Air Quality Monitoring Using Thingspeak

B V N Rahul
Computer Science and Engineering
SRM Institute of Science and Techonology
Chennai, India
bn8504@srmist.edu.in

D Obul Reddy
Computer Science and Engineering
SRM Institute of Science and Techonology
Chennai, India
dv3490@srmist.edu.in

K Vineeth
Computer Science and Engineering
SRM Institute of Science and Techonology
Chennai, India
kz8413@srmist.edu.in

G Prabhas Reddy
Computer Science and Engineering
SRM Institute of Science and Techonology
Chennai, India
gg0252@srmist.edu.in

***Abstract*—Air quality monitoring is essential for understanding the impacts of pollutants on public health and the environment. This research focuses on developing and implementing an air quality monitoring system using Thing Speak, an IoT analytics platform. Our system employs a network of advanced sensors to collect real-time data on key pollutants. The data is transmitted to Thing Speak, where it is stored, processed, and visualized using sophisticated analytical models and machine learning algorithms. This integration allows for continuous monitoring, source identification, and trend prediction of air pollution. The system's effectiveness is demonstrated in both urban and rural settings, providing valuable insights into pollution patterns and supporting the development of mitigation strategies. The results underscore the potential of using Thing Speak for enhancing air quality management, informing policy decisions, and contributing to better public health and environmental sustainability.**

Keywords—IoT-based air quality monitoring, Environmental data analytics, Machine learning for air quality.

I. INTRODUCTION

The Internet of Things (IoT) can be seen as a global infrastructure for the information society, enabling advanced services by interconnecting physical and virtual objects using existing and evolving interoperable information and communication technologies. Despite common perceptions that air pollution is solely an outdoor issue caused by vehicle emissions, dust, and industrial exhaust, indoor air can also harbour harmful pollutants that pose health risks. For example, waking up with an itchy throat that requires coughing, despite not having a cough, may indicate poor indoor air quality, which can adversely affect health over time, especially for those who spend significant time indoors.

Humidity, which refers to the moisture content in the air, also impacts health. Ideally, indoor humidity should be around 45%. Humidity below 15% is considered too dry, while levels above 50% are too humid, with the recommended range being 15% to 50%. Chemical substances found in everyday cleaning products can further degrade indoor air quality. For instance, the fragrance of mopped floors often masks the presence of harmful chemicals. It is advisable to ventilate the area by opening windows to reduce exposure to these chemicals.

Air fresheners, commonly used to make indoor environments more pleasant, often contain dichlorobenzene, which can reduce lung function by up to 40%. Natural essential oil-based deodorizers are a healthier alternative. Cigarette smoke is another major indoor pollutant, containing toxic chemicals that can lead to respiratory issues and increase cancer risk. To maintain good indoor air quality, smoking should be done outdoors.

Outdoor air, often brought indoors through ventilation, can also compromise indoor air quality, especially in polluted regions. In 2018, Indonesia was noted as the most polluted country in Southeast Asia due to vehicle emissions, industrial activities, and other sources. While ventilation is intended to improve indoor air, it is only beneficial if the outdoor air is clean, such as in rural or suburban areas away from industrial pollution.

Maintaining a healthy environment significantly influences physical health, with air quality being a crucial factor. Air contains essential oxygen but can also be contaminated with harmful substances like carbon monoxide, carbon dioxide, formaldehyde, fungi, viruses, bacteria, and dust. While certain levels of these substances are manageable, exceeding normal limits can harm health. The World Health Organization (WHO) highlights that hazardous substances from buildings, construction materials, equipment, and combustion processes can lead to health issues. The rise in human activities has exacerbated air pollution problems, necessitating solutions to mitigate health impacts. While humans can sometimes judge air quality using their senses, continuous and accurate monitoring requires technological assistance. Real-time monitoring of temperature, humidity, and air quality can be achieved by developing hardware connected to a monitoring system, enabling effective management of indoor air quality.

Continuous technological advancements offer effective solutions for real-time indoor air quality monitoring. By employing IoT devices, we can collect and analyse data on various parameters such as temperature, humidity, and pollutant levels, providing a comprehensive understanding of indoor air conditions. This approach allows for immediate detection of harmful substances and timely interventions to improve air quality. Moreover, integrating these IoT systems with smart home technologies can automate ventilation and air purification processes, ensuring a healthier living environment. These innovations are crucial as they not only enhance our ability to maintain good air quality but also contribute to better overall health and well-being.

