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Air Pollution Control Management and Cloud Infrastructure

A PROJECT REPORT

for

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in

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Introduction

Air pollution is defined as the contamination of the environment via means of physical, chemical or biological agents. It is one of the most potent yet underrated issues of this century. Polluted air has immense repercussions on lung development and is a major catalyst of respiratory diseases such as Chronic Obstructive Pulmonary Disease (COPD), Asthma, Emphysema. All these are major problems which are caused by a polluted environment.

Industrial emissions, household emissions, motor vehicles are amongst the largest group of air pollutants. These are some very reducible factors here but the pursuit of innovation only increases the potency of these factors. Air pollution is the reason for about 7 million deaths in a calendar year. These fine particulate matters settle deep in the respiratory organs and further develop and cause immense complications that go ahead and lead to chronic health problems.

This recognition has led to amazing innovations for air pollution detection, data processing, data analysis and pollution control. In this paper, they will explore some air pollution control methodologies, how they're implemented and the significance of data and its flow throughout these systems.

Abstract

Air quality is one of the important aspects to human life and environment and this will matter a lot to the upcoming generations due to the extreme climate variations. As a result, it is critical to not only monitor quality of the air, but also to make information readily available to people responsible for storage and network monitoring, decision makers, and the general public. Furthermore, throughout the last few decades, the advancement of information technologies has allowed for the development of real-time pollution monitoring, data collection and analysis. The work covered here focuses on the design of different types of softwares that may be used to effectively monitor environmental parameters and air pollution.

This review paper illustrates some of the methods and ways to overcome and mitigate the issues of air pollution and also on how researchers have worked on their methodologies to experiment and execute to make their analysis right on controlling air pollution.

Existing Methodologies

Traditional reference-grade FRM/FEM monitors, stationary low-cost sensors, satellite monitoring technology, mobile air quality sensors, and alternative kinds of monitoring are all in use today. When deciding which sort or types of monitoring technology will be the greatest fit for a monitoring project or programme, it's a good idea to look at the entire range of options. This allows you to investigate which use cases each technology is best suited for, as well as any specific benefits and drawbacks.

The variety of monitoring systems available are growing as air quality monitoring improves around the world.

Each sort of monitoring technology has its own set of benefits and drawbacks. Each method of measuring air quality generates new data, accuracy, and so on; and hence can lead to quite diverse understandings of the nature of air pollution. As the public's desire for better air quality data develops, air quality monitoring systems will continue to evolve to fulfill these demands.

There are many programmes that show effective air quality monitoring that combines the strengths of several technologies to create the most detailed visuals of pollution; this is where they see air quality monitoring heading in the future.

Literature Survey

Sr. No	Title	Author	Summary
1	A review of Various Techniques for Forecasting Pollution and Air Quality Indexing	Snehlata Beriwal, John A	The level of pollution is rising day by day as a result of the development of technologies, industries, and deforestation. Various countries' air quality index ranges, pollution forecasting methods and corresponding algorithms, different input parameters for forecasting, some metrics of forecasting performance evaluations, and finally the challenges and future direction of the research are summarized in this article in order to carry out further possible research.
2	Federated Learning for Air Quality Index Prediction using UAV Swarm Networks	Prateek Chhikara,Rajkumar Tekchandani , Neeraj Kumar, Sudeep Tanwar, Joel J. P. C. Rodrigues	Within a UAV swarm, the study presents a distributed and decentralized Federated Learning technique. The sensors' gathered data is fed into the Long Short Term Memory (LSTM) model as an input. Before transmitting the local model to the central base station, each UAV used its locally collected data to train a model. The central base station develops a master model by integrating all of the participating UAVs' local model weights in the FL process and transmitting it to all of the UAVs in succeeding cycles. The suggested model's effectiveness is compared to that of other machine learning models utilizing several assessment criteria and test data from India's capital city, Delhi.
3	IoT Based Smart Monitoring of Environmental Parameters and Air Quality Index	Udit Mittal, Yash Yadav, Abhilasha Pawar, Rahul Sharma, Dr.	In the proposed model, real-time data from the sensors is collected on the ThingSpeak server, an IoT cloud platform. AQI is measured by the MQ5 sensor and temperature and humidity are tracked by the DHT22 sensor. All sensors are connected to

		Gunjan Varshney, Satyajeet	different pins on the Node MCU. The NodeMCU acts as a central hub, combining sensors into a small package to provide a cost-effective, reliable and compact solution. If you exceed a parameter threshold set for a particular environment, you can send an email to the end user as an alert to help the end user decide how to improve and manage the environment.
4	Real-Time Event-driven Air Quality Inspection Framework for City-wide Pollution Level Monitoring	**Simon Winberg, Subha Singh**	This white paper reported on the development and testing of a real-time event-driven air quality index (EAQI) framework, a basic reusable coding framework for building AQI applications. The EAQI framework was built for scalability, extensibility, and data analysis. This was achieved by integrating CQRS, event sourcing, and MVC architectural patterns to achieve the performance required by stakeholders. While this framework was designed around a specific selection of air quality monitoring sensors, the framework architecture was designed for adaptability to support alternative sensors, sensor data, and processing needs
5	AI and Machine Learning Based Classification of Air Quality Index Using COVID-19 Lockdown Period Data	**Sandeep Kumar Sunori, Pradeep Juneja, Pushpa Bhakuni Negi, Sudhanshu Maurya, Pratul Raj,**	The purpose of this study is to evaluate the AQI range of the presented input so that it can be classified into one of two classes: "harmful AQI" and "moderate AQI". To address this binary classification problem, two separate models, the ANN model and the SVM model, were developed and trained in MATLAB. The response of both models is observed in a particular test dataset. Both models have been shown to give good classification results, but by comparison, the accuracy of the SVM model is far more promising than that of the ANN model.

		Deepa Nainwal	
6	Intellectual Fuzzy System Air Pollution Control	**Yuri Kravchenko, Olga Leshchenko, Nataliia Dakhno, Vladyslav Deinega, Halyna Shevchenko, Oleksandr Trush**	In this paper, theory of fuzzy logic, especially the basics of fuzzy set theory, the structure of fuzzy inference systems, fuzzy inference algorithms, defensive methods, etc. were carried out. An intelligent fuzzy system has also been developed to assess indoor air pollution. It demonstrates fuzzy inference by building the fuzzy inference system Mamdani(method to create a control system by synthesizing a set of linguistic control rules obtained from experienced human operators). The proposed approach creates an intelligent system that solves complex management problems that adapt to changing operating conditions in the face of complexity, that is, statistical and structural uncertainty.
7	Effectiveness Evaluation Of China's Air Pollution Control Action Plan Using Satellite Aerosol Product	**Xinyue Yang, Qianjie Wang, Qingmiao M , Yingjie Li, Yun Ling, Xin Li, Fang Chen , Jing Chen, Nan Huang, Xing Zeng**	In this paper, they have illustrated how the satellite aerosol products from the Moderate Resolution Imaging Spectroradiometer (MODIS) in eastern China were collected and processed to evaluate the effectiveness of the project. The results show that the average optical aerosol depth (AOD) in eastern China decreased by about 23.17% in 2017 compared to 2012, and the domain-wide MODIS-AOD trend from 2010 to 2019 is -0.012 per year. The plan, which shows that and shows air pollution, is well implemented to achieve the expected goals.

