Smart Air Quality Monitoring and Purifying system

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***Abstract*- This paper presents the concept and functional physical model of an air purification system for small public spaces or apartments. The purifier is controlled by a microcontroller of the Arduino UNO series. The model is equipped with a set of sensors that are used to determine the air quality. After exceeding the adopted threshold in the software, the system automatically starts the process of air filtering. To monitor and to the development of efficient and effective air quality measuring systems using air purifiers. However, recent technological advancements such as IoT (Internet of Things) with Cloud Computing have allowed us to obtain and monitor real-time data. In this paper, an IoT-enabled industrial air quality monitoring device is proposed. This device is enabled with an MQ-135 gas sensor for precisely monitoring the air quality and detecting the presence of foreign contaminants such as alcohol. The proposed device also uses a Node MCU ESP 8266 Wi-Fi module to efficiently transmit real-time data to a smart device (E.g. Smartphone) using an IoT platform.**

Keywords—Temperature, Humidity, Buzzer module, and ESP8266 Wi-Fi Module, Hardware, Software, IoT, Arduino, Micro Controller, Monitoring, Sensors.

I. INTRODUCTION

Today, air pollution is a major environmental concern. A healthy environment is the first and foremost thing for our happiness. We need pollution-free surroundings to live a safe and secure life. The recent increase in pollution levels in metropolitan cities, especially in Delhi, is a worrying sign. In a world that is advancing rapidly with technology where cars can drive on their own and drones can capture your food, air pollution should not be of much concern but the above statistics just prove it wrong. Our application is one such thing that can provide the surrounding air quality index to the user. This is a basic level system that notifies the user of the various pollutants and their levels present in the air. We have also additionally included a buzzer alarm that notifies the user when the pollutant level breaches a certain threshold mark. This will make the user understand that the place is not healthy and safe to live. So, the user can now take necessary steps to reduce air pollution or move to a safer location.

Atmospheric circumstances endure to weaken early causing devastating effects on climate and the ecosystem.Manysolemnhealthissuesasrespiratoryproblems, cardiovascular issues, and dermatological diseases in humans are caused by air pollution. The air is polluted by toxic gases and contaminants. The pollutants released from various industrial plants and factories, vehicle emissions, and countless other sources consequently increase the concentration of greenhouse gases such as CO2, NO2, and SPM (Suspended Particulate Matter) in the atmosphere. Now more than ever, the need for monitoring air quality is of utmost importance. The production of affordable IoT-based air quality monitoring devices and their widespread use has allowed people to detect the air quality in concerned areas swiftly. In this paper, one real-time portable quality of air Monitoring system based on several air parameters like the level of CO2, and the presence of smoke, alcohol, and other foreign contaminants is proposed.

In this modern world, technology provides us with many useful features that can be implemented to have a healthy and safe environment. We all are aware of the fact that in places like Delhi and other metropolitan cities, the air quality index is changing from bad to worse. People living in such places should necessarily carry an air Purifying System. An air pollution monitoring system consisting of all facilities to keep track of the air quality index and take necessary steps to improve the quality of air in immediate surroundings.

To regulate the air quality from the data obtained, the propounded IoT-based industrial air quality monitoring system uses pre-defined standards for indoor air quality [Table1] through levels of CO2 in parts per million (ppm) as mentioned in Indoor Air Quality Control Act

CO_2 Concentration	Health effects
< 400 ppm	Normal outdoor level- no observable effect [6].
400-2000 ppm	Respiratory problems, severe headaches, loss of cognitive function, eyesight impairment, dizziness are observed [6].
2000-5000 ppm	Increased heart rate, restrictive lung behavior, unhealthy blood carbon dioxide levels, drowsiness and nausea are observed [6].
5000-40,000 ppm	Sleep disruption, lethargy, mental slowness and increased lung dead space volume are observed [6].
>40,000 ppm	Exposure to this level will lead to severe oxygen deprivation which will cause lifelong brain damage, paralysis, coma or may even prove to be fatal [6].