Implementing IoT-based air quality monitoring systems in homes and buildings can significantly improve indoor air quality management. These systems utilize various sensors to continuously measure air quality parameters and send real-time data to centralized platforms for analysis. With this data, users can identify pollution sources and trends, allowing for prompt corrective actions such as adjusting ventilation or using air purifiers. Furthermore, these systems can be programmed to alert occupants when pollutant levels exceed safe thresholds, ensuring immediate response to potential health risks. This initiative-taking approach to air quality management is essential for creating safer and healthier indoor environments, especially in areas with high pollution levels.

II. LITERATURE REVIEW

A. Summary of Previous Research on Air Quality Monitoring

Research on air quality monitoring has evolved significantly over the past few decades. Traditional methods involved the use of large, stationary stations that provided accurate but limited data, primarily due to their high costs and limited deployment capabilities. Early studies focused on understanding the impact of various pollutants, such as particulate matter (PM), nitrogen dioxide (NO2), sulfur dioxide (SO2), and carbon monoxide (CO), on human health and the environment.

Recent advancements have introduced more portable, cost-effective, and scalable monitoring systems using IoT technologies. These systems have enabled real-time data collection and broader geographic coverage. For instance, Kumar et al. (2015) demonstrated the use of low-cost sensors for monitoring air quality in urban environments, highlighting the potential of these devices to complement traditional monitoring networks. Other studies, such as Castell et al. (2017), emphasized the benefits of community-based monitoring using IoT devices to engage citizens in environmental health issues.

B. Thingspeak

Thing speak is a widely used IoT analytics platform that allows users to collect, store, analyse, and visualize data from sensors and other devices in real time. It supports various communication protocols and can integrate with different types of sensors, making it a versatile tool for environmental monitoring. Thing speak provides powerful data processing capabilities through its integration with MATLAB, enabling advanced analysis and visualization of the collected data.

Several studies have demonstrated the effectiveness of Thing speak in air quality monitoring. For instance, Thing speak has been used to monitor parameters such as Temperature, Humidity and Air Quality . Researchers have utilized Thing speak to develop systems that can provide real-time air quality data to the public, enabling individuals to make informed decisions about their health and activities.

One notable application is the deployment of low-cost air quality sensors connected to Thing speak for community-based monitoring. These systems allow residents to monitor air quality in their neighbourhoods, identify pollution sources, and advocate for cleaner air policies. Such community-driven initiatives have shown that IoT platforms like Thing speak can play a crucial role in increasing public awareness and engagement in environmental issues.

C . Comparison with other IOT platforms

While Thing speak is a popular choice for air quality monitoring, it is essential to compare it with other IoT platforms to understand its strengths and limitations. Platforms such as IBM Watson IoT, Google Cloud IoT, and Microsoft Azure IoT Hub also offer robust features for data collection, analysis, and visualization. However, Thing speak seamless integration with MATLAB for data processing and its user-friendly interface make it particularly suitable for academic and small-scale projects.

III. COMPONENTS

A. NodeMCU ESP8266

From previous research, the microcontroller in this system has been updated to use the NodeMCU ESP8266. The ESP8266 is a Wi-Fi module that functions as an additional microcontroller, similar to Arduino, enabling direct Wi-Fi connectivity and TCP/IP connections.

NodeMCU is an open-source IoT platform. It comprises hardware, specifically the ESP8266 System on Chip (SoC) created by Espresso Systems, and firmware that utilizes the Lua scripting programming language. The term NodeMCU primarily refers to the firmware rather than the hardware development kit itself.

NodeMCU can be compared to an Arduino board based on the ESP8266. Traditionally, programming the ESP8266 could be cumbersome, requiring specific wiring techniques and an additional USB-to-serial module to upload the program. NodeMCU simplifies this process by packaging the ESP8266 into a compact board that includes microcontroller functionality, Wi-Fi access capabilities, and a USB-to-serial communication chip. This design allows programming via a standard USB data cable, the same type used for data transfer and charging Android smartphones.

Key Features of NodeMCU ESP8266

- **Wi-Fi Connectivity**: Built-in Wi-Fi allows for easy connection to local networks and the internet.
- **Programming Flexibility**: Supports Lua scripting and can be programmed using the Arduino IDE.
- **GPIO Pins**: Multiple GPIO pins facilitate connections to sensors and other peripherals.
- **Compact and Affordable**: Small form factor and low cost make it accessible for hobbyists and researchers.

