

# IoT Indoor Air Quality Monitoring System with Android App Integration

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## Abstract

Poor indoor air quality is a growing concern, especially in enclosed spaces in educational buildings such as classrooms and laboratories, due to its impact on human health, comfort, and productivity. This project presents an IoT-based indoor air quality monitoring system integrated with an Android mobile application. The system utilizes an ESP32 microcontroller connected to MQ-135, MQ-7, PM2.5, and DHT22 sensors to measure key air quality parameters, including carbon monoxide (CO), volatile organic compounds (VOCs), particulate matter (PM2.5), temperature, and humidity. Data is transmitted in real-time to the ThingSpeak platform, which then displays on the custom-built Android App. An extractor fan is also integrated to automatically turn ON when the pollutant exceeds the defined threshold value. This system was tested at multiple laboratories and classrooms for its efficiency. Based on the test, the system has successfully detected pollutant levels and also activated the extractor fan at high pollution readings.

## 1. Introduction

Indoor air quality (IAQ) is essential for ensuring a healthy, safe, and productive indoor environment, particularly in enclosed spaces like classrooms, laboratories, and offices where people spend extended hours. Poor IAQ has been linked to various health issues such as respiratory ailments, allergic reactions, cognitive decline, and decreased performance [1]-[2]. Common indoor pollutants like carbon monoxide (CO), volatile organic compounds (VOCs), and particulate matter (PM2.5) often build up due to poor ventilation, while high humidity levels can foster mold growth and worsen air quality, especially for individuals with pre-existing conditions [3]-[4]. To address these challenges, this project developed an IoT-based indoor air quality monitoring system integrated with an Android application for real-time data visualization and control. The system utilizes multiple sensors: MQ-135 for VOCs and ammonia, MQ-7 for CO, PM2.5 for fine particulates, and DHT22 for temperature and humidity. These are connected to an ESP32 microcontroller, which transmits data wirelessly to the ThingSpeak cloud platform. The Android app, built using Android Studio in Java, retrieves and displays the data in a user-friendly format. An extractor fan is automatically triggered when pollutants exceed set threshold.

