Analysis of Air Quality

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Contents

1 ABSTRACT

This project focuses on the data analytics of air quality using the Air Quality Analysis API. The primary objective is to collect, store, and visualize air quality data for three countries: Poland, Switzerland, and Germany. The data is fetched using the API, processed in Node-RED, stored in InfluxDB, and visualized using Grafana. The project emphasizes the importance of monitoring air quality parameters such as PM2.5 and PM10, which are critical for public health. The Grafana dashboards provide interactive visualizations, including graphs and bar charts, to analyze trends and answer specific questions about air quality.

2 INTRODUCTION

Air quality is a critical environmental factor that directly impacts human health and ecosystems. Pollutants such as PM2.5 and PM10 are known to cause respiratory and cardiovascular diseases. Monitoring air quality helps in understanding pollution levels, identifying sources, and implementing mitigation strategies. This project leverages the Air Quality Analysis API to collect real-time air quality data for Poland, Switzerland, and Germany. The data is processed and visualized using a combination of Node-RED, InfluxDB, and Grafana. The project aims to provide actionable insights through interactive dashboards that highlight trends, thresholds, and anomalies in air quality data.

3 ABOUT AIR QUALITY AND KEYWORDS

3.1 Air Quality Parameters

- **PM2.5**:
  - PM2.5 refers to fine particulate matter with a diameter of 2.5 micrometers or less.
  - These particles are small enough to penetrate deep into the lungs and even enter the bloodstream, causing severe health issues such as respiratory and cardiovascular diseases.
  - Sources include vehicle emissions, industrial processes, and combustion of fossil fuels.
- **PM10**:
  - PM10 refers to coarse particulate matter with a diameter of 10 micrometers or less.
  - These particles are larger than PM2.5 and primarily affect the respiratory system.
  - Sources include dust, pollen, and emissions from construction sites and industrial activities.

Air Quality	PM2.5 (µg/m³)	PM10 (µg/m³)
Good	0 – 12	0 – 20
Moderate	12 – 35	20 – 50
Unhealthy for Sensitive Groups	35 – 55	50 – 100
Unhealthy	55 – 150	100 – 250
Very Unhealthy	150 – 250	250 – 350
Hazardous	250+	350+

Figure 1: Air Quality table readings

3.2 Importance of PM2.5 and PM10

- **Health Impacts**:
  - PM2.5 is more dangerous than PM10 because it can penetrate deeper into the lungs and bloodstream, leading to long-term health problems.
  - PM10 primarily affects the respiratory system, causing issues such as asthma, bronchitis, and other respiratory diseases.
- **Environmental Impacts**:
  - High levels of PM2.5 and PM10 contribute to reduced visibility (haze) and can harm ecosystems by depositing on soil and water bodies.

3.3 Standard PM Concentration Ranges

- The **World Health Organization (WHO)** and the **Air Quality Index (AQI)** provide standard ranges for PM2.5 and PM10 to classify air quality. These ranges are used to determine whether the air quality is good, moderate, or unhealthy.
  - **Monitoring Air Quality:**
  - PM2.5 and PM10 values are measured in real-time using air quality sensors and monitoring stations.
  - These values are used to calculate the Air Quality Index (AQI), which provides a simple and standardized way to communicate air quality to the public.
- **Setting Thresholds:**
  - Governments and organizations use PM2.5 and PM10 thresholds to issue health advisories and take action to reduce pollution.
  - For example, if PM2.5 levels exceed 55 µg/m³, the air quality is classified as "Unhealthy," and people are advised to limit outdoor activities.
- **Visualizations**:
  - In this project, PM2.5 and PM10 values are visualized using Grafana dashboards. The dashboards use color-coded thresholds (e.g., green for good, red for hazardous) to indicate air quality levels.
- **Key Questions Answered by PM2.5 and PM10 Data**
- **What is the current air quality**?
  - PM2.5 and PM10 values are used to determine whether the air quality is good, moderate, or unhealthy.
- **Is the air quality safe for sensitive groups**?
  - PM2.5 and PM10 values help identify whether sensitive groups (e.g., children, elderly) are at risk.
- **How does air quality vary over time**?
  - Historical PM2.5 and PM10 data can be analyzed to identify trends and patterns in air quality.

