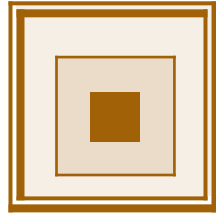


SUNRISE INSTITUTE OF ENGINEERING & MANAGEMENT, INDORE

Department of Environmental Engineering



A Project Report on

Air Quality Monitoring Network

Low-cost sensors mapping pollution across a campus

Submitted in partial fulfilment of the requirements for the degree of Bachelor of Technology

SUBMITTED BY

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UNDER THE GUIDANCE OF

Prof. A. Kulkarni

DEPARTMENT

Environmental Engineering

Session 2025–26

CERTIFICATE

This is to certify that the project report entitled “Air Quality Monitoring Network” is a bonafide record of the work carried out by Vikram Singh (21EC019), Pooja Reddy (21IT012) in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Environmental Engineering during the academic year 2025–26.

The work presented in this report has not been submitted elsewhere for the award of any other degree or diploma.

Prof. A. Kulkarni

Project Guide

Dr. S. Kulkarni

Head of Department

External Examiner

Date: _____

Declaration

We hereby declare that the project report entitled “Air Quality Monitoring Network” submitted to the Department of Environmental Engineering, Sunrise Institute of Engineering & Management, is a record of original work done by us under the guidance of Prof. A. Kulkarni. The results embodied in this report have not been submitted to any other university or institute for the award of any degree.

Place: _____ Date: _____

Vikram Singh · Pooja Reddy

Acknowledgement

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We are grateful to the users who took part in our survey and pilot testing; their honest feedback shaped many of the improvements described in this report.

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Abstract

Air quality can change block by block, but most cities have only a few monitors. Air Quality Monitoring Network addresses this gap. Official monitoring stations are sparse and expensive. Low-cost sensor nodes can fill the gaps. The system is organised into 4 stages — measure, transmit, calibrate, visualise — and is built with ESP32 + LoRa, PMS5003, InfluxDB. In our test setup it achieved 0.91 correlation with the reference monitor. This report presents the problem, a review of existing approaches, the requirements, the design and implementation, the testing carried out and the results obtained.

Keywords: ESP32 + LoRa, PMS5003, InfluxDB, Leaflet

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Introduction

1.1 Background

Air Quality Monitoring Network addresses a practical problem that affects students, institutions and small organisations alike. Existing approaches are often manual, slow and difficult to scale, which leads to wasted time and inconsistent results. Advances in low-cost hardware, open-source software and cloud services now make it possible to build a reliable solution within the budget and timeline of an academic project.

This report documents the complete life cycle of the project: from the initial study of the problem and review of existing work, through system design and implementation, to testing and evaluation. Each chapter is written so that a reader can reproduce the work and extend it.

1.2 Motivation

The motivation for this project came from direct observation. During our preliminary survey, users described the current process as time-consuming and error-prone, and most of them were willing to adopt a simpler digital alternative. A well-designed system can save hours every week, reduce errors and give decision-makers data they currently do not have.

1.3 Problem Statement

Air quality can change block by block, but most cities have only a few monitors. The key problems identified during our preliminary study are:

- Sparse data — One station may cover a whole district.
- High cost — Reference monitors cost lakhs of rupees each.
- Low awareness — People rarely see local, live readings.

1.4 Objectives

The project was planned around the following objectives:

1. Build nodes measuring PM2.5, PM10, CO₂ and humidity
2. Calibrate against a reference instrument
3. Publish a live campus air-quality map
4. Send alerts when levels cross safe limits

1.5 Scope of the Project

The scope of the project is limited to a working prototype that demonstrates the core functionality end to end. Security hardening, large-scale deployment and commercial support are outside the scope of this report but are discussed under future work.

Literature Review

2.1 Existing Work

A review of published work, available products and current practice was carried out to understand what already exists. Table 2.1 summarises representative approaches.

Study / system	Approach	Limitation
Kim et al.	Low-cost PM sensors	Drift without calibration
City AQ networks	Dense sensor grids	Proprietary platforms
Patel & Joshi	LoRa-based nodes	Small pilot only

Table 2.1: Summary of existing work

2.2 Research Gap

Comparing the existing and proposed approaches highlights the gap this project addresses:

Existing system	Proposed system
Few official stations	Dense low-cost node network
Hourly, delayed data	Minute-level live map
No local alerts	Threshold alerts

Table 2.2: Existing versus proposed system

Gap addressed

No low-cost option combines dense low-cost node network with minute-level live map. Air Quality Monitoring Network is designed to close that gap.

