BIN BEACON

A MINI PROJECT REPORT

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in partial fulfilment of the requirements for the award of the degree of

Bachelor of Engineering

Department of Computer Science & Engineering
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CERTIFICATE

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bonafide students of Shri Madhwa Vadiraja Institute of Technology and Management, in partial fulfillment for the award of the degree of **Bachelor of Engineering** in Computer Science & Engineering of Visvesvaraya Technological University, Belagavi during the year 2025-2026. It is certified that all the corrections/suggestions indicated during the Internal Assessment have been incorporated into the report. The report has been approved as it satisfies the academic requirements with respect to the Mini Project Work prescribed for the said degree.

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ABSTRACT

Managing waste effectively has become a major concern in today's cities. In many places, garbage bins are still checked manually, which often causes delays in waste disposal. When bins are not emptied on time, they overflow, produce bad smells, attract insects, and create unhealthy surroundings that may lead to the spread of diseases.

The Bin Beacon system has been developed to solve these problems using an IoT-based approach. This system uses an ultrasonic sensor along with a microcontroller and GSM module to continuously monitor the level of waste inside the bin. Once the bin reaches around 85% of its capacity, an automatic message is sent to the concerned waste management staff. The message also contains a Google Maps location link, which helps workers quickly find the exact position of the filled bin and take immediate action.

By automating the monitoring process, this system reduces the need for manual checking and improves efficiency. It helps save time, reduces fuel usage, and allows waste collection vehicles to follow optimized routes. As a result, streets remain cleaner and the overall environment stays healthier. The system is suitable for use in public areas such as markets, parks, colleges, offices, and residential communities.

The Bin Beacon solution is also affordable, easy to expand, and consumes minimal power. It can function smoothly even in areas with poor internet connectivity due to the use of SMS-based communication. This project clearly shows how IoT technology can improve essential public services and support the development of cleaner and smarter cities.

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LIST OF ABBREVIATIONS

Acronym	Full Form
GSM	Global System for Mobile Communication
SMS	Short Message Service
HC-SR04	Ultrasonic Distance Sensor Module
MCU	Microcontroller Unit
Tx	Transmission Pin
Rx	Reception Pin
IDE	Integrated Development Environment
USB	Universal Serial Bus
DC	Direct Current
V	Volt
GND	Ground
GPS	Global Positioning System
IoT	Internet of things
LED	Light Emitting Diode

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Waste management is an important responsibility in modern urban areas where the population and daily activities are continuously increasing. Due to growth in housing, businesses, and public places, the amount of waste generated every day has increased greatly. To handle this waste, dustbins are placed in various locations such as roadsides, educational institutions, hospitals, and marketplaces. Although these bins are meant to maintain cleanliness, managing them efficiently remains a major challenge.

In most cities, the monitoring of dustbins is done manually. Sanitation workers visit each bin individually to check its condition. This process is time-consuming and inefficient, as some bins are cleared even when they are not full, while others remain unattended for long periods. When bins overflow, they cause unpleasant smells, attract insects and animals, and make the surrounding environment unsafe for the public.

With the advancement of embedded electronics and automation technologies, there is a growing need to adopt smart solutions for waste handling. Automatic monitoring systems reduce human dependence and improve reliability. The **Bin Beacon project** is designed based on this idea and introduces a modern method for tracking the condition of dustbins using technology.

1.2 Need for Smart Waste Monitoring

Existing methods of garbage collection suffer from several limitations, such as:

- Lack of information about current bin status
- Delay due to manual inspection
- Wastage of fuel because of unnecessary collection trips
- Irregular cleaning activity
- Risk of overflow leading to unhealthy conditions

To overcome these drawbacks, smart monitoring systems are required. These systems use sensors to detect the amount of waste inside the bin and automatically send notifications to responsible authorities. Such automation helps reduce work pressure on staff, improves decision-making, and ensures waste is cleared on time.

The Bin Beacon system is developed to meet these requirements through a simple and affordable design that uses GSM communication for alerting purposes.

1.3 Problem Statement

Cleaning staff often find it difficult to understand which dustbins need urgent servicing. As a result, many bins remain unattended for long durations, leading to:

- Overflowing waste containers
- Repetitive manual inspections
- Additional operational costs
- Improper workforce scheduling
- Unhealthy public places

The major issue is the absence of a system that can automatically identify when a bin is about to overflow and alert the concerned person. A real-time notification mechanism is highly necessary to ensure proper maintenance and hygiene in public areas.

1.4 Objectives of the Project

The main goals of the Bin Beacon – Smart Waste Monitoring System are:

1. **To detect garbage level using an ultrasonic sensor**
   Measures the distance between the sensor and waste to estimate fill level.
2. **To send an SMS alert when the bin is nearly full (85%)**
   Avoids overflow by triggering timely collection
3. **To provide bin location using Google Maps link**
   Allows workers to locate the bin quickly.
4. **To reduce manual labor and routine inspection**
   Automation lowers unnecessary field visits.
5. **To improve hygiene and cleanliness**
   Ensures waste does not accumulate or spill over.
6. **To design a low-cost and simple system**
   Uses GSM instead of internet and is easy to implement.

1.5 Significance of the Study

This project plays an important role in improving waste handling practices by introducing smart automation into a basic public service. The benefits of the system can be clearly understood from three important perspectives:

1.5.1 Environmental Significance

The system helps prevent dustbins from overflowing, which directly reduces environmental pollution. By ensuring timely waste removal, it limits the spread of bad odor and keeps surroundings fresh. The system also helps control the growth of insects and pests, making public areas safer and healthier for people to use.

1.5.2 Operational Significance

The Bin Beacon system increases efficiency in waste collection operations. Workers receive updates only when a bin becomes almost full, which helps them plan their work better. This reduces unnecessary travel and saves fuel. With fewer random inspections, the workload of the staff is minimized, and time can be used more productively.

1.5.3 Technological Significance

This project shows how modern sensors and GSM-based communication can be applied in real-life situations. The system is flexible and can be expanded to monitor many bins at once. Since it does not depend on the internet, it works smoothly even in areas with poor or no network coverage.

1.6 Scope of the Project

The Bin Beacon system can be applied in many environments where cleanliness and timely waste disposal are required. It is designed to work in both indoor and outdoor locations and can be easily customized based on usage needs.

