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Implementation of Rainwater Harvesting (RWH) on a College Campus

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A B S T R A C T

Rainwater harvesting (RWH) presents a sustainable solution to address water scarcity, reduce dependence on external water sources, and promote environmental stewardship within college campuses. This study focuses on the implementation and benefits of RWH systems in educational institutions, specifically designed to collect, store, and utilize rainwater for non-potable purposes such as landscaping, toilet flushing, and cleaning. By utilizing vast rooftop areas and open spaces, college campuses are ideal locations for the deployment of RWH systems. The research examines the effectiveness of RWH systems in reducing water consumption, lowering water bills, and contributing to groundwater recharge, especially in regions facing erratic rainfall or water shortages. Additionally, the study highlights the educational potential of RWH systems, serving as a hands-on tool to raise awareness among students about water conservation and sustainable resource management. Though primarily designed for non-potable uses, the potential for upgrading RWH systems to produce potable water through advanced filtration and treatment processes is explored. Challenges such as initial costs, maintenance requirements, and system scalability are also discussed. The findings demonstrate that RWH systems, when effectively implemented, can significantly contribute to water sustainability efforts, while also providing educational benefits to students on college campuses.

Keywords: Rainwater harvesting (RWH), Educational institutions, College campuses, Water conservation, Advance filteration.

1. Introduction

1.1 General

Rainwater harvesting (RWH) is a sustainable water management practice that involves collecting and storing rainwater for future use. Implementing RWH on college campuses serves multiple purposes, such as conserving water, reducing reliance on external sources, replenishing groundwater, and minimizing waterlogging during heavy rains. This eco-friendly initiative also lowers water utility costs and promotes environmental awareness among students and staff. A typical RWH system includes a catchment area like rooftops or open spaces, a conveyance system of pipes and gutters, a filtration unit to remove contaminants, and storage or recharge structures to store or replenish groundwater. Harvested rainwater can be used for irrigation, toilet flushing, cleaning, laboratory needs, and emergency water supplies, significantly reducing water demand and associated costs.

Despite requiring an initial investment and consistent maintenance, the long-term benefits of RWH outweigh these challenges. Regular upkeep, such as cleaning catchment areas, inspecting filtration systems, and monitoring storage tanks, ensures the system's efficiency and durability. By adopting RWH, colleges can lead by example, demonstrating sustainable practices to their communities and inspiring others to follow suit. This initiative aligns with global sustainable development goals, addressing water scarcity, reducing environmental impact, and fostering a culture of conservation and responsibility among students and staff. Ultimately, RWH on campuses contributes to a more resource-efficient and environmentally conscious future while inspiring nearby communities to implement similar practices.

1.2 Objectives

- To collect and store rainwater for non-potable purposes such as landscaping, irrigation, and toilet flushing.
- To reduce the college's water bill by utilizing stored rainwater.
- To create awareness about water conservation among students and staff.
- To assess the campus's potential for rainwater harvesting and its impact on water management.
- To contribute to reducing the load on the local water supply and prevent soil erosion through controlled runoff.

1.3 Need of Project

The implementation of rainwater harvesting (RWH) on a college campus is a vital step toward addressing critical challenges related to water scarcity, environmental sustainability, and economic efficiency. By collecting and utilizing rainwater, campuses can significantly reduce their dependence on municipal or groundwater sources, conserving precious freshwater for future needs. Additionally, RWH facilitates groundwater recharge by directing excess rainwater into recharge pits or percolation systems, helping to replenish aquifers and counteract the effects of over-extraction. This initiative reflects the institution's commitment to environmental stewardship, aligning with broader goals of sustainability and minimizing ecological impact. Moreover, as educational institutions play a pivotal role in shaping community values, implementing RWH not only benefits the campus but also inspires surrounding communities to adopt similar practices, extending the impact beyond institutional boundaries.

