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.2026.77862

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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 Management System

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***Abstract:*** ***The high rate of urban population has further increased the problem of solid waste management manifolds. Conventional systems of waste collection are based on manual inspection and predetermined schedule that results into overflow, inadequate sanitation and slow reaction to dangerous situations. In this paper, an IoT Based Smart Waste Management System will be introduced, which allows monitoring dustbin fill level and smoke or fire hazards. The system exploits the ESP32 microcontroller with a built-in ultrasonic sensor to measure the level and an MQ-135 gas sensor to detect smoke. The information is presented on a local OLED screen and sent via Wi-Fi to a remote monitoring Blynk cloud dashboard. Telegram creates instant alert messages whenever something important happens. The system is reliable and scalable as well as cost-effective in smart city use.***

***Keywords: IoT, Smart Waste Management, ESP32, Ultrasonic Sensor, MQ-135, Blynk Dashboard, Telegram Alerts, Real-Time Monitoring, Smart City.***

## I. INTRODUCTION

Waste management is a silent issue that has emerged to be one of the largest challenges in the contemporary cities. With the increase in population and development of cities, there is an increase in the quantity of garbage that is produced daily. The streets become congested, houses become taller, and consumption becomes more speedy than ever. The problem? Conventional waste collection systems have not been developed at the same rate. Even the majority of cities rely on fixed schedules and manual inspection to control dustbins. That is when everything begins to go awry. Bins are overflowing before collection, odours are emitted in the streets and inappropriate conditions cause serious health risks. Apparently, we should have wiser solutions. This is something that people do not consider very often, it is necessary to mention that most waste bins are inspected only when a complaint is made, or when it is time to collect garbage. They are not attended to until then they are full. This reduction can easily become a hygienic problem in such congested areas as railway stations, shopping centers, hospitals, and residential buildings. But what would happen when bins were able to check themselves and give warnings? This is where smart garbage management with the use of IoT comes in. Rather than having to check the level of fill of a dustbin manually, sensors are able to continuously monitor the level and identify potentially dangerous situations, such as smoke or dangerous gases. A sensor that is ultrasonic will be able to determine the degree of fullness in the bin whereas a gas sensor can detect fire hazards that might be present in the bin. After processing data with a microcontroller such as ESP32, it is possible to present it locally and send wirelessly to the cloud platforms. Wireless Internet connectivity, a Web-based dashboard, and real-time mobile notifications are added to the system, and the whole process becomes an automated one. A smartphone or a web interface can allow authorities to remotely monitor the status of bins. It is possible to avoid overflow situations before they occur, and dangerous conditions may be recognized at an early stage. Therefore, the provision of a smart waste management system based on an IoT is not simply a technical improvement. It is a realistic and extendable method to ensure that cities are clean, safe and efficient toeveryone.

## II. LITERATURE SURVEY

We shall see where this idea originates. Researchers have debated over the years on the various methods of enhancing waste management through automation and sensors, wireless communication technology among others. With growth in urban waste creation, there was numerous research aimed at creating intelligent dustbins that can gauge the quantity of waste in the bin and provide a warning. Consideration of previous studies assists us to comprehend what has already been done, what remains unavoidable and what can be done to the modern systems to enhance them further.The perceptions of ultrasonic sensors in monitoring the level of bins have been extensively studied. These sensors give the distance between the sensor and the waste surface with the help of the echo signals. Some of the projects showed that ultrasonic sensors are capable of successfully establishing whether a bin is empty, partially filled, or full. Nevertheless, certain prior applications had complications including inaccurate measurements because of uneven waste or interference with the environment.Another research area that was ventured into by the researchers was wireless communication like GSM modules that were used to transmit SMS alerts when the bins were filled.