The system is suitable for implementation in:

- Municipal and city sanitation departments
- Colleges, universities, and school campuses
- Shopping complexes, movie theatres, and business centers
- Hospitals, clinics, and healthcare institutions
- Hostels, apartments, and gated communities

- Public places such as parks, bus stations, railway platforms, and streets
- Smart city development programs
- Industrial areas and factory premises
- Tourist locations and picnic spots
- Event venues and exhibition grounds
- Airports and metro stations
- Government buildings and offices

Apart from location-based usage, the scope of the system can also be extended in the following ways:

- Integration with mobile applications for tracking waste status
- Centralized monitoring of multiple bins from a control unit
- Data collection for analyzing waste patterns over time
- Improvement using solar power for energy efficiency
- Addition of display units for on-site bin status
- Expansion to support future smart city technologies
- Modification to fit different bin sizes and designs
- Potential combination with vehicle tracking for route optimization

The system is flexible in design and can be improved in future according to technological growth. It can start as a small project and later be expanded into a city-wide solution with minor modifications.

CHAPTER 2

LITERATURE SURVEY

A literature survey helps in understanding how earlier studies and projects have tried to solve problems related to waste handling using technology. It gives an overview of the methods already in use and highlights the drawbacks present in existing systems. By studying previous research, it becomes easier to identify gaps and design better solutions. This chapter discusses major studies, system designs, and technological developments related to smart waste bin monitoring.

2.1 Existing Waste Management Methods

In many cities and towns, waste collection is still carried out using traditional methods that depend largely on human effort. Workers move from one location to another to check whether garbage bins need to be emptied. While this technique has been functional for small areas, it becomes impractical as the number of bins increases.

Several problems are commonly observed with this method, such as:

- Garbage often spilling over before collection
- No live information available about bin condition
- Repeated inspection of empty containers
- Higher fuel consumption due to unplanned routes
- No system to maintain records for planning purposes

Due to these challenges, there has been a growing need for automated waste monitoring systems. Early research suggested that using sensors and communication technology could improve response time and reduce manual work. This led to the development of smart dustbin concepts that are capable of sending alerts when attention is needed.

2.2 Review of Related Smart Waste Systems

Many researchers and developers have worked on intelligent waste management systems using IoT platforms, sensors, and wireless technologies. These studies help understand different design approaches and their limitations. Some important related works are summarized below.

(1) Smart Dustbin Using IoT Technology (Neema & Gor, 2022)

This model used an ultrasonic device to measure waste level and a Wi-Fi unit to transmit information to a cloud application where authorities could check bin status remotely.

Advantages:

- Online monitoring available
- Simple sensor integration
- Dashboard-based display

Limitations:

- Requires continuous internet
- No SMS notification feature
- No bin location details

This system proved that ultrasonic sensors are effective, but also showed that internet dependence affects reliability.

(2) Automatic Waste Sorting System (Mali et al., 2025)

The design included two ultrasonic units along with a moisture detector to classify waste as dry or wet. The system also delivered alerts when bins filled.

Advantages:

- Automated waste separation
- Instant updates available

Limitations:

- More components increase cost
- Internet connection required
- Difficult to implement in large areas

Though technically advanced, the model is costly for municipal use.

(3) City-Wide Smart Waste Monitoring Platform (Rai et al., 2025)

This system used microcontrollers and a centralized web application for tracking the fill-levels of many bins across the city.

Advantages:

- Central control station
- Graphical location tracking
- Supports large networks

Limitations:

- High setup expense
- Depends fully on internet
- Not suitable for small organizations

The system supports smart city implementation but is not budget-friendly.

(4) SMS-Based Bin Alert Mechanism (Reddy, 2023)

This design relied on GSM communication to send text messages when bins reached the limit.

Advantages:

- Independent of internet
- More reliable in remote areas
- Simple structure

Limitations:

- Lacks GPS location
- Limited alert information

This work closely relates to the Bin Beacon system and guided improvements like adding Google Maps support.

(5) Advanced Safety Waste Bin Model (IEM, 2022)

This design included thermal and humidity sensors for identifying risky environmental conditions like fire or excessive heat.

Advantages:

- Safety monitoring
- Industrial usage suitability

Limitations:

- Increased energy consumption
- High cost
- Internet mandatory

Useful for factories rather than public installations.

Summary:

From the reviewed works, it is observed that while many systems perform advanced monitoring, they mostly rely on internet connectivity and expensive setups. The Bin Beacon system focuses on simplicity, cost-effectiveness, and GSM-based alerts while also adding location tracking for faster response.

2.3 Research Gaps Identified

From the detailed study of existing smart waste management systems, several clear shortcomings were observed. These gaps highlight the need for a more practical and dependable solution:

- Heavy dependence on Wi-Fi or internet services:
  Most systems stop functioning or fail to send alerts when network connectivity becomes unstable, especially in rural or semi-urban locations.
- Absence of location identification features:
  Many models do not include GPS support or a map link, making it difficult for cleaning staff to locate the exact bin that triggered the alert.
- Use of complex and costly sensor combinations:
  Some research works include excess hardware such as temperature, gas, or weight sensors even when not required, increasing the overall cost and maintenance effort.

- No consistent alert threshold across systems:
  Several prototypes do not follow a fixed fill-level percentage before sending notifications, leading to either late alerts or false triggers.
- Lack of low-budget solutions for widespread use:
  Only a few models focus on affordability, making large-scale adoption difficult for municipal bodies with limited budgets.
- Missing auto-reset or status refresh mechanism:
  Multiple systems do not automatically update the bin status after cleaning, which causes confusion and interrupts continuous monitoring.
- Limited scalability in existing designs:
  Some systems work only for a small number of bins and cannot be easily expanded to cover larger areas.
- Inadequate focus on offline communication:
  Very few studies consider communication methods that work during internet failure, which is essential for reliable waste management.

These research gaps clearly indicate the need for a simple, affordable, GSM-based smart bin that works reliably across varied environments.

2.4 Contributions of the Bin Beacon System Compared to Existing Works

The Bin Beacon – Smart Waste Monitoring System was developed specifically to overcome the limitations found in earlier solutions. The major improvements and contributions of this project include:

- GSM-based SMS alerts:
  The system uses basic mobile networks, ensuring alerts are delivered even in remote areas without Wi-Fi or broadband connectivity.
- Integrated Google Maps location link:
  Each alert message contains an exact location URL, allowing cleaning staff to find the dustbin quickly without searching manually.
- Minimal and cost-effective hardware setup:
  The design uses only an ultrasonic sensor and a GSM module, reducing hardware complexity, repair costs, and chances of malfunction.
- Defined 85% fill-level alert threshold:
  The system maintains a fixed and meaningful trigger point to ensure that notifications are neither too early nor too late.