Beyond its environmental benefits, RWH offers valuable educational, reputational, and financial advantages. The system can serve as a practical learning tool, providing students and faculty with opportunities to study sustainable water management, hydrology, and environmental engineering. It can also support research on water conservation and sustainability, enriching academic programs. By demonstrating leadership in sustainability, the campus enhances its reputation, attracting environmentally conscious students, and faculty, and partnerships with organizations dedicated to green initiatives. Over time, the financial savings from reduced water bills and low operational costs make RWH a cost-effective solution, ensuring long-term benefits for the institution. Through RWH, colleges can exemplify responsible water management, contributing to a more sustainable and resource-efficient future.

1.4 Scope of Project

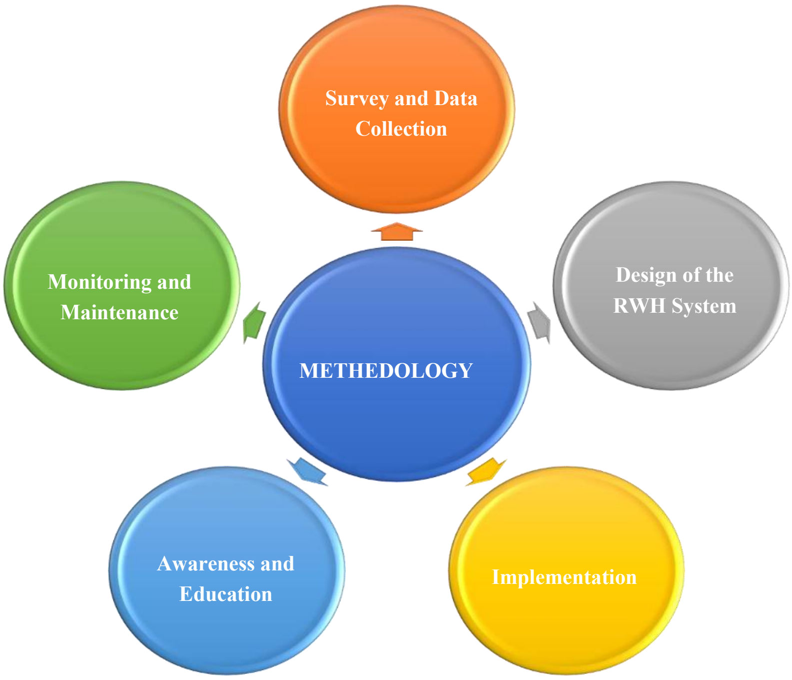
- Water Conservation
- Groundwater Recharge
- Cost Savings
- Long-term Investment

