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## Portable Device for Air Quality Monitoring and Filtration



**Abstract:** - In this research a portable indoor air quality monitoring and filtration device is presented which could provide an effective solution for indoor environmental well-being. The proposed device intended to detect air pollutants like nitrogen dioxide (NO<sub>2</sub>), carbon monoxide (CO), and particulate matter (PM). The device consists of typical sensors for different pollutants and filtration mechanism for improvement of the air quality facilitated with an OLED display screen. This device allows for active air filtration in the monitored indoor area. The results showed the reliability of a device in measuring pollutant levels and reducing airborne impurities over time through its filtration mechanism. The device is compact in design and powered by battery operation which makes it easy to use without needing fixed installations. Overall, this research presents a convenient solution for household use with ease of operation.

**Keywords:** Air Quality Monitoring, Air Filtration, Carbon Monoxide, Nitrogen Dioxide, Particulate Matter

### I. INTRODUCTION

The rapid technological advancements have resulted in challenges, including deteriorating air quality and environmental damage. Growth in industrialization and urbanization and the unchecked use of fossil fuels led to a decline in air quality index. These changes results in release of harmful pollutants like Carbon Monoxide (CO), Nitrogen Dioxide (NO<sub>2</sub>), and particulate matter in the environment. These pollutants possess serious impacts on human health and living organisms.

This paper offers a portable air quality monitoring and filtration device system intended to measure air pollutants such as CO, NO<sub>2</sub>, and particulate matter in the indoor air. It also provides real-time updates into environmental conditions. The system combines the MiCS-2714 NO<sub>2</sub> sensor, MEMS-based CO sensor, and the GP2Y1010AU0F dust sensor to analyze the Air Quality Index (AQI) and display pollutant levels on an OLED screen [1].

In order to address pollution removal, the system includes an activated carbon filter for particulate matter and an activated carbon foam filter to absorb gaseous pollutants like CO and NO<sub>2</sub>. This hybrid system not only monitors air quality but also filters the air that passes through which creates a safer environment for users. By using reliable sensor technology and an integrated filtration system, this research aims to provide a complete solution for individuals and communities.

### II. MATERIAL AND METHODOLOGY

#### 2.1 Materials Used

The main aim of this system is to develop a prototype for an air quality monitoring system that provides real-time measurements of harmful pollutants. The proposed system integrates three key sensors: the MiCS 2714 NO<sub>2</sub> Sensor, MEMS CO Sensor, and GP2Y1010AU0F Particulate Matter Sensor and activated carbon filters for real-time filtration of impure air. These sensors work in conjunction to provide a comprehensive analysis of air quality by detecting specific pollutants, measuring their concentration levels, and displaying the readings on an OLED display. Additionally, the system calculates the Air Quality Index (AQI) and provides feedback based on the classified air quality levels.

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The development of the proposed air quality monitoring and filtration system involves integrating sensing, computational, and filtration components to ensure both pollutant detection and reduction. The components were selected based on performance-to-cost efficiency, reliability, and portability.

### 2.1.1 MICROCONTROLLER UNIT – ARDUINO UNO



Fig.1. Arduino UNO

Figure 1, represents Arduino UNO used in the system which functions as the central control unit, facilitating sensor communication, data processing and display control. It was chosen for its ease of use, robust performance, and compatibility with a wide variety of sensors.

### 2.1.2 NO<sub>2</sub> DETECTION - MiCS 2714 SENSOR



Fig.2. NO<sub>2</sub> Sensor

MiCS 2714 NO<sub>2</sub> sensor uses a metal-oxide semiconductor element that changes resistance based on NO<sub>2</sub> concentration as shown in figure 2. It provides reliable analog output mapped to NO<sub>2</sub> levels in the air.

