A Review on Air Pollution Monitoring Technique

Dr. Durgesh Wadhwa

SOBAS, Sanskriti University, Mathura, Uttar Pradesh, India

Email Id- hodchem@sanskriti.edu.in

ABSTRACT: Global air quality has deteriorated as a result of increased industrial activity and increasing urbanization of human populations. Every day, thousands of companies and billions of cars emit massive quantities of pollutants into the air, endangering human health. Many epidemiological studies have linked air pollution to a variety of health problems, which is why air quality monitoring has become a need for preventing or limiting these problems. Traditional measuring station methods are costly and provide little data granularity. As a result, internet of things (IOT)-based solutions are becoming increasingly popular among academics. However, developing a new air quality monitoring system necessitates knowledge of the current state of the art as well as mastery of a certain set of skills. This article seeks to address these needs by evaluating existing research on IoT-based air quality monitoring, with an emphasis on recent developments and problems.

KEYWORDS: Internet of Things, Air Pollution, Air Quality Monitoring, Pollution and Health

1. INTRODUCTION

Excessive industrialization has disturbed the natural environment's equilibrium, resulting in worse air quality and significant health consequences for residents. As a result, it is critical to monitor air quality in order to safeguard and improve residents' quality of life. As a result, current costly air quality monitoring systems with limited data granularity are rapidly giving way to more efficient and cost-effective Internet of Things-based solutions (IOT). The internet of things (IoT) is a new generation of internet that allows many different devices and sensors to be linked together. IoT enables the creation of distributed and somewhat intelligent systems, allowing us to control our appliances remotely and without moving them. The Internet of Things is intimately intertwined with many aspects of smart city concepts. Researchers are increasingly turning to the Internet of Things to monitor air quality, detect excessive amounts of pollution over time, and specify measures to take [1].

Given the critical impact of air pollution and its monitoring on human life and health, and in light of recent advances in IOT, we created this paper to provide researchers with a detailed study of this IOT-Air quality monitoring axes combination, as well as to present a comprehensive state-of-the-art in this field and various research leads [2], [3].

Monitoring air quality using IoT has sparked a lot of interest, with a lot of different systems and techniques being proposed and evaluated in various literature studies. A subcategory of research articles is dedicated to air quality monitoring from a well-defined health monitoring perspective, with a primary focus on smart health-care for patients; this is another element of IOT application, but outside the scope of this study. Our survey is the first to offer medical explanations of contaminants, diverse platforms, and explain the architectures utilized, as far as we know. We also highlight various air quality monitoring systems, which provide a hopeful indication of the role of medical personnel, given the substantial effect of air quality on health.

1.1. Pollutants:

Any substance in the air that has a high concentration and above a specific threshold is hazardous to people, animals, and plants. These materials, also known as substances or pollutants, can be volatile gases, particulate matter, or solid and liquid organic and inorganic in the atmosphere. These chemicals, as well as their origins and kinds, are discussed. Figure 1 shows the pollutant categories. Pollutant categories is divided into two categories primary air pollution, secondary air pollution [4].

