IoT-Enabled Waste Management System for Enhancing Urban Sustainability

Ms. A. Ranjana
Assistant Professor, Department of CSE
Parisutham Institute of Technology and Science,
Thanjavur, India.
ranjanaanthonydasse98@gmail.com

S.T. Venkata Saravanan
Department of CSE
Parisutham Institute of Technology and Science,
Thanjavur, India.
venkat092002@gmail.com

K. Rohan
Department of CSE
Parisutham Institute of Technology and Science,
Thanjavur, India.
rohankalai1610@gmail.com

A. Abdul Rafek
Department Of CSE
Parisutham Institute of Technology and Science,
Thanjavur, India.
abdulrafek2000@gmail.com

A. Abdur Rahaman
Department of CSE
Parisutham Institute of Technology and Science
Thanjavur, India.
rahamancse05@gmail.com

***Abstract*— — Addressing the complex challenges arising from rapid urbanization and population expansion, this innovative project introduces a transformative approach to waste management, leveraging the power of Internet of Things (IoT) technology. By seamlessly integrating ultrasonic and MQ135 sensors with an Arduino NANO microcontroller and GSM module, the system pioneers a holistic solution for detecting hazardous gases emitted from waste materials. Upon detection, the system swiftly triggers automatic closure of the waste bin lid, effectively containing the spread of harmful emissions. The ultrasonic sensor plays a pivotal role in providing precise measurement of waste levels, ensuring accurate monitoring and management of waste accumulation. Simultaneously, the MQ135 sensor identifies hazardous gases, enabling timely intervention to mitigate potential health and environmental risks associated with their release. .Through the utilization of IoT connectivity, the system offers real-time monitoring and alerts, enhancing operational efficiency and safety standards in waste management practicesThis real-time monitoring capability empowers stakeholders to proactively respond to emerging issues, ensuring swift and effective interventions to safeguard public health and environmental well-being.**

Keywords— IoT, MQ135 Sensor, Ultrasonic Sensor, Waste Management, Hazardous gases

I. INTRODUCTION

In response to the multifaceted challenges posed by rapid urbanization and population growth, innovative solutions in waste management have become imperative. This paragraph encapsulates a pioneering project that aims to revolutionize waste management practices through the strategic integration of cutting-edge Internet of Things (IoT) technology. By combining ultrasonic and MQ135 sensors with an Arduino NANO microcontroller and GSM module, the system endeavors to address the critical issue of detecting hazardous gases emitted from waste materials. This proactive approach seeks to mitigate potential health and environmental risks associated with the release of such gases into the environment. Through real-time monitoring and alerts facilitated by IoT connectivity, the system enhances operational efficiency and safety standards, enabling stakeholders to respond promptly to emerging issues. Moreover, by automating waste containment processes, the project endeavors to minimize the environmental impact of waste disposal, contributing to long-term sustainability efforts. As urban populations continue to burgeon, innovative initiatives like this hold the promise of ushering in a new era of efficient and environmentally responsible waste management practices, ensuring the well-being of communities and ecosystems alike.

II. EXISTING SYSTEM

The MQ2 sensor-based smart dustbin represents an innovative solution to manage waste efficiently in urban environments. By integrating the MQ2 sensor, capable of detecting various gases including methane, carbon monoxide. and LPG, into the design of a dustbin, this technology enables automatic waste management and timely alerts for garbage collection. The sensor communicates with a central system or a mobile application, providing real-time data onthe fill level and the presence of hazardous gases, facilitating optimized waste management strategies. However, despite its promising potential, the MQ2 sensor-based smart dustbin also poses certain challenges. These include susceptibility to false alarms due to environmental factors like humidity and temperature fluctuations, as well as the need for regular maintenance. In addition to its capability to detect gases such as methane, carbon monoxide, and LPG, the MQ2 sensor-based smart dustbin offers the potential to significantly reduce the environmental impact of waste management practices in urban areas.

