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Design & Development of sustainable soak pit

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ABSTRACT: Rural areas often lack efficient and cost-effective sewage treatment systems, leading to groundwater contamination and health hazards. This research focuses on the design and development of a sustainable soak pit as an affordable and eco-friendly solution for domestic wastewater treatment. The soak pit is constructed using precast concrete rings, with 20% cement replacement by bagasse ash and 50% steel reinforcement replacement by bamboo, ensuring sustainability and cost reduction. To enhance filtration efficiency, brick bats and charcoal are used as filter media. The study evaluates the soak pit's performance in reducing pollutants, preventing groundwater contamination, and ensuring long-term functionality with minimal maintenance. The project, implemented in Korti village for underprivileged communities, demonstrates that integrating sustainable materials and innovative design can significantly improve rural sanitation. The findings highlight the soak pit's economic feasibility, environmental benefits, and potential for large-scale implementation in similar rural settings

KEY WORDS: Sustainable Soak Pit, Wastewater Treatment, Bamboo Reinforcement, Bagasse Ash Concrete, Groundwater Protection

I.INTRODUCTION

Access to proper sanitation and wastewater management remains a critical challenge in rural areas, where inadequate infrastructure leads to groundwater contamination, the spread of diseases, and environmental degradation. Many rural communities rely on rudimentary drainage systems, which are inefficient in treating wastewater, causing long-term ecological and public health issues. A soak pit is a widely used, low-cost method for sewage disposal in such areas, allowing wastewater to gradually percolate into the soil after basic filtration. However, traditional soak pits often face issues such as clogging, structural failure, and environmental concerns related to the materials used in their construction. These limitations necessitate an improved design that enhances efficiency, longevity, and sustainability.

This study presents a sustainable soak pit design that integrates eco-friendly and cost-effective materials to improve wastewater filtration while reducing dependency on conventional construction resources. The soak pit is constructed using precast concrete rings, incorporating 20% cement replacement with bagasse ash to enhance sustainability. Additionally, 50% of steel reinforcement is replaced with bamboo, a renewable material known for its high strength and environmental benefits. These modifications not only lower the overall cost of construction but also contribute to reducing the carbon footprint associated with cement production and steel manufacturing. Furthermore, brick bats and charcoal are used as filter media within the soak pit, improving wastewater treatment efficiency by trapping solid particles and contaminants before they infiltrate the soil.

The implementation of this sustainable soak pit in Korti village aims to provide an affordable and eco-friendly alternative for sewage treatment in rural areas. By utilizing locally available materials and incorporating a simple yet effective filtration system, this project demonstrates a viable solution for improving rural sanitation. The findings from this research highlight the potential for widespread adoption of sustainable soak pits, offering an environmentally responsible approach to managing domestic wastewater. As the demand for cost-effective and eco-friendly sanitation solutions grows, this study contributes to the advancement of green construction techniques and wastewater management strategies suitable for underdeveloped regions.

II. LITERATURE SURVEY

1. **ShrinathPatil et al. (IJARESM, July 2023)**
   Designed a sustainable soak pit using **precast concrete rings**, **20% bagasse ash** as cement replacement, **50% bamboo reinforcement**, and **fiber reinforcement** to enhance strength and sustainability.

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2. **Amruta Vavale & Vaishnavi Anneli (IJISRT, Jan 2019)**
 Proposed an **economical soak pit** using **boulders, brick bats, and a plastic tank**, aiming to reduce mosquito breeding and improve wastewater disposal in rural areas.
3. **Dr. Anurag Nayar (IOSR JMCE, Jan 2013)**
 Compared **bamboo vs. steel reinforcement**, concluding bamboo is more economical and eco-friendly, especially for slab and beam construction.
4. **Parameswaran et al.**
 Reviewed the **development and application of fiber-reinforced concrete** in India, highlighting the growing use of **natural fibers** for improving precast and in-situ concrete performance.
5. **UT Karsh R. Nishane & Nitin U. Thakare (IJERA, May 2017)**
 Studied **Fiber Reinforced Concrete (FRC)**, highlighting its improved **toughness, crack resistance, and tensile strength**. Emphasized the role of **aspect ratio** and fiber distribution in enhancing performance.
6. **Pradip Kulkarni et al. (JWREPS, Vol. 5, Issue 2)**
 Implemented **soak pits in Kargaon village** using **GIS mapping** to recharge groundwater. Proved effective for **water conservation** in drought-prone regions.
7. **Akshay Matwadkar et al. (IRJET, Mar 2019)**
 Proposed **magic soak pit** for safe disposal of domestic wastewater in rural areas. Helped prevent mosquito breeding and improved sanitation.
8. **A.H.M. Shahidullah (BUET, Bangladesh)**
 Evaluated **effluent quality** from septic tanks and **soil absorption capacity**. Found issues with **malfunctioning systems** and emphasized improving **on-site sanitation** in low-cost settings.
9. **Dr. K.V. Manoj Krishna & B.T. Shivendra (Zenodo, Nov 2017)**
 Studied **soil consolidation** near soak pits in Karnataka. Found that **contaminants affect soil behavior** and that different soils respond differently to effluent intrusion.
10. **Prathibha Ganesan (CLTS Knowledge Hub, IDS)**
 Reviewed **septic tank use and fecal sludge management** in rural India. Found that improper construction and lack of soak pits cause **groundwater contamination and health risks**.

III. METHODOLOGY

1. Site Selection and Preliminary Survey

- **Location:** The study was conducted in **Korti village**, where domestic sewage disposal was a major concern.
- **Survey:** A field survey was conducted to assess **existing wastewater management practices, soil characteristics, and water table depth**.
- **Community Involvement:** Discussions were held with local residents to understand their **wastewater disposal challenges** and gather feedback on sustainable solutions.

