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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.*

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. This deeply entrenched practice, primarily involving the manual removal of human excreta from open drains, septic tanks, and manholes, continues to endanger the lives of those engaged in this work. Often recruited from marginalized communities such as Dalits (historically oppressed castes), workers face significant social stigma, making it difficult for them to escape the cycle of manual labour and poverty. The hazardous working conditions in manholes expose workers to toxic gases such as methane, hydrogen sulphide, and ammonia, increasing the likelihood of respiratory diseases like tuberculosis and asthma. Direct contact with human waste further exposes workers to skin infections, eye problems, and waterborne diseases such as cholera, typhoid, and hepatitis. Over time, continuous exposure to these hazards can lead to long-term disabilities, a lowered life expectancy, and in extreme cases, death. According to the National Commission for Safai Karamcharis, dozens of manual scavengers die each year in India due to asphyxiation while cleaning sewers. The 2013 Act not only prohibits the employment of manual scavengers but also mandates their rehabilitation through skill development programs and alternative employment. However, enforcement remains weak due to a lack of monitoring mechanisms, inadequate rehabilitation efforts, and cultural acceptance of manual scavenging in some regions. Local governments often turn a blind eye to violations, especially in areas where mechanized alternatives are not available or considered too expensive. Moreover, social discrimination against scavengers perpetuates their exclusion from formal sectors, forcing them back into hazardous jobs for survival. The introduction of mechanized tools and systems is critical to eliminate human involvement in these dangerous tasks. However, current adoption rates of mechanized alternatives are slow due to high initial costs, lack of awareness, and the

unavailability of affordable, accessible technology for urban local bodies (ULBs). This paper proposes the design and implementation of an affordable and user-friendly **Manhole Clog Removal Machine** that can efficiently remove blockages, thus eliminating the need for manual intervention. This solution has the potential to drastically reduce fatalities and improve the dignity and working conditions of sanitation workers. The inadequacy of sewage systems contributes to recurrent sewage overflows, particularly during the monsoon season, when rainwater mixes with untreated sewage. This not only causes blockages but also contaminates local water bodies, leading to the spread of waterborne diseases like cholera, dysentery, and leptospirosis. According to the World Health Organization (WHO), 80% of diseases in developing countries are linked to poor sanitation and unsafe water, underscoring the urgent need to improve sewage management.

Many ULBs are financially constrained, lacking the resources to invest in modern infrastructure or maintain the existing systems effectively. Additionally, ULBs often face challenges related to outdated sewage networks, poor maintenance, and inadequate workforce training, resulting in frequent breakdowns and delays in clog removal. Manual labor remains the default solution in many areas due to the unavailability of cost-effective mechanized alternatives, further exacerbating the public health risks associated with the mishandling of waste.

Figure 1: Current Manual Scavenging Practices in India

Figure2: Sewage Overflow Issues Due to Blocked Drains

The two images highlight the persistent challenges of **manual scavenging** and **urban sewage management** in India. Despite laws prohibiting manual scavenging, the practice remains widespread, forcing workers from marginalized communities to enter hazardous manholes and clean human waste without adequate protection. Furthermore, urban infrastructure is often overwhelmed by rapid population growth, leading to frequent sewage overflows, particularly during the monsoon season, as seen in the second image.Mechanization offers a scalable, long-term solution to these challenges by automating the process of sewer cleaning and maintenance, which reduces reliance on manual labour. In particular, the Manhole Clog Removal Machine **proposed** in this paper is designed to address key pain points, including ease of operation, affordability, and the ability to handle high volumes of waste. By automating clog removal, the machine reduces the risk of human exposure to toxic gases and contaminated waste, and its scalable design allows for widespread adoption in cities of various sizes. This solution not only improves the safety of sanitation workers but also enhances the efficiency of ULBs, enabling them to address urban sanitation challenges more effectively.

2. Literature

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. Several researchers and engineers have attempted to develop mechanical solutions to address the issue of drainage and sewage management, focusing on minimizing human intervention in hazardous environments and improving the efficiency of waste removal. Below is an overview of significant contributions to this field:

Prabhushankar N et al. [1] This team designed a drainage dewatering machine that utilized a reciprocating pump instead of a centrifugal pump. Their rationale was that centrifugal pumps, while commonly used, were ineffective at handling suspended and heavy solids, and were also more expensive. By contrast, the reciprocating pump, powered by a pneumatic cylinder and a spring system, provided a more cost-effective solution. However, they observed that the system lost some force due to the spring mechanism, which reduced its overall efficiency.