III. PROBLEMS IN EXISTING SYSTEM

i. Lack of Real Time Monitoring

ii. Regular maintenance increases operational cost

iii. Delay in Response time

iv. System may suspectable to false alarm

IV. PROPOSED SYSTEM

The proposed system integrates ultrasonic sensors, MQ135 sensors, Arduino NANO microcontrollers, and GSM (Global System for Mobile Communications) modules to create a comprehensive waste management solution. The Automated Sanitary Waste Disposal with Toxic Gas Detection and Neutralization comprises several key components working in tandem to achieve efficient waste collection and monitoring. Ultrasonic sensors installed in waste bins to measure fill levels. These sensors transmit data to Arduino NANO microcontrollers, which process the information and communicate with a central server using GSM modules. Additionally, MQ135 gas sensors are integrated into the system to monitor air quality around the waste bins. Meanwhile, the MQ135 sensor detects harmful gases emitted from decomposing waste, ensuring a healthier environment for communities. Upon detection, the bin automatically closes and initiates sanitization by spraying disinfectant, maintaining hygiene standards. Arduino NANO serves as the central processing unit, collecting data from sensors and transmitting it to the cloud for analysis. Through GSM connectivity, stakeholders receive instant alerts and comprehensive reports, empowering them to make informed decisions swiftly. This innovative solution not only enhances operational efficiency but also promotes environmental monitoring and sustainability. By leveraging IoT technology, we transform wastage management into a proactive, data-driven process, minimizing costs and maximizing resource utilization. Block diagram of proposed system is shown in Fig. 1.

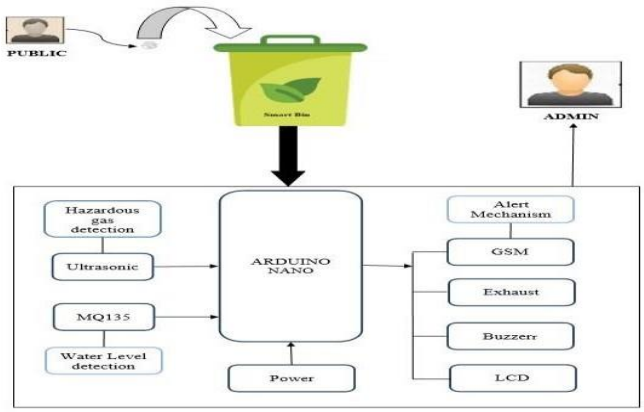

Fig. 1. Architecture diagram of proposed system

A. Advantages of Proposed System

- Real-time Monitoring
- Improved environmental sustainability
- Cost-effective
- Enhanced Safety of both public and waste management personnel.

V. HARDWARE USED

A. Arduino NANO Board

The Arduino Nano is a compact and versatile microcontroller board based on the ATmega328P chip. It offers a wide range of digital and analog input/output pins, making it suitable for various projects. With its small size and USB connectivity, it's ideal for embedded applications, prototyping, and DIY electronics projects.

B. Ultrasonic Sensor

An ultrasonic sensor measures distance by emitting ultrasonic waves and detecting the time it takes for the waves to bounce back. It consists of a transmitter and receiver, providing accurate distance measurements without contact. Ultrasonic sensors are commonly used in robotics, automation, and distance sensing applications due to their reliability and precision.

C. MQ135 Sensor

The MQ135 is a gas sensor designed to detect a variety of gases, including carbon dioxide, ammonia, nitrogen oxides, and benzene. It operates on the principle of gas conductivity, with changes in resistance corresponding to changes in gas concentration. MQ135 sensors are widely used in air quality monitoring systems, indoor air quality detectors, and pollution detection devices.

D. GSM Module

The SIM800C is a willingly available in the GSM/GPRS device which is used in many cellular/digital phones and radio devices. These modules are used to design the IOT devices. A GSM module enables communication between devices using the Global System for Mobile Communications (GSM) network. It allows devices to send and receive SMS messages, make phone calls, and access the internet. GSM modules are commonly used in IoT applications, security systems, and remote monitoring solutions, providing reliable wireless connectivity over long distances.

E. LCD Screen

A liquid crystal display (LCD) is an digital display screen that produces the result in an image using liquid crystals for itsoutput. Here we had used 16x2 LCD display. LCD is a flat-panel display technology commonly used for displaying alphanumeric characters or graphical information. It consists of liquid crystals sandwiched between two transparent electrodes and polarizing filters. LCDs are widely used in electronic devices such as calculators, digital watches, and appliances, providing a visually clear and energy-efficient means of displaying information.

F. Buzzer

A buzzer is an electromechanical device that produces sound when an electrical current is passed through it. It typically consists of a coil and a vibrating diaphragm, which creates audible vibrations when energized. Buzzer modules are commonly used for alert notifications, alarms, and user feedback in electronic devices and systems. They offer a simple and cost-effective way to provide auditory feedback in various applications.