### 2.1.3 CARBON MONOXIDE DETECTION – MEMS CO SENSOR

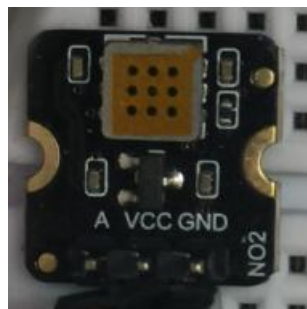


Fig.3. CO Sensor

The MEMS-based sensor shown in figure 3, helps in accurate measurement of Carbon Monoxide (CO) concentrations. Its compact design and high sensitivity make it ideal for indoor detection.

#### 2.1.4 DETECTION OF PARTICULATE MATTER – GP2Y1010AU0F

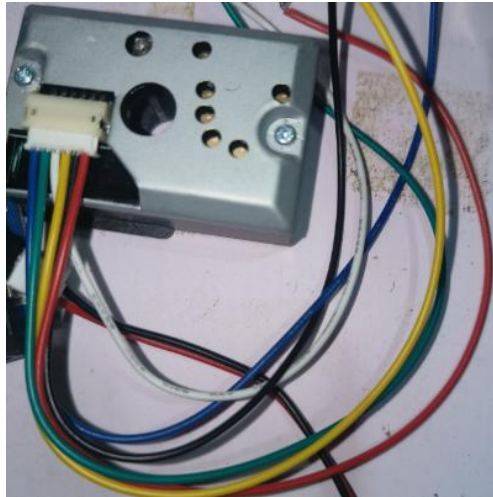


Fig.4. Particulate Matter Sensor

Figure 4, represents an optical dust sensor which is capable of detecting PM1.0, PM2.5, and PM10 using infrared scattering. It calculates the average of these values and reports the value. It outputs real-time concentration data in  $\mu\text{g}/\text{m}^3$ .

#### 2.1.5 OLED DISPLAY (0.96'' SSD1306)



Fig.5. OLED Display

The OLED screen has shown in figure 5 displays sensor readings and AQI classifications in a compact, readable format for user interpretation.

#### 2.1.6 POWER SUPPLY – RECHARGEABLE POWER BANK

A 5V USB power bank serves as the power source, supporting portability and flexible placement in indoor and outdoor environments.

#### 2.1.7 ACTIVATED CARBON FILTER AND ACTIVATED CARBON FOAM FILTER

To enhance air quality and facilitate filtration, an activated carbon filter is used to capture particulate matter before it reaches the sensing chamber. An activated carbon foam filter is positioned to absorb harmful gases such as CO and NO<sub>2</sub>, reducing their impact on both users and sensor degradation.

In order to enhance air quality and facilitate filtration, combined activated carbon filter and activated carbon foam filter is used (figure 6). This combined filtration system helps to capture various gaseous pollutants such as CO and NO<sub>2</sub> and particulate matter from the air in the vicinity before it reaches the sensing chamber.



Fig.6. Activated Carbon Filter and Activated Carbon Foam Filter

#### 2.1.8 DC Motor Fan



Fig.7. DC Motor Fan

A 2-pin DC fan shown in figure 7 was integrated into the system to facilitate active airflow across the sensors and the filtration unit [2] which helps in real time filtration and monitoring.

## 2.2 METHODOLOGY

### 2.2.1 HARDWARE INTEGRATION

Sensors are connected to the Arduino UNO through analog and digital pins. The activated carbon filter and activated carbon foam filter are attached at the opposite end to ensure air filtration.

### 2.2.2 SIGNAL PROCESSING AND AQI COMPUTATION

Raw sensor outputs are processed and converted into pollutant concentrations. The AQI is computed using established guidelines (e.g., WHO, CPCB), and air quality is categorized into qualitative levels from "Good" or "Hazardous."

### 2.2.3 REAL – TIME DISPLAY

The OLED display continuously updates and shows NO<sub>2</sub>, CO, and PM concentrations, Corresponding AQI value and Health-related AQI classification.

### 2.2.4 PORTABILITY AND USE CASE

The device is compact and lightweight, making it ideal for use in homes, offices, or temporary installations. Its plug-and-play capability enhances usability across diverse indoor locations.

