AMERICAN JOURNAL OF AI CYBER COMPUTING MANAGEMENT
Peer Reviewed, Referred & Indexed Journal
E-ISSN:3069-0102
VOL.6, NO. 1(2026)

IoT BASED WASTE MANAGEMENT SYSTEM

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ABSTRACT:

The growing complexity of urban solid waste management demands intelligent and autonomous monitoring solutions to ensure environmental sustainability and operational efficiency. This paper presents a novel IoT-enabled smart waste management architecture that integrates embedded sensing, real-time data analytics, and network-based communication for systematic waste supervision. The proposed system utilizes a Wi-Fi-enabled microcontroller interfaced with level detection, material identification, and disposal sensing modules to continuously evaluate bin status and classify waste at the source. Sensor data is transmitted to a centralized cloud interface where threshold-based alerts and status updates are generated for timely collection. The inclusion of geolocation support further enhances route optimization and logistical planning. The designed framework minimizes human intervention, improves segregation accuracy, and reduces overflow-related health hazards. Experimental validation demonstrates reliable performance, low power consumption, and scalable deployment capability, making the system suitable for smart city waste infrastructure applications.

Index Terms: Real-time monitoring, sensors, smart waste management, IoT, and route optimization, ESP32, Blynk live visualiser.

1. INTRODUCTION

At present, rapid urbanization has led to a significant increase in waste generation. In many areas, garbage accumulation can be observed on roadsides and in public places due to improper waste management practices. As a result, pollution levels are rising, leading to various health problems, new types of allergies, and the spread of infectious diseases. Many localities are becoming unhygienic, negatively affecting both environmental conditions and public health. Therefore, it has become essential to implement an effective and intelligent solution to address these growing challenges and ensure proper waste management.

To solve this issue, we have implemented an IoT-based Waste Management System that enables efficient and automated waste monitoring. The system uses the ESP32 microcontroller, which supports Wi-Fi connectivity and offers multiple GPIO pins for sensor interfacing, making it suitable for IoT applications. It performs sensor-based object detection, wet and dry waste segregation using a motor mechanism, and height measurement to determine the bin fill level. When waste is detected, a buzzer alert is activated, and the LCD displays details such as fill percentage, type of waste, and motor direction. The data is transmitted in real time through the Blynk live visualizer, sending notifications to the nearby municipal corporation along with the percentage of the filled bin via email.

Through real-time monitoring and automated alerts, the system reduces manual effort, improves time management, prevents overflow, and helps maintain a clean, hygienic, and healthy environment.

2.LITERATURE REVIEW

In recent years, rapid urbanization and population growth have significantly increased the volume of municipal solid waste, creating major challenges for conventional waste management systems. Traditional collection methods generally follow fixed schedules without considering the actual fill level of waste bins, leading to problems such as overflow, foul Odor, unnecessary fuel consumption, and inefficient use of manpower. To overcome these limitations, researchers and developers have explored the integration of Internet of Things (IoT) technology into waste management practices. IoT-based waste management syst

IoT-based waste management systems have gained significant attention as an efficient alternative to traditional waste collection methods. Conventionally, waste management relied on manual monitoring and fixed collection schedules, which often resulted in inefficient resource utilization, overflow of bins, and increased operational costs. To overcome these limitations, sensor-based approaches such as ultrasonic sensors, weight sensors, and infrared sensors were introduced to monitor waste levels in bins, enabling smarter decision-making.

With the advancement of Internet of Things (IoT) technology, smart waste management systems have become more reliable and scalable. IoT platforms enable real-time monitoring of waste bins through embedded systems like Arduino and ESP32, allowing data

transmission to cloud servers for analysis and visualization. This facilitates optimized waste collection routes, reducing fuel consumption and manpower requirements.

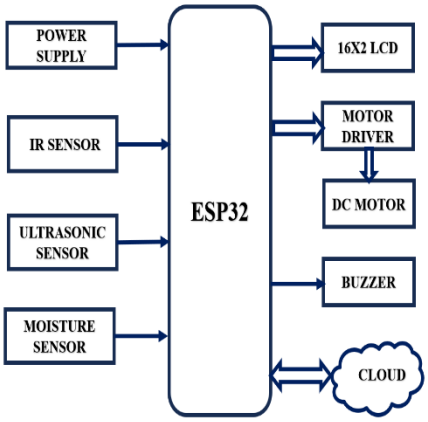
The integration wireless communication technologies such as Wi-Fi further enhanced the efficiency of these systems by enabling remote monitoring and control. Additionally, mobile applications and dashboards have been developed to provide live updates on bin status, improving responsiveness and maintenance planning.

