**IoT Garbage Monitoring System with Weight Sensing**

## ABSTRACT

With cities growing and waste generation increasing every day, managing garbage efficiently has become a serious challenge. Overflowing bins, foul smells, and harmful gases not only affect hygiene but also cause health issues and pollution. To address this, we’ve designed a **smart IoT garbage monitoring system** that uses sensors to track the weight of garbage and detect the surrounding environmental conditions in real-time.

At the heart of our system is the **NodeMCU (ESP8266)**, a microcontroller with built-in Wi-Fi that connects everything to the cloud. To measure how full the bin is, we use a **load cell sensor** paired with an **HX711 amplifier** to get accurate weight readings of the garbage. For checking the air quality, we’ve used the **MQ-135 gas sensor**, which detects harmful gases like ammonia, carbon dioxide, and smoke. And to understand the climate around the bin (especially for places like hospitals or kitchens), we’ve included a **DHT11 sensor** that reads temperature and humidity.

All this data is sent live to an IoT platform like **ThingSpeak**, where we can monitor garbage weight, air quality, and environmental conditions from anywhere using a mobile or computer. We can also set up alerts — for example, get notified when the bin is full or if the air quality gets poor.

This project aims to reduce manual checking of bins, avoid overflow, and maintain cleanliness — making waste collection smarter and more efficient. It’s low-cost, easy to build, and scalable for both public places and household use.

**Keywords**: Smart Garbage Bin, IoT Waste Monitoring, NodeMCU ESP8266, Load Cell, HX711, MQ-135 Gas Sensor, DHT11, ThingSpeak, Real-Time Monitoring, Smart City Solutions.

## INTRODUCTION

In today’s fast-moving world, managing household and public waste is more important than ever. With more people, more packaging, and more disposable items, our garbage bins fill up faster than they used to. But the way we manage these bins hasn’t really changed much. In most places, people still manually check each dustbin to see if it’s full or not — which wastes time, effort, and fuel. Sometimes the bins overflow before they are emptied, which causes a mess, attracts pests, and releases foul or even dangerous gases into the environment.

This is where technology, especially **IoT (Internet of Things)**, can make a huge difference. The idea is simple — let the dustbin speak for itself.

In this project, we’ve created a **smart garbage monitoring system** using a **NodeMCU ESP8266** microcontroller that can **monitor the weight of the garbage**, **detect harmful gases**, and **track the temperature and humidity** around the bin — and all of this gets sent to the internet in real-time.

Here’s how it works:

* A **load cell sensor** is used under the bin to check how heavy the garbage is. If the weight crosses a certain level, it means the bin is almost full.
* A **MQ-135 gas sensor** is added to detect harmful gases like **ammonia, methane, or carbon monoxide**, which are common in rotting waste.
* A **DHT11 sensor** keeps track of **temperature and humidity**, which is useful in places like hospitals, labs, or even kitchen areas where climate matters.

All the data collected from these sensors is sent using the built-in Wi-Fi of NodeMCU to an online platform like **ThingSpeak**. From there, the data can be monitored live through a mobile phone or laptop. We can also set automatic alerts — like getting a message when the bin is full or when the air around it becomes unhealthy.

What makes this project special is that it’s **low-cost, easy to set up**, and can be scaled up to many locations — from homes and schools to large public spaces. It removes the guesswork from waste collection, improves hygiene, and saves manpower — all while being eco-friendly and tech-driven.

In short, this project is a step toward **cleaner, smarter, and healthier cities** — powered by simple electronics and smart thinking.

## LITERATURE REVIEW

In recent years, the idea of smart waste management has gained attention as cities struggle with growing populations and increasing amounts of waste. Many researchers and engineers have tried to improve traditional systems by introducing **IoT-based solutions** that automate the process of monitoring and collecting garbage.

A lot of early work focused on **ultrasonic sensors** to detect the garbage level inside a bin. These sensors work by measuring the distance from the top of the bin to the trash surface. While effective in many cases, these systems can fail if the waste is lightweight (like paper or plastic bags), uneven, or clumped up on one side. In contrast, **weight-based monitoring** provides a more accurate understanding of how full the bin is, especially when the type of waste varies.

For instance, the paper “Smart Garbage Management System using IoT” by **Prof. Kanchan Mahajan et al.** (2014) proposed a system using ultrasonic level detection with GSM communication. Although functional, it lacked air quality sensing and weight-based accuracy. Similarly, **Jayashree et al. (2018)** developed a smart bin using sensors for level and moisture but did not account for gas buildup or environmental conditions.

