iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** III **Month of publication:** March 2026

DOI: https://doi.org/10.22214/ijraset.2026.78255

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue III Mar 2026- Available at www.ijraset.com

IoT-based Smart Waste Monitoring and Escalation Alert System

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Abstract: ***Waste management is a critical problem around the world, especially in smart cities. The IoT-based Smart Waste Monitoring and Esalation Alert System aims to solve waste management problems by introducing an efficient and technologically advanced solution this system integrates a smart underground dustbin in local areas such as roads, temples, and government buildings, using sensors and GSM technology to send alert messages and calls to cleaners and corporators. This smart underground is equppied with an ultrasonic sensor to monitor the fill levels of waste in real-time system. when the dustbin reaches 75% capacity, an automatic text message is sent to the cleaner of that area stating that the dustbin is 75% full requesting a response within 15 minutes, that system aumatically places a call to the cleaner. if the waste id not collected and dusbin reaches 90%capacity,the system automatically escalates the alert by calling the corporater using an Arduino microcontroller interfaced with a GSM module. This guarantees prompt waste collection, minimises overflow, and fosters urban cleanliness. This solution reduces the need for human monitoring and promotes a more sustainable and clean urban environment by utilising IoT and GSM technology. This project is an example of a smart waste monitoring and escalation alternative system.***
Keywords: Ultrasonic Sensor, GSM Module , Arduino Uno, Buzzer .

I. INTRODUCTION

The management of waste is one of the biggest issues that need to be addressed globally, primarily in expanding metropolitans and smart cities. Due to the growth of population and urbanization, the generation of waste daily is also on a rise. This could lead to such dustbins overflowing in many of the cities, as waste may not get collected ontime. This leads to unhygienic situation which allows various diseases caused by insects and mosquitoes to develop. As leading to cleanliness and health issues an effective parametrization system is crucial to avoid waste measurement overloading or underloading. Most traditional waste collection systems rely on manual monitoring. Typically, garbage is collected in the scheduled time intervals irrespective of dustbin status. This technique is not very effective, as in some cases the dustbins get filled before they are collected, while in other cases these are collected even before they fill up. Thus, there is a requirement of smart & automated system which can sense the level of garbage and notify it to authorities in time. To solve this problem, you have to use the latest IoT-Based Smart Waste Monitoring and Escalation Alert System. Ultrasonic sensor for Waste level detection. If the waste is 75% full in dustbin then system will automatically sends alert message to cleaner of that particular line by using GSM module. If the cleaner fails to respond within a certain time frame, an automatic phone call is placed by the system. If the dustbin reaches 90% and the alert is not met, it calls up the corporator of that particular area. The Arduino Uno microcontroller, which manages the entire system, is connected to the sensor and the GSM module. The sophisticated method is made to avoid the annoyance of overflowing trash, guaranteeing prompt refuse collection and greatly increasing the effectiveness of waste management. By utilizing IoT technology, the system reduces human labor and supports the goal of creating sustainable, healthy, and clean smart cities.

II. LITERATURE REVIEW

A. Smart Waste Management Using IoT and GSM Technology

This study shows how GSM and IoT (Internet of Things) technology can be used to automate waste management systems. This method uses sensors to measure the rubbish level within dustbins. When the bin fills up, the GSM module is also used to automatically notify the appropriate authority. This automation reduces human verification and promotes more effective waste collecting. The article also underlines that this system is cost-effective & minimizes human effort.

B. IoT-Based Garbage Monitoring System for Smart Cities

We want to research based on smart sensors that monitor the level of garbage in dust bins across the city. The sensors receive data regarding waste level and transmit it to municipal servers via IoT platforms.

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This system uses Wi-Fi & Bluetooth mainly to transmit the data. But, the study also states that these technologies rely on stable internet connectivity. Hence, in regions with unpredictable internet service, GSM communique could be a greater option.

C. Smart Dustbin System for Efficient Waste Management in Urban Areas

This paper presents a smart dustbin system in which the ultrasonic sensors are used to find out the level of garbage inside the bin. The sensor finds the disstance of waste from lid of the dustbin, hence giving how full is the bin. When this garbage reaches certain level so the system send an SMS alert to respective authorities by GSM technology. This would ensure timely cleaning and also stop dustbins from overflowing in open places.

