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AQM LK: An Air Quality Monitoring System for Urban Sri Lanka

M.I.Fathima Nihla
nihla@seu.ac.lk
W.A.D.A.Wicrama Arachchi
W.M.D.H.Wijekoon
W.T.Sanduni
Jagath Wickramarathne

Faculty of Graduate Studies and Research
Sri Lanka Institute of Information Technology

Abstract

Given that people need to breathe to survive, air pollution has a negative impact on human health. Even more concerning is the fact that air pollution appears to be becoming worse every day as a result of either natural or man-made pollution, such as a large forest fire. The lack of a real-time monitoring system prevents the authorities from knowing the current air quality conditions. Therefore, it is clear that air quality monitoring is now a crucial component of smart city solutions. This research aims in the use of technology to track air quality in Sri Lankan cities. To monitor the air quality in metropolitan areas, a qualitative study technique has been adopted. A Figma prototype of the suggested system has also been put into practice. The findings of this study show that information on which cities have the best, adequate, and worst air quality may be obtained through air quality monitoring systems. Additionally, the applications provide real-time data on air quality. The drawback is that only information from major cities is comprehensive and easily available.

Key Words: Air Quality, Stakeholder Survey, Figma, Urban Sri Lanka

Introduction

Monitoring air quality in large cities, generally, and close to significant industrial targets, in particular, is a growing controversial subject today. One of the fundamental rights of human society is the right to breathe clean air. Since Hippocrates' "On Airs, Waters, and Places" which he wrote in 400 B.C.E [1], people have been aware of the connection between air quality and one's health. Consequently, air pollution is a significant environmental problem that is of global importance and has a negative health impact on humans.

The air that we breathe is made up of a combination of minuscule solid, liquid, and gaseous particles. An adult typically breaths 20,000 liters, or 20 cubic meters, of air each

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day. Due to the world's fast population expansion, economic progress, and technological advancements, many resources are needed to support human activities [2].

As a result, a variety of pollutants are discharged into the environment, seriously polluting the air. Due to shared sources of pollution and atmospheric circulation, air pollution is not only a serious problem in urban Sri Lanka, but it also poses the greatest threat to the entire world. A combination of undesired materials or any unwanted particles in the air that pose threats to human health is known as air pollution. Carbon monoxide, ozone, sulfur dioxide, nitrogen dioxide, and other particulate materials are six of the most dangerous pollutants that cause air pollution.

9 out of 10 people worldwide who reside in metropolitan areas breathe air that does not satisfy WHO standards for air quality. Thus, 99% of people living in metropolitan areas worldwide breathe contaminated air. According to the objective list for UN Sustainable Development Goal 11, Reduce the negative per capita environmental effect of cities by 2030, especially with regard to air quality.

The importance of autonomous air quality monitoring has increased as a result of the worsening air quality caused by growing industrial and traffic volumes [3]. Also, it is well-known that air pollution has an impact on both human health and the environment's suitability for human survival. As a result, many nations have made plans to monitor changes in the air's major pollutants' density over an extended period of time and to conduct research on the processes involved in their emissions.

Continuous autonomous monitoring of urban air quality has gained popularity in recent years and is a useful tool for reducing air pollution. In that sense, a number of air quality monitoring systems have been created to keep track of the air and alert the general public when it becomes unsafe to breathe. The authors of this paper suggest an air quality monitoring system that can be used in urban Sri Lanka with the goals of creating an inventive system that can cover these areas, monitoring the air quality index using smartphone applications, and suggesting preventive measures using smartphones when the air quality level exceeds threshold values.

The structure of this paper is as follows: The literature review on air quality monitoring systems is included in Section. Section III provides a description of the air quality monitoring system design. Section IV presents the findings and a thorough analysis of the suggested system. Section V brings the paper to a close.