Mr. P. M. Sirsat et al [2] mentioned that in accordance with the river cleaning projects like “Namami Gange”, ‘’Narmada Bachao” and many major and medium projects in various cities like Ahmadabad, Varanasi etc. a machine is designed to clean river water surface. This machine consists of DC motors, RF transmitter and

receiver, propeller, PVC pipes and chain drive with the conveyor attached to it for collecting wastage from water bodies. It also consists of a collecting plate which is coupled with conveyor belt and chain drives which rotate by the PMDC motor. The collected waste is thrown on the collecting tray. Propeller is used to drive the machine on the river & run with help of PMDC motor. The total electrical devices are controlled by RF transmitter and receiver which are used to control the machine remotely. This machine has been designed from an economical point of view and is easy to operate and helpful for water cleaning.

M. Mohamed Idris et al [13] explained that the motive of the project is to automate the sewage cleaning process in drainage. A machine consisting of a chain and sprocket and driven by a motor is made use of in the cleaning process. When the motor runs, the chain starts to circulate and it makes the lifter to move upwards. The waste material is lifted by lifter teeth and stored in a collector bin. Once the collecting bin is full, the waste material is removed from the bin manually.

Ndubuisi C. Daniels [3] This group demonstrated a drainage system cleaner machine that automatically removes waste and sewage, aiming to mitigate environmental hazards. The machine's primary components were a propeller, cleaner, and pan, which worked together to efficiently clear blockages, highlighting an environmentally conscious approach to drainage management.

Ganesh U L [4] To reduce the need for manual cleaning, Ganesh U L proposed a mechanical drainage cleaner. This system incorporated a semi-automated drainage water cleaner, which filters waste frequently to ensure efficient water flow through the drains. The cleaner helps minimize the environmental and health risks associated with manual drainage cleaning.

S D Rahul Bharadwaj [5] suggested that automatic wastewater cleaning systems can play a crucial role in mitigating climate change impacts, such as global warming and the melting of glaciers. His research stressed the importance of wastewater treatment plants, which can purify water before it is reintroduced into natural bodies of water, thus preventing the spread of pollutants.

Dr. K. Kumaresan's [8] research focused on converting manual sewer cleaning tasks into an automated sewage cleaning system. His system featured separate handling of gaseous substances and effective water flow management, which reduced human involvement in hazardous operations. By leveraging automation technology, the team successfully created a cost-effective solution with broad applicability.

Nitin Sall's [9] work highlighted the challenges of wastewater management by explaining that an individual generates between 200 to 500 liters of wastewater daily. His research emphasized that advanced wastewater technology can remove pollutants from sewage systems, thereby preventing environmental contamination.

R. Sathiyakala et al. [7] This team devised a drainage cleaning system that utilized an E-bucket to lift sewage, followed by an evaporation treatment process that converted wet sewage into dry matter. The system was automated using an ARM board (Arduino), demonstrating a novel approach to sewage treatment.

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.

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.

