

# IoT-Based Air Pollution Monitoring System

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## Abstract

Nowadays, Air pollution is a major health issue for a humans, birds, animals and trees etc. because of plastic waste, vehicles, industry which is harmful for us. These factors have harmful effects on human health for people who are directly exposed to the polluted air. That's why level of air pollution is increased day by day. So, clean air is important for everyone's health and safety. However, air quality is getting worse in many cities across India like Delhi, Patna etc. The main cause of pollution is fine particulate matter, which leads to health diseases like asthma, lung diseases and other respiratory problems. There is a need for a low-cost air pollution monitoring system so it can be easily used anywhere. This paper represents a low-cost air pollution monitoring system that uses different sensors to measure the air quality. The MQ2 sensor detects gases like Hydrogen, LPG and Smoke. The MQ135 sensor measure the air quality and the DHT11 sensor is used to measure the temperature and humidity. All these different sensors are connected to an ESP32 microcontroller, which sends the collected data to the cloud. Then the results are shown on LCD display so users can see easily and understand the air quality around them.

## Introduction

Air pollution from vehicles happens mainly because fuel does not burn completely. So, this produces harmful gases such as carbon monoxide(CO) and nitrogen oxides(NO). These gases are dangerous for the environment, humans, plants and animals. Using this device with different sensors, a microcontroller, a platform and a buzzer then we can monitor the pollution caused by vehicles. There are different types of pollution, but the most serious one is air pollution. Air pollution is the major problem not only in India but also around the world. Air pollution monitoring systems are designed to detect the pollution and it checks the level of pollution using different sensors and devices. As time passes, air pollution continues to increase, which also raise the death rate. Nowadays, the number of vehicles are growing rapidly with the increasing population. So in this paper air pollution monitoring system that checks air quality in real time. In this system we use Internet of Things (IoT) with ESP32 microcontroller. The main purpose is to detect the harmful content in the environment and monitor it continuously.

## Literature Survey

In 2019, air pollution monitoring system using mobile sensor nodes was focused on developing a mobile node-based air pollution monitoring system. The limitation of their work was that the accuracy depended on the mobile node location and sensor calibration. Their research suggested improving the system by developing fixed sensor networks for higher accuracy and stability.

In 2019, air quality monitoring system was research that hardware calibration and the limited number of sensors were major challenges, indicating the need for proper calibration standards and sensor fusion techniques.

In 2020, cloud-based air pollution detection system was accuracy was limited by gas sensor calibration and cloud integration. It recommended using cloud platforms to enhance data analysis and air quality prediction.

In 2021, low cost air pollution detector using IoT was studied emphasized the need for multisensory integration and continuous cloud data visualization.

In 2022, This Monitoring device can survey actual calculation of air quality. This system helps better qualities of air with the help of Arduino microcontroller or also check air environment. Perfect air quality sensing in particular areas required periodic compression of huge low-price sensor in real time, because low price sensor travel from more perfections and quickness.

In 2023, A wireless standard has been used in an air pollution monitoring system to conceptualize, construct, and observe the combination of the principal air pollutant gases. This system monitors several gases, including SO<sub>2</sub>, NO<sub>2</sub>, and CO, with the usage of semiconductor sensors [5]. The equipment includes a one-chip microcontroller, a number of air quality sensors, a GSM-Chip, and a GPS-Chip. Main-Server is a cutting-edge desktop machine application server with internet access. The hardware device gathers the SO<sub>2</sub>, NO<sub>2</sub>, and CO amount of air pollutants and bundles them with the GPS position, date and time [1]. The frame is then installed into a GSM-Modem and transmitted to the main server through the wireless network.

In 2024, IoT-enabled smart environment air pollution monitoring system was research showed that system with limited sensors and no advanced analytics were effective only on a small scale. It was proposed to add more sensors, test on a larger scale and develop energy efficient portable designs.

In 2025, Energy-efficient IoT framework for air pollution monitoring system was faced limitations in testing area and scalability. The system does not perform well in extreme weather. Future improvements include large areas and city monitoring with better energy efficiency and offline processing capabilities.