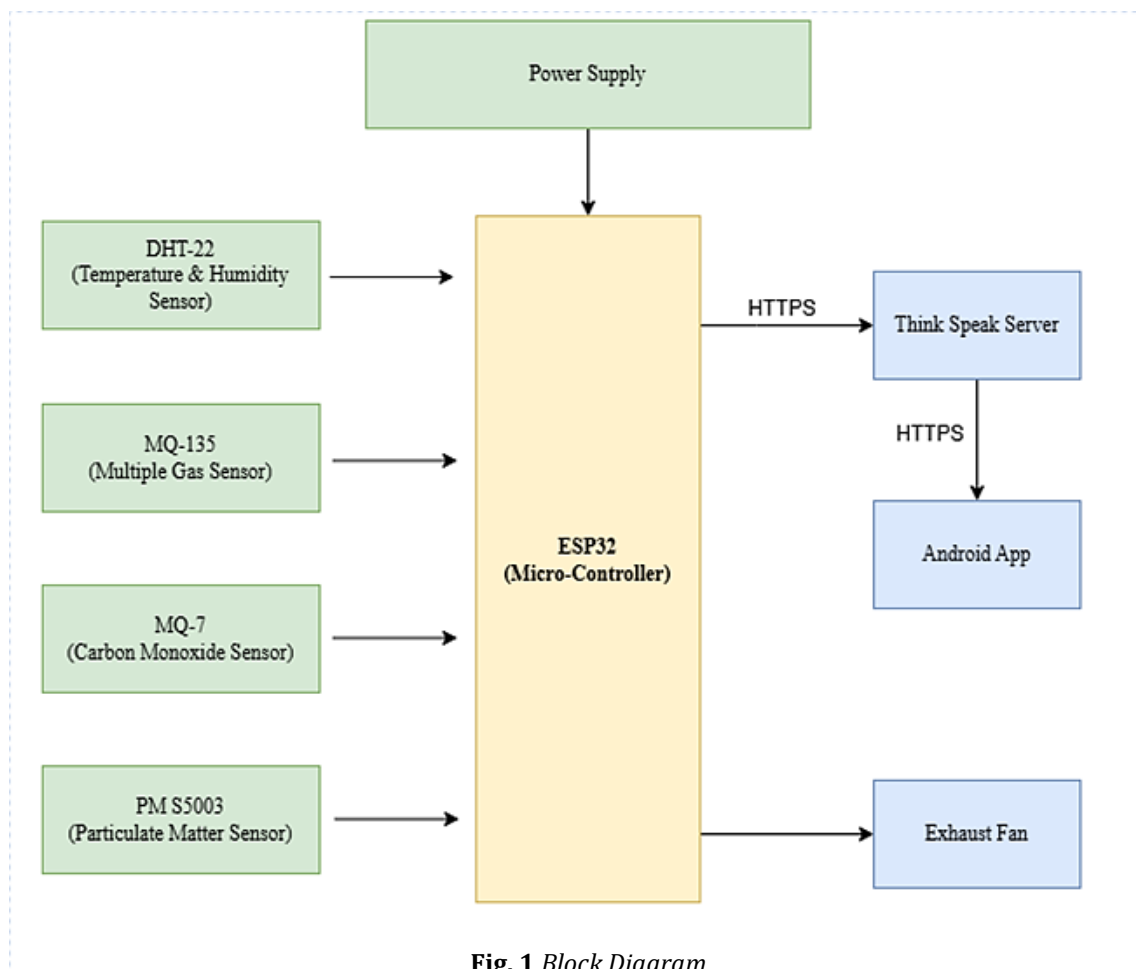
## 2. Methodology

The methodology for this project involves designing an IoT-based indoor air quality monitoring system utilizing a combination of hardware and software components. The hardware consists of an ESP32 microcontroller connected to various sensors, including MQ-135 for detecting general air pollutants, MQ-7 for carbon monoxide, PM2.5 for particulate matter, and DHT22 for temperature and humidity. These sensors collect real-time data,

which is transmitted wirelessly to the ThingSpeak cloud platform for analysis and visualization. An Android application was developed to display the collected data in an easily accessible format. Additionally, the system integrates an automatic air ventilation mechanism, consisting of an extractor fan that is activated when pollutant levels exceed predefined thresholds. The system was tested in several environments, including laboratories and office spaces, to evaluate its performance and effectiveness in maintaining healthy indoor air quality.

## 2.1 Block Diagram

For a complete understanding and operation of the project flow, a few illustrations have been provided. Fig. 1 shows the block diagram of the system, which indicates the connections between different hardware components. The block diagram also visually represents how the data from the sensors is captured and transmitted to the cloud platform for further analysis and display on the Android application. Fig. 2 illustrates the Flowchart that details the software workflow and how data is processed, starting from sensor readings, through data transmission, and up to the activation of the ventilation system when pollutant levels exceed thresholds. Finally, the System Connection in Fig. 3 demonstrates the physical setup, where the sensors and ESP32 microcontroller are connected to the breadboard, and the extractor fan is integrated to activate based on the real-time air quality data collected by the system.