Table-1:StandardsforCO2LevelsofIndoorAIR

II. MATERIALSANDMETHODS

HARDWARERE QUIREMENTS:
General Hardware requirements are:
- Arduino UNO
- Wi-Fi module (ESP8266)
- DHT11 Temperature and Humidity Sensor
- Pressure sensor
- MQ135sensor
- MQ2 sensor
- Buzzer Module
- LCD Display board (16*2)
- MQ7 sensor
- 2 Fans
- Motor Driver
- Battery

SOFTWARE REQUIREMENTS:
Operating System: Window
Programming Language: Embedded C
- IDE: Arduino IDE.
- IoT Platform: Thingspeak

❖ **Arduino Uno Board (ATmega328P):**

Arduino Uno is an open-source microcontroller board developed by Arduino.cc. It is based on the Microchip AT mega328P microcontroller. It is one of the most popular Arduino development boards and is universally known as 'stock Arduino'. It is a small development board with having size 2.7 in * 2.1 in. Having the Microcontroller in a larger DIP package means it can be removed or replaced easily. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the Microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

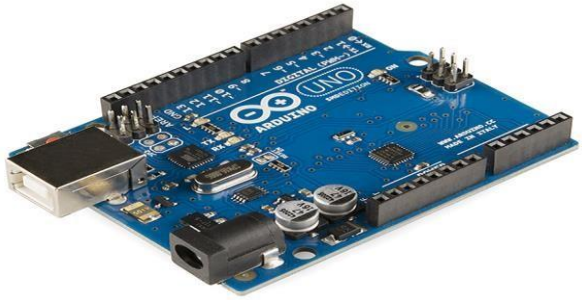


Fig.1. Arduino Uno Board

❖ **Wi-Fi Module (ESP8266):**

The ESP8266 12e module which is a low-cost, self-contained chip consists of a TCP/IP protocol stack that is used to provide network access to any microcontroller. It is highly compact and easily portable and thus this is interfaced with the Arduino to provide the robot with a Wi-Fi facility. The ESP-8266 is shown in belowfig2.

Fig2. Wi-Fi module

❖ **DHT11 Sensor:**

DHT stands for Digital Humidity and Temperature. The DHT sensor is a low-cost digital sensor for sensing temperature and humidity. The DHT11 is a basic, ultra-low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin.

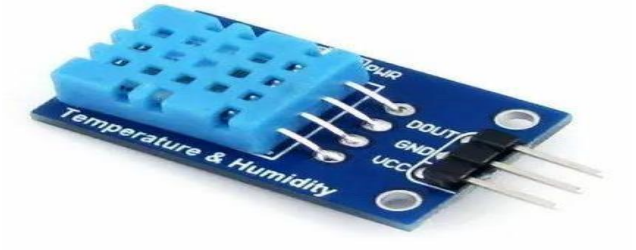


Fig3.DHT11 Sensor

❖ **Pressure Sensor:**

A pressure sensor is defined as a transducer that converts an input mechanical pressure into an electrical output signal the most common type of pressure sensor used is a transducer (piezoelectric and strain gauge) Sensors work by detecting physical changes in the device's environment and outputs them as analog voltages or digital signals. This is then sent to a human-readable display where it can be monitored transmitted, or relayed to other electronic devices for further processing.

Fig4. Pressure Sensor

❖ **MQ2Sensor:**

The MQ sensor in full form typically refers to a "Methane/CH4 Quality Sensor" in the context of gas sensors. MQ2 gas sensor is an electronic sensor used for sensing the concentration of gases in the air such as LPG, propane, methane, hydrogen, alcohol, and smoke. The MQ- 2 is a smoke and combustible gas sensor from Winsen. It can detect flammable gas in a range of 300- 10000ppm. Its most common use is domestic gas leakage alarms and detectors with a high sensitivity to propane and smoke.

