Project Presentation on
"IoT-Based Indoor Air Quality Monitoring System"
in
Final Year Computer Engineering (Regional) Course

Shravani Chidrewar 121B1D035
Neera Patil 121B1D045

Under the guidance of
Dr. Sujata Kolhe

(A. Y. 2024-25)

Department of Computer Engineering (Regional Language)
PCET's Pimpri Chinchwad College of Engineering

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CONTENTS

INTRODUCTION

- Real-time IAQ Monitoring: Develop a system using temperature, humidity, PM, and VOC sensors to measure indoor air quality.
- IAQ Index Calculation: Process sensor data to compute an accurate IAQ index for assessing air quality conditions.
- Android App for Visualization: Build a user-friendly Android application to display IAQ results, enabling Arklite Industries to monitor and improve workplace air quality.

PROBLEM DEFINITION

- Traditional IAQ monitoring systems lack real-time analysis and require manual intervention, making timely detection difficult in industrial settings.
- Poor indoor air with high VOCs, PM, and humidity fluctuations can lead to serious health risks and regulatory issues.
- A real-time IAQ monitoring system using sensors (Temp, Humidity, VOC, PM) with data sent to ThingSpeak and visualized via a Flutter app.
- Firebase enables user login and historical data storage, allowing

MOTIVATION

- Poor IAQ can cause respiratory issues, fatigue, and decreased productivity; real-time monitoring ensures a healthier work environment.
- Industries must adhere to air quality standards; this system helps in tracking and maintaining compliance with environmental regulations.
- Continuous monitoring and historical data analysis enable proactive measures to improve workplace air quality, reducing long-term risks.

SCOPE OF WORK

1. The system will measure temperature, humidity, PM, and VOC levels continuously to assess indoor air quality.

2. A mobile application will display live IAQ data and historical trends for easy access and analysis.

3. ThinkSpeak will handle real-time data streaming, while Firebase will store user authentication details and historical records.

4. The system can be deployed in manufacturing units, offices, and other indoor spaces to maintain healthy air quality.

OBJECTIVES

- Enable Arklite Industries to monitor and improve workplace air quality, ensuring compliance with environmental and safety standards.
- Develop a real-time IAQ monitoring system with sensor integration and an Android app for easy data visualization and decision-making.
- Analyze the impact of temperature, humidity, PM, and VOC levels on IAQ and optimize the IAQ index calculation for industrial settings.

LITERATURE SURVEY

Reference 1	An IoT-Based Handheld Environmental and Air Quality Monitoring Station
Objectives	• Develop a **portable IoT-based weather and air quality monitoring system** that measures key environmental parameters. • Enable **real-time data collection and cloud-based storage** for continuous monitoring and analysis.
Proposed Solution	• A **sensor-based device** is designed to measure **temperature, humidity, PM2.5, PM10, VOC, and CO levels**. • Uses **ThingSpeak cloud platform** for real-time data transmission via Wi-Fi and GSM. • A **mobile application** is developed to display real-time sensor readings and historical trends.
Results	• The system successfully provides **real-time environmental monitoring** with **high accuracy** after calibration. • Data can be accessed **remotely** through Wi-Fi, enabling global access and analysis. • The device offers a **user-friendly and portable solution** for monitoring air quality in various environments.
Advantages	• **Low-cost and portable** solution compared to traditional monitoring systems. • **Easy to install and maintain**, eliminating the need for trained technicians.
Limitations	• Limited battery life, requiring **external power sources** or regular recharging. • **Sensor accuracy may vary**, requiring periodic calibration for reliable readings.

Reference 2	Building an Indoor Air Quality Monitoring System Based on IoT Architecture
Objectives	• Develop a **smart home-based IAQ monitoring system** using IoT technology. • Utilize **fuzzy control logic** to optimize air quality management.
Proposed Solution	• Uses **Arduino Uno, ESP8266 Wi-Fi module**, and multiple sensors to monitor indoor CO_2, CO, and fine particulate matter. • Data is analyzed using **fuzzy control** to automate air purification and ventilation decisions. • A **MATLAB-based simulation** validates the system's performance.
Results	• The system effectively monitors **real-time IAQ** and automatically adjusts ventilation based on pollution levels. • **Fuzzy logic control improves decision-making** over traditional threshold-based approaches.
Advantages	• **Automated air quality control** using real-time data and AI-based decision-making. • **Wireless communication** ensures seamless data transmission and monitoring.
Limitations	• Requires **continuous internet connectivity** for real-time cloud-based monitoring. • **Limited scope to smart homes**, requiring modifications for industrial environments.