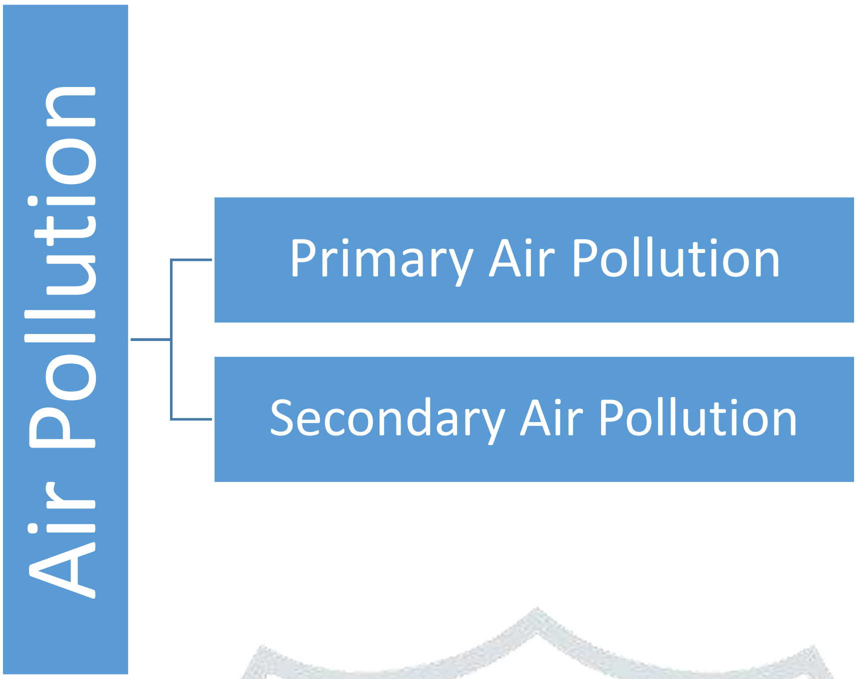

Figure 1: Illustrates the various category of air pollution in our surrounding.

1.1.1. Primary Air Pollution:

Emitted from a variety of sources, including manufacturing chimneys, exhaust pipes, and wind-suspended polluted dust; however, their primary source is fossil fuel-based energy generation (traffic, power plants, heating systems, etc.).

1.1.2. Secondary Air Pollution:

The most well-known example is ozone, which is formed nearly exclusively through photochemical interactions between nitrogen oxides and volatile organic compounds in the atmosphere, perhaps including natural components like oxygen and water.

1.2. Health Impacts Of Air Pollution:

Air pollution has been a major issue for human health in recent decades. Pollutant concentrations are steadily rising as a result of increased human activities, such as traffic and industry. According to the World Health Organization (WHO), nine out of 10 people on the planet today breathe filthy air. Several studies have linked air pollution to a variety of diseases affecting various systems in the human body. In certain cases, these diseases can potentially result in death. Figure 2 shows the impacts of air pollution on human body such as impact on respiratory system, cardiovascular system, etc. [5].

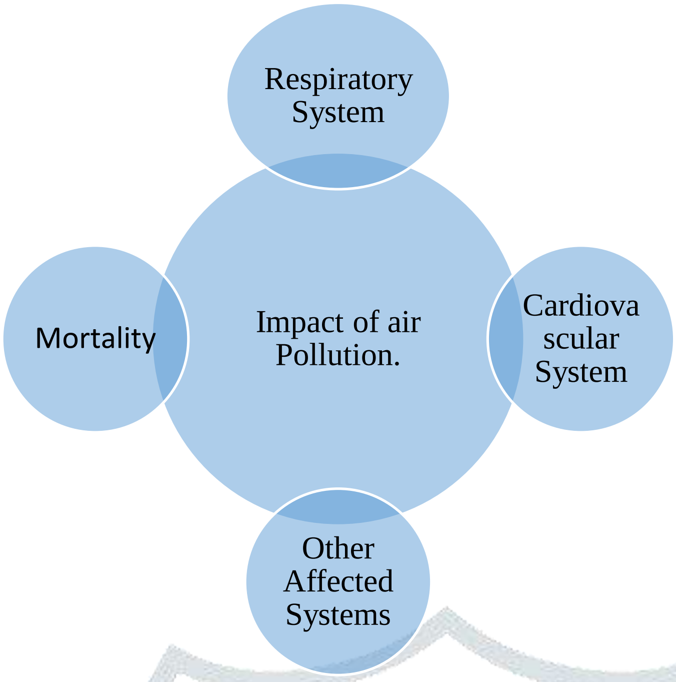

Figure 2: Illustrates the impact of air pollution on Human Body.

1.2.1. Respiratory system:

The state of one's respiratory system is inextricably linked to air quality. It is particularly impacted by the lesions induced by air pollution since it is the absorption point for them. Many studies support and explain the relationship between air pollution intake and the rise in respiratory illnesses in the population. In addition, air pollution has a particularly negative impact on youngsters and those with lung lesions and illnesses. While O3 has been proven to produce oxidative stress, inflammatory reactions, and immune illnesses in experimental animals, a brief inhalation of SO2 causes fast onset of breathing problems in both healthy and asthmatic patients. Particle maters, likewise, have a significant impact on and damage to the human respiratory system. Because of their tiny size, they can go deep into the lung bronchioles and alveoli, where gas exchange takes place, causing inflammation and pulmonary oxidative stress. This oxidative stress has been linked to the onset of asthma, chronic obstructive pulmonary disease, respiratory infections, and lung cancer [6].