Literature Review

Air pollution has become a massive threat to people who lives in especially urban areas. United Nations Sustainable development project noted that nine out of ten people who live in urban areas breathe polluted air. This is quite a dangerous situation because every single time breathing polluted air leads to serious diseases like asthma, pneumonia,

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Bronchitis, and heart diseases. Chat bot embedded mobile application was introduced to identify risky areas and predict future hazards. This was entirely based on air pollution mapping with sensor- based technology. Sensors-embedded drones self-identify the location, reach those locations, and collect the composition of the air. After using the collected data pass those details to the algorithm and use them for prediction purposes. Visualization and notification parts handle by a mobile application where a chat bot [4] is integrated to enhance the user experience level. This has become a good approach in the sense that drones reach places where humans cannot.

Air pollutants like Sulphur Oxides (Sox) and Lead (Pb), Nitrogen Oxides (NOx), Carbon Monoxide (CO), Ground level Ozone (O3), Carbon Dioxide (CO2), Particulate Matter (PM) matter most to the environment as well as to the human health. The air quality monitoring prediction system was introduced as Air voice which helps to monitor the air quality in the ambient air and predict the atmosphere gas composition. This helps users to mitigate elevated risk areas and travel through less polluted areas. The main objective of this research paper is to provide an awareness to kids, old people, and patients who suffer from respiratory diseases. Heat map generation helps people to avoid high polluted areas and visualize the minimum polluted accurate route [5].

Fine particulate matter (PM2.5) is considered a hazardous air pollutant which can transmit through the lungs and causes various respiratory diseases and heart attacks. When Fine particulate matter (PM2.5) level increases in the atmosphere it makes the air hazy due to its tiny particles. Due to high expensive sensors, monitoring stations are extremely limited to several regions. Estimating Fine particulate matter (PM2.5) present in the ambient air using image analyzing is a good replacement for high expensive sensors. Analyzing results indicate that the Random Forest classification method granted a 63.62 percentage of accuracy level [6].

Air pollution can be happened due to a range of factors like VOCs, CO2, PM2.5, PM10, temperature, humidity, and illuminance. Pollution is not limited to outdoor it can happen indoors too. A Portable IoT (Internet of Things) base device is a based option for monitoring indoor air quality solution introduced [7]. It is low cost 30 hours battery-operatable device to identify indoor air pollutants like VOCs, CO2, PM2.5, PM10, temperature, humidity, and illuminance. Based on the analytical results device can provide recommendations to the users such as increasing the ventilation reducing the activity level.

The air quality model was suggested by [8] which effectively predicts the Air quality level and Air quality index. Different regression models have been used to establish the model accuracy and prediction capabilities which have been later compared with each other. Here as characterization factors PM2.5, PM10, SO2, NO2, CO and O3 have been considered and the air quality index set as the decision factor. Among various algorithms like linear regression, lasso regression, ridge regression and tree regression results indicate that random forest regression algorithm and gradient boosting algorithm delivered best results. The data set was provided by the National earth science data center in China. Moreover, researchers concluded that above mentioned two algorithms have additional advantages like high parallelization, strong noise resistance etc.

The purpose of the study conducted by [9], is to look at how technology may be used to track urban air quality. The technique utilized to measure the air quality in metropolitan areas is descriptive study with data from the app that was given. According to the study's findings, there are several applications for monitoring air quality in major cities throughout the globe. Systems for tracking air quality can reveal which cities have the best, adequate, and worst air quality. Additionally, the applications provide real-time data on air quality. The drawback is that only information from major cities is comprehensive and easily available.

By designing and building a portable device and mobile app that can generate and broadcast real-time Air Pollutant Index (API) and GPS coordinates, the study by [10] aims to provide real-time air quality and location data. The different air pollutant gases and issues with the current air quality monitoring system have been evaluated in this article. Carbon Monoxide (CO) and Nitrogen Dioxide (NO2) sensors, as well as the NEO-6M Global Positioning System (GPS) module, are two separate pollutant gas sensors that have been suggested.