4 TOOLS AND TECHNOLOGIES USED

4.1 Node-RED

Node-RED is a flow-based development tool used to connect APIs, databases, and other services. In this project, Node-RED is used to:

- Fetch air quality data from the Air Quality Analysis API using HTTP GET requests.
- Process the JSON response and push the data into InfluxDB.

4.2 InfluxDB

InfluxDB is a time-series database optimized for storing and querying time-stamped data. Three buckets were created to store air quality data for Poland, Switzerland, and Germany. The data includes parameters such as PM2.5, PM10, and timestamps.

4.3 Grafana

Grafana is a visualization tool used to create interactive dashboards. It connects to InfluxDB to fetch and display air quality data in various formats, such as line graphs, bar charts, and gauges. The dashboards are designed to answer specific questions about air quality trends and thresholds.

4.4 JSON

JSON (JavaScript Object Notation) is used as the data format for API responses. Node-RED processes the JSON data to extract relevant air quality parameters.

5 VISUALIZATIONS AND DASHBOARDS

5.1 Dashboard Setup

- **Data Sources**: InfluxDB buckets for Poland, Switzerland, and Germany.
- **Panels**:
  - Line graphs showing trends in PM2.5 and PM10 levels over time.
  - Bar charts comparing weekly averages for the last 15 weeks.
  - Gauges displaying real-time PM2.5 and PM10 levels with color-coded thresholds.
  - Tables listing the highest and lowest values for the day, week, or month.

6 DASHBOARD FOR MONITORING AIR QUALITY (P1 AND P2 VALUES OF SWITZERLAND)

The dashboard provides a comprehensive view of air quality in Switzerland, focusing on PM10 (P1) and PM2.5 (P2) values. The

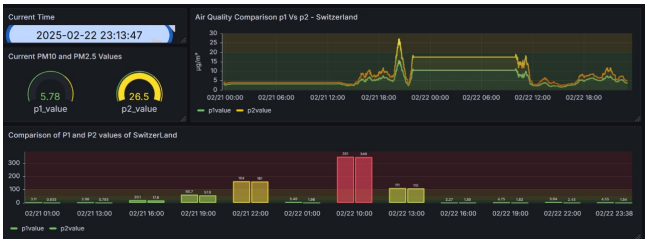


Figure 2: Dashboard for Monitoring Air Quality P1 and P2 values of Switzerland

Figure 3: Air Quality Compression standards in Switzerland

Figure 4: Comparison of P1 and P2 values of Switzerland

dashboard includes visualizations such as line graphs, bar charts, and gauges.

- This dashboard provides an in-depth analysis of P1 (PM10) and P2 (PM2.5) values in Switzerland, offering valuable insights into air quality patterns and trends. By leveraging real-time and historical data, this visualization helps identify pollution levels, detect anomalies, and determine the best times with optimal air quality.

Air Quality Compression standards in Switzerland:

Explanation of the Graph

- **X-Axis (Time)**:
  - Represents the timeline, starting from **02/21 00:00** to **02/22 18:00**.
  - The timeline is divided into intervals of 6 hours.
- **Y-Axis (Concentration in µg/m³)**:
  - Represents the concentration of particulate matter (PM10 and PM2.5) in micrograms per cubic meter (µg/m³).
  - The scale ranges from **0 to 20 µg/m³**.
- **Lines**:
  - **P1 (PM10)**: Represented by one line, showing the concentration of coarse particulate matter.
  - **P2 (PM2.5)**: Represented by another line, showing the concentration of fine particulate matter.
- **Color Codes**:
  - PM10 is typically represented in **green**.
  - PM2.5 is typically represented in **yellow** or **orange**.

