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DESIGN AND FABRICATION OF MANHOLE CLOG REMOVAL MACHINE

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Abstract
Manual scavenging, the practice of manually removing human waste from sewers and open drains, remains a severe social and health issue despite being officially banned in many countries, including India. This practice exposes workers, often from marginalized communities, to hazardous conditions, including direct contact with toxic waste and harmful pathogens. Manual scavenging, especially the removal of clogs from manholes, is a dangerous and inhumane practice. The current method, which involves human intervention without safety equipment, poses severe health hazards to workers. This practice endangers workers' health due to unsanitary working conditions and the lack of safety equipment. Despite legal prohibitions, this practice continues due to the lack of effective technological alternatives. This paper proposes the design and fabrication of a **Manhole Clog Removal Machine** to address these issues. The machine is equipped with a tilting bucket, telescopic guide, and rotational mechanism for efficient clog removal. Through this mechanized solution, human intervention in hazardous environments is minimized, thus reducing health risks and fatalities. Testing shows that the machine performs efficiently under real-world conditions, providing a viable and cost-effective alternative to manual scavenging.

Keywords:
Manhole clog removal, mechanized scavenging, sanitation, sewage cleaning, tilting bucket, sewage management.

1. Introduction

1.1 Manual Scavenging and Its Hazards

Despite legal bans, manual scavenging remains prevalent in many regions, exposing workers to hazardous and unsanitary conditions. The manual removal of waste from manholes can lead to severe health risks, including respiratory diseases, infections, and long-term disabilities. Legal frameworks such as the **Prohibition of Employment as Manual Scavengers and Their Rehabilitation Act (2013)** aim to eliminate this practice, but lack of viable mechanical alternatives has hindered progress. Marginalized communities remain disproportionately affected by this issue due to socio-economic factors. This paper proposes a mechanized solution for manhole clog removal, thus minimizing human intervention and improving worker safety.

Figure 1: Current Manual Scavenging Practices in India

Figure 2: Sewage Overflow Issues Due to Blocked Drains

1.2 Urbanization and Sewage Management Challenges

India's rapid urbanization has overwhelmed existing sewage infrastructure. The 2011 Census indicates that the urban population rose from 27.8% in 2001 to 31.8% in 2011. However, inadequate planning has left many cities grappling with ineffective sewage management systems, leading to blockages, sewage overflows, and waterborne diseases, particularly in densely populated areas. Many urban local bodies (ULBs) lack both the infrastructure and resources to tackle these challenges efficiently.

In this context, mechanization can address these growing issues by providing scalable, cost-effective solutions. This paper presents the design and testing of a Manhole Clog Removal Machine to mitigate these challenges.

2. Literature Review

The literature reviewed explores various advancements in the mechanization and automation of sewage and drainage cleaning systems to reduce hazardous manual labour and improve efficiency: **Prabhushankar N et al.** focused on the use of reciprocating pumps instead of centrifugal pumps for dewatering drainage systems, emphasizing the cost-effectiveness and ability to handle suspended solids. However, the pneumatic and spring system used led to some inefficiency due to force loss during operation. **T. Duricic et al.** investigated the electrocoagulation process for phosphate removal from wastewater. Their findings demonstrated that aluminum electrodes were more effective than iron electrodes in achieving higher phosphate removal, providing insights into wastewater treatment optimization. **Nithyavathy N et al.** developed a remote-controlled sewage cleaning machine, enhancing safety by allowing operators to control the machine from a distance. This approach reduced direct human involvement in hazardous environments and made the system accessible to less skilled workers. **Ndubuisi C. Daniels** designed an automatic drainage cleaner with three main components (propeller, cleaner, and pan) that autonomously removed waste and sewage, reducing the need for manual labour and protecting the environment from hazards. **Ganesh U L** designed a semi-automated drainage cleaner to prevent health risks by regularly filtering waste in drain pipes. His system reduced the need for workers to interact with contaminated waste, enhancing safety and operational efficiency. **S D Rahul Bharadwaj** emphasized the environmental benefits of wastewater treatment, especially in mitigating global warming. His research promoted the use of renewable energy to power wastewater treatment processes. **Dr. K. Kumaresan** proposed an automated sewage cleaning system designed to clear blockages in drainage pipes while separating gaseous substances, making the system cost-effective and reducing the need for manual labour. **Nitin Sall** highlighted the significant amount of wastewater generated daily and stressed the importance of removing pollutants through effective wastewater treatment technology, essential for environmental protection. Collectively, these studies emphasize the need for mechanized and automated systems to reduce human interaction with hazardous waste, improve operational safety, and contribute to environmental sustainability in sewage and drainage management.

3. Methodology

3.1 Design Principles

The design of the Manhole Clog Removal Machine focuses on safety, ease of operation, and efficiency. Its core components include:

- **Tilting Bucket:** A bucket designed to reach into manholes, collect waste, and tilt for easy disposal.
- **Guided Telescopic Mechanism:** Facilitates the vertical movement of the bucket into and out of manholes.
- **Rotational Mechanism:** Allows the bucket to rotate inside the manhole, ensuring that clogs are effectively removed from all areas.