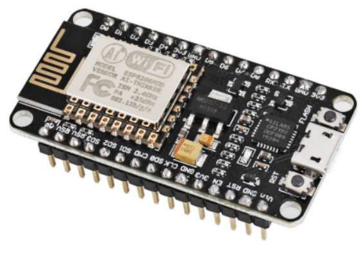

Fig-1: *NodeMCU ESP8266*

B. DHT11 Sensor

The DHT11 sensor is a popular component for measuring temperature and humidity, often utilized in air quality monitoring systems. It combines a capacitive humidity sensor and a thermistor to measure the ambient air, providing accurate digital outputs for easy interfacing with microcontrollers.

The DHT11 sensor is capable of measuring two environmental parameters simultaneously temperature and humidity. It incorporates an NTC-type thermistor for temperature measurement. Additionally, it features a resistive humidity sensor and an 8-bit microcontroller that processes data from both sensors. The results are then sent to the output pin using a single-wire bidirectional communication format.

The DHT11 sensor is essential in air quality monitoring systems due to its ability to provide precise temperature and humidity readings. These readings help in assessing indoor air quality and maintaining a comfortable and healthy environment. By monitoring humidity levels, the sensor can help detect conditions that might promote Mold growth or other harmful effects, ensuring better air quality and contributing to overall health and well-being.

Key Features of DHT11 Sensor

- **Temperature Measurement:** The range is 0 to 50°C and the accuracy is ±2°C.
- **Humidity Measurement**: The range is 20% to 90% Relative Humidity (RH) and the accuracy is ±5% RH.
- **Digital Output**: The DHT11 sensor delivers data in a digital format, making it straightforward to connect with systems like Arduino and NodeMCU.
- **Low Cost and User-Friendly**: This sensor is affordable and easy to use, making it suitable for both beginner projects and more advanced applications.
- **Compact Design**: Its small size allows for versatile integration into various devices and systems without occupying significant space.

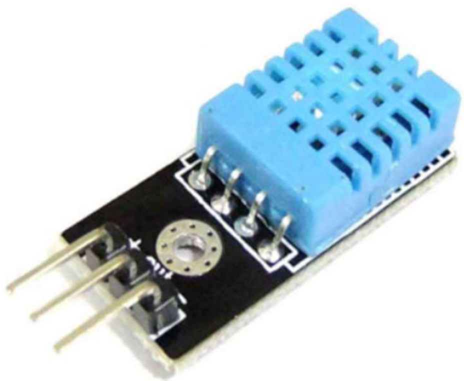

Fig-2: *DHT11 Sensor*

C. MQ135 Sensor

The MQ-135 sensor is designed to detect gases, exhibiting low conductivity in clean air. As the concentration of gases increases, the sensor's conductivity also rises. To convert the sensor's output to gas density, an additional electrical circuit is necessary. This sensor is highly sensitive to harmful gases such as ammonia, sulphide, and benzene across various concentrations. It boasts a long operational lifespan and is cost-effective, making it a valuable tool for air quality monitoring.

The MQ-135 sensor is widely utilized in air quality monitoring for detecting harmful gases such as ammonia, sulphide, and benzene. It functions by having low conductivity in clean air, with conductivity increasing as the concentration of target gases rises. An additional electrical circuit is required to convert this change in conductivity into gas density measurements. The MQ-135 sensor is valued for its high sensitivity across various gas concentrations, long operational life, and affordability, making it an ideal component for monitoring air quality and ensuring a healthier environment.

Fig-3: *MQ135 Sensor*

Key Features of MQ135 Sensor

- **Wide Detection Range**: Capable of detecting various harmful gases including ammonia, sulphide, benzene, and other VOCs.
- **High Sensitivity**: Exhibits high sensitivity to low concentrations of target gases, making it effective for detecting even small changes in air quality.
- **Fast Response and Recovery Time**: Quickly responds to changes in gas concentration and rapidly returns to baseline levels once the gas concentration decreases.
- **Long Lifespan**: Designed for long-term use, providing reliable performance over extended periods.
- **Wide Operating Range**: Functions effectively across a wide range of temperatures (-20 to 50°C) and humidity levels (up to 95% RH).

Applications

- Indoor Air Quality Monitoring
- Industrial Safety
- Smart Home Systems

D. Internet of Things(IOT)

The Internet of Things (IoT) refers to uniquely identifiable objects that can be virtually represented within the structure of the Internet. IoT is a concept in which objects have the capability to transfer data across a network without necessitating human-to-human or human-computer interaction. These "things" in IoT can include a variety of subjects, such as a person with a heart implant monitor, a farm animal with a biochip transponder.