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Although efficient, GSM-based systems were more costly in terms of operations and needed SIM-based connection. Since the development of Wi-Fi-enabled microcontrollers, such as ESP8266 and ESP32, more recent systems began to use internet, allowing faster, more dependable data transfer.The other novelty in the recent research is the usage of gas and smoke alerts. Most of the traditional smart bins were dedicated to the monitoring of the fill level though subsequent studies emphasized the need to monitor dangerous gases or fire hazards within the waste bins. MQ-series gas sensors have broadly been utilized to sense smoke, ammonia and other dangerous gases and enhance safety and early warning of hazards.IoT monitors have also adopted cloud platforms like Blynk. Through such platforms, real time data can be visualized in form of dashboards, which will allow authorities to observe numerous bins remotely. The researchers discovered that the adoption of cloud dashboards enhances transparency and is useful in streamlining waste collection paths.Discussing all the work done before, one can understand that a more complete and reliable system is built by incorporating fill-level detection, smoke monitoring, cloud visualization, and instant alert mechanisms. The present project is based on the previous studies by combining ultrasonic sensing, MQ-135 smoke detector, Telegram warnings and Blynk cloud service monitoring into a simple, inexpensive and scalable smart waste management system, which can be presently used in the real-life environment.

## III. PROBLEM STATEMENT

The issue of waste management has been an alarming reality in urban centers that are expanding at a high rate. As population and daily consumption continue to increase, solid waste produced in cities has escalated by a great margin. Nevertheless, the majority of waste collection processes still depend on manual inspection and regular collection times. This archaic style usually leads to congested dustbins, bad smells and unsanitary environments before the garbage is picked up. These situations not only cause pollution to the environment but also health hazards to the people.Dustbins are only emptied at regular intervals in most of the places where people gather like in railway stations, hospitals, shopping malls, and residential complexes. When a bin gets full and is not picked up at the required time, it is not taken care of until an individual notices it and reports. Such a delay is inconveniencing, contaminating, and lowering the hygiene of the premises in general. Moreover, the conventional systems lack any system to monitor any dangerous conditions like smoke or accumulation of harmful gases within the dustbin that could result in fire hazards or unsafe environments.The other significant issue is absence of real-time monitoring of data and centralized control. Without adequate monitoring systems, municipal authorities will not be able to maximize collection paths and focus on bins that must be addressed at the earliest possible. Paper-based supervision adds to the labor expenses and lowers their efficiency.

## IV. PROPOSED METHODOLOGY

He proposed IoT-Based Smart Waste Management System is a system based on sensors and the wireless network, which is used to track the conditions of dustbins in real-time. The dustbin is fitted with an ultrasonic sensor mounted at its top to detect the level of fill material in the bin by comparing the distance between the sensor to the waste level. Meanwhile, an MQ-135 gas sensor will enter smoke or toxic gases that are present in the bin. The ESP32 microcontroller processes the sensor data and calculates the fill percentage, and verifies whether it is greater than set threshold values. When the bin is overfilled or the smoke is sensed more than a safe range, then the system will alert about it as a critical state. The ESP32 updates Blynk cloud dashboard to monitor remotely and provides instant notifications of an alarm via Telegram through WiFi connectivity. This computerized system offers round-the-clock surveillance, prompt action, and enhanced efficiency of managing waste.

## V. COMPONENTS USED

1) *ESP32 Microcontroller:* Consider the ESP32 to have been the brain of the whole system. It gathers the information of the sensors and interprets the information and then takes a decision, which is made depending on the predetermined conditions. It also controls the WiFi communication and sends real-time updates to the cloud dashboard and creates Telegram alerts when needed. It has an in-built WiFi, which makes the entire set up small and effective.

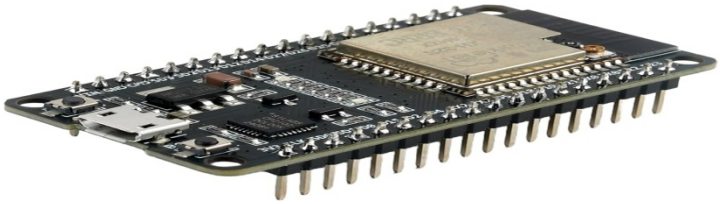


Fig. 1 ESP 32 Microcontroller 38 Pins

*2)* Ultrasonic Sensor (HC-SR04): This sensor is used to determine the fullness of the dustbin. It emits sound waves of ultrasonic nature to the waste and measures the distance by the reflection of the sound. The ESP32 will read this distance and use it to turn the bin into a percentage fill to either know that the bin is empty, partially filled or full.