2. Literature Review

1. **Pawar C. B. et. Al. (2014):** The population in India is expected to stabilize at around 1640 million by the year 2050, as a result, gross per capita water availability will decline from 1820 m3/year in 2001 to as low as ~ 1140 m3/year in 2050. Thus, the growing concern about water scarcity challenges us to think of alternative solutions to avoid the current problem of water scarcity. The micro-watershed development, which ensures the availability of water for agriculture and domestic purposes, and the roof-top rainwater harvesting measures, which provide water for domestic consumption are often suggested as solutions for overcoming water shortage in drought-prone areas of India. This article presents the success story of the rooftop rainwater harvesting program in Renavi village in Sangli District of Maharashtra, India. The potential assessment of the village revealed that approximately 20 lakh liters of water collected from rooftops, will satisfy the demand of a population of 1300 for at least 78 days. This estimation is as per the United Nations standard, which prescribes the requirement of 20 liters of water (cooking and domestic uses) per person per day in India. Rainwater harvesting in Renavi demonstrates how community-driven initiatives can address water scarcity. By expanding the program to include additional houses, the village could achieve sustainable water security, benefiting all residents while conserving groundwater resources.
2. **Reddy Ranga Reddy (2019):** In recent years, India has experienced a significant decline in surface water availability, leading to increased reliance on groundwater through private tube wells. Climate change has exacerbated the situation, further depleting groundwater levels. Over-extraction in some regions has caused issues like saline water intrusion in coastal areas and land subsidence. Factors such as reduced rainfall and policies like free electricity for farmers have intensified groundwater usage, making it critical to adopt measures like rainwater harvesting (RWH) for artificial recharge. This study focuses on implementing RWH at CBIT campus to address water scarcity and replenish the aquifer. Covering an area of 50 acres, the campus could recharge approximately 191,525 liters of groundwater daily during the monsoon season, potentially raising the water table by 17 cm annually. This improvement not only helps balance the groundwater table but also reduces energy consumption for pumping, contributing to sustainable water management on campus.
3. **U. K. Banerjee et. Al. (2020):** India faces a severe water crisis due to uneven water distribution, frequent floods and droughts, population growth, and climate change. With only 4% of the world's freshwater resources but 18% of its population, the strain on water resources is immense. Over-reliance on groundwater, especially during the Green Revolution, has led to unsustainable extraction, resulting in falling water tables and increasing water-stressed regions. In Varanasi, including the Banaras Hindu University (BHU) campus, groundwater levels have been steadily declining, posing a significant threat to future water availability. Large institutions like BHU, Asia’s largest residential university, have a critical role in addressing water scarcity by adopting rainwater harvesting (RWH). The campus, with its extensive infrastructure, can efficiently collect and store clean rainwater for reuse and recharge groundwater resources. RWH systems, such as earthen tanks and recharge pits, can prevent rainwater from entering polluted municipal drains, reducing treatment costs and promoting sustainability. By implementing these measures, BHU can supplement its water supply, conserve resources, and set an example for sustainable water management.

4. **Mr. S.S. Shinde et. AL. (2020):** The paper discusses rainwater-harvesting implementation at an educational institute from rural part of Maharashtra. The authors have carried out the research work in the year 2018-19 & 2020. The selected institute belongs to an drought prone area hence it is considered to be useful research for the water conservation efforts taken by government and other private entities. Initially all relevant data has been collected through various verifiable sources and is used for optimization of rainwater harvesting task. The data collected was number of Students, no of bore well, roof area, average rainfall and coefficient of runoff. Then product of roof area, average rainfall and coefficient of runoff etc. The implementation part is helpful for minimizing the duplication of ground water table. The ultimate aim of the work is to reduce the dependency of occupants on other water resources. The rainwater harvesting of college campus carried out in this work shows that rainwater can be successfully utilized for it's uses in summer season. The project payback period is 2 years. This route project is feasible and commercially visible option for water conservation.

3. Methodology



4. Study of Components

Rainwater Harvesting (RWH) systems consist of various components that work together to efficiently collect, store, and use rainwater. Here is an overview of the key components used in an RWH system:

1. Catchment Area

- **Definition**: The surface from which rainwater is collected.
- **Examples**:
  - Roofs (the most common for urban RWH systems)
  - Pavement areas
  - Open grounds, parking lots
- **Key Considerations**:
  - Clean and impermeable surfaces are ideal.
  - Material should not cause contamination of water.

2. Conveyance System

- **Definition**: The system that transports water from the catchment area to the storage or treatment system.
- **Components**:
  - **Gutters**: Installed along the edges of the catchment area (usually the roof) to collect rainwater.

  - **Downspouts**: Vertical pipes connected to the gutters that direct water from the roof to the storage system.
  - **Drains and Channels**: Used in non-roof catchment systems (e.g., pavement, open fields).
- **Key Considerations**:
  - Proper alignment and size to handle the water flow.
  - Sufficient slope for gravity-driven water flow.

3. First Flush Diverter

- **Definition**: A device used to divert the first portion of rainwater, which may carry contaminants such as dust, bird droppings, and debris, away from the storage system.
- **Key Considerations**:
  - Ensures cleaner water enters the storage tanks.
  - Typically designed to divert the initial 5-10 minutes of rainwater.