Recent developments have also incorporated machine learning and image processing techniques for waste classification and segregation, improving recycling efficiency. Despite these advancements, limited work has been done on integrating multiple parameters such as moisture detection, segregation, and automated actuation within a single system.

This system extends existing research by combining IoT-based monitoring with real-time waste segregation and alert mechanisms, ensuring efficient waste handling and improved environmental sustainability.

3.PROPOSED SYSTEM

The proposed system aims to develop a smart and automated waste management solution using Internet of Things (IoT) technology. The system consists of an ESP32 microcontroller as the main processing unit, integrated with various sensors and communication modules. An ultrasonic sensor is used to measure the fill level of the garbage bin, while additional sensors are used for object detection and waste identification. Based on the detected waste type, a motor mechanism automatically segregates waste into wet and dry categories. The ESP32 processes the sensor data and continuously monitors the status of the bin in real time.

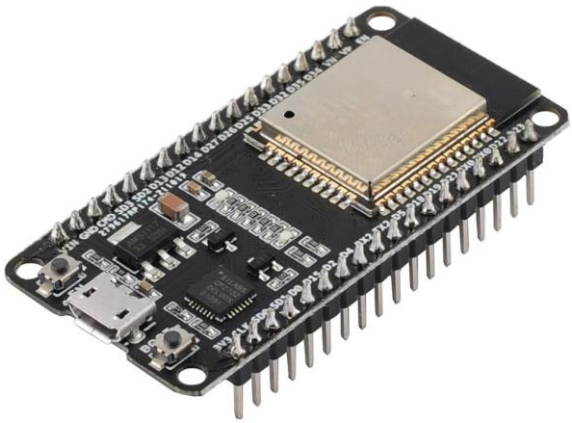


Whenever the waste level reaches a predefined threshold, the system generates an alert through a buzzer and displays the bin status, waste type, and fill percentage on an LCD screen. Using Wi-Fi connectivity, the collected data is transmitted to a cloud platform such as Blynk for real-time monitoring and visualization. An automated notification

is sent to the municipal authorities via email when the bin is full

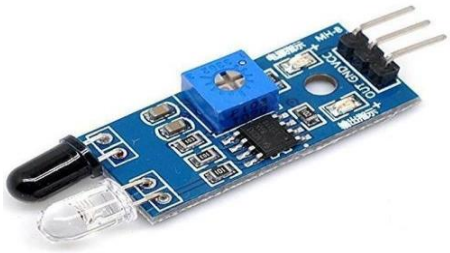
A. ESP32

The ESP32 module is a powerful and versatile microcontroller designed for IoT and embedded system applications. It comes with built-in Wi-Fi and Bluetooth connectivity, enabling seamless wireless communication. The module features a dual-core processor that provides high processing speed and efficient multitasking capabilities. It includes multiple GPIO pins for interfacing with sensors, actuators, LCD displays, and other peripheral devices, along with support for both analog and digital input/output operations. The ESP32 supports various communication protocols such as UART, SPI, and I2C, making it highly flexible for different hardware integrations.



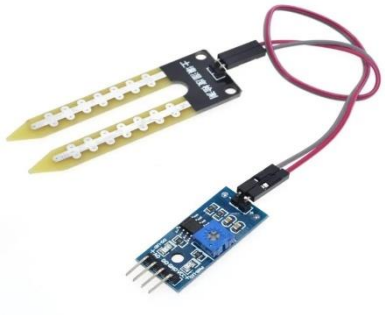
B.IR Sensor

An IR (Infrared) sensor is an electronic device used to detect objects and obstacles by emitting and receiving infrared radiation. It works on the principle of reflection, where the transmitter emits infrared light and the receiver detects the reflected signal when an object comes in front of it.



C.Moisture Sensor

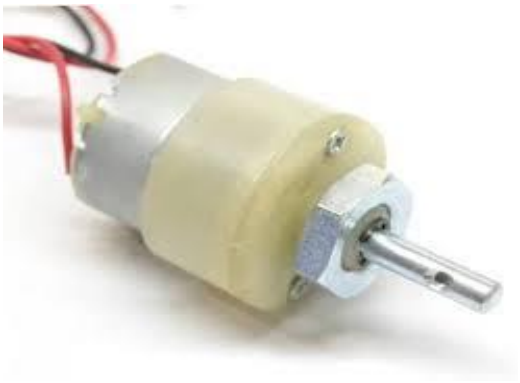
A moisture sensor is an electronic device used to detect the presence and level of moisture in materials. It works by measuring the electrical conductivity or resistance between its probes, which changes based on the amount of water present.



