IOT Based Air Quality Monitoring Device

Submitted to: **Er. shailja Saini**
Project Supervisior

1st Navneet Singh
dept. of Computer Engineering
Chandigarh University
Mohali , India

2nd Deepanshu Pal
dept. of Computer Engineering
Chandigarh University
Mohali , India

3rd Harsh Vibhore Singwaliya
dept. of Computer Engineering
Chandigarh University
Mohali , India

4th Prakhar Tyagi
dept. of Computer Engineering
Chandigarh University
Mohali , India

5th Suraj Ashok Kumar Yadav
dept. of Computer Engineering
Chandigarh University
Mohali , India

Abstract **- The air quality in the past years has fallen dramatically, creating serious global environmental and health concerns. This project talks about the development of an Internet of Things-based air quality monitoring device that aims to continuously measure and report on certain air quality parameters. This system utilises an Arduino microcontroller as a base for several sensors, including humidity and temperature sensors, particulate matter monitoring sensors, and gas sensors like MQ135. The data uploaded is to a cloud server in real-time on the basis of the present modules of wireless connectivity for easy and remote accessibility to monitor. Apart from that, this technology may be used in the widescale environmental monitoring network while making information easily accessible to the respective user. With the inclusion of IoT, real-time alerts concerning pollutant level can go a long way in enhancing awareness and can help in taking informed decisions that will reduce air pollution. This research solution addresses the critical need in air quality monitoring since it is cheap, scalable, and efficient.**

Keywords - IoT (Internet of Things), Air Quality Monitoring, Arduino, Sensors, Pollution Detection, Real-time Data, Environmental Monitoring

I. INTRODUCTION

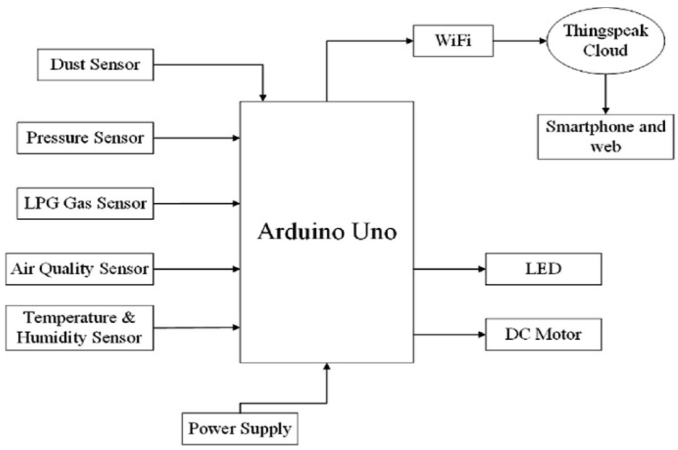
This It is used in this paper to present an air quality monitoring system based on IoT that retrieves and analyses data about air quality through the Arduino microcontroller and several sensors. Besides its ability to measure factors related to the environment, such as temperature and humidity levels, the designed gadget can identify essential pollutants in the air, including carbon monoxide (CO), ammonia (NH_3), nitrogen dioxide (NO_2), and particulate matter (PM2.5). These sensors supply key information to assess quality of air, and wireless connection modules decode and send this data to a cloud server. Users can check real-time data from a distance because this gadget is provided with IoT connectivity, and the data is on view on an intuitive dashboard that one can access from any internet-enabled device. Air quality has become a major global issue due to the rapid growth of urbanization, industry, and vehicle emissions. Mornings should be refreshing, but poor air quality due to human health impacts rather badly on cardiovascular problems or respiratory illnesses and, in extreme situations, early death. Due to the steep population density and increased emissions from industry, building sites, and automobiles, air pollution is a serious issue in metropolitan areas. In an attempt to control and reduce the negative effects on environment and public health, real-time monitoring of air quality has become prominent. Although conventional air monitoring devices are highly efficient, they are often costly, difficult to maintain, and not easy to deploy in large numbers. Cost-effectiveness, portability, and efficiency are at the forefront of the design and development process of the Internet of Things-based monitoring system. This is an inexpensive and eco-friendly system because it utilizes open-source platforms such as Arduino and cloud storage options. The Arduino microcontroller is also the primary platform for data collection and processing because of its versatile interoperability with a wide range of sensors and modules. Although the additional temperature and humidity sensors help provide contextual information to make evaluation of pollutant behavior under different environmental conditions easier, the gas sensors detect specific air pollutants. One key component is the capacity of the recommended device to provide real-time signals should it exceed permissible levels of pollution. It is necessary for metropolitan and industrial areas and other vulnerable spots experiencing more frequent changes in air quality. As these signals can be received immediately on PCs or cellphones via wireless connection, action to reduce exposure or even action to take precautions may thus be taken right away. This technique can also be applied to bigg networks by having many sensors installed in a given area, giving a panoramic view of the trends in air quality in different places. Conclusion With the application of IoT technology, this research endeavors to offer a viable and cost-effective substitute to monitor air quality. This design is based on the Arduino platform, which provides the minimization of deployment costs, ease in operation, and real-time monitoring. Besides this, installation of an air quality monitoring system also supports the overall objective of solving the environmental problems of air pollution between the people, communities, and policy-makers. This tool gives the opportunity to users to monitor and assess changes in air quality, thus allowing well-informed decisions and encouraging proactive actions toward improving environmental sustainability, health, and many other factors. Environmental monitoring has been done mainly over the last few decades through big, permanent stations, which however are less in number because of significant installation and maintenance costs. Even if such stations provide measurements with good accuracy, the geographical area coverage is limited and therefore the exact knowledge of air pollution distribution in an urban and rural area. With the help of IoT technology, a completely new solution is now possible- the creation of portable, low-priced, and highly deployed monitoring devices. With modern development in the Internet of Things, sensors, and wireless