8	One-step Prediction of Air Pollution Control Parameters using Neural-Like Structure Based on Geometric Data Transformations	**Oleksandra Mishchuk, Roman Tkachenko**	This paper aims to study one-step predictions with neural-like structures using models of geometric data transformations. This task describes the one-step prediction timestamp method. It has been shown that the smaller the time frame of the parameters selected for environmental monitoring, the more accurate the prediction error.
9	Mobility Turnaround, Air Pollution Control and Secure the Budget - Electric Mobility in the Urban Area of Tension	**Janine Mielzarek**	This white paper describes the Stadtwerke Offenbach Group's broad efforts in the field of electric vehicles. It also covers the current challenges posed by traffic upturns, urban air pollution, and political requirements.
10	New Conception of Air Pollution Control in China	**Luo Hong, Lv Lianhong, Xue Jie, Zhao Juan**	This paper illustrates many new characteristics and new problems of air pollution, establishing joint prevention and management mechanisms, implementing total nitrogen oxide control and total carbon consumption control, and improving air quality assessment systems and others.In the "11th Five-Year" China did not work on effective measures to be taken for NOx emission, energy consumption resulting in increased NOx emission. New ideas, and "12 Five-Year", new air pollution control measures will be applied to control these emissions and other vast pollution problems.
11	Review of urban computing in air	**Akshara Kaginalkar,**	This white paper describes the role of urban computing in UAQM (Urban Air Quality

	quality management as smart city service: An integrated IoT, AI, and cloud technology perspective	**Shamita Kumar, Prashant Gargava, Dev Niyogi**	Management) through scholarly publications and a review of the "gray literature" from technical reports from government, international and institutional websites. It provides an interdisciplinary knowledge base for urban computing applications of air quality functions. It enables data-driven strategic and real-time governance actions on mitigation and highlights the potential of integrated technologies to help citizens make informed decisions.
12	An Iot Based Environmental Strategic Solution For Fire And Air Pollution Using Cloud Computing Platform	**Rahul Mishra, Manish Gupta, Vikram Rajpoot**	Their goal for this analysis research is to integrate an IoT, Cloud Computing Platform, and sensor Network Technology for a long-term, really environmentally friendly solution. This document also gives risk assessment guidelines for new researchers, vendors, and service providers, as well as practitioners. Taking safeguards, when implementing IoT, is a recent inventive rise and also a burning technology. They have used MQ series sensors to detect fire and air pollution that send back alerts to the authority to take action immediately without fail.
13	A critical evaluation of air quality index models (1960–2021)	**Priti K, Prashant Kumar**	This paper illustrates from 1960 through 2021, a comprehensive literature evaluation of a wide range of developed AQI models from diverse countries reveals worries about poor air quality, but also a lack of a consistent AQI strategy. For different pollutants, the threshold value varies by country. Pollution limits are lower in undeveloped and underdeveloped countries than in developed countries (more stringent). As a result, comparing

			AQI across countries creates ambiguity when it comes to interpreting monitored data.
14	Epiphytic phytoplankton in response to divergent air pollutants from urban and commercial zones of Chennai District, Tamil Nadu, India: A case study towards phytoplankton based Air Quality Index	**Sagaya John Paul Joseph, Sreekala Kannikulathel Gopidas, Gomathi Gnanam, Sathish Kumar Boopathi, Nagaraj Subramani**	The goal of this study was to learn more about the relationship between sulfur and nitrogen gaseous oxides, particulate matter with diameters less than 10 and 2.5 m (PM10, PM 2.5), and the population density, abundance, and frequency of terrestrial epiphytic microalgae in Chennai District, Tamil Nadu. The above-mentioned air pollutants had a significant association with members of the Chlorophyceae, Bacillariophyceae, and Cyanophyceae families. The interaction pattern was discovered using cluster analysis, CCA, and NMDS analysis.
15	Smart Navigation System Using Air Quality Index	**Ritik Jain, Ishan Agarwal, Shubham Dwivedi, Shubham Kumar Singh, Archana Purwar, Dhanalekshmi Gopinathan**	The need to respond to a request to switch to a less polluted route takes on greater significance. This study proposes a smart navigation system that takes into consideration the air quality index and road distance to offer the safest and fastest path. To find the best path, it employs the A* algorithm. It has the tendency to reduce the negative effects of air pollution. On a data set for two separate routes, the proposed model is validated. The routes generated by the proposed model are compared to those generated by Google Map.
16	Measurement of Air Quality Index using Internet of	**Lalita Mishra, Vikash, Shirshu**	In this study, they used a generic air quality sensor and the Scientech 6205 IoT builder to sense the air in the local area. There are several contaminants in

	Things	Varma	the air, but they will focus on the PM2.5 component for this study because it is the most dangerous of all the pollutants. After that, the data is sent to the Thingspeak cloud platform. The data is first processed and then evaluated in the cloud to determine the value of the air quality index. The graphical representation is then used to visualize the generated results. On the basis of which, one can take preventative actions to live a healthy life.
17	K-Means Clustering Analyzing Abrupt Changes in Air Quality	Jana Shafi, Amtul Waheed	This paper proposes one of the most widely used data-mining methods for large datasets. The K-Means algorithm, which is one of the ML clustering algorithms, is used in this article to analyze the frequent changes in air pollution in Southampton city's data. The environment in the Air Quality Index (AQI) has a pm2.5 value that is calculated and compared to determine the ups and downs in air pollution layer in a specific location before and after a fire outbreak map into a set of five and three distinct qualitative pm2.5 classes that are required to analyze the air quality at the city level.
18	A portative gas recognition system based on metal oxide gas sensor array [air pollution applications]	P. Strobel; A. Lfakir; M. Siadat; M. Lumbreras	Their multisensor system is appealing because of its complete autonomy, low weight and small size for embedded applications, as well as its versatility. Six commercial gas sensors (Figaro) with intriguing cross-relationship. The sensor has a high sensitivity and consumes almost no power; a microcontroller with a built-in flash memory ensures data collection, analysis, and data management transferring or storing. The prototype is tested for