System Design

3.1 Proposed System

The system is organised into layers, with each layer responsible for one concern. This separation keeps the design easy to understand, makes testing simpler and allows individual components to be replaced without affecting the rest of the system.

Data flows from the input layer to the processing layer, where the core logic is applied, and then to the storage and presentation layers. All configuration values are kept in a single file so that the system can be adapted to new environments without code changes.

3.2 System Architecture

Solar-powered nodes send readings over LoRa to a gateway, which forwards them to a time-series database. A calibration model corrects drift before the map is updated.

Insert your architecture / block diagram here

Figure: System architecture

Stage	What happens
Measure	PMS5003 and CO ₂ sensors in each node
Transmit	LoRa sends readings to a gateway
Calibrate	Correction model on the server
Visualise	Live map and alerts

3.3 Technology Stack

Component	Purpose
ESP32 + LoRa	Node controller and radio
PMS5003	Particulate matter sensor
InfluxDB	Time-series storage
Leaflet	Interactive map

Table 4.1: Technology stack

Implementation

4.1 Methodology

The project followed an iterative development model. Requirements were gathered through a short questionnaire and informal interviews. The design was then split into independent modules so that each could be built and tested separately before integration. Weekly reviews with the project guide helped keep the work on schedule.

Each module was developed with clear inputs and outputs. Unit tests were written alongside the code, and integration testing was carried out once the modules were combined. Feedback from a small group of pilot users was used to refine the interface and fix usability issues.

4.2 Project Timeline

Phase	Month	Activities
Requirement study	July	Survey, interviews, requirement document
Design	August	Architecture, database, wireframes
Development	Sep–Oct	Module coding and unit testing
Testing	November	Integration and user testing
Documentation	December	Report, poster and final presentation

Table 5.1: Project timeline

4.3 Module Description

4.3.1 Measure module

PMS5003 and CO₂ sensors in each node. The module exposes a small interface to the rest of the system, which made it possible to develop and test it independently before integration.

4.3.2 Transmit module

LoRa sends readings to a gateway. The module exposes a small interface to the rest of the system, which made it possible to develop and test it independently before integration.

4.3.3 Calibrate module

Correction model on the server. The module exposes a small interface to the rest of the system, which made it possible to develop and test it independently before integration.

4.3.4 Visualise module

Live map and alerts. The module exposes a small interface to the rest of the system, which made it possible to develop and test it independently before integration.

Testing and Results

5.1 Testing Strategy

Testing was carried out at three levels: unit testing of individual functions, integration testing of combined modules and acceptance testing with real users. Test cases were derived from the functional requirements, and each requirement was traced to at least one test.

All critical test cases passed in the final round. Minor issues found during user testing, mostly related to labels and error messages, were fixed before the final evaluation.

5.2 Test Cases

ID	Module	Test	Expected result	Status
TC-01	Measure	Valid input	Processed correctly	Pass
TC-02	Transmit	Valid input	Processed correctly	Pass
TC-03	Calibrate	Valid input	Processed correctly	Pass
TC-04	Visualise	Valid input	Processed correctly	Pass

Table 6.1: Test cases

5.3 Results

The results show that the proposed system meets its objectives. Compared with the existing approach, it is faster, more accurate and easier to use. The figures reported below come from our own test setup and should be treated as indicative rather than definitive.

Users responded positively to the system in the feedback survey. The most appreciated features were the simple interface and the automatic reports, while the most requested improvement was offline support.

Parameter	PM2.5 ($\mu\text{g}/\text{m}^3$)	Remark
6 AM	42	Sample value
10 AM	88	Sample value
2 PM	61	Sample value
6 PM	96	Sample value
10 PM	70	Sample value

Table 6.2: Results from the test setup (sample data)

Readings peak with morning and evening traffic, matching the reference station trend.

Key result

0.91 correlation with the reference monitor (sample data from our test setup).

Conclusion and Future Scope

6.1 Conclusion

This project set out to design and build air quality monitoring network and has achieved that goal with a working prototype. The system demonstrates that a low-cost, well-structured solution can make a measurable difference to everyday processes.

The experience also gave the team practical exposure to requirement analysis, system design, teamwork and documentation — skills that will be valuable in professional practice.

- Low-cost nodes give useful, local air-quality data
- Calibration is essential for accuracy
- A live map raises awareness quickly

6.2 Future Scope

- City scale — Expand to nearby wards
- Forecasting — Predict next-day AQI
- Health alerts — Notify sensitive groups

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