

DATE: 28-11-2022

INDOOR AIR POLLUTION

ProjectSixtyPercent

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MOTIVATION

Every year, 3.8 million people die from indoor air pollution.

Source: [World Health Organization](#)

CAUSES

- SOLID COOKING FUELS
- COOLING SYSTEMS

EFFECTS

- PREMATURE DEATHS
- HEART DISEASES AND CANCER
- SICK BUILDING SYNDROME (SBS)

Necessity is the Mother of Invention

Indoor Air Quality Statistics in Delhi



Source: <https://epic.uchicago.in/delhi-homes-record-poor-indoor-air-quality-low-willingness-for-demanding-clean-air/>

Permissible Limits of Air Pollutants

CARBON DIOXIDE

Low: > 250 ppm

Medium: > 1000 ppm

High: > 2000 ppm

VOLATILE ORGANIC COMPOUNDS INDEX

Low: 0 - 100

Medium: 101 - 200

High: 200 - 500

PARTICULATE MATTER

PM 2.5 PM 10

Low: < 50 µg/m³ < 50 µg/m³

Medium: 50-150 µg/m³ 50-150 µg/m³

High: > 150 µg/m³ > 150 µg/m³

Overview

Our Smart IoT-device calculates the levels of various air pollutants such as CO₂, particulate matter of sizes 2.5 & 10 microns , VOCs and also measures Heat Index by keeping track of Temperature and Humidity.

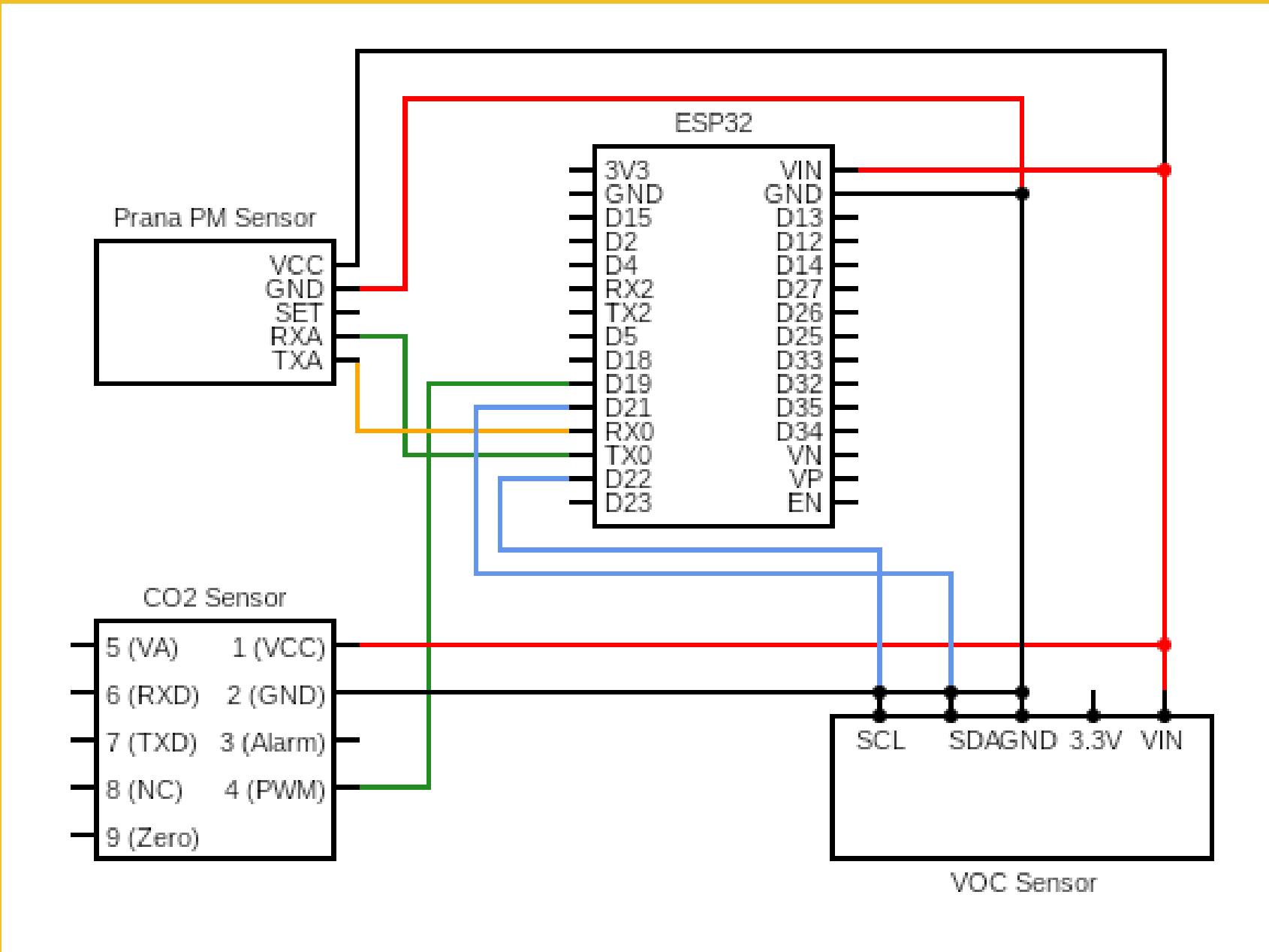
Hardware

- ESP32
- DHT11/SHT4X sensor
- Prana-Air CO₂ sensor
- Prana-Air SDS sensor
- PCBs
- Power Source

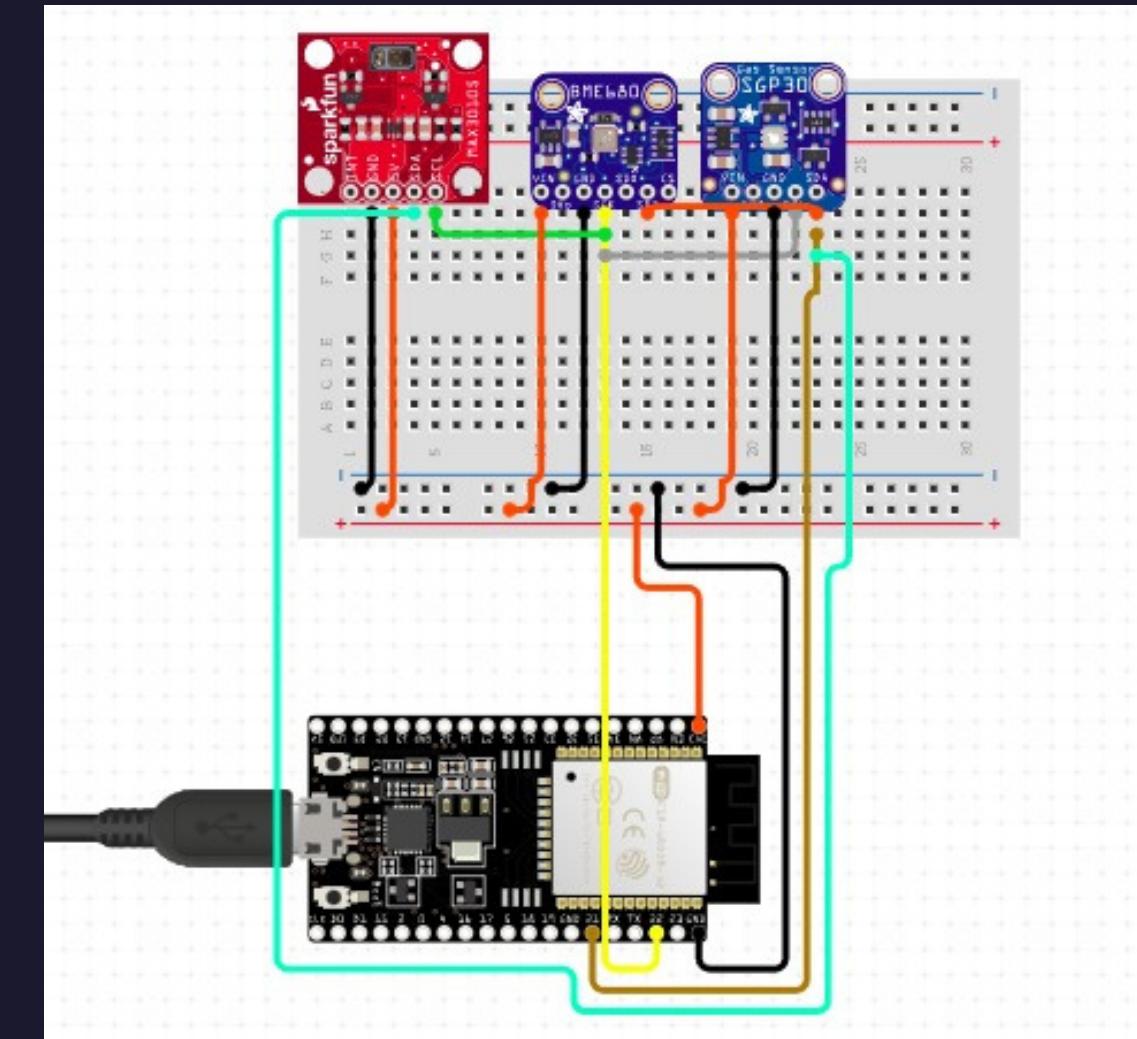
Software

- Arduino
- ThingSpeak + OM2M
- Python
- React JS + Tailwind CSS
- Node JS + MongoDB + Express JS