After evaluating several mechanisms such as the chain drive and screw conveyor, the **lead screw mechanism** was selected due to its simplicity in translating rotary motion into vertical movement.

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3.2 CAD Modeling and Design Process

The machine was modeled using **AutoCAD**, ensuring detailed planning for every component. The lead screw mechanism was integrated to achieve efficient vertical movement. Special attention was paid to minimizing the machine's footprint while ensuring it could handle varying waste types. The **AutoCAD design** is shown below in Figure 3.

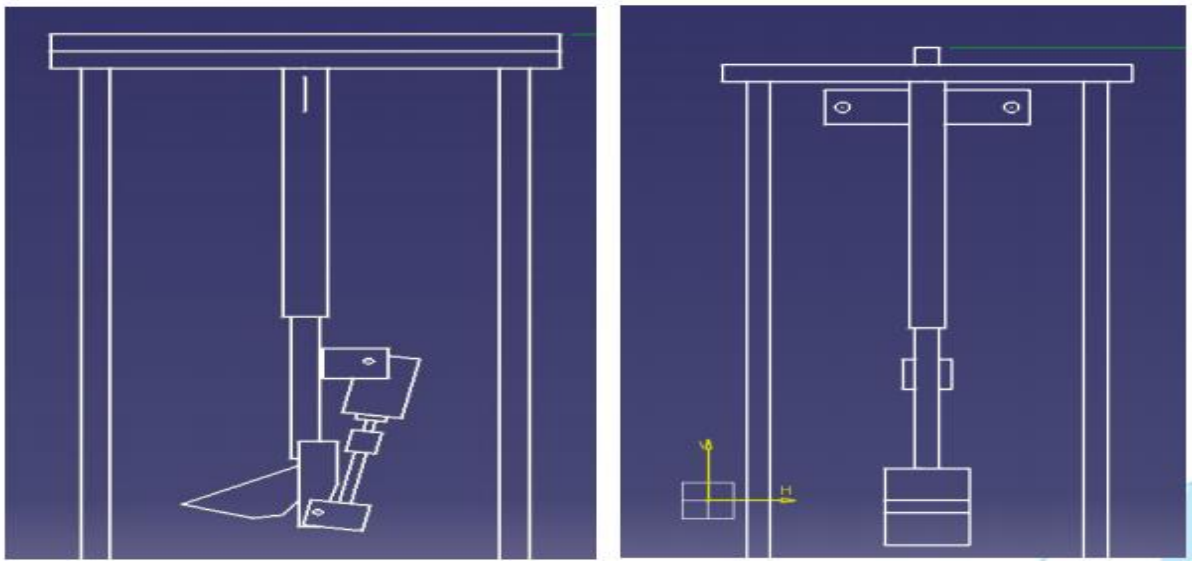

Figure 4: AutoCAD Design of the Manhole Clog Removal Machine

3.3 Material Selection and Fabrication

The materials selected for this machine prioritized durability and cost-effectiveness. **Mild steel** was used for its structural frame and bucket due to its high strength-to-weight ratio and affordability. The bucket, with dimensions of 70mm width and 2mm thickness, was designed to accommodate different types of solid waste. The lead screw mechanism was used from which provides a smooth vertical movement.

The machine's components were fabricated using standard manufacturing processes, such as cutting, machining, and welding, ensuring robust construction. Corrosion-resistant paint was applied to extend the machine's lifespan in harsh environmental conditions.

3.4 Testing and Evaluation

After assembly, the machine underwent several tests to assess its performance under real-world conditions:

- **Weight Lifting Capacity:** The machine was capable of lifting up to **1 kg** of solid waste from a manhole.
- **Operational Speed:** The bucket operated at a speed of **5 km/h**, sufficient for typical urban sewage environments.

The machine was tested in environments with varying clog types and volumes to ensure versatility. It consistently performed well, lifting waste efficiently and without human intervention.

4. Results and Discussion

The Manhole Clog Removal Machine demonstrated significant advantages over manual scavenging methods, particularly in terms of safety and efficiency. During testing, it was observed that the machine could clear blockages with minimal human interaction, reducing the risk of infections and respiratory problems for workers.

Figure 6: Fabrication Machine Testing and Performance

- **Lifted Weight:** The machine efficiently lifted **1 kg** of solid waste per cycle.
- **Speed:** At a speed of **5 km/h**, it performed faster than manual methods, allowing for quick clearance of manhole clogs.

The machine also showed potential for scalability and integration with urban sewage management systems. Its simple operation makes it suitable for deployment by semi-skilled workers, further increasing its practicality for use in cities across India.

5. Conclusion and Future Work

The development of the Manhole Clog Removal Machine presents a significant step forward in mechanizing sewage management. Its design minimizes human exposure to hazardous waste and provides a cost-effective solution to urban sanitation challenges. The machine can be scaled and modified to handle larger waste volumes or integrated with sensors for automated clog detection. Future research can explore improving the machine's capacity, enhancing sensor technology for real-time clog detection, and reducing manufacturing costs. Additionally, with sufficient government and municipal support, this machine can help achieve the Swachh Bharat Mission's goals of improving sanitation and eliminating manual scavenging in India.

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