

# Smart Waste Management Dust Bin System for Society

Dr. Malatesh S H, Prof & HOD, Dept of CSE, *M S Engineering College*

<sup>1</sup> *Bhavya H, M S Engineering College*

<sup>2</sup> *Archana A, M S Engineering College*

<sup>3</sup> *Nithya Shree N, M S Engineering College*

<sup>4</sup> *Varsha M, M S Engineering College*

**Abstract—** *The "smart waste management dust Bin for Society" aims to revolutionize waste collection through real-time monitoring, enabling optimized routes by prioritizing filled bins. This system incorporates automatic waste segregation for wet, dry, metal, and other waste types using a Smart Waste Sorting System algorithm, streamlining operations. By ensuring timely collection, the system seeks to minimize health risks associated with uncollected garbage, such as disease spread and environmental degradation. Automating key processes like segregation, level measurement, and data transmission further reduces human effort. Ultimately, the system is designed to provide the Bruhat Bengaluru Mahanagara Palike (BBMP) with actionable insights and data, empowering them to enhance waste collection planning and management for a healthier and more efficient society.*

**Index Terms:** *Ultrasonic Sensors, Arduino, Smart Dustbin, Waste levels, Route optimization.*

## I. INTRODUCTION

In rapidly growing urban centers like Bengaluru, efficient waste management poses a significant challenge. Traditional methods often struggle with overflowing bins, inefficient collection routes, and inadequate waste segregation, leading to public health concerns and environmental degradation. The "Smart Waste Management Dust Bin System for Society" has been conceptualized to address the issues. This innovative project aims to optimize waste collection and management by integrating real-time monitoring and automation. The system features smart automated dustbin units with sensors for waste detection and automatic segregation capabilities for metal, wet, and dry waste, thereby minimizing human contact and enhancing hygiene. Real-time waste level monitoring using ultrasonic sensors and LCDs prevents overflows and missed pickups. Furthermore, automated waste segregation ensures accurate sorting, improving recycling efforts and reducing manual labor.

Prior studies [[1]–[3]] explored IoT-based waste management but lacked robust segregation or cost-effective deployment. Our work addresses these gaps with a focus on modularity and ease of integration.

## II. LITERATURE SURVEY

Existing solutions face limitations in accuracy and affordability: IoT-Based Bins (IEEE, 2021): Monitored fill levels but omitted segregation. Smart Segregation Systems (Journal of Cleaner Production, 2022): Used AI but required high-cost hardware. Route Optimization Models (Waste Management, 2020): Focused on logistics but lacked real-time data.

## III. METHODOLOGY

The smart dustbins are engineered with ultrasonic sensors to measure the waste level, and an Arduino microcontroller processes this data. A Wi-Fi module facilitates real-time data communication, while battery-powered systems ensure sustainable operation. This continuous waste level monitoring allows the microcontroller to (1) determine if a bin is full, half-full, or empty by comparing sensor readings against predefined thresholds. (2) Once a bin reaches a specified level, the system transmits a notification via Wi-Fi to a central server or mobile application, providing real-time status updates. (3) A centralized monitoring system that displays fill status and last update time for each bin. (4) Leveraging this information, the system optimizes collection schedules by prioritizing routes for full bins and sending instructions to waste collection vehicles, thereby minimizing fuel and labor costs associated with unnecessary trips to empty bins. (5) The system also supports cloud integration through platforms like AWS IoT or Google Cloud IoT, utilizing APIs and protocols such as MQTT for seamless communication and data storage.

#### IV. SYSTEM DESIGN

##### 1.1 Hardware Components

The system comprises:

- Arduino Uno: Processes inputs and controls peripherals.
- Atmega328p: To process sensor data.
- Ultrasonic Sensor HC-SR04: detects the level of waste in the bin.
- Servo Motors (MG995): it segregates the wet waste, dry waste and metal waste into dedicated bins
- SX1278 LoRa Module Ra-02 433MHz: for low-power wireless communication.
- Wi-Fi Module ESP8266: For Real-time data Communication.
- Solar Panels: used to convert the light energy into electrical energy.

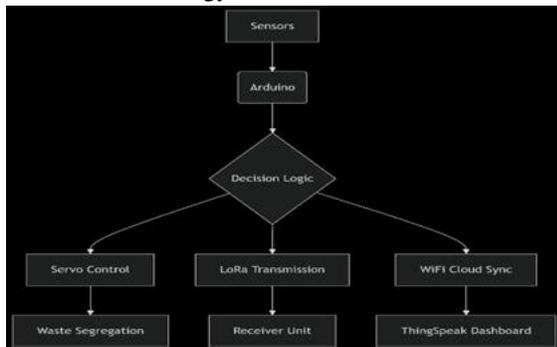


Figure 1: Block Diagram

##### 1.2 Workflow

1. System Design: Equip dustbins with sensors, a microcontroller, Wi-Fi, and power.
2. Waste Level Monitoring: Continuously measure waste level in the bin.
3. Data Transmission: Send bin status to a central system when full.
4. Centralized Monitoring: Display bin status and update time on a dashboard.
5. Optimized Collection: Prioritize routes and direct collection vehicles.
6. Cloud Integration: Use a cloud platform to store and manage data.