Comparison of P1 and P2 of Switzerland

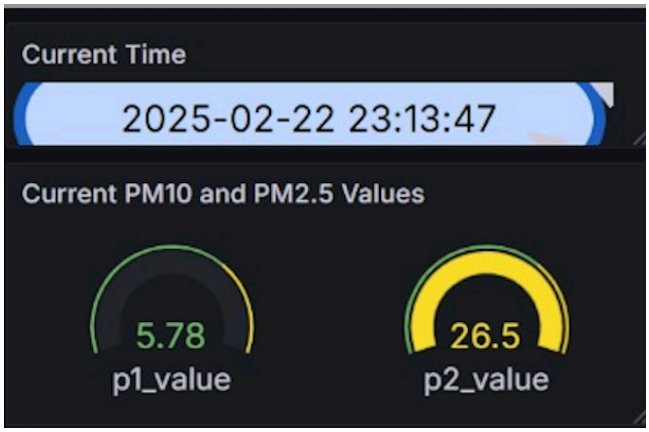


Figure 5: Current Time of P1 and p2

- **X-Axis (Time)**:
  - Represents the timeline, starting from **02/21 01:00** to **02/22 23:38**.
  - The timeline is divided into intervals of several hours.
- **Y-Axis (Concentration in µg/m³)**:
  - Represents the concentration of particulate matter (PM10 and PM2.5) in micrograms per cubic meter (µg/m³).
  - The scale ranges from **0 to 300 µg/m³**.
- **Lines**:
  - **P1 (PM10)**: Represented by one line, showing the concentration of coarse particulate matter.
  - **P2 (PM2.5)**: Represented by another line, showing the concentration of fine particulate matter.
- **Color Codes**:
  - PM10 is typically represented in **green**.
  - PM2.5 is typically represented in **yellow** or **orange**.

Current Time of P1 and p2:

- The timestamp is **2025-02-22 23:13:47**, indicating the exact date and time when the data was recorded.

Current PM10 and PM2.5 Values:

- **P1 (PM10)**: The current value of PM10 (coarse particulate matter) is displayed.
- **P2 (PM2.5)**: The current value of PM2.5 (fine particulate matter) is displayed.

6.1 Threshold Colors in Dashboards

In this section, we explain the use of threshold colors in the dashboards and how they align with the World Health Organization (WHO) standards.

Figure 6: Thershold Colours

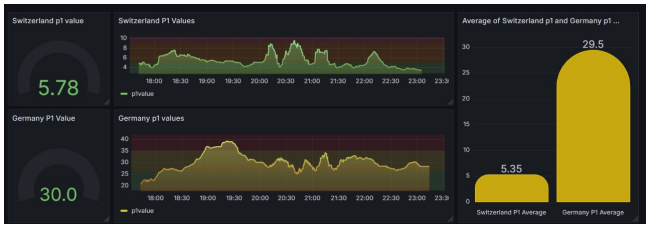


Figure 7: Comparison of P1 values between Switzerland and Germany

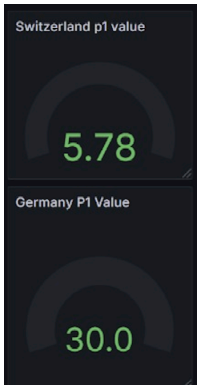


Figure 8: Switzerland and Germany P1 value

6.2 Overview of Threshold Colors

The **threshold colors** in the dashboards are used to visually represent air quality levels based on **PM10 (P1)** and **PM2.5 (P2)** concentrations. These colors are aligned with the **World Health Organization (WHO)** guidelines and provide a quick way to assess air quality.

6.3 Color Coding and Thresholds

- **Green**:
  - Represents **safe levels** of PM10 and PM2.5.
  - **PM10**: 0–20 µg/m³.
  - **PM2.5**: 0–12 µg/m³.
- **Yellow/Orange**:
  - Represents **moderate levels** of PM10 and PM2.5, indicating potential health risks for sensitive groups.
  - **PM10**: 20–50 µg/m³.
  - **PM2.5**: 12–35 µg/m³.
- **Red**:
  - Represents **unhealthy levels** of PM10 and PM2.5, indicating significant health risks for everyone.
  - **PM10**: 50–100 µg/m³.
  - **PM2.5**: 35–55 µg/m³.

6.4 Application in Dashboards

- **Bar Graphs**:
  - The background of the bar graphs is color-coded based on the threshold levels.
  - For example, if the PM10 value is **30 µg/m³**, the corresponding bar will have a **yellow/orange background**, indicating moderate air quality.
- **Line Graphs**:
  - The background of the line graphs is also color-coded based on the threshold levels.
  - For example, if the PM2.5 value is **40 µg/m³**, the corresponding section of the line graph will have a **red background**, indicating unhealthy air quality.

