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AUTOMATED MIXED GARBAGE SEGREGATION AND COLLECTION ALERT SYSTEM

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ABSTRACT:
Urbanization and population growth have increased the volume and complexity of solid waste, creating challenges in segregation, disposal, and recycling. Improper handling of mixed waste leads to environmental pollution, health risks, and reduced recycling efficiency. This project presents an Automated Mixed Garbage Segregation and Collection Alert System that integrates sensor-based classification, mechanical sorting, and smart alerts. Inductive metal, moisture, and infrared sensors accurately identify waste types, while a compact servo-driven mechanism directs waste into metal, wet, and dry bins without bulky conveyors.
IR- sensor monitor bin levels in real time, triggering buzzer alerts and Wi-Fi notifications when bins are full, ensuring timely collection and preventing overflow. The modular and scalable design supports future expansion, IoT integration, and data logging. Overall, the system offers a hygienic, efficient, and sustainable solution for modern waste management.

Keywords:
Waste Segregation, Smart Waste Management, Automated Garbage System, Sensor-Based Classification, Inductive Sensors, Rain Sensors, Infrared Sensors

1.INTRODUTION

Waste management has become a critical challenge in modern urban and residential environments due to rapid population growth, urbanization, and changing consumption patterns. The increasing generation of mixed solid waste, including biodegradable, non-biodegradable, and metallic materials, has led to serious environmental concerns, including soil pollution, water contamination, and greenhouse gas emissions. Improper segregation at the source reduces recycling efficiency and increases landfill burden, while manual waste handling remains labor-intensive, time-consuming, and unhygienic.
To address these issues, this work proposes an Automated Mixed Garbage Segregation and Collection Alert System that integrates sensor-based classification, embedded control, and real-time monitoring. The system utilizes inductive, moisture, and infrared sensors to accurately identify metal, wet, and dry waste, while a servo-driven mechanism enables efficient sorting. Additionally, ultrasonic sensors monitor bin levels, and alert mechanisms ensure timely waste collection.
The proposed system is compact, cost-effective, and suitable for residential and institutional use. By combining automation, smart sensing, and real-time alerts, it enhances waste management efficiency, reduces human intervention, and promotes sustainable environmental practices.
Furthermore, the system promotes source-level waste segregation, which is essential for improving recycling efficiency and reducing environmental impact. It also minimizes human exposure to harmful waste, thereby enhancing safety and public health. The integration of real-time monitoring and alert mechanisms ensures better coordination in waste collection processes. With its modular design and adaptability, the system can be further extended with advanced technologies such as artificial intelligence and cloud-based analytics. Hence, this solution represents a significant step toward developing smart, efficient, and sustainable waste management systems for future urban environments.

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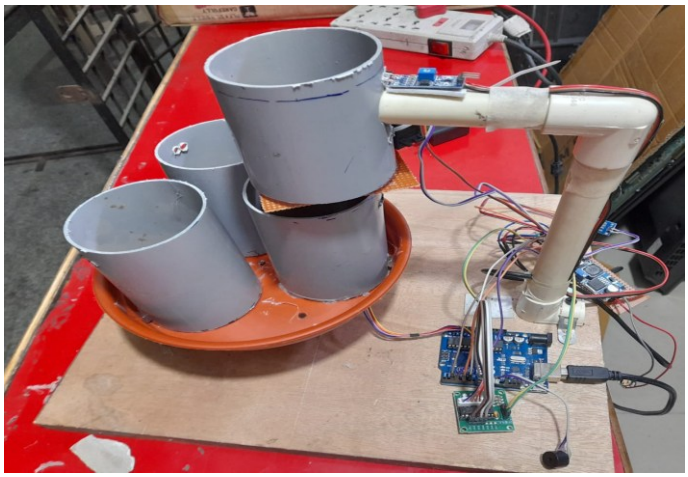

Figure No 1: Prototype Set Up

2.LITERATURE REVIEW

Recent advancements in waste management systems have focused on improving efficiency through automation, sensor integration, and IoT-based monitoring. Early systems primarily used ultrasonic sensors for bin-level detection, enabling real-time monitoring of waste and reducing the need for manual inspection. However, these systems lacked waste segregation capabilities, limiting their effectiveness in recycling processes. Subsequent research introduced IoT-based waste management solutions that incorporated wireless communication and cloud platforms for real-time monitoring and alert generation. These systems improved operational efficiency and enabled timely waste collection. However, they largely focused on monitoring rather than segregation, resulting in continued challenges related to mixed waste handling. Sensor-based waste segregation systems have been widely studied, employing inductive sensors for metal detection, moisture sensors for distinguishing wet and dry waste, and infrared sensors for object detection. These approaches achieved moderate to high classification accuracy but often lacked integration with monitoring and alert mechanisms. Additionally, many existing systems relied on bulky conveyor-based sorting mechanisms, which increased system complexity, cost, and space requirements.