CIRCUIT DIAGRAM



REFERENCE CIRCUIT



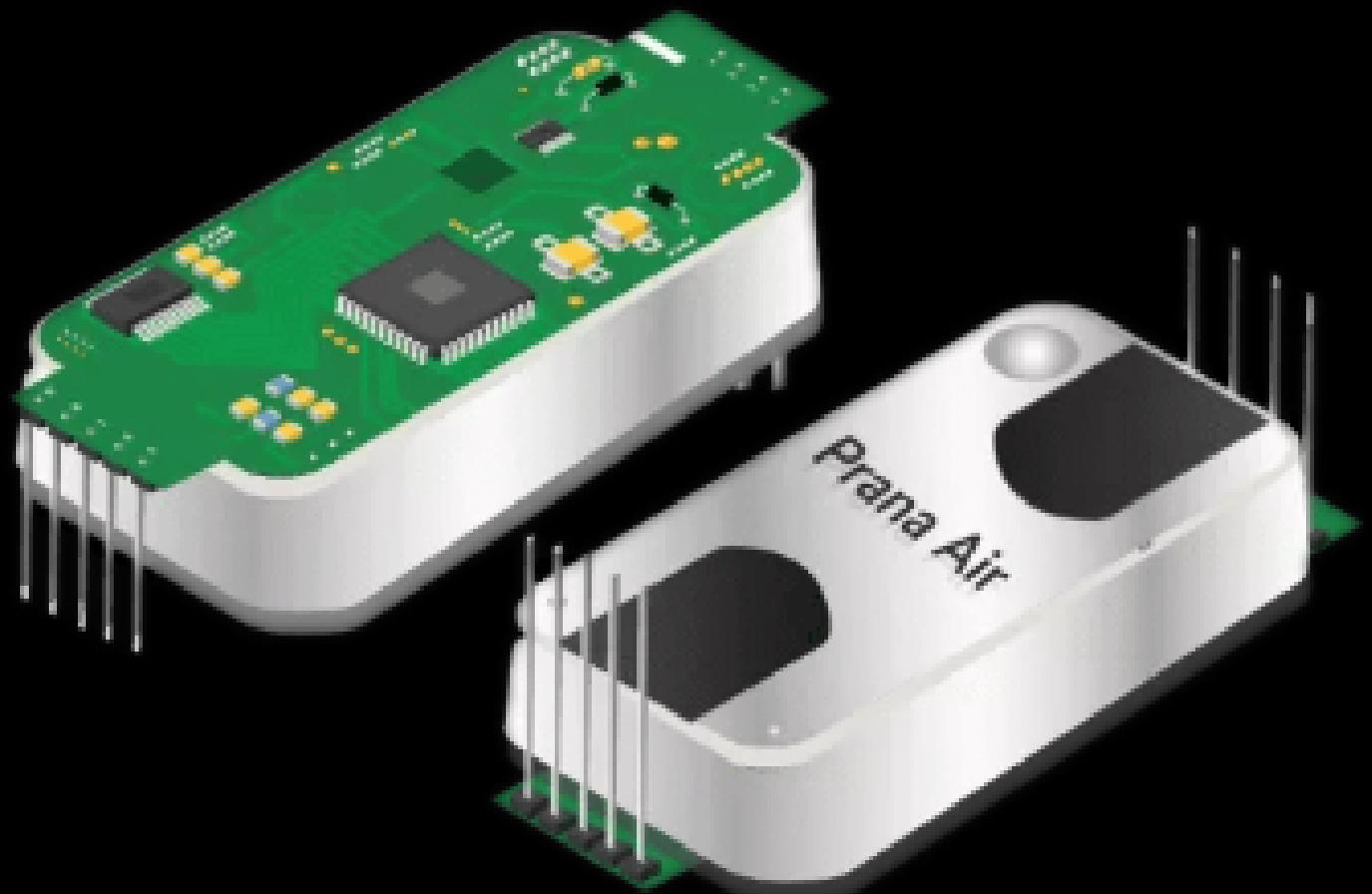
Sensors used:

Prana Air NDIR CO2 Sensor
SGP40 Sensor (VOC, Temp, Humidity)
Prana Air SDS Sensor (PM2.5 and PM10)

Node deployment

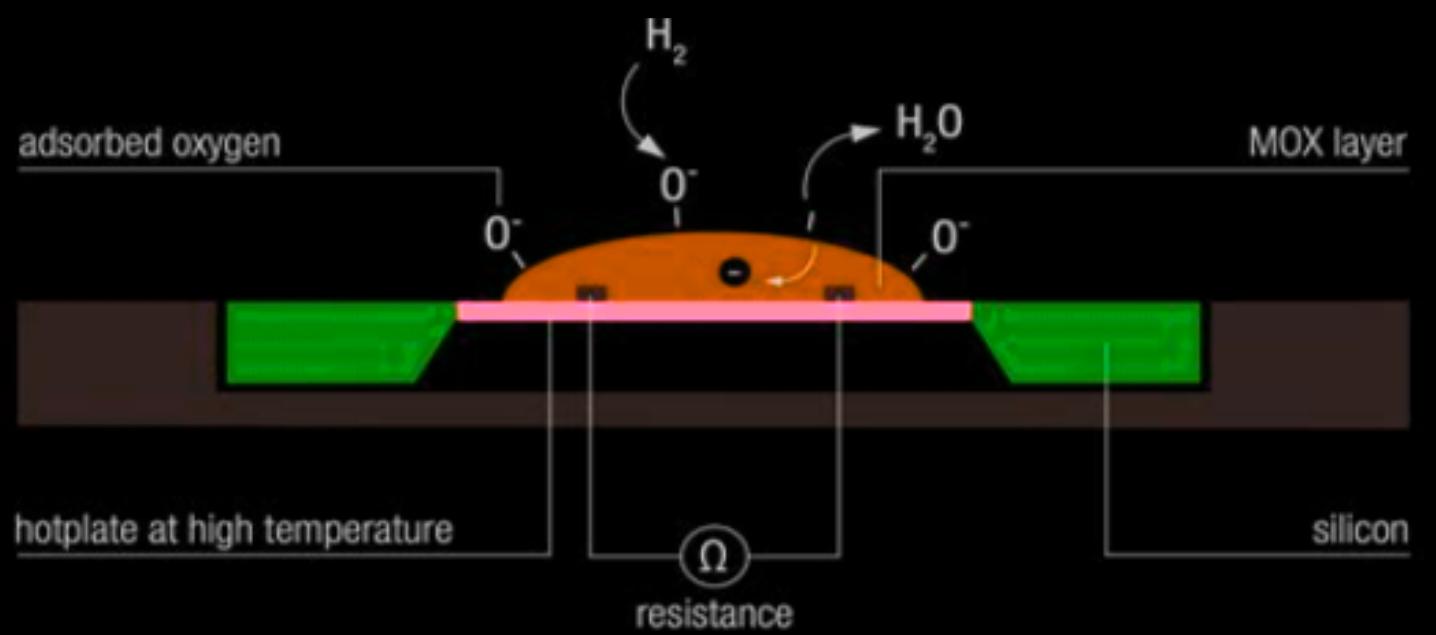


Working of Prana-Air CO2 Sensor



- CO2 sensor works on NDIR (Non Dispersive Infra-Red detection) principle.
- It projects infrared (IR) lamp directing waves of light through the sensor air cavity filled with samples of air.
- Air moves towards an optical filter in front of an IR light detector
- IR light detector measures the amount of IR light that passes through the optical filter
- Amount of absorbed IR waves \propto concentration of CO2 particles.
- It uses Digital Serial Communication to send data to ESP32

Working of SGP40+SHT4X Sensor



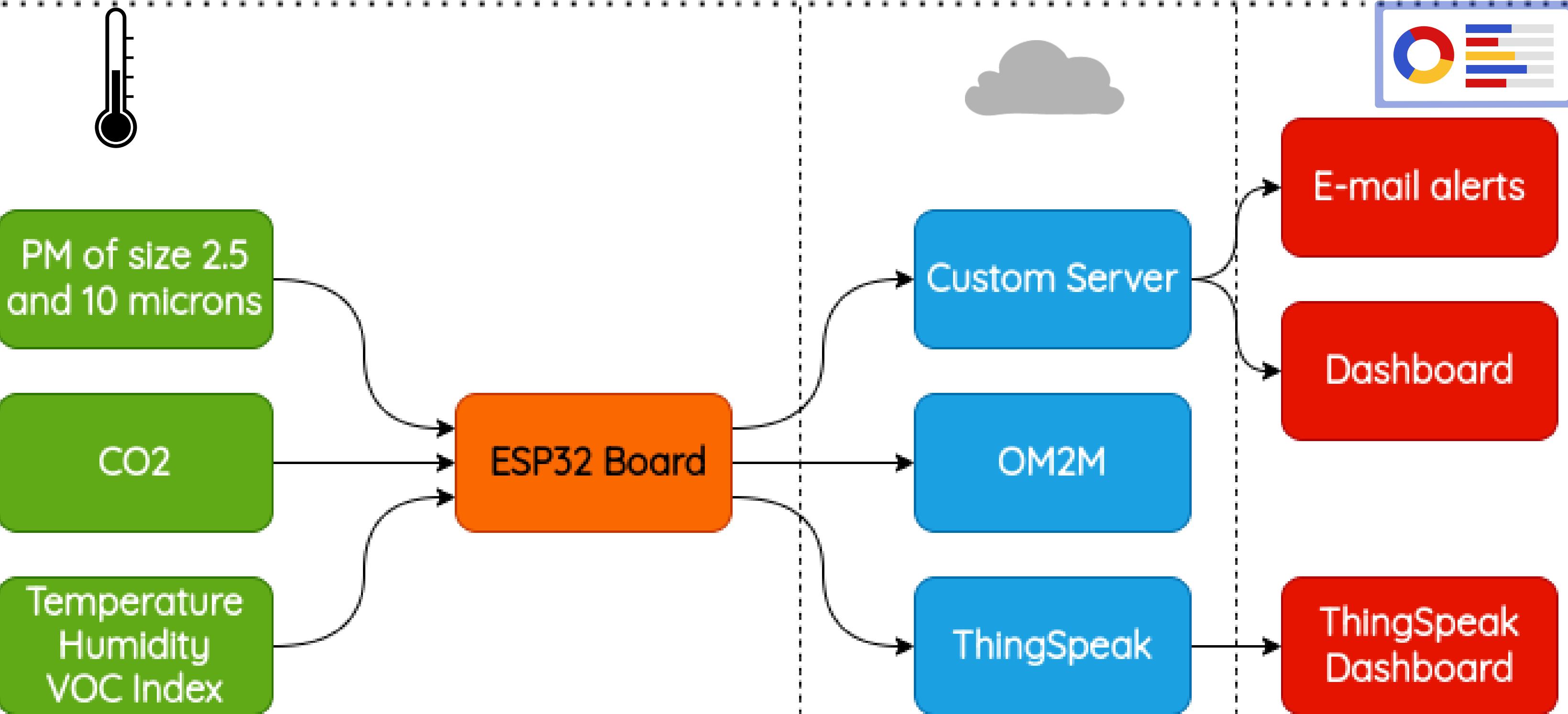
- **SGP40 Sensor is internally composed of two different detectors: SHT and SGP useful for Humidity and Temperature; Volatile Organic Compounds respectively.**
- **SGP40 Sensor works on a temperature controlled hotplate and humidity compensated signal denoting the values.**
- **It has a MOX Surface that is coated with an electrochemical layer to react with Hydrocarbons in air.**
- **The communication happens through I2C Protocol, using the SDA and SCL ports for the clock pulses.**
- **We simply use the Adafruit_SGP40 Library to declare an object instance of the sensor and extract values from it.**