			the first time in laboratory by creating a variety of atmospheres three polluting gas concentrations (H2S, NO2 and SO2) in a variety of industrial settings with varying humidity rates. The gas natures have a great group separation; a multidimensional data analysis was used to generate algorithms that can also determine concentration gaseous mixture.
19	Air Quality Measurement Device Using Programmable Quadcopter Drone Towards Internet of Drone Things	**Nyoman Karna, Deriel Laska Lubna, Soo Young Shin**	In the context of the Internet of Drone Things, this study offers an air quality assessment system above the ground utilizing a programmable quadcopter drone. MQ-135 and DHT22 sensors are used to monitor air quality. The measurement value is processed and sent to Firebase via NodeMCU, which can then be monitored in real time by a smartphone. The air quality measurement test was conducted in two locations: one in a tranquil setting surrounded by trees, and the other in a bustling area surrounded by construction projects. When compared to ground-level measurements, the method demonstrates that higher height (5 meters) results in a better air quality index (0 meter). Even at night, the morning yields a superior air quality score than other sampling times, especially where there are lots of trees surrounding the environment.
20	A study on fire prediction method using air quality measurement sensors of smart	**Eun Joo Kim, Woongshik You, Cheol Sig Pyo**	They presented a machine learning-based solution for detecting the severity of a fire anomaly using an indoor parking lot's air quality sensor. Artificial intelligence algorithms for early fire detection in parking spaces have recently been developed. When a fire develops, it is required to collect air quality

	indoor parking lot		sensor data in order to construct an artificial intelligence model. Through fire testing employing air quality sensors, it was discovered that CO2, PM2.5, and VOC have a significant impact on fire. When the collected data exceeds the threshold, the danger of fire is anticipated to be high, according to this paper's autoencoder-based anomaly detection algorithm.
21	Remote Monitoring Real Time Air pollution - IoT (Cloud Based)	**Murat Karabatak, Twana Mustafa, Chawan Hamaali**	This paper outlines the framework of a workable model based on Internet of Things (IoT) concepts for continuous monitoring of various environmental variables using commonly available and low-cost sensors that are connected to the cloud. (HDT11, MQ6, ESP8266, ATMega328p, Internet, and RemoteXY cloud server) were used in this paper. Using an ATmega328p microcontroller and a few sensors, several ecological factors such as temperature, wetness, and Liquefied Petroleum Gas (LPG) are continuously monitored for air pollution, prepared, and managed. A control system that uses the RemoteXY cloud server has been given strong control as well as cloud-based manual control.
22	IoT based Air Pollution Monitoring device using Raspberry Pi and Cloud Computing	**Riddhika Singh, Nidhi Gaur, Shikha Bathla**	This paper shows various sensors utilized in this study to detect carbon dioxide gas in the air, as well as humidity, temperature, and atmospheric pressure. The Raspberry Pi 3 and Arduino UNO boards are used to interface the sensors indicated above. The MQ-135 air pollution gas sensor is connected to an Arduino Uno, while the DHT11 temperature and humidity sensor, as well as the

			HW-611 e/p 280 atmospheric pressure detection sensor, are connected to a Raspberry Pi 3. The result of the atmospheric pressure sensor detecting air pressure, humidity, and temperature will be automatically transmitted into the ThingSpeak IOT app.
23	WSN Node for Air Pollution Monitoring	**M. Godase, M. K. Bhanarkar**	The primary goal of this study is to build and construct a reliable and cost-effective sensor node. Furthermore, wireless sensor nodes are essential components of advanced WSNs, and the node's ability to communicate wirelessly determines its utility. As a result, the created sensor node has two wireless modules. The ZigBee modules can aggregate and transmit data over a private ZigBee homogeneous network. The WiFi module then successfully uploads data to cloud websites (e.g. thingspeak.com). This type of module-based setup improves dependability.
24	Evolving Air Pollution Monitoring Systems for Green 5G: From Cloud to Edge	**Pimmy Gandotra, Brejesh Lall**	The multi-access edge computing (MEC) paradigm has been highlighted as a critical solution in the Internet of Things (IoT) age, with a large amount of data being generated and saved. This paper examines current air pollution monitoring systems and emphasizes the relevance of computing at the edge, or MEC, in these systems. There are also some ongoing studies in this sector, as well as the obstacles that the research community is facing. Green communication in 5G and beyond wireless communication networks could benefit from such technologies. In the subject of air pollution

			monitoring, future research directions have also been identified.
25	Prediction of air pollution through machine learning approaches on the cloud	**Ziyue Guan, Richard O. Sinnott**	There are many different machine learning approaches, and determining which one is optimal for the task at hand can be difficult. In this paper, data on air pollution, specifically particulate matter less than 2.5 micrometers (PM2.5), was gathered from a variety of web-based sources and then cleaned using various machine learning models such as linear regression, Artificial Neural Networks, and Long Short Term Memory recurrent neural networks. They evaluate the accuracy and capability of these various models in predicting harm! pollution levels. These models' pros and shortcomings are also examined.
26	A survey report of air polluting data through cloud IoT sensors	**K.Indira Devi, S.Meivel, K.Ranjit Kumar, J.Vijayamena ka**	This paper proposes a clever and economical technique to monitor the environment. With the help of five sensors, the air pollution monitoring system with Internet of Things concept was tested experimentally, and the measured values were communicated to the Cloud. Furthermore, this data will be relevant for future research and can be shared effectively across individuals. Finally, this proposed approach will aid in monitoring air pollution levels and, as a result, ensure general wellbeing in an effective and simple manner, as well as provide a consistent response to screen nature.
27	An IoT-Based e-Health System Integrated With	**Mostafizur Rahaman Laskar,**	They've created an embedded software programme aimed at health-conscious individuals concerned about air pollution. It aids in the selection of the

	Wireless Sensor Network and Air Pollution Index	**Prasanta Kr Sen, Shyamal Kumar Das Mandal**	best path among various options based on the concentration of contaminants in the air. The Google Map Application Programming Interface (API), which is extensively used for localization and navigation, is used in the interface. They provide a software development framework based on the Android Platform for displaying real-time ambient air quality from data gathering units mounted on highways in this article. It also advises users to pick the optimal way with the lowest pollution index.
28	Communicating respiratory health risk among children using a global air quality index	**Laura A.Gladson, Kevin R.Cromar, MaryaGhazipura, K. EmmaKnowland, Christoph A.Keller, BryanDuncan**	They provide the first health-based air quality indicator that may be used in cities all over the world to reflect children's respiratory risk. According to their findings, the most effective way to communicate respiratory danger from air pollution on a worldwide scale is to use an index that is modified for extreme pollution values and controls for co-pollutants. Environmental agencies all across the world can utilize this index, which is based on daily index values from three criteria pollutants, to generate local air quality alerts, either using regional observations or publically available model projections like NASA's GEOS-CF.
29	Prediction of Air Quality in Major Cities of China by Deep Learning	**Choujun Zhan, Songyan Li, Jianbin Li, Yijing Guo, Quansi Wen, WeiSheng Wen**	This paper shows many resources that have been invested in exploring and mitigating air pollution by researchers from numerous fields, as well as governments and businesses. The Air Quality Index (AQI) is one of the most important indicators of air quality or pollution levels. A new dataset has been created that includes hourly AQI data from 1,615 observation locations in China from 2015 to 2019.

