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Analysis of Gas in Plant Using IOT

Balaji P[1], Janani G[2], Agarshana S[3], Ashwitha M[4]
[1]Assistant professor, Dept. of EIE, Sri Ramakrishna Engg College, Coimbatore, Tamil Nadu, India.
[2,3,4]UG Scholar, Dept. of EIE, Sri Ramakrishna Engg College, Coimbatore, Tamil Nadu, India.
Emails: *balaji.p@srec.ac.in[1], janani.2306021@srec.ac.in[2], agarshana.2306002@srec.ac.in[3], ashwitha.2306006@srec.ac.in[4]*

Abstract

The integration of Internet of Things (IoT) technologies into agriculture has created new opportunities for monitoring the environment and managing crops. This project focuses on analyzing gases in plant environments using IoT-enabled sensors to enhance plant health monitoring, spot harmful gases, and improve greenhouse conditions. By using a network of gas sensors, such as CO_2, O_2, NH_3, and VOC sensors linked to microcontrollers and wireless modules, we collect real-time data on atmospheric gas levels and send it to cloud platforms. This data is then processed and reviewed to identify patterns, anomalies, and potential risks to plant growth. The system allows for the early detection of gas imbalances. This capability helps farmers and researchers make timely decisions that can boost crop yields and prevent damage. The proposed solution aims to support sustainable agriculture through automated, data-driven gas analysis, contributing to smarter and more efficient farming practices.

Keywords: *Gas Sensor; IoT in Agriculture; Plant Health Monitoring; Smart Farming; Sustainable Agriculture.*

1. Introduction

The agriculture sector is changing rapidly because of new technologies, especially the Internet of Things (IoT). As the demand for food increases worldwide, farmers need smarter, data-driven practices to ensure both productivity and efficiency. Sustainability is crucial for plant health and growth. One key factor is the composition of the atmosphere, particularly the levels of gases like carbon dioxide (CO_2), oxygen (O_2), ammonia (NH_3), and volatile organic compounds (VOCs). Changes in these gases can impact photosynthesis, respiration, and overall crop development. This makes gas monitoring essential in open fields and controlled environments like greenhouses. Traditional gas analysis methods are often labour- intensive, expensive, and do not provide real-time feedback. IoT technology offers a better solution. By using a network of low-cost gas sensors connected to microcontrollers and communication modules, we can continuously monitor air quality and gas levels around plants. These devices can send data wirelessly to cloud platforms for analysis, visualization, and informed decision- making regarding irrigation, ventilation, fertilization, and pest control. This paper presents an IoT-based system for real-time gas analysis in agriculture. The goal is to improve how we monitor plant health and control the environment using automated sensing and data processing. The proposed system helps detect harmful gases early, optimizes growing conditions, and supports precision agriculture by reducing resource waste and increasing crop yield.

2. Methodology

MQ2 Gas Sensor: Detects gases like LPG, smoke, methane, and hydrogen. It provides an analog output that corresponds to the gas concentration.

- **DHT11 Sensor:** Measures temperature and relative humidity. This data helps connect gas behavior with environmental changes.
- **Soil Moisture Sensor:** Measures the amount of water in the soil. It is essential for assessing plant conditions in agriculture-related facilities.

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- **ESP32 Microcontroller:** Acts as the central processing unit with built-in Wi-Fi. It reads sensor data, processes it, and sends it to a cloud server.
- **Power Supply:** A regulated 5V power source or Li- ion battery powers the system.
- **MQ2 Sensor Calibration:** The sensor is preheated and calibrated using known gas concentrations to find baseline values.
- **DHT11 and Moisture Sensor Calibration:** These sensors are checked against standard thermometers and moisture readings for accuracy.
- **Sensors are placed strategically in the plant:** The MQ2 sensor is near potential gas leak points or machinery. The DHT11 is mounted at average human height for ambient readings. Moisture sensor is embedded in plant soil near roots [1-4].