Reference 3	Low-Cost IoT-Based Indoor Air Quality Monitoring
Objectives	• Develop a **low-cost, real-time IAQ monitoring system** that integrates multiple sensors for enhanced indoor air quality assessment. • Design an **IoT-based network** for real-time data visualization, storage, and analysis.
Proposed Solution	• A **multi-sensor setup** for **CO_2, VOC, temperature, humidity, and PM levels**, with data transmitted via an **IoT platform**. • Uses a **stationary monitoring device** that collects and visualizes real-time IAQ data while ensuring affordability and scalability.
Results	• The system provided **real-time IAQ monitoring**, allowing for better environmental control and decision-making. • Achieved a **balance between cost and accuracy**, making IAQ monitoring more accessible.
Advantages	• **Cost-effective and scalable** compared to existing commercial solutions. • **Improved spatial coverage** with multiple connected devices forming a broader IAQ monitoring network.
Limitations	• **Requires periodic sensor calibration** to maintain accuracy. • **Limited battery life**, requiring continuous power supply or optimized energy management.

Reference 4	AirQMon - Indoor Air Quality Monitoring System Based on Microcontroller, Android, and IoT
Objectives	• Develop an **Arduino-based indoor air quality monitoring system** to raise awareness about air pollution risks. • Enable **real-time air quality tracking** using sensors and an Android application.
Proposed Solution	• Uses **MQ135 sensor** to detect air pollutants, connected to an **Arduino Uno** and **Ethernet Shield** for data transmission. • Sensor data is uploaded to **ThingSpeak**, which is then retrieved and displayed through the **AirQMon Android application**. • Includes a **buzzer alarm** that activates when air quality reaches hazardous levels.
Results	• The system successfully **monitors IAQ in real-time** and alerts users when pollution levels exceed safe thresholds. • The **Android app provides graphical visualization** of air quality, making data easily accessible.
Advantages	• **Low-cost and easy to install** compared to traditional IAQ monitoring systems. • **Real-time alerts** using a buzzer and app notifications for instant awareness.
Limitations	• **Limited connectivity options**, as it relies on an Ethernet shield instead of Wi-Fi. • **Lacks additional sensors** (e.g., PM2.5, VOC) for a more comprehensive IAQ assessment.