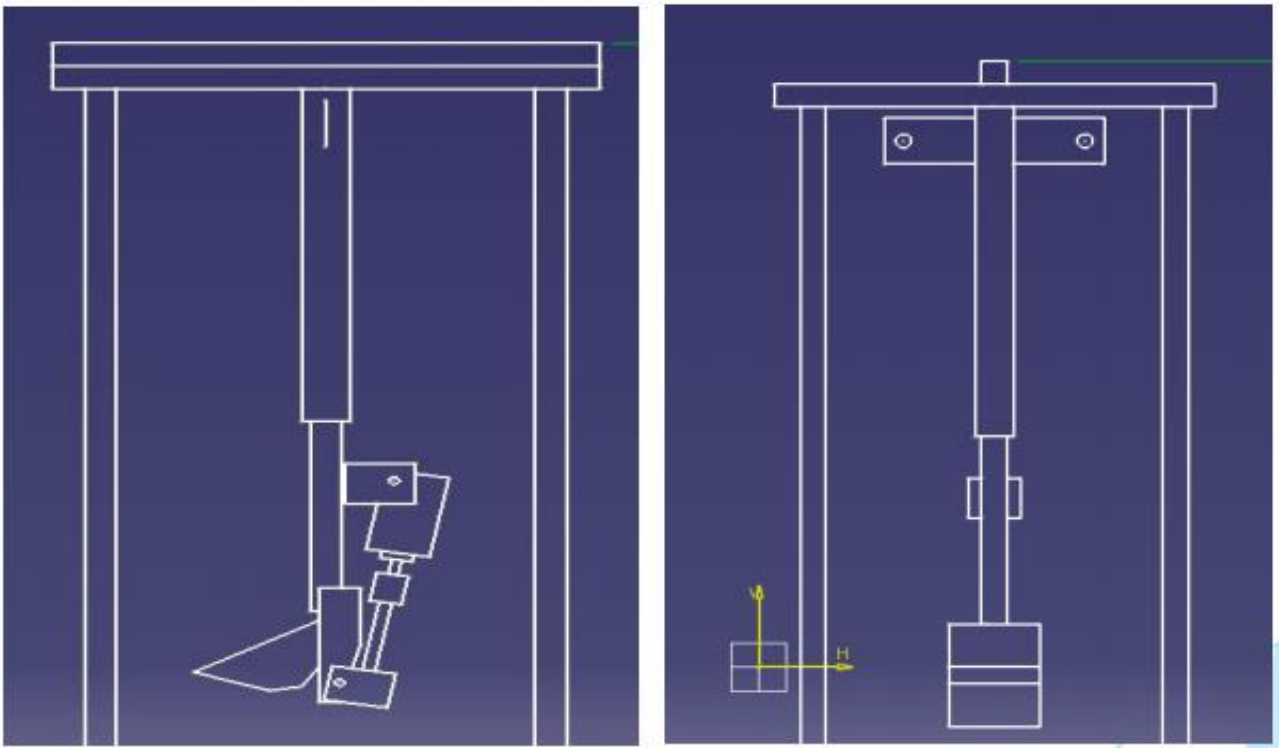

Figure 3: AutoCAD Design of the Manhole Clog Removal Machine

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 the assembly, the Manhole Clog Removal Machine was subjected to a series of tests to evaluate its performance under real-world conditions. These tests were designed to assess the machine's effectiveness in various urban sewage environments, focusing on parameters critical to operational success:

- **Weight Lifting Capacity**: The machine demonstrated the ability to lift up to **1 kg of solid waste** from a manhole. This capacity ensures that the machine can handle common types of debris encountered in urban sewage systems, including plastic waste, leaves, and other non-biodegradable materials that often contribute to blockages.
- **Operational Speed**: The bucket operated at a speed of **5 km/h**, which was deemed sufficient for navigating typical urban sewage systems. This speed enables the machine to maintain a steady pace during cleaning operations while allowing for precise control when dealing with delicate or tightly clogged areas.
- **Versatility in Different Clog Types**: The machine was tested in environments with various types of clogs, including light debris (such as leaves and paper) and more complex blockages (such as heavy mud or solid waste). It consistently lifted and removed waste efficiently, proving its adaptability across different clogging scenarios.
- **Volume Handling**: The machine's performance was evaluated with varying volumes of waste. It maintained consistent efficiency, successfully handling both minor and extensive blockages. The machine's design minimized the risk of re-clogging by ensuring the complete removal of waste in a single operation.

- **Safety and Ease of Use**: One of the primary objectives of the testing was to confirm the machine's ability to function **without human intervention** inside the manhole. The remote-control feature allowed operators to manage the machine from a safe distance, reducing the risks associated with toxic gas exposure and physical injuries.

The results from the testing phase indicate that the Manhole Clog Removal Machine performs effectively in diverse urban settings. Its combination of adequate lifting capacity, operational speed, and ability to handle various clog types makes it a viable alternative to manual scavenging, significantly improving safety for sanitation workers and overall efficiency in sewage management.Further evaluation is ongoing to optimize the machine's weight lifting capabilities and ensure its scalability for larger waste removal operations.

Figure 4: Fabrication, Machine Testing and Performance

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. 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

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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