**Fig. 1** Block Diagram

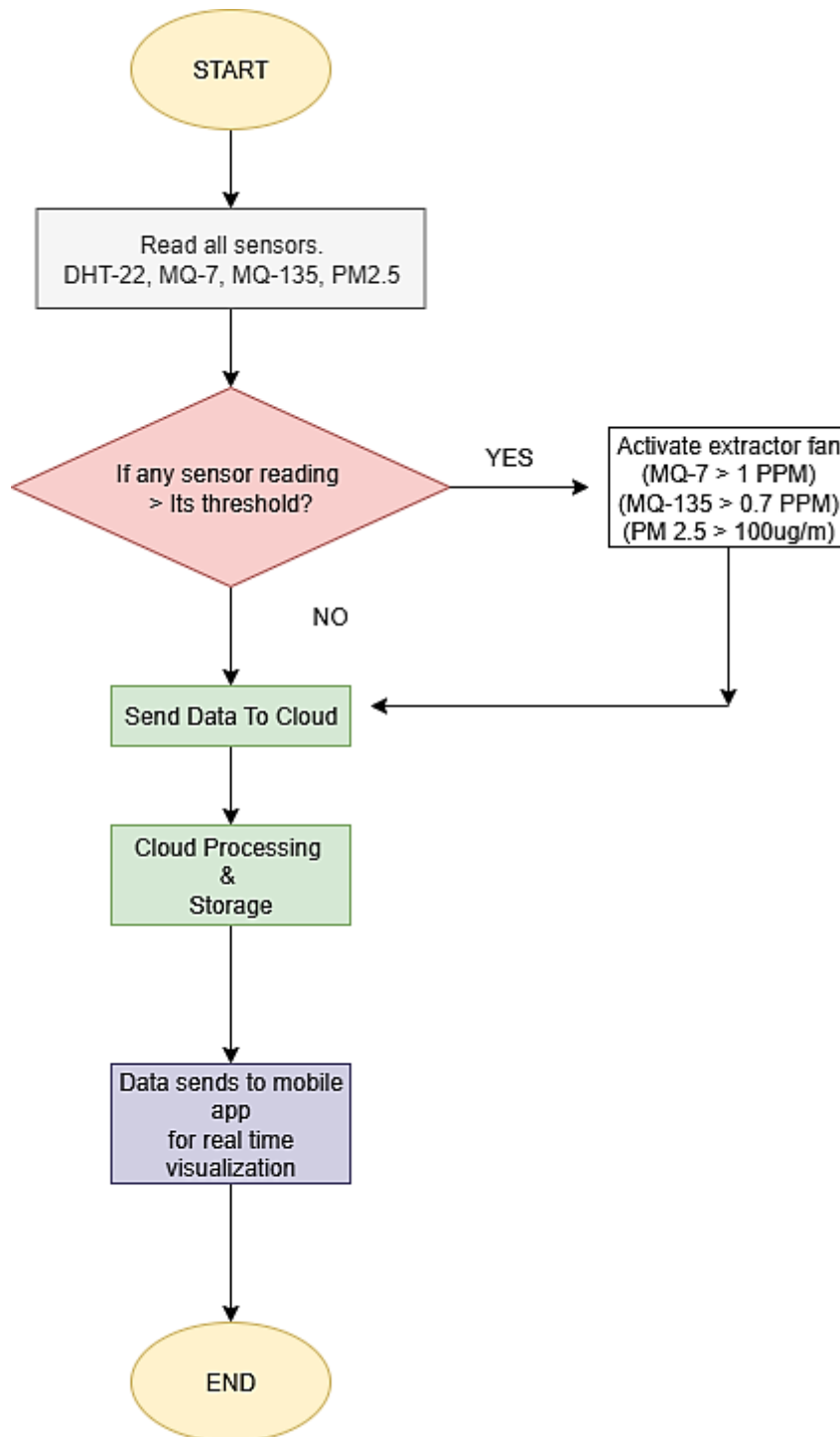
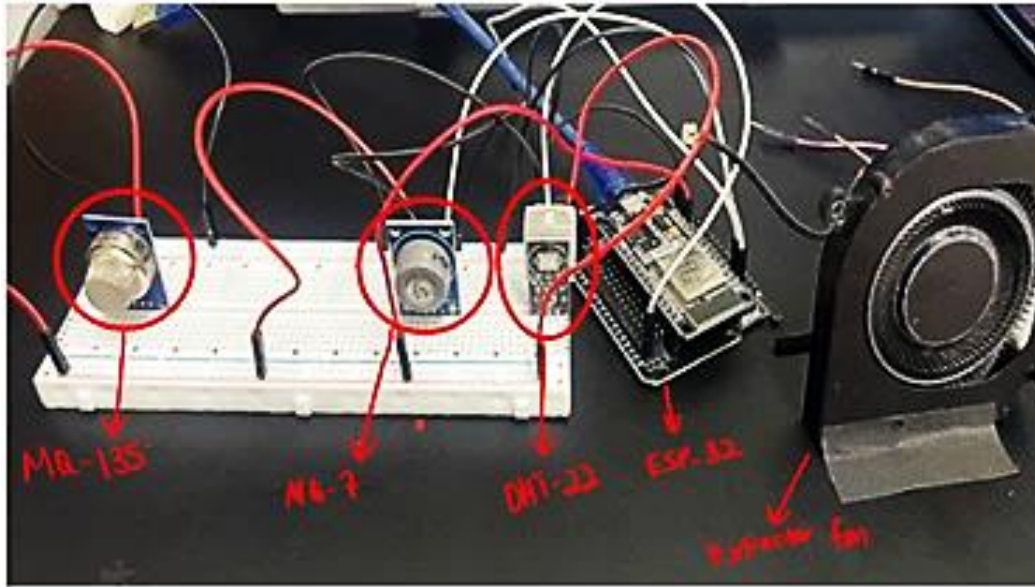