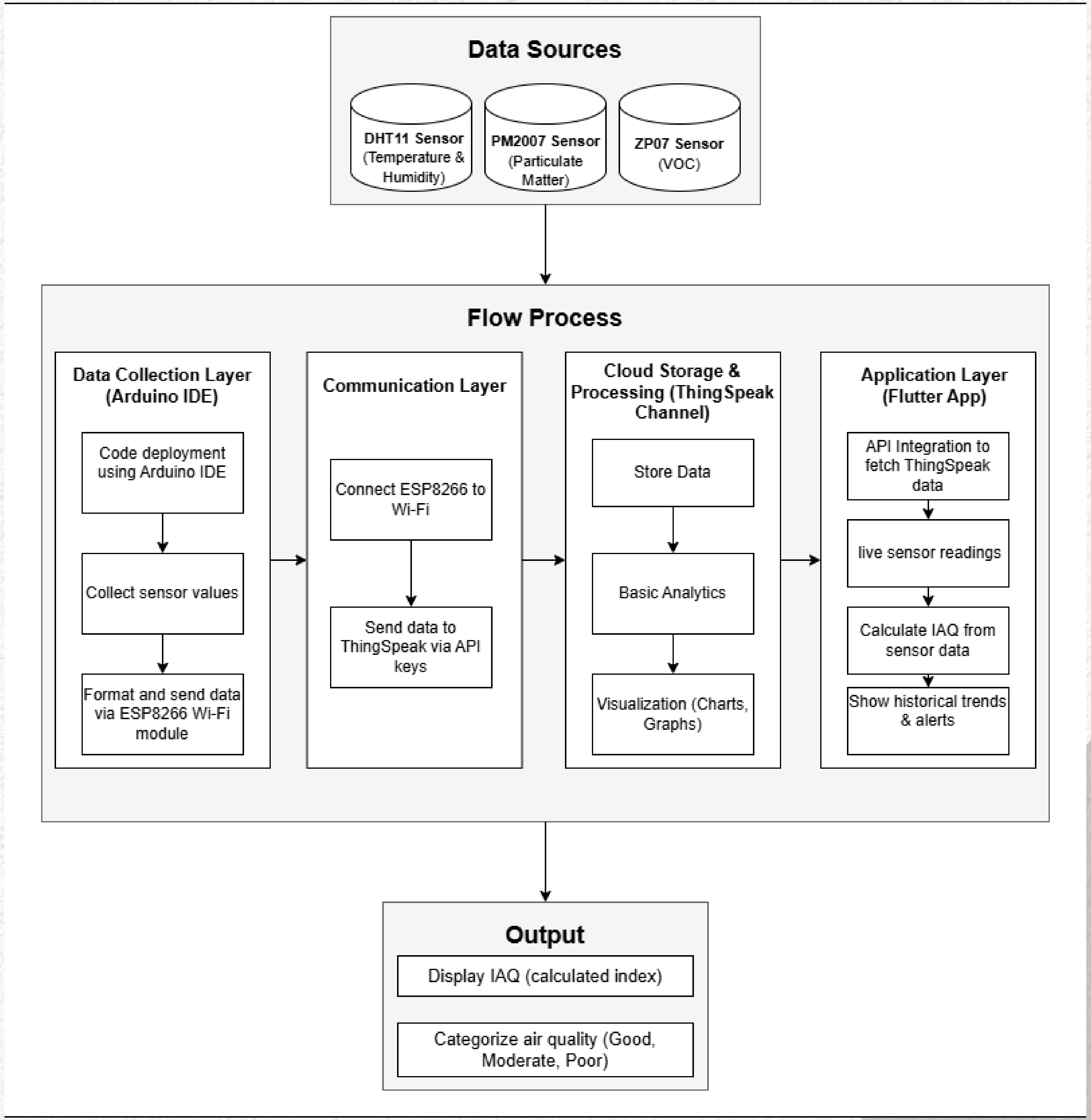
Reference 5	Development of an IoT-Based Indoor Air Quality Monitoring Platform
Objectives	• Develop a **cloud-integrated IAQ monitoring system** using IoT sensors. • Ensure **real-time data transmission and analysis** for improved indoor air quality management.
Proposed Solution	• A **Smart-Air** device with sensors for **aerosols, VOC, CO, CO_2, temperature, and humidity** transmits data via LTE to a **cloud-based web server**. • The system allows users to **remotely monitor air quality through a web interface and mobile application**.
Results	• The system was successfully deployed and validated in a university building. • **Real-time monitoring and alerts** helped users take proactive actions to improve air quality.
Advantages	• **Scalable and cloud-based** solution enables remote access and analysis. • **Automated alert system** notifies users of poor air quality conditions.
Limitations	• **High dependency on internet connectivity** for real-time functionality. • **Sensor calibration needed periodically** to maintain accuracy.

PROJECT REQUIREMENTS

1. Hardware Requirements:
   - Sensors:
     - Temperature & Humidity Sensor: DHT11
     - VOC Sensor: ZP07 V4.0
     - PM Sensor: PM2007
   - Microcontroller with Wi-Fi: ESP8266MOD
   - Breadboard & Jumper Wires for circuit connections

2. Software Requirements:
   - Arduino IDE (for microcontroller programming)
   - ThinkSpeak (for IoT data handling and visualization)
   - Android Studio (for Flutter-based Android app development)
   - Flutter & Dart (for mobile app development)
   - Firebase (for user authentication and IAQ data storage)

PROPOSED SYSTEM



PROPOSED SYSTEM

The proposed system is an **IoT-based Indoor Air Quality Monitoring System** designed to track real-time environmental conditions and assist in decision-making for safer indoor environments.

- **Real-Time Monitoring:**
  Continuously collects temperature, humidity, VOC, and PM data using embedded sensors.
- **Microcontroller-Based Transmission:**
  ESP8266 NodeMCU reads and sends sensor data to the cloud using ThingSpeak API.
- **Cloud Integration & Storage:**
  Sensor readings are stored on ThingSpeak and Firebase, enabling historical analysis and data access from anywhere.
- **IAQ Index Calculation:**
  The system computes IAQ based on pollutant levels and maps it to standardized health categories (e.g., Good, Moderate, Unhealthy).
- **Mobile App Interface:**
  A Flutter-based Android app displays live IAQ data, graphical trends, and user-specific history with secure Firebase login.