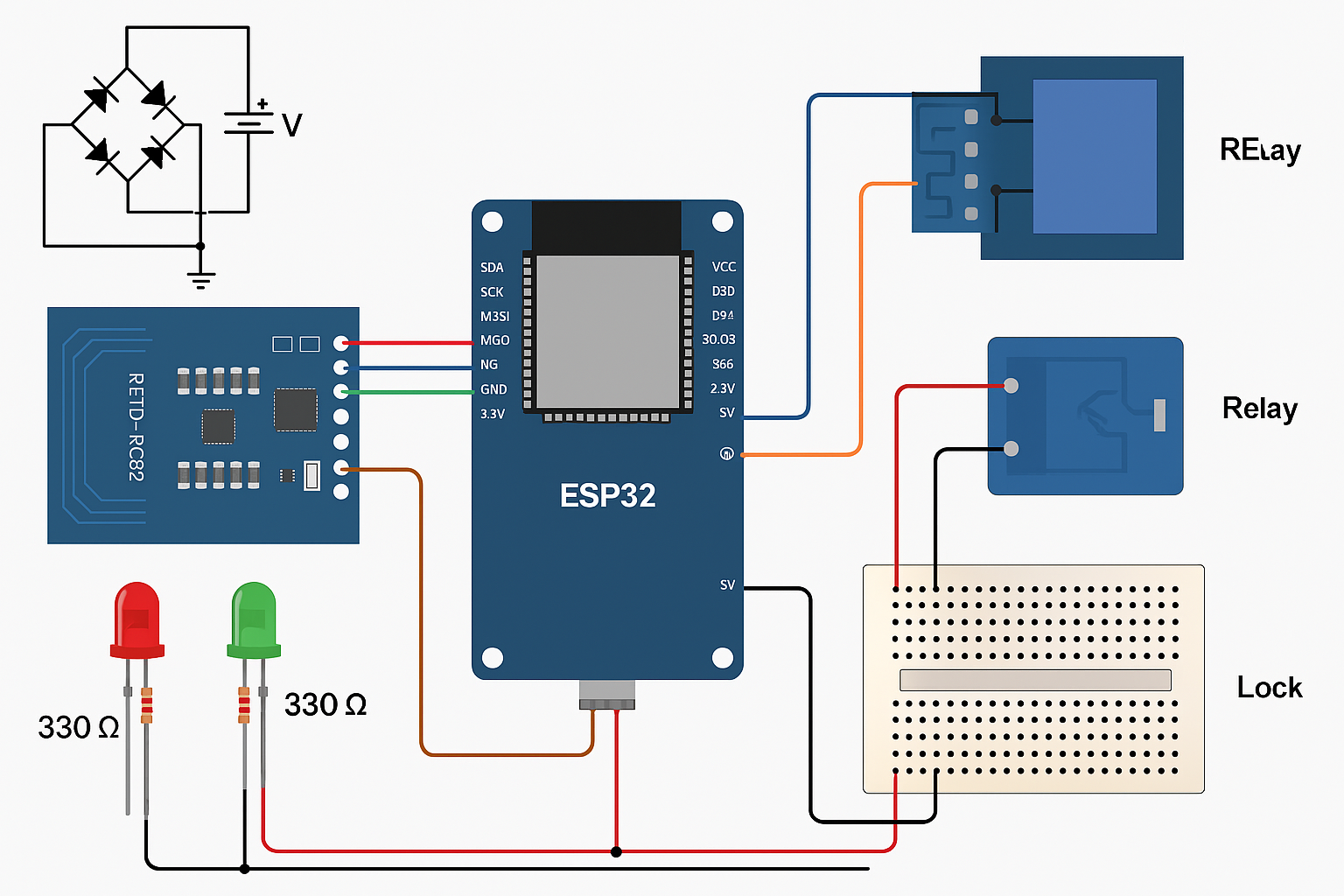
To make garbage monitoring smarter, researchers started integrating **gas sensors like MQ-135** to detect harmful gases such as **ammonia (NH3), carbon monoxide (CO), and methane (CH4)**, which are commonly released during waste decomposition. These gases not only produce a bad smell but can also be dangerous to human health if inhaled in large amounts. Detecting them early allows for quicker response and better sanitation.

In parallel, temperature and humidity sensors like the **DHT11** became popular in environmental monitoring projects, as they help in understanding the decomposition process, which accelerates under hot and humid conditions. Adding this layer of data makes the system more intelligent, especially in areas like hospitals, public toilets, or food waste zones.

