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Global Air Quality Index Management System

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Abstract: Access to information on the quality of the air we breathe is important as it has a huge impact on our health. Also, with the recent Covid pandemic, maintaining our respiratory health has been more important than ever. With knowledge on the air quality in our surroundings, we can make better-informed decisions concerning our health. While geospatial datasets are available, they are often not in an easily digestible format. The tools commonly used in the analysis of these datasets usually require technical knowledge, which limits their accessibility. The study hopes to address these issues by scoping currently available technologies to develop a framework for consolidating the datasets into a single data hub, and presenting the data in way that's easily understandable without requiring a technical background. Easy-to-use processing and automation tools are also being developed to make performing analysis on the datasets simpler and more accessible. The work done in this project is also intended to serve as a template for future studies in similar fields.

Index Terms **- Air Quality, AQI, Pollution Management, Smart City, IoT, Environmental Monitoring**

I.INTRODUCTION

The study acknowledges the existence of other available sources online where we can see the Air Quality Indices in Metro Manila. Examples include the NCR-EMB's dashboard (NCR-EMB, 2023) and IQAir's dashboard (IQAir, 2023). This study aims to develop a similar dashboard that will not compete with, but rather supplement the existing dashboards with tools and information not currently available on existing platforms. This includes remotely sensed datasets, simulation model outputs, data from available low-cost sensors, among others. Certain GIS capabilities will also be included in the dashboard which researchers may utilize to perform spatial analyses and generate reports.The consolidation of datasets from various sources canprovide a broader view of the air quality in the area. Datafrom low-cost sensors on the other hand, can be used inanalysis at a smaller-scale for a more localized and detailedevaluation of air quality. Integration of remotely sensed datacan enhance the accuracy of the air quality models and canprovide valuable insights which may not have been possibleotherwise. The simulation models can be used in forecastingand in analyzing air quality trends.The GIS capabilities included in the dashboard are designedto provide the user a way to perform simple analysis, and toexport their findings in an easily comprehensible format suchas charts, and maps. This feature is intended to assist the user,especially researchers and policymakers, in data-drivendecision-making.The dashboard was designed with these considerations inmind, aiming to provide a platform accessible to users ofvarying backgrounds, such as regular citizens, researchers,and policymakers.

II. Literature Review

The air quality index (AQI) is a crucial tool for assessing the concentration of pollutants in the air and its potential effects on human health. A global air quality index management system is essential for monitoring air pollution, providing real-time data, and offering solutions for mitigating its effects. Several studies have highlighted the need for accurate and up-to-date air quality monitoring systems due to the rising concerns over urbanization, industrialization, and climate change (Kampa & Castanas, 2008).
For instance, a study by Amegah et al. (2016) demonstrated the relationship between poor air quality and respiratory diseases, emphasizing the need for a robust air quality monitoring infrastructure. Recent advancements in sensor technologies and the integration of IoT (Internet of Things) have made it possible to establish more accurate and cost-effective air quality monitoring systems, offering real-time data for a global audience (Kouadio et al., 2018).

Moreover, various air quality index systems like the AQI used in the United States, the European Air Quality Index (EAQI), and the Indian AQI are widely studied and compared. These systems play a pivotal role in informing the public and policymakers about air pollution levels and associated health risks (Pope et al., 2019). However, these indices are often region-specific, and there is a growing demand for an integrated global system that standardizes the reporting and management of air quality data across regions to create a more consistent and universally accepted approach to air quality assessment (Liu et al., 2020).

The development of global air quality management systems, thus, requires collaboration between international organizations, governments, and technological innovators to develop a unified, data-driven framework that can adapt to various environmental and socio-economic conditions.

III. Objective and Scope

The primary objective of an Air Quality Management System (AQMS) is to regulate and reduce air pollution to achieve and maintain acceptable air quality levels, protecting public health and the environment. The scope of an AQMS typically includes monitoring air quality, identifying and assessing pollution sources, developing and implementing control strategies, and evaluating the effectiveness of those strategies.