Fig. 2 Flowchart



**Fig.3** Hardware Connection

### 3. Results and Discussion

#### 3.1 Prototype of System

All the figures below show the outcome of the design. Fig. 4(a). shows the top view of the system, providing a general layout of the components. Fig. 4(b) presents the left side view, where the MQ-135 Multiple Gas Sensor, MQ-7 Carbon Monoxide Sensor, and DHT-22 Temperature and Humidity Sensor are located. Fig. 5(a) displays the front view, where the PM2.5 Air Quality Sensor is positioned. Fig. 5(b) shows the right-side view with the extractor fan, for regulating airflow. Finally, Fig. 6 shows the internal view, wiring and connections of the system.



(a)



(b)

**Fig. 4** Hardware (a) top view; (b) left side view

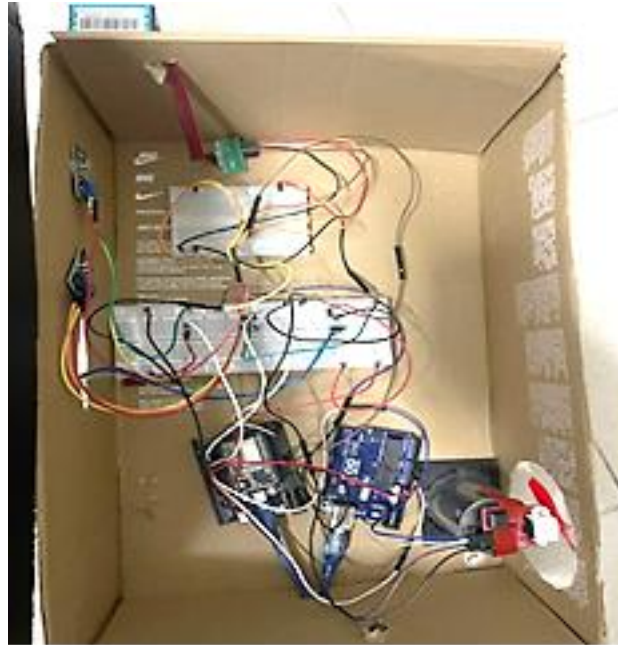


(a)



(b)

**Fig. 5** Hardware Connection (a) front view; (b) right side view



**Fig. 6** Inside View

### 3.2 Testing and Setup

Few tests were conducted at the FKEE's Microfabrication Lab and Advanced Printed Circuit Design Lab, as shown in Fig. 7. This environment was chosen because it provides an ideal environment for evaluating the performance of the developed system. The Advanced Printed Circuit Design Lab was chosen for its high presence of solder fumes. This lab is normally used for the soldering process. Therefore, the environment will be an excellent choice for testing the system's ability to detect solder fumes. These testing locations ensured that the system met the necessary technical and environmental requirements before full deployment.