			To forecast hourly AQI, a variety of methods are used, including linear models and state-of-the-art techniques like Back Propagation Neural Networks (BPNN), Convolutional Neural Networks (CNN), Gated Recurrent Unit (GRU), Long Short-Term Memory (LSTM), and Bi-directional Long Short-Term Memory (BiLSTM).
30	Forecasting Air Pollution using a Modified Compositional Learning Approach	**Samuel A. Ajila, Karthik Dilliraj**	They illustrated this paper by using the Beijing air quality datasets, the goal of this work is to determine the best combination of machine learning approaches for forecasting the Air Quality Index (AQI). PM2.5, PM10, SO2, NO2, CO, and O3 are among the six air pollutant properties in the dataset, which are essential variables in generating the Air Quality Index. Their first findings revealed that the Linear Regression model is ineffective at predicting and forecasting air pollution. When compared to Linear Regression, Random Forest and Random Committee models fared better in terms of MAE and RMSE values.
31	IoT Based: Air Quality Index and Traffic Volume Correlation	**Omar Alruwaili, Ivica Kostanic, Ali Al-Sabbagh, Hamad Almohamedh**	This paper shows how the Environmental Protection Agency (EPA) recommends measuring these compounds using a variety of ways to determine their concentration. This paper also describes how an Internet of Things (IoT) device is used to monitor air quality in real time. It makes use of a series of sensors that monitor air quality on the street. The relationship between traffic volume and the Air Quality Index (AQI) as established by EPA criteria was investigated in this paper. The statistical model for the association between traffic

			volume and the Air Quality Index is created using Multiple Linear Regression (MLR) (AQI).
32	Machine Learning for Air Quality Classification in IoT-based Network with Low-cost Sensors	Nebojša Z. Bogdanović, Mladen T. Koprivica and Goran B. Marković	This article illustrates an investigated wide range of Machine Learning (ML) and Deep Learning (DL) models in order to perform a classification assignment for AQI, but with the assumption of low-cost sensor deployment in a real-world application. The findings of a thorough investigation show that the DL models developed, optimized, and tested in this paper are the most viable and appropriate answer for these requirements.
33	Analyzing and Predicting Air Quality In Delhi: Comparison of Industrial and Residential Area	Adyant Tripathy, Divyansh Vaidya, Arpita Mishra, Shardul Bilolikar, Vijayetha Thoday	As you can see the rising levels of air pollution, they urgently require a model that continuously monitors and forecasts the Air Quality Index (PM2.5, PM10, O3, NO2, SO2, CO) over time. This report offers a scientific solution to the problem. To anticipate pollutants and particulate levels while also predicting the AQI, they used machine learning algorithms such as XGBoost, Random Forest, Facebook Prophet, and Recurrent neural network (RNN). The data was gathered from various measuring stations in the urban and industrial areas of Delhi, India, for the years 2018 and 2019. These supervised learning algorithms are promising in terms of efficiency and accuracy, and they could aid the meteorological department in predicting air quality.
34	Data Analytics based Statistical	Sachin Bhat, Gopika C B, Shetty	This paper reveals the air quality data from the Indian state of Karnataka being studied in this

	Analysis of Air Pollution in the Major Cities of Karnataka	**Namratha Anil, Shreya H P, Prajwala Shetty**	article to see if there were any standards or styles that may help them understand how severe the problem is. To our knowledge, this investigation deals with identifying a pollutant source as starting from a specific location using collected data. This provides a useful technique for managing air quality, and the consequence could be significant in terms of both ecological and financial concerns.
35	A Smart Environment Monitoring Framework Using Big Data and IoT	**Y C A Padmanabha Reddy, T.Parameswaran, R.Sathiyaraj**	By placing a visible Air Quality Meter (AQM), this study presents a system for monitoring ambient air quality on roadways and tracking vehicles that generate pollutants above a predetermined limit, thus safeguarding the smart environment. Real-time AQMs deployed along roadsides are an efficient technique of informing and raising awareness about air pollution. To overcome this problem, the study presents a system that uses the Internet of Things (IoT) to monitor the quality of air contamination at several places by combining Radio Frequency Identification (RFID), Electrochemical Toxic Gas Sensors, and IoT technology devices. The proposed solution also employs Big Data approaches to extract insights from patterns, resulting in data that can be used to monitor and safeguard the environment in order to keep it safe.
36	Environmental air pollution management system: Predicting user	**Muhammad Shahbaz, Changyuan Gao, LiLiZhai, FakharShahz**	The goal of this research is to look at the new phenomena of a big data analytics-environmental air pollution (BDA-EAP) management system, as well as to present a research model of the elements that influence acceptance of such a system. The

	adoption behavior of big data analytics	ad, ImranKhan	task-technology fit (TTF) and unified theory of acceptance and use of technology (UTAUT) principles are used in the study model. Using the structural equation modeling approach, a comprehensive BDA-EAP management system is developed, and the potential adoption speed of such a system is tested by distributing structured questionnaires to employees of important environmental agencies, producing 412 valid responses.
37	Emerging challenges of air pollution and particulate matter in China, India, and Pakistan and mitigating solutions	Muhammad NaveedAnwar, MuneebaShabbir, EzaTahiraMahnoorIftikhar, HiraSaifaAjwaTahir, Malik AshirMurtaza, Muhammad FahimKhokhar, Mohammad Rehan, MortazaAghbashlo, MeisamTabatabaei, Abdul-Sattar Nizami	The extensive research presented here revealed that, during the last few decades, ambient air pollution has had a substantial role in the burden of diseases across South Asia. In Pakistan, India, and China, the number of deaths linked to air pollution has steadily climbed over the last 25 years. Any multidisciplinary approach to decreasing air pollution in these countries must include coal-burning restrictions. Other options should be investigated, such as a smooth transition from fossil fuels to renewable energy carriers to power the transportation industry, and, in particular, renewable energies derived from waste. Furthermore, emission rules that aid in the systematic reduction of air pollution should be put in place efficiently to provide incentives and, if necessary, penalize polluting systems.