6.5 Alignment with WHO Standards

- The color coding in the dashboards is based on the **WHO standards** for PM10 and PM2.5 concentrations.
- This ensures that the visualizations provide accurate and meaningful insights into air quality levels.

7 COMPARISON OF P1 VALUES BETWEEN SWITZERLAND AND GERMANY

In this section, we analyze the comparison of PM10 (P1) values between Switzerland and Germany. The data is visualized using a line graph, which highlights the trends and differences in air quality between the two countries.

Switzerland and Germany P1 value

- **Switzerland P1 Value**:
  - The current PM10 value for Switzerland is **5.78 µg/m³**.
- **Germany P1 Value**:
  - The current PM10 value for Germany is **30.0 µg/m³**.

Standards Used

- **WHO Standards**:
  - The values are compared against the **World Health Organization (WHO)** guidelines for PM10 concentrations.
  - According to WHO:

Figure 9: Switzerland and Germany P1 value Graph

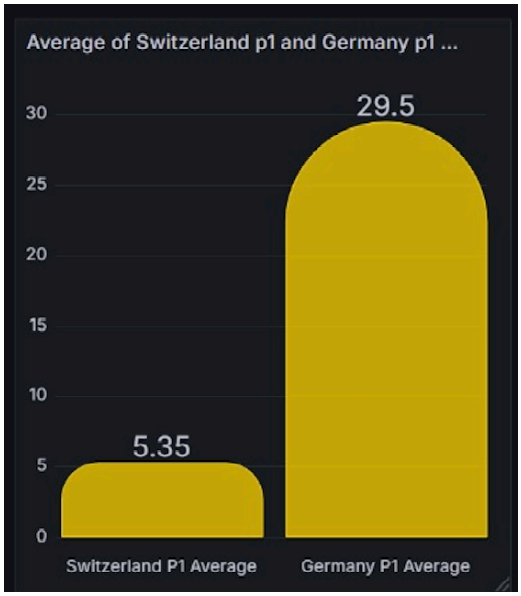


Figure 10: Average Switzerland and Germany P1 value

- **PM10**: Safe level is **0–20 µg/m³**.

– **AQI Standards**:
  * The values are also aligned with the **Air Quality Index (AQI)** standards, which classify air quality based on PM10 concentrations.

Color Codes

– **Green**:
  * Represents **safe levels** of PM10, as per WHO and AQI standards.
– **Yellow/Orange**:
  * Represents **moderate levels** of PM10, indicating potential health risks for sensitive groups.
– **Red**:
  * Represents **unhealthy levels** of PM10, indicating significant health risks for everyone.

Switzerland and Germany P1 value Graph

– **X-Axis (Time)**:
  * Represents the timeline, starting from **18:00** to **23:31**.
  * The timeline is divided into intervals of 30 minutes.
– **Y-Axis (Concentration in µg/m³)**:
  * Represents the concentration of PM10 (coarse particulate matter) in micrograms per cubic meter (µg/m³).
  * For Switzerland, the scale ranges from **0 to 10 µg/m³**.
  * For Germany, the scale ranges from **0 to 40 µg/m³**.
– **Lines**:
  * **Switzerland P1 Values**: Represented by one line, showing the concentration of PM10 over time.
  * **Germany P1 Values**: Represented by another line, showing the concentration of PM10 over time.

7.1 Observations from the Graph

– **Switzerland P1 Values**:
  * The PM10 values for Switzerland are relatively low, ranging between **4 and 8 µg/m³**.
  * The values remain stable over time, with minor fluctuations.
– **Germany P1 Values**:
  * The PM10 values for Germany are significantly higher, ranging between **20 and 35 µg/m³**.
  * The values show more fluctuations, with peaks and troughs over time.

7.2 Standards Used

– **WHO Standards**:
  * The graph uses the **World Health Organization (WHO)** guidelines for PM10 concentrations.
  * According to WHO:
    - **PM10**: Safe level is **0–20 µg/m³**.
– **AQI Standards**:
  * The graph also aligns with the **Air Quality Index (AQI)** standards, which classify air quality based on PM10 concentrations.

7.3 Color Codes

– **Green**:
  * Represents **safe levels** of PM10, as per WHO and AQI standards.
– **Yellow/Orange**:
  * Represents **moderate levels** of PM10, indicating potential health risks for sensitive groups.
– **Red**:
  * Represents **unhealthy levels** of PM10, indicating significant health risks for everyone.