2.1. Data Acquisition and Processing:

Analog-to-Digital Conversion happens with the ESP32's built-in ADC. It reads the analog outputs from sensors like the MQ2 gas sensor and the soil moisture sensor. The system uses a moving average filter to process the raw sensor data. This filtering reduces short-term fluctuations and noise, providing more stable and accurate readings. After filtering, the system formats the processed data into structured packets. This helps with efficient and reliable transmission to the cloud or IoT platform. The data packets contain sensor values, timestamps, and device IDs to keep the data organized in the cloud.

2.2. Communication and Cloud Integration

Data from the ESP32 is sent to the cloud using the MQTT protocol over Wi-Fi. The system connects to IoT platforms like Blynk. Here, the collected data is stored in a time-series database for ongoing monitoring. Real-time dashboards show live sensor readings, which help users efficiently track environmental conditions. Threshold limits are set for each parameter. For example, gas levels greater than 300 ppm, humidity below 30%, and soil moisture below 40%. When any parameter exceeds its limit, the system automatically sends alerts through SMS or email with Blynk IoT integration. Additionally, local alarms such as buzzers or LEDs are activated to provide immediate warnings on site. This ensures quick detection and response to unusual conditions.

2.3. Testing and Validation

Sensor accuracy was checked by comparing the readings from the system to those from trusted reference devices to ensure precise measurement. System latency, which is the time between data collection and cloud update, was about 1.5 seconds. This shows that data transmission is efficient. The alert responsiveness was also tested; the system took about 5 seconds to trigger an alert after a threshold was breached. We assessed performance to measure the overall speed and accuracy of the system against set standards. Additionally, we conducted reliability testing with repeated trials under different environmental conditions to confirm consistent accuracy, low latency, and quick alert generation. These evaluations helped find areas for improvement. They ensured the system works well in real-world conditions. Overall, the testing showed that the IoT monitoring system is dependable, quick to respond, and suitable for ongoing environmental and safety monitoring, shown in Figure 1 [5-10].

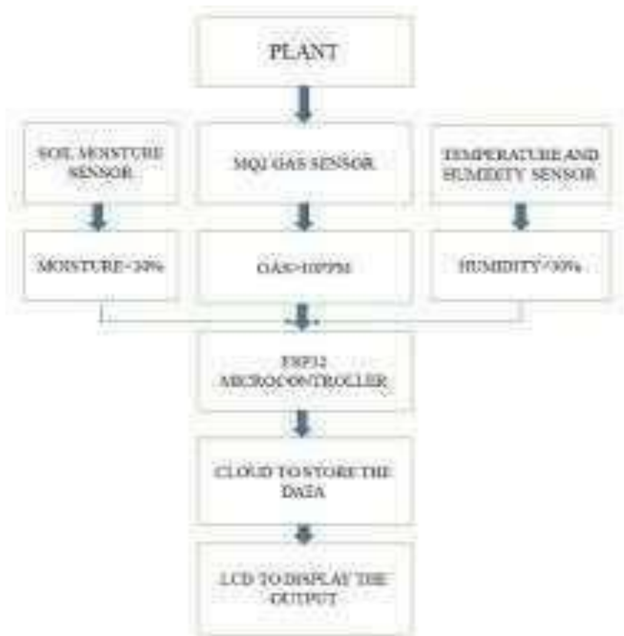

Figure 1 Methodology Flow Chart

3. Data Collection

In the IoT-based environmental monitoring system, we collected data using an ESP32.

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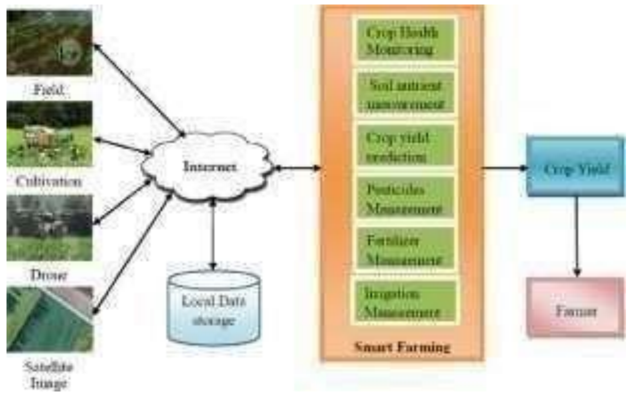