VI. WORKING

The project utilizes a combination of sensors, a microcontroller, and communication modules to automate waste management processes effectively. The Ultrasonic sensor measures the waste level within the bin by emitting ultrasonic waves and calculating the time taken for the waves to return after bouncing off the surface of the waste. Meanwhile, the MQ135 sensor detects hazardous gases emitted from the waste, such as methane, carbon monoxide, and LPG, by analyzing changes in gas conductivity. Once hazardous gases are detected, the Arduino Nano

microcontroller processes this information and triggers the automatic closure of the waste bin lid to contain the emissions. Simultaneously, the microcontroller initiates a sanitization process to neutralize the hazardous gases within the bin. The GSM module facilitates real-time communication by sending alert notifications to designated recipients, such as waste management authorities or personnel, about the gas detection event. Additionally, a buzzer may be employed to provide audible alerts locally. Through IoT connectivity, the system enables remote monitoring of waste levels and gas detection data, allowing for timely intervention and optimized waste collection strategies.

Fig. 2. Work flow of Waste Management System

VII. EXPLANATION

This project utilizes advanced sensor technology and microcontrollers to automate waste management processes. Sensors detect waste levels and hazardous gases emitted from the waste. When hazardous gases are detected, the system triggers automatic lid closure and initiates a sanitization process. Real-time alerts are sent via GSM modules to notify authorities. Additionally, the system can provide audible alerts locally through a buzzer. Through IoT connectivity, stakeholders can remotely monitor waste levels and gas detection data. Overall, the project aims to optimize waste containment, enhance operational efficiency, and mitigate health and environmental risks associated with waste management..

VIII. RESULTS

This project demonstrate successful integration of sensors, microcontrollers, and communication modules to automate waste management processes effectively. The system accurately detects waste levels and hazardous gases, triggering appropriate actions such as lid closure and sanitization. Real-time alerts ensure timely intervention, enhancing operational efficiency and promoting environmental sustainability. Furthermore, the project's implementation of IoT connectivity enables remote monitoring and data analysis for effective waste management.