PROJECT PLAN

Phase	Tasks	Duration
Research and Planning	• Literature review on IAQ & sensors • Finalize sensor selection & requirements	2 weeks
Hardware Setup	• Connect and test sensors with Arduino • Calibrate sensors for accurate readings	2 weeks
System Development	• Program ESP8266 for data transmission • Send sensor data to ThingSpeak	3 weeks
App Development	• Build Flutter frontend to fetch/display data • Integrate ThingSpeak APIs in app	3 weeks
Testing and Debugging	• Validate real-time data accuracy • Test app responsiveness and edge cases	2 weeks
Deployment and Review	• Final deployment of system • Optimize performance & power usage • Prepare documentation	2 weeks

SOFTWARE TESTING

UNIT TESTING -

ID	Description	Input	Expected Output	Status
TC01	Successful user registration	Valid name, email, and password	Account is created successfully	Pass
TC02	Registration with invalid email	Invalid email format	Error message: "Invalid email format"	Pass
TC03	Login with correct credentials	Valid email and password	User is redirected to dashboard	Pass
TC04	Login with incorrect password	Valid email, wrong password	Error message: "Incorrect credentials"	Pass
TC05	Display sensor data on dashboard	App launch with sensors active	Sensor values are displayed in real-time	Pass
TC06	IAQ calculation with valid input	Temperature, humidity, VOC, PM values	IAQ Index and Category shown correctly	Pass
TC07	Profile update with new email	Updated email address	Profile updated confirmation	Pass
TC08	Change password from profile	New password input	Password changed successfully	Pass
TC09	Navigation to History page	Click on "History" in side menu	Redirects to History screen	Pass
TC10	Add record to history after IAQ calculation	Perform IAQ calculation	New record appears in history list	Pass

SOFTWARE TESTING

INTEGRATION TESTING -

ID	Description	Input	Expected Output	Status
IT01	Register and autologin flow	Valid registration details	User registered and redirected to dashboard	Pass
IT02	Login and load real time sensor data	Valid login credentials	Dashboard loads with real-time sensor readings	Pass
IT03	IAQ Calculation updates dashboard and history	Calculate IAQ after sensor data loads	IAQ displayed and entry added in History	Pass
IT04	Update profile and verify dashboard name/email updates	Update profile name and email	New name/email reflected on dashboard/profile	Pass
IT05	Change password and validate new login	Change password, log out, then login with new password	Login successful with new password	Pass
IT06	Calculate IAQ → View History entry	Perform IAQ calc → Navigate to History	Recent IAQ entry shown in History	Pass
IT07	View Profile info after login	Login → Go to Profile screen	Shows correct user details (name, email)	Pass
IT08	Logout and ensure user is redirected to login screen	Tap Logout from sidebar menu	Redirected to login screen	Pass
IT09	Login with another account and verify separate history/profile	Login with a different user	Different profile info and history shown	Pass
IT10	Ensure IAQ calculation only works after sensor data is loaded	Click “Calculate IAQ” without sensor data	Show error or no action until sensor values are ready	Pass

SOFTWARE TESTING

SYSTEM TESTING -

ID	Description	Input	Expected Output	Status
ST01	End-to-end user flow: Register → Login → Monitor IAQ	New user details, valid IAQ inputs	User can complete the full cycle and see IAQ result	Pass
ST02	Validate real-time sensor data updates on dashboard	Launch dashboard with active sensors	Temperature, humidity, VOC, and PM values update in real-time	Pass
ST03	IAQ calculation based on latest sensor readings	Live sensor values	IAQ Index and Category calculated and displayed correctly	Pass
ST04	View full IAQ history for logged-in user	User with multiple IAQ calculations	History screen shows all previous records accurately	Pass
ST05	Profile update reflects across system	Change name/email in Profile screen	New info reflected on sidebar and login details	Pass
ST06	Password change updates credential and allows secure relogin	New password input	System accepts new password on next login	Pass
ST07	User logout redirects to login and prevents access to internal pages	Tap logout	Redirects to login; blocks unauthorized access to dashboard/history	Pass
ST08	Ensure system handles invalid inputs (e.g. empty fields, wrong email)	Leave fields blank or input bad formats	Shows validation errors and prevents form submission	Pass
ST09	Navigation between all screens works smoothly	Navigate via sidebar menu (Home, History, Profile)	Each section loads correctly and with expected data	Pass
ST10	System performs consistently under typical usage	Register/login, monitor IAQ, update profile, view history	No crashes, hangs, or inconsistencies observed	Pass