4. Filtration System

- **Definition**: A system that filters out dirt, debris, and pollutants from the collected rainwater.
- **Types of Filters**:
  - **Mesh or Screen Filters**: Installed in the gutters or downspouts to trap large debris.
  - **Sand Filters**: Used to filter out finer particles.
  - **Carbon Filters**: Used to remove organic contaminants and improve water quality.
- **Key Considerations**:
  - Regular maintenance is needed to avoid clogging.
  - The type of filtration depends on the intended use of the water.

5. Storage Tanks

- **Definition**: Containers used to store collected rainwater for future use.
- **Types**:
  - **Overhead Tanks**: Positioned on rooftops or higher platforms for gravity-fed systems.
  - **Underground Tanks**: Built below ground to save space and maintain temperature.
  - **Cisterns**: Large, often underground, tanks for large-scale storage.
- **Key Considerations**:
  - Size of the tank is determined based on the catchment area and water usage.
  - Materials can include plastic, concrete, or steel.
  - The tank should be covered to prevent contamination.

6. Pump (Optional)

- **Definition**: A device used to pump water from storage tanks to where it is needed.
- **Types**:
  - **Manual Pumps**: For small-scale systems.
  - **Electric Pumps**: Used for larger systems or when water needs to be pumped over long distances or heights.
- **Key Considerations**:
  - Efficiency and power consumption.
  - Water pressure requirements for distribution.

7. Overflow Mechanism

- **Definition**: A system that directs excess rainwater away from the storage tank when it reaches full capacity.
- **Components**:
  - Overflow pipes or drains.
- **Key Considerations**:
  - Proper sizing to handle the overflow during heavy rainfall.
  - Prevents flooding and damage to the tank.

8. Recharge Wells or Trenches (Optional)

- **Definition**: Structures used to allow rainwater to seep into the ground and recharge the groundwater table.
- **Types**:
  - **Recharge Pits**: A hole or trench filled with gravel to allow water infiltration.
  - **Recharge Trenches**: Long, narrow pits that direct rainwater into the ground.
- **Key Considerations**:
  - Suitable for areas with permeable soil.
  - Helps in maintaining the water table and preventing groundwater depletion.

9. Distribution System

- **Definition**: The network of pipes or channels used to deliver harvested rainwater to different parts of the campus (e.g., gardens, toilets, etc.).
- **Components**:
  - **Pipes and Valves**: For directing water to the required locations.
  - **Taps and Outlets**: For controlling the flow of water to specific areas.
- **Key Considerations**:
  - Ensure the system is designed to minimize water wastage.
  - Easy maintenance access.

10. Monitoring and Control Systems (Optional)

- **Definition**: Tools and devices used to monitor the performance of the RWH system.
- **Components**:
  - **Water Level Indicators**: To measure the amount of water stored in the tank.
  - **Flow Meters**: To monitor the amount of water being collected and used.
  - **Automated Control Systems**: For switching between different water sources (e.g., municipal supply, RWH).
- **Key Considerations**:
  - Ensures efficient operation and water conservation.

5. Details of Model

Natural filtration units refer to systems that use natural processes to filter and purify water, air, or other materials. These systems rely on biological, chemical, and physical processes to remove contaminants without the need for chemicals or artificial methods. Below are some examples:

1. Constructed Wetlands:

- Constructed wetlands mimic natural wetlands, using plants, microorganisms, and soil to filter water. The plants absorb excess nutrients, while microorganisms break down organic contaminants.
- Often used in wastewater treatment.

2. Sand Filters:

- Sand filtration is a natural method where water passes through a bed of sand. The sand particles trap debris, bacteria, and other contaminants.

- This method is commonly used in water treatment plants, aquariums, and aquaculture.

3. Vegetated Buffer Zones:

- These are areas of natural vegetation planted around water bodies. They filter runoff by absorbing nutrients, sediment, and contaminants before they reach the water.
- Often used to protect rivers, lakes, and coastal areas from agricultural runoff.