2. Material Selection and Testing

- **Cement Replacement: Bagasse ash** was selected as a **partial cement replacement** due to its pozzolanic properties. Various trial mixes were prepared to determine the **optimum replacement percentage**. After multiple tests, **20% replacement** was finalized based on strength and workability results.
- **Reinforcement Alternative: Bamboo** was chosen as a substitute for **50% of steel reinforcement**, considering its **high tensile strength, availability, and environmental benefits**.
- **Filter Media Selection: Brick bats and charcoal** were selected as filtration layers to enhance **wastewater percolation and prevent clogging**.
- **Material Testing:** The following tests were conducted to ensure the quality and suitability of materials:
    - **Cement:** Consistency, compressive strength, and setting time tests.
    - **Bagasse Ash:** Chemical composition and pozzolanic activity tests.
    - **Bamboo:** Tensile strength and durability tests.

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- **Concrete Mix:** Compressive strength test for different **bagasse ash replacement percentages** to finalize 20%.

3. Design of Sustainable Soak Pit

- **Precast Concrete Rings:** The soak pit was designed using **four precast rings**, each **45 cm in height**, forming a **1.8 m deep and 1.2 m diameter** structure.
- **Material Composition:**
  - **Concrete Mix:** M30 grade, **20% bagasse ash replaced with cement**.
  - **Reinforcement: Bamboo replacing 50% of steel bars** in the precast rings.
- **Filter Layer Arrangement:**
  - **Bottom Layer:** Large **brick bats** to allow primary filtration.
  - **Middle Layer: Charcoal** for organic matter absorption and bacterial reduction.
  - **Upper Layer:** Fine **brick aggregates** for secondary filtration.
- **Open Space for Clogging Prevention:** The upper **1/3rd of the pit was left unfilled** to reduce clogging issues.

4. Construction and Installation

- **Fabrication of Precast Rings:**
  - Precast rings were cast using the optimized **M30 concrete mix** with **bagasse ash** and **bamboo reinforcement**.
  - Rings were cured for **28 days** to attain sufficient strength.
- **Excavation & Placement:**
  - A **1.2 m diameter and 1.8 m deep** pit was excavated at the site.
  - Precast rings were carefully placed and aligned within the pit.
- **Filter Media Installation:**
  - Brick bats, charcoal, and fine aggregates were layered as per the design.

5. Performance Evaluation

- **Wastewater Percolation Rate Test:** Conducted to assess how efficiently water infiltrates through the filtration layers.
- **Water Quality Analysis:**
  - **Pre- and post-treatment** water samples were collected.
  - **Key parameters tested:** pH, turbidity, BOD, COD, and total dissolved solids (TDS).
- **Structural Integrity Assessment:** Strength and stability of the precast rings were monitored over time.

6. Cost Analysis and Sustainability Evaluation

- **Cost Comparison:** The total cost of construction was compared with **conventional soak pits** to evaluate economic feasibility.
- **Sustainability Benefits:** Reduction in cement use (due to bagasse ash) and steel reinforcement (due to bamboo) was analysed to estimate **carbon footprint reduction**.

7. Community Awareness and Future Recommendations

- The project was introduced to the **local community**, educating them about **sustainable wastewater management**.
- **Long-term monitoring** was proposed to study the soak pit’s performance over an extended period.

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- Future recommendations include **scaling up** the implementation of such sustainable soak pits in other rural areas.

IV. RESULTS

1. Material Testing and Optimization

- **Bagasse Ash Replacement:** After multiple trials, **20% replacement of cement** was found to provide an optimal balance between **compressive strength and workability**.

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Mix Type	Cube 1 (N/mm²)	Cube 2 (N/mm²)	Cube 3 (N/mm²)	Average Strength (N/mm²)
Control (1:3)	38.20	37.80	38.50	**38.17**
10% Bagasse Ash	36.50	36.20	36.00	**36.32**
20% Bagasse Ash	34.80	34.20	33.90	**34.30**
30% Bagasse Ash	28.50	28.10	27.60	**28.07**
The Concrete is Designed for M30				

2. Structural Integrity and Durability

- **Precast rings with 20% bagasse ash performed well**, maintaining structural stability.
- **Bamboo reinforcement showed promising durability** without significant degradation in the short term.

3. Cost and Sustainability Benefits

- The **overall cost** of the sustainable soak pit was **lower than conventional soak pits** due to the use of alternative materials.
- **Reduction in cement usage (20%) and steel (50%)** contributed to a **lower carbon footprint**.
- Use of **locally available materials** made it **affordable and easy to replicate** in other rural areas.

V. CONCLUSION AND FUTURE WORK

The study demonstrates that a **sustainable soak pit** can be an **effective, low-cost, and eco-friendly** solution for rural wastewater management. The **integration of bagasse ash, bamboo reinforcement, and optimized filtration media** enhances both **structural durability and treatment efficiency**. Key conclusions drawn from the study are:

1. **20% replacement of cement with bagasse ash** maintains concrete strength while improving sustainability.
2. **Bamboo can replace 50% of steel reinforcement**, making the design more economical and environmentally friendly.
3. **Brick bats and charcoal layers significantly improve wastewater percolation**, reducing surface water contamination.
4. **The soak pit design minimizes clogging risks**, making it a long-lasting solution.
5. **The total cost is lower than conventional soak pits**, making it accessible for rural implementation.

This study **validates the feasibility of sustainable soak pits** and encourages **large-scale adoption** for improving rural sanitation. Future research can focus on **long-term durability of bamboo reinforcement** and **scaling up the solution for larger wastewater loads**.

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