Recent studies have also explored advanced techniques such as machine learning and image processing for waste classification. Although these methods provide high accuracy, they require significant computational resources, making them unsuitable for low-cost and small-scale applications. From the literature, it is evident that most existing systems address either waste monitoring or segregation independently, with limited integration of both functionalities in a compact and cost-effective design. This gap highlights the need for an integrated system that combines automated waste segregation, real-time monitoring, and alert mechanisms. The proposed system addresses these limitations by integrating multi-sensor-based classification, a compact servo-driven sorting mechanism, and real-time alert features using embedded systems and IoT technology. This approach provides an efficient, scalable, and practical solution for modern waste management, particularly in residential and institutional environments.

3.EXISTING SYSTEMS

The existing waste management systems primarily rely on manual segregation and basic monitoring techniques. In most residential and urban areas, waste is collected in mixed form without proper classification into wet, dry, and recyclable categories. This lack of segregation at the source leads to inefficient recycling, increased landfill usage, and environmental pollution. Traditional systems depend heavily on human labor for sorting waste,

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which is time-consuming, labor-intensive, and unhygienic. Workers are exposed to harmful substances, increasing health risks. Moreover, manual segregation often results in errors and inconsistent classification.
With technological advancements, some automated systems have been developed using sensors and IoT-based monitoring. For instance, ultrasonic sensors are used to detect bin levels, and GSM or IoT modules are employed to send alerts when bins are full. However, these systems mainly focus on monitoring and do not perform waste segregation.
Other advanced systems use conveyor belts and mechanical sorting mechanisms combined with multiple sensors. While these systems can segregate waste effectively, they are bulky, expensive, and require high maintenance, making them unsuitable for small-scale or household applications. In addition, recent approaches using machine learning and image processing techniques provide high accuracy in waste classification. However, these methods involve high computational complexity, increased cost, and dependency on advanced hardware, limiting their practical implementation in low-cost environments. Overall, existing systems either focus on waste monitoring or segregation independently and lack an integrated, compact, and cost-effective solution. These limitations highlight the need for an efficient system that combines automated segregation, real-time monitoring, and alert mechanisms, which is addressed by the proposed system.

4.METHODOLOGY /SYSTEM DESIGN

4.1 System Architecture

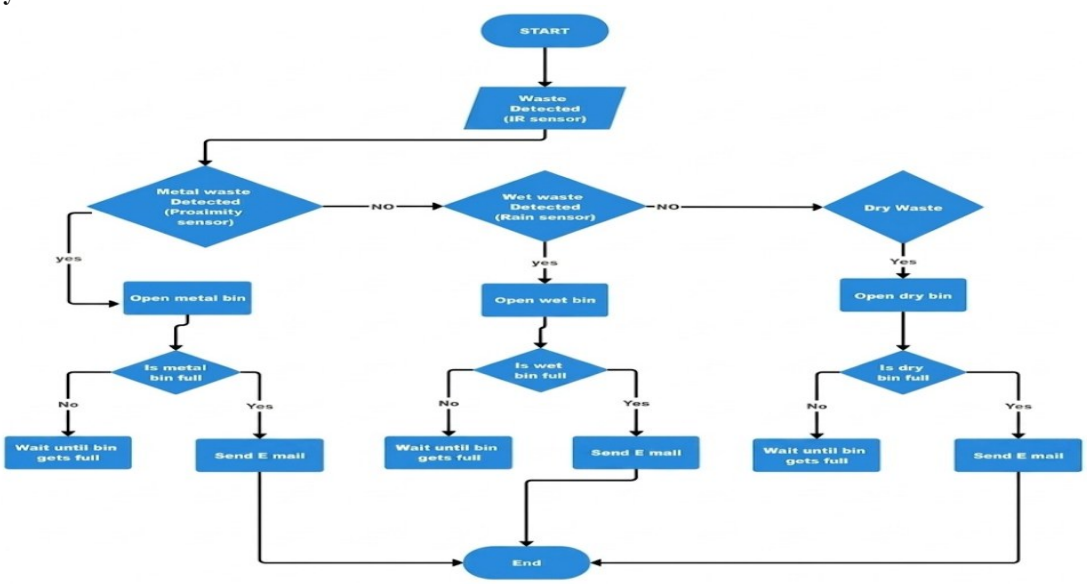

Figure No: 4.1 System Architecture

4.1.1 Overall Architecture of the System

The overall architecture of the proposed Automated Mixed Garbage Segregation and Collection Alert System is designed as an integrated framework consisting of sensing, processing, sorting, monitoring, and communication units. The system begins with the input stage, where waste is placed into the system and detected using an infrared (IR) sensor. This detection triggers the processing unit to initiate the classification process. The sensing unit includes an inductive proximity sensor for detecting metallic waste and a moisture sensor for identifying wet and dry waste. These sensors continuously provide real-time data to the microcontroller. The Arduino-based control unit processes the sensor inputs using predefined logic and determines the appropriate waste category. Based on the classification result, the mechanical sorting unit, which consists of a servo motor-driven rotating flap, directs the waste into the corresponding bin (metal, wet, or dry). This compact mechanism ensures efficient segregation without the need for complex conveyor systems.
Each bin is equipped with an IR sensor to monitor the fill level. The monitoring unit continuously checks the bin status and sends the data to the control unit. When the waste level reaches a predefined threshold, the alert system is activated. A buzzer provides local notification, while the communication module NodeMCU/ESP8266 enables remote alerts through G-Mail . Additionally, a 16×2 LCD is integrated into the system to provide real-time information such as waste type . The power supply unit ensures the stable operation of all components.