1.2.2. Cardiovascular System:

The link between air pollution and coronary artery disease has been demonstrated in several experimental and epidemiological investigations. Carbon monoxide reduces air transfer capacity, and NO2 has been linked to an increase in hospitalization for heart failure events. Many studies have also shown that PM has an influence on the occurrence of coronary risk events (myocardial infarction). PM is also suspected of producing hypercoagulability and thrombophilia by altering the venous circulation. Finally, a research revealed that in people with coronary artery disease, a lower major artery elasticity index was linked to higher ozone levels [7].

1.2.3. Other Affected Systems:

Many studies and inquiries in the literature have pointed to the involvement of air pollution in the spread and/or aggravation of many diseases. The neurological system is affected by heavy metals such as lead and dioxins, which are generated by traffic and industrial activity. Pollutants have an impact on the reproductive system as well. Most well-known air pollutants (PM, O3, NO2, SO2, CO) were linked to various difficulties such as preterm births, congenital impairments, and infant mortality.

1.2.4. Mortality:

The most researched health end point in relation to air pollution is mortality. The availability of large-scale mortality data is one explanation, and the relevance of mortality in assessing health consequences is another. Many of the research examined in utilized data on daily mortality and linked it with time series of outdoor air pollutants concentrations, giving evidence about the impact of a variety of pollutants (PM, O3, NO2, SO2, CO) on all causes of death.

1.3. Automatic Air Pollution Monitoring

1.3.1. Air Pollution Sensor:

Sensors are the final layer in all IoT systems; they are in close touch with the environment and are impacted by it. Their major goal is to collect data from this environment and send it to the next system layer. They are the most important element of a monitoring system since they are the source of information. Researchers are currently using a range of sensors to evaluate air quality. The type of sensor employed depends on the pollutant being measured (gas or solid), the technology utilized to monitor it, and the pollutant itself.

- *Gas sensor:*

A substantial majority of contaminants that are detrimental to human health are found in gaseous form in the environment. A wide selection of low-cost sensors are available on the market to monitor these chemicals. These sensors collect the concentrations of dangerous gases in the air using various technologies. Solid state sensors and electrochemical sensors are two of the most commonly utilized technologies in air quality monitoring systems. Solid state gas sensors and electrochemical gas sensors are the two types of gas sensors [8].

- *Particulate Matter Sensor:*

Because the growth of micro-particles in the air poses a health risk, it is critical to obtain precise and consistent measurements of their concentration. Various low-cost sensor technologies are available for this purpose. Light scattering and light obstruction detectors are the most commonly utilized in the field of IOT [9].

1.3.2. Hardware Platform:

Electronic boards are in charge of receiving data from various sensors and transmitting it to the proper destination as part of an IoT air monitoring system. They are also in responsible of maintaining and supplying electricity to these sensors. Single computer boards and microcontroller boards are the two types of boards. Depending on the function of the card, it has varied features. The comparison reveals that the boards have similar types of input-output ports, but there are differences in processing power, memory capacity, and wireless support connection. The nodeMCU (esp8266 and esp32) appears to be a smart choice for IOT-based air quality monitoring system since it has the most powerful CPU, greatest memory characteristics, and integrated wifi support. The amount of pins on nodeMCU boards is the only drawback when compared to other boards.

1.3.3. IoT Architecture for Air Pollution:

There are three main categories for air quality monitoring systems shown in Figure 2: centralized architectures, decentralized architectures and cloud-based architectures.