D.DC Geared motor

The 12V DC geared motor is a high-torque electromechanical drive that is used to perform various tasks in automated systems. It is essentially a DC motor that uses a gearbox to reduce its speed while increasing its output. The 12V DC geared motor can't be directly connected to the microcontroller because

it operates at 12V. It should be connected to a relay module to ensure its safe operation. The Arduino will control a relay to ensure that 12V power is supplied to the motor.



E.DC Motor Driver

A DC motor driver is an electronic module used to control the speed and direction of a DC motor. Since a microcontroller like the ESP32 cannot directly drive a motor due to low current output, a motor driver acts as an interface between the motor and the controller. It provides sufficient current and voltage required for motor operation and protects the microcontroller from damage. Motor drivers such as L298N or L293D allow bidirectional control, meaning the motor can rotate in both clockwise and anticlockwise directions



F. Ultrasonic Sensor

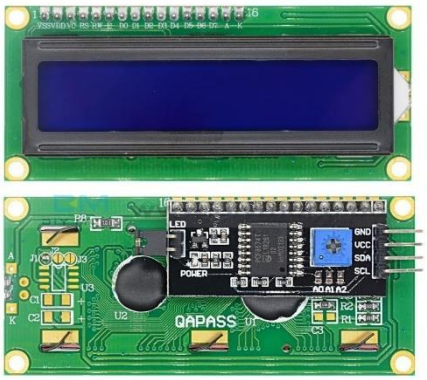
An Ultrasonic Sensor is an electronic device used to measure distance by using high-frequency sound waves. It works on the principle of echo and reflection of sound. The sensor consists of a transmitter and a receiver. The transmitter sends ultrasonic sound waves (usually above 20 kHz), and when these waves hit an object, they reflect back to the receiver



G.I2C LCD Display

An I2C LCD Display is a type of liquid crystal display that communicates using the I2C (Inter-Integrated Circuit) protocol. It is commonly used with microcontrollers like ESP32 and Arduino to display text and basic information. Unlike a normal 16x2 LCD that requires many connection pins, the I2C LCD uses only two communication wires – SDA (Serial Data) and SCL (Serial Clock) – along with VCC and GND. This reduces wiring complexity and saves GPIO pins. I2C LCD displays are mostly based on a 16x2 or 20x4 LCD module with an I2C

backpack (usually PCF8574 IC). They are widely used in IoT projects to display sensor readings such as temperature, distance (from ultrasonic sensor), moisture level, and system status messages. The display is cost-effective, easy to interface, consumes less power, and is suitable for embedded and smart monitoring applications.



H. Buzzer

A buzzer is an electronic audio signalling device used to produce sound alerts in embedded and IoT systems. It converts electrical energy into sound energy and is commonly used for alarms, notifications, and warning indications.



feature helps in reducing manual monitoring efforts by

I.Blynk Live visualizer

The Blynk Live Visualizer plays a crucial role in the IoT-based waste management system by providing real-time monitoring and user-friendly visualization of sensor data. It acts as an interface between the hardware components and the end user, enabling efficient tracking and management of waste levels. In this system, the Blynk platform is integrated with an ESP32 microcontroller to transmit data collected from sensors such as the ultrasonic sensor and moisture sensor. The data is sent to the Blynk cloud and displayed on a mobile application using virtual pins.

The bin level is continuously monitored and displayed as a percentage using a gauge widget, allowing users to easily understand the fill status of the dustbin. Additionally, waste classification is visualized by indicating whether the waste is dry or wet using LED indicators and text labels. This improves awareness and supports proper waste segregation. The live visualization

providing instant updates. It also enables timely action when the bin reaches a critical level, thereby preventing overflow and maintaining cleanliness.

Overall, the Blynk Live Visualizer enhances the efficiency, usability, and effectiveness of the smart waste management system by offering a simple and interactive monitoring solution.