Fig5. MQ2 Sensor

❖ **MQ7Sensor:**

This is a simple-to-use Carbon Monoxide (CO) sensor, suitable for sensing CO concentrations in the air. The MQ-7 can detect CO-gas concentrations any where from10 to 500 ppm. This sensor has a high sensitivity and fast response time. The sensor's output is an analog resistance. MQ-7 CO Carbon Monoxide Coal Gas Sensor Module detects the concentrations of CO in the air and outputs its reading as an analog voltage. The sensor can measure concentrations of 10 to 10,000 ppm. The sensor can operate at temperatures from -10 to 50°C and consumes less than150 mA at5V.

Fig6.MQ7 Sensor

- **Buzzer Module:**

A buzzer is used to add the sound feature. It is light in weight, Good performance, general purpose musical buzzer are commonly used in alerting / alarming circuits, kids toys, etc. This buzzer is used as an external buzzer which operates in a wide range of voltage (3V to 12V). The most commonly used buzzers operate at 9V & 12V. They have a long life, stable performance, and High Quality with the SOT plastic package.

Fig7. Buzzer Module

- **LCD Display board (16*2):**

A 16×2 LCD is a liquid crystal display that can show 16 characters in each of its two rows, providing a total of 32 characters of information. It's commonly used to display alphanumeric information on various electronic devices. LCD 16x2 is a type of liquid crystal display (LCD) that can display up to16characters per line and 2 lines. These displays are widely used in a variety of applications, such as displaying text or data in electronic projects.

Fig8.LCD Display (16*2)

- **Motor Driver:**

It is a dual H-bridge motor driver integrated circuit (IC). The L298N is a dual full-bridge high current motor driver. The L298N is a dual H-Bridge motor driver that allows speed and direction control of two DC motors at the same time. The module can drive DC motors that have voltages between 5 and 35V, with a peak current of up to 2A. This L298N Motor Driver Module is a high-power motor driver module for driving DC and Stepper Motors.

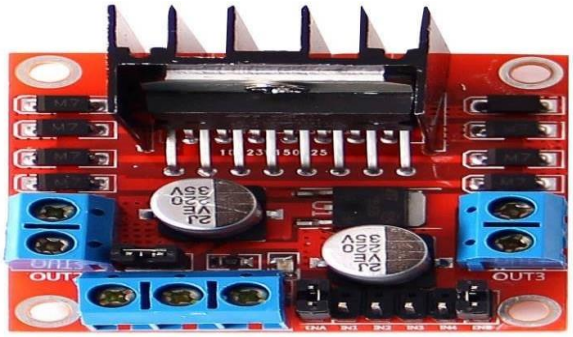


Fig9. Motor Driver (L298N)

MQ135Sensor:

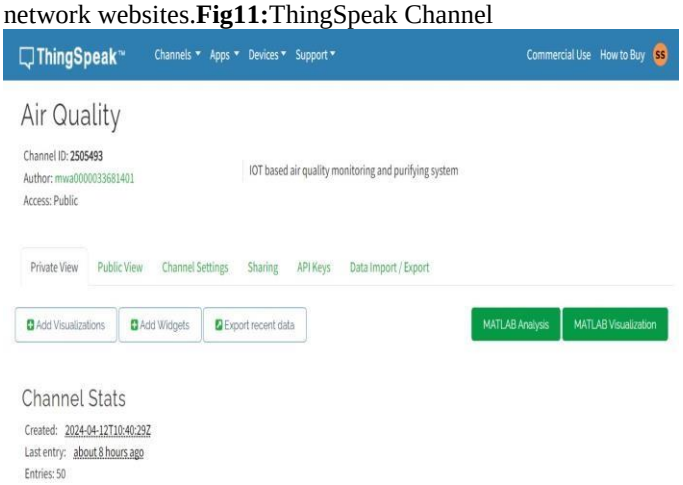
The MQ135 is one of the popular gas sensors from the MQ series of sensors that are commonly used in air quality control equipment. The MQ-135 Gas sensor can detect gases like Ammonia (NH3), sulfur(S), Benzene (C6H6), CO2, and other harmful gases and smoke. Similar to other MQ series gas sensors, this sensor also has a digital and analog output pin. When the level of these gases goes beyond a threshold limit in the air the digital pin goes high. This threshold value can be set by using the on-board potentiometer.

