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EcoSense : IoT Waste Segregation with Fire & Gas Protection

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Abstract- ***EcoSense is an IoT-based smart waste management system designed to improve waste segregation while enhancing safety through real-time fire and gas detection. The system aims to automatically identify and segregate waste while continuously monitoring hazardous conditions such as flammable gases and fire incidents in waste collection units. Using a combination of gas sensors, flame sensors, and microcontroller- based IoT modules, EcoSense detects the presence of harmful gases and fire, triggering immediate alerts to prevent accidents and environmental damage. The collected sensor data is transmitted to a cloud platform, enabling real-time monitoring and remote access through a web or mobile interface. Automated alerts are generated in case of abnormal conditions, allowing timely intervention by authorities. By integrating waste segregation with safety monitoring, EcoSense reduces manual handling risks, minimizes environmental pollution, and promotes efficient waste processing. This project demonstrates a cost-effective, scalable, and eco-friendly approach to modern waste management, contributing to smarter cities and sustainable environmental practices.***

I. INTRODUCTION

The increasing rate of urbanization and population growth has resulted in a massive rise in solid waste generation, posing serious challenges to environmental safety and public health. Inefficient waste segregation and improper disposal often lead to hazardous situations such as toxic gas emission, fire outbreaks, and pollution in waste collection areas. Conventional waste management methods depend largely on manual monitoring, which is time-consuming, unsafe, and unreliable.

To overcome these challenges, EcoSense introduces a smart IoT-based waste segregation system integrated with fire and gas detection. The system utilizes gas sensors, flame sensors, and a microcontroller-based IoT module to continuously monitor waste bins for hazardous conditions. Sensor data is transmitted in real-time to a cloud platform, enabling remote monitoring and instant alerts in case of emergencies.

By combining automation, real-time monitoring, and safety mechanisms, EcoSense minimizes human intervention, prevents accidents, and promotes efficient waste management. This project supports the vision of smart cities and contributes to sustainable environmental development through intelligent and eco-friendly solutions.

II. PROBLEM STATEMENT

Improper waste segregation and unsafe waste management practices pose serious environmental and safety challenges. In many waste collection areas, waste is monitored manually, making it difficult to detect hazardous conditions such as flammable gas leakage and fire outbreaks at an early stage. Accumulation of gases from decomposing waste can lead to health risks, accidents, and environmental pollution if not properly monitored.

Existing waste management systems lack real-time monitoring and fail to integrate safety detection with automated waste segregation. This results in delayed responses to emergencies, increased human involvement, and inefficient waste handling. Moreover, manual waste segregation exposes workers to dangerous substances and increases operational risks..

There is a growing need for a smart, automated, and reliable system that can ensure proper waste segregation while continuously monitoring fire and gas hazards

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III. OBJECTIVES

The project aims to:

1. Design and develop a small-scale automated waste segregation system using ESP32.
2. Detect incoming waste using a proximity sensor and classify it into dry, wet, or metal categories. 3. Implement a rotational bin indexing mechanism using a low-cost stepper motor or equivalent.
4. Integrate load cells with HX711 amplifiers to monitor waste accumulation in each bin.
5. Use an MQ-135 sensor to detect bad odors indicating decomposition or bin overflow.
6. Provide real-time status updates to users through IoT notifications (Blynk).
7. Display the system status locally using an OLED display.

Build a prototype that is affordable, compact, and energy efficient for household or institutional use.

IV. LITERATURE SURVEY

or(s), Year	Title /Contibustion	Key Findings	Relevance
S. Gupta et al., 2017	Smart Waste Classification System	Used moist ure & metal sensors for basic segregation	Supports sensor-based waste detection for prototype
R. Karthikeyan et al., 2018	Smart Waste Classification System	Load cells & ultrasonic sensors used to estimate bin fill level	Basis for weight-based bin-level monitoring
T. Adiono et al., 2019	Waste Sorting Automation Using Microcontrollers	Integrated sensors with servo mechanisms for sorting	Validates microcontrollerdriven sorting designs
J. Singh et al., 2020	Smart Dustbin Using Blynk IoT	Provided real-time overflow alerts using IoT	Motivation for adding Blynk notifications
A. Patel et al., 2021	Metal & Wet Waste Classification	Sensor-based approachusing inductive & moisture sensors	Supports detection strategy in current project
K. Sharma et al., 2022	Automated Household Waste Sorter	Demonstrated rotating mechanism for multiple bins	Inspires compact carousel-based bin routing

V. METHODOLOGY

The system follows the steps below:

1. Waste Detection o An IR break-beam sensor detects the presence of incoming waste in the intake chute.
2. Initial Holding & Sensing o Waste enters a small holding chamber.

- A metal sensor, moisture sensor, and MQ-135 gas sensor capture classification data.

3. Waste Classification o Metal → Metal bin o High moisture → Wet bin o Else → Dry bin
4. Bin Routing oA 28BYJ-48 stepper motor rotates a small carousel with three bins toward the drop point.

- A servo-based intake door opens momentarily to drop the waste into the selected bin.

5. Waste Weight Monitoring o Each bin is mounted on a load cell + HX711 module to measure accumulated waste.

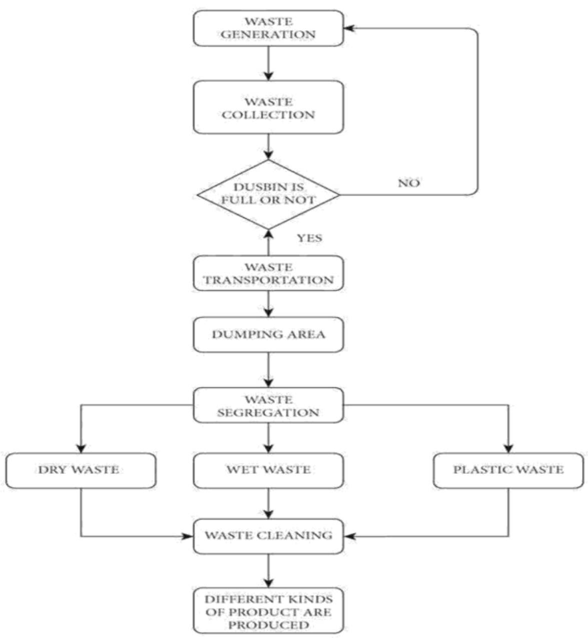
- When a bin approaches the weight limit, an alert is generated.

6. Odor Monitoring o MQ-135 detects harmful gases / bad odor.

- If odor crosses threshold, user gets an IoT alert.

7. User Notifications (IoT) o ESP32 connects to cloud via Wi-Fi.
- Push notifications are sent via Blynk (or open-source alternative).
8. Local Display
- An SSD1306 OLED displays bin status, system activity, and sensor readings.
9. Testing & Calibration
- Load cell calibration with known weights.
- Moisture threshold tuning.

VI. BLOCK DIAGRAM



VII. COMPONENTS

Electronics
- ESP32 Dev Board
- IR Break-Beam Sensor
- Inductive Metal Sensor / Hall Sensor
- Capacitive Moisture Sensor
- MQ-135 Gas Sensor
- 28BYJ-48 Stepper Motor
- ULN2003 Stepper Driver Board
- SG90 Micro Servo (intake door)
- 3 × Load Cells (small form)
- 3 × HX711 Modules
- SSD1306 OLED Display
- 5V Power Supply (2–3A)
- Wires, connectors, breadboard/perfboard

Software
- Arduino IDE
- ESP32 Board Package
- Libraries: HX711, Blynk, Adafruit SSD1306, AccelStepper
- Blynk IoT / MQTT / HTTP server

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