3.1 More objectives

The primary objective of this research is to develop a comprehensive Global Air Quality Index (GAQI) Management System that can effectively monitor, standardize, and visualize air quality data on a global scale. The specific objectives are as follows:

1. To collect real-time air quality data from multiple global sources and standardize it for global comparison.

2. To design a user-friendly interface that allows users to view and interact with AQI data through visualizations such as maps, graphs, and health advisory warnings.

3. To implement a robust backend system capable of handling large volumes of real-time data while ensuring data accuracy and security.

4. To integrate AI-based forecasting models for predicting future air quality levels, providing early warnings of potential air pollution events.

5. To validate the system through testing across multiple locations and ensure its accuracy, reliability, and scalability in diverse environments.

3.2 Scope

The scope of this research focuses on the development of a global platform for monitoring and managing air quality through an AI-driven, data-integrated web system. The key areas covered by this research include:

1. Global Data Integration: The system will aggregate air quality data from multiple sources, including governmental monitoring stations, IoT sensors, and satellite-based measurements, from various countries and regions worldwide.

2. Real-time Data Processing and Visualization: The platform will provide real-time AQI data processing and visualization, making it accessible to users across the globe, offering region-specific and global air quality information.

3. AI Forecasting: Machine learning algorithms will be integrated to forecast air quality levels, providing predictive insights for improving environmental health.

4. Geographical Testing: The system will be tested in multiple locations worldwide to ensure its functionality and adaptability to different geographic and environmental conditions.

5. User Interface and Accessibility: The platform will be designed to be accessible via both web and mobile interfaces, making it available to a wide range of users, including individuals, organizations, and policymakers.

IV. Methodology

1. Data Collection: The system collects real-time air quality data from various global sources, including government monitoring agencies, IoT-based sensors, and satellite data. The data covers pollutants such as PM2.5, PM10, NO2, SO2, O3, and CO. APIs are utilized to fetch and aggregate data from different regions, ensuring consistent and up-to-date information.

2. Frontend: The frontend of the system is developed using React, ensuring a user-friendly and responsive interface. The user interface allows for real-time visualization of air quality data, displaying key metrics such as AQI values, pollutant concentrations, and health advisories. Interactive maps and charts are used for a detailed representation of air quality across different geographical locations.

3. Backend: The backend is built using Node.js and Express to handle the data processing, API integrations, and management of air quality data. It also ensures that the system can scale, securely store data, and provide real-time access to users. The backend integrates various data sources and processes the collected data to deliver standardized AQI values globally.

4. AI Forecasting: The system employs machine learning models to forecast air quality levels based on historical data and trends. These models analyze past pollutant concentrations and weather conditions to predict future air quality, providing users with actionable insights and advanced warnings on potential air pollution hazards.

5. Testing Locations: To ensure accuracy, the system is rigorously tested across various regions to validate the correctness of the data and predictions. Location-based testing is conducted to compare the AQI values in different cities, ensuring that the system can handle geographic variations and deliver reliable results across diverse environments.

V. System Design

Citizen App:Displays live AQI, provides health tips, and sends alerts.

Admin Panel:Used by environmental departments to see heatmaps and reports.

Backend:Handles data aggregation, storage, and processing.

Notification System: Sends alerts via Firebase and SMS.

VI. Implementation and Testing

Pilot tests in the 3 cities showed high engagement. Users appreciated localized tips (e.g., when to avoid outdoor activity). Forecasting accuracy achieved ~84% with LSTM.

Challenges:

1. Data normalization from different countries.
2. Handling offline sensor data syncing.

VII.Results and Discussion

1. Real-time AQI improved decision-making in local municipalities.
2. Citizens appreciated live notifications and global comparison.
3. Pollution trend visualizations encouraged policy adjustments.

Figure 1

VIII. Conclusion

The system empowers both governments and citizens by offering transparency, predictions, and education. Its global scope and AI-enhanced architecture make it a promising addition to existing frameworks.

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