38	Design and Implementation of IoT Solution for Air Pollution Monitoring	**Aarathi Ramesh Muppalla, Mahesh Pathakoti, Vinod M Bothale, Biswadip G, Sesha Sai M.V.R, Subramania n V, Rajan K S**	They offer an end-to-end prototype method for monitoring air contaminants in this research. A low price In this prototype application, LoraWAN CO2, CO, and PM2.5 sensors are employed. They also created a real-time monitoring system using web dashboards and the open source tools elasticsearch and kibana to perform real-time analysis. A prototype web dashboard displaying the sensor values in real time, as well as temperature and humidity values, is also being built. Other contaminants from various sites around Hyderabad will be investigated further.
39	IoT Enabled Low-Cost Indoor Air Quality Monitoring System with Botanical Solutions	**Supreet Kaur, Seema Bawa, Seemu Sharma**	The research offers a Smart Indoor Air Quality Monitoring System for measuring carbon dioxide and particulate matter in the home and workplace. For monitoring the aforementioned pollutants, low-cost sensors such as the MQ-135 and a dust sensor (Sharp GP2Y1014AUAF) were utilized. The prototype of the proposed IAQ monitoring system is built on a cloud-based IoT platform. The work was presented in the form of an Android application for data visualization and notification that was both user-friendly and information-rich. The findings reveal that the suggested system successfully measures these indoor air contaminants and delivers botanical solutions (plants) for air quality improvement.
40	Improving the Awareness of	**Tuan-Vinh La,**	In this paper they are using images acquired from personal devices (e.g., cellphones, cameras, lifelog

	Sustainable Smart Cities by Analyzing Lifelog Images and IoT Air Pollution Data	**Minh-Son Dao, Kazuki Tejima, Rage Uday Kiran, Koji Zettsu**	cameras), and this study presents a simple and cost-effective method for assessing PM2.5 in the present and predicting PM2.5 in the short and medium future. The proposed method seeks to uncover a set of periodic-frequent patterns and create the PM2.5 estimation model by leveraging the relationship between urban nature (e.g., street greenness, street building), urban traffic (e.g., vehicle volume), and air pollution (e.g., PM2.5). The estimated PM2.5, in combination with a collection of patterns, is used to forecast PM2.5 in the near future. The suggested method's productivity is demonstrated by testing it on several datasets acquired from India and Vietnam.
41	Analysis of Air Pollution Utilizing Virtual Sensor Models	**Gabriel Oliveira Campos, Leandro Aparecido Villas, Felipe Domingos da Cunha**	They created synthetic data and provided additional information using virtual sensing models. This method is critical for examining aspects for which no physical sensors exist. One of the issues raised in the literature on air pollution analysis is the cost of purchasing sensors, as well as the loss of data and the storage of erroneous data. As a result, this article examines a number of aspects that influence virtual sensing in air pollution and compares several models for generating virtual sensors for a variety of toxins found in the environment. Finally, the Boosted Trees model outperformed all other models in terms of root-mean-squared error, including the model provided in this study.
42	Cloud-based Portable and	**Hiral M Joshi,**	The goal of this study is to calculate personal exposure to particulate matter in the near

	Cost-Effective Particulate Matters Concentration Estimation System	**Hiteshkumar J. Lad, Vibhutikumar G. Joshi**	neighborhood. The concentration of airborne particulate matter, PM2.5, PM10, and weather data will be measured using a cloud-based monitoring platform. The prototype system was built with a low-cost PM sensor, a temperature and humidity sensor, an ATMEL(advanced technology for memory and logic)-based microprocessor, and a Wi-Fi module. The goal of a cloud-based system is to provide real-time monitoring and forecasting of future trends. PM concentrations have been measured in a variety of settings, including residential areas, traffic intersections, and construction sites.
43	Air Quality Monitoring in Urban Areas Using In-Situ and Satellite Data Within Era-Planet Project	**Andrii Shelestov, Andrii Kolotii, Mykola Lavreniuk, Kyrylo Medyanovskyi, Vladimir Vasiliev, Tatyana Bulanaya, Igor Gomilko**	In this paper they're working on a distributed system for AQ city estimation and satellite air quality products based on a network of mobile sensors. It will be implemented in Kyiv as part of the SMURBS/ERA-PLANET initiative as a pilot city. IGOSP and SMURBS projects within ERA-PLANET will use developed information technology for in-situ and satellite data fusion for air quality monitoring, with the goal of continuously estimating all important air compounds, organic pollutants, and other dangerous compounds, and fusing all available data for new ecological map production.
44	Emerging Low-Cost Air Quality Monitoring Techniques for	**Piyush Yadav, Tejas Porwal, Prof. S. Indu, Vedanta Jha**	In this work, they designed and built a fixed-wing solar-powered UAV with the ability to fly indefinitely on solar power and provide real-time air quality data. Because a fixed wing UAV has less propeller wash on sensor data and more flight

	Smart Cities with UAV		duration than a quadcopter, it was chosen for this study. This UAV system was successfully field-tested at a low altitude, and air quality data was collected, stored, and transmitted on the ground using a data fusion module consisting of a low-cost OPC R1 sensor, Raspberry Pi, and Pixhawk Flight Controller. They conduct a spatiotemporal analysis of the system's generated PM 2.5 data, which could be particularly valuable in identifying pollution hotspots in urban areas, industrial regions, and smart cities, as well as spotting stubble burning sites.
45	Air Quality Management System	**Pearl Pullan, Chitra Gautam, Vandana Niranjan**	Their proposed solution is an Air Quality Management (AQM) System that gets pollution data by taking into consideration PM2.5 levels and calculates the Air Quality Index as a result (AQI). This information acquired from mobile nodes stationed at various areas can be utilized to plot a path between two points for the user via a mobile application. Using various color codes, the plotted trail would represent the degrees of pollution. As a result, the user can make an informed decision regarding the route they should take.
46	Technology for Monitoring Urban Air Quality on the Basis of Satellite Navigation Data, Mobile Ecometric	**Mikhail G. Grif, Alexander M. Grif**	The author considers a method for acquiring trustworthy data on urban air quality. Based on the regression model created using satellite navigation data, it is proposed to take into consideration city traffic flows. The terrain of the city, 3D-models of the buildings, and current climatic data are all taken into account while simulating the dispersal from transportation. By solving the inverse problem with

	Stations and the Finite Element Method		data from mobile ecometric stations, the emissions of a stationary source can be estimated. The software implementation of the technique, as well as the device and component composition of the air pollution sensor, are described.
47	Research on Data Processing Method of Air Quality Monitoring System	**Yang Luyue, Wang Yongshun, Song Hui**	This research introduces a new data processing approach that combines ROLAP technology with BP neural networks. The method uses sample data to train the BP neural network model, debug relevant parameters, and produce a better classification prediction model. The linear regression algorithm is introduced after accessing and processing unpublished data using ROLAP multidimensional display to produce a more sensitive warning impact. The novel method successfully combines data mining technology and data warehousing technologies, as evidenced by the comparison of experimental outcomes and warning duration. The paper's shortcoming is that just the BP neural network is employed to predict air quality classification.
48	Implementation of Microservice Architectures on SEMAR Extension For Air Quality Monitoring	**Yohanes Yohanie Fridelin Panduman, Sritrusta Sukaridhoto, Mochamad Rifki Ulil Albaab, Anang Tjahjono, Adnan**	This study presents a solution to this problem by integrating microservice architecture in cloud computing with an air quality monitoring system based on mobile sensors. This system consists of a cloud computing service called Smart Environment Monitoring and Analytical in Real-Time (SEMAR) that is coupled to a Vehicle as a Mobile Sensors Network (VaaMSN) for air quality detection. Cloud computing services are broken down into microservices that include communication, massive