The technology calculates the Air Pollutant Index (API) value and uploads the location data to the cloud database. Anyone who has the built mobile app can access the data and obtain real-time information about the place and its air quality. The system has undergone two rounds of testing, and the outcomes have been compared with those from internet sources that track air quality. The system gives a 92.3%, which is 5.1% more accurate than previous systems, according to the results. The suggested approach may offer a crucial foundation for the growth of smart cities.

The research conducted by [11] offers the notion and physical model of a small-scale air filtration device for residences or public places. A microprocessor from the Arduino UNO family manages the purifier. The model has a number of sensors that are used to assess the quality of the air. The system begins the air filtration process automatically when the adopted threshold in the program is exceeded. When determining whether to turn the air purifier on or off based on the condition of the air in the room, the air purification system relies on data from the optical dust sensor. Wood and filters make up the air purifier's body. Pre-filters, dust filters, and fine filters are utilized. The purifier decreases VOC pollution and absorbs solid contaminants. An LCD display that informs the user of the air parameters and air quality being cleansed is part of the system.

When the air quality drops below a certain level, which occurs when enough harmful gases like CO2, smoke, alcohol, benzene, and NH3 are present in the air, the authors of the study will create an IOT-based air pollution monitoring system that will monitor the air quality over a web server using the internet. On the LCD and on the website, the air quality will be displayed in PPM so that it may be easily monitored. With this IOT project, you may use a PC or a mobile device to check the pollution level from anywhere [12].

In another study, the authors have created a low-cost air quality monitoring system

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based on the Internet of Things (IoT) to monitor the air quality in Chittagong, a district in Bangladesh's southeast. The suggested technology not only monitors the air quality in real-time but is also economical. Parts per Million (PPM) measures were used to measure the air quality [13].

Materials and Methods

are shifting or being influenced by the proposed system. The following Fig.2 and Fig.3 illustrates the stakeholder survey forms of the system.

A. Overview

The study's suggested design is affordable, portable, simple to deploy, and compact. Information on environmental pollution levels is provided via an air quality monitoring system that operates in real-time. It offers accurate and thorough information on the air quality in the home environment and aids in the planning of measures that will enhance the air quality in Sri Lanka's cities. In that context the methodology has been suggested to be applied on top of buildings, in industrial locations, near traffic, and in residential areas where air quality sensors are deployed in the target area (conceptual). To manage the network of sensors, a micro controller is attached to these sensors. The micro controller transmits the data it has gathered to the cloud for processing. Through a smartphone app, the public is given access to the examined data.

B. System Architecture

The suggested solution's architecture includes a mobile application, data warehouse, sensor nodes, and an Azure IoT hub. The Fig.1 below shows the system architecture of the proposed solution.

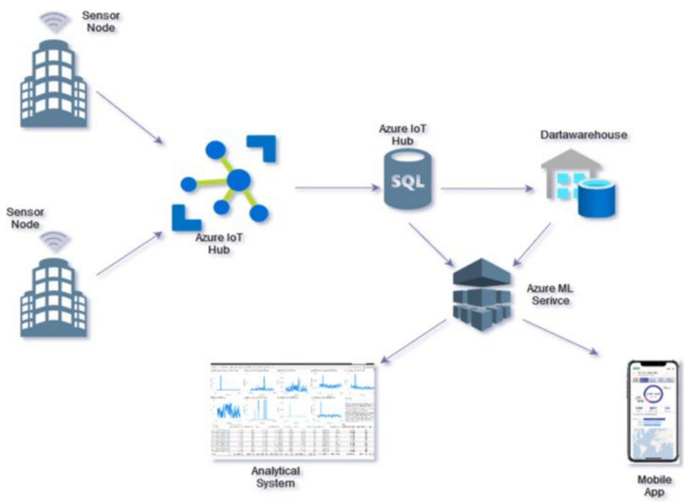

Fig. 1. System Architecture

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C. Stakeholders of the System and Stakeholder Survey

Two types of parties have been identified as the stakeholders of the system.

