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Smart Waste Management: Dump Garbage Cart Automation for Smell Reduction and Waste Segregation

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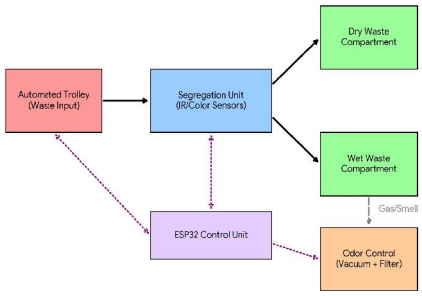
Abstract: *This paper presents the design and development of a Smart Garbage Collection and Odor Control System for municipal waste vehicles to improve efficiency, hygiene, and environmental sustainability. The system integrates an automated front-mounted trolley for external waste collection, which is lifted and emptied into the main vehicle compartment without manual handling. Inside the vehicle, waste is mechanically segregated into wet (organic) and dry (recyclable) categories using smart sensors. A vacuum-based odor control unit extracts harmful gases such as methane, ammonia, and hydrogen sulphide from organic waste, which are then neutralized using eco-friendly chemicals before being released into the atmosphere. Ultrasonic sensors detect waste levels, and gas sensors monitor odor intensity, all controlled by an ESP32 microcontroller. The system reduces human involvement, enhances operational efficiency, and contributes to cleaner and more sustainable urban waste management practices.*

Keywords: *Smart Garbage Collection*

I. INTRODUCTION

Rapid urbanization, population growth, 1and industrial development have significantly increased the amount of municipal solid waste generated worldwide. Traditional waste collection methods often involve manual handling of garbage, inefficient segregation processes, and inadequate odor control mechanisms, resulting in environmental pollution, public health risks, and reduced operational efficiency. Organic waste undergoes decomposition and produces unpleasant odors and harmful gases such as methane, ammonia, and hydrogen sulfide, contributing to air pollution and greenhouse gas emissions.

Fig 2: System Architecture Diagram



Conventional garbage collection vehicles mainly focus on transporting waste and lack automated systems for waste handling, segregation, and odor management. The proposed Smart Garbage Collection and Odor Control System

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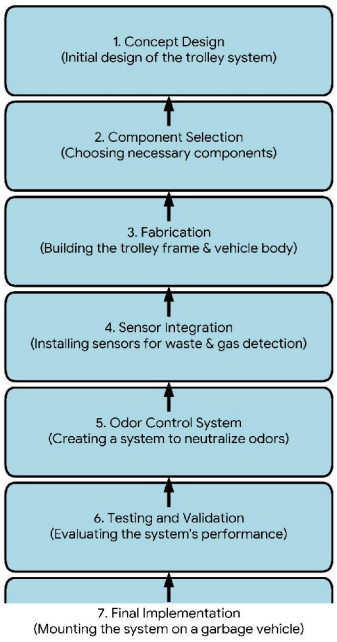
addresses these challenges through automation and intelligent monitoring technologies. It incorporates a front-mounted trolley mechanism for automatic waste lifting, mechanical segregation into wet and dry categories, and a vacuum-based gas extraction system with chemical neutralization to maintain a clean environment.

II. LITERATURE REVIEW

Recent advancements in smart city technologies have encouraged the adoption of sensor-based waste monitoring systems. Studies have shown the effectiveness of IoT-based waste monitoring systems equipped with odor detection and control modules. For instance, Patel et al. (2023) developed a system using gas sensors to detect harmful gases, triggering a vacuum pump and deodorizing chemical spray, achieving an 87% reduction in odor. Similarly, Sharma et al. (2022) proposed a smart garbage vehicle capable of automatic collection, segregation, and IoT-based control, revealing a 30% improvement in efficiency.

Furthermore, research by Zhang et al. (2023) emphasized the use of deep learning and IoT for waste classification, achieving over 94% accuracy. The current project builds upon these concepts by integrating an automated trolley, mechanical segregation using IR/color sensors, and a dual-stage filtration system (chemical and activated carbon) to create a comprehensive mobile waste management unit.

Fig 1: Methodology for Automatic Waste Management System



III. SYSTEM ARCHITECTURE AND METHODOLOGY

The system is designed to minimize human intervention and improve collection efficiency. The methodology involves the following key stages:

A. Automated Garbage Collection: A front-mounted detachable trolley collects waste externally. Once filled, a DC motor-driven lead screw mechanism automatically lifts and transfers the waste into the main vehicle compartment.

B. Waste Segregation: An automatic segregation system uses sensors (IR and color) to differentiate between biodegradable and non-biodegradable waste. A servo motor-driven flap directs the waste into respective compartments.

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C. Odor Control Unit: A dedicated vacuum extraction unit continuously monitors gas levels using MQ-135 sensors. When harmful gas concentrations exceed a threshold, a vacuum pump extracts the gases and passes them through a neutralization chamber containing lime/sodium hydroxide and activated carbon before releasing purified air.

D. Control System: An ESP32 microcontroller serves as the central processing unit. It processes data from ultrasonic sensors (for waste level) and gas sensors, controlling the motors, vacuum pump, and actuators accordingly.

IV. COMPONENT DESIGN AND IMPLEMENTATION

1. Structural Frame: Fabricated using mild steel square pipes (1-inch, 2 mm thickness) and 20-22 gauge sheet metal, providing a lightweight yet durable enclosure.
2. Control Unit: ESP32 Uno coordinates all operations, processing inputs and triggering relays/actuators. It is powered by a 12V 7Ah battery.
3. Actuation: A 12V DC linear actuator (100-200 RPM) is used for trolley lifting, while L298N motor drivers manage the high-current DC motors.
4. Sensors: HC-SR04 ultrasonic sensors detect waste fill levels, and MQ-135 sensors monitor volatile organic compounds (VOCs).
5. Filtration: A dual-stage filter uses activated carbon to absorb odors and a chemical pad to neutralize acidic/basic gases.

V. ADVANTAGES AND LIMITATIONS

Advantages:

- Reduces manual labor and human exposure to harmful waste.
- Mechanical separation of wet and dry waste improves recycling efficiency.
- Vacuum and chemical neutralization significantly reduce foul smells from organic waste.
- Real-time monitoring enables timely interventions and prevents overflow.

Limitations:

- Initial setup cost for sensors, motors, and vacuum systems is high.
- Requires regular maintenance of mechanical moving parts and periodic refilling of deodorizing chemicals.

VI. CONCLUSION AND FUTURE SCOPE

The Smart Garbage Collection and Odor Control System successfully integrates mechanical, electrical, and environmental control systems to modernize municipal waste vehicles. The prototype demonstrates efficient automated waste collection, sensor-based segregation, and effective odor filtration. It reduces human involvement and promotes a cleaner environment.

Future developments could include full IoT integration for real-time tracking and predictive route planning, AI-based waste sorting using computer vision, and the incorporation of solar panels to enhance energy efficiency. This system lays the foundation for cleaner, safer, and smarter urban waste management.

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