### 2.2.5 PROPOSED SYSTEM WORKFLOW

Filtered air passes through activated carbon elements. Sensors collect and transmit pollutant data. Arduino processes and calculates AQI. Data is displayed in real time on the OLED interface [3] [4]. Flowchart representing the system workflow is shown in figure 8.

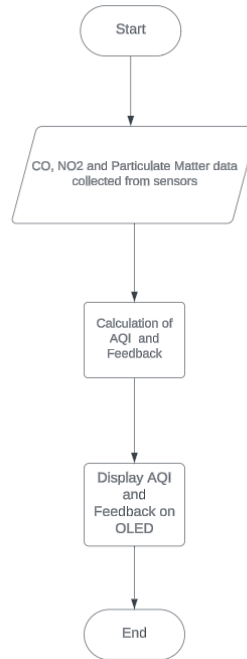


Fig.8. Air Quality Detection Flowchart

| AQI Range | Feedback     |
|-----------|--------------|
| 0-50      | Good         |
| 51-100    | Satisfactory |
| 101-200   | Moderate     |
| 201-300   | Poor         |
| 301-400   | Very Poor    |
| >400      | Hazardous    |

Table 1. AQI Categories

### III. SYSTEM ARCHITECTURE

The device consists of organized sensing, processing, filtering, and display components. The Arduino UNO microcontroller integrates these various components to process the air after it enters the device through an inlet with a DC motor fan and travels through the sensor array. The OLED screen displays output data. Table 1 shows the standard AQI categories. Eventually, filtration mechanisms act to create cleaner, pollution-free air. Figure 9 represents the block diagram of the system and figure 10 shows the top view of the entire device.

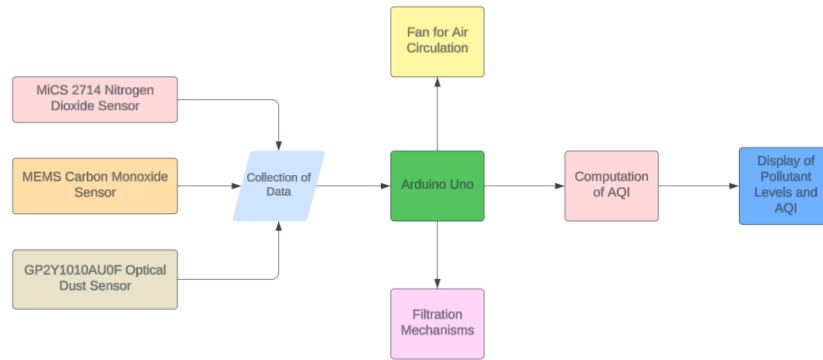


Fig.9. Block Diagram of the System

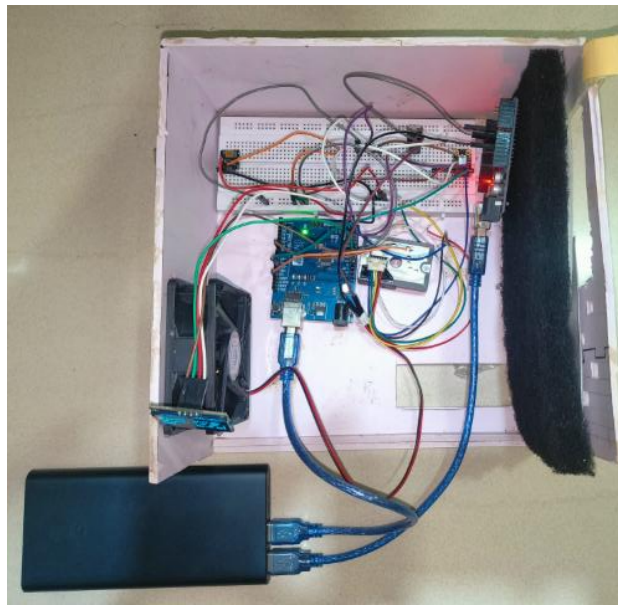


Fig.10. Top View of the Device

#### IV. RESULTS

The portable air quality monitoring and filtration system was tested in various indoor and outdoor conditions that included classrooms, labs, open terraces, and parks. Upon deployment, the system detected levels of nitrogen dioxide ( $\text{NO}_2$ ), carbon monoxide (CO), and particulate matter (PM) with its sensors. Readings updated in real-time on the OLED display which enabled users to easily check the air quality conditions [6] [7]. Figure 11 shows the output of the sensor data and AQI on the OLED display. Also, table 2 represents sensors and their range of values.