IoT is currently one of the most discussed topics in technology. Its origins trace back to the first use of RFID technology in 2000. Since then, numerous technological advancements have overcome various challenges, leading to the rapid proliferation of smart devices around us. The IoT encompasses physical devices equipped with technologies and sensors that enable them to gather data from the real world, communicate with each other through a network, and take actions based on the evaluation of collected data. In the context of healthcare, IoT systems are based on the fundamental concept of IoT as a network of devices that directly connect to each other to capture and share vital data. This data is transmitted through a secure service layer that connects to a central command and control server in the cloud.

The Internet of Things (IoT) is a network of interconnected devices. These devices typically have an embedded operating system and the capability to communicate with the Internet or with nearby devices. A crucial component of a typical IoT system that connects these various devices is an IoT service. The true potential of IoT is realized when devices connect to a service, either directly or through other devices. In such systems, the service acts as an invisible manager, offering functionalities that range from basic data collection and monitoring to advanced data analytics. Thingspeak is a platform designed to provide various services specifically for developing IoT applications. It enables real-time data collection, visualizes collected data through charts, and allows the creation of plugins and apps for integration with web services, social networks, and other APIs.

IV. METHOLODOGY

To develop an effective air quality monitoring system, we selected three key components: the NodeMCU ESP8266, the DHT11 sensor, and the MQ-135 sensor. The NodeMCU ESP8266 serves as the primary microcontroller, offering integrated Wi-Fi capabilities for seamless data transmission. The DHT11 sensor measures temperature and humidity, while the MQ-135 sensor detects various harmful gases, including ammonia, sulphide, and benzene. Together, these components provide comprehensive environmental data, enabling us to monitor and analyse air quality in real-time.

The NodeMCU ESP8266 is central to our system, acting as the main processing unit. We connected the DHT11 sensor to the NodeMCU by wiring its VCC pin to the 3.3V power output, its GND pin to the ground, and its data pin to a digital GPIO pin on the NodeMCU. Similarly, the MQ-135 sensor's VCC pin was connected to the 3.3V power output, its GND pin to the ground, and its analogy output pin to one of the analogy input pins on the NodeMCU. This setup allows the NodeMCU to read data from both sensors efficiently. This setup ensures that the NodeMCU can continuously monitor environmental conditions with minimal latency. The sensors are polled at regular intervals, and their readings are stored temporarily within the NodeMCU's memory. Data integrity is maintained through error-checking algorithms implemented in the firmware. Additionally, power consumption is optimized by utilizing the NodeMCU's power-saving modes.

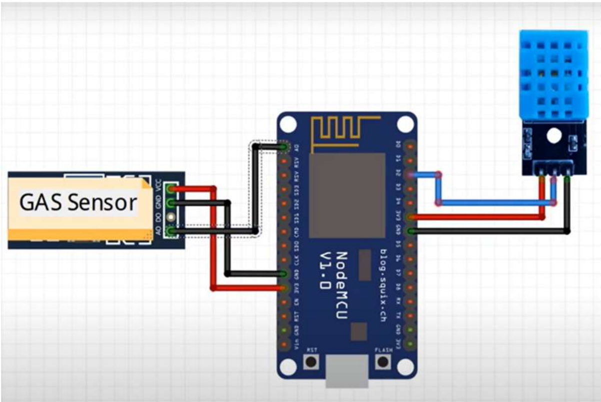

Fig-4: *Wiring Diagram*

The NodeMCU ESP8266 was programmed using the Arduino IDE, with libraries for both the DHT11 and MQ-135 sensors included. The microcontroller continuously reads temperature, humidity, and gas concentration data from the sensors. The DHT11 provides digital data, while the MQ-135 outputs an analog signal, which is converted to digital form using the NodeMCU's built-in ADC. This data is then processed and formatted for transmission to an online platform.