(a)



(b)

**Fig. 7** PCB Lab (a) environment; (b) testing setup

**Table 1** Sensor Output Data Across Multiple Locations

Locations	Temperature (°C)	Humidity (%)	MQ-7 CO (PPM)	MQ-135 (PPM)	PM2.5 (µg/m <sup>3</sup> )
Block QA, FKEE Building (Ground Floor)	28.5	73.0	0.38	0.63	14
Block QB, FKEE Building (Ground Floor)	27.8	64.7	0.32	0.53	8
Micro-Control System Laboratory	22.4	60.9	0.33	0.51	9
Pusat Sumber Block QB, FKEE	28.5	72.1	0.35	0.58	44
Bilik Seminar A3, Block B6	28.2	55.3	0.44	0.75	6
MIL, Block G1 (soldering process)	31.7	78.6	0.13	1.38	189
Chemical Store, MFM (no chemical leak)	24.4	56.6	0.30	0.37	2
Chemical Store, MFM (chemical leak)	24.4	56.8	0.31	0.71	1
MRLT, Block G1 (PCB fabrication process)	27.8	64.7	0.32	0.53	8

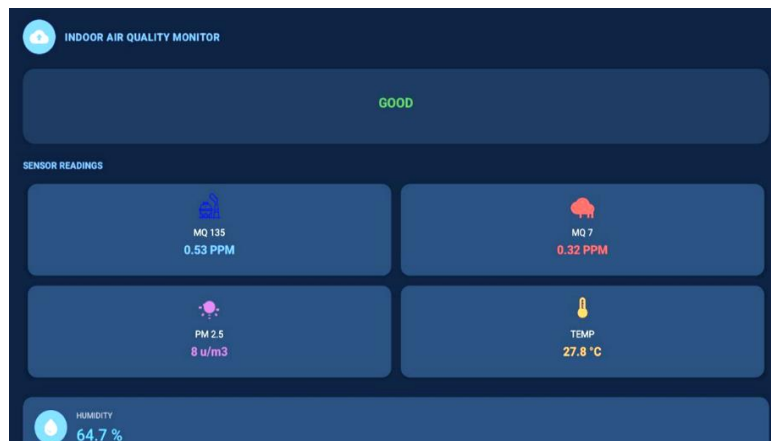
### 3.3 Data Collection Discussion

Testing was conducted across a variety of indoor locations within the university to evaluate the robustness and responsiveness of the developed IoT-based air quality monitoring system under different environmental conditions. Notably, one of the strategic test sites was Bilik Seminar A3, Block B6, which was selected to simulate a typical classroom environment. This site was of particular interest due to its close proximity to the Evergreen manufacturing plant, raising potential concerns over external pollutant infiltration. The recorded data at this location showed a CO level of 0.44 PPM and an MQ-135 reading of 0.75 PPM, which were the highest among classroom areas tested, indicating possible ambient pollution influence. However, PM2.5 levels remained low at 6 µg/m<sup>3</sup>, suggesting no immediate particulate threat during the measurement window.