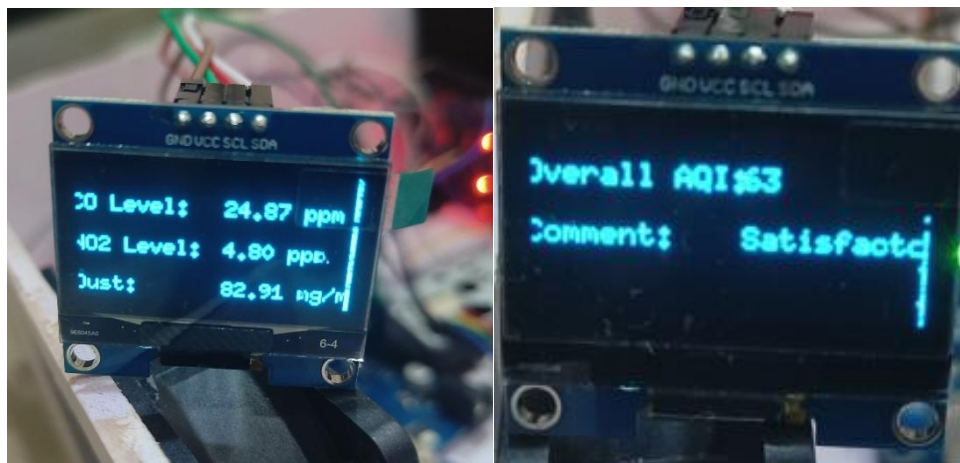


Fig.11. Output on the OLED Display

| Parameters                          | Range and Units            |
|-------------------------------------|----------------------------|
| Carbon Monoxide (CO)                | 0 to 50 ppm                |
| Nitrogen Dioxide (NO <sub>2</sub> ) | 0 to 10 ppb                |
| Particulate Matter (PM)             | 0 to 600 µg/m <sup>3</sup> |
| Air Quality Index (AQI)             | 0 to 400                   |

Table 2. Range of Sensor Values

Air filtration mechanism with the airflow from the fan enables the reduction in the air pollutants concentration over time in the confined monitored area [8]. Decrease in the PM concentrations and carbon monoxide and NO<sub>2</sub> levels were observed in the measurements taken before and after. This provides the confirmation that the device is applicable for monitoring air quality as well as air purification. Compact design, easy to move and continuous operation for several hours are the features of this device. The results show that the system is reliable for real-time data monitoring and better air quality benefits.

## V. CONCLUSION

This device is a dual functioning set up which helps in monitoring and improvement of indoor air quality. It is a compact and portable device. Arduino Uno microcontroller equipped with various sensors and filtration module together forms a robust system. Activated carbon filter and activated carbon foam filter utilized in the system enhances air purification ability, allowing it to both detect and remove harmful pollutants [9]. Results showed that the prototype reliably detected and displays accurate pollutant data and AQI values in both indoor and outdoor environments. Its compact and portable design makes it easy to use in homes, offices, schools, and various other locations. This project confirms that an affordable, portable solution for monitoring and improving indoor air quality is possible.

## VI. FUTURE SCOPE

The various methodologies can be applied to enhance the future developments in this system. Introduction of Wi-Fi modules using ESP32 will facilitate smooth data synchronization. New mobile apps for the iOS and Android operating systems could be developed, AI powered prediction based analyses could be added using machine learning algorithms. More sensors could be added to monitor temperature, humidity, sulphur dioxide (SO<sub>2</sub>), volatile organic compounds (VOCs), and carbon dioxide (CO<sub>2</sub>) to achieve wider scale environmental applications.

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