Average Switzerland and Germany P1 value

– **Switzerland P1 Average**:
  * The average PM10 value for Switzerland is displayed.
– **Germany P1 Average**:
  * The average PM10 value for Germany is displayed.
– **Overall Average**:
  * The overall average PM10 value for both countries is **29.5 µg/m³**.

7.4 Standards Used

- **WHO Standards**:
  - The values are compared against the **World Health Organization (WHO)** guidelines for PM10 concentrations.
  - According to WHO:
    - **PM10**: Safe level is **0–20 µg/m³**.
- **AQI Standards**:
  - The values are also aligned with the **Air Quality Index (AQI)** standards, which classify air quality based on PM10 concentrations.

7.5 Color Codes

- **Green**:
  - Represents **safe levels** of PM10, as per WHO and AQI standards.
- **Yellow/Orange**:
  - Represents **moderate levels** of PM10, indicating potential health risks for sensitive groups.
- **Red**:
  - Represents **unhealthy levels** of PM10, indicating significant health risks for everyone.

8 REPORT DEMONSTRATE

This report demonstrates the use of modern data analytics tools to monitor and visualize air quality data. By integrating Node-RED, InfluxDB, and Grafana, the project provides a scalable and interactive solution for air quality analysis. The dashboards offer valuable insights into pollution trends, helping stakeholders make informed decisions. Future work could include expanding the dataset to more countries and incorporating machine learning models for predictive analysis.

8.1 Sample Questions Answered

- What was the highest PM2.5 value in Germany yesterday?
- Is the current PM10 level in Poland within the safe range?
- Show the weekly average PM2.5 values for Switzerland over the last 15 weeks.
- How many times did PM10 levels exceed the unhealthy threshold in the last month?

9 FLOW DESCRIPTION

In this section, we provide a detailed explanation of the data flow from physical sensors to visualization in Grafana.

9.1 Data Collection from Physical Sensors

- **Sensors Used**:
  - **Temperature Sensors**: Measure ambient temperature.
  - **Air Quality Sensors**: Measure PM2.5 and PM10 values.
- **Data Transmission**:
  - The sensors collect real-time data and send it to a **Raspberry Pi**.
  - The Raspberry Pi acts as a central hub for data collection and processing.

9.2 Data Processing in Raspberry Pi

- **Python Code**:
  - The Raspberry Pi runs a Python script to process the data received from the sensors.
  - Python libraries and frameworks (e.g., Flask, FastAPI) are used to develop a **REST-based Air Quality API**.
- **Air Quality API**:
  - The API stores the current values of temperature, PM2.5, and PM10.
  - The API is REST-based, meaning it can be accessed over the web using HTTP methods (e.g., GET, POST).

9.3 Data Access via REST API

- **GET Method**:
  - The current air quality data can be retrieved using the **GET method**.
  - For example, a GET request to the API endpoint (e.g., '/api/airquality') returns the latest sensor data in JSON format.

9.4 Data Integration in Node-RED

- **Node-RED Setup**:
  - Node-RED is a flow-based development tool used to integrate the Air Quality API with InfluxDB.
  - An HTTP GET request is made to the Air Quality API to fetch the latest data.
- **Data Parsing**:
  - The data received from the API is in **JSON format**.
  - Node-RED parses the JSON data to extract relevant values (e.g., PM2.5, PM10, temperature).

9.5 Data Storage in InfluxDB

- **InfluxDB Setup**:
  - InfluxDB is a time-series database used to store the parsed data.
  - Two buckets are created in InfluxDB:
    - **Switzerland**: Stores air quality data for Switzerland.
    - **Germany**: Stores air quality data for Germany.
- **Data Insertion**:
  - Node-RED pushes the parsed data into the respective buckets in InfluxDB.

9.6 Data Visualization in Grafana

- **Grafana Setup**:
  - Grafana is connected to InfluxDB as a data source.
  - The data source is configured using the **bucket name** and **localhost ID**.
- **Visualization**:
  - Grafana retrieves data from the InfluxDB buckets and visualizes it using different types of graphs:
    - **Line Graphs**: Show trends in PM2.5 and PM10 values over time.
    - **Bar Charts**: Compare weekly or monthly averages.