1. Direct Stakeholders: Technical officers (TO) who approve industrial building and households (Pradeshiya Sabha)

2. Indirect Stakeholders: Citizens who like to check air quality of the area before they start any constructions.

Stakeholder survey participants were questioned in order to collect information. It has been created in a way to solicit input from the community or comprehend how people's viewpoints

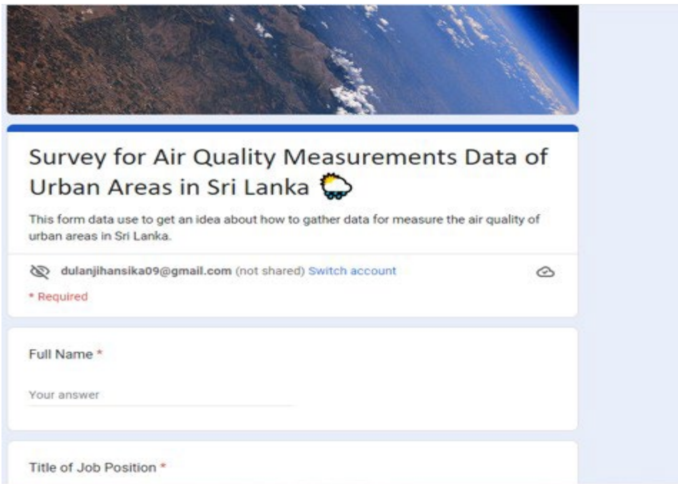

Fig. 2. Survey for air quality measurements

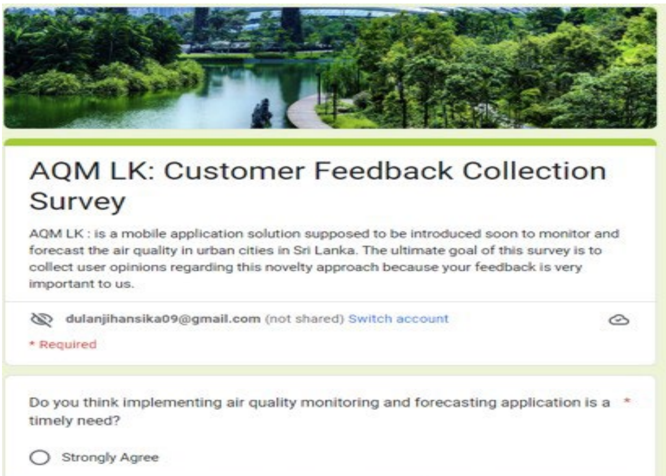

Fig. 3. Customer feedback collection

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Based on these stakeholder surveys, the user research analysis has been done in order to understand the user behaviors, wants, and motivations as well as how users engage with systems can help designers determine whether their needs are being met by the solutions they are creating.

D. Data Collection

The real time air quality index data was gathered from [14] and using this original website, the data is collected through an API. Fig.4 below shows the basic data source in the format of API data line.

E. Database Design

Since there is no real data accessible, data is pulled from API and placed into databases. The research creates databases using MS SQL Azure cloud storage. After that is completed, it is anticipated that information would be stored in a data warehouse, particularly information history. Then, using machine learning techniques, the prediction is carried out.

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Fig. 4. API-Basic Data Source

F. Figma Prototype

Figma tool has been used to design the prototype of the proposed air quality monitoring system. Accordingly, the following interfaces are designed.

1. Launch Screen 01
2. Launch Screen 02
3. Welcome Page
4. Sign Up Page
5. Sign In Page
6. Home Page
7. Search By Location Page
8. Air Quality Forecast Page
9. Notification Panel
10. Settings and Log Out

The prototype designed can be viewed in Figma Prototype which links the prototype's URL.

Results & Discussion

Quantitative research has been conducted for this study. Because our groups were bigger than our research samples, we chose this one. Researchers who use quantitative methods frequently want to be able to generalize about groups that are bigger than their study samples.

