IoT Empowered Open Sensor Network for Environmental Air Pollution Monitoring System in Smart Cities

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DECLARATION

I hereby declare that the work presented in this master's thesis, titled "IoT Empowered Open Sensor Network for Environmental Air Pollution Monitoring System in Smart Cities," is my original contribution and has not been submitted for any other degree. All sources used are properly cited. No plagiarism or academic dishonesty was involved.

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The above Candidate conducted master's thesis research under my supervision.

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Date: 04.09.2023

DEDICATION

To my beloved Mother and my respected Supervisor B.H Sudantha,

Your unwavering love, encouragement, and guidance have been the cornerstones of my success. This thesis is dedicated to both of you with heartfelt gratitude and appreciation.

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ABSTRACT

Designing an IoT-based air pollution monitoring system is a great initiative to address the issue of air pollution and its impact on the environment. Such a system can provide real-time data on air quality and enable timely actions to be taken when pollution levels exceed acceptable limits. Here's an overview of how the system has been designed:

Hardware Components:

1. Air Quality Sensors: Select appropriate sensors capable of measuring key pollutants such as particulate matter (PM2.5, PM10), nitrogen dioxide (NO2), ozone (O3), VOC (Volatile Organic Compounds) and humidity, and temperature etc. These sensors should be able to provide accurate readings.
2. Microcontroller: The Arduino Mega 2560 microcontroller board has been selected considering the open platform to interface with the sensors, process the data, and control the system's operations.
3. Communication Module: A communication module added to have GSM connectivity to transmit the collected data to a central server or a cloud platform.
4. Power Supply: As the reliable power source for the system, renewable power sources such as a 50 W solar panel is used together with a rechargeable lithium iron phosphate (LiFePO4) battery, to make it independent of the electrical grid.

Software Components:

1. Sensor Data Collection: Developed firmware and software to retrieve data from the air quality sensors connected to the microcontroller. The data is sampled at regular intervals.
2. Data Processing: Implemented algorithms to process the collected data, perform necessary calibration, and convert it into meaningful air quality parameters. These parameters can include Air Quality Index (AQI) or pollutant concentrations.
3. Data Transmission: Established a secure connection between the microcontroller and a central server or cloud platform. Protocols like MQTT or HTTP were used to transmit the processed data over cellular networks.
4. Data Storage and Analysis: Stored the received data in a database for historical analysis and trend monitoring. Data analytics must be done to identify patterns, pollution sources, and correlations with other environmental factors.

5. Alerting System: Set threshold levels for different pollutants, and when the measured values exceed these thresholds, trigger alert signals. Alerts can be sent via SMS, email, mobile app notifications, or other appropriate communication channels.
6. User Interface: Develop a user-friendly web-based or mobile application to visualize the real-time and historical air quality data. This interface should allow users to monitor air quality, view alerts, and access additional information or recommendations.

Security and Privacy: Implement appropriate security measures to protect the system from unauthorized access. Ensure data encryption during transmission and storage. Follow best practices to safeguard user privacy.

Integration and Scalability: Consider the scalability of the system to accommodate additional sensors or monitor air quality in multiple locations. Allow for easy integration with existing environmental monitoring networks or systems.

Deployment and Maintenance: Deploy the IoT-based air pollution monitoring system in strategic locations, such as urban areas, industrial zones, or near sensitive ecological areas. Regularly calibrate and maintain the sensors to ensure accurate measurements. Update the software and firmware as needed to address any issues or improvements.

By designing and implementing an IoT-based air pollution monitoring system, you can effectively monitor air quality, raise awareness about pollution levels, and enable timely actions to mitigate the harmful effects of air pollution.

Key Words: Air pollution, AQI, Semiconductor Sensors, Microcontrollers, Arduino Mega, IoT, Air Quality, MQTT

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LIST OF ABBREVIATIONS

AQMS – Air Quality Management System

AQI – Air Quality Index

ppb - Parts per billion

STIM - Smart Transducer Interface Module

TEDS - Readable Transducer Electronic Data Sheet