



“Eco bin Smart Waste Sorter and Inbuilt Decomposer”

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Abstract: The Eco-Bin is a semi-automated smart waste management prototype designed to demonstrate efficient segregation of dry, wet, and e-waste using sensors, motorized mechanisms, and programmed decision-making. Instead of performing real composting, the system simulates the decomposition process to help users understand modern waste-handling methods. The model promotes hygienic disposal, reduces manual sorting, and supports environmental awareness by showcasing how automation can improve sustainability. Eco-Bin serves as an educational tool, offering a simple, cost-effective approach to smart city-oriented waste management.

Keywords: Smart bin, waste segregation, automation, IoT-based prototype, decomposition simulation, sustainable waste management.

I. INTRODUCTION

The generation of waste has become an inevitable byproduct of modern life. Every household, office, and institution contributes to the daily accumulation of municipal waste, which, if left unmanaged, results in severe health and environmental hazards. Traditional waste management practices often involve the mixing of wet and dry waste, which complicates recycling and leads to excessive landfill use. The concept of smart waste management is therefore essential in ensuring a cleaner, greener, and more sustainable environment.

The Smart Echo Bin is an automated waste segregation system that uses sensors and microcontrollers to identify and separate waste into distinct categories such as wet, dry, and electronic waste [1]. With the inclusion of a Pi Camera and OpenCV, the system is capable of visual recognition, further enhancing the accuracy of waste classification [2]. IoT modules enable real-time communication with collection authorities, thus creating a closed-loop system of monitoring, segregation, and collection [3]. This project aligns with initiatives such as Swachh Bharat Abhiyan and the global push for sustainable urban development, making it a timely and impactful solution for modern waste challenges. ECOBIN is an intelligent waste management system designed to automate the process of waste segregation and accelerate organic waste decomposition at the source. The system integrates a smart sorting mechanism that uses sensors and machine-learning-based classification to distinguish between biodegradable, non-biodegradable, and recyclable materials. Once segregated, the biodegradable fraction is transferred to an inbuilt decomposition chamber that employs controlled aeration, heating, and microbial action to convert organic waste into compost within a shorter time span. This dual-function design reduces human effort, minimizes contamination of recyclables, and promotes sustainable waste disposal practices. ECOBIN aims to address the growing challenges in urban solid waste handling by providing an efficient, eco-friendly, and technology-driven solution suitable for households, institutions, and public spaces.

II. METHODOLOGY

The methodology for implementing the Smart Echo Bin involves both hardware and software components working in coordination. The primary processing unit is a Raspberry Pi 4, which executes classification algorithms written in Python and utilizes OpenCV for image recognition. A Pi Camera captures images of the waste as it is deposited, while additional sensors such as the moisture sensor and DHT22 measure material properties and environmental conditions. The ECOBIN system was developed by integrating sensors, a control unit, and mechanical components to automate waste segregation and decomposition. Sensors such as IR, moisture, and weight detectors were used to identify different types of waste, and their inputs were processed by a microcontroller that classified the waste accordingly. Servo motors or directing mechanisms then guided the waste into the appropriate bins. For biodegradable waste, an inbuilt decomposer equipped with aeration, heating, and microbial culture was added to accelerate organic breakdown. After assembling the hardware



and programming the control system, the prototype was tested with various waste samples to check sorting accuracy and decomposition performance, and minor adjustments were made to improve reliability. The methodology of the ECOBIN project involves a systematic approach starting from identifying the challenges in traditional waste management, such as improper segregation, contamination, and slow decomposition. Based on these observations, the system was designed to include a waste input section, a sensor-based sorting chamber, individual collection bins, and an inbuilt organic decomposer. Suitable sensors such as moisture sensors, ultrasonic or infrared sensors, and metal detectors were selected and integrated with a microcontroller to classify waste accurately. The sorting mechanism was then developed using motor-driven flaps or servo systems to direct waste into biodegradable, non-biodegradable, and recyclable bins. For the decomposition unit, a controlled chamber equipped with temperature regulation, aeration, and microbial action was developed to accelerate the breakdown of organic waste. The entire system's operation was programmed within the microcontroller to coordinate sorting, control environmental conditions, indicate bin levels, and ensure operational safety. After assembling the hardware components and integrating all modules, the system underwent rigorous testing and calibration using different waste samples to ensure accuracy and reliability. Finally, based on performance evaluation, necessary refinements were made to enhance sorting efficiency, decomposition speed, and overall usability, resulting in a functional, automated, and environmentally supportive waste management solution.