Fig10.MQ135 Sensor

SOFTWARER EQUIREMENTS:

Thingspeak:

Thingspeak is an IoT analytics platform service that allows you to aggregate, visualize, and analyze live data streams in the cloud. You can send data to Thingspeak from your devices, create instant visualization of live data, and send alerts. Thingspeak is an open-source software written in Ruby that allows users to communicate with internet-enabled devices. It facilitates data access, retrieval, and logging of data by providing an API to both the devices and social network websites.**Fig11:**ThingSpeak Channel



❖ **Arduino IDE:**

The IDE we used here is 'Arduino IDE' and the programming language used is 'Embedded C'. The Arduino has all the features-as shown in below fig6.

- Editor •Cross compiler
- Debugger •Serial Monitor

The programming codes are known as sketches. The sketches are saved with the file extension .ino. It runs on Windows, MAC, and LINUX. Thus through this software, we can code for the robotic movements and also for the sensors interfaced with the Arduino board.

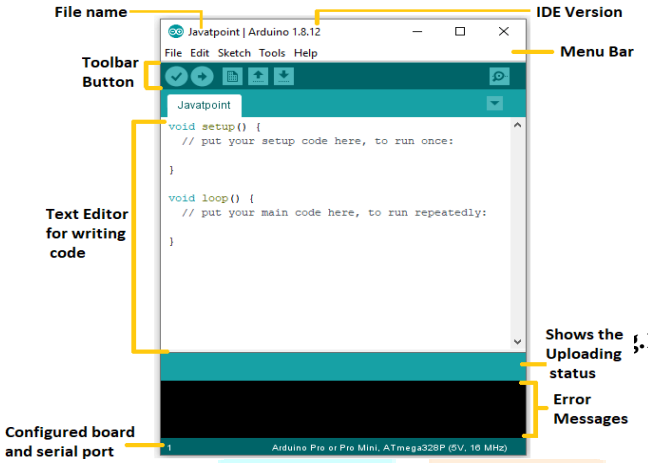


Fig12. Arduino IDE

III. WORKING

The suggested system includes a variety of sensors as shown in the Fig.13.Block diagram. The Smart Air Quality Monitoring and Purifying System Project aims to create a comprehensive solution for monitoring and improving air quality. It involves using various sensors and fans to monitor and purify the air quality. The main objective is to develop a functional prototype that includes sensors like MQ135, MQ2, MQ7, and DHT11, which can detect different gases and environmental conditions such as LPG, smoke, alcohol, humidity, and temperature.

To enable data collection and analysis, the system uses an Arduino UNO microcontroller board. Additionally, a Wi-Fi module (ESP8266) is incorporated to allow for connectivity and remote control of the system over the Internet. This feature allows users to monitor air quality levels and manage the system from anywhere, providing convenience and accessibility.

The system is designed to promote healthier living conditions by providing timely information about air quality levels. Threshold values are pre-set in the source code for the sensors, and when these values are exceeded, actions are triggered. For example, when the air quality deteriorates beyond the set thresholds, fans are activated to purify the air in the surrounding area. This innovative approach helps to minimize health risks associated with poor air quality and contributes to sustainable development efforts by optimizing energy consumption.

Additionally, the system utilizes the Thingspeak cloud platform to visualize and store air quality data. This enables users to track trends over time and make informed decisions about air quality management. Overall, the Smart Air Quality Monitoring and Purifying System represents a Significant step towards creating healthier and more sustainable environments.