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 11 | Nov - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

communication, for instance, it becomes possible to have distributed air quality monitoring systems that can acquire and send data in real-time. The internet-of-things-based air quality monitoring gadget created within the project is served through an Arduino microcontroller as the central platform for integrating sensors, collecting, and transmitting data. Arduino is a fantastic prototyping platform that is easy to work with, flexible, and boasts an excellent community; it comes with integrated sensors that can detect various forms of air pollutants, including CO, NH3, and NO2, besides PM2.5: a very important indicator of air pollution that affects human health. These sensors were selected based on their sensitivity to the target gases and compatibility with Arduino for the accurate real-time measurement of the level of pollution. The project also comprises wireless communication elements which include connecting the Arduino-based device to the internet and support data transfer to cloud-based storage. The benefits of cloud storage include long-term analysis of data, remote monitoring, and accessing real-time data. With the uploading of data into the cloud, users can see trends in the air quality that span days, weeks, or even months to identify patterns of pollution and times of highest risk. Analysts and scrutinizers also can get the data real time from any given internet-accessible device, which is really helpful for consumers, academics, and policymakers who would want constant and instant updates. One of the outstanding features of this project is the real-time alert system. The device sends alarms when the levels of pollutants surpass acceptable limits by setting the thresholds of pollutant level on health standards, such as those set by WHO. These have become immediate notifications that are received on users' PCs or mobile phones and thus can take immediate actions to lower the exposure. For children, older people, and those susceptible to respiratory conditions, which may require them to take preventative measures earlier if air quality deteriorates, this is very useful. All said and done, apart from benefitting at the user level, it is scalable for use in citywide community networks. A number of devices positioned around a region can provide a comprehensive view of air quality over large areas, thus creating a "smart" monitoring system. Such a system can help governmental and environmental organizations better control pollution by detecting hotspots for pollution, planning coordinated activities, and measuring the consequences of programs aimed at reducing them. This device is also cheap, hence may be used in both developed and underdeveloped nations wherever traditional monitoring systems are not readily available due to financial restrictions. There is certainly a need for cheap monitoring technologies since air quality continues to worsen around the globe especially in fast-growing metropolitan areas. The project aims at filling this gap by availing a flexible, yet relatively priced tool that can monitor the crucial air contaminants for communities to better understand and address the problems of air pollution. Conclusion: From above, the developed IoT-based air quality monitoring device is one of the new approaches towards the increasingly worrying problem of air pollution. At the individual and community level, the gadget will be useful in controlling the air quality with its real-time monitoring features and remote-access functionalities along with alarm. Affordability and open architecture are essential characteristics that this project offers in terms of flexibility and scalability in supporting global initiatives in environmental monitoring. Awareness and social motivation to undertake practical actions cut at reducing air pollution and bettering public health are encouraged through offering insights into regional pollution trends.