Working of Prana Air PM Sensor

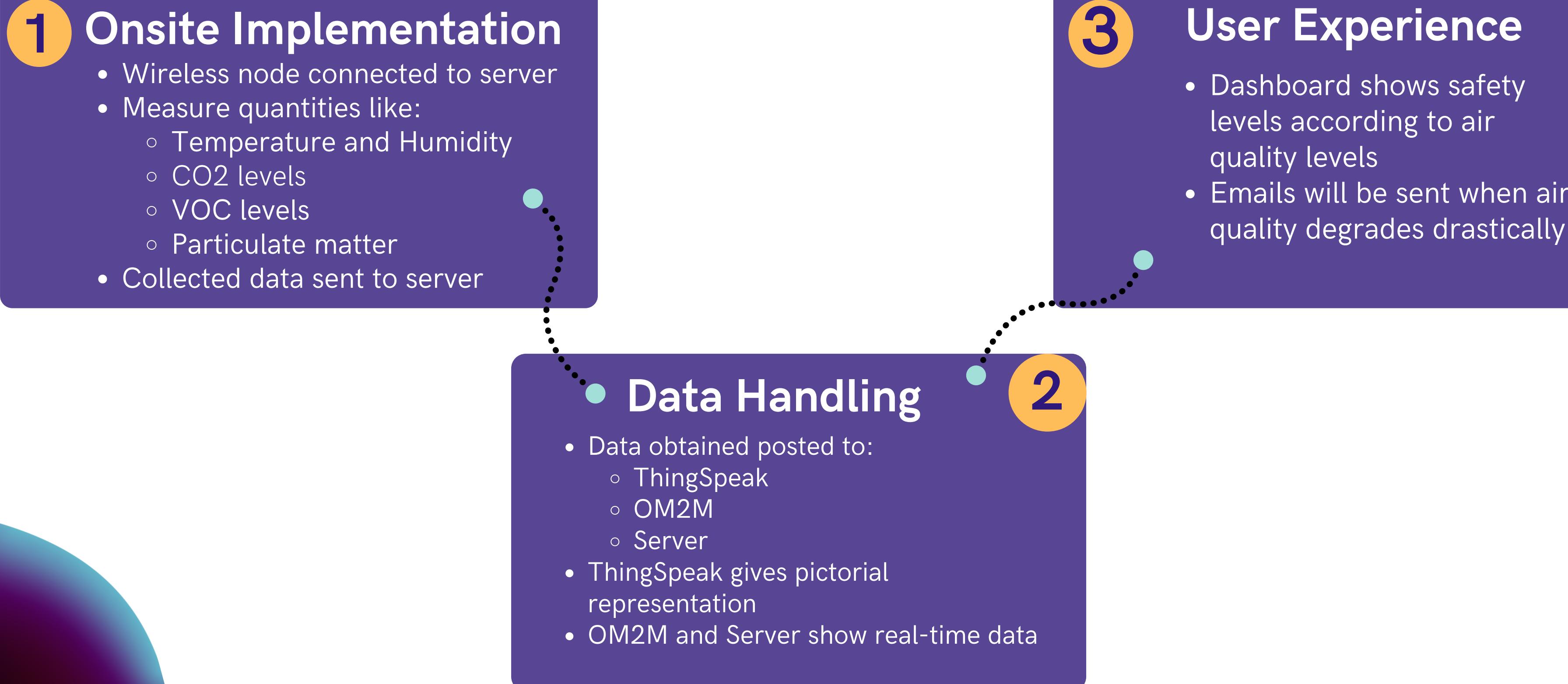


- The Particulate Matter SDS sensor works using Ultraviolet Light projection.
- It projects energetic photons into the air cavity with the sample of air, and determines the amount of PM concentration along with their sizes using the principle of "Scattering of light" with the dust particles.
- A photodetector detects the wavelength and Intensity of the scattered light.
- It uses UART Protocol to transmit the data to the ESP32 through RX and TX ports.
- Note that these ports are also used in uploading code during flashing, hence need to be unplugged and plugged back when flashing the code.

Flow of Information



Project Flow



Data Processing

Calibration

Improper data samples can be ingested since sensors can have different sets of calibration points. To overcome this, we are planning to use **Linear Regression** to train our project with data samples

Outlier Detection

IQR is employed to identify samples that do not fit the expected data distribution.

Validation & Prediction

Linear Regression through pre-calibrated sensor is employed for validation of the obtained data samples and can ultimately be used to predict future data

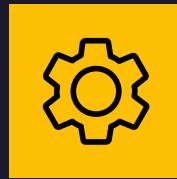
Calibration

Proper Sensor Calibration yields accurate measurements



Machine Learning

ML is employed to map reference data (used as training data) to experimental data



Linear Regression

LR is used along with plots over numerous data-points (1800+) collected for more than 24hrs



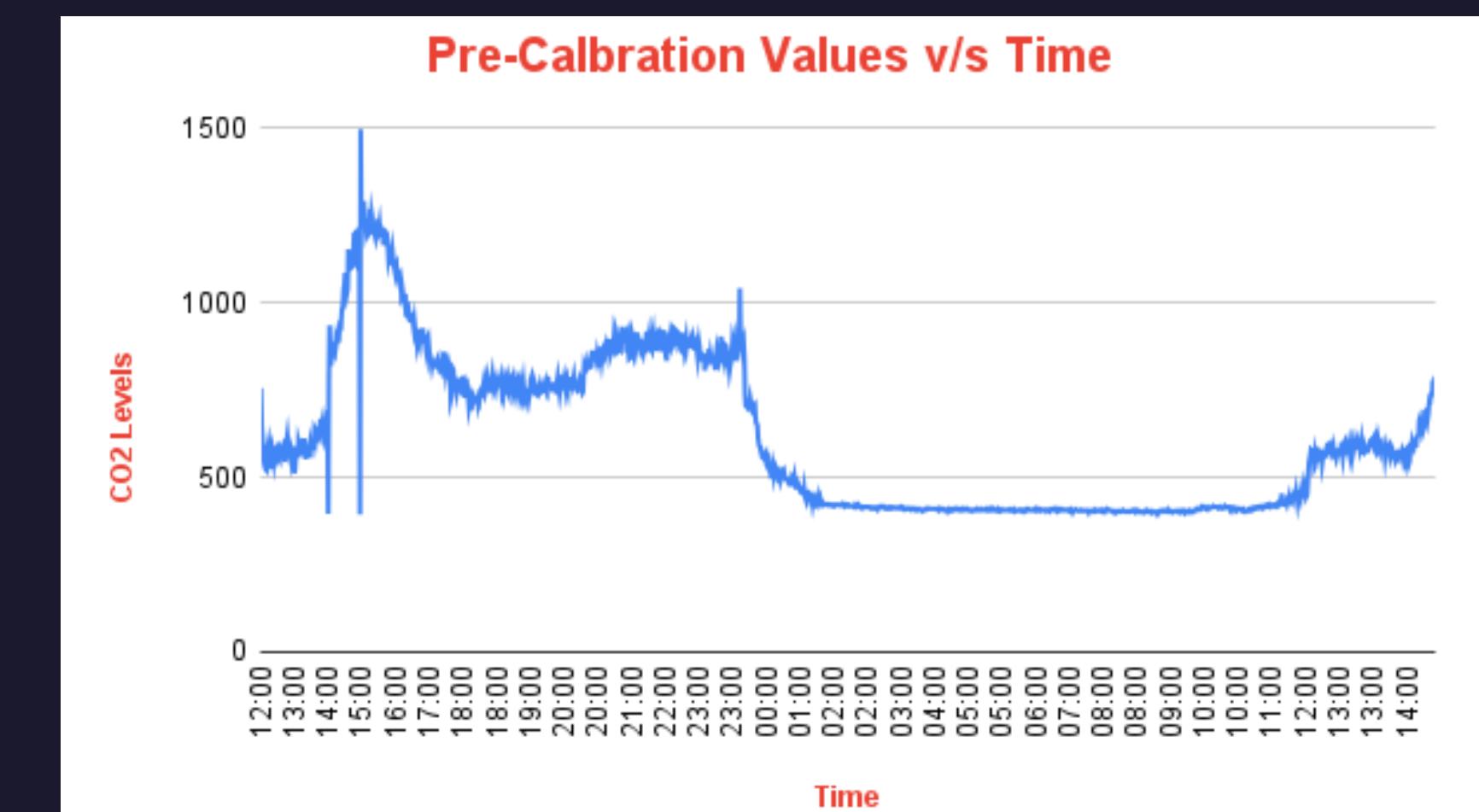
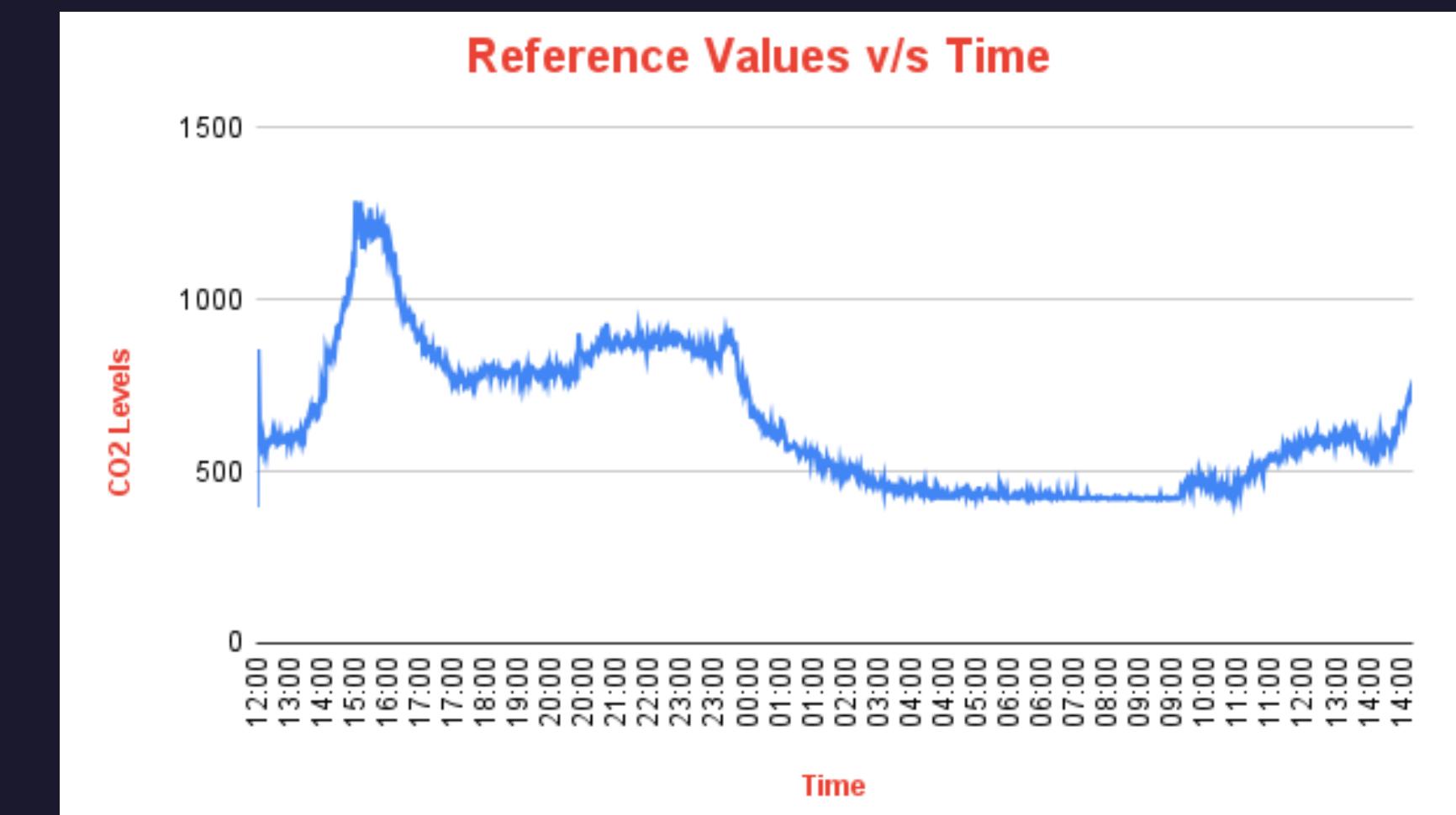
Identical Trends

The plots are largely similar , but considerable difference in amplitude of reference and experimental plots is observed



Linear Regression Line

Assuming y to be the reading of the reference CO₂ sensor and x to be the reading of the uncalibrated sensor, we obtain a relation as $y = ax + b$ where $a = 0.896869239565473$ and $b = 93.18648988932932$