4. Biofilters:

- Biofilters utilize a layer of biological material (often a combination of soil, gravel, and plants) to filter out pollutants. These are commonly used in air filtration systems, where microorganisms degrade harmful pollutants.
- Used in green roofs, storm water management, and air purifiers.

5. Aquatic Plants and Algae:

- Certain aquatic plants, like water hyacinth, can naturally filter water by absorbing toxins, heavy metals, and excess nutrients.
- Algae can also be used for bioremediation of polluted water bodies.

5.1 WATER FILTER USING CHARCOAL, SAND & AGGREGATE

A natural water filter using charcoal, sand, and aggregates (such as gravel or pebbles) is a simple and effective filtration system that relies on the physical and chemical properties of these materials to remove impurities from water. This type of filtration system is commonly used in both emergency and sustainable water purification applications, such as in household filters or small-scale water treatment systems. Below is a detailed overview of how such a filtration system works and the components involved:

Components of a Natural Water Filter using Charcoal, Sand, and Aggregates

1. **Charcoal (Activated Carbon)**
    - Purpose: Charcoal, especially activated carbon, is used to remove organic compounds, chemicals, chlorine, odours, and some heavy metals from water.
    - Mechanism: Activated carbon has a high surface area, which allows it to adsorb (attract and hold) contaminants like chlorine, pesticides, herbicides, and other volatile organic compounds (VOCs). It is effective in improving water taste and odour.
    - Use in the Filter: Charcoal is typically placed in the middle layer of the filter. As water passes through, the contaminants adhere to the surface of the charcoal.
2. **Sand**
    - Purpose: Sand helps remove larger particulate matter such as dirt, sediment, and debris from the water.
    - Mechanism: Sand acts as a physical filter, trapping larger particles as water flows through it. The smaller the sand particles, the finer the filtration, which can improve the clarity of the water.
    - Use in the Filter: Sand is typically used in the top or bottom layers of the filter, where it captures suspended solids and debris.
3. **Aggregates (Gravel or Pebbles)**
    - Purpose: Aggregates, such as gravel or pebbles, are used to support the other layers, promote even water flow, and prevent clogging of the filter.
    - Mechanism: Aggregates allow water to pass freely through the system and help keep the other filtration layers from compacting. They also serve as a base for the sand and charcoal layers, ensuring proper filtration and flow.
    - Use in the Filter: Aggregates are typically placed at the bottom of the filter, although small gravel layers may be placed above the sand layer to prevent sand from escaping and to support the layers above.

5.2 How a Charcoal, Sand, and Aggregate Filter Works

This type of filter generally follows a multi-layer filtration process, where each layer is designed to remove specific types of contaminants from the water:

1. Water enters the filter from the top, usually through an inlet or funnel.

2. Coarse aggregates (gravel or pebbles) are the first layer the water passes through. These larger materials help remove large debris, stones, or large organic matter, and provide structure to the filter.
3. Fine sand is the next layer. It helps trap smaller particles, including dirt, silt, and other suspended solids. The sand helps clear up the water, improving its clarity.
4. Activated charcoal is the next layer, where chemical contaminants like chlorine, pesticides, and volatile organic compounds are adsorbed by the carbon. Charcoal can also remove certain heavy metals, like lead or mercury, although its effectiveness for heavy metal removal depends on the specific type of charcoal used.
5. Filtered water exits the filter from the bottom, where it is collected as clean water ready for use.

5.3 Building a Natural Water Filter with Charcoal, Sand, and Aggregates

Here's a step-by-step guide for creating a simple natural water filter using charcoal, sand, and aggregates:

Materials Needed:

- A container or a vertical column (like a plastic bottle or PVC pipe) to hold the filtration layers.
- Activated charcoal (charcoal that has been treated to have a large surface area, available in most home or garden stores).
- Fine sand (clean, untreated sand).
- Coarse aggregates (gravel, pebbles, or small stones).
- A clean cloth or mesh to prevent the filter materials from escaping.
- A funnel (if necessary) for easier water entry.