A. Customer Feedback

We attempted to apply judgmental sampling with the sampling size of 113. Judgmental sampling, as the name indicates, entails the researcher choosing individuals in accordance with the standards he has established. Get mostly those who want to learn about air content; utilize this only when you are certain that the participant is representative of the whole target audience.

55.8% of the customers have strongly agreed that implementing air quality monitoring and forecasting application is a timely needed one whereas 44.2% also agree that such application is needed.

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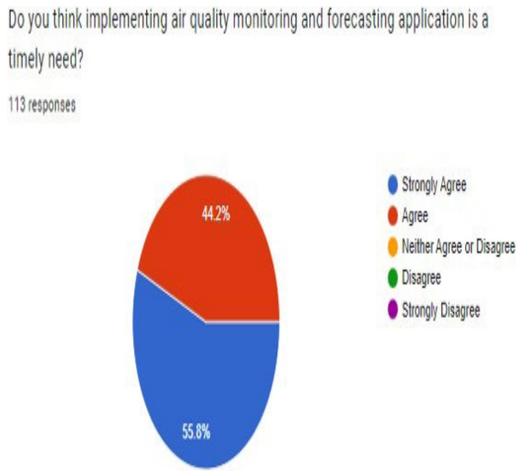

Fig. 5. The percentages of customers agreed in implementing air quality monitoring application

Around 42.5% of the customers have responded that they will use the application on a daily basis. In contrast to this, 9.7% have responded that they will never use the application. The figures; Fig 5, Fig 6, Fig 7 and Fig 8 below shows the results obtained from the customer survey.

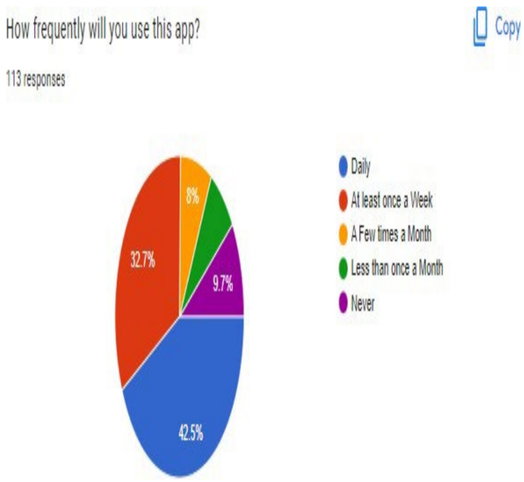

Fig. 6. The expected frequency of application usage

32.1% of the customers strongly agree that good respiratory health can be achieved by utilizing technical solutions.

When asked about how likely are they to recommend the certain application, around 46.4% have given the 5 rating.

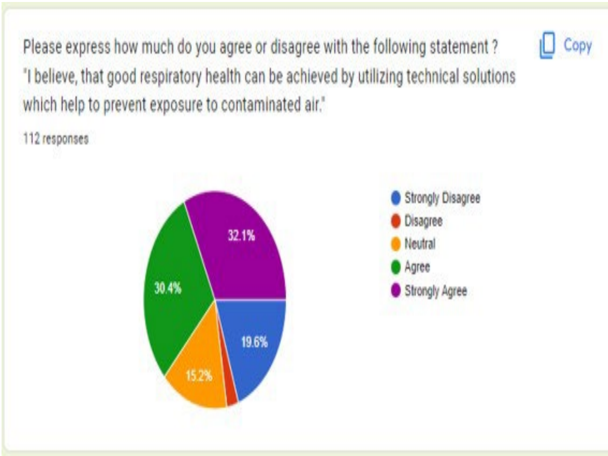

Fig. 7. The percentages of customers agreeing on good respiratory health can be achieved by utilizing technical solutions.