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Thus, the system architecture combines sensor-based detection, embedded processing, mechanical actuation, and IoT-based communication to achieve efficient, automated, and real-time waste management.

5. RESULTS AND DISCUSSIONS

5.1 Metal Waste Bin Results

The system successfully detects metallic waste using the inductive proximity sensor. When a metal object is identified, the Arduino processes the signal and activates the servo motor to direct the waste into the metal bin. The detection is fast and reliable due to non-contact sensing. The IR sensor continuously monitors the bin level, and when the bin reaches the predefined threshold, an alert is triggered. The system also sends an email notification indicating that the metal bin is full, confirming successful implementation of the alert mechanism..

Figure No: 5.1 Email Confirmation Of Metal Bin Full

5.2 Wet Waste Bin Results

The wet waste bin operation is based on moisture detection using the Rain sensor. Waste containing water or organic content is accurately identified as wet waste and directed into the wet bin through the servo mechanism. The system performs efficiently under normal conditions, although slight variations may occur with low moisture levels. The ultrasonic sensor monitors the bin level in real time. Once the bin reaches maximum capacity, both buzzer alert and email notification are generated, ensuring timely waste collection.

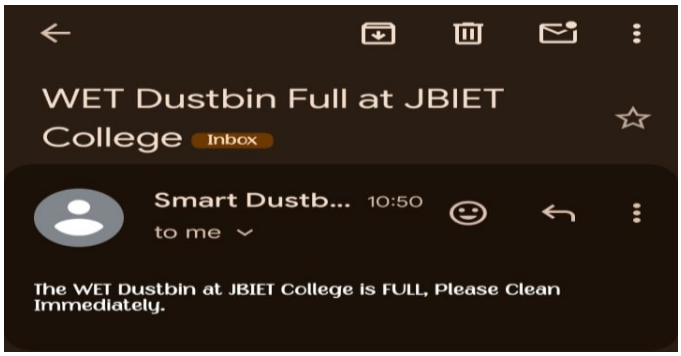

***Figure No : 5.2** Email Confirmation Of Wet Bin Full*

5.3 Dry Waste Bin Results

Dry waste such as paper, plastic, and other non-metallic materials is classified when no metal or moisture is detected. The system correctly identifies such waste and directs it into the dry bin. The servo mechanism ensures proper placement without delay. The ultrasonic sensor effectively tracks the fill level of the dry bin. When the bin becomes full, the system triggers alerts and sends an email notification, demonstrating reliable monitoring and communication.

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Figure No: 5.3 Email Confirmation Of Dry Bin Full

5.4 Discussion

The experimental results demonstrate that the proposed system effectively performs automated waste segregation and real-time monitoring with satisfactory accuracy and reliability. The integration of multiple sensors enables proper classification of waste into metal, wet, and dry categories, while the servo-based mechanism ensures smooth and efficient sorting. Compared to traditional manual methods, the system significantly reduces human effort and improves hygiene. The alert mechanism, including buzzer and email notifications, plays a crucial role in preventing bin overflow and ensuring timely waste collection. The successful generation of email alerts for all bins confirms the proper functioning of the IoT-based communication system. Additionally, the use of ultrasonic sensors provides accurate real-time monitoring of bin levels, enhancing system efficiency.

However, certain limitations were observed during operation. The moisture sensor may produce slight inaccuracies when dealing with low or uneven moisture content, which can occasionally affect classification. The system performance also depends on network availability for sending email notifications. Furthermore, mixed or complex waste materials may lead to minor misclassification. Despite these limitations, the system achieves its primary objective of providing a compact, low-cost, and efficient waste management solution. With further improvements such as advanced sensors, machine learning-based classification, and enhanced communication systems, the overall performance and scalability of the system can be significantly improved.

6.CONCLUSION

The Automated Mixed Garbage Segregation and Collection Alert System has been successfully designed and implemented, demonstrating effective waste detection, classification, and segregation into metal, wet, and dry categories. The system utilizes a combination of sensors, including an IR sensor, an inductive proximity sensor, and a rain sensor, to ensure accurate identification of different waste types. The Arduino Uno functions as the central control unit, processing sensor inputs and controlling the servo motor to enable precise waste segregation. Additionally, the IR sensor facilitates real-time monitoring of bin levels

The NodeMCU module enables IoT-based communication by providing timely alert notifications through Wi-Fi when bins reach their maximum capacity. The integration of an LCD further enhances user interaction by providing continuous system status updates. The proposed system is compact, cost-effective, and easy to deploy, making it suitable for small-scale applications such as households and institutional environments. It significantly reduces manual effort, improves hygiene, and enhances the overall efficiency of waste management processes.

In conclusion, the system successfully fulfills its objective of automating waste segregation and enabling real-time alert mechanisms, thereby contributing to sustainable waste management and promoting cleaner and smarter environments.

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