Instructions:

1. **Prepare the Container:**
    - Use a plastic bottle (with the bottom cut off) or a vertical column as the container for the filter.
    - Place a clean cloth or mesh at the bottom to prevent the filter materials from falling out when water is poured in.
2. **Add the Coarse Aggregates (Gravel):**
    - Add a layer of coarse gravel (about 2-3 inches or 5-8 cm) at the bottom of the container.
    - The gravel layer supports the filter, allows water to flow evenly, and helps trap large debris.
3. **Add the Sand Layer:**
    - On top of the gravel, add a layer of fine sand (about 3-4 inches or 8-10 cm).
    - The sand will remove finer particles like silt and dirt. The more evenly you spread it, the more effectively it will filter.
4. **Add the Charcoal Layer:**
    - Above the sand, add a layer of activated charcoal (around 3 inches or 8 cm).
    - The charcoal will adsorb chemical impurities, chlorine, and odours. Make sure the charcoal is evenly distributed and not packed too tightly to allow proper water flow.
5. **Add More Sand or Gravel (Optional):**
    - You can optionally add a final layer of sand or gravel on top of the charcoal to help prevent clogging and to further filter out particles.
6. **Install the Filter:**
    - Ensure that the filter is placed vertically, allowing gravity to pull the water through each layer.
    - The clean, filtered water will exit from the bottom of the container.
7. **Test the Filter:**
    - Pour water through the filter and check the water quality. The water should be clearer, and any noticeable odours or tastes should be reduced.

Fig. No. 1 shows the Model of the Rainwater Harvesting Filter

5.4 Advantages of Charcoal, Sand, and Aggregate Filters

1. Simple and Inexpensive: This type of filtration system is easy to build and uses inexpensive, natural materials.
2. Effective for Particulate Matter: The sand and aggregates are good at filtering out dirt, silt, and larger contaminants.
3. Chemical Contaminant Removal: Activated charcoal adsorbs many types of organic compounds, chemicals, and odors.
4. Sustainable: This filter is a sustainable solution for basic water purification, using natural, non-toxic materials.
5. Low Maintenance: The filter materials require minimal maintenance. Charcoal may need to be replaced periodically, but the sand and gravel generally do not need replacement unless they become compacted or clogged.

5.5 Limitations and Considerations

1. Not Effective for All Contaminants: While this system is good for removing larger particles, chlorine, and some chemicals, it is not effective at removing all types of contaminants, especially dissolved solids like salts or heavy metals.
2. Flow Rate: Water flow through the filter may be slow depending on the size of the filter and the materials used.
3. Periodic Maintenance: The charcoal layer will become saturated and may need to be replaced periodically, depending on the quality of the water being filtered.
4. Not a Sterilizing Filter: While it can remove many types of impurities, it doesn't necessarily kill pathogens like bacteria or viruses. For microbial contaminants, additional treatment like boiling or UV sterilization may be required.

6. Future Scope

The future scope for rainwater harvesting (RWH) systems in a college campus presents significant opportunities for environmental conservation, education, and cost efficiency. By implementing these systems, institutions can drastically reduce reliance on external water sources, addressing issues of water scarcity and enhancing groundwater recharge. As water scarcity becomes a pressing global concern, expanding the adoption of RWH systems in educational institutions not only mitigates local water stress but also contributes to broader sustainable development goals. Additionally, RWH initiatives can evolve into educational and research hubs. Campuses can serve as live laboratories for students, fostering awareness and innovation in sustainable practices. Research into optimizing RWH design, enhancing filtration methods, or integrating advanced monitoring technologies could amplify their impact. Beyond the campus, successful models of RWH can inspire neighboring communities to adopt similar water conservation techniques, creating a ripple effect of sustainability practices and long-term environmental benefits.