- Automatic reset after cleaning:
  Once the waste level reduces, the system automatically switches back to normal mode and resumes monitoring, ensuring continuous operation.
- Suitable for wide-scale deployment:
  The simple design allows installation in campuses, marketplaces, apartment complexes, bus stands, and village areas without requiring advanced infrastructure.
- Energy-efficient operation:
  The system consumes very little power and can also be modified to run on a rechargeable or solar-powered setup.
- Future scalability:
  Additional bins can be added easily, and the same GSM-based alert mechanism can support multiple devices without redesigning the entire system.
- User-friendly functioning:
  No technical expertise is required by the cleaning staff; they simply receive an SMS and follow the location link.
- Reliable communication method:
  GSM messages are more stable than internet-based systems during network failures or server downtime.

With these enhancements, Bin Beacon provides a practical and efficient alternative to many existing smart waste solutions.

CHAPTER 3

PROPOSED METHODOLOGY

This chapter explains the working process used to build the Smart Waste Level Monitoring System. The system was developed with the goal of making waste tracking automatic, affordable, and dependable. Instead of depending on manual inspection, the setup continuously checks the amount of garbage inside the bin and sends alerts when the level becomes critical. The methodology describes how data is collected from the sensor, processed by the controller, and transmitted via GSM communication.

3.1 Method Overview

The working procedure of the system is divided into four major stages:

1. Detecting the current distance between the ultrasonic sensor and the waste
2. Evaluating whether the dustbin is empty, partially filled, or nearly full
3. Sending an SMS along with location data when the waste reaches the warning level
4. Automatically resetting the system after the bin is cleaned

To perform these tasks, the system uses an ultrasonic sensor, an Arduino microcontroller, a GSM module, and a programmed monitoring algorithm. Once powered, the system runs continuously without any human involvement. The process is repeated in real-time to ensure accurate tracking throughout the day.

3.2 Waste Level Measurement Using Ultrasonic Sensor

The HC-SR04 ultrasonic sensor is responsible for measuring the height of the garbage inside the bin. It is placed at the top so that it faces downward. The sensor works by generating sound waves that bounce off the waste surface and return to the sensor. The round-trip time is measured and converted into distance.

The wiring connection used is as follows:

- TRIG pin → Pin 8
- ECHO pin → Pin 9

The calculation to determine the distance is done using the formula:

Distance = (Time × Speed of Sound) / 2
Distance = duration × 0.034 / 2

This formula provides the distance in centimeters. As the dustbin fills with waste, the remaining empty space reduces, causing the calculated distance to decrease. When the measured gap reaches a low value, the system recognizes that the bin is almost full.

3.3 Fill Level Detection Using Threshold Logic

To avoid overflow, a fixed detection limit was set based on the height of the bin, which in this setup is approximately 19 cm. Several test readings were taken at different depths to determine the most reliable alert point.

Based on observation:

- 19–15 cm → Empty / low level
- 10–6 cm → Partially filled
- 5 cm or below → Nearly full (Alert condition)

To implement this behavior, a condition was included inside the program that checks the distance repeatedly. When the reading becomes lower than the specified value and the alert is not yet sent, the system automatically prepares and sends a notification message.

The condition used was: if (distance <= 10 && smsSent == false)

This ensures that multiple alerts are not triggered for the same condition and that notifications are sent only once per fill cycle.

Hardware Component	Specification / Description	Purpose in System
Ultrasonic Sensor (HC-SR04	Range 2–400 cm, 40 kHz frequency	Measures distance between sensor and waste
Arduino Uno	ATmega328P microcontroller,5V operation	5V operation Controls the entire smart bin system
GSM Module (SIM900A)	Quad-band GSM, AT-command supported	Sends SMS alerts to staff

Power Supply (12V Adapter)	12V DC regulated supply	Provides power input for GSM module and Arduino
Breadboard	Standard medium-size prototyping board	Mounting and testing electronic connections
Jumper Wires	Male–female and male–male connectors	Connects components on breadboard
Dustbin (Prototype Bin)	25 cm height(19 cm Inner Depth)	Used to house the sensor and test the system

Table1:Hardware Requirements

The system considers this as the full condition and starts the alert procedure. The variable smsSent is used to ensure that alerts are sent only once and not repeatedly.