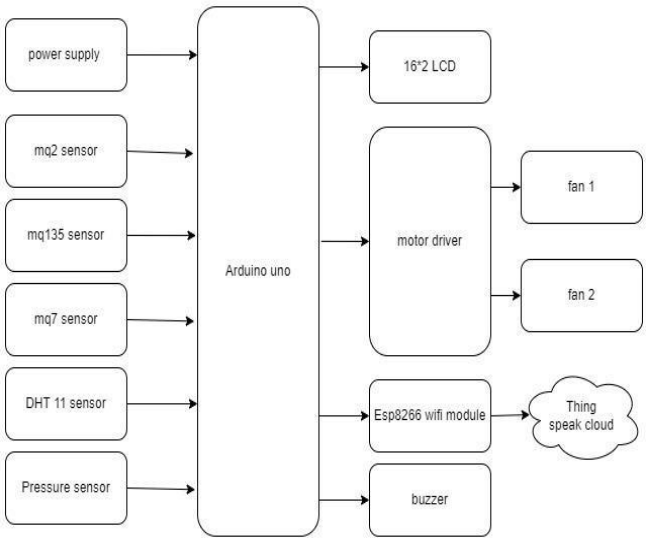


Fig.13. Block diagram of our Smart Air Quality Monitoring and Purifying System

The Block Diagram Represents the Overall design of the proposed system. The total design can be obtained by using Arduino UNO. The result is obtained by using the IoT platform called Thingspeak (Graphical Representation of Sensor values).

System Architecture:

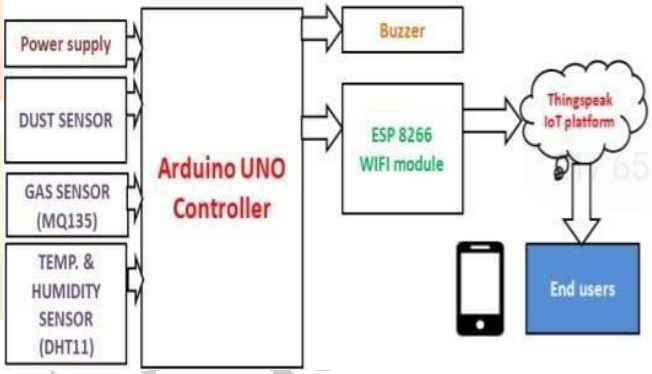


Fig14. SystemArchitectureofpaper

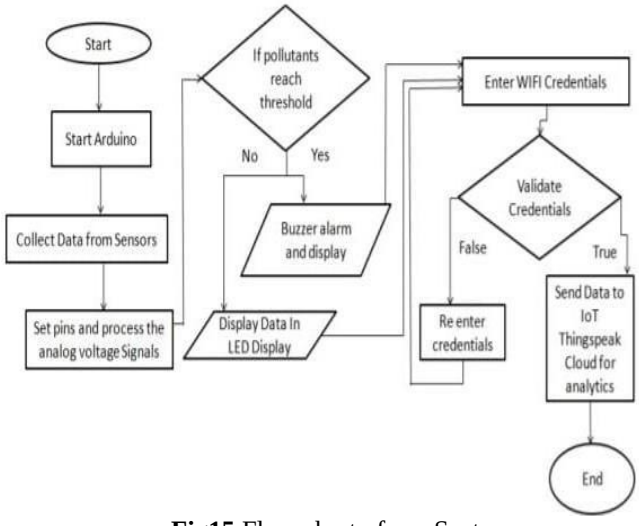


Fig15. Flow chart of our System

IV. RESULTS AND DISCUSSIONS

- The Arduino UNO, LCD, MQ2, MQ7, and MQ135Sensor, DHT11 Sensor, and Pressure sensor, Buzzer, L298N Motor Driver, Fan-1, and Fan-2 are integrated on the board. In below **Fig.16**, we can see how the setup works and gives the air quality levels as an output.

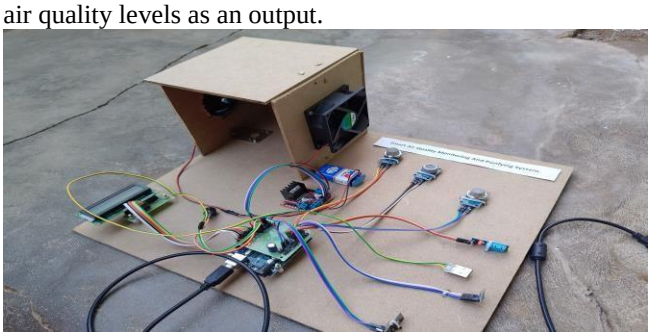


Fig16. Implemented System of our paper showing us Basic Hardware Connection

- The kit we have developed is shown in Fig. 16.and theoutputswe obtained areinFig. 17.below.