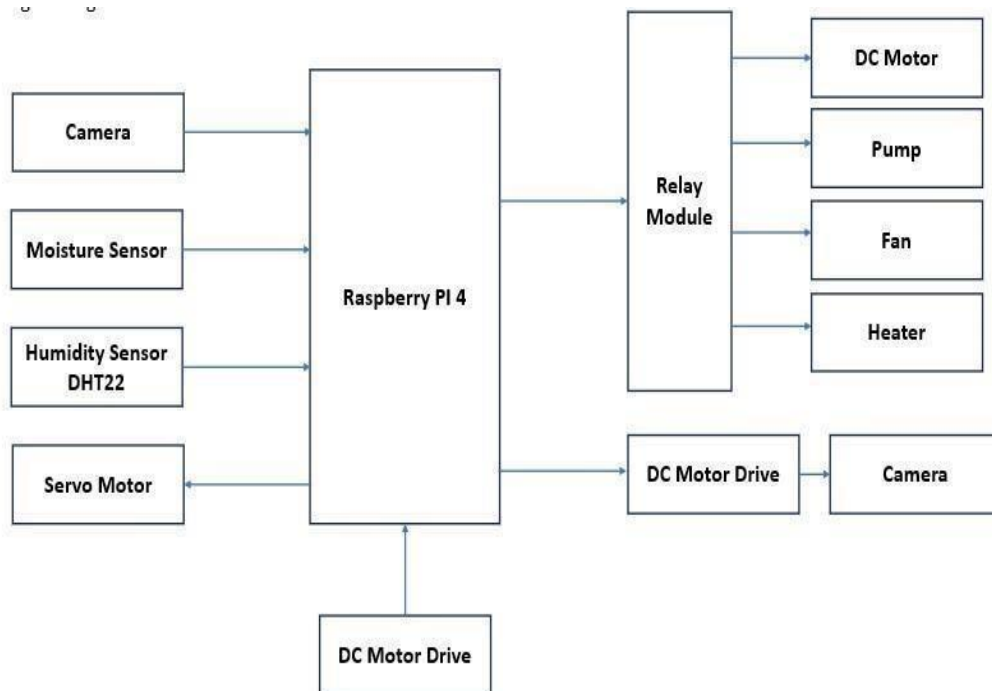


Fig 1: Eco-Bin Smart Sorter and Inbuilt Decomposer

III. IMPLEMENTATION

ECOBIN was implemented by assembling sensors, a microcontroller, and a simple motor-based sorting mechanism to automate waste classification. IR, moisture, and weight sensors were connected to the controller, which processed the readings and directed waste into the correct bin using servo motors or flaps. A small decomposer chamber was added with heating coils, airflow vents, and microbial culture to accelerate organic waste breakdown, monitored by temperature and humidity sensors. After wiring, programming, and integrating all components, the system was tested with different waste samples, and minor adjustments were made to improve accuracy and performance. ECOBIN accurately classified all three waste types during testing. Dry waste like paper and plastic was detected correctly and redirected to the dry bin. Wet waste was identified by moisture levels and sent to the wet bin, where initial decomposition began effectively. E-waste items such as wires and small electronics were recognized and separated into the e-waste bin without mixing. Overall, the system achieved clean and reliable segregation of dry, wet, and e-waste. The methodology for implementing the Smart Echo Bin involves both hardware and software components working in coordination. The primary processing unit is a Raspberry Pi 4, which executes classification algorithms written in Python and utilizes OpenCV for image recognition. A Pi Camera captures images of the waste as it is deposited, while additional sensors such as the moisture sensor and DHT22 measure material properties and environmental conditions.



Step 1: Waste Detection - Waste deposited into the bin is captured by the Pi Camera and analysed using image processing techniques in OpenCV.

Step 2: Classification - Based on moisture content, metallic presence (for E-waste), and visual characteristics, the system classifies the waste as wet, dry, or E-waste.