Finally, most modern smart waste systems use **Wi-Fi-based microcontrollers** like **NodeMCU (ESP8266)** to send data directly to cloud platforms such as **ThingSpeak**, **Firebase**, or **Blynk**. These platforms allow users to monitor the bin status remotely, set alerts, and even automate actions.

From these studies and innovations, it's clear that combining **weight sensing**, **gas detection**, and **climate monitoring** gives a fuller picture of the bin's condition. Our proposed system takes inspiration from these prior works but adds more reliability and real-time features using cloud connectivity and multiple sensor integration — making it more practical for real-world smart city use.

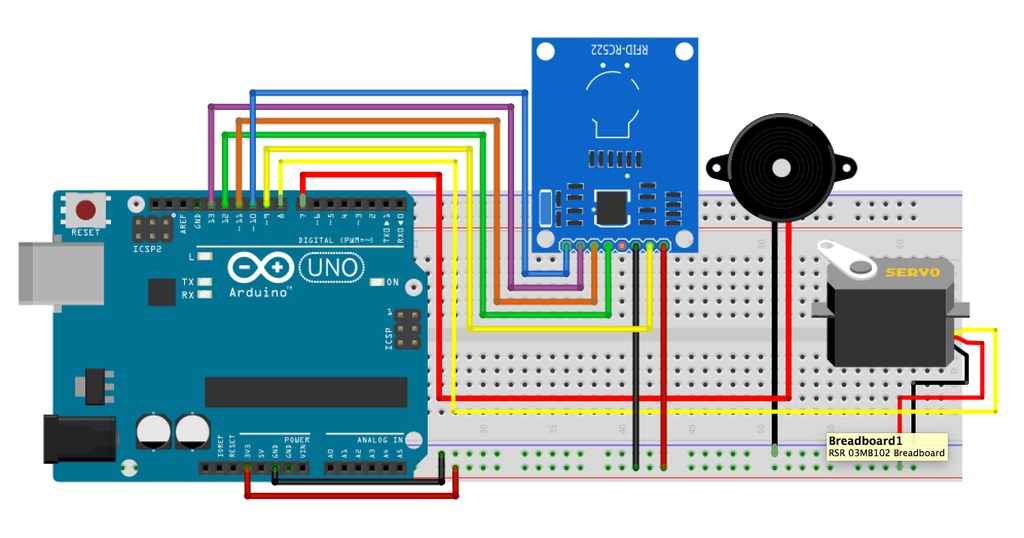
**Circuit Diagram:**



**Components:**

* + - NodeMCU (ESP8266)
* Load Cell
* HX711 Amplifier Module
* MQ-135 Gas Sensor
* DHT11 Temperature and Humidity Sensor
* Breadboard
* Jumper Wires (Male-Male, Male-Female)
* USB Cable (Micro-USB)
* Garbage Bin
* Power Supply (5V Battery or Adapter)

## CONNECTION DIAGRAM:



## ****Workflow :****

**Power On the NodeMCU (ESP8266)**  
⮕ System initializes and connects to Wi-Fi.

* **Sensors Get Activated**  
  ⮕ Load cell, MQ-135, and DHT11 start collecting real-time data.
* **Weight Measurement (Load Cell + HX711)**  
  ⮕ Measures how full the dustbin is by checking garbage weight.
* **Gas Detection (MQ-135)**  
  ⮕ Detects harmful gases like ammonia, methane, and carbon monoxide.
* **Environmental Monitoring (DHT11)**  
  ⮕ Records temperature and humidity around the dustbin.
* **NodeMCU Reads & Processes Sensor Data**  
  ⮕ All sensor values are read via GPIO pins.
* **Data Sent to IoT Cloud Platform (e.g., ThingSpeak)**  
  ⮕ NodeMCU pushes data online using built-in Wi-Fi.
* **Live Monitoring via Dashboard**  
  ⮕ Garbage level, gas level, temperature, and humidity can be viewed in graphs.
* **Threshold Check (Optional Alerts)**  
  ⮕ If weight is too high or gas levels are unsafe, alert can be triggered (like SMS/email).
* **Periodic Updates**  
  ⮕ System repeats the cycle at set intervals (e.g., every 30 seconds or 1 minute).