Fig. 2Ultrasonic Sensor (HC-SR04)

*3)* MQ-135 Gas/Smoke Sensor: The MQ-135 sensor records smoke and unfriendly gases in the dustbin. The system gives an alert when the smoke level rises beyond a predefined range. This provides safety since potential fire risks or gas concentration has been identified.




Fig. 3MQ-135 Gas/Smoke Sensor

*4)* OLED Display (0.96” SSD1306): The OLED display provides real-time data including the status of bins, fill percentage, and level of smoke. It also offers local surveillance without the use of a smart phone or computer.




Fig. 4OLED Display (0.96” SSD1306)

*5)* LM2596 DC–DC Buck Converter: The LM2596 acts as a voltage regulator that supplies power to the ESP32 and sensors. The LM2596 reduces high voltage levels to an acceptable voltage that can power the devices.




Fig. 5 LM2596 DC-DC Buck Converter

*6)* Power Supply (Li-ion Battery): The system can be powered by a Li-ion battery or a DC adapter for power supply. A stable power supply is crucial in ensuring that the monitoring is uninterrupted, the sensor is functioning properly, and the system is working continuously



Fig. 6 18650 Li-ion Battery

*7)* Blynk Cloud Dashboard (Software Component): It also offers a remote monitoring system via a mobile or web interface. It indicates the fill percentage as well as the smoke level in real time. It also offers a centralized system for monitoring multiple bins.