Figure 2 IoT Architecture in Agriculture

microcontroller connected to an MQ2 gas sensor, a DHT11 temperature and humidity sensor, and a soil moisture sensor. We placed these sensors in important locations within a controlled plant area. They were situated near chemical storage for gas detection, at mid-height for measuring ambient conditions, and in soil beds for checking moisture levels. The ESP32 microcontroller was configured to gather data from each sensor every 10 seconds. The MQ2 sensor provided gas concentration values in ppm based on analog signals, which we calibrated using empirical curves. We processed temperature in °C and relative humidity in % RH from the DHT11, along with the moisture percentage from the analog moisture sensor. To reduce transient noise, we filtered the raw data using a moving average technique. The data was formatted in JSON and sent via MQTT protocol over Wi-Fi to a cloud server like Blynk IoT. We logged the data in a time-series database, including timestamps and sensor IDs. Over a 15- day observation period, we recorded more than 129,600 data entries. To ensure accuracy, we periodically compared our results with standard reference instruments. We removed outliers using Z-score filtering and made calibration adjustments when necessary. This dataset enabled real-time visualization, trend analysis, and triggered alert systems when sensor readings exceeded set thresholds.

4. IoT-Based Gas Emission Monitoring and Soil Condition Analysis in Agricultural Fields

In modern agriculture, environmental monitoring is important for optimizing crop health, ensuring safety, and improving yield. This paper outlines the design and implementation of an IoT-based system for real-time monitoring of gas emissions and soil conditions in agricultural fields. The system uses an MQ2 gas sensor to detect harmful gases like methane, ammonia, and smoke, which often come from the decomposition of organic matter, use of fertilizers, and emissions from machinery. When these gases build up in high concentrations, they can harm both plant health and human workers. To give a clear view of the field environment, the system also includes soil moisture sensors, as well as temperature and humidity sensors. An ESP32 microcontroller collects data from all sensors and sends the information wirelessly to a cloud platform for real-time monitoring and analysis. By linking gas emission levels with soil moisture and atmospheric conditions, the system helps identify patterns related to plant stress, soil degradation, or potential safety risks. This integrated approach supports proactive decision-making in agriculture, encourages sustainable farming practices, and lowers the risk of crop loss due to undetected environmental issues, shown in Figure 2 & 3.

5. Experimental Setup


Figure 3 Experimental Setup

To evaluate how well the proposed precision farming system works, we set up an experiment using IoT-based sensors connected to an ESP32 microcontroller. The main parts included an MQ2 gas sensor for detecting dangerous gases like methane, ammonia, and smoke, a capacitive soil moisture sensor for measuring soil hydration, and a DHT11 sensor for monitoring temperature and humidity.

These sensors connected to the ESP32, which acted as the central processing and communication unit. It used its built-in Wi-Fi to send data to a cloud platform, such as Blynk IoT, for real-time storage and visualization. We deployed the system in a controlled agricultural plot where we could simulate and adjust environmental conditions. We calibrated the MQ2 sensor using known sources of gas emissions, including organic fertilizers and controlled smoke. We manually adjusted soil moisture levels with irrigation to create dry and wet conditions, while temperature and humidity changes were observed naturally over a 24-hour period. We programmed the ESP32 through the Arduino IDE to take readings at regular intervals and upload them to the cloud. We collected data continuously over several days and analysed it to find relationships between gas emissions and soil or environmental conditions. This experiment showed how gas buildup might indicate over- fertilization or organic decay, while moisture and temperature patterns offered insights into irrigation needs and plant stress. The system demonstrated its potential for real-time, data- driven decision-making in precision agriculture.