		Rachmat Anom Besari	data storage, data analysis, and real-time visualization with maps, graphs, and tables as outputs. Microservice architecture can be implemented on SEMAR with data transmission to cloud computing, according to the results of the trials. This technology displays data in real time at a specified spot so that it may be analyzed.
49	Performance evaluation of mathematical predictive modeling for air quality forecasting	**S. Selvi, M. Chandrasekaran**	This paper used the UCI repository to evaluate the effectiveness of a prediction model based on several data mining technologies. The researchers were shown how to apply a variety of prediction and data mining techniques with their data sets. For the purpose of evaluating the predictive models, simulation tests were carried out. For many of the data sets, the R package outperforms the other tools. With various data sets such as car appraisal, glass identification, HTRU2, Indian liver patient, iris, irys, and wine quality, the R programme displays 90 percent accuracy. In this research, a mathematical predictive modeling algorithm (MPMA) is introduced, and its effectiveness is tested for air pollution prediction using the UK air quality archive.
50	Comprehensive Air Quality Management System for Rapidly Growing Cities in Developing Countries	**A. Kakarla, V.S.K.R. Munagala, A. Qureshi, S. Thatikonda, S. De, T. Ishizaka, A. Fukuda, S.**	Air quality data is frequently not transmitted in an accessible way, resulting in ineffective law enforcement. To this purpose, they envision a system that takes measurements not just at traditional monitoring stations, but also via a densely deployed network of low-cost tiny sensors. Following that, the suggested system combines the collected data with appropriate models to produce

		Jana	detailed pollution maps. Finally, the system would transmit suitable levels of abstraction to the necessary stakeholders. We believe that, when applied at the local level, such systematic architecture will guide the establishment of effective policies, transparent law enforcement, and a balance between economic development and environmentally friendly economic operations.

CASE STUDIES:

1. **Ensuring clean air through campus monitoring – Dayalbagh Institute**

   In terms of PM2.5, the air quality in Agra is currently 5.5 times higher than the WHO annual air quality guideline value (Particulate Matter 2.5). Because the college is so close to the city, inhabitants must take precautions to ensure that they are inhaling clean air. The amounts of pollution, dust, and other seasonal and regional fluctuations in the air had to be determined. On the Dayalbagh campus, however, they lacked an air quality monitoring system that would have assisted them in accomplishing this goal. Continuous monitoring of PM2.5, PM10, NO, NO2, CO2, Ozone, and CO were required to verify that the occupants of the campus had safe breathing air. Oizom brought its ambient air quality monitoring equipment to the table.

2. **Construction site monitoring with Cambrian Engineering Corporation, Singapore**

   The remodeling of a primary school in Singapore was the project. The principal contractor for this project was Chan & Chan. However, dangerous dust is present in the air during building.
   At the construction site, an Oizom Dustroid device was placed. This is the ideal tool for determining the concentration of dust particles such as PM1, PM2.5, PM10, and PM100 in the air. It would also provide exact, real-time information. Dustroid monitors the air using the light scattering method. It reflects and diffracts through the air sample obtained in the apparatus. The grain size distribution and concentration are determined by the strength of

the beam scattered by the particles. As a result, the baseline data obtained aids in the formulation and implementation of the Environmental Management Plan (EMP).

3. **Monitoring air pollution and mitigation for workplace safety at a Cement Factory in India**
   Two Dustroid atmospheric dust detection methods from Oizom were fitted at the cement manufacture to monitor air quality and analyze dust particle concentrations. It also permitted the EHS team to have a clear grasp of the problem's scope. Devic Earth, Oizom's solution partner, implemented its Pure Skies technical solution after monitoring the air quality for about a week. Dustroids were used to track the air quality on a weekly basis to see how it changed. The comparison was done on a frequent basis to assure that data on air quality, and is often depending on activity, was consistent (which varies day-to-day but is predominantly similar across weeks). Wind sensors were mounted as an external module on the two Dustroid units, which also produced meteorological data.

4. **Air Pollution Monitoring for Davangere Smart City**
   Davanagere smart city is recognized for its cotton mills and is Karnataka's Manchester. The town is a big trading hub in Karnataka, where varied crops from other Karnataka districts are collected for distribution. Pollution levels in the air have risen over time as Davanagere's urbanization has grown. Poor road quality and adequate paths are the main factors of dust pollution. The number of automobiles on the road has increased as a result of urbanization. Increased traffic has exacerbated road degradation, raising dust levels in the environment. As humans constantly inhale Particulate Matter, the

rise in airborne dust has become a serious threat to their health (PM). A huge amount of airborne particles could create a chronic difficulty in breathing, forcing their lungs to degrade.

5. **Airport Monitoring at Riyadh Airport**
   Saudi Arabia's second largest airport is Riyadh King Khalid International Airport. Each year, a huge total passengers transit through the airport, increasing aircraft traffic at KKIA. The measurement, control, and reduction of air emission is amongst the most immediate concerns in the aviation sector. Pollutants including CO2, CO, SOx, and NOx are formed by the airplane's engine. Apart from that, activities such as loading and unloading cargo, refilling engines, and so on all add to pollution. Dust storms are common at KKIA, resulting in the production of Particulate Matter (PM). The major pollutants released by these dust storms are PM2.5 and PM10. What are the most prevalent symptoms of chronic asthma among adult citizens? As a result, the officials implemented real-time pollution at the airport in order to fix the pollution study aimed to reduce the impact on people's health. Professionals can take corrective action and send alerts based on real-time data.

