Smart Dustbin with Dry and Wet Waste Segregation using IOT

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Bachelor of Computer Applications

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# Abstract

The growing need for effective waste management calls for innovative solutions that can efficiently handle waste segregation. This project introduces a *Smart Dustbin* system with an automated dry and wet waste segregation mechanism, enhanced by Internet of Things (IoT) technology for continuous monitoring and data accessibility. By employing a variety of sensors, including infrared, ultrasonic, and moisture sensors, the smart dustbin can distinguish between wet and dry waste, allowing for accurate sorting into designated compartments. The system is managed by microcontrollers that process the sensor data and relay real-time updates on waste levels, composition, and collection needs to an IoT-based platform. This enables municipal authorities to remotely monitor waste levels, plan optimized collection routes, and prevent overflow incidents, thus ensuring timely waste disposal. The proposed smart dustbin not only minimizes human intervention but also reduces contamination in recyclable materials, promoting sustainable waste management practices. This automated system represents a forward-thinking approach to environmental conservation and efficient urban waste handling, addressing key challenges in modern waste management systems.

# Introduction

In today’s rapidly urbanizing world, effective waste management has become a critical environmental and public health concern. Traditional waste handling methods often lack efficiency, resulting in unsorted waste, overfilled landfills, and the loss of recyclable resources. The integration of the Internet of Things (IoT) offers a promising solution to this problem by enabling the development of intelligent waste management systems. This project focuses on designing a \*Smart Dustbin\* that can automatically segregate dry and wet waste while utilizing IoT technology for real-time monitoring. The system aims to improve waste segregation efficiency, reduce human intervention, and facilitate optimal waste collection management by municipal authorities.

IoT-enabled systems have become increasingly favored for such applications due to their capacity for seamless data transmission, remote monitoring, and automation. In particular, the use of microcontrollers such as the Raspberry Pi, which is equipped with integrated Wi-Fi and Bluetooth, allows for straightforward connectivity with sensors, actuators, and cloud platforms. This adaptability and connectivity make the Raspberry Pi an ideal choice for building a smart dustbin that can efficiently sort waste and relay data to an IoT platform, providing real-time insights for waste management operations [1, 2].

The proposed \*Smart Dustbin\* system incorporates sensors to identify the type of waste being disposed of. For example, moisture sensors help differentiate wet waste from dry waste, while infrared sensors detect the presence of waste items. Once the waste type is identified, the system directs it to the appropriate compartment, ensuring effective segregation. This automated classification minimizes human effort and reduces the likelihood of contamination in recyclable materials. Data from the sensors is processed by the Raspberry Pi and transmitted to an IoT platform, where authorized personnel can monitor bin fill levels and receive alerts when collection is required, optimizing waste management logistics [2, 3].

A defining feature of this smart dustbin system is its IoT integration, which enables municipal waste management teams to monitor waste levels remotely through a mobile app or web dashboard. This connectivity allows for dynamic collection scheduling based on actual bin usage, reducing overflow incidents and enhancing operational efficiency. In contrast to conventional waste collection systems, the IoT-based approach provides a higher level of situational awareness and control, improving overall waste management and promoting a cleaner environment [4].

The Raspberry Pi microcontroller is highly suitable for this project, as it supports real-time data processing, sensor integration, and wireless connectivity. For future enhancements, the system could include additional sensors, such as odor sensors for organic waste detection or weight sensors for more precise fill-level monitoring. Furthermore, by connecting with cloud-based data analytics services, the system can generate insights on waste trends and user behavior, helping cities to plan more effective waste reduction strategies [4, 5].

This report discusses the design and implementation of the smart dustbin system, detailing the hardware components, software development, IoT integration, and system testing processes. Related research on IoT-based waste management solutions is reviewed, focusing on the advantages and limitations of existing technologies. A comprehensive assessment of the system’s performance is provided, demonstrating the Raspberry Pi-based dustbin’s effectiveness in meeting waste segregation and monitoring objectives. The report concludes with an exploration of potential future developments, highlighting opportunities for scalability and the broader impact of smart waste management systems on urban sustainability. [5, 6].

Through this project, we aim to contribute to sustainable urban development by introducing a smart dustbin that facilitates automated waste segregation and efficient data-driven waste management. By focusing on real-time monitoring, remote accessibility, and modularity, this system signifies a step forward in waste management practices. As IoT technology continues to evolve, such systems are likely to become an integral component of smart city infrastructures, fostering a cleaner and more resource-conscious society.

This project seeks to develop a smart home security system by incorporating advanced technologies, making it both efficient and available to a diverse group of users. Focusing on real-time monitoring, remote control, and scalability, the system marks an important advancement in enhancing home security. As IoT progresses, these systems are anticipated to become a common aspect of contemporary homes, providing a more secure and interconnected living space.[6]

# Related Work

Prior work in the field of IoT-enabled waste management systems has predominantly focused on smart bins that can automatically compact waste and alert authorities when full. However, there has been limited research on smart dustbins that can segregate waste into dry and wet categories.

**[Dr. Nilima Kulkarni]** The waste management process includes steps from waste collection to its final disposal. Waste management is required to avoid adverse effects of the waste on human beings. When dry and wet waste mixed, it breakdowns into landfills and creates some dangerous greenhouse gases. Thus, the segregation of waste is an important process under waste management. Segregating waste helps to turn away it from landfill ensuring it’s recycled properly. Mixed dry waste like glass and paper can be turned into new different products. This prevents the energy and resources needed to create different products from raw material. If waste not segregated and disposed of properly it results in huge damage to the environment. This work proposes a smart waste bin for household applications. Rasberry-Pi, servo motors, and batteries are used for implementation. The benefits of this work are

1. The waste segregation results in simplified waste management and thus protect the environment.2. The economic value of waste is best realized when it is separated and 3. It helps in reducing the health problems caused to the waste separating workers by decreasing the chances of getting infected. In India, there is limited work carried in the field of segregation of dry and wet wastes in a single bin at a household level. We propose a smart waste bin that is low-cost, easy to use for a segregation system at households. The collected waste can directly be sent for processing. Smart Waste Bin employs different sensors to differentiate wet and dry waste. Experimental results show that the segregation of waste into wet and dry waste has been implemented successfully.

**[V. Sowndharya]** The amount of waste has been increasing due to the increase in human population and urbanization. In cities, the overflowed bin creates an unhygienic environment. Thus degrades the environment , to overcome this situation “Automatic Waste Segregator” is developed to reduce to work for the ragpickers the wastes are segregated by the human beings which leads to health problems to the workers. The proposed system separates the waste into three categories namely wet, dry and metallic waste. This developed system is not only cost efficient also makes the waste management productive one. Each of the wastes are detected by the respective sensors and gets segregated inside the bins which is assigned to them the details of amount of waste disposal is updated in the server regularly.

**[Mani Kumar Reddy]** Waste management is a major duty for the government to handle, because cities must be clean, beautiful, and sanitary for a country to grow. According to estimates, India produces 62 million tonnes of waste every year, making it the world’s second most populous metropolis behind China. However, because of the massive scale mixing of the waste, it is a difficult and costly procedure to separate in the final stages. Of the total 62 million tonnes of rubbish, 5.6 million tonnes are plastic waste. As we all know, plastic can be readily recycled, and if plastic is put on Earth/landfills, it poses a severe issue of global warming. For proper recycling process and to provide a cleaner, safer, and more sanitary workplace, as well as increased operational efficiency while lowering management costs and resources segregation of the garbage a Smart way of garbage management with help of modern cutting-edge technologies like Artificial Intelligence and Internet of things should be done. So, in the current work a system which automatically segregates the waste using image processing and Waste/trash is divided into bins provided beneath the conveyer utilising a conveyer system is proposed. Machine Learning and Deep Learning are subsets of Artificial Intelligence using ML and DL we can efficiently segregate trash using camera module and separate them into bins/chambers. And using Internet of things we can remotely control the trash inside the bins with help of readings from ultrasonic sensors inserted, once the trash is above the threshold, we can notify the respected cleaning department which prevents the overflow of the trash.

**[Saurabh Parulekar]** Smart bin has multiple features and its main feature is garbage segregation. Smart bin will have 4 different compartments for the waste: for plastic waste, for wet waste, for dry waste and lastly for the wastewater from the auto clean feature. Apart from this, it will also have ultrasound sensors for the bin to open when a person approaches the dustbin to throw garbage thus making it hands-free and evidently more hygienic. The smart bin will also have an analysis done to tell the user the amount and type of garbage they dispose of. Daily, weekly and monthly garbage disposal will be analyzed through graphs and data through live data reception. The bin will also have a reminder sent to the phone from the app connected to the bin to tell us that it is time to throw the garbage. This idea will help us dispose of the wastes separately and thus also be able to distinguish the recyclable and non-recyclable waste. The smart bin is an efficient and hygienic waste disposal and segregation system which will eventually help in waste optimization.

**[Ranjit Kumar Behera]** On these modern days, segregation of wet and dry dust is very important. Although people understand the difference between dry and wet waste, they seem too ignorant while putting them in a bin which makes the life difficult for the garbage collector. Hence a special dustbin is conceptualized and designed which can automatically differentiate between wet and dry waste. When someone throws the waste, the system automatically segregates wet and dry dust and put them in appropriate bins. Once someone throws the waste, it come to a platform where there are three sensors, 1st one for sensing the waste, second one for measuring the quantity of dusts inside each bin and the third one for differentiate the wet and dry dust. After sensing these three parameters, the conveyor tilts on one direction to put the waste on right dustbin. These sensing data sends notification to smart phone and updates it to cloud platform as well as in a database.

The comparative analysis of the existing method is shown in **Table 1**.

**Table 1:** Comparative analysis of the existing method

|  |  |  |  |
| --- | --- | --- | --- |
| **Author**  **(Year)** | **Techniques used** | **Pros** | **Cons** |
| Dr. Nilima Kulkarni. [5]  (2023) | Smart Waste Bin using Rasberry-Pi  And NodemCU | * Efficient Waste Segregation * Reduced Greenhouse Gas Emissions | * Technical Complexity * Maintenance and Power Requirement |
| V.Sowndharya [3]  (2023) | Smart Dustbin using  Sensor integration for real-time monitoring | * Data-Driven Waste Management: * Improved Hygiene | * Initial Cost: * Limited Capacity |
| Mani Kumar Reddy [4]  (2022) | Secure IoT connection &  Using lib and sensors. | * Enhanced data security, multi-level authentication | * Lacks real-time anomaly detection |
| Saurabh Parulekar [5]  (2024) | IoT-enabled power management system with security | * Perform several more operation using diff-diff more sensors. | * Limited remote control functionalities |
| Ranjit Kumar Behera [6]  (2024) | Comparative analysis of NodeMCU and Raspberry Pi using database. | * Suitable for complex tasks, video surveillance | * High power consumption of Raspberry Pi |

# Project Implementation

The block diagram of the proposed system is shown in **Figure 1**.

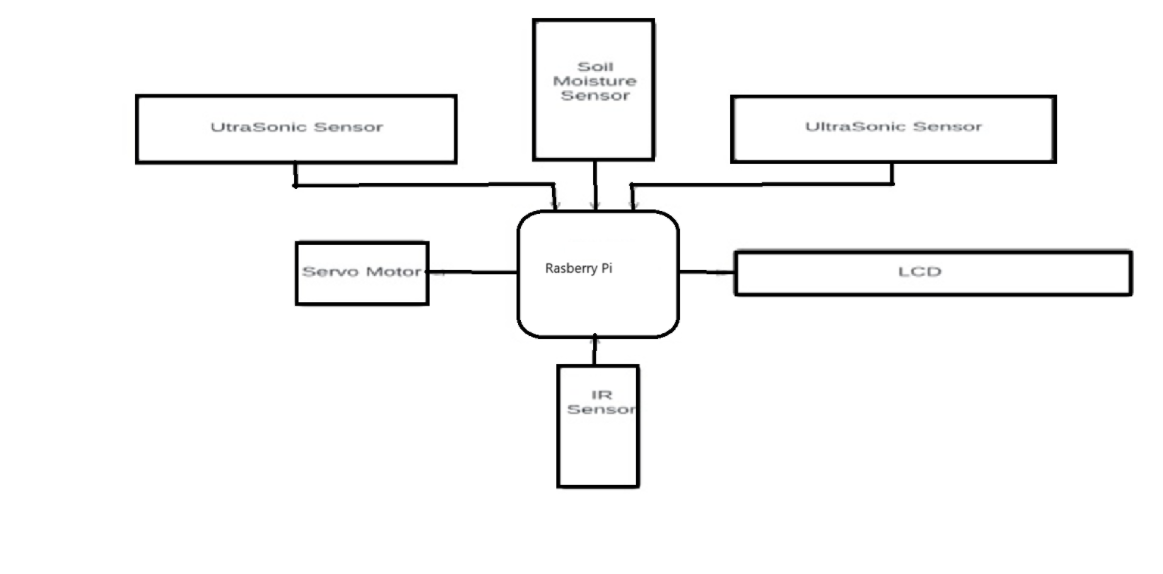


Figure.1

**Raspberry Pi:**

* Acts as the central processing unit of the system.
* Controls and processes data from all connected sensors and actuators.
* Sends data to an IoT platform for real-time monitoring and alerts.

**Ultrasonic Sensors (Two):**

* Measure the level of waste inside the dustbin.
* Detects if the bin is full or if there is space available for more waste.
* Provides data to the Raspberry Pi for efficient waste monitoring.

**Soil Moisture Sensor:**

* Identifies the type of waste by detecting moisture levels.
* Helps differentiate between dry and wet waste, assisting in automated segregation.
* Sends moisture data to the Raspberry Pi for waste classification.

**IR (Infrared) Sensor:**

* Detects the presence of waste at the bin’s opening.
* Triggers the system to activate waste segregation when waste is detected.
* Sends detection signals to the Raspberry Pi for further processing.

**Servo Motor:**

* Controls the compartment mechanism to segregate waste.
* Operates according to the classification (wet or dry) determined by the Raspberry Pi.
* Moves to direct waste into the appropriate section based on sensor input.

**LCD:**

* Displays real-time status of the dustbin, such as bin level, waste type, and any alerts.
* Provides visual feedback to users and helps monitor system status on-site.

**Blynk IoT Cloud**

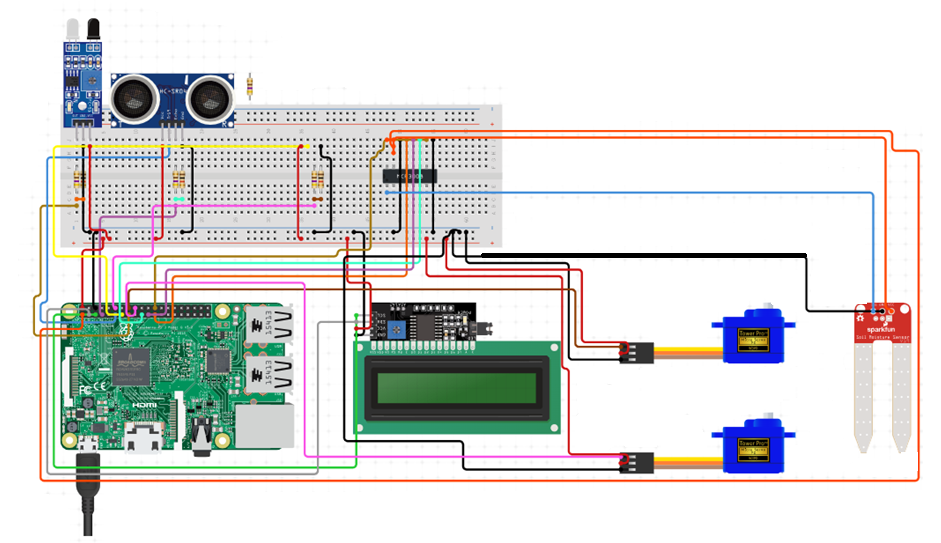
A cloud platform used for remote monitoring and control.

• Users can access system data and manage devices via a smartphone app.

• Facilitates real-time notifications and status updates.

In summary, this system combines sensors, a motor, and a display to facilitate automated waste segregation, while the Raspberry Pi processes and monitors data for IoT-based waste management.

The circuit diagram of the Smart Dustbin with Dry and Wet Waste Segregation using IOT is shown in **Figure 2** respectively.



**Sensor Readings**: The soil moisture sensor and ultrasonic sensor continuously monitor the soil moisture and light levels.

**Data Processing**: The Raspberry Pi reads the analog signals from the sensors and converts them to digital values.

**Decision Making**: The Raspberry Pi compares the sensor readings to pre-set thresholds. If the soil moisture is below a certain level or the light level is low, it determines that watering is necessary.

**Control Signals**: The Raspberry Pi sends control signals to the servo motors, which then open or close the valves connected to the water pump.

**Display**: The LCD display shows the current sensor readings (soil moisture and light level), the system status (watering on or off), and possibly other relevant information.

# Conclusion

During this project we as a team find several innovative output that- The *Smart Dustbin with Dry and Wet Waste Segregation using IoT* offers an innovative and efficient solution to the pressing challenges of urban waste management. By leveraging IoT technology and the capabilities of the Raspberry Pi, this system automates waste segregation, enhances collection efficiency, and minimizes the need for manual sorting. The real-time monitoring feature allows municipal authorities to optimize waste collection schedules, reduce overflow incidents, and improve operational efficiency.

During testing ,we faced problem in connecting the sensor with cloud this was the difficult task but we find the solution with the guidance of our subjective teacher as the result the system demonstrated effective segregation of dry and wet waste, real-time data transmission, and reliable alerts for bin status. The automation of waste classification not only promotes recycling and reduces contamination but also contributes to a cleaner and more sustainable environment. However, challenges such as refining sensor accuracy, improving system scalability, and addressing power efficiency highlighted areas for further enhancement.

Future developments, such as integrating AI for waste pattern analysis, improving energy management, and incorporating additional sensors, could further elevate the system's performance. This project represents a significant step forward in IoT-based waste management, supporting cleaner cities and fostering a more resource-conscious society.

# 7 Future Scope

The Raspberry Pi-based Smart Dustbin with Dry and Wet Waste Segregation using IOT presents significant opportunities for future improvements and expansion. As IoT technology advances, the system can be enhanced to include sophisticated features, providing improved performance, security, and flexibility to meet new demands. The subsequent points highlight essential areas for future development:

**Future Scope for Smart Dustbin:**

* **Enhanced Sensors:** Improved waste classification, real-time analysis, weight/volume monitoring.
* **AI and ML:** Predictive maintenance, optimized collection scheduling, user behavior analysis.
* **Improved User Experience:** Voice control, gamification, mobile app integration.
* **Sustainability:** Solar power integration, energy-efficient components, data-driven waste reduction.
* **Smart City Integration:** Real-time waste monitoring, integration with recycling facilities, community engagement.
* **Voice Control:** Integrate voice assistants like Alexa or Google Assistant to allow users to control the dustbin and receive real-time updates on waste levels and collection schedules.
* **Gamification:** Develop gamified features to encourage user engagement and promote responsible waste disposal, such as rewarding users for correct waste segregation.
* **Mobile App Integration:** Create a mobile app to provide users with detailed insights into their waste disposal habits, offer personalized recommendations, and facilitate remote monitoring and control.

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[8] <https://youtu.be/QDRX421WGkk?si=_EWNvLVqtHXI1wrg>Smart Dustbin

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**Appendix**

import RPi.GPIO as GPIO

import time

import smtplib

from email.mime.text import MIMEText

from RPLCD.i2c import CharLCD

from time import sleep

import blynklib

**# LCD Settings**

I2C\_ADDR = 0x27 # I2C address for your LCD (adjust if necessary)

LCD\_WIDTH = 16

LCD\_HEIGHT = 2

lcd = CharLCD('PCF8574', I2C\_ADDR, cols=LCD\_WIDTH, rows=LCD\_HEIGHT)

**# Email Settings**

SENDER\_EMAIL = 'ssjover9000123@gmail.com'

SENDER\_NAME = 'Raspberry Pi'

SENDER\_PASSWORD = 'sise qhiq disj znyl'

RECIPIENT\_EMAIL = 'mohitd2004@gmail.com'

EMAIL\_SUBJECT = 'Alert'

**# GPIO Pins**

SERVO\_PIN = 15

D\_TRIGGER\_PIN = 19

D\_ECHO\_PIN = 18

W\_TRIGGER\_PIN = 12

W\_ECHO\_PIN = 13

IR\_SENSOR\_PIN = 26

SOIL\_PIN = 4 # Digital soil moisture sensor connected to GPIO 4

**# Blynk Settings**

BLYNK\_AUTH\_TOKEN = "4WLYv3MoesdlDoxo540VYLucEHSPeyxm"

blynk = blynklib.Blynk(BLYNK\_AUTH\_TOKEN)

**# Setup GPIO and Servo**

GPIO.setmode(GPIO.BCM)

GPIO.setup(SERVO\_PIN, GPIO.OUT)

servo = GPIO.PWM(SERVO\_PIN, 50)

servo.start(0)

GPIO.setup(D\_TRIGGER\_PIN, GPIO.OUT)

GPIO.setup(D\_ECHO\_PIN, GPIO.IN)

GPIO.setup(W\_TRIGGER\_PIN, GPIO.OUT)

GPIO.setup(W\_ECHO\_PIN, GPIO.IN)

GPIO.setup(IR\_SENSOR\_PIN, GPIO.IN)

GPIO.setup(SOIL\_PIN, GPIO.IN) # Setup soil moisture sensor as input

def move\_servo(angle):

duty = angle / 18 + 2

GPIO.output(SERVO\_PIN, True)

servo.ChangeDutyCycle(duty)

sleep(0.5)

GPIO.output(SERVO\_PIN, False)

servo.ChangeDutyCycle(0)

def measure\_distance(trigger\_pin, echo\_pin):

GPIO.output(trigger\_pin, False)

sleep(0.2)

GPIO.output(trigger\_pin, True)

time.sleep(0.00001)

GPIO.output(trigger\_pin, False)

start\_time = time.time()

stop\_time = time.time()

while GPIO.input(echo\_pin) == 0:

start\_time = time.time()

while GPIO.input(echo\_pin) == 1:

stop\_time = time.time()

time\_elapsed = stop\_time - start\_time

distance = (time\_elapsed \* 34300) / 2 # Distance in cm

return distance

def send\_email(message):

smtp = smtplib.SMTP\_SSL('smtp.gmail.com', 465)

smtp.login(SENDER\_EMAIL, SENDER\_PASSWORD)

msg = MIMEText(message)

msg['Subject'] = EMAIL\_SUBJECT

msg['From'] = SENDER\_NAME

msg['To'] = RECIPIENT\_EMAIL

smtp.sendmail(SENDER\_EMAIL, RECIPIENT\_EMAIL, msg.as\_string())

smtp.quit()

**# Main Loop**

try:

while True:

blynk.run() # Run the Blynk event handler

# Measure distances

wet\_distance = measure\_distance(W\_TRIGGER\_PIN, W\_ECHO\_PIN)

dry\_distance = measure\_distance(D\_TRIGGER\_PIN, D\_ECHO\_PIN)

h = 20

dry\_level = int(((h - (dry\_distance - 7)) / h) \* 100)

wet\_level = int(((h - (wet\_distance - 6)) / h) \* 100)

# Send data to Blynk

blynk.virtual\_write(0, dry\_level)

blynk.virtual\_write(1, wet\_level)

# Display levels on LCD

lcd.clear()

lcd.write\_string(f"Wet Waste: {wet\_level}%")

lcd.cursor\_pos = (1, 0)

lcd.write\_string(f"Dry Waste: {dry\_level}%")

# Garbage detection and sorting logic

if GPIO.input(IR\_SENSOR\_PIN) == 0:

moisture = GPIO.input(SOIL\_PIN) # Reading digital soil moisture

if moisture == GPIO.LOW and wet\_level < 90: # Wet garbage detected

lcd.clear()

lcd.write\_string("Wet Garbage")

lcd.cursor\_pos = (1, 0)

lcd.write\_string("Detected")

move\_servo(20)

sleep(2)

move\_servo(70)

elif moisture == GPIO.HIGH and dry\_level < 90: # Dry garbage detected

lcd.clear()

lcd.write\_string("Dry Garbage")

lcd.cursor\_pos = (1, 0)

lcd.write\_string("Detected")

move\_servo(120)

sleep(2)

move\_servo(70)

elif moisture == GPIO.LOW and wet\_level >= 90: # Wet bin full

lcd.clear()

lcd.write\_string("Wet Garbage")

lcd.cursor\_pos = (1, 0)

lcd.write\_string("Is Full")

send\_email("Wet Garbage is Full")

elif moisture == GPIO.HIGH and dry\_level >= 90: # Dry bin full

lcd.clear()

lcd.write\_string("Dry Garbage")

lcd.cursor\_pos = (1, 0)

lcd.write\_string("Is Full")

send\_email("Dry Garbage is Full")

sleep(1)

except KeyboardInterrupt:

print("Program stopped by user")

finally:

GPIO.cleanup()

servo.stop()

lcd.close()