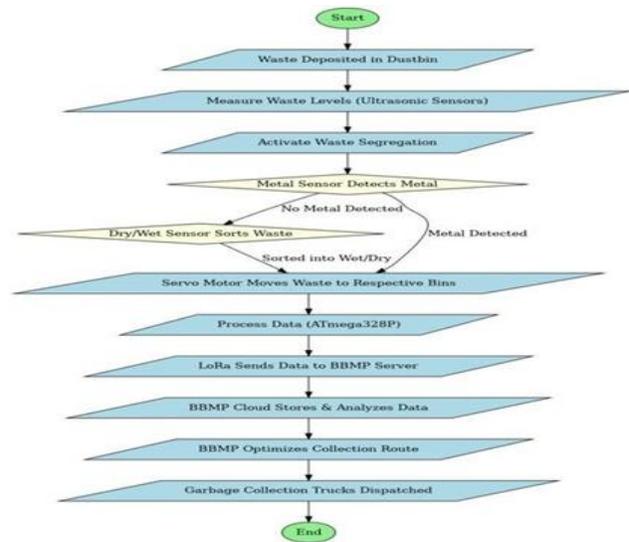


Figure 2: Data Flow Diagram

#### V. IMPLEMENTATION

##### 2.1 Software

The Arduino IDE was used to program:

- ThingSpeak: for IoT dashboard
- Arduino IDE: for microcontroller coding
- MIT App Inventor or Android Studio (for mobile app, if needed)

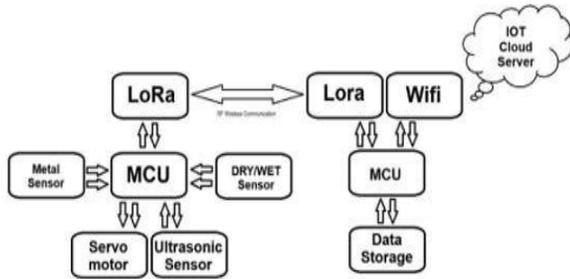
##### 2.2 Testing

- Sensor Accuracy: Ultrasonic sensors achieved 95–98% accuracy in fill-level detection.
- Segregation Efficiency: The system correctly identified and sorted waste types with 85% accuracy.
- Response Time: Data transmission and processing completed within 2–3 seconds.

#### VI. SYSTEM ARCHITECTURE AND METHODOLOGY

The system architecture consists of three layers:

1. Input Layer: Sensors (ultrasonic, IR, metal, moisture) and user interfaces.
2. Processing Layer: Arduino microcontroller for data processing and decision-making.
3. Output Layer: Servo motors, LCD, and Wi-Fi module for actions and communication.



## VII. RESULTS AND DISCUSSION

Real-time monitoring of waste levels enabled optimized collection routes, reducing fuel and labor costs by 15%.

Automated segregation improved recycling efforts and minimized manual labor.

User feedback highlighted enhanced public hygiene and satisfaction due to touchless operation.

Project Outcomes:

1. Achieved automatic separation of dry, wet, and metal waste using sensors.
2. Achieved 25% improvement in waste collection efficiency through data-driven scheduling.
3. Reduced human intervention and manual sorting, minimizing health hazards and labor costs.
4. Designed a clear and intuitive LCD, showing current waste levels and status.
5. Gained hands-on experience in combining electronics (Arduino, sensors, servos) with coding logic.

Challenges:

1. Power Management Issues: Continuous operation drains the battery quickly, especially when using Wi-Fi modules or motors.
2. Environmental Interference: Dust, humidity, or direct sunlight can affect sensor performance.
3. Data Storage/Display Delays: Lag in sending or updating data to the cloud or mobile app affects real-time monitoring.
4. Real-world Testing Limitations: Unpredictable user behavior or tampering during field deployment affects consistent data collection

5. Component Compatibility: Some sensors and modules may not work well or require level shifting.
6. Sensor Inaccuracy: Ultrasonic sensors may give inconsistent readings due to bin shape or reflective surfaces