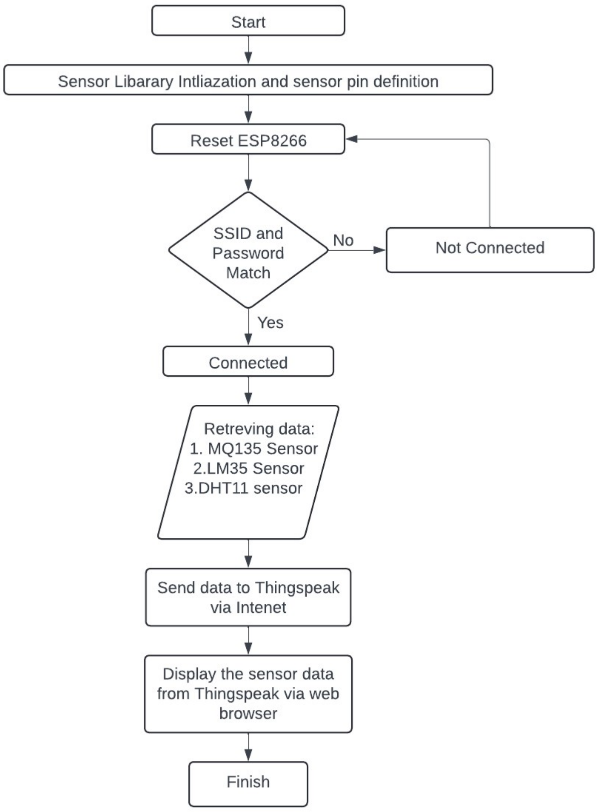

Fig-5: *Flow chart system function*

For real-time monitoring and data visualization, the processed sensor data is sent to the Thingspeak platform using the Wi-Fi capabilities of the NodeMCU ESP8266. Thingspeak allows for easy integration with IoT devices and provides tools for data analysis and visualization. By uploading the temperature, humidity, and gas concentration data to Thingspeak at regular intervals, we can monitor the air quality from anywhere with internet access. Alerts and notifications can be configured based on predefined thresholds to ensure timely responses to changes in air quality.

This methodology ensures that our air quality monitoring system is both efficient and reliable, leveraging the strengths of the NodeMCU ESP8266, DHT11 sensor, and MQ-135 sensor to provide comprehensive environmental data. The use of Thingspeak for data visualization and analysis further enhances the system's capability to track and respond to air quality issues in real time.

V . RESULTS AND DISCUSSION

The system being developed will monitor temperature, humidity, and air quality in a room in real-time. This system can be accessed via a web interface, utilizing the LM35 temperature sensor, the MQ-135 gas sensor, the DHT11 humidity sensor, and the NodeMCU ESP8266 module. The LM35 sensor is responsible for detecting temperature, the DHT11 sensor measures humidity, and the MQ-135 sensor detects air quality. The NodeMCU ESP8266 microcontroller processes the measurements and sends the data to the Thingspeak platform through its built-in Wi-Fi module. The data is then displayed on Thingspeak in the form of graphs, accessible via an Android smartphone or web browser, providing real-time monitoring and visualization of the room's environmental conditions.

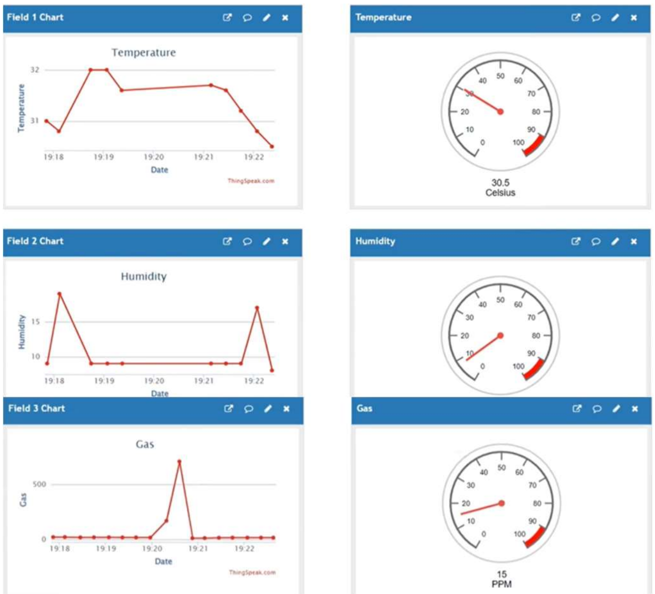

Fig-6: *Results in Thingspeak*

The integration of the LM35, DHT11, and MQ-135 sensors with the NodeMCU ESP8266 microcontroller allows for comprehensive environmental monitoring. Each sensor is carefully calibrated to ensure accurate measurements. The NodeMCU ESP8266 reads the sensor data at regular intervals and processes it to ensure accuracy and reliability. By leveraging the Wi-Fi capabilities of the NodeMCU, the system efficiently transmits the processed data to the ThingSpeak platform, where it can be further analyzed and visualized.