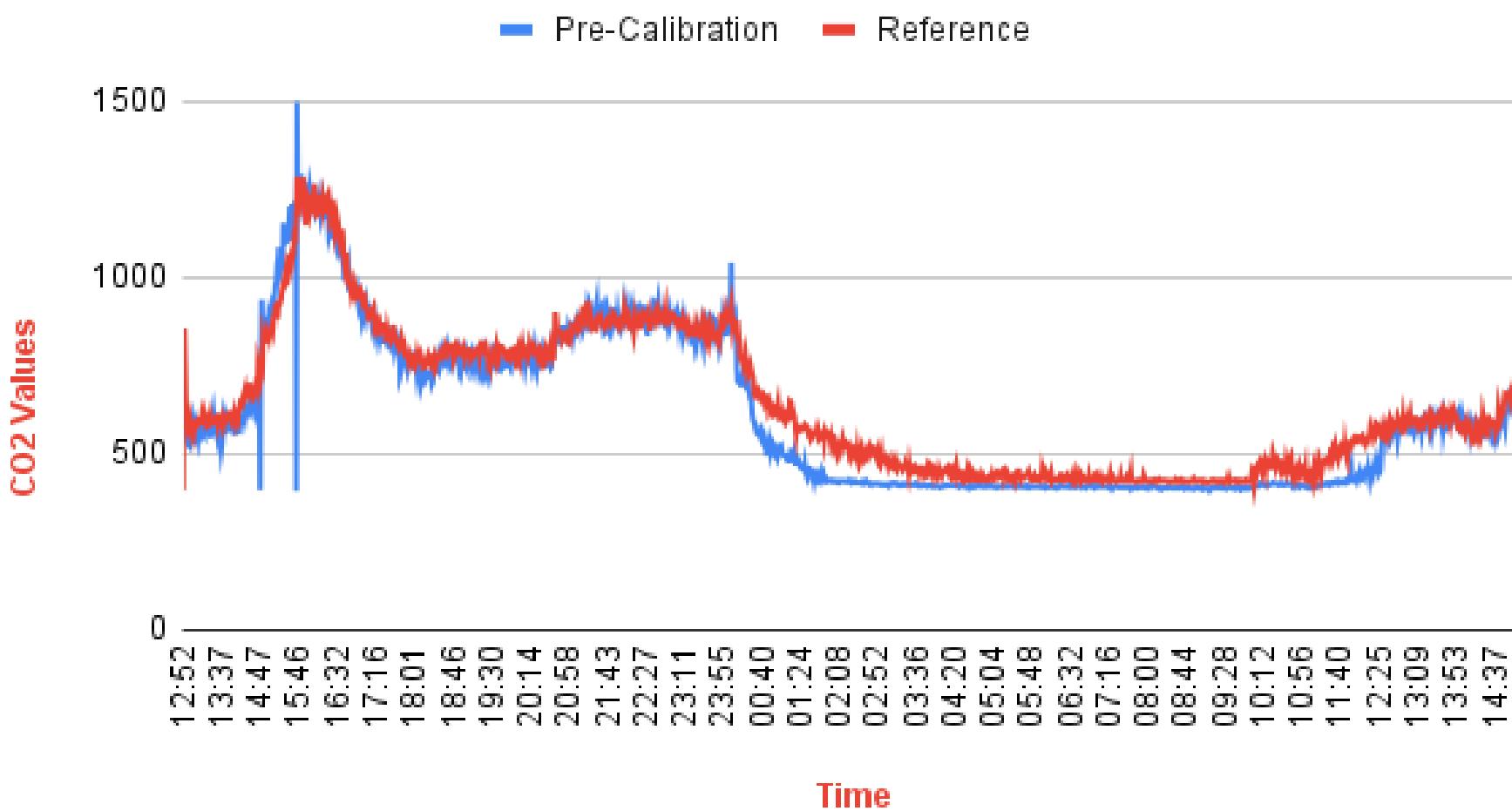


Calibration Curves

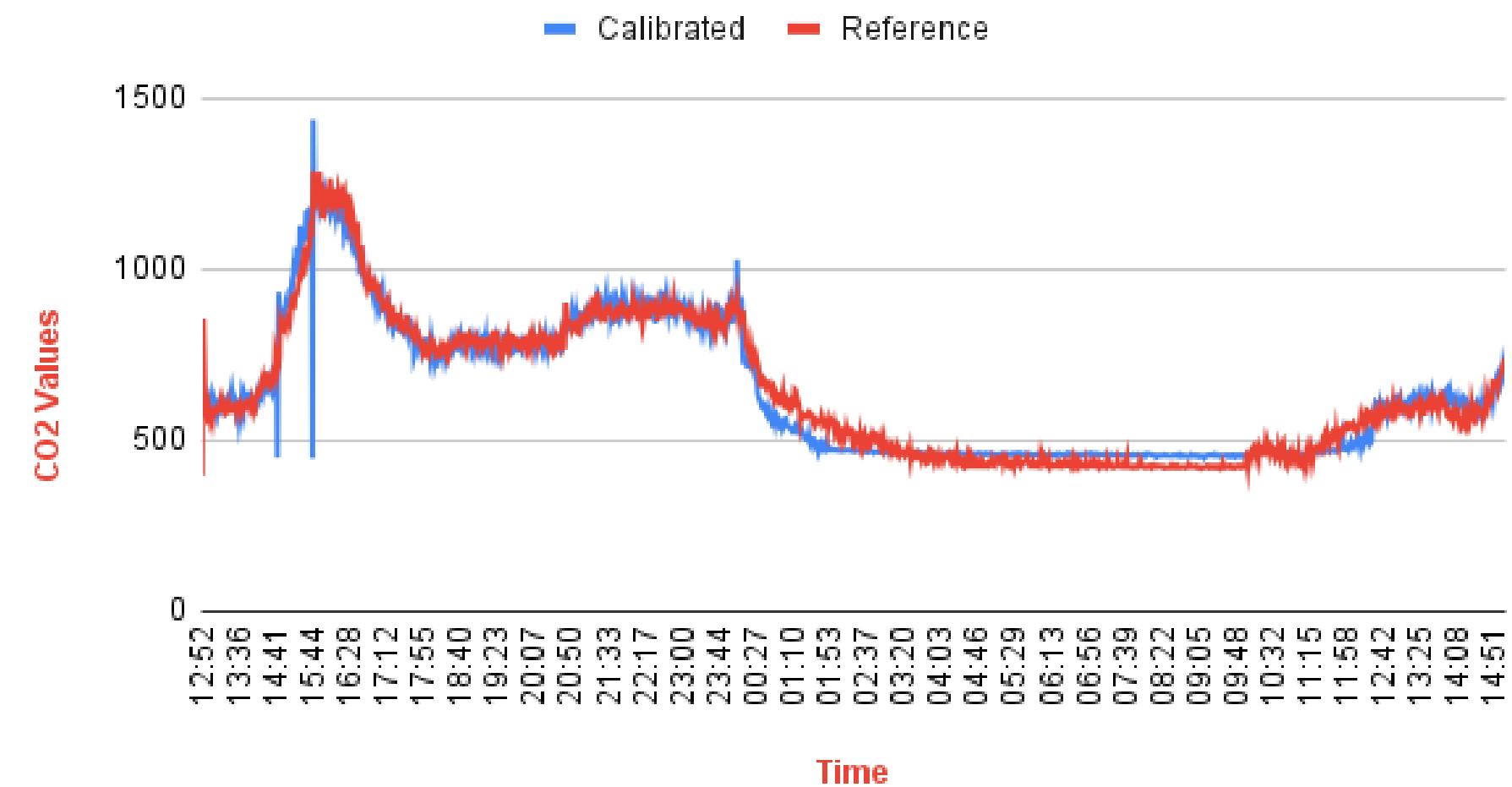
Reference sensor is the node deployed in the SPCRC Lab.