RESULTS AND DISCUSSIONS

Key Outcomes –

- **Real-Time Monitoring:**
  Accurate tracking of VOCs, PM2.5, PM10, temperature & humidity. Instant IAQ index helps users respond quickly.
- **User-Friendly Mobile App:**
  Built with Flutter; includes Home (Live Data), History (Graphs), and Profile (User Data) screens.
- **Data Storage & Trends:**
  Firebase stores historical IAQ data; users can visualize patterns and compare pollution levels over time.
- **Location-Based Insights:**
  IAQ varies with environment:
  - **Lab/Classroom:** Poor ventilation leads to moderate VOC/PM.
  - **Industrial Areas:** Highest PM/VOC values.
  - **Open Grounds:** Cleanest air.
  - **Homes:** VOC spikes during cleaning/cooking.
- **Health Awareness:**
  System improves understanding of indoor pollution and encourages prompt actions.

RESULTS AND DISCUSSIONS

Sr. No.	Location	Time	Temp (°C)	Humidity (%)	VOC (ppb)	PM2.5 (µg/m³)	IAQ Index	Analysis
1.	Nigdi	4:59 pm	37	27	40	56	151 (Unhealthy)	Urban traffic and heat led to poor air quality.
2.	Ravet	5:06 pm	36	26	43	68	157 (Unhealthy)	Roadside and industrial dust raised PM levels.
3.	PCMC metro station	5:22 pm	34	23	187	67	157 (Unhealthy)	Enclosed space, peak hours caused VOC and PM spike.
4.	Pimple Saudagar	7:56 pm	30	24	89	51	139 (Unhealthy for sensitive groups)	Evening activities, traffic caused VOC rise.
5.	Wakad	8:18 pm	30	22	93	54	147 (Unhealthy for sensitive groups)	VOCs from dense urban activity; moderate PM.
6.	Hinjewadi	9:01 pm	28	26	113	78	163 (Unhealthy)	High PM and VOC from tech park and low ventilation at night.
7.	Home	8:31 am	28	55	143	43	119 (Unhealthy for sensitive groups)	Indoor VOCs from morning activity; moderate PM.
8.	Baner	9:17 am	30	44	57	38	107 (Unhealthy for sensitive groups)	Mild urban traffic; VOC slightly elevated.
9.	Shivajinagar	9:56 am	32	37	88	83	165 (Unhealthy)	Dense traffic zone; high PM and VOC levels.
10.	Swargate	10:22 am	33	37	122	89	168 (Unhealthy)	Peak traffic hub; poor ventilation and pollution.

RESULTS AND DISCUSSIONS

Sr. No.	Location	Time	Temp (°C)	Humidity (%)	VOC (ppb)	PM2.5 (µg/m³)	IAQ Index	Analysis
12.	Chakan	1:01 pm	37	53	204	163	201(Very Unhealthy)	Industrial area; extremely high PM and VOC levels.
13.	PCCOE playground	1:42 pm	39	41	46	97	172 (Unhealthy)	Open sun and dust raised PM significantly.
14.	PCCOE badminton court	1:47 pm	39	53	138	43	119 (Unhealthy for sensitive groups)	High humidity and indoor VOC buildup noted.

- The system effectively captured how IAQ varies with different environments.
- Industrial zones showed the highest pollution levels, while open grounds maintained the cleanest air.
- Indoor spaces like homes, classrooms, and courts showed fluctuating VOC and PM levels based on activity and ventilation, validating the system’s responsiveness and real-time monitoring accuracy.

Challanges Faced

Real-Time Sync Issues in Flutter App

- Challenge: Flutter UI lagged or crashed when live data changed rapidly or arrived late, especially with null/undefined values.
- Solution: We used the GetX state management to handle live updates reactively and added null-safety checks to prevent crashes.

ThingSpeak API & Rate Limit Errors

- Challenge: ThingSpeak threw errors when too many requests were sent or wrong API keys were used.
- Solution: We implemented a timer to space out data uploads to match the 15-second limit and ensured secure storage of API keys to avoid misconfigurations.