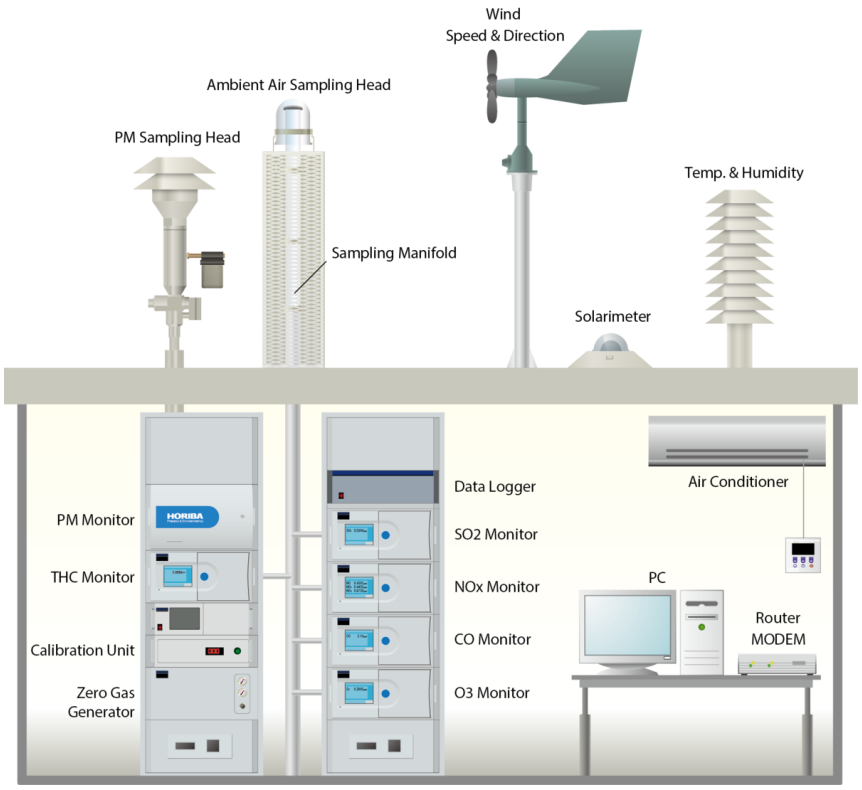
Applications Used in Air Pollution Management:-

Talking about air pollution applications, there are quite a lot of types of sensors from low range prices to high cost devices. These applications have emerged or improved year by year to improve the air pollution quality measure, air quality index and how the data is stored to further analyze the results obtained.

We have mentioned some applications used in different industries and by small businesses that use cloud technology and IoT Technology to measure, store and analyze the air pollution data from different places and regions.

Here are some applications of IoT based Air Quality Monitoring:-

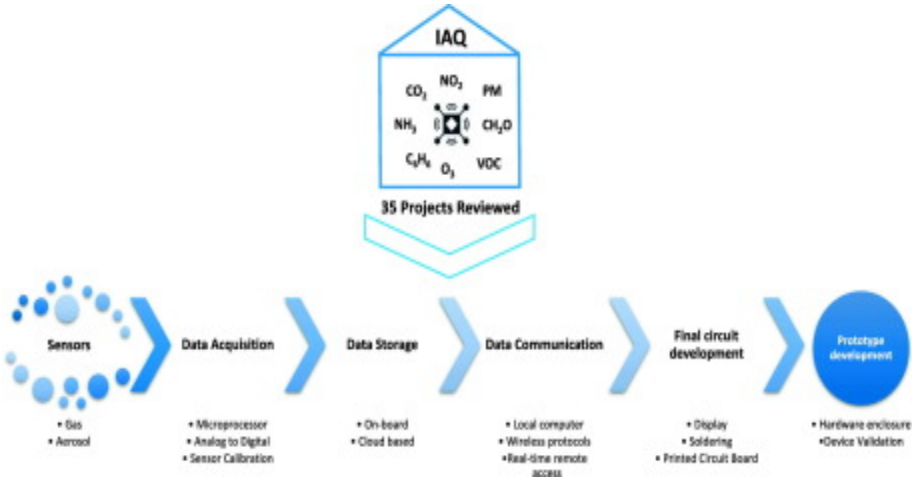
1)Outdoor Air Quality Monitoring System:



For decades, environmental health has been a hot topic. To maintain excellent air quality, several laws and regulations pertaining to pollutant emissions in the air have been enforced. As a result, it is critical for enterprises to monitor the production of dangerous gasses in order to keep the emission rate well within the established criteria.

Companies can track the air quality index surrounding their industrial units and, as a result, manage their emission rates by using outdoor air quality monitoring systems. This aids them in adhering to standards and avoiding any legally enforced fines from air quality management agencies when pollution levels surpass acceptable levels.

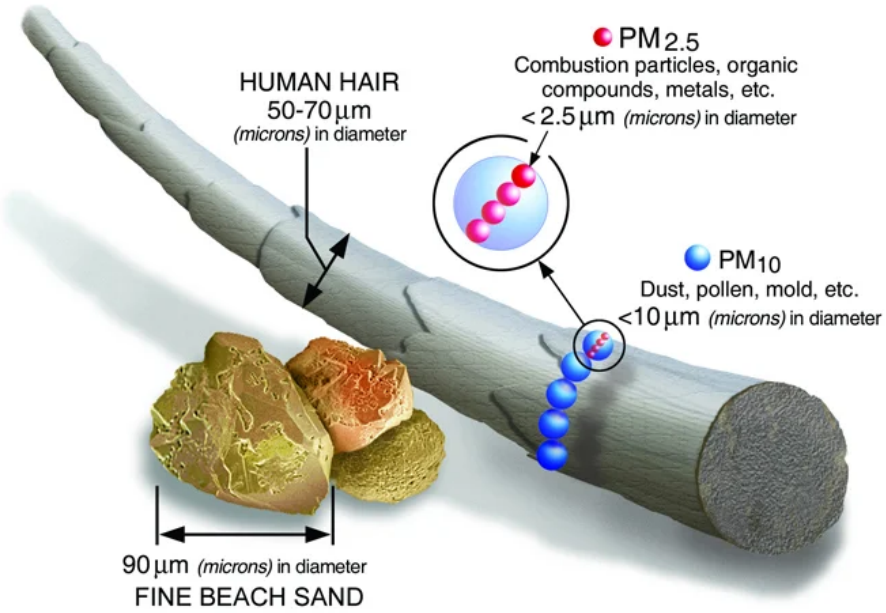
2)Indoor Air Quality Monitoring System:



It's astonishing to learn that indoor air pollution kills almost 3.8 million people each year. When particulate matter and dangerous gasses are present in the air, the quality of the air is lowered, which can lead to serious illnesses such as asthma, lowered lung function, and even cancer when inhaled.

While the data applies to both the industrial and commercial sectors, the impact of air pollution on employees is greater due to higher toxins concentrations. As a result, the indoor air quality monitoring system assists businesses in creating a healthier working environment and keeping the AQI in check. Companies can assist sufficient ventilation, regulate the production of pollutants in their facility, and maintain temperature and humidity in a friendly and comfortable way by comparing real-time air quality data with optimum conditions.