Paper No.	Author Name(s) & Years	Methodology	Key Strengths	Research Gap
[1]	O. Yildiz et al. (2025)	Low-cost IoT sensors are combined with machine learning models for improved accuracy.	ML is a real-time cloud dashboard also improves readings and creates short term forecasts.	ML needs good training data and model drift over time.
[2]	A. Parmar et al. (2024)	Designed by IoT technique which densely deployed PM measures with cloud dashboards.	Real-time dashboards for cities and shows scalable architecture	Data quality, maintenance and sensor needs long term operational plans.
[3]	A. R. Upadhyaya et al. (2024)	Measurements of black carbon and CO <sub>2</sub> on roads	Manifests local hotspots and traffic related peaks that fixed stations miss.	Combining the mobile and fixed data into unified maps is challenging.
[4]	S. Nobell et al. (2023)	Deployed low-cost PM sensors and perform calibration against reference monitors.	Shows calibration methods and improved accuracy after correction.	Calibration helped but sensors still show seasonal bias, long term drift remains a problem.
[5]	J. Prakash et al. (2021)	Evaluation of real-time atmospheric air quality monitoring stations network at multiple Indian sites.	Regulatory grade provides baseline data and highlight gaps in it.	Rare area in many cities, high cost limits number of stations.
[6]	R. K. Kodali et al. (2021)	Designed a smart air pollution alert system using mobile app and send the data to user in continuously.	Single gas sensor is limited for this system and does not measure dust or pollutants.	Needs the multiple sensor integration and real-time cloud data visualization in system
[7]	R. K. Jha et al. (2020)	Designed IoT system for measure and reduce the air pollution from vehicles.	Accuracy finite by gas sensor range and lacks cloud integration.	Need for IoT integration with machine learning for better result.
[8]	Ahmed et al. (2019)	Combined sensor data and weather data to improve the results.	Better accuracy and some false readings by using multiple sensors.	Combination of models can be complex and required lots of clean data.

## Sensors and devices

In air pollution monitoring system, low-cost sensors are used for sense and collect the data. Gas sensors, dust sensor, temperature and humidity sensor this is main sensors of this system.

1. ESP32: ESP32 is the one of the most efficient and low-cost microcontroller which integrated both Wi-Fi and Bluetooth capabilities which is controls the sensors and sends the collected data to the cloud(Thinkspeak).
2. MQ2: The MQ2 is a gas sensor which is detects the LPG, propane and hydrogen gases. It is low-cost sensor used for many purposes. It can also sense smoke and other gases.
3. MQ135: The MQ135 it is a gas sensor which is used to detect gases like nitrogen oxide, ammonia, alcohol, carbon dioxide and benzoic acid. This sensor has a digital pin that lets it work even without a microcontroller, which is useful to detect only one type of gas.
4. DHT11: The DHT11 sensor which measures both temperature and humidity.
5. Solar panel: A solar panel converts sunlight into electrical energy to power sensors and eco-friendly operation.

## Working of system

The air pollution monitoring system is works by continuously measuring the quality of air using different sensors. MQ2, MQ135 and DHT11 sensors are used to detect the gases like carbon dioxide(CO<sub>2</sub>), carbon monoxide(CO), ammonia(NH<sub>3</sub>) and measure temperature and humidity. These sensors collect the data from the surrounding air and sends to the ESP32 microcontroller for processing. The controller analyze the collected data and compares it with standard air quality levels to determine the air quality is clean or polluted. Then the results of air quality is displayed on the LCD screen and sent to a ThingSpeak cloud platform for remote monitoring. If the pollution level goes beyond the safe limit, the system alerts the user through a buzzer and notification. This process runs continuously, allowing the system to monitor air quality in real time and helps to reduce the pollution.

## Conclusion and future scope

The conclusion of this paper is an improved way to monitor air quality. In this system, different sensors and IoT technology are used. This system is small, easy to use and more efficient. It helps user to understand pollution levels and then take quick action to keep the environment clean and safe for peoples. In future, more sensors can be added in this system to check air

quality in more detail. The system should also be made flexible and scalable so it can be used on a larger scale area for better results.

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