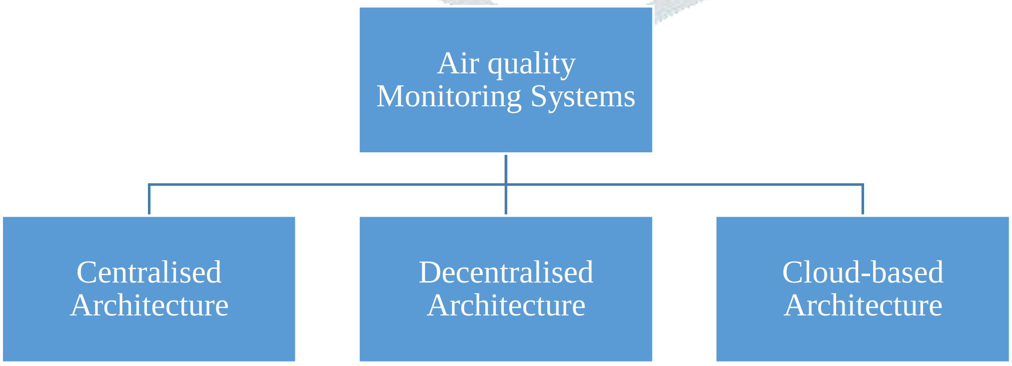

Figure 2: Illustrates the categories of air quality monitoring systems.

- *Centralized Architectures:*

Smart gadgets, under this design, function as data fountains that constantly feed a central organization. This entity gathers all of the created data, processes it, combines it, and distributes it to consumers. To track air quality, the central unit uses the gathered air pollutants levels given by IOT devices equipped with sensors. When a pollution measure exceeds a certain threshold, the central system notifies users and the appropriate authority. A system based on the hierarchical deployment of static terminal sensor nodes inside and outside smart buildings, in floors and open areas between buildings, respectively. They gather data and send it to an information processing center through routers, where it is stored in a database and displayed in a web front-end system. In real time, the latter creates high-quality air quality monitoring maps of the interior and exterior of buildings [10].

- *Distributed Architectures:*

A vision with no central unit is represented by a distributed architecture. The processing is distributed over a network of entities capable of retrieving, processing, combining, and sharing data and services. These entities must also make the resultant data available to the users. Due to the underlying difficulties of network-working, information distribution, sensors, and application access, developing a completely distributed IOT air quality monitoring system is a difficult task. The network's intelligence is housed in multiple central entities that communicate and exchange data with one other and with sensing nodes in these hybrid techniques. This form was created for pollution and air quality monitoring with the goal of consolidating some processes, such as data collection and user alerts, in a single central organization for a given city.

Recently, a fully decentralized air quality monitoring system based on Block Chains (BC) with the best benefit of data integrity was demonstrated. For long-range and low-power communication, the system uses the Ethereum Block chain and the LoRaWAN protocol to secure data storage and transmission. Although a web application is responsible for collecting data from the BC and monitoring it. The solution is unique and provides a promising new direction to pursue.

- *Cloud-Based Architectures:*

The data processing in these designs is done by cloud computers in a big, centralized manner. Cloud computing systems enable large-scale resource utilization, including data storage, data mining, visualization tools, and applications. Cloud computing is widely used in air quality and pollution monitoring systems. The major issue with cloud-based systems is interruptions caused by the rapid growth of endpoints, which are inherited from centralized designs. Fog computing is a cloud expansion that is offered to maintain decentralization.

2. DISCUSSION

The cloud, with its massive infrastructure, meets storage and processing needs. In an IoT architecture, centralised services are essential; nevertheless, many scenarios necessitate autonomous communication between smart devices without the use of a central node. Decentralized IoT solutions are becoming increasingly common. Several recent studies focus on decentralised architectures, with an emphasis on fog computing, which is the most current advancement in the idea of IOT systems for air quality monitoring. The scalability to cope with large-scale end devices and the geographical spread of the monitored zones are two factors that contribute to this architecture style's recent success.

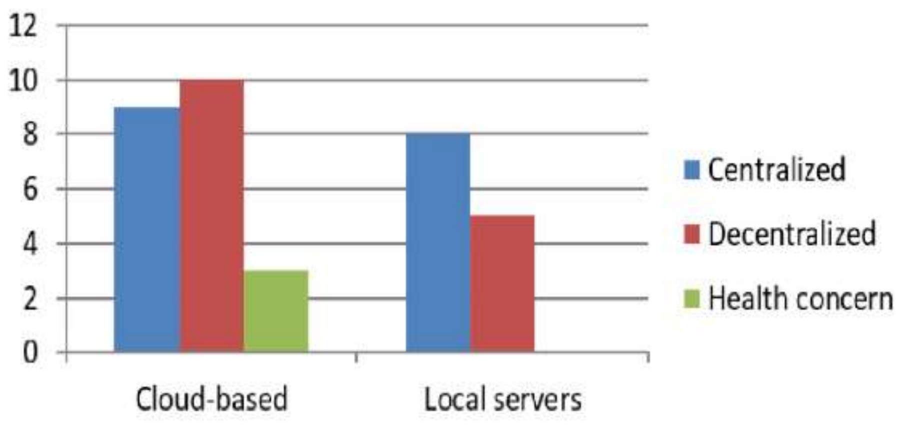

Figure 3: Illustrates the architecture of IoT and the involvement of health concern.