3)Particulate Matter Monitoring (PM) :



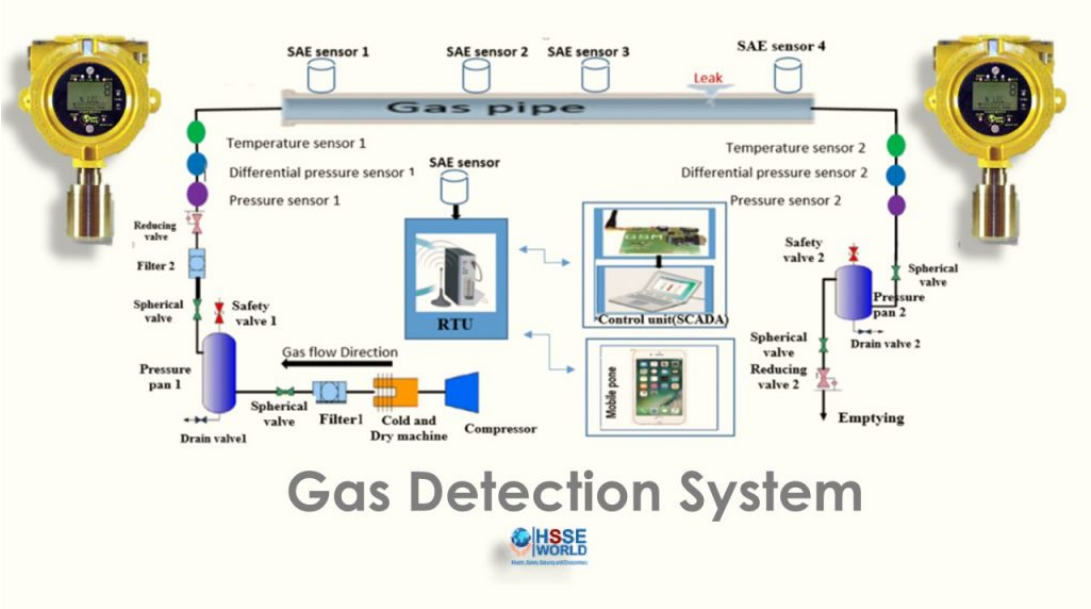
Particulate matter (PM) or Particulates are small particles suspended in the air that are solid or liquid. These particles, also known as aerosols, are invisible to the naked eye and can be made up of a variety of materials such as acids, metals, soil, dust, organic molecules, and so on.

Because these particles are so small, they can easily be ingested and cause health problems. The size of these particles has a direct relationship with the severity of the health problems. Coarse PM, which can be found near highways or dusty industries, has a diameter of 2.5 to 10 micrometers. Particles smaller than 2.5 micrometers, on the other hand, are more harmful since they can easily pass through the nose and throat and into the lungs.

Controlling the production of these particles during manufacturing or any other activity is therefore critical in companies, as continual exposure can have a negative impact on workers' health and performance. Companies can monitor the amount of particulate matter present in their facility by employing a PM monitoring sensor in conjunction with air quality monitoring equipment. When particles pass through the sensor, the laser scatters. The level of PM in the air can be determined via laser scattering.

As a result, businesses can take actions to lower aerosol concentrations in their facilities and provide a healthy work environment for their employees.

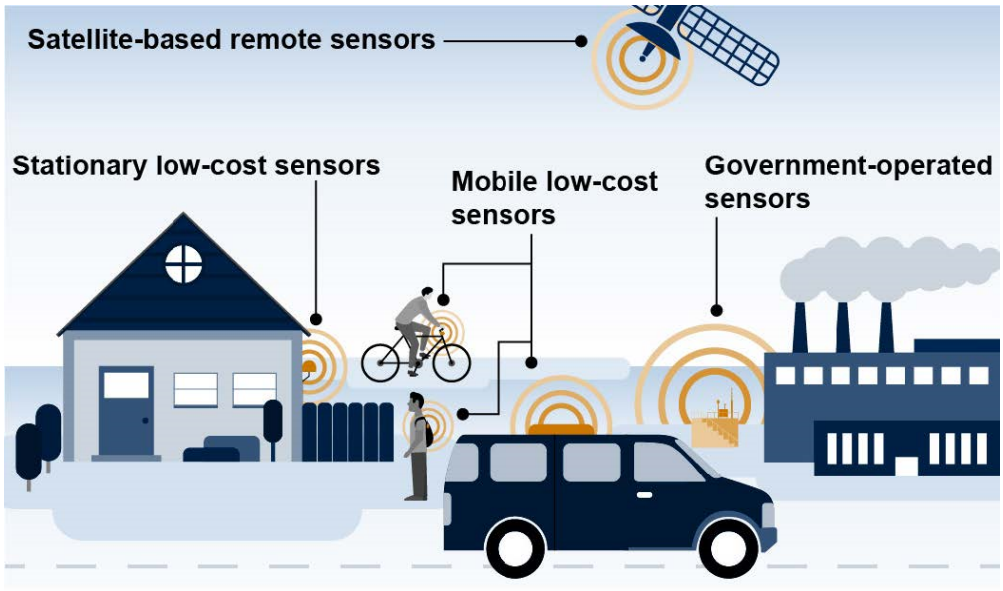
4)Gas Detection System:



Long periods of time spent working in the presence of H2S or SO2 can harm a worker's respiratory system. Long-term exposure can induce severe headaches, convulsions, nausea, and conjunctivitis, as well as damage mental health. Leaks of flammable gasses like LPG or methane can also cause explosions, resulting in injuries to surrounding operators and equipment damage. Furthermore, oxygen-displacing gasses (also known as asphyxiants) such as methane or propane can lower oxygen levels, resulting in serious mental health problems and even death.

The leakage of poisonous and combustible gasses can be detected using gas detection systems, and steps can be taken to roll out the evacuation process, minimize equipment damage, and prevent the spread of the gasses.

5) Low-cost Stationary Sensors:



Source: GAO. | GAO-21-189SP

These sensors are located in one place at a number of fixed sites, monitor the air quality index and analyze the captured data. If a large enough number of sensors/monitors are used, the findings can reveal information about spatiotemporal variations, transport rates, and pollution sources. At the same time, a high number of monitors and locations does not necessarily create a network unless they are linked together or transfer data to a central location via wireless connectivity. There are currently no established protocols that define the number of nodes that should be placed in a network to obtain adequate coverage of any environmental pollutant.

The bulk of the research we looked at fit into the first category, which is stationary deployment. These experiments were largely carried out when low-cost sensors were still in their infancy.

Conclusion:

In this paper we conducted an extensive literature survey and analyzed the different papers from different researchers. We have collected different types of air pollution management techniques and compared them at the end by selecting the most commonly used applications in today's modern world. Researchers have surely worked on new techniques to improve year by year on how to measure air quality index and ways to work on the issues and preventing further disruptions caused by air pollution. We have also compared air quality index management ways of different cities within India and also from neighboring countries to compare and make recommendations on how to improve and increase accuracy. Further in this paper, we have also discussed the various data analytics that can be implemented for greater data storage in the cloud, and also different IoT applications used in industries to manage the working environment and workers health.

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