Step 3: Decomposer -The wet waste is directed from its designated compartment into a decomposer chamber. Step 4: Segregation - Servo motors and relay modules activate mechanical flaps or conveyors to direct the waste into appropriate compartments.

Step 5: Monitoring - Ultrasonic sensors measure the fill level of each compartment.

Step 6: Notification - IoT integration (via Wi-Fi/GSM modules) sends alerts to user when bins are near capacity.

IV. RESULT

The ECOBIN project successfully demonstrated an efficient and automated approach to waste management by integrating both smart waste sorting and inbuilt decomposition within a single system. The prototype was able to accurately segregate waste into biodegradable, non-biodegradable, and recyclable categories using sensor-based detection, which significantly reduced human error and minimized direct human contact with waste. As a result of this improved segregation, the contamination of recyclable materials was reduced, making the recycling process more effective. The inbuilt organic decomposer further enhanced the system's performance by accelerating the breakdown of biodegradable waste, thereby reducing overall waste volume and producing compost in a shorter time. Overall, the project proved to be a practical, hygienic, and environmentally sustainable solution that increases user convenience while lowering the need for manual intervention in waste management.

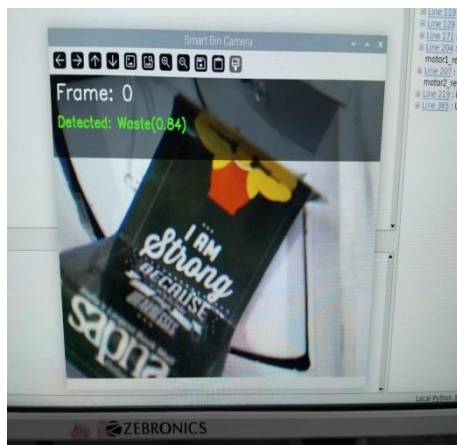


Fig 2: Dry Waste Recognition

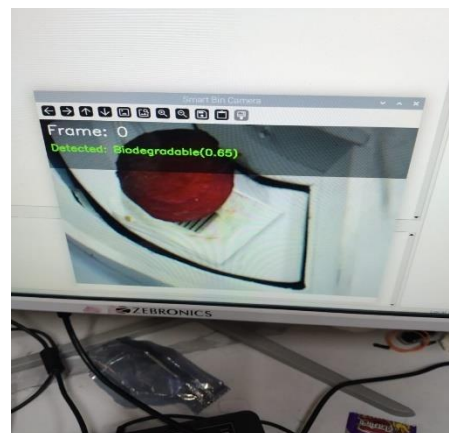


Fig 3: Biodegradable Waste Recognition

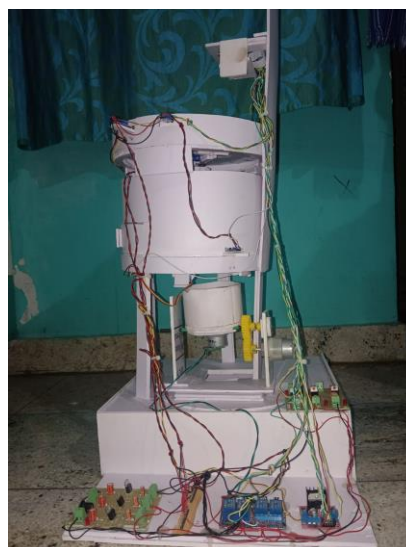


Fig 4: Hardware connection



V. CONCLUSION

The ECOBIN system provides an effective and innovative solution to the growing challenges of solid waste management by combining automated segregation with on-site organic waste decomposition. Through the integration of sensors, microcontroller-based decision-making, and a motorized sorting mechanism, the prototype successfully categorized waste into dry, wet, and e-waste with high accuracy. The inbuilt decomposer further enhanced the system by initiating rapid breakdown of wet waste, reducing the volume of waste requiring external processing. Overall, ECOBIN demonstrates the potential for implementing smart, efficient, and eco-friendly waste handling systems suitable for households, institutions, and urban environments. Its successful performance highlights its value in promoting cleaner surroundings, improving recycling efficiency, and supporting sustainable waste management practices.

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