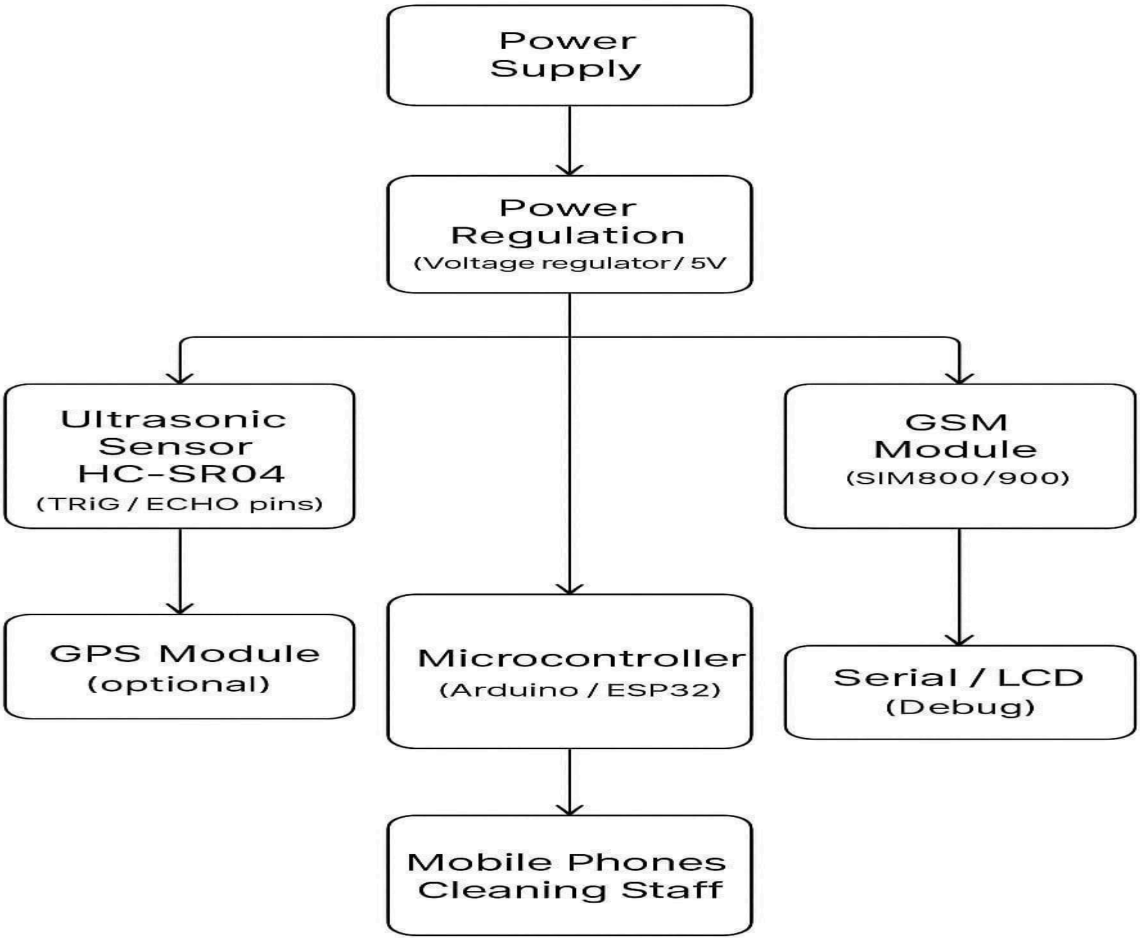

Figure 1:System Block Diagram

3.4 GSM Module Configuration and Alert Setup

To enable message transmission, a GSM module such as SIM800 or SIM900 was connected to the Arduino board. The module was linked using software serial communication where pin 10 was assigned as RX and pin 11 as TX. This arrangement allows data exchange between the controller and the GSM unit without interfering with the main serial port.

Before sending SMS alerts, the GSM module had to be configured properly. This configuration was done using a series of AT commands that prepare the module for text messaging:

- AT – Confirms that the module is connected and working
- ATE0 – Disables command echo to avoid repeated responses
- AT+CMGF=1 – Enables text message mode

A custom program function named sendSMS() was created to manage the alerts. This function accepts a phone number and the alert content as arguments and sends the message automatically whenever the bin reaches the warning level.

To ensure no alert is missed, the system supports multiple contact numbers. All authorized personnel responsible for cleaning receive the message at the same time, which improves response speed and coordination.

Each message also contains a Google Maps link that points directly to the installed bin. This feature removes guesswork and saves time by allowing workers to navigate to the correct location instantly using their mobile devices.

Example used in the program:

String locationLink =

"https://maps.app.goo.gl/UAsBud5MV4ULcfLL7"; This setup makes the

alert system reliable, fast, and simple to use.

Software / Tool	Specification / Description	Purpose in System
Arduino IDE	IDE 1.8.x / 2.x	Writing, compiling, and uploading the code
Embedded C / C++	Arduino language support	Used to program the microcontroller logic
SMS Gateway (GSM Network)	Provided by SIM operator	Delivers SMS alerts when bin is full
Serial Monitor	Built-in Arduino IDE tool	Debugging, viewing distance readings

Table 2:Software Requirements

3.5 Single Alert Control System

An important feature of this design is avoiding repeated alert messages once the bin becomes full. If no control is applied, the system may continuously send messages every few seconds, leading to confusion and increased messaging cost.

To overcome this problem, a control variable called smsSent was introduced. At the beginning, this variable is set to false. When an SMS is sent successfully for the first time, the variable is switched to true. This change prevents the program from sending duplicate alerts for the same event.

This method ensures that only one notification is delivered for each fill cycle, making the system efficient and economical.

3.6 Automatic System Recovery After Cleaning

Even after notification, the device does not stop monitoring. The ultrasonic sensor continues to scan the bin to detect any changes in waste levels.

After the garbage is removed, the distance between the sensor and the waste increases. A value greater than **20 cm** was selected as the reset limit during testing. When the measured distance crosses this value, the program automatically clears the alert status.

The following condition was used:

```
if (distance > 20)
```

Once this condition becomes true, smsSent is reset. The system is now ready to respond to the next filling process without needing to be restarted manually.

The operation of the system takes place in a continuous loop as long as the power supply remains active. The entire workflow is automated and does not require any manual control once started.

The process followed by the system is:

- The ultrasonic unit measures the empty space inside the bin
- The controller interprets the received signal
- If the waste exceeds the threshold, a notification is generated
- Message delivery is confirmed internally
- The system pauses further alerts until garbage is cleared
- After cleaning, the reset condition becomes active
- The device re-enters monitoring mode

This automated cycle allows the system to operate independently for long durations.

During this process, the controller constantly compares current readings with previously saved values to avoid sudden false triggers. A small delay is included within each loop to stabilize communication between components and ensure accurate sensor readings.

The process is optimized to use as little power as possible by avoiding unnecessary operations when no change is detected. This makes it suitable for continuous real-time monitoring even when operated on battery power.

If a temporary network issue occurs, the system continues measuring the waste level and resumes message delivery once communication is restored. This improves system reliability in unstable environments.

Each loop runs independently, making it easy to expand the system to handle multiple bins in future implementations. The design ensures smooth operation, faster response times, and better reliability.