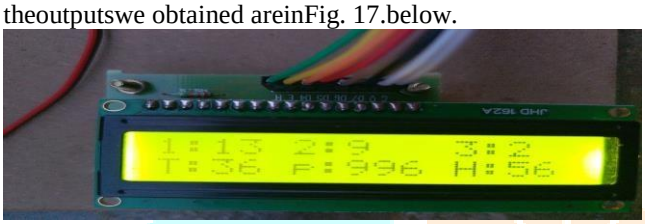


Fig17. Observations on LCD Display.

- The above Fig17. LCD Display contains the Values of Temperature, humidity & Gas sensor values.
- Also, the below **Fig.18.** Shows the circuit diagram of the proposed air quality monitoring and purifying system and shows the real-time implementation of the proposed system. It describes the working and sensing of a smart system.

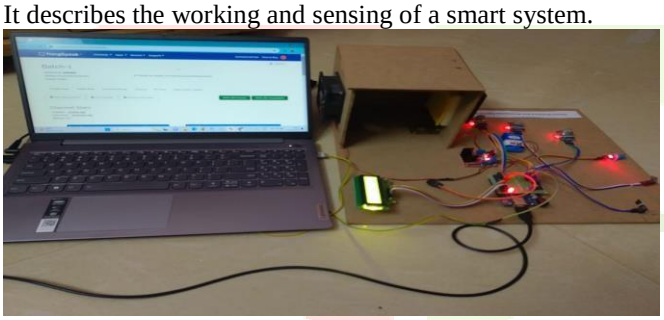


Fig18. Real-Time Implementation

The Arduino UNO board is used to implement the project. The code for the system is written and embedded into an Arduino UNO board. The Arduino UNO board is programmed in such a way that it processes the input from the five sensors like gas sensors (MQ2, MQ7, and MQ135), temperature and humidity, and pressure sensors. These five sensors detect various possibilities of air quality and provide input to the Arduino board for processing. The Arduino UNO board is powered by an external power supply. It processes the input data from the sensors which are in analog form. The data is processed and sent to the IOT cloud platform Thingspeak through the ESP8266 Wi-Fi Module. The Thingspeak platform can be used to design our application interface, store, and visualize. The Wi-Fi module successfully transfers the data to the cloud platform (Thingspeak). The Thingspeak platform successfully displays the data in a user-friendly and visualized manner. So, the user can monitor the changes in air quality through the Thingspeak IOT platform. Now we have observed the plots of sensors given below.