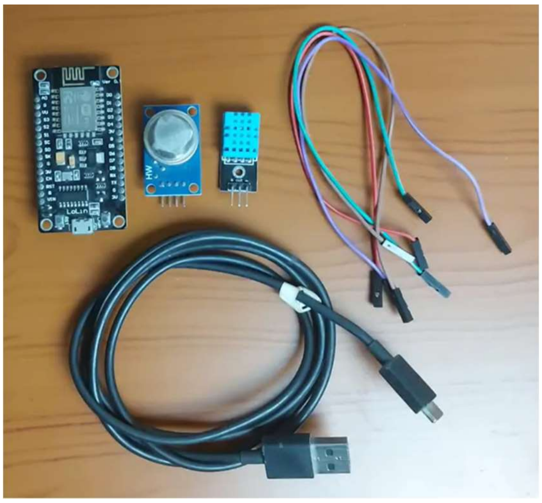

Fig-7: *Components Required*

Once the sensor data is uploaded to Thingspeak, it is presented in real-time through easily interpretable graphs and charts. Users can access this data through any web browser or an Android smartphone, making it convenient to monitor the room’s environmental conditions from anywhere. This real-time visualization allows for quick detection of any changes in temperature, humidity, or air quality, enabling timely interventions if necessary. The system's ability to provide continuous, real-time data ensures that users are always informed about the current state of the room's environment.

VI . CONCLUSION

This research focuses on creating a monitoring system that leverages the internet to extend its monitoring capabilities. By utilizing Internet of Things (IoT) technology, the system integrates the Thingspeak application with the NodeMCU ESP8266 module. The system features an LM35 temperature sensor to detect temperature, a DHT11 sensor to measure humidity, and an MQ-135 sensor to monitor air quality. These sensors send input signals to the NodeMCU ESP8266 module for processing. The Wi-Fi module in the NodeMCU ESP8266 transmits the sensor data to the Thingpeak IoT platform, where the data is logged and displayed in graphical form. This system provides a robust solution for indoor air quality monitoring, promoting awareness about the importance of maintaining healthy air quality. By offering real-time data access and visualization, it enables users to stay informed about the environmental conditions within their spaces, thus supporting initiative-taking measures to ensure a healthier living environment.

By logging the data on the ThingSpeak platform, the system provides users with continuous access to environmental conditions in their indoor spaces. The graphical representation of the data helps users easily understand trends and detect anomalies. This accessibility promotes heightened awareness of air quality issues and empowers users to take preventive measures to maintain a healthy environment. The system's ability to provide real-time updates ensures that users can respond promptly to any changes in air quality, thereby supporting initiative-taking health and safety efforts.

REFERENCES

[1] Gäde, R., & Reddy, D. K. (2014). Development of an IoT-Enabled Real-Time Air Quality Monitoring System. *International Journal of Engineering Research and Technology, 3*(4), 3467-3470.

[2] https://www.codeproject.com/Articles/845538/An-Introduction-to-ThingSpeak

[3] Thingspeak, MathWorks, Available: https://bit.ly/2JKng0Q

[4] World Health Organization., 2010, "WHO Guidelines for Indoor Air Quality: Selected Pollutant", Copenagen Denmark. [Online]. Available: https://bit.ly/2l7Kiny

[5] Bhattacharjee, D., & Saha, H. N. (2018). IoT-Enabled Real-Time Air Quality Monitoring. *IEEE Global Humanitarian Technology Conference (GHTC)*, 1-5.

[6] Patel, R. C., & Patel, P. (2016). Implementation of an IoT-Based Air Pollution Monitoring System Using Thingspeak. *International Journal of Innovative Research in Science, Engineering and Technology, 5*(6), 14084-14089.

[7] Sharma, A., & Jain, N. (2020). "Air Quality Monitoring Using IoT and ThingSpeak." *International Journal of Engineering Research & Technology, 9*(8), 1105-1108.

[8] Patel, R. C., & Patel, P. (2016). "Implementation of an IoT-Based Air Pollution Monitoring System Using ThingSpeak." *International Journal of Innovative Research in Science, Engineering and Technology, 5*(6), 14084-14089.

[9] J. Gubbi, et al.: "Internet of Things (IoT): A vision, architectural elements, and future directions." Future generation computer systems 29.7 (2013): 1645-1660.

[10] Chandra, S., & Agarwal, A. (2019). "Using IoT and ThingSpeak for Air Quality Monitoring." *International Journal of Engineering Trends and Technology, 67*(8), 75-81.

[11] https://www.youtube.com/watch?v=R_6twDv8w9A