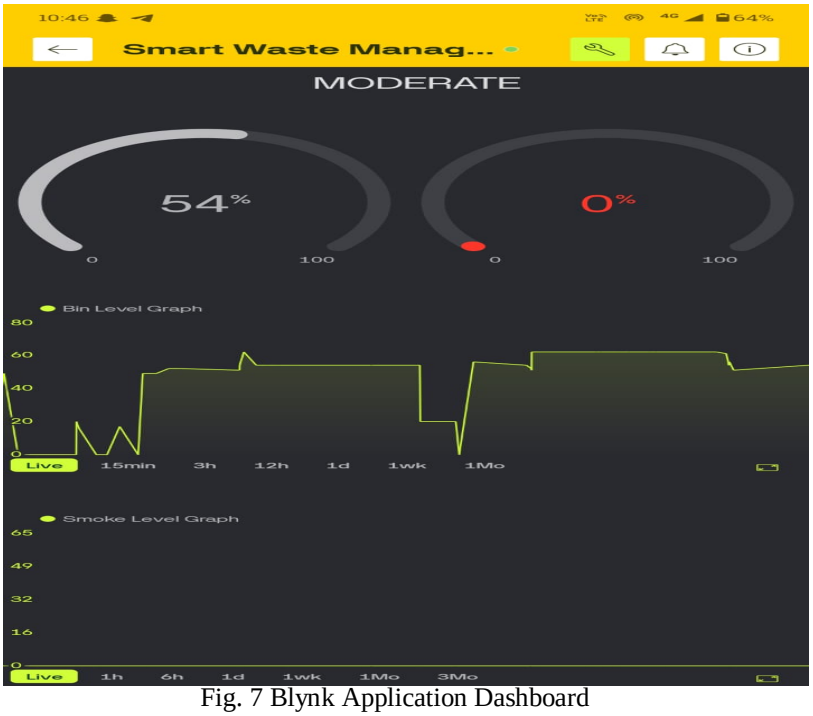
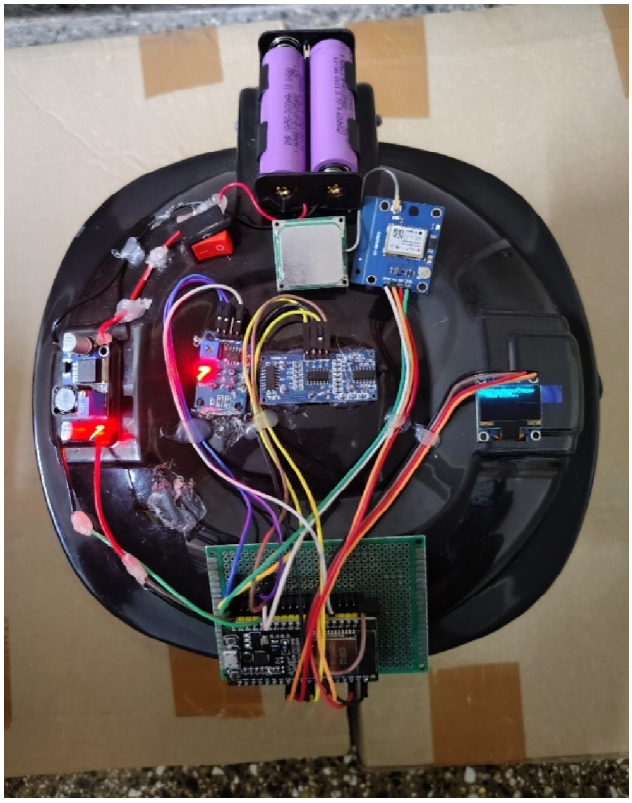
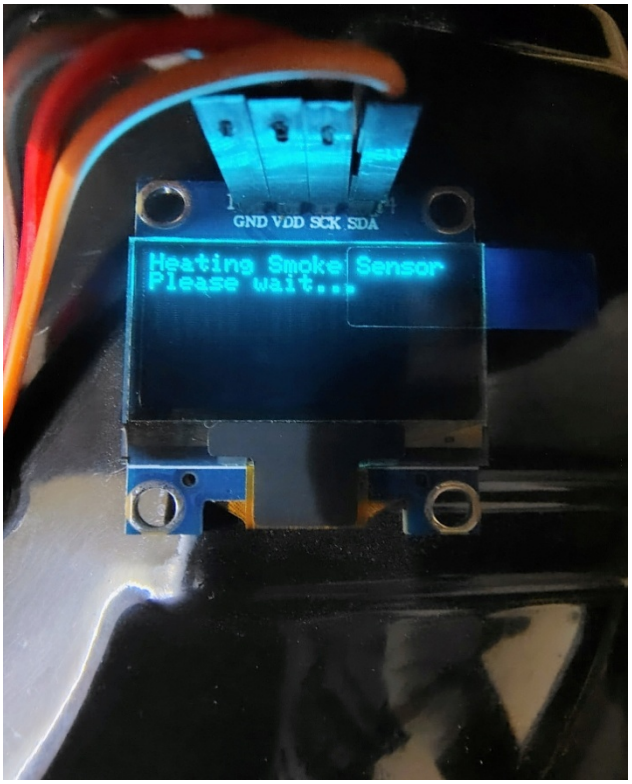