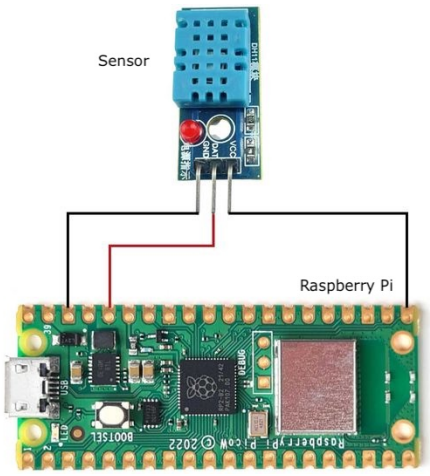
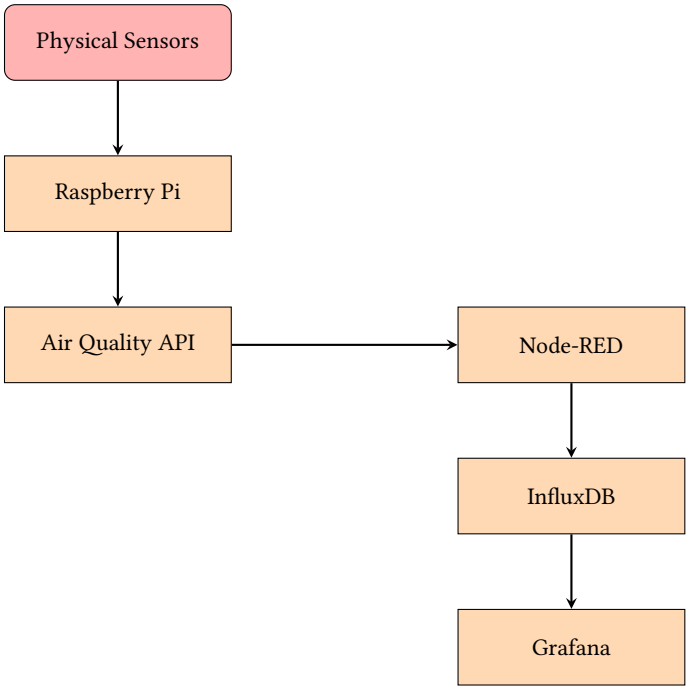


Figure 11: Sending data from physical sensor to Rasberry Pi



- **Gauges**: Display real-time PM2.5 and PM10 levels with color-coded thresholds.

* Dashboards are designed to provide meaningful insights, such as:
  - Identifying periods of high pollution.
  - Comparing air quality between Switzerland and Germany.
  - Setting alerts for threshold breaches.

9.7 Insights and Benefits

- **Meaningful Insights**:
  * The visualizations help in understanding air quality trends and patterns.
  * Users can identify areas with poor air quality and take corrective actions.
- **Benefits**:
  * Real-time monitoring of air quality.
  * Historical data analysis for better decision-making.
  * Alerts for threshold breaches to protect public health.

9.8 Key Questions Answered

The visualizations were designed to answer specific questions about air quality, such as:

- What was the highest PM2.5 value in Germany yesterday?
- Is the current PM10 level in Poland within the safe range?
- Show the weekly average PM2.5 values for Switzerland over the last 15 weeks.
- How many times did PM10 levels exceed the unhealthy threshold in the last month?

9.9 Tools and Technologies Used

The following tools and technologies were used in the project:

- **Node-RED**: For data collection and processing.
- **InfluxDB**: For data storage.
- **Grafana**: For data visualization.
- **JSON**: For data formatting.
- **Air Quality Analysis API**: For fetching air quality data.

10 CONCLUSION

This project successfully demonstrates the use of modern data analytics tools to monitor and visualize air quality data. By integrating Node-RED, InfluxDB, and Grafana, the project provides a scalable and interactive solution for air quality analysis. The dashboards offer valuable insights into pollution trends, helping stakeholders make informed decisions. Future work could include expanding the dataset to more countries and incorporating machine learning models for predictive analysis.

11 REFERENCES

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- Air Quality Analysis API Documentation: https://api.airqualityanalysis.com/docs