4. SYSTEM SETUP AND OUTPUT

A. Hardware Setup and Configuration

The system is built using an ESP32 microcontroller integrated with sensors such as an ultrasonic sensor for bin level detection and a moisture sensor for waste classification. Additional components like a DC geared motor, motor driver, buzzer, and LCD display are connected to perform automation and provide local output.

B. Software Setup and Initialization

The program is developed using Arduino IDE, where necessary libraries for ESP32, Wi-Fi communication, and sensor interfacing are included. The Blynk IoT platform is configured with virtual pins to visualize the sensor data. After uploading the code, the ESP32 connects to the Wi-Fi network and initializes communication with the Blynk cloud.

C. Sensor Data Acquisition

The ultrasonic sensor continuously measures the distance between the waste and the top of the bin to calculate the fill level. Simultaneously, the moisture sensor detects the presence of moisture in the waste to classify it as dry or wet. These sensor values are processed by the ESP32 in real time.

D. Data Processing and Decision Making

The collected sensor data is analysed using predefined threshold values. The bin level is converted into percentage form, and the moisture value is used to determine the type of waste. Based on these values, the system decides whether the bin is full and identifies the waste category.

E. IoT Communication with Blynk

The processed data is transmitted from the ESP32 to the Blynk cloud using Wi-Fi. Virtual pins are used to send parameters such as bin level percentage, dry waste indication, and waste type. This enables real-time remote monitoring through the Blynk mobile application.

F. Actuation and Alert Mechanism

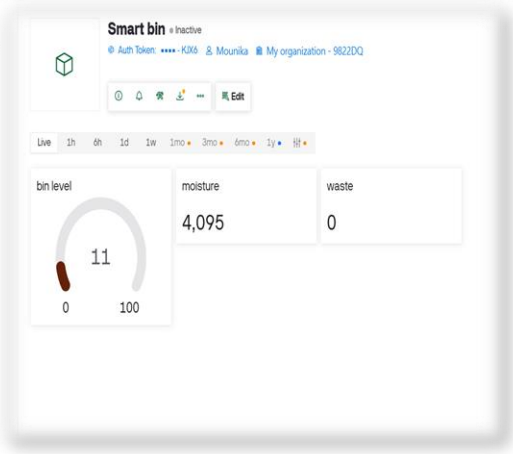
When the bin level exceeds a predefined limit (e.g., 80%), the system activates a buzzer to provide a local alert. Additionally, the motor mechanism can be used for automatic waste segregation or lid control. Notifications are also sent through the Blynk app to alert the user.

G. Output Visualization and Monitoring

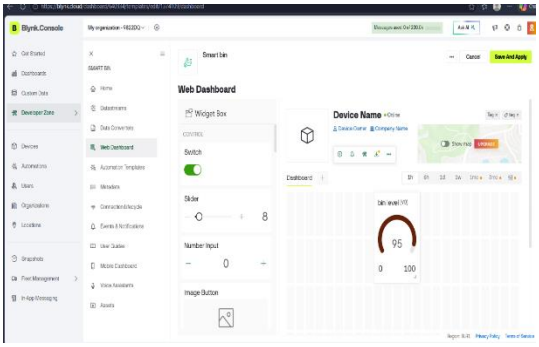
The Blynk dashboard displays the bin level, waste type (dry/wet), and system status in real time. The LCD also shows local information for easy monitoring. This ensures that users can track the condition of the waste bin both locally and remotely.

5.Results

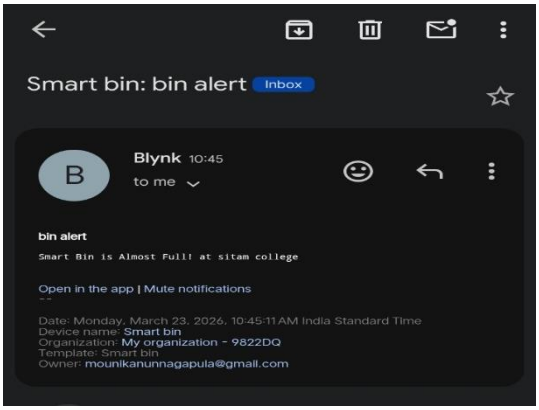
The Blynk dashboard provides a user-friendly interface for real-time monitoring of the dustbin status. It displays the percentage of the bin level, moisture level, and the type of waste, indicating whether the waste is dry or wet.