Fig. 7 Blynk Application Dashboard

## VI. RESULT





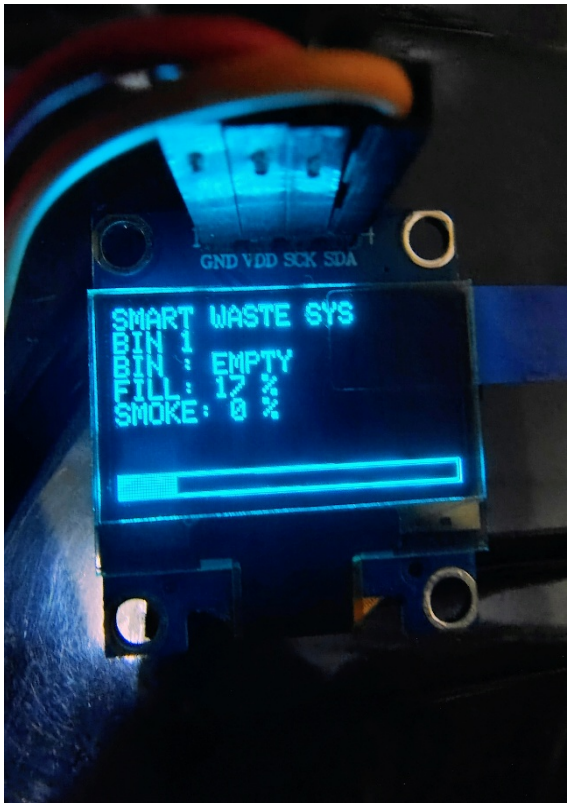




Fig. 10 Final Readings Bin Level and Smoke Sensor Value

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The IoT-Based Smart Waste Management System was successfully designed, implemented, and tested in different environmental conditions. The ultrasonic sensor was able to measure the distance between the sensor and the waste surface and compute the fill percentage of the dustbin in real time. During testing, the system was able to identify the states of the waste bin, such as empty, partially filled, near full, and full based on the predefined values. It was observed that the accuracy of the average fill level of the waste bin was found to be around 95%, with minor deviations due to irregular waste surfaces. The MQ-135 gas sensor was able to sense smoke and harmful gases inside the dustbin. When the concentration of smoke exceeded the safe limit, the system was able to identify the hazardous situation. During testing, the response time of the system to sense smoke was found to be less than2seconds. The OLED display was able to show the real-time data such as the status of the bin, the fill percentage, and the level of the smoke. At the same time, the ESP32 was able to transmit the real-time data to the Blynk cloud dashboard through its WiFi connectivity. The fill percentage and the level of the smoke were accurately shown on the dashboard with little delay.The notification of the Telegram alert was successfully received in 1-2 seconds once the threshold conditions were met. The WiFi connection was stable, and the system was able to run without interruptions.The system was able to show its reliability, response time, and accurate monitoring capabilities.

## VII. FUTURE SCOPE

The IoT-Based Smart Waste Management System has a lot of potential in the real world, especially in areas like cities and towns, as the generation of waste in those areas is always increasing. Areas around railway stations, shopping malls, hospitals, schools, residential areas, and streets can be greatly benefited by this smart waste management system. The installation of smart bins in those areas can greatly reduce the problem of overflowing bins.In the future, a lot of scope is available for improving the efficiency of this IoT-Based Smart Waste Management System. The use of advanced and accurate sensors can be made for better precision and lesser environmental interference. The system can be extended for monitoring multiple bins through a centralized cloud-based interface for the development of a smart city.Energy optimization is another area in which this IoT-Based Smart Waste Management System can be improved. The integration of solar panels in this smart waste management system can make it an energy-efficient smart waste management system and enable its deployment in the outdoors without the need for WiFi connectivity. The use of a GSM/LoRa communication module can be made for its deployment in areas without WiFi connectivity.The system can further be enhanced with data analytics and machine learning algorithms. By using historical patterns from past data on wastes, it can predict when the bins are likely to get filled. This can help reduce operational costs and make it more efficient.Moreover, it can be integrated with GPS technology, which can help authorities manage large numbers of smart waste containers. With the help of real-time monitoring, predictive analytics, and renewable energy, it can be made a complete smart system for waste management.In conclusion, with advancements in technology and proper strategies, it is believed that the proposed system has the potential to make a significant contribution towards cleaner, smarter, and more sustainable cities.