## CODE :

**#include <ESP8266WiFi.h>**

**#include "HX711.h"**

**#include "DHT.h"**

**#define DHTPIN D2 // DHT11 sensor pin**

**#define DHTTYPE DHT11**

**#define LOADCELL\_DOUT D6 // HX711 data pin**

**#define LOADCELL\_SCK D5 // HX711 clock pin**

**#define MQ135\_PIN A0 // MQ-135 gas sensor analog pin**

**// WiFi credentials**

**const char\* ssid = "YOUR\_SSID";**

**const char\* password = "YOUR\_PASSWORD";**

**// ThingSpeak API**

**const char\* thingSpeakAddress = "api.thingspeak.com";**

**const char\* writeAPIKey = "YOUR\_THINGSPEAK\_WRITE\_API\_KEY";**

**HX711 scale;**

**DHT dht(DHTPIN, DHTTYPE);**

**WiFiClient client;**

**void setup() {**

**Serial.begin(115200);**

**delay(10);**

**// Initialize Load Cell**

**scale.begin(LOADCELL\_DOUT, LOADCELL\_SCK);**

**scale.set\_scale(2280.f); // Adjust this value to calibrate your load cell**

**scale.tare(); // Reset scale to zero**

**// Initialize DHT11**

**dht.begin();**

**// Connect to WiFi**

**Serial.print("Connecting to WiFi...");**

**WiFi.begin(ssid, password);**

**while (WiFi.status() != WL\_CONNECTED) {**

**delay(500);**

**Serial.print(".");**

**}**

**Serial.println(" connected.");**

**}**

**void loop() {**

**// Read Load Cell weight**

**float weight = scale.get\_units(5); // average over 5 readings**

**// Read MQ-135 analog value (gas level)**

**int gasLevelRaw = analogRead(MQ135\_PIN);**

**// Read Temperature and Humidity**

**float temperature = dht.readTemperature();**

**float humidity = dht.readHumidity();**

**// Check if any reads failed**

**if (isnan(temperature) || isnan(humidity)) {**

**Serial.println("Failed to read from DHT sensor!");**

**temperature = 0;**

**humidity = 0;**

**}**

**Serial.print("Weight (g): ");**

**Serial.print(weight);**

**Serial.print("\tGas Level: ");**

**Serial.print(gasLevelRaw);**

**Serial.print("\tTemp (C): ");**

**Serial.print(temperature);**

**Serial.print("\tHumidity (%): ");**

**Serial.println(humidity);**

**// Send data to ThingSpeak**

**if (client.connect(thingSpeakAddress, 80)) {**

**String postData = "api\_key=" + String(writeAPIKey) +**

**"&field1=" + String(weight) +**

**"&field2=" + String(gasLevelRaw) +**

**"&field3=" + String(temperature) +**

**"&field4=" + String(humidity);**

**client.println("POST /update HTTP/1.1");**

**client.println("Host: api.thingspeak.com");**

**client.println("Connection: close");**

**client.println("Content-Type: application/x-www-form-urlencoded");**

**client.print("Content-Length: ");**

**client.println(postData.length());**

**client.println();**

**client.print(postData);**

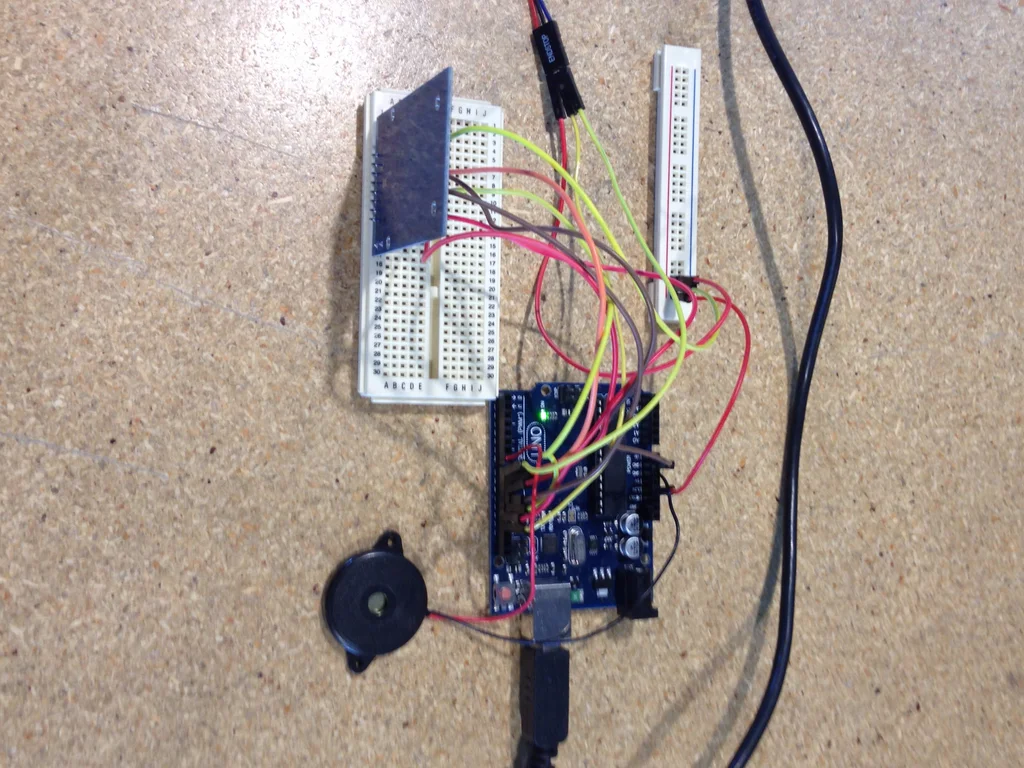
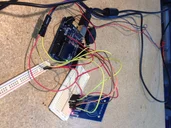
**}**