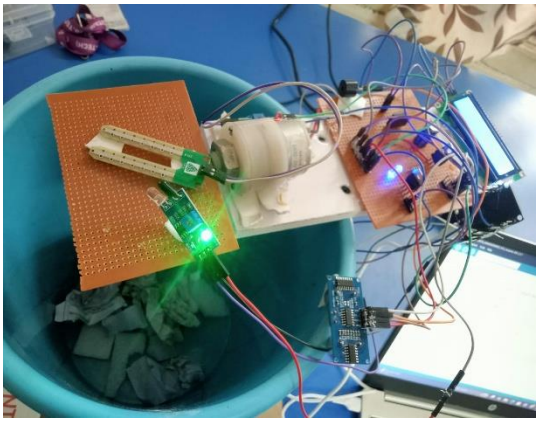
The above figure shows that the bin level, moisture level and type of waste. This dashboard enables users to remotely monitor the condition of the bin efficiently and take necessary actions when required. The integration with the Blynk platform enabled live visualization of data, allowing users to monitor bin status from anywhere. The bin level updates were transmitted in real-time, ensuring timely awareness of the fill status.



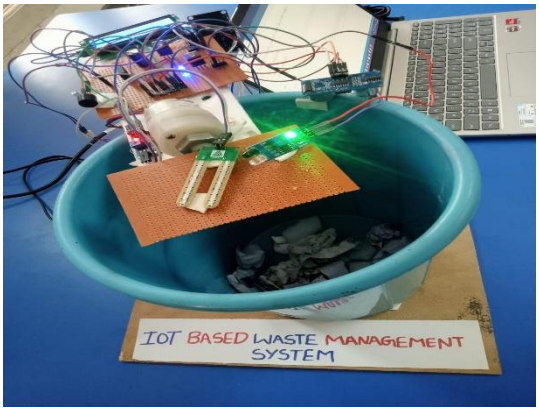
The above figure shows that the maximum bin level reaching if the bin reaches the maximum threshold it will sends the message to our then we get alert the buzzer also then the bin level wis displayed on lcd.



The above figure shows that the if the bin reaches the threshold level the alert message will be sent to our mobile.



The above figure shows that the hardware implementation of the system includes ESP32, ultrasonic sensor, moisture sensor, DC geared motor, motor driver, buzzer, LCD display, and power supply. These components work together to detect waste levels, classify waste type, and provide alerts, ensuring smooth and automated system operation.



The above figure shows that the Overall,system proved to be cost-effective, efficient, and user-friendly. It reduces human effort, improves waste management efficiency, and supports smart city applications. The system also contributes to environmental sustainability by promoting proper waste segregation and timely waste disposal.

6.CONCLUSION

The proposed IoT-based waste management system successfully demonstrates an intelligent and automated approach to waste monitoring and segregation by integrating sensor technology with cloud-based visualization. Real-time detection of bin levels and moisture-based waste classification, along with Blynk-based live monitoring and alert mechanisms, ensures reliable and efficient system performance. The solution is cost-effective, user-friendly, and scalable, making it suitable for smart city applications and future advancements in sustainable and automated waste management systems.

7.REFERENCES

[1] Blynk Inc., “Blynk IoT Platform Documentation,” 2023. This reference describes the Blynk platform used for real-time data visualization and remote monitoring in simple IoT applications.

[2] F. Folianto, Y. S. Low, and W. L. Yeow, “Smartbin: Smart waste management system,” in *IEEE Conference on Intelligent Sensors, Sensor Networks and InformationProcessing*,2015. This paper presents a smart waste management system using

sensors to monitor bin levels and optimize waste collection processes in real time.

[3] S. S. Navghane, M. S. Killedar, and V. M. Rohokale, "IoT Based Smart Garbage and Waste Collection Bin," *International Journal of Advanced Research in Electronics and Communication Engineering*, vol. 5, no. 5, 2016. This project focuses on using IoT technology to monitor garbage levels and send notifications for timely waste collection.

[4] P. S. Gayathri, P. M. Nandhini, and M. V. Sharmila, "Smart Waste Management System Using IoT," *International Journal of Pure and Applied Mathematics*, 2018. This work presents a simple IoT-based system for monitoring waste bins and sending alerts when full.

[5] S. Longhi, D. Marzioni, E. Alidori, G. Di Buò, M. Prist, and M. Crisostomo, "Solid Waste Management Architecture Using Wireless Sensor Network Technology," in *IEEEConference*,2012. This paper presents a basic waste monitoring system using simple sensor networks for detecting bin status.