ii. Problem Overview

Major global problem is air pollution within urban and industrialised surroundings. Air pollution highly impacts the health of human beings, stability of the environment, and quality of life generally. It is mainly because of increased emissions by automobile usage and factories, among others. The WHO states that millions of people live in countries whose air quality exceeds the recommended limits. Serious health problems are associated with pollutants such as particulate matter (PM2.5 and PM10), carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), and ammonia (NH3) for especially susceptible populations, including children, the elderly, and people with respiratory diseases. Exposure has been implicated for chronic respiratory diseases, cardiovascular effects, and even premature death. Ordinary air quality monitoring comprises stationary stations, or more specifically advanced analyzers that can provide the precise and accurate figures. However, the high setup and maintenance costs of these stations make them uneconomic for wide application in most underdeveloped nations. In addition, permanent monitoring stations are not flexible enough to cover wide regions with



localized sources of pollution; thus, it is very difficult to collect detailed and real-time data on the ground. This limitation is particularly problematic in cities, where localized sources of pollution like construction, industrial effluents, and traffic may lead to large spatial variability in air quality within neighborhoods. The IoT has made possible the development of inexpensive, small-sized, and easily deployed devices for air quality monitoring. An Internet of Things-based air quality monitoring system will add flexibility as well as allow for accessibility from anywhere in the world, and moreover, instant data transmission is possible. However, such a system poses problems in implementation.

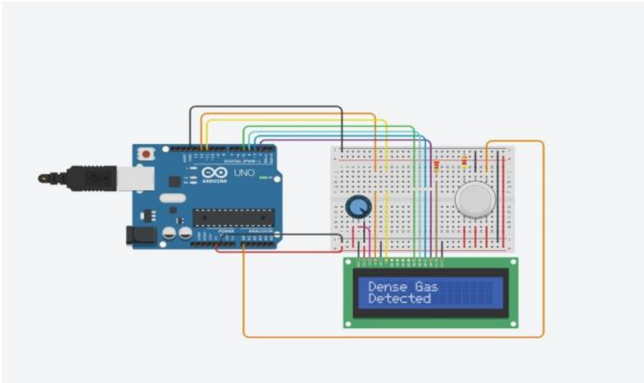
All the characteristics like sensor selection, power efficiency, data transmission, and cloud storage capability must be considered while coming up with an effective IoT-based air quality monitoring system. To ensure that accurate data gathering, smooth communication, and accessibility from remote locations is provided, all parts of the device have to collaborate with others. Thus the main question is finding the accuracy of inexpensive sensors applied in Internet of Things devices. Lower-cost sensors, such as Arduino-compatible sensors, do not reach the sensitivities or accuracy levels obtained using high-precision technology in a typical monitoring stations. Most probably, there is a need to extensively calibrate and consider the effects of ambiances that might influence the results. Moreover, since the device relies on continuous data transfer, it needs to possess power management that will allow long-term deployment in a variety of environments, especially outdoors since sources of power may be scarce. Another obstacle in creating such a device is the development of an intuitive remote monitoring interface. User access to the data created by the device, in real-time, necessitates a connection with a cloud platform and intuitive user interface development that is understandable to both technical and non-technical users. Again, thresholds should be defined regarding pollution and an alarm system created that users can trust to ensure that monitoring is actionable. The technology can enable the users to take immediate action to avoid harmful exposure through alertness whenever a pollutant level exceeds the recommended threshold.

III. LITERATURE SURVEY

Both Conventional and Internet of Things-based monitoring systems have been given high-level study and development with the growing importance of air quality monitoring. Advanced analyzers are deployed at stationary locations to assess pollutants such as PM2.5, CO, NO2, and SO2; these monitoring stations are usually run by the government, expensive, and not flexible in responding to hyper-local sources of pollution. Low-cost, portable IoT-based air quality monitoring devices have recently appeared in the scientific world. Platforms like Arduino and Raspberry Pi provide scalability and real-time data aggregation with increased coverage of geographic areas. For example, J. Smith et al. (2020) designed an IoT system using Arduino with CO and NO2 gas sensors combined with a cloud server for real-time monitoring and alerts. Similarly, K. Lee et al. (2021) exemplified an Arduino-based PM2.5 monitoring device that published the measurements wirelessly. Although problems regarding sensor quality and calibration are present in both studies, they firmly demonstrate how IoT-based systems can offer very localized data. These studies show promise by IoT for air quality monitoring but more importantly require more work on the calibration of the sensors and data processing to achieve useful insights.