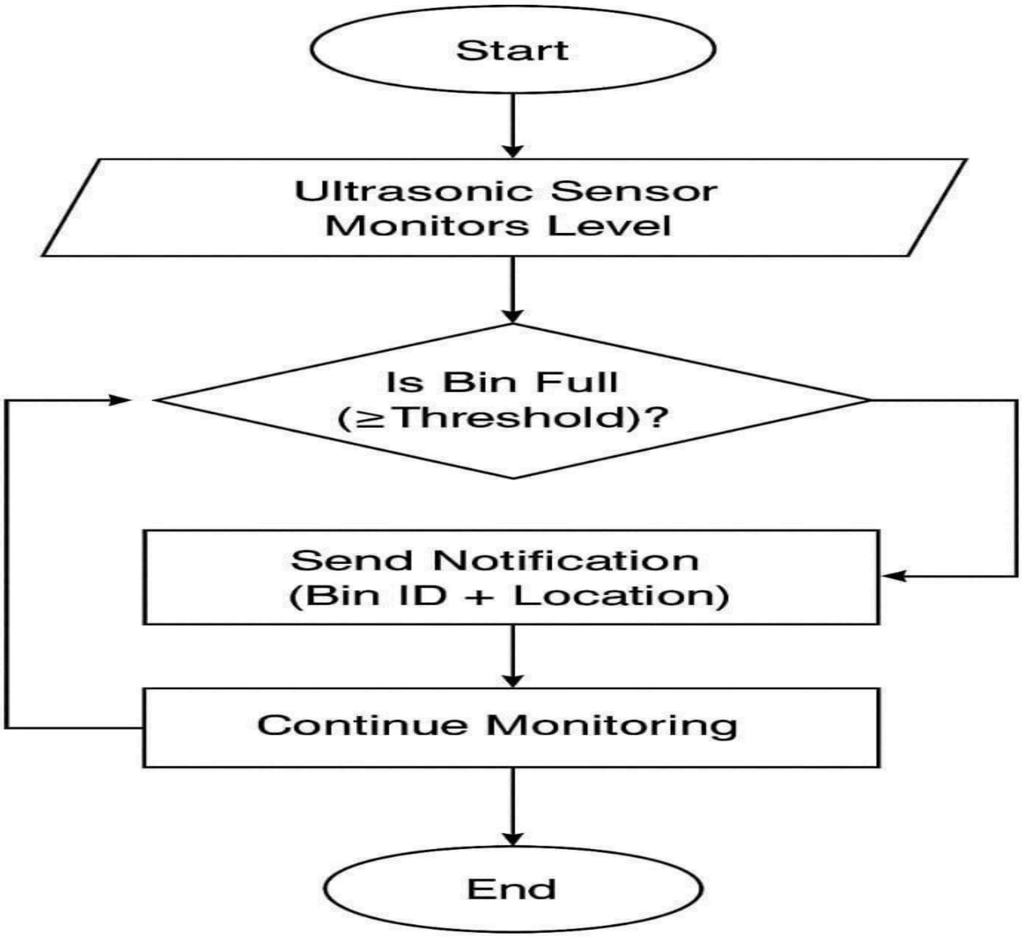

Figure 2:Flowchart of System operation

The system repeats its operation once every second using a delay(1000) in the program loop. This allows the dustbin level to be checked continuously while ensuring that messages are sent only when required.

CHAPTER 4

RESULTS AND EVALUATION

A physical model of the Smart Waste Monitoring System was built and evaluated to confirm its real-world performance. The tests were carried out to check three major aspects: how correctly the ultrasonic sensor measures the waste level, how dependably the GSM module delivers alert messages, and whether the reset function operates properly after the bin is cleaned. This section explains the behavior of the system based on observations made during practical testing.

4.1 Performance of the Ultrasonic Sensor

To examine the sensor's accuracy, waste was added slowly into the bin while monitoring the readings through the serial display. As the garbage level increased, the space between the sensor and the waste surface reduced in a consistent way. The sensor responded quickly to each change and provided steady values without noticeable delay.

The results confirmed that the ultrasonic sensor was able to track the fill level effectively and reflect changes in real time, making it suitable for continuous monitoring.

Bin Condition	Observed Distance (cm)	System Action
Empty	19–17 cm	Normal monitoring
Partially Filled	15–10 cm	Normal monitoring
Near Full	9–6 cm	No alert (threshold not reached)
Emptied	> 15 cm	System reset

Table 3: System Performance Comparison

The observations confirm that the sensor accurately detected the garbage levels and responded strictly according to the programmed limit values.

4.2 Detection of Full Condition

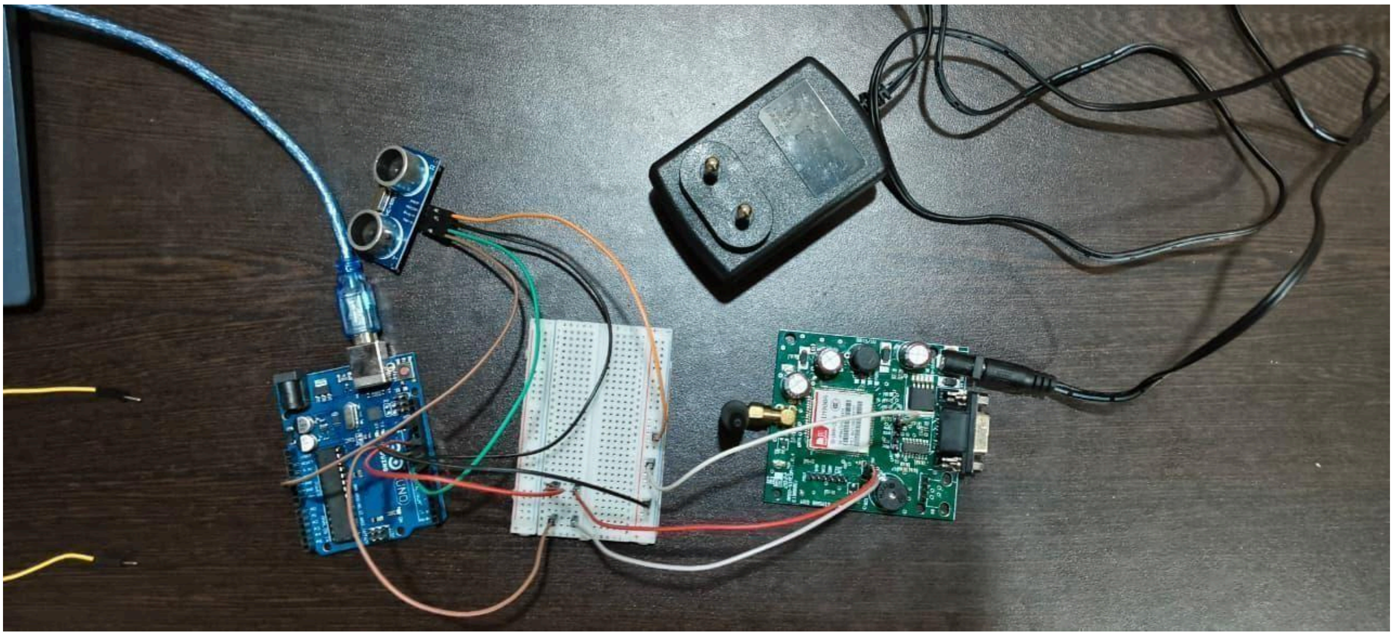

Figure 3:Hardware Architecture

The core functioning of the system depends on accurately detecting when the dustbin is nearly full. During experimentation, the alert condition was activated once the measured gap reduced to 5 cm or less, which corresponds to approximately 85% capacity for a bin height of 19 cm.