Sensor Not Working… or So We Thought (Power & Wiring Issue)

- Challenge: Initially, the PM (Dust) sensor was giving flat/zero readings even in normal environments. Being from a CS background, we suspected software or logic bugs.
- Real Cause: After detailed testing, we discovered the issue was not software-related but due to unstable power and improper wiring — the sensor wasn't drawing enough current and was also affected by noise due to long/loose jumper wires.

CONTRIBUTION TO SUSTAINABLE DEVELOPMENT GOALS

1. **SDG Integration:**
   The project supports **SDG 3 (Health)**, **SDG 9 (Innovation)**, and **SDG 11 (Sustainable Cities)** by promoting indoor air quality awareness through real-time monitoring and mobile access.
2. **Health & Well-Being (SDG 3):**
   Tracks pollutants (PM2.5, VOCs, temp, humidity) to reduce health risks and support informed decisions using visual IAQ categorization.
3. **Innovation & Infrastructure (SDG 9):**
   Combines low-cost sensors (DHT11, PM2007, ZP07) with ESP8266 and Flutter app to offer a scalable, cloud-connected smart monitoring solution.
4. **Sustainable Communities (SDG 11):**
   Enables households, schools, and industries to maintain healthier indoor environments through continuous data logging and visualization.
5. **Long-Term Impact:**
   Reduces chronic respiratory issues, empowers digital innovation, supports research, and enables smarter infrastructure decisions via long-term IAQ insights.

CONCLUSION AND FUTURE SCOPE

CONCLUSION –

The project presents a cost-effective IoT-based air quality monitoring system that tracks temperature, humidity, VOCs, and PM levels using ESP8266 and integrated sensors.
Data is transmitted to ThingSpeak for real-time cloud storage and visualized through a Flutter-based mobile app, while Firebase ensures secure authentication and historical data management.
The system performed reliably across various environments such as homes, classrooms, and industrial areas.
Its modular design supports future scalability, enabling features like smart alerts or multi-location monitoring.
Overall, the solution effectively combines IoT, cloud, and mobile technologies to deliver an accessible and user-friendly IAQ monitoring platform.

CONCLUSION AND FUTURE SCOPE

FUTURE SCOPE –

1. **AI-Based Prediction & Alerts**
   Use machine learning to predict air quality trends and trigger automated health alerts and recommendations.
2. **Smart Home Integration**
   Connect with HVAC systems, air purifiers, and virtual assistants (Alexa, Google Home) for automated control.
3. **Expanded Sensor Network**
   Add sensors for CO_2, NOx, O_3, and CO for broader pollutant detection and outdoor monitoring.
4. **Advanced Mobile App Features**
   Include real-time dashboards, analytics, cross-platform support, and user-contributed location-based data.
5. **Smart City & Industrial Deployment**
   Scale to factories and urban areas for regulatory monitoring and large-scale environmental data collection.

PAPER PUBLICATION DETAILS

Submissions   Contact Chairs   Help Center   Select Your Role : **Author**   ICCUBEA2025   shravani Chidrewar

Submission Summary

Print   Email

Conference Name	9th International Conference on Control Communication, Computing and Automation
Track Name	Internet of Things and Computer Networks
Paper ID	545
Paper Title	IOT Based Indoor Air Quality
Abstract	Indoor air quality (IAQ) significantly impacts health, safety, and productivity in enclosed spaces. Rising air pollution and its associated health risks highlight the need for affordable, continuous IAQ monitoring. This work proposes a low-cost, real-time IAQ monitoring system using a NodeMCU (ESP8266) microcontroller integrated with sensors to measure temperature, humidity, VOCs, and particulate matter. Data is transmitted to the ThingSpeak cloud platform and visualized through a Flutter-based mobile application, which also computes a user-friendly IAQ index. Firebase is utilized for secure authentication and historical data storage, enabling both real-time insights and trend analysis. The system leverages IoT, cloud, and mobile technologies to enable remote monitoring and alerts when pollutant levels exceed safe thresholds—offering a scalable, user-centric solution for healthier indoor environments. Keywords: Indoor Air Quality, IoT Monitoring, VOCs, Particulate Matter, Cloud Storage, ThingSpeak, Mobile App, NodeMCU
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Authors	**shravani Chidrewar** (PCCOE) <shravanichidrewar01@gmail.com>
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THANK YOU