7. Result

The project focuses on implementing a rainwater harvesting (RWH) system within a college campus to address water conservation, environmental sustainability, and educational enrichment. The system involves collecting rainwater from rooftops and open spaces, filtering it for quality assurance, and storing or redirecting it to recharge groundwater. This initiative supports non-potable water uses like irrigation, sanitation, and cleaning, effectively reducing the campus's dependency on external water supplies, cutting costs, and addressing water scarcity challenges. Through practical implementation, the project not only demonstrates environmental responsibility but also fosters educational opportunities for students and staff by serving as a live model of sustainable water management. It aligns with sustainable development goals, promotes awareness of water conservation, and showcases how campuses can lead by example, inspiring broader community adoption. Despite challenges like initial costs and maintenance, the long-term environmental and financial benefits affirm its feasibility and impact.

8. Conclusion

In conclusion, implementing a rainwater harvesting (RWH) system on a college campus aligns perfectly with the project's scope, addressing critical challenges related to water conservation, groundwater recharge, and sustainable resource management. By capturing and utilizing rainwater, the campus can significantly reduce its reliance on external water sources, mitigate the effects of water scarcity, and contribute to the replenishment of local aquifers. This initiative not only promotes environmental sustainability but also offers financial benefits by lowering water utility expenses and reducing runoff-related soil erosion. Beyond its practical benefits, the RWH system serves as an educational tool, fostering awareness and active participation among students and staff in sustainable practices. It transforms the campus into a model of environmental responsibility, demonstrating the feasibility and impact of such initiatives to the broader community. By addressing environmental, economic, and social goals, the project underscores the vital role of educational institutions in leading efforts toward a sustainable and resource-efficient future.

References

Pawar, C. B. et. Al. (2014). A case study of rooftop rainwater harvesting of Renavi village in Sangli District of Western Maharashtra: New approach of watershed development in India. African Journal of Agricultural Research, 9(25), 1941–1947. https://doi.org/10.5897/AJAR11.121

Reddy, R. R. (2019). Rooftop rainwater harvesting – A case study. Pramana Research Journal, 9(2), 452–460. ISSN 2249-2976.

Banerjee, U. K. et. Al. (2020). Environmental impacts of rainwater harvesting: A case study of Varanasi. Journal of Scientific Research, 64(2), 50–57. https://doi.org/10.37398/JSR.2020.640206

Shinde, S. S. et. Al. (2020). Water conservation: Rainwater harvesting project for college campus. International Research Journal of Engineering and Technology (IRJET), 7(3), 1701-1703.

Chalkhure, A. N., Marve, S. R., Wankar, M. S., Bhendale, A. N., Daulatkar, D. P., & Chopade, P. S. (2020). Design of Harvestine filter unit. International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), 9(4), 2227–2235. https://doi.org/10.342802375

Shende, S. R., Pathan, S. F., Jumnake, A. G., Bhashakhetre, C. S., & Marve, S. R. (2018). A Review on Design of Public Transportation System in Chandrapur City. Journal for Research, 4(1), 41-47.

Marve, S. R., Shende, S. R., & Chalkhure, A. N. (2018). Public Transportation System in Chandrapur City. International Journal of Scientific Research in Science, Engineering and Technology, 4(10), 306-312.

Tajne, G. B., Shende, S. R., & Marve, S. R. (2022). A review on manufacturing process and techniques of Hume concrete. International Journal of Research Publication and Reviews, 3(11), 3285-3287. https://doi.org/10.55248/gengpi.2022.3.11.51

Giri, R. A., Khan, A., Shende, S. R., Khanke, S. A., Marve, S. R., Kaurase, A., & Dethe, N. (2023). A review on analysis and design of multistorey hospital building (G+4). International Journal of Research Publication and Reviews, 4(3), 4700-4705.

Shende, S. R., Sawai, G., & Bodane, M. (2024). Comparative assessment of different types of slabs by using software. International Journal of Research Publication and Reviews, 5(5), 12805–12811. https://doi.org/10.55248/gengpi.5.0524.1450