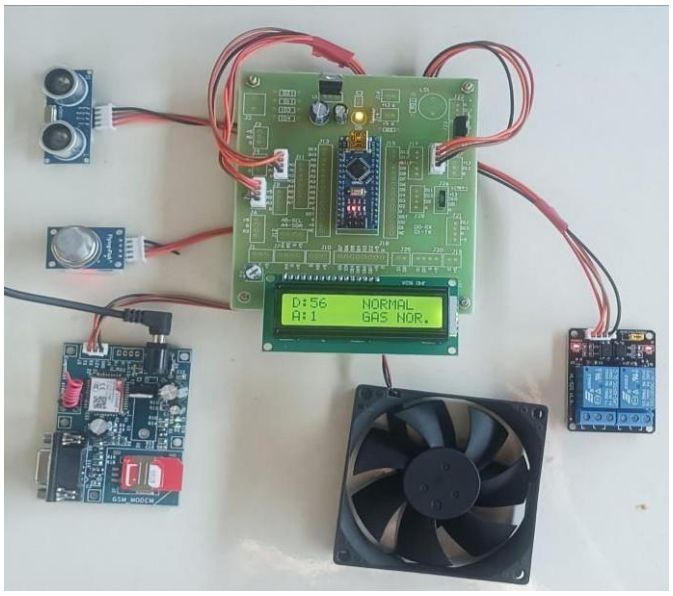

Fig. 3. Starting IoT kit

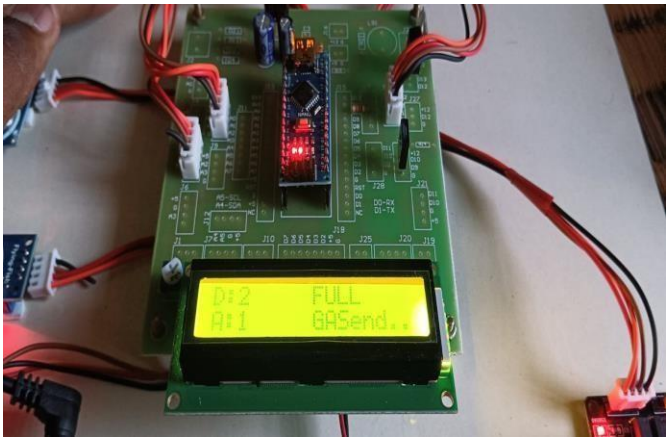

Fig. 4. Displaying Waste Level and Gas Concentration

Fig. 5. Blowing of Exhaust fan when harmful Gas is detected

IX. CONCLUSION

The Waste management system represents a significant advancement in waste management technology, addressing the pressing challenges of urbanization, population growth, and environmental sustainability. By integrating ultrasonic and MQ135 sensors with an Arduino NANO microcontroller and GSM module, the system offers a comprehensive solution for detecting waste levels and hazardous gases emitted from waste materials. The automatic closure of the waste bin lid upon detection of hazardous gases, coupled with the initiation of a sanitization process, exemplifies the proactive approach taken to mitigate health and environmental risks associated with waste disposal. Furthermore, the real-time monitoring and alert capabilities facilitated by IoT connectivity enhance operational efficiency and safety standards in waste management practices. Through instant notifications delivered via GSM modules, relevant authorities can promptly respond to gas detection events, minimizing potential hazards and ensuring public safety. Additionally, the inclusion of audible alerts through a buzzer provides localized warnings, further enhancing user awareness and safety. The project's integration of advanced sensor technology, microcontrollers, and communication modules not only streamlines waste management processes but also lays the groundwork for future advancements in the field. With the potential for further enhancements, such as predictive maintenance and renewable energy integration, the Automated Sanitary Waste Disposal system demonstrates a commitment to continuous improvement and innovation in environmental sustainability. In summary, this project represents a significant step towards achieving efficient, safe, and sustainable waste management practices in urban environments. By automating waste containment processes, enhancing operational efficiency, and leveraging advanced technologies, the system contributes to the preservation of public health, environmental quality, and community well-being.

X. FUTURE ENHANCEMENT

In future the waste management system can develop by integrating AI and machine learning to optimize collection routes and schedules dynamically, reducing fuel consumption and carbon emissions. Robotic waste sorting systems could autonomously categorize waste streams, improving accuracy and increasing recycling rates. These systems utilize computer vision and IoT technology for real-time monitoring of sorting performance and waste composition trends. By automating the sorting process, contamination in recycling streams can be reduced. Machine learning algorithms adapt collection schedules based on historical data and seasonal variations, ensuring timely waste disposal. Integration of sensors enables data-driven decision-making for waste management strategies. Overall, these advancements enhance efficiency, sustainability, and user experience in waste management practices.

X. ACKNOWLEDGEMENT

We would like to express our sincere gratitude to all individuals and organizations who contributed to the success of this project. Special thanks to our team members for their dedication and hard work throughout the development process. We are grateful for the support and guidance provided by our mentors and advisors, whose expertise and insights were invaluable. Additionally, we extend our appreciation to the suppliers and manufacturers for their assistance in sourcing materials and components.

REFERENCS

[1] Ahmed Mohamed; Yara ElSayed; Hassan Mahasneh, “Intelligent Trash Bin for Smart Cities”, 2023 1st International Conference on Advanced Innovations in Smart Cities (ICAISC), 2023.

[2] Ahmed, Marzia, Rony Shaha, Kaushik Sarker, Rifat Bin Mahi, and Mohammod Abul Kashem. "Design and Implementation of Intelligent Dustbin with Garbage Gas Detection for Hygienic Environment based on IoT." In 2022 International Conference on Advancement in Electrical and Electronic Engineering (ICAEEE), pp. 1-7. IEEE, 2022.

[3] Sreya, Kolachalama Venkata Naga, Rengarajan Amirtharajan, and Padmapriya Praveenkumar. "Smart BIN for a Smarter city: Monitoring and Alerting for a Clean Environment." In 2022 International Conference on Computer Communication and Informatics (ICCCI), pp. 1-5. IEEE, 2022.

[4] Akshayaa, S., R. Evangeline, S. Haritha Sree, and B. Banuselvasaraswathy. "Smart bin for Clean Cities using IOT." In 2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS), vol. 1, pp. 1280-1283. IEEE, 2021.

[5] S. Murugaanandam, V. Ganapathy and R. Balaji, "Efficient IOT Based Smart Bin for Clean Environment", 2018 International Conference on Communication and Signal Processing (ICCSP), pp. 0715-0720, 2018.