The spikes were obtained by lighting incense sticks near the node

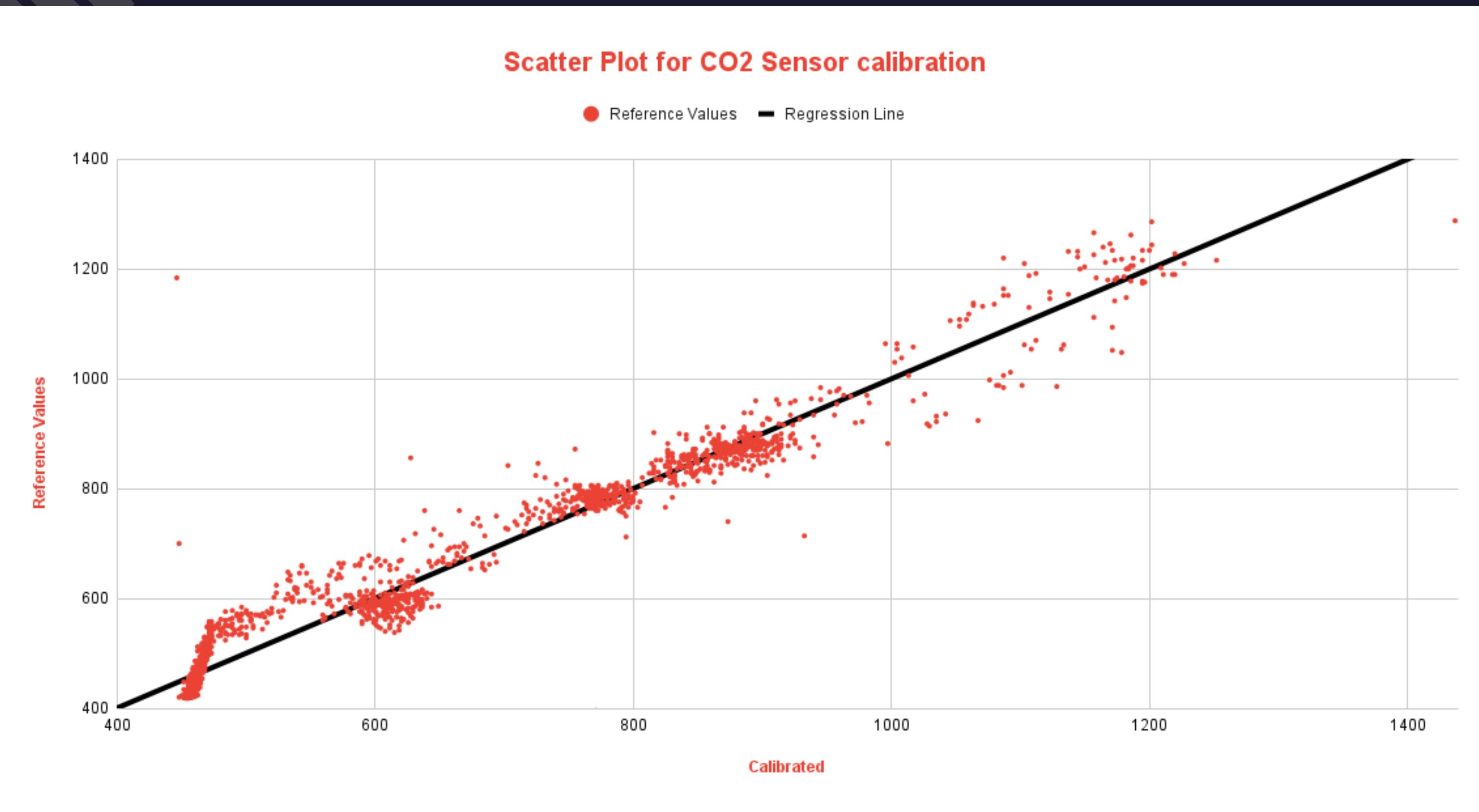
Pre-Calibrated v/s Reference Values



Calibrated v/s Reference Values



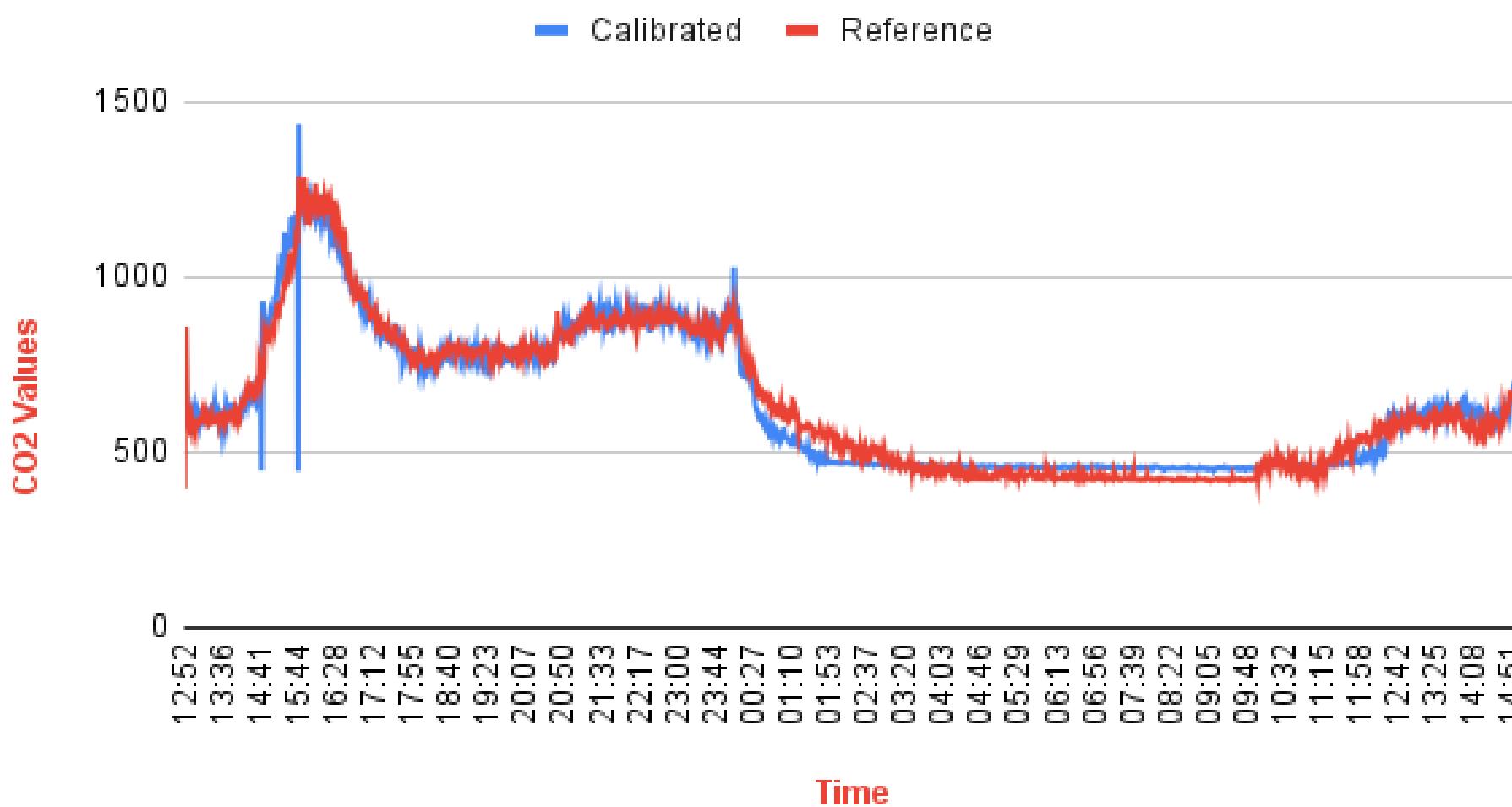
Scatter Plot



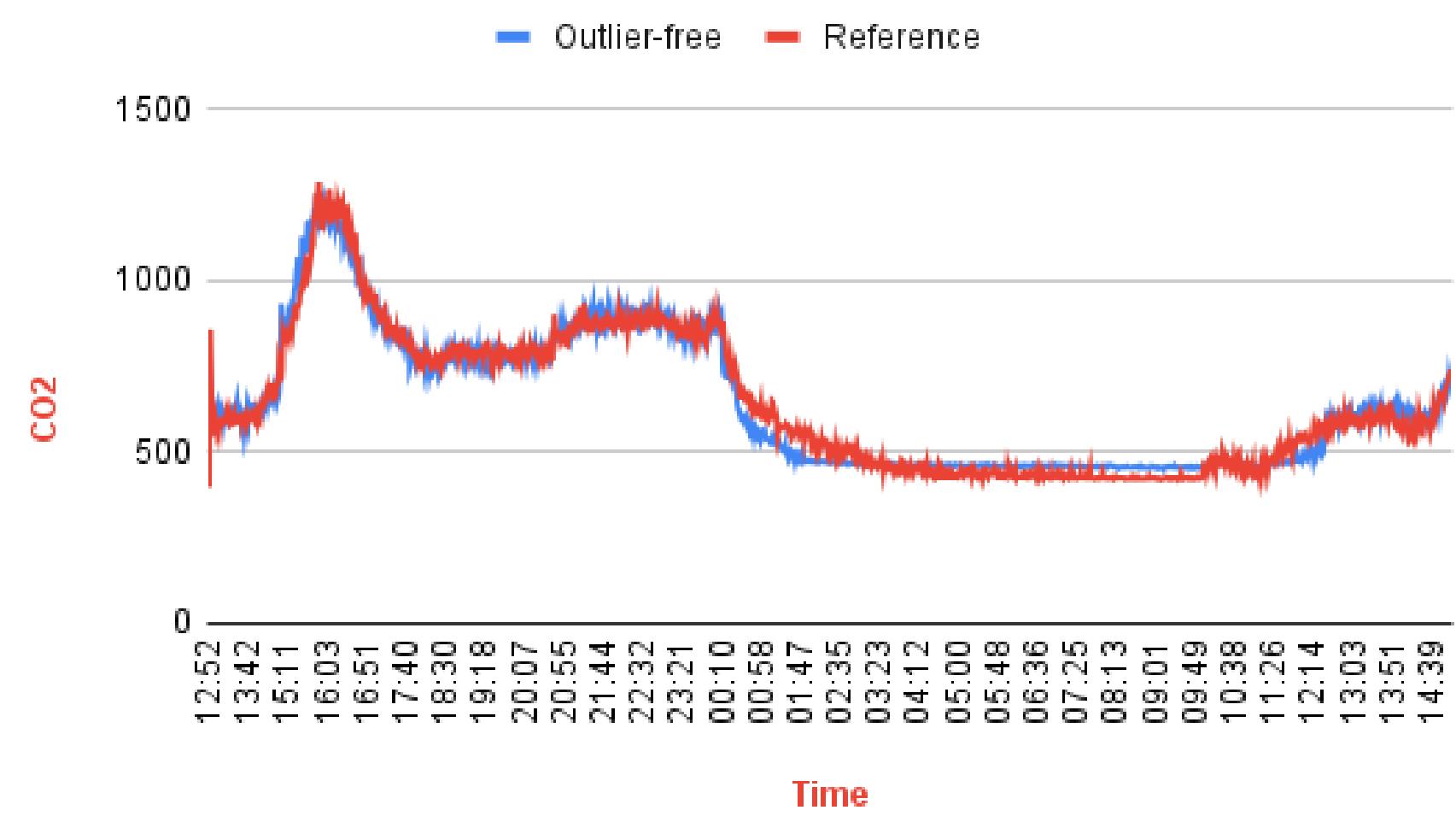
Outlier Detection

Outlier values have been eliminated using IQR
(Inter-Quartile Range) method

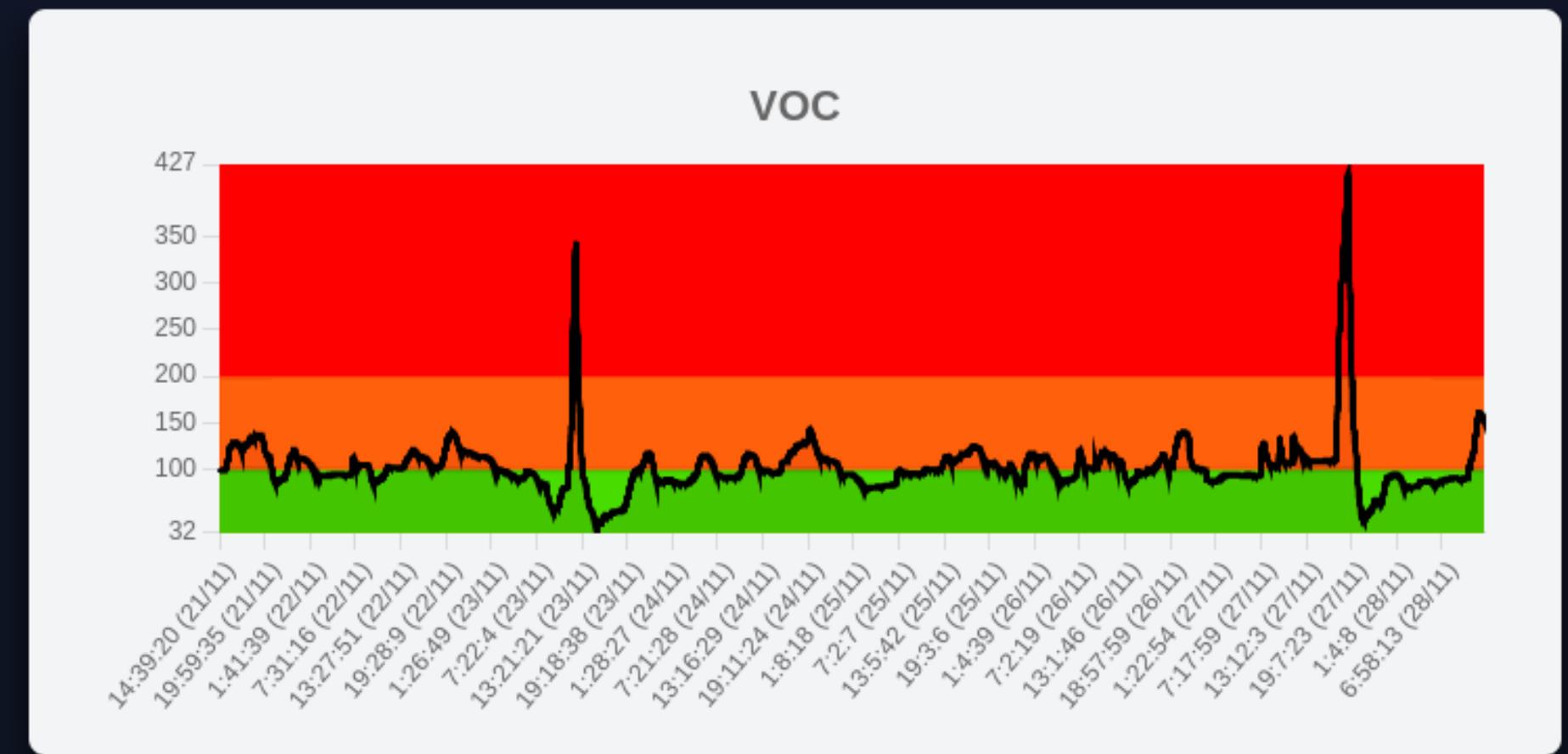