Figure 3 exposes an interesting trend of considering the involvement of medical or health personnel in air quality monitoring systems. This type of system makes up the smallest percentage of the works examined. Nonetheless, it is unique and has interesting concepts. According to studies on health and air monitoring, monitoring alone is insufficient: hospital collaboration among health personnel is required.

3. CONCLUSION

Environmental protection and human health are both dependent on air quality monitoring. As a result, it is now critical to equip smart cities with effective surveillance systems that inform residents and protect them from potential threats. We surveyed a sample of research papers on the use of IOT systems for pollution and air quality monitoring in this paper, presented the major pollutants, diseases associated with them, and established some classifications. In addition, we presented an important component of a research project on the effects of pollutants on human health. We also went over the hardware, such as sensors, microcontrollers, and single computer boards, as well as the architectures used in air quality monitoring system development. In addition, we discussed the reviewed documents and identified some flaws. This review, however, is not exhaustive: some difficult aspects, such as security and privacy, adaptability and other categorizations of energy consumption formulas, or user implication, are not addressed here and will be addressed in a longer version of this paper, as well as statistical studies.

REFERENCES

[1] P. Gupta, R. Kumar, S. P. Singh, and A. Jangid, "A study on monitoring of air quality and modeling of pollution control," *IEEE Reg. 10 Humanit. Technol. Conf. 2016, R10-HTC 2016 - Proc.*, 2017, doi: 10.1109/R10-HTC.2016.7906800.

[2] M. Benammar, A. Abdaoui, S. H. M. Ahmad, F. Touati, and A. Kadri, "A modular IoT platform for real-time indoor air quality monitoring," *Sensors (Switzerland)*, 2018, doi: 10.3390/s18020581.

[3] S. Brienza, A. Galli, G. Anastasi, and P. Bruschi, "A low-cost sensing system for cooperative air quality monitoring in urban areas," *Sensors (Switzerland)*, 2015, doi: 10.3390/s150612242.

[4] A. A. A. Mohtar *et al.*, "Variation of major air pollutants in different seasonal conditions in an urban environment in Malaysia," *Geoscience Letters*. 2018, doi: 10.1186/s40562-018-0122-y.

[5] R. Afroz, M. N. Hassan, and N. A. Ibrahim, "Review of air pollution and health impacts in Malaysia," *Environ. Res.*, 2003, doi: 10.1016/S0013-9351(02)00059-2.

[6] Y. F. Xing, Y. H. Xu, M. H. Shi, and Y. X. Lian, "The impact of PM2.5 on the human respiratory system," *Journal of Thoracic Disease*. 2016, doi: 10.3978/j.issn.2072-1439.2016.01.19.

[7] M. Laeremans *et al.*, "Short-term effects of physical activity, air pollution and their interaction on the cardiovascular and respiratory system," *Environ. Int.*, 2018, doi: 10.1016/j.envint.2018.04.040.

[8] S. Asaduzzaman and K. Ahmed, "Proposal of a gas sensor with high sensitivity, birefringence and nonlinearity for air pollution monitoring," *Sens. Bio-Sensing Res.*, 2016, doi: 10.1016/j.sbsr.2016.06.001.

[9] K. E. Kelly *et al.*, "Ambient and laboratory evaluation of a low-cost particulate matter sensor," *Environ. Pollut.*, 2017, doi: 10.1016/j.envpol.2016.12.039.

[10] J. Esquiagola, M. Manini, A. Aikawa, L. Yoshioka, and M. Zuffo, "Monitoring Indoor Air Quality by using IoT Technology," 2018, doi: 10.1109/INTERCON.2018.8526380.