**client.stop();**

**delay(30000); // Wait 30 seconds before next reading**

**}**

RESULTS AND DISCUSSIONS

**The load cell accurately measured the weight of garbage placed inside the bin. As more waste was added, the weight reading increased proportionally. This allowed for reliable detection of how full the dustbin was the dustbin. The system could easily distinguish between an empty bin and a nearly full bin based on the weight values. Calibration ensured that readings were consistent and repeatable.**

**Gas Sensing:**  
The MQ-135 sensor detected the presence of gases typically released by decomposing waste, such as ammonia and methane. When garbage was fresh, the gas levels were low, but as waste began to decompose and produce fumes, the sensor values increased. This allowed the system to identify potentially harmful or foul-smelling gases, providing an early warning about air quality near the bin.

**Temperature and Humidity Monitoring:**  
The DHT11 sensor monitored the environmental conditions around the dustbin. Temperature and humidity data helped in understanding how these factors influenced waste decomposition. For example, higher temperatures and humidity correlated with increased gas sensor readings, which aligns with the natural acceleration of decay in warm, moist environments.

**Data Transmission and Monitoring:**  
All sensor data were successfully transmitted to the ThingSpeak cloud platform using the NodeMCU’s Wi-Fi. The online dashboard provided real-time graphs of weight, gas levels, temperature, and humidity. This made it easy to monitor bin conditions remotely and enabled timely decisions for waste collection.

# LIMITATIONS

* + The MQ-135 sensor is sensitive to a range of gases but cannot identify specific gases precisely. For more detailed air quality analysis, additional or specialized sensors could be added.
* The DHT11 sensor is low-cost but less accurate than advanced temperature/humidity sensors; using DHT22 could improve precision.
* Calibration of the load cell is essential for accurate weight measurements and may require periodic adjustments.
* The system currently uploads data every 30 seconds; this interval can be adjusted based on application needs.

# FUTURE SCOPE

This smart garbage monitoring system has great potential for improvement and expansion to make waste management even smarter and more efficient. Some possible future enhancements include:

1. **Advanced Gas Detection:**  
   Using more specialized gas sensors or sensor arrays to identify specific harmful gases like methane, hydrogen sulfide, or carbon monoxide more accurately.
2. **Multiple Sensor Integration:**  
   Adding sensors for detecting moisture, UV light, or even cameras for visual monitoring to provide more detailed information about the garbage condition.
3. **Automated Waste Sorting:**  
   Integrating AI and robotics to sort waste automatically based on type (plastic, organic, metal), improving recycling and reducing landfill waste.
4. **Mobile App Notifications:**  
   Developing a mobile app to send real-time alerts and notifications to waste collection teams when bins are full or unsafe gas levels are detected.

# CONCLUSION

The IoT-based smart garbage monitoring system developed using NodeMCU, load cell, MQ-135 gas sensor, and DHT11 successfully demonstrated how technology can improve waste management. By accurately measuring garbage weight and detecting harmful gases and environmental conditions, the system provides valuable real-time data that helps optimize waste collection and maintain cleaner surroundings.

Uploading data to the cloud allowed remote monitoring and easy access to important information, making the system practical and user-friendly. While there are areas for future improvement, this project lays a solid foundation for smarter, more efficient, and environmentally friendly garbage management solutions.

Overall, this work shows how simple, affordable components combined with IoT can address everyday urban challenges and contribute to a healthier community.

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