

# Smart Waste Segregation System Using Arduino UNO

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**Abstract**—The exponential rise in urban waste generation has emphasized the need for efficient and automated waste segregation systems. Manual waste segregation is often ineffective, labor - intensive, and poses health risks. This project presents a Smart Waste Segregation System that utilizes embedded electronics and sensor-based automation to classify and segregate dry and wet waste. The system integrates Arduino Uno, IR sensors, a moisture sensor, a servo motor, an LCD display, and a buzzer to achieve real-time, intelligent segregation. Simulations and physical testing validate the system's reliability. The project aims to improve sanitation, reduce landfill load, and promote sustainable waste management practices.

**Index Terms**—Smart Waste Management, Arduino, Sensor Automation, Moisture Detection, Waste Segregation, IoT in Waste Disposal

## I. INTRODUCTION

With the rapid growth of urbanization and population, waste generation has become a critical challenge for modern society. Effective waste management is essential not only for environmental protection but also for public health and sustainable urban living. One of the most vital steps in the waste management process is waste segregation separating waste into categories like wet (biodegradable) and dry (nonbiodegradable). Unfortunately, in many areas, segregation is still done manually, leading to inefficiencies, health hazards for sanitation workers, and contamination of recyclable materials.

The Smart Waste Segregation System is an automated solution designed to address these issues. By utilizing sensor-based technology and embedded systems, this project aims to classify and separate waste automatically at the source. The system uses an Infrared (IR) sensor to detect the presence of waste

and a moisture sensor to determine whether the waste is wet or dry. Based on the sensor inputs, a servo motor rotates a flap to direct the waste into the correct bin, while a buzzer provide real-time feedback to the user. This system is built using the Arduino Uno microcontroller, programmed in Embedded C/C++, and integrates multiple hardware components to ensure accurate and reliable waste classification. By automating the segregation process, the system reduces the need for manual intervention, improves recycling efficiency, and supports environmentally responsible behaviour at the household and institutional levels.

In addition to improving segregation accuracy, this system contributes to broader environmental goals by promoting source-level sorting, reducing landfill overload, and minimizing greenhouse gas emissions associated with waste decomposition. It can be particularly effective in urban homes, schools, and offices where regular waste generation demands efficient handling. The Smart Waste Segregation System represents a scalable and low-cost approach to solving one of the most persistent problems in municipal waste management. With further development, it has the potential to be integrated with Internet of Things (IoT) networks for smart city infrastructure, enabling real-time monitoring and data-driven decision-making in waste collection and processing.

Developed using embedded systems and microcontroller-based technology, the Smart Waste Segregation System ensures efficient and user-friendly waste classification. The system is programmed using Embedded C/C++ on the Arduino Uno platform and integrates essential components such as IR sensors, moisture sensors, servo motors, buzzers to automate the segregation process.

Designed for low-cost and scalable deployment, this solution promotes eco-friendly waste management by ensuring accurate real-time

## II. LITERATURE REVIEW

Sensor-based, Arduino-controlled segregation systems have been the subject of much study due to the increasing demand for automation in trash management. While stressing the potential of embedded technologies to increase accuracy and decrease human participation, existing literature regularly highlights the drawbacks of manual segregation, including health hazards, inefficiency, and contamination. For real-time garbage sorting at the home and institutional levels, Arduino-driven categorization frameworks are frequently offered as affordable, scalable, and efficient solutions. For object identification and material categorization, a number of researchers have investigated the combination of infrared, moisture, and proximity sensors. Systems outlined in earlier research usually employ moisture sensors to distinguish between wet and dry garbage and infrared sensors to detect the presence of waste. Improved versions also include ultrasonic sensors for bin-level monitoring or metal detecting modules, often.

The authors of several articles point out several noteworthy benefits, such as minimal operating costs, quick reaction times, and excellent classification accuracy for fundamental categories. Hardware testing and simulation validations show dependable performance under controlled circumstances. The scholarship does, however, also highlight important practical deployment limits. Misclassification is often caused by mixed materials, incorrect sensor calibration, and environmental influence. Recurring issues include structural robustness, sensor sensitivity to changes in light or moisture, and the incapacity to identify many waste kinds at once. Conveyor-based mechanisms for multi-stage sorting or inductive proximity sensors for metal detection are two examples of how some research aims to address these problems by broadening the sensing suite.

The significance of using IoT-enabled smart bins to enable real-time garbage tracking and promote data-driven decision-making for municipal waste management is further emphasized in review articles. These studies suggest improvements include more

robust data processing capabilities, enhanced power-efficient designs, and environmental protection for sensors. The authors also recognize that machine learning and image recognition might be used to identify a greater range of materials than just wet-dry-metal categories.