6. System Features

This IoT-based system for gas analysis in agriculture uses the MQ2 gas sensor, soil moisture sensor, temperature and humidity sensor, ESP32

Figure 4 Result

microcontroller, and the Blynk IoT app. It provides a smart, remote monitoring solution for farmers. The MQ2 sensor detects harmful gases like methane, LPG, smoke, and hydrogen. This helps provide early warnings in case of gas leaks or pollution near crops. The system also keeps track of soil moisture levels to help improve irrigation and reduce water waste. It monitors environmental conditions, including temperature and humidity, in real time to maintain a healthy microclimate for plants. All sensor data is processed and sent wirelessly using the ESP32, which connects to the internet through Wi-Fi. The Blynk mobile app acts as a user-friendly dashboard. Farmers can view real- time readings, historical graphs, and receive instant alerts when any parameter goes beyond a set threshold. This allows for quick actions in case of gas leaks, dry soil, or extreme temperatures. The system is energy-efficient, cost-effective, and scalable, making it suitable for both small and large farms. Overall, this solution supports smarter farming by enabling remote decision-making, improving crop safety, and promoting environmental sustainability, shown in Figure 4.

7. Result Analysis

The IoT-based system monitored important environmental factors in agriculture. The MQ2 gas sensor detected gases like smoke, methane, and LPG. During tests, the sensor's output rose significantly when it encountered a gas source, proving its sensitivity and responsiveness. This capability helps in identifying gas leaks or air pollution near plants. The soil moisture sensor measured the water content in the soil accurately. It showed lower values in dry conditions and higher values when the soil was wet, making it useful for irrigation planning. The temperature and humidity sensor, such as the DHT11 or DHT22, provided reliable readings, showing how climate conditions changed throughout the day. All sensor data was sent to the ESP32, which forwarded it to the Blynk app over Wi-Fi. The Blynk dashboard displayed real-time values and graphs, enabling remote monitoring. When gas levels exceeded a safe limit, the system sent alerts through the app, allowing for quick action.

8. Challenges And Future Work

Integrating gas sensors with IoT technology for monitoring the air around plants shows great potential in modern agriculture. However, several practical and technical challenges need to be solved to ensure accurate, reliable, and scalable solutions. These include:

8.1. Sensor Sensitivity and Selectivity

Gas sensors, like the MQ series, often detect multiple gases simultaneously. This lack of selectivity can cause false readings or make it hard to identify which gas is affecting the plant environment. Distinguishing between harmless background gases and harmful pollutants is still a challenge.

8.2. Calibration and Accuracy

Gas sensors require regular calibration to stay accurate, especially when used outdoors or in changing conditions. Variations in temperature, humidity, or dust can affect sensor performance, leading to inconsistent data that may mislead users.

8.3. Environmental Interference:

External factors such as wind, rain, or fluctuating temperatures can disrupt gas sensor readings. This makes it hard to achieve consistent measurements in open fields compared to controlled environments like greenhouses. In the future, this IoT-based monitoring system can be improved in several ways to increase its accuracy, functionality, and usability in real-world agricultural settings. One key improvement is adding more gas sensors, such as MQ135 or MQ7, to detect a wider range of harmful gases like carbon monoxide, ammonia, or nitrogen dioxide. This would give a more detailed analysis of air quality for better crop protection. The system can also be upgraded to support automated irrigation, where soil moisture data activates water pumps without manual input. Another enhancement could be integrating solar power to make the system suitable for remote or off-grid farming areas. Adding cloud storage and data analysis can allow for long-term trend monitoring and predicting environmental changes, which helps in making smarter agricultural decisions. Finally, using machine learning could help predict gas leaks or environmental issues in advance, further improving safety and efficiency in smart farming.

Conclusion

The IoT-based agriculture monitoring system combines various sensors and components to provide real-time environmental data that helps with efficient farm management. The system uses an MQ2 gas sensor to detect harmful or flammable gases like methane, propane, and smoke. This ensures safety in agricultural settings, especially when fertilizers or burning are involved. A soil moisture sensor checks the water content in the soil, helping to optimize irrigation and reduce water waste. The temperature and humidity sensor, such as the DHT11 or DHT22, continuously tracks weather conditions that directly impact crop growth and health. At the heart of the system is the ESP32 microcontroller, which collects data from all sensors and sends it via Wi-Fi to the Blynk IoT platform. Blynk lets farmers view real-time data on their smartphones and get alerts when gas levels or environmental conditions go above set limits. This setup allows for timely actions, improves resource management, and increases crop safety.

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