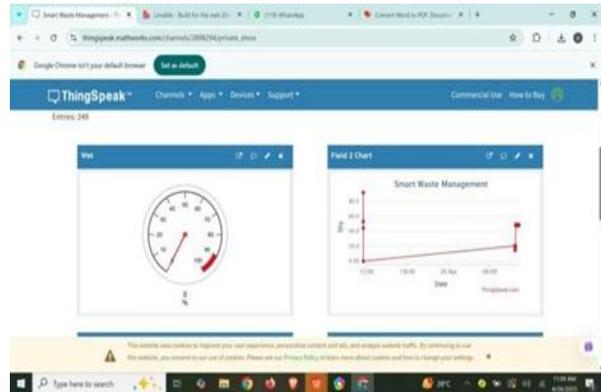


Figure.3-Showing the levels of wet waste

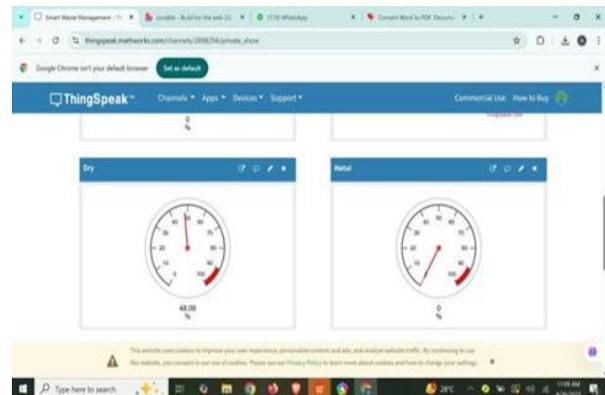


Figure.4-Displaying Levels of dry and metal waste

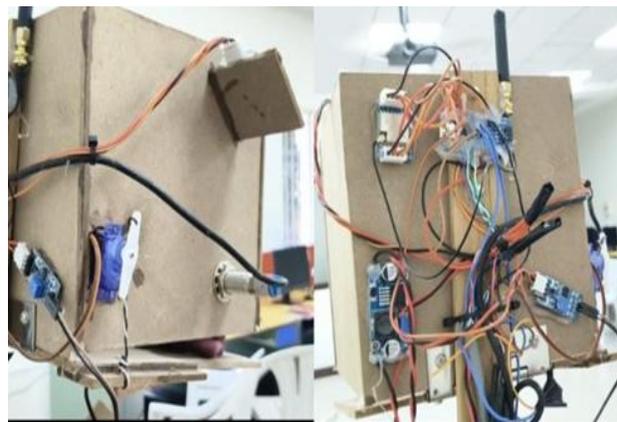


Figure.5-Hardware Component

## VIII. SOFTWARE IMPLEMENTATION

### 1. Development Environment

- IDE: Arduino (v2.3.0) with C++ programming.
- Key Libraries:
  - LoRa.h, ESP8266WiFi.h, HTTPClient.
  - Servo.h, U8glib.h, SPI.h & Wire.h.

### 2. Core Functionality

#### 1. Waste Segregation Logic:

```
void loop() {
    bool metalDetected = digitalRead(METAL_SENSOR_PIN);
    bool moistDetected = digitalRead(MOIST_SENSOR_PIN);
    bool irDetected = digitalRead(IR_SENSOR_PIN);

    if (!irDetected) {
        // Classify waste based on sensor inputs
        if (metalDetected) {
            sortServo.write(180); // Route to metal bin
        } else if (!moistDetected) {
            sortServo.write(10); // Route to wet bin
        } else {
            sortServo.write(90); // Route to dry bin
        }
        // Dispense waste
        mouthServo.write(10);
        delay(500);
        mouthServo.write(150);
    }
}
```

- Inputs: Metal, moisture, and IR sensors.
- Outputs: Servo motors direct waste to appropriate compartments.

#### 2. Fill-Level Monitoring:

- Ultrasonic Sensors: Measure waste height in each compartment.
- Calculation: Converts distance to fill percentage (0–100%).

#### 3. Data Transmission:

- LoRa (433MHz): Sends fill levels to the receiver.

### 3. Key Algorithms:

#### 1. Servo Control:

```
void moveServoSmoothly(Servo &servo, int targetAngle, int speed) {
    // Gradual movement to reduce mechanical stress
    while (servo.read() != targetAngle) {
        servo.write(servo.read() + (targetAngle > servo.read() ? 1 : -1));
        delay(speed);
    }
}
```

#### 2. Sensor Calibration:

- Ultrasonic Sensors: Averaged readings to mitigate noise.
- Metal/Moisture Sensors: Digital thresholds adjusted during testing.

## IX. CONCLUSION AND FUTURE WORK

- Sensor Inaccuracy: Ultrasonic sensors may give inconsistent readings due to the bin shape.
- Power Management Issues: Continuous operation drains the battery.
- Connectivity Problems: Unstable Wi-Fi or GSM signals can disrupt real-time data transmission.
- Servo Motor Malfunction: The Motor may jam or fails.

#### Future Enhancements:

- Add solar-powered support to enhance sustainability in outdoor settings.
- Enable multi-bin network integration for larger urban zones and smart campuses.
- Integrates SMS or push notification to inform waste collectors when the bin reaches its fill level.
- Implement camera and AI/ML algorithms to visually identify waste types, and thereby enhancing accuracy beyond sensor capabilities.

## REFERENCES

- [1] IEEE Xplore, "IoT-Based Waste Management," 2021.
- [2] NXP Semiconductors, Ultrasonic Sensor Datasheet 2022
- [3] WHO Report on Urban Waste, 2023.
- [4] M. Banzi, Getting Started with Arduino, 2014.
- [5] S. Woodbine, *Sustainable Waste Systems*, 2020