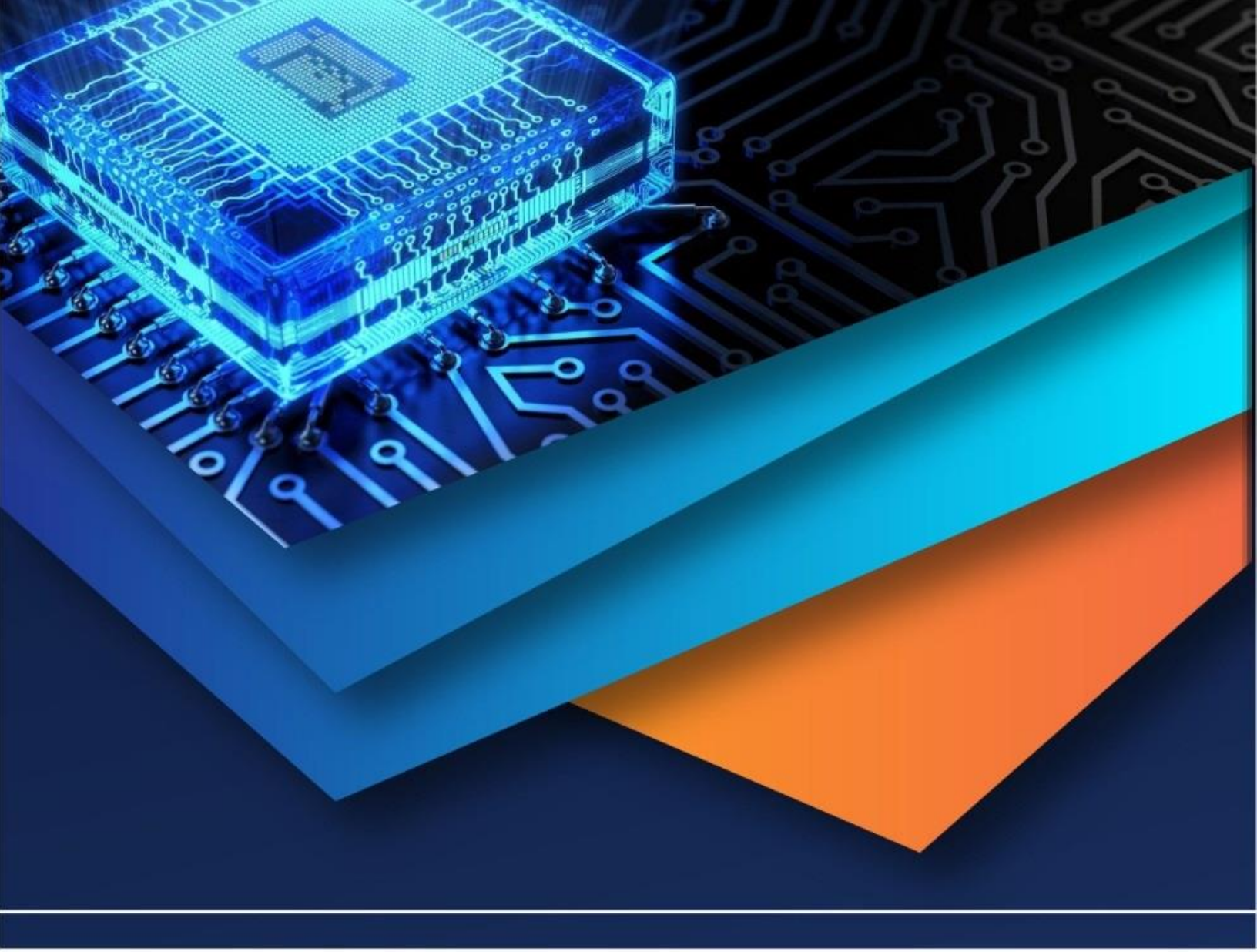
## VIII. CONCLUSION

The "IoT-Based Smart Waste Management System" provides an efficient method of automatic dustbin level monitoring as well as detecting hazardous conditions like smoke or harmful gases. This is achieved by using an ultrasonic sensor along with an MQ-135 gas sensor, which are connected to an ESP32 microcontroller. This provides continuous real-time monitoring of the dustbin level without the need for manual intervention. The sensor readings are shown locally using an OLED screen, as well as being remotely shown using the Blynk application.If the dustbin level reaches the full level or if the level of smoke exceeds the safe limits, then instant notifications are sent to the Telegram application. This ensures immediate action by the authorities, thus avoiding overflow, bad odor, or fire hazards. It has shown good performance, low latency, as well as precise detection of the dustbin level under different conditions.The proposed "IoT-Based Smart Waste Management System" is cost-effective, efficient, and useful for public areas like railway stations, hospitals, apartments, and commercial spaces. It contributes to maintaining clean and green environments.The proposed project demonstrates the application of "IoT" technology in developing "Smart Waste Management Systems."

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