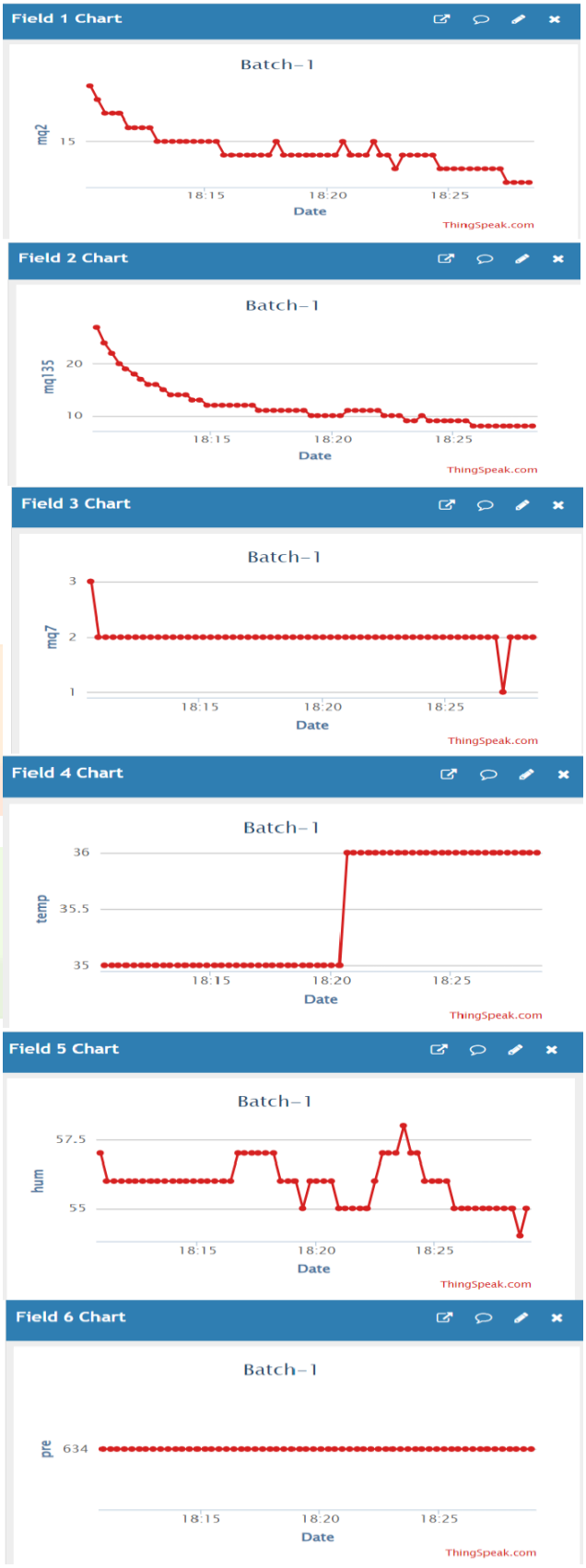


FIG.19.IMPLEMENTED SCREENSHOTS:

Graphical representation of variation in data: Screenshots taken from Thingspeak IoT Platform.

X-Axis: Temperature, Humidity, Gases, Pressure.

Y-Axis: Time (inch: mm24-Hour Format).

The above **fig19.** Shows the graphs/fields (different sensor values) sent to the IOT analytical platform called Thingspeak which aggregates, analyses, and gives the visualization of the live data instantly. The first graph shows the smoke value obtained from the MQ2 sensor. The second graph shows the ammonia and sulfide values obtained from the MQ135 sensor. And third graph shows the carbon monoxide value obtained from the MQ7 sensor. The fourth and fifth graphs show the temperature and humidity values obtained from the DHT11 sensor and the sixth graph shows the value of pressure that is obtained from the pressure sensor.

The plots change according to the air quality levels of the surrounding areas. If the values of the input change or exceed the pre-set values then the corresponding plots also change, then the fans are activated and purify the air in that particular area through the motor driver which is connected to the Arduino UNO board. The use of cost-efficient sensors makes it an affordable system which is important for people

CONCLUSION

In Conclusion, Everyone would agree to the fact that a healthy surrounding is the foremost thing we need in our lives. Here we provide a pollution detection system with the help of technology. This proves the fact that technology is touching every field which in turn shows that everything is dependent on technology. With the use of technology, our system focuses on providing the air quality index of the surroundings to the user.

In this paper, the air quality monitoring and air purifying system using Arduino provides an effective solution for improving indoor air quality. By continuously monitoring air quality parameters and activating the air purifier when necessary, the system helps maintain a healthy environment. Further enhancements and optimizations can be made to improve the system's performance and usability.

The output expected is working seamlessly. The idea which we wanted to implement earlier is what exactly we have done in this project successfully. The use of cost-efficient sensors makes it an affordable system which is important for people living in metropolitan cities. The system works even during power shutdown as it also uses an external battery apart from the power supply. The system also alerts the user when the pollutant level reaches a threshold value so that the user can take necessary action or move to a safe location. For Storage of Data and detailed and visualized analysis, the Thingspeak IoT platform is useful for future analytics. The Wi-Fi module successfully transfers the data to the cloud platform (Thingspeak). The Thingspeak Platform successfully displays the data in a user-friendly and visualized manner. So, the user can monitor the changes in air quality via a smart phone seamlessly through the Thingspeak IoT platform.

Our air pollution monitoring system has been implemented successfully and could be enhanced with further developments and extended use of technology.

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