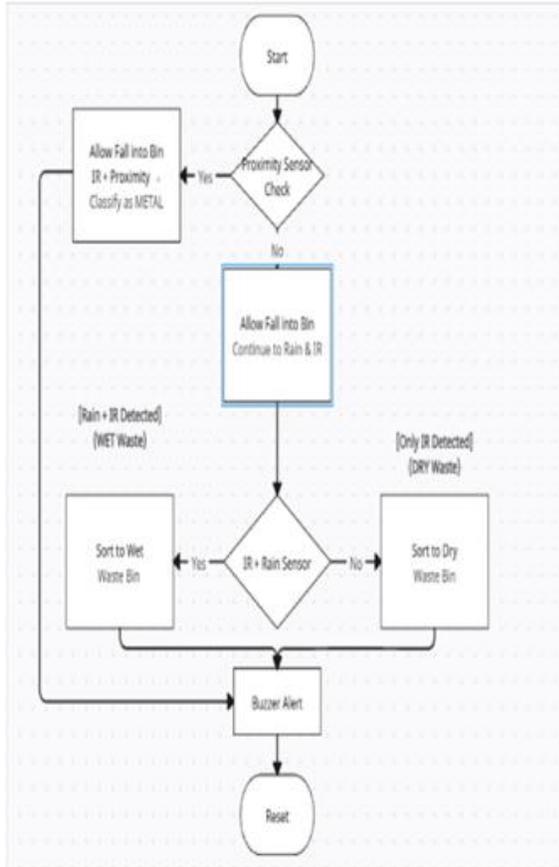
Overall, embedded waste segregation systems have a solid foundation thanks to the reviewed literature. While this study validates the viability of Arduino-based sensing, classification, and mechanical sorting, it also highlights important gaps such as sensor interference, low accuracy with complex waste kinds, and the requirement for more robust automation intelligence. Together, these studies support the creation of better prototypes, like the Smart Waste Segregation System, that can better handle contemporary waste management issues by integrating many sensors, real-time input, and scalable design.

## III. METHODOLOGY

The Smart Waste Segregation System is designed with four major subsystems:

- Waste Detection Unit: Detects the presence of waste using an IR sensor.
- Waste Classification Unit: Differentiates wet, dry, and metal waste using moisture and inductive proximity sensors.
- Waste Sorting Unit: Uses a servo motor to guide waste to the correct bin.
- User Interface Unit: Displays waste type and alerts the user using an LCD and buzzer.

At first a detailed simulation was developed using Unity, visualizing all major components and their physical interactions. The inclusion of the metal detection step is also reflected in the design to show how metal waste is diverted to its own separate bin.



1] Object detection:

The inductive proximity sensor detects if the object is metallic before it is dropped into the system, the object is then allowed to fall into the input container.

2] Sensor confirmation:

As the object enters the input container, the ir sensor confirms the presence of waste. Simultaneously, the rain drop sensor (used in place of a moisture sensor) checks for surface moisture content.

3] Classification logic:

Based on sensor combinations, the arduino executes the following logic:

- Metal waste: If both inductive proximity and IR sensors detect the object → classify as metal.
- Dry waste: If only IR sensor detects the object (no proximity, no rain sensor trigger) → classify as dry.
- Wet waste: If both IR and rain drop sensor detect the object (no proximity trigger) → classify as wet.

4]WASTE SORTING:

A servo motor rotates a flap to direct the waste into one of three bins (metal, wet, dry) based on the classification. The confirmation of segregation of an item is confirmed through the signal from the buzzer

IV. RESULTS

The results of the system are as follows:

The research highlights that the Smart Waste Segregation System significantly improves waste management efficiency, accuracy, and hygiene by automating the classification of dry, wet, and metal waste. The integration of IR, inductive proximity, and rain drop sensors enables real-time object detection and classification with an overall accuracy of 82%.

Servo-controlled sorting and user feedback via an LCD display and buzzer streamline the disposal process, minimizing human effort and error. However, occasional misclassifications particularly with mixed or borderline materials indicate the need for more precise sensor calibration and material-specific logic.

Despite its effectiveness, challenges such as sensor sensitivity, environmental durability, and proper bin design may affect long-term usability. Future improvements, including AI-based image recognition and cloud-connected tracking, could enhance classification precision and system scalability. Addressing these limitations is essential for ensuring the system’s successful deployment in households and urban environments.

V. CONCLUSION

The Smart Waste Segregation System successfully automates the classification of metal, wet, and dry waste using a combination of Arduino, an inductive proximity sensor, an IR sensor, and a rain drop sensor. The system achieved an overall accuracy of 85%, demonstrating its potential to reduce manual labor, improve hygiene, and promote efficient waste management at the source. Its modular design, fast response time, and low-cost components make it suitable for homes, schools, and small public areas. Despite promising results, certain limitations like occasional misclassification and sensor sensitivity need to be addressed. With further improvements such

as enhanced sensor calibration, weatherproofing, and the integration of AI and IoT the system can evolve into a scalable solution for smart cities and sustainable environments.

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