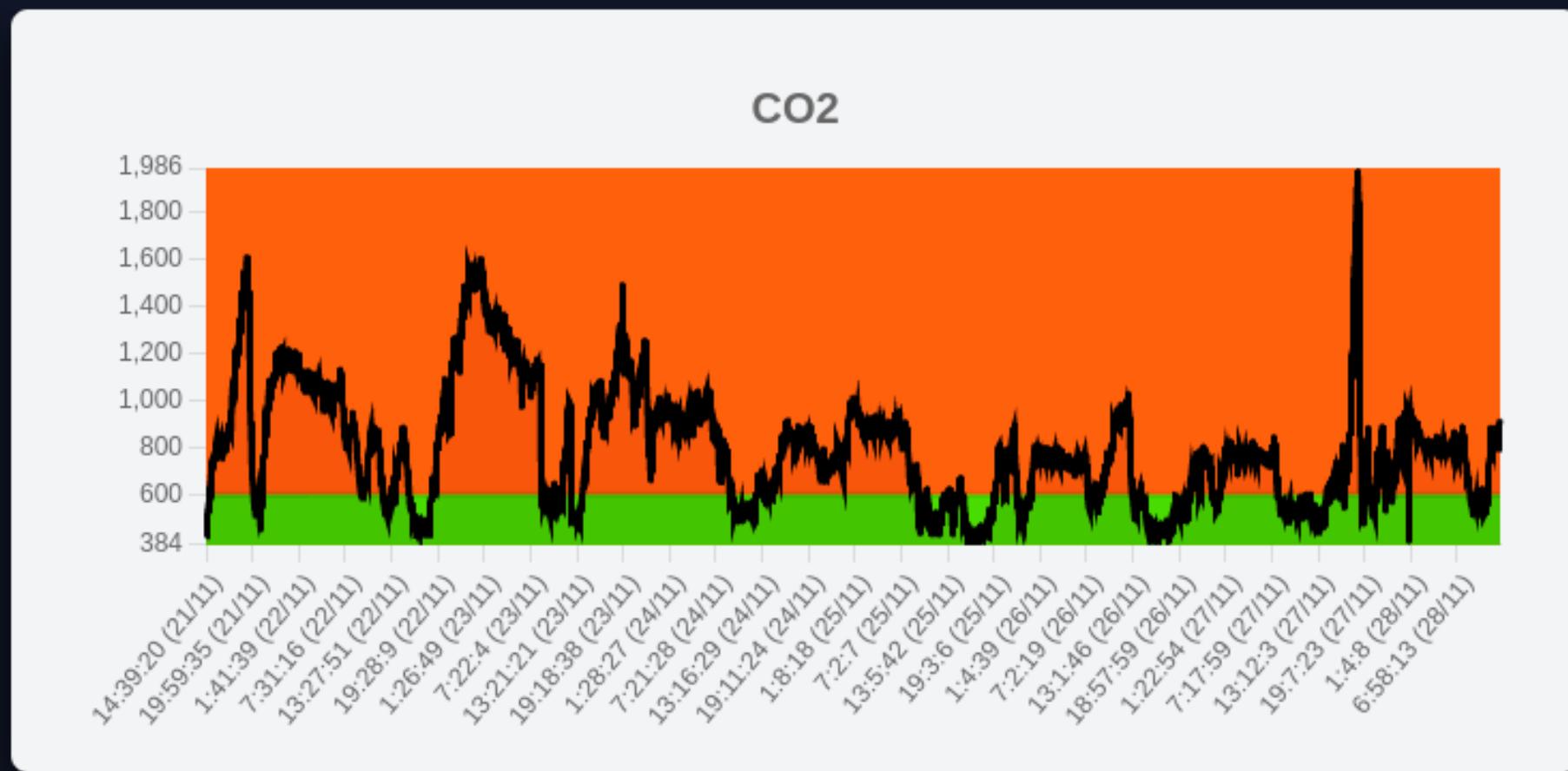
Calibrated v/s Reference Values



Outlier-free v/s Reference Values



Data Analysis - Properly ventilated room



Large Spikes:

- Incense Sticks (Agarbatti)
- Burning something

Small Spikes:

- When ventilation was low
- When more people gathered

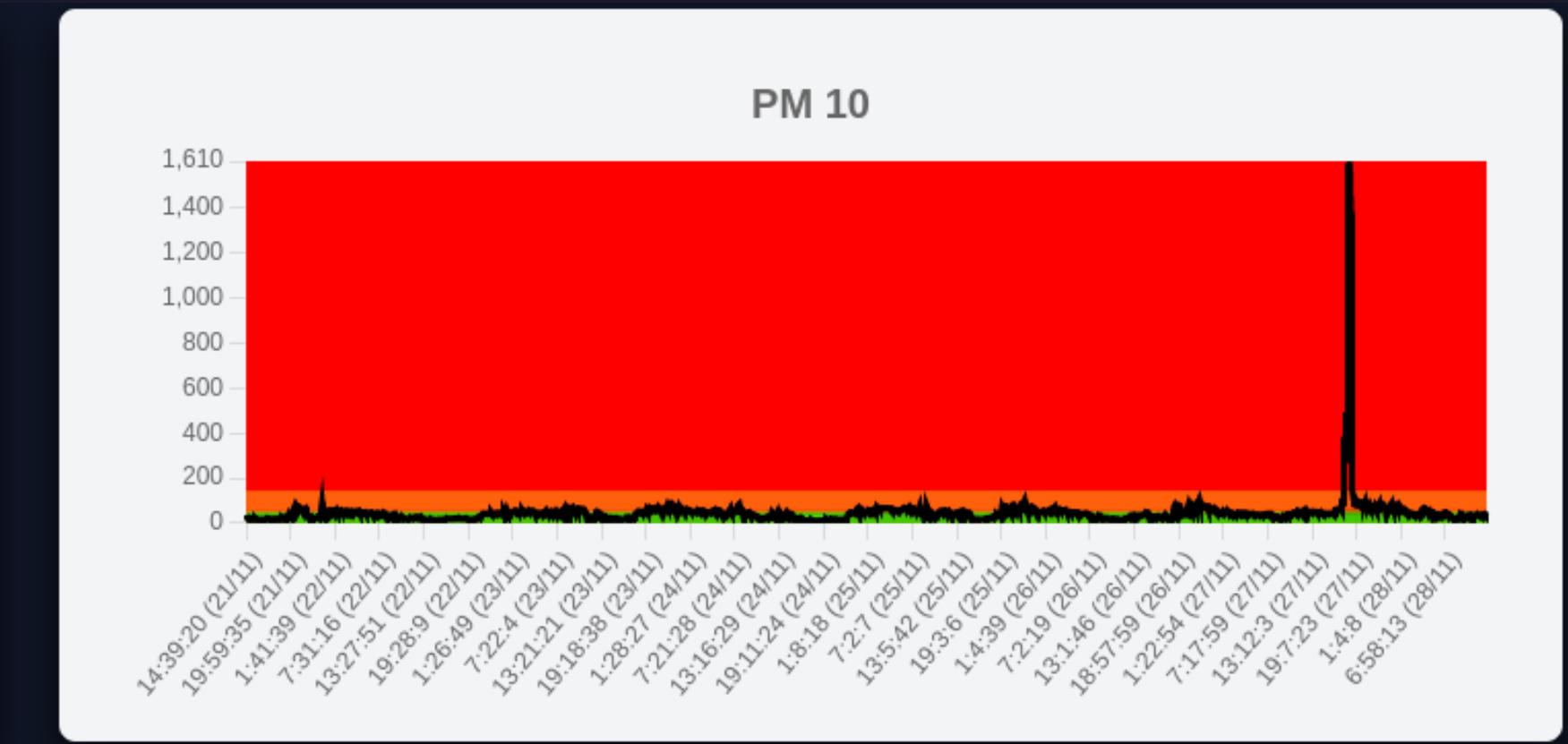
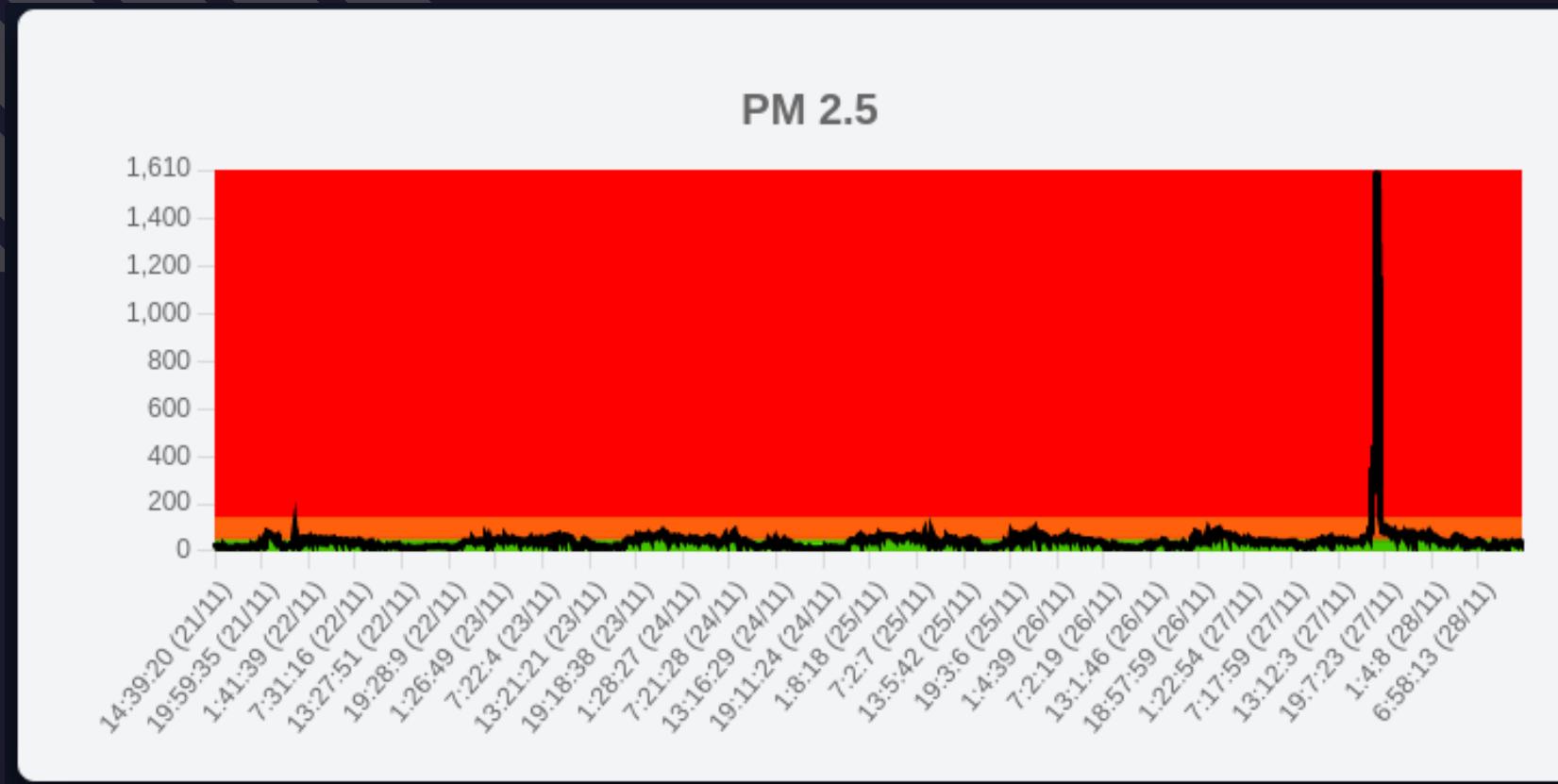
Lows:

- When we opened door and windows for ventilation

Spikes:

- When we used perfumes/aerosols
- On burning agarbatti

Data Analysis - Properly ventilated room



The large spikes were observed when incense sticks were lit up in the room during which we also observed differences between the readings of PM 2.5 and PM 10

Features of Dashboard

Live

Displays the latest sensor-wise data with appropriate colour coding where **GREEN**, **ORANGE** and **RED** are used to show values that are in safe, moderate and hazardous levels respectively

Alerts

Users subscribe to E-mail alerts to get notified when air pollutants rise to hazardous amounts

Graphs

Displays readings versus time graphs for different air pollutants and also shows if the node is **ONLINE** or not



Dashboard UI

Indoor Air Pollution

Live Graphs Alerts



CO2

518



VOC

90



Temperature

27.32



Humidity

63.93



PM 2.5

103



PM 10

111

Last Updated at 22:52:3 (4/11)

Node is Online

Dashboard UI

Indoor Air Pollution

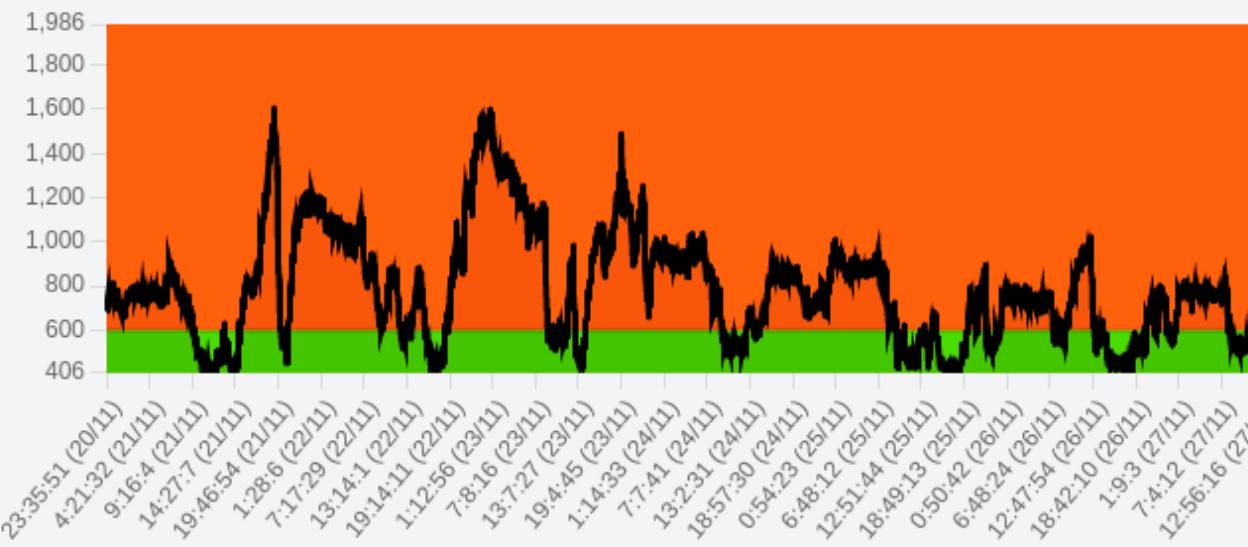
Live Graphs Alerts

Hour

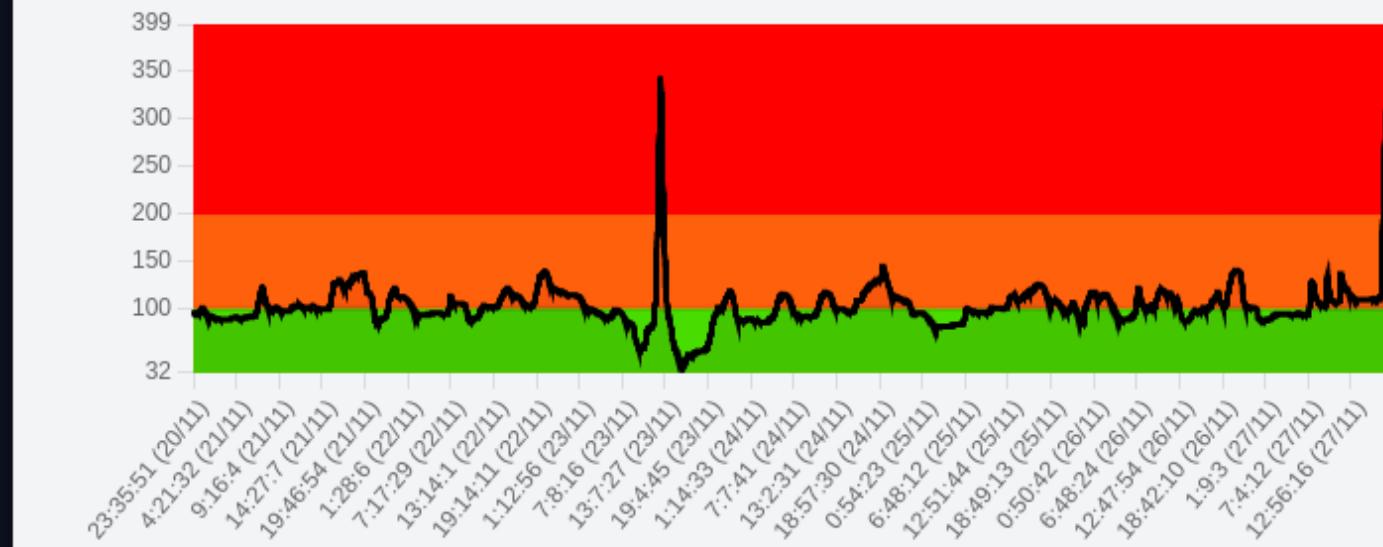
Day

Week

CO2



VOC

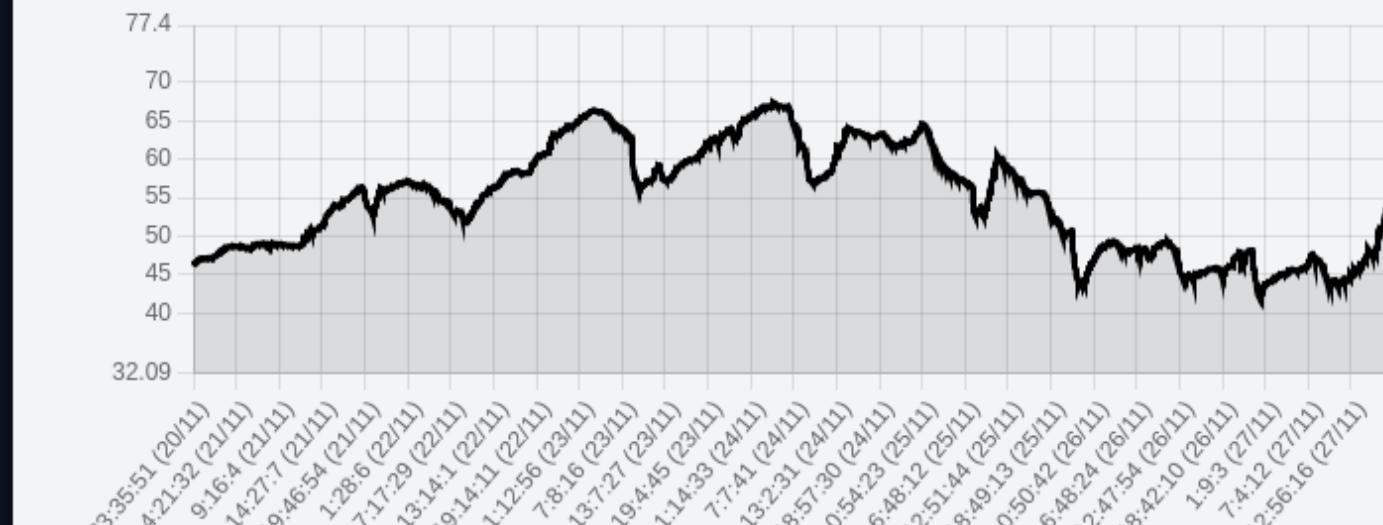


Temperature



Node is Online

Humidity



ALERT SYSTEM MECHANISM

Indoor Air Pollution

Subscribe for email alerts
Subscribed emails will receive alerts whenever air quality degrades

Email

Submit

How To Subscribe for Alerts
Three steps to go:

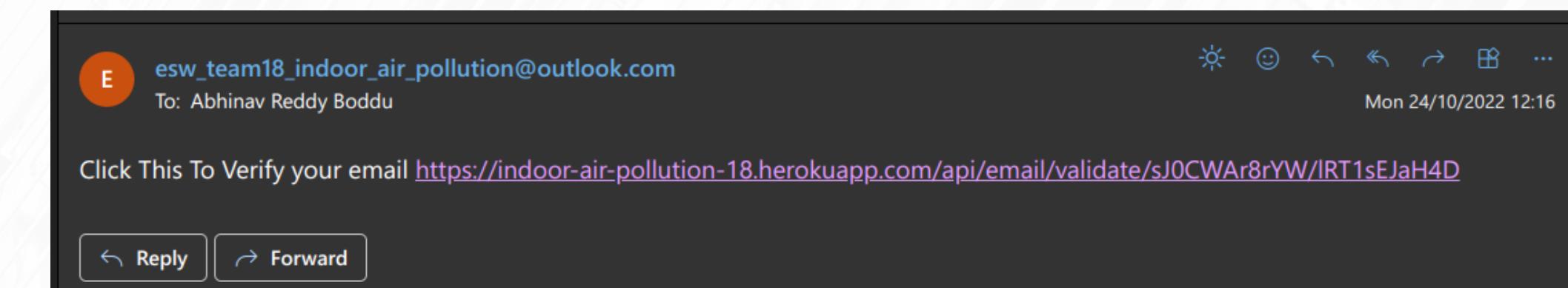
- Enter your email
- Validate your email
- Start receiving alerts