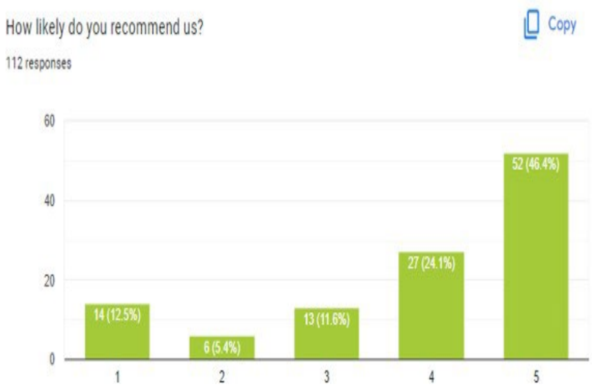

Fig. 8. Ratings from the customers.

B. Technical Officer Feedback

A person's (or an event's) likelihood of being chosen for membership in the sample is

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known when using probability sampling procedures. Non-probability sampling approaches pick the sample based on predetermined criteria, meaning that not every member of the population will be chosen. For online surveys, these sample techniques are frequently employed. Because of this, we employ non-probability sampling.

The air content to be measured in finding the air quality, whether is it helpful if the third-party service provides the air quality conditions report in the area, the preferred type of application to get the report, the maximum approval count of industrial construction of one area and the number of days spent on getting the approval the aspects on which the technical officer (one of the stakeholders) survey was conducted and the results were obtained.

C. Implementation & Prediction

As per the Figma prototype, the mobile app implementation of air quality monitoring system was done. Here the users are expected to check the air quality of a particular area in Sri Lanka, by typing (searching) for the particular location. Additionally, the air quality prediction was implemented. Using the Azure Machine Learning, the air quality prediction for the next two weeks has been done. The figures, Fig 9, Fig 10, Fig 11 and Fig 12 show the implementation based on the prototype.

Fig. 9. Location quality calculations

Conclusion

Monitoring of air quality has become more popular recently. Effective methods for managing data and monitoring air quality are required for smart cities. An air quality monitoring system for urban Sri Lanka is given in this study.

By identifying the polluting gases that cause air pollution, the suggested air quality monitoring system has been effective in tracking the outside air quality in real-time. Additionally, users in Sri Lanka's urban cities may get real-time air quality information. performed a stakeholder survey, The gadget is responsive to air contaminants, according to tests and validations, and is regarded as a helpful instrument. For planning and essential actions, the capacity to retain a record of historical data is particularly helpful to the appropriate authorities. More sensors and a solar power source can be added to the suggested gadget to make it even better. A step towards a smart city may be seen in the established air quality monitoring system.

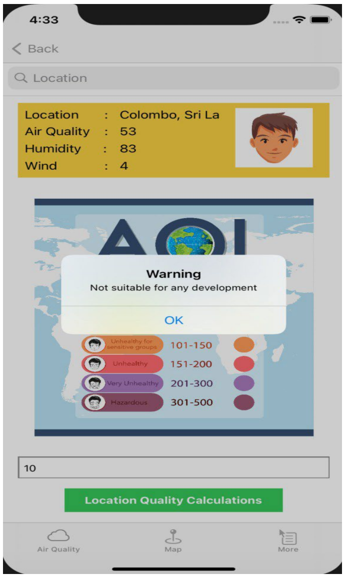

Fig. 10. Notification based on the air quality of the location

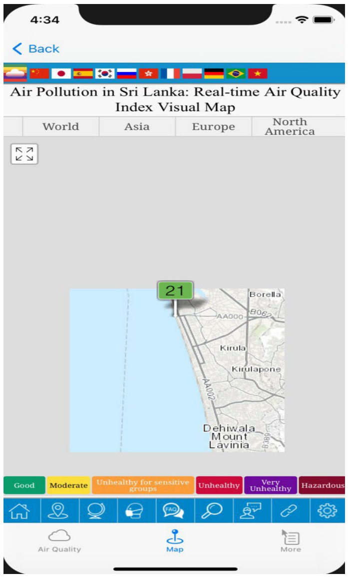

Fig. 11. Air quality visualization

Fig. 12. Air quality prediction

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