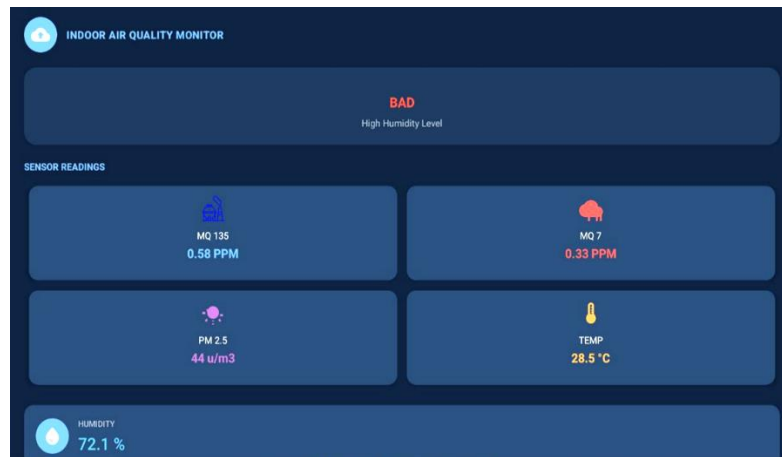
This environment enabled assessment of the system’s sensitivity to subtle air quality variations potentially introduced by nearby industrial activities. Furthermore, the diverse testing environments, including the Micro-Control System Laboratory, chemical stores before and after leak tests, and fabrication areas like MIP and MRLT in Block G1, allowed the system to demonstrate accurate detection across both controlled and high-pollution scenarios. For instance, during soldering in MIP, PM2.5 spiked to 189 µg/m<sup>3</sup>, clearly identifying hazardous exposure levels. In contrast, readings from the Chemical Store (no leak) registered significantly lower values compared to while carrying out the leak test, verifying the system’s effectiveness in distinguishing between normal and contaminated environments. This range of test scenarios validates the device’s applicability for use in both academic and semi-industrial indoor settings. Table 1 presents a detailed breakdown of environmental parameters measured across different locations using the developed air quality monitoring system.

### 3.4 Android Application System

Fig. 8 shows an example of the app interface displaying data collected at the FKEE building (ground floor). The values recorded were below the danger levels; therefore, the app displayed a “Good” status. All the sensor data is shown within the app itself. Fig. 9, on the other hand, indicates a “Bad” status due to high humidity levels. Bad status is triggered when the readings exceed the predefined thresholds, which are set based on sensor calibration. These thresholds are: 1 ppm for CO (MQ-7), 0.7 ppm for general air pollutants (MQ-135), 100 µg/m<sup>3</sup> for PM2.5, and 30%–70% for humidity.



**Fig. 8** Android application interface



**Fig. 9** Android application interface while in detection of harmful gas of high humidity level

### 3.5 Fan Activation Behavior

Table 2 highlights the threshold conditions when the Fan Activation occurs based on the desired calibration of sensors. Fig. 10(a) shows the fan in an OFF state, while Fig. 10(b) shows it in an ON state.

**Table 2** Fan Activation Condition

Sensor	Threshold Condition	Fan Action
MQ-135	> 0.7 ppm	Turn ON
MQ-7 (CO)	> 1.0 ppm	Turn ON
PM2.5	> 100 $\mu\text{g}/\text{m}^3$	Turn ON



(a)



(b)

**Fig. 10** Fan at (a) OFF state; (b) ON state

## 4. Conclusion

This project successfully developed an IoT-based indoor air quality monitoring system integrated with an Android application for real-time data visualization and control. By employing a combination of sensors, including MQ-135, MQ-7, PM2.5, and DHT22, alongside an ESP32 microcontroller, the system effectively detects various air pollutants, temperature, and humidity levels. The integration of ThingSpeak cloud services and mobile app functionality provides users with accessible and timely information about indoor environmental conditions. Additionally, the system features an automatic extractor fan that activates when air quality parameters exceed safe thresholds, improving ventilation and maintaining healthy air standards. The results from testing in different indoor environments demonstrate the system's reliability, accuracy, and potential as a scalable solution for ensuring safe and comfortable indoor air quality in laboratories and classroom settings.

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## Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

## Author Contribution

The authors confirm contribution to the paper as follows: **study conception, design and manuscript preparation:** Shailiesh Gopal Krishnan; **manuscript verification:** Wan Nur Hafsha Wan Kairuddin. All authors reviewed the results and approved the final version of the manuscript.

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