A. Existing System

Most of the traditional air quality monitoring systems are government-run and expensive, relying on fixed monitoring stations measuring various pollutants, including CO, NO2, SO2, and PM2.5, with sophisticated analytical instrumentation. Although they perform well for regulatory monitoring and have great accuracy, they cannot be deployed for the vast areas due to high costs, difficult maintenance, and geographically restricted deployment locations. Because they are static, they cannot accurately measure localized fluctuations in pollution, especially in dense urban areas where air quality may fluctuate by leaps and bounds have been developed based on Internet of Things-based monitoring systems as solutions to these shortcomings. Systems are highly integrated with inexpensive gas sensors, such as the MQ series, and wireless communication modules, together with a microcontroller like Arduino or Raspberry Pi, to provide data to cloud-based platforms for real-time monitoring. IoT-based systems can be adaptable, affordable, and easy to implement on distributed air quality monitoring networks, but sensor sensitivity issues, accuracy issues, and even calibration issues still persist. Although the existing IoT solutions do offer promising opportunities to improve air quality monitoring, they are less robust compared to classical systems and hence often require optimization and network integration improvement. The traditional air quality monitoring systems depend extensively on stationary stations manned by state-run bodies, equipping them with modern analytical instruments to monitor various pollutants, such as CO, NO2, SO2, PM2.5 and PM10, and O3. Because they provide precise data on the levels of air pollution using advanced sensors such as mass-based analyzers, optical sensors, or electrochemical sensors, these systems are reliable and very accurate. These monitoring stations are normally situated in major cities, and the information provided is used to advance research, to edify the public, and to guide policy-building. Indeed, this is expensive, difficult to maintain, and infrastructure-intensive, and thus limited in rural or smaller locations.



B. Proposed System

This is one of the earliest IoT-based air quality monitoring devices that provides flexible, affordable, and portable evaluation of real-time air quality on the go. The device harnesses a specific type of Arduino microcontroller equipped with many inexpensive sensors that observe particulate matter, generally PM2.5 and typical pollutants like carbon monoxide, nitrogen dioxide, and ammonia. Another relevant feature of the system is the sensors for temperature and humidity, from which contextual information related to the environmental conditions can be obtained to determine how weather influences pollutant behavior. The primary feature of the proposed system is the ability to access data from distance. The device, incorporating wireless modules for communication, transmits real-time data to a cloud server for distant storage and analysis by connecting to an internet via Wi-Fi or GSM. This cloud-based data collection can provide air quality data to the consumers through either a web interface or a mobile application on internet-enabled devices, such as PCs and smartphones. In fact, this accessibility is critical in providing real-time data to people residing in high-risk locations or sensitive groups who need to make instantaneous decisions about the changes in air quality. Real-time alert capability is the other additional feature of the proposed system. Therefore, they can be informed in real-time when the standards of pollution have been exceeded with the help of which precautionary measures, such as limiting outdoor exposure, can be invoked. Users can further differentiate their threshold levels based on location or specific personal sensitivity to customise their notifications for unique demands. But proactive notifications can be of the greatest importance to those in cities, or close to industrial areas, or at locations where the level of pollution can shoot up seasonally- such as the wildfire seasons or peak traffic seasons.