E esw_team18_indoor_air_pollution@outlook.com
To: Abhinav Reddy Boddu

Unsafe Levels of Air Pollutants Have been detected at node location

CO2: 463
VOC: 92
Temperature: 28
Humidity: 60
PM 2.5: 152
PM 10: 152

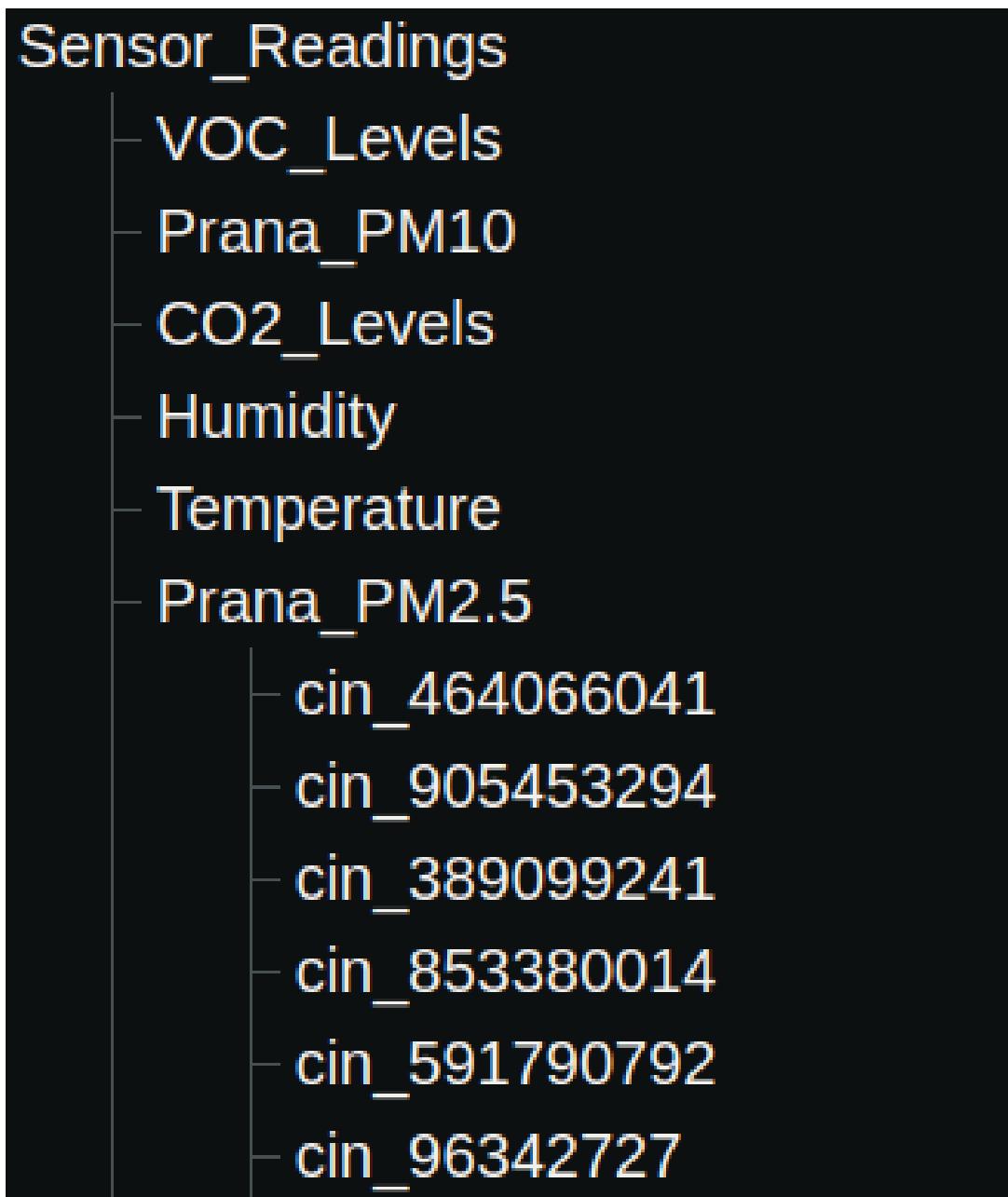
Visit <https://indoor-air-pollution-18.onrender.com/>



OM2M

Python script is used to create application entity and containers in OM2M and then data is sent through HTTP requests from the node as container instances which are posted into one of the following containers in the following format:

```
String cnt[] = {"Prana_PM2.5", "Prana_PM10", "CO2_Levels",  
"VOC_Levels", "Temperature", "Humidity"}
```



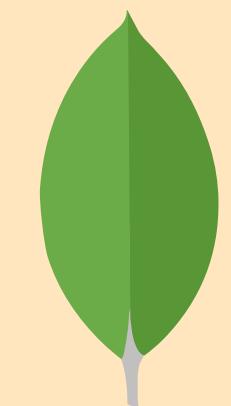
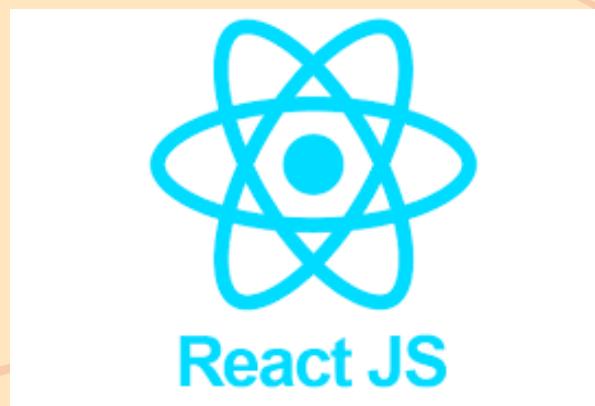
ThingSpeak

Using "ThingSpeak.h" library functions and HTTP Requests through POST-API queries, we send data to ThingSpeak into 6 fields where:

- Field 1 - Particulate Matter 2.5
- Field 2 - Particulate Matter 10
- Field 3 - Carbon Dioxide
- Field 4 - Volatile Organic Compounds
- Field 5 - Temperature
- Field 6 - Humidity



Softwares used



mongoDB



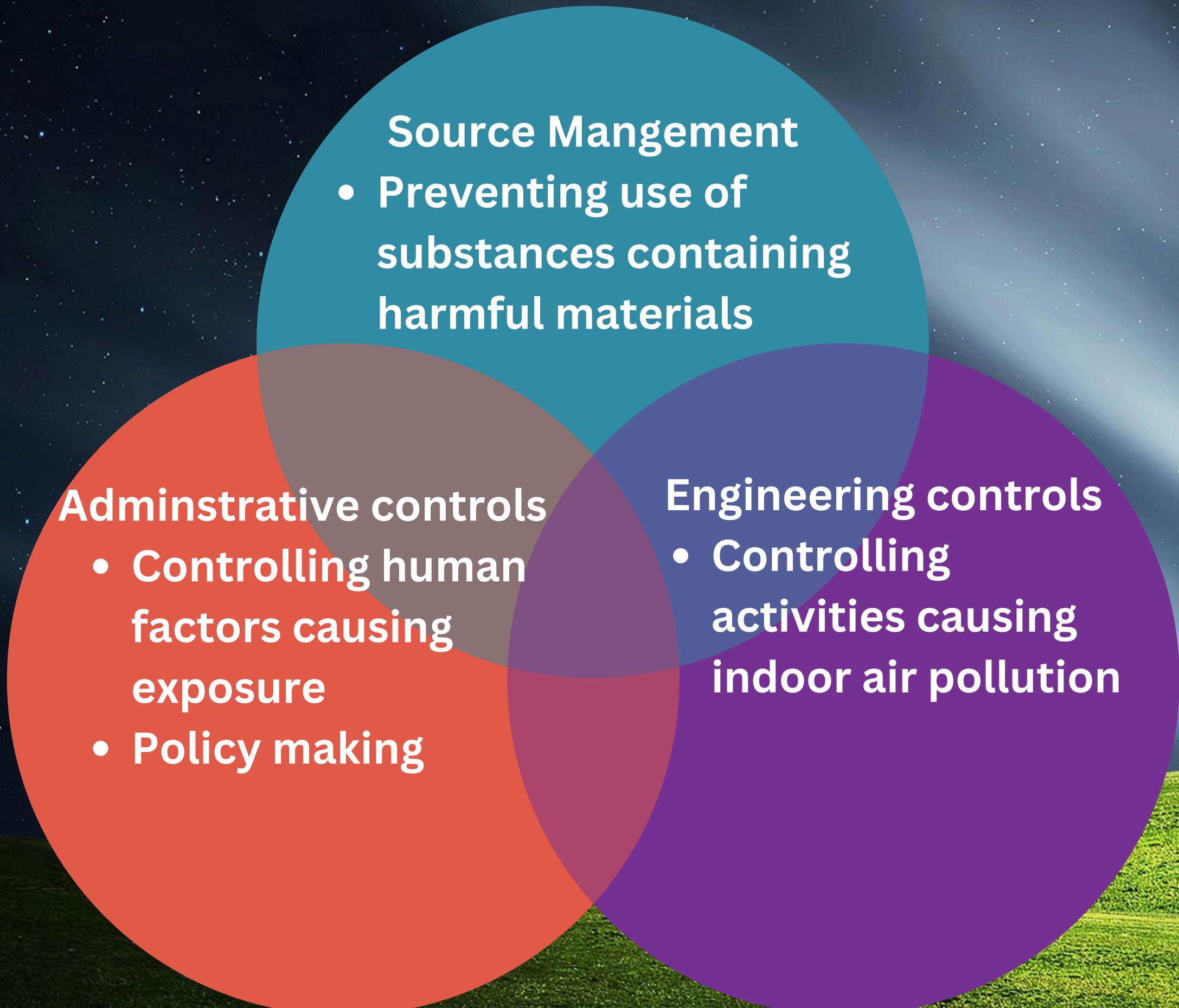
SUMMARY

- Email alerts are sent when measured values cross permissible limits
- Users can access the dashboard via QR Code/URL from any location

FUTURE SCOPE

- Our device with the collaboration of other smart IoT devices can form a Smart Home providing an access to easier life in every household
- Reports can be provided to users every month about the air quality based on the readings taken
- Our device can aid in detecting locations that cause excessive harm to the environment.

Mitigation Strategies



Steps to improve Indoor Air Quality

01

Ventilation

Improve Ventilation in the building

02

Monitoring

Monitor the Indoor Air Quality time by time

03

Air filtering

Check on your heating systems and use air purifiers

04

Cleanliness

Keep your workspace clean

05

House plants

Use indoor plants effectively

WORK PROGRESS

FINAL WEEK

Integrating IIITH OM2M
network with node
Ground deployment
Management
Data collection

WEEK 1

Brainstorming
Hardware prototyping
Circuit interfacing on
Zero PCB

WEEK 2

Microprocessor code
ThingSpeak and
OM2M integration

WEEK 3

Dashboard
Alert mechanism
Interfacing PM sensor

WEEK 4

Calibration
Analytics
Validation

DIVISION OF WORK

ABHINAV REDDY

DASHBOARD & CUSTOM SERVER

ROHIT GOWLAPALLI

HARDWARE & PCB DESIGN

GNANA PRAKASH

SENSOR, OM2M & THINGSPEAK CODE

LSA MOURYA

DATA ANALYSIS & REPORTS