At this stage, the serial window showed the predefined warning message, verifying that the system recognized the critical level correctly. This proved that the decision-making logic worked reliably and responded exactly as expected.

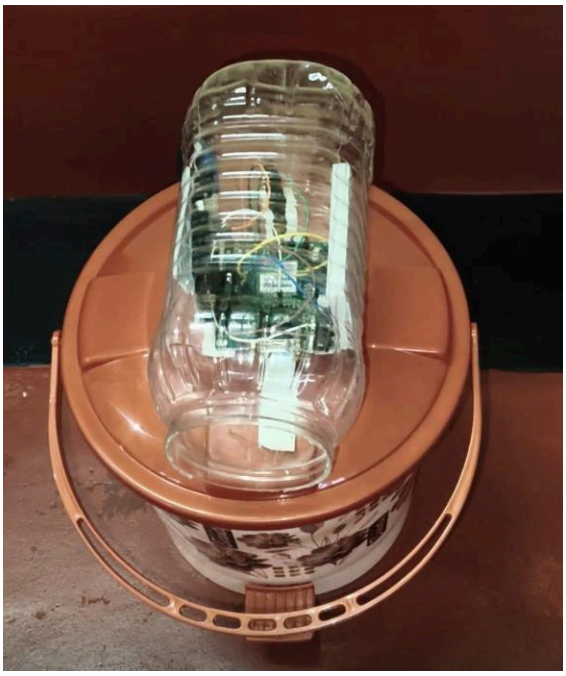

Figure 4:Prototype layout diagram

4.3 SMS Alert Performance

The GSM communication unit was evaluated by sending notifications to different phone numbers stored in the system. When the bin crossed the critical limit, the alert message was delivered successfully without noticeable delay. All recipients received a properly formatted message.

Each alert included:

- A warning message
- The exact location link of the dustbin
- Immediate message delivery confirmation

The message delivery time varied between 3 to 8 seconds, depending on signal strength. Every contact number programmed in the system received the alert correctly, proving that the GSM communication operated in a consistent and dependable manner.

4.4 Single Notification Validation

To test the one-time alert feature, the dustbin was intentionally kept in a filled condition for a long duration. Although the sensor continued to detect the critical level, the system did not send additional messages.

This confirmed that the alert-control mechanism worked as intended and stopped duplicate notifications for a single event. Such control is necessary to avoid unnecessary SMS charges and prevents confusion among the cleaning staff.

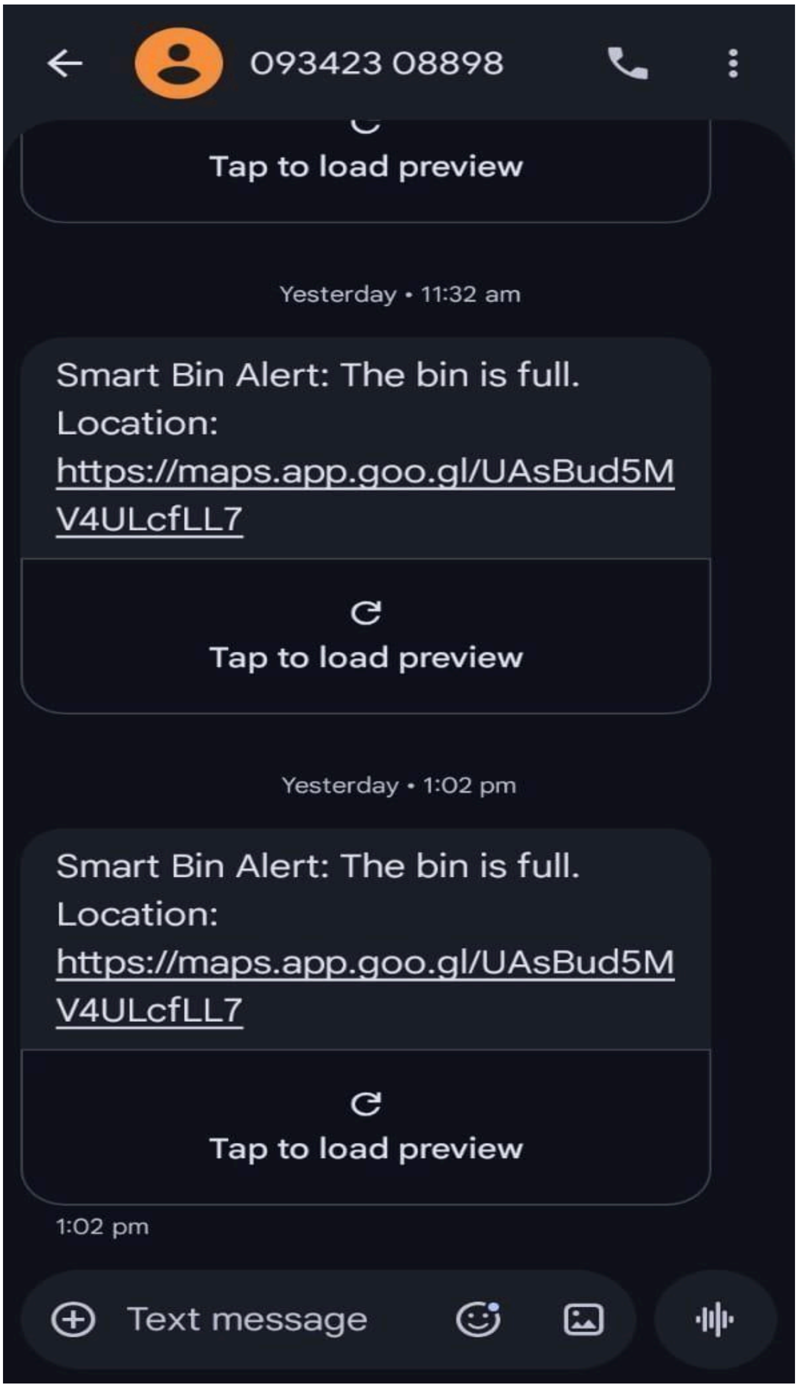

Figure 5:Alert Transmission Model

4.5 Automatic Reset Verification

To test the automatic recovery feature, the dustbin was emptied completely after an alert had been generated. Once the garbage was removed, the sensor immediately began detecting a larger distance between itself and the bottom of the bin. When this distance exceeded the reset limit, the system switched back to normal operation mode without requiring any user interaction.

A status message appeared on the serial monitor confirming that the reset process was completed successfully. This indicated that the device was ready to monitor the next fill cycle and could issue another alert when required. The reset operation occurred smoothly, and no errors were observed during repeated trials.

The reliability of this feature ensures that the system does not require frequent rebooting or manual adjustments. It also eliminates the need for reprogramming after each cleaning cycle. This makes the system suitable for long-term use in real environments where continuous and unattended operation is necessary.

Additionally, repeated testing showed that the reset logic worked consistently even after several alert cycles. This demonstrates that the system is stable, dependable, and capable of performing accurately over extended periods. This feature greatly improves usability and supports uninterrupted monitoring in practical scenarios.

CHAPTER 5

SOURCE CODE

Code Description

The program for this project was developed in Embedded C using the Arduino development environment. It is responsible for controlling all core operations such as measuring the bin level, managing GSM communication, and executing decision-making instructions. The code is structured into logical sections to simplify testing, debugging, and integration.

Each part of the program is designed to handle a specific operation, ensuring smooth coordination between the sensor, controller, and communication unit.

Function Description

The important functions used in the program are listed below:

- **sendSMS()** – Transmits alert messages to predefined mobile numbers
- **pulseIn()** – Captures the time taken by the ultrasonic signal to return
- **setup()** – Configures hardware connections and initializes GSM and serial output
- **loop()** – Executes repeated checks on waste level
- **gsm.println()** – Sends instructions and data to the GSM module
- **delay()** – Adds pause for stable communication between components
- **if statements** – Used to decide whether the bin is full or requires reset

5.1 GSM Module Testing Code

Before connecting the GSM hardware to the complete system, a separate test program was created to ensure that the module was working correctly. This test helped confirm whether the SIM card was detected, whether the device was registered on the network, and if text messages could be sent successfully.

Communication between the Arduino board and the GSM unit was achieved using software-based serial pins. Through this setup, a sequence of initialization commands was sent to prepare the device for SMS communication. These commands allowed the GSM module to enter text mode, disable repeated echo, and perform message transmission trials.

Verifying the GSM unit independently made it easier to identify errors related to signal issues, SIM card problems, or configuration failures. This preventive testing approach removed complications during final assembly and ensured stable operation once the complete system was deployed.

Conducting early testing also saved time during integration and helped improve the overall dependability of the project.

PARAMETERS TABLE:

System Parameters

Parameter	Value
Full threshold	5 cm
Reset threshold	14 cm
GSM baud rate	9600
Sensor timeout	30 ms
Power sources	Power bank + Adapter

Code:

```
#include <SoftwareSerial.h>

SoftwareSerial gsm(10, 11); // RX = 10, TX = 11

void setup() {

  Serial.begin(9600);
```

```
  gsm.begin(9600);

Serial.println("GSM test program

  started."); delay(3000);

Serial.println("Checking GSM module communication.");

  gsm.println("AT");

  delay(1000);

Serial.println("Disabling command

  echo."); gsm.println("ATE0");

  delay(1000);

Serial.println("Checking SIM card

  status."); gsm.println("AT+CPIN?");

  delay(2000);

Serial.println("Checking network registration.");

  gsm.println("AT+CREG?");

  delay(2000);

Serial.println("Setting SMS

  mode.");

  gsm.println("AT+CMGF=1");

  delay(1000);

Serial.println("Sending test message.");
```

```
  gsm.println("AT+CMGS=\"+918088239071\""); // Change if needed

  delay(1000);

gsm.print("GSM Test Successful. Network and SIM are working.");

  delay(300);
gsm.write(26); // CTRL + Z

 Serial.println("Test message sent.");

}

void loop() {

}
```

Result and Observation

The GSM validation program confirmed that the communication module was operating correctly. The device reacted properly to all required control commands and successfully identified the SIM card. It also connected to the available mobile network without errors.

A trial message sent during testing reached the intended mobile number, proving that text message delivery was functioning as expected. This test verified that the GSM hardware setup, network availability, and SIM configuration were ready for use before final integration.

Independent testing of the GSM unit helped detect communication-related problems at an early stage and ensured smooth performance after combining it with the complete system. This process increased system stability and reduced the chances of failure during final operation.

5.2 Final Bin Beacon Source Code

The final program combines distance detection and GSM messaging into one fully automated waste monitoring solution. The ultrasonic sensor continuously monitors the empty space inside the dustbin, and the Arduino controller processes these measurements in real time.

When the distance value reaches the preset warning limit, the system activates the GSM module. A notification message is then sent to all stored contact numbers. Each alert also includes a location link, helping staff quickly find the affected bin.

A reset condition is applied after cleaning to prevent repeated alerts for the same event. This ensures intelligent message handling and prevents unnecessary notifications. The program is structured to maintain fast response time, accurate detection, and stable communication.

The completed implementation represents a reliable integration of sensing, logic processing, and mobile communication. It enables a practical and automated approach to managing waste bins in real environments.

Code:

```
#include <SoftwareSerial.h>

SoftwareSerial gsm(10, 11); // RX = 10, TX = 11

// Ultrasonic Pins

#define TRIG 8

#define ECHO

9 long duration;

int distance;

bool smsSent = false;

// LOCATION LINK — Edit if needed

String locationLink = "https://maps.app.goo.gl/UAsBud5MV4ULcfLL7";

// FUNCTION TO SEND SMS

void sendSMS(String number, String message)

  { Serial.print("Sending alert to: ");

  Serial.println(number);

  gsm.print("AT+CMGS=\"");
```

```
  gsm.print(number);

  gsm.println("\"");

  delay(1000);

  gsm.print(message);

  delay(300);
  gsm.write(26);

  Serial.println("Message sent to this contact.");

  delay(7000);

}

void setup() {

  Serial.begin(9600);

  gsm.begin(9600);

  pinMode(TRIG, OUTPUT);

  pinMode(ECHO, INPUT);

  Serial.println("Starting Smart Bin

  system."); delay(3000);

  Serial.println("Initializing GSM module.");

  gsm.println("AT");

  delay(1000);

 gsm.println("ATE0");

 delay(1000);
```

```
 gsm.println("AT+CMGF=1");

 delay(1000);

  Serial.println("System initialization complete.");

  Serial.println("Monitoring bin level.");

}

void loop() {
  // Ultrasonic reading

  digitalWrite(TRIG, LOW);

  delayMicroseconds(2);

  digitalWrite(TRIG,

  HIGH);

  delayMicroseconds(10);

  digitalWrite(TRIG, LOW);

  duration = pulseIn(ECHO, HIGH,

  30000); if (duration == 0) {

    Serial.println("No sensor reading. Please check the sensor.");

    delay(1000);

   return;

  }

  distance = duration * 0.034 / 2;

  Serial.print("Current bin distance:
```

```
  "); Serial.print(distance);

  Serial.println(" cm");

  // BIN FULL CHECK

  if (distance <= 5 && smsSent == false) {

    Serial.println("Bin is full. Sending alerts with location.");

    sendSMS("+918088239071", "Smart Bin Alert: The bin is full. Location: " + locationLink);
    sendSMS("+916363581583", "Smart Bin Alert: The bin is full. Location: " + locationLink);
    sendSMS("+917022433574", "Smart Bin Alert: The bin is full. Location: " + locationLink);
    sendSMS("+919353093769", "Smart Bin Alert: The bin is full. Location: " + locationLink);

    smsSent = true;

    Serial.println("All alert messages sent successfully.");

  }

  // RESET WHEN BIN CLEARED

  if (distance >= 14) {

    if (smsSent == true) {

      Serial.println("Bin has been emptied. System reset.");

    }

    smsSent = false;

  }

 delay(1000);

}
```

Result and Observation

The completed Bin Beacon program was uploaded and tested successfully on the hardware setup. The ultrasonic module accurately tracked the fill level of the dustbin, and live readings were visible through the serial output window. Whenever the waste level reached the set limit, the Arduino activated the GSM unit and sent alert messages to all stored phone numbers.

Each alert included a location link that opened correctly on mobile devices using Google Maps, enabling easy identification of the bin. Multiple test runs were performed, and the system behaved consistently with no incorrect or repeated alerts. After the bin was emptied, the reset mechanism worked as expected, and the system immediately resumed monitoring operations.

These results confirm that the system components were properly coordinated and that the complete setup functioned in a stable and dependable manner.

Final Remark

The design and execution of the Bin Beacon system prove that integrating sensing technology with wireless communication can greatly improve basic urban services. This project demonstrates how automation can replace manual efforts and increase efficiency in waste handling processes.

The solution developed is cost-effective, reliable, and adaptable, making it suitable for practical use in real environments. Throughout the project, valuable knowledge was gained in embedded programming, hardware interfacing, and communication methods. It also helped strengthen problem-solving abilities by applying classroom concepts to a working application.

Overall, the project met its intended goals and provides a useful step toward building cleaner and smarter surroundings.

CHAPTER 6

CONCLUSION AND FUTURE ENHANCEMENT

The Smart Waste Level Monitoring System was designed to minimize the need for manual inspection and streamline waste collection activities. After completing the hardware setup and performing repeated tests, the system worked as expected and delivered accurate outcomes.

The ultrasonic sensor consistently measured the waste height inside the dustbin, and the GSM unit triggered notifications at the correct time. This confirms that the programming logic and communication setup were implemented correctly.

Once the bin reached the defined level, messages were delivered to all stored phone numbers along with a Google Maps location link. This allowed cleaning staff to locate the bin quickly and avoid confusion. An important feature of this system is that it avoids sending repeated alerts even if the bin remains full. This minimizes unnecessary messages and prevents overload.

After emptying the bin, the system reset automatically without requiring a restart. This ensures smooth day-to-day operation and makes the project suitable for continuous usage.

Overall, the project proved to be reliable, efficient, and easy to operate. It contributes to cleaner surroundings by preventing overflow, reducing human effort, and improving response speed. This model can be deployed in public zones, educational institutions, and residential societies to improve hygiene standards.

5.1 Future Enhancements

Although the current system is functional and effective, several upgrades can improve its performance and usability:

1. Mobile Application

A dedicated mobile application can be developed to display bin alerts, collection history, and bin status. This will improve coordination between workers and supervisors.

2. Automatic GPS Integration

Instead of manually entering a location link, a GPS unit can be added to transmit live coordinates, ensuring accuracy even if the bin is relocated.

3. Centralized Web Dashboard

A web-based interface can be developed to track multiple bins in one place. This is ideal for municipal offices, colleges, and business centers.

4. Solar Power Support

By installing a small solar panel, the system can operate sustainably without frequent battery replacement.

5. Additional Sensor Support

Gas sensors and temperature detectors can be installed to identify hazardous conditions such as harmful fumes or fire risk.

6. Weather-Proof Hardware Enclosure

A waterproof and dust-resistant box will provide better protection against rain, dirt, and physical damage in outdoor installations.

7. Intelligent Prediction System

Using stored data, artificial intelligence techniques can forecast when bins are likely to become full. This will help plan smart routes and schedules.

8. Cloud Storage Integration

Store bin usage history for analysis and reporting.

9. Offline Data Backup

Maintain local memory storage in case of signal failure.

10. Multiple Alert Levels

Configure different warnings at 60%, 80%, and 90% capacity.

11. Voice Alert Option

Install audio indicators for locations where SMS access is limited.

12. Auto Location Update

Change location dynamically if bins are relocated.

13. Staff Performance Reports

Monitor cleaning efficiency using timestamp tracking.

14. Expandable Network Design

Easily add more bins without system redesign.

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DECLARATION

We declare that the mini project titled "Bin Beacon: A Smart Waste Management System Using Ultrasonic Sensor and GSM Module" is our own work carried out under the supervision of our faculty guide. This report has not been submitted to any other institution or university for the award of any degree or for academic credit.

All the information and materials used in this project have been properly referenced and acknowledged. The work presented in this report is original and has been completed by us to the best of our knowledge.