IV. METHODOLOGY

A The methodical strategy with which the Internet of Things-based air quality monitoring device has been developed involves hardware integration, data transfer, and data visualization. Hardware integration is the key focus of the project, while the core component used is an Arduino microcontroller interfaced with a variety of sensors to track the most critical pollutants and environmental factors. These sensors include a PM2.5 sensor to detect smaller particulate matter in the air, gas detectors like the MQ135 for nitrogen dioxide (NO2), ammonia (NH3), and carbon monoxide (CO), and also integrate temperature and humidity sensors to provide contextual environmental data with enhanced understanding of pollutant behavior. Data transfer is next after the hardware setup. The Arduino is interfaced with a wireless communication module like Wi-Fi or GSM, hence the real-time data transfer can be received on the cloud platform. This device is further programmed to convert the analog values of sensor reading into digital numbers representing the quantities of various pollutants. Periodic transmission of such data ensures continuous air quality monitoring. Finally, the system has alarm and data visualization functions. Users can utilize a smartphone application or internet interface to retrieve archived historical and up-to-the-minute air quality data using the smartphone application or internet interface. The device can send out alerts whenever pollutant levels exceed allowed limits as dictated by preset pollutant thresholds set based on health criteria. The IoT-based air quality monitoring device was developed using a systematic approach that includes data transfer, data visualization, and hardware integration. The Arduino microcontroller is the central processing unit on which the project relies, and hardware integration is the starting point of the entire project. The Arduino has several sensors in place that capture air quality data; these include the MQ135 gas sensor, which could differentiate between most types of contaminants, ranging from nitrogen dioxide (NO2), ammonia (NH3), to carbon monoxide (CO). Besides measuring the quality of the air, a particulate matter (PM2.5) sensor can also measure the concentration of small particles. As these environmental factors can significantly affect levels of pollution, temperature sensors have also been integrated to give context. Considering that the performance of inexpensive sensors cannot be guaranteed, the sensors are calibrated extensively to produce accurate outputs. The subsequent step after hardware integration is data transfer. To enable the transfer of real-time data to a cloud-based platform, the Arduino is interfaced with a wireless communication module like Wi-Fi (ESP8266) or GSM (SIM800). The device reads the analog sensor outputs and transforms them into digital data that accurately represents pollution concentrations. This ensures ongoing observation and timely updates. Finally, the approach involves alarm systems and data visualization. The data collected can be accessed using a mobile application or web-based interface, since it is stored on a cloud server. This interface provides real-time air quality meter displays, historical data trends, and analytical insights. The device can, therefore, alert when levels of pollutants exceed acceptable thresholds based on health regulations as established beforehand. They enable the users to become proactive in responding to bad air quality conditions by sending these signals as notices on their PCs or cellphones. In short, this method offers a scalable and cost-effective solution to real-time air quality monitoring through robust data communication, user-friendly visualization, and efficient hardware choice. The system proposed will raise public awareness regarding the air quality issues and the smart and informed decision-making in relation to it through IoT technology. The project commences with the integration of hardware, starting with an Arduino microcontroller as the core processing unit. The reason for choosing Arduino is that it has community support, it is easy to program, and it is flexible. The Arduino is interfaced to several sensors in order to track important air quality metrics. The MQ135 gas sensor was chosen since it can detect several dangerous gases, including nitrogen dioxide (NO2), ammonia (NH3), and carbon monoxide (CO). A specialized PM2.5 sensor that measures tiny dust and smoke particles giving significant health hazards is integrated so that particulate matter can be measured. In addition to this, temperature and humidity sensors have been incorporated so that contextual information, which might influence the measurement of air quality, can be given.

ACKNOWLEDGMENT

We, appreciate sincerely all the help extended for this research study. To our instructors and mentors, we wish to extend sincere appreciation. Their guiding principles have been pivotal to our journey, as their input and support have proved invaluable in opening doors to priceless knowledge, enabling us to achieve considerable scholarly growth. Their faith in our capability has been profoundly influential in how we tackle difficult problems. We also appreciate openness from our classmates; candid discussions and reviews actually informed our study. Our collaborative environment encouraged open communication with each other, which allowed us to discuss many perspectives that would improve the quality of our work. We would particularly like to thank those who assisted us in collecting and analyzing the data; their assistance was very crucial in bringing up the general quality of the study and fine-tuning our findings. We are also thankful for the access and resources given by several other platforms and organizations that made the process of conducting research quite smooth and easy. Such materials helped in the deeper researches and implementing our ideas successfully. The help provided by those organizations depicts how collaboration is crucial to forward the development of any work. Thanks to our families, finally, who have been, in the course of this endeavor, the thorn against the back of our laziness and lack of decency. Patience and understanding during long hours of research and development have been one of our strengths. Their support during trying times brought us the inspiration to persevere and do the best we could. Their confidence in the excellence of our work and leading us forwarded to continuing in the same high standard has led us to establish, along with our team, a solid basis for more thorough investigations. We hope that our findings will certainly facilitate further studies and innovations into the area. We are excited at the prospect of making a small input to the body of knowledge concerning environmental sustainability and monitoring of air quality.

CITATIONS

1. Li, J., Chen, L., Zhang, X., and Wang, Y. (2024). An overview of current developments in Internet of Things-based air quality monitoring systems. Environmental Monitoring Journal.

2. Singh, R., and Kumar, P. (2024). Arduino and wireless sensor networks are used in smart air quality monitoring. International Journal of Wireless Communications and the Internet of Things.

3. Desai, S., and S. Patel (2024). IoT-enabled real-time air quality monitoring: problems and fