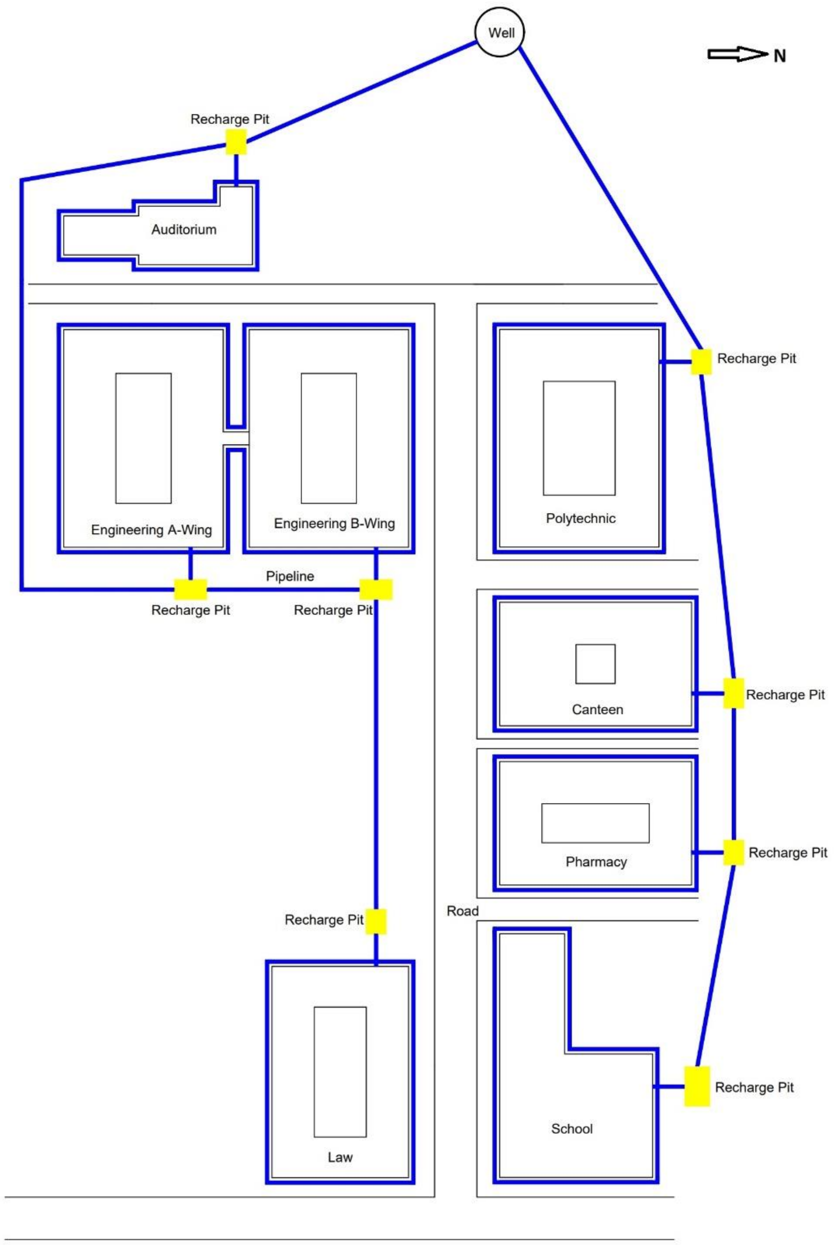

Figure 4. Schematic Representation of Rainwater Harvesting System

5.8 Length of Pipes

The discharge pipe was selected considering the catchment area. The diameter of pipes is selected as 110 mm. Total length of pipes required to convey water from building to the well is 2582.26 m. Out of that 1746 m length of pipe is required to convey water from building to the recharge pit and 254 m length of pipe from one recharge pit to another proceeding pit.

Table 10: Length of Pipe Through the Perimeter of Building

Location	Length of Pipe (m)	Diameter of Pipe (mm)
Law Building	219	110
School	249	110
Pharmacy	199	110
Canteen	199	110
Polytechnic	237	110
Engineering A-Wing	237	110
Engineering B-Wing	237	110
Auditorium	169	110
Total	**1746**	

Table 11: Length of Pipe from one Recharge Pit to another

Location	Length of Pipe (m)	Diameter of Pipe (mm)

Law to Engineering B-Wing	117	110
Engineering B-Wing to Engineering A-Wing	53.57	110
Engineering A-Wing to Auditorium	241.55	110
Auditorium to Well	85.95	110
School to Pharmacy	86.83	110
Pharmacy to Canteen	43.5	110
Canteen to Polytechnic	116.19	110
Polytechnic to Well	91.67	110
Total	**836.26**	

5.9 Working of Rainwater Harvesting System

1. The rainwater collected from the internal rainwater harvesting system will be directly conveyed to the well in the campus from the existing pipeline system.
2. The rainwater collected from external rainwater harvesting system will be conveyed to the recharge pits, for ground water recharge.
3. As soon as the recharge pits are full, the surplus water will be conveyed to the proceeding recharge pit, and further to the well.
4. The water stored in the well will be used for the usage in washrooms, gardening and cleaning purpose.

5.10 Estimation of Rainwater Harvesting System

Abstract sheet contains the quantities of all the items of work their rate and the total amount required to complete the project. The quantities of all items of work are taken from measurement sheet, The Unit rate of all the items of work are taken from PWD SSR 2022 -2023. The total estimated cost of construction of compost pit is Rs. 1,698,108.64

Table 9.2: Abstract Sheet of Rainwater Harvesting System

Sr. No	Item Description	Quantity	Unit	Rate	Amount
		Recharge Pits			
1	Excavation for Recharge Pits	101	cum	Rs. 258.00	Rs. 26,058.00
2	Supplying, filling, spreading & leveling coarse fine aggregate (crushed sand VSI grade finely washed etc.) of size range 1.5mm to 2mm in recharge pit	20.2	cum	Rs. 1,457.00	Rs. 29,431.40
3	Supplying, filling, spreading & leveling gravels of size range 5mm to 20mm, in the recharge pit	20.2	cum	Rs. 1,457.00	Rs. 29,431.40
4	Supplying, filling, spreading & leveling stone boulders of size range 5cm to 20cm in recharge pit	60.6	cum	Rs. 1,309.00	Rs. 79,325.40
				Total	**Rs. 164,246.20**
		Pipe System			
5	Providing, laying and fixing P.V.C. pipe of 110 mm. dia.	2582.26	RMT	Rs. 594.00	Rs. 1,533,862.44
				Total	**Rs. 1,533,862.44**
				Total Amount	**Rs. 1,698,108.64**

6. Results and Discussion

6.1 Size Compost Pit

- Internal Dimensions = 3m x 2m x 1m
- External Dimensions = 3.46m x 2.46m x 1m
- Capacity of Compost Pit
  V = 3 x 2 x 1 = 6 cum
- Thickness of Wall
  T = 230mm = 0.23m

6.2 Recharge Pit Potential

As per site assessment and calculations, the recharge pits have an average of 72.43% of recharge potential. This will help in potential ground water recharge in the campus region in addition to fulfilling the water scarcity condition.
Recharge Pit Potential = Daily water obstruction in recharge pits X Number of days in rainy season
Recharge Pit Potential = 101 cum X 153 Days = 15453 cum

6.3 Water Balance

It is observed that the total demand of water is estimated as 14052.5 cum per annum. To fulfil this water demand campus is totally dependent upon bore wells and Nagarpanchayat water supply. The total rainwater harvesting potential is calculated as 32152.304 cum.

Water Balance = Total rainwater harvesting potential – Recharge pit potential – Water demand

Water balance = 32152.304 cum – 15453 cum - 14052.5 cum = 2636.5 cum

After the ground water recharge and annual water consumption 2636.6 cum of water balance will be remained.

7. Conclusion

Composting is an alternative solid waste management system. It can be used for the recycling of organic material into manure. In addition, it can also be used to control the increase in waste. If the compost pit is implemented in the campus, it will help in reduction of waste in the campus. The environmental impact of solid waste can be reduced.

The obtained size of Compost Pit is 3m x 2m x 1m with a capacity of 6cum. Estimated cost of the Compost Pit is found to be Rs. 1,58,458.15

Rainwater harvesting is the practice of collecting and storing rain for reuse, rather than letting the water runoff and be absorbed into the ground or channeled into drains, streams, or rivers. The rainwater harvesting is one of the cost effective measures to overcome the problems faced due to water scarcity. In case of Rainwater Harvesting System is implemented in the campus, this will help in artificial recharge of groundwater in the campus region in addition to fulfilling the water scarcity condition. The water collected from rainwater harvesting system if stored can be utilized in the campus. The stored water can be used in the campus for gardening, cleaning and usage in washrooms.

The annual rainwater harvesting potential is 32152.5 cum. The designed recharge pits will help in ground water recharge in the campus region in addition to fulfilling the water scarcity condition. 15453 cum of the rainwater from the RWH system can be obstructed in the recharge pits. After the ground water recharge and annual water consumption 2636.6 cum of water balance will be remained. Estimated cost of Rainwater Harvesting System is found to be Rs. 1,698,108.64

8. Acknowledgment

We have taken efforts in these projects. However, it would not have been possible without the kind support & help of Principal of Shivajirao S. Jondhle College of Engineering & Technology Dr. (Mrs.) Geetha K Jayaraj and our Head of Department Dr. Y. S. Patil We would like to extend our sincere thanks to them. We are highly indebted to Prof. Milind Telavane and their guidance and constant supervision as well as for providing necessary information regarding the project and also for their support in completing the project.

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