D. Arduino-Based IoT Applications for Smart Cities

This paper reviews Arduino boards to create various IoT applications related to smart cities. It is easily compatible with sensors and communication modules like GSM. It describes the construction of an intelligent waste monitoring system, which uses Arduino to collect data from sensors and sends alerts whenever necessary.

E. A Comprehensive Review of Smart Waste Management Systems

A literature overview on smart waste management technologies for modern cities. This analysis examined multiple communication technologies, including RFID, Zigbee, and GSM that are utilized to monitor waste levels. It concludes that GSM is a reliable communication method capable of delivering real-time information over long distances without the need for constant internet availability. This makes GSM appropriate for the urban and rural waste management system.

F. Impact of Smart Dustbins on Urban Waste Management

The study explores the role of smart dustbins in enhancing cleanliness and sanitation of cities. The system tracks the waste level in real-time and auto-sends SMS alerts when bins are full. This minimizes the need for manual inspections, and enables waste collection teams to respond accelarated. Smart waste management systems are also significant for sustainability purposes and keeping cities cleaner, adds the research.

III. SYSTEM ARCHITECTURE

The diagram shows the working process of a smart dustbin monitoring system. First, the system starts and an ultrasonic sensor measures the level of waste inside the dustbin. The Arduino then calculates how full the dustbin is in percentage. After this, the system checks whether the dustbin has reached 75% capacity. If the level is below 75%, the system continues monitoring the waste level. If the level increases further, the system checks whether the dustbin has reached 90% capacity. When the dustbin becomes 90% full, the system sends an SMS alert to the cleaner or responsible person. It then waits for 15 minutes for a reply. If there is no response, the system automatically makes a call to remind the cleaner to empty the dustbin. After that, the system checks whether the dustbin has been emptied. If the dustbin is emptied, the system resets and the process ends. If the dustbin is not emptied, the system continues monitoring the waste level again. This process helps ensure that the dustbin is cleaned on time and prevents overflow.

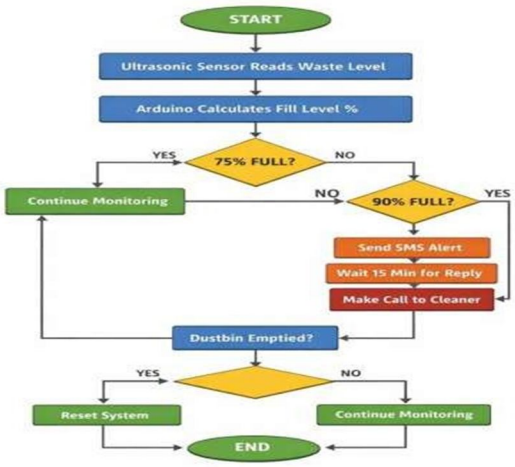


FIG. 1. Smart Dustbin Waste Level Monitoring System Flowchart

Block diagram of smart dustbin monitoring system These are different units that operate in harmony. The ultrasonic sensor (HC-SR04) is used to read the waste inside the dustbin. The data is transmitted to the Arduino UNO control unit, which receives the information and compares how full the dustbin is. The GSM module (SIM800/SIM900) send sms or call to cleaner when dustbin reaches the given level.

A **buzzer** also gives a sound alert when the bin is full. After receiving the alert, the **cleaner empties the dustbin**, and the system automatically resets and starts monitoring again.

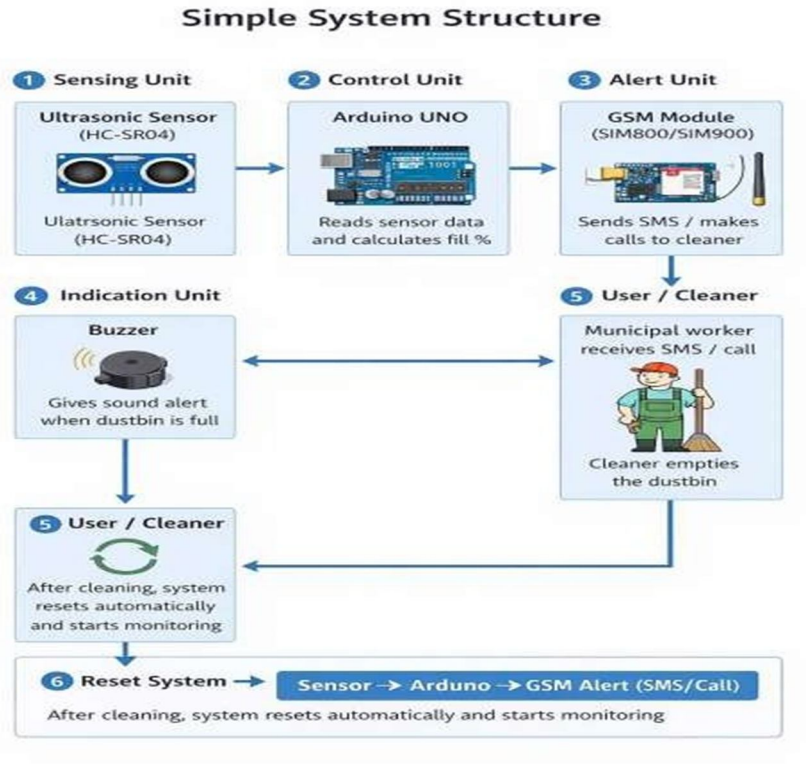


Fig. 2. Block Diagram of Smart Waste Monitoring System

The architecture diagram describes how different hardware components are connected and interact with each other. The input device that measures the distance between the waste and the sensor is an ultrasonic sensor. The primary controller that interprets sensor data and manages other parts is the Arduino UNO. By providing the user SMS or call warnings, the GSM module facilitates communication. When the garbage is full, the buzzer serves as a local alert system. This design contributes to the development of an automated trash monitoring system that lessens the need for manual dustbin inspections and increases cleanliness.

Working :-

1) Garbage Level Detection

1. The ultrasonic sensor is placed on the top of the dustbin.
2. It measures the distance between sensor and garbage.

2) Data Processing 3. Threshold Levels

3. The Arduino reads sensor data and calculates the fill level of the dustbin.
   1. 75% Full → SMS alert is sent to the cleaner.
   2. 90% Full → Automatic phone call is made (escalation).

3) Alert System

1. GSM module sends SMS to the cleaner or authority.
2. If no reply is received within a fixed time, the system makes a call automatically.

4) Local Indication 6. System Reset

3. Buzzer gives sound alert when garbage is added or dustbin is full.
4. When the dustbin is emptied, the system resets automatically and starts monitoring again

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue III Mar 2026- Available at www.ijraset.com

IV. HARDWARE DESCRIPTION

A. Ultrasonic Sensor

Ultrasonic sensors use ultrasonic waves to measure distance. The ultrasonic wave is transmitted from the sensor head, and the echo wave reflected from the target is received. Ultrasonic sensors utilize the time it takes for a sound wave to make its round trip between the transducer and target. Optical sensor has a transmitter and receiver, ultrasonic sensor simply uses oneultrasonic element both as an emitter and a detector

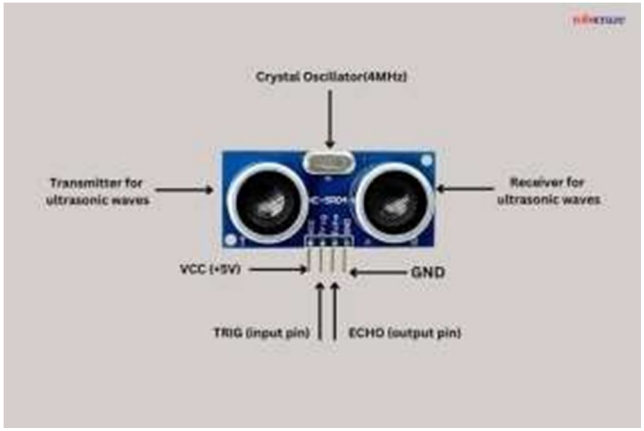


Fig. 4.1 Ultrasonic Sensor.

B. GSM SIM 800

GSM (Global System for Mobile communications) is a standard developed to describe the protocols for second generation digital cellular networks used by mobile phones. While the first generation wireless systems are analog, GSM is digital and uses TDMA transmission methods. GSM is circuit-switched and each 200 KHz channel has eight25 KHz timeslots. In Europe, GSM is to be found in the 900 MHz and 1.8 GHz bands while for the US it is in 1.9 GHz and 850 MHz. In Australia, Canada and many South American countries, the 850 MHz band is also used for GSM and 3 GSM. GSM is capable of data transfer rates up to 9.6 kbit/s and offers basic data services (like SMS (Short Message Service)). One of its most significant advantages is that it can be used for international roaming, since you get access to the same services while retaining your home number when traveling abroad. This enables consumers within over 210 countries with seamless and samenumber connectivity services when traveling abroad as at home. This gives consumers seamless and samenumber connectivity in more than 210 countries.



Fig. 4.2. GSM SIM 800

C. Arduino Uno

Arduino is an open-source electronics platform based on easy-to-use hardware and software. An input, such as a light on a sensor, a finger on a button, or a Twitter message, can be read by Arduino boards and converted into an output, such as turning on an LED, turning on a motor, or publishing anything online. By delivering a set of instructions to the microcontroller on your board, you may direct it on what to do. You achieve this by using the Arduino software (IDE), which is based on Processing, and the Arduino programming language, which is based on Wiring.

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Fig. 4.3. Arduino Uno

D. Buzzer

A buzzer is a small electronic device that produces a sound when it receives an electrical signal. In the smart dustbin system, the buzzer is used as an alert device. When the dustbin becomes full or reaches a certain waste level, the Arduino sends a signal to the buzzer. The buzzer then makes a beeping sound to inform people nearby that the dustbin needs to be emptied. It helps provide a quick local warning without needing to check the dustbin manually. The buzzer is simple, low cost, and easy to connect with microcontrollers like Arduinos.


Fig. 4.4.Buzzer

V. RESULTS AND EVALUATION

The smart dustbin monitoring system was successfully designed and tested using an ultrasonic sensor, Arduino UNO, GSM module, and buzzer. The ultrasonic sensor was able to accurately measure the waste level inside the dustbin. The Arduino processed the sensor data and calculated the fill level of the dustbin effectively.

During testing, the system was able to detect when the dustbin reached the predefined levels such as 75% and 90%. When the dustbin became almost full, the GSM module successfully sent an SMS alert and could also make a call to notify the cleaner. The buzzer also produced a sound alert to indicate that the dustbin needed to be emptied. The results show that the system can monitor the garbage level automatically and reduce the chances of dustbin overflow. It also helps in maintaining cleanliness by informing the responsible person on time. Overall, the system worked efficiently and proved to be useful for smart waste management.





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Fig. 5.1. Main Module System.



Fig. 5.2. GSM Through Message Sent

VI. CHALLENGES AND LIMITATIONS

There were some challenges faced while implementing the smart dustbin system. If the rubbish surface is uneven or if something blocks the sensor, the ultrasonic sensor may give out inaccurate readings at times. This may slightly influence the reading of the waste level.

Another concern is the reliance on mobile network. Also, if the GSM signal is poor or non-existent, alert message sending and call making by the system may not work.

If GSM signal is low or not there you may not be to send alert messages and System wont be able to make calls too. System must 24avel with stable power source.

The system can only do a dustbin fullness check and cannot identify what kind of waste is in the bin. If you also can have this, you may need to regularly perform hardware jobs periodically enough for your system to work smoothly.

VII. CONCLUSION AND FUTURE WORK

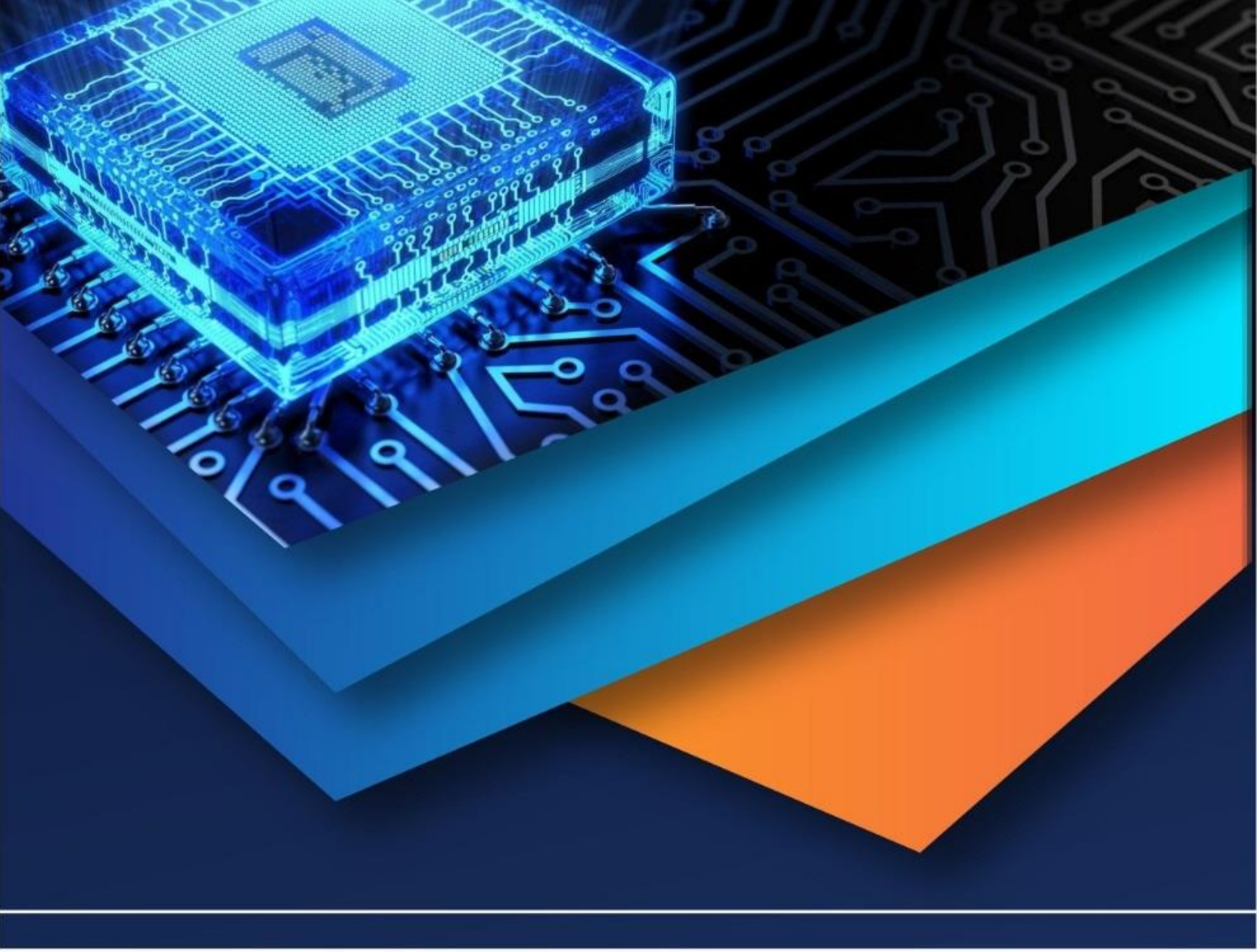
The smart dustbin monitoring system is a method that improves waste management by automatically verifying the garbage level in the dustbin. Ultrasonic sensor is used in the system to detect waste level & Arduino is used for data processing. Dustbin this gives a alert message and sound notification to empty the dust bin, when it gets full. This system avoids garbage overflow and keeps the surrounding area clean. It also decreases manual checking &makes wastage management relatively easier.

A. Future Work

1) Add IoT technology to monitor the dustbin through a mobile app or website.
2) Use GPS tracking to know the exact location of dustbins.
3) Use solar power to save energy and make the system eco-friendly.
4) Add more sensors to improve waste level detection.
5) Connect multiple dustbins to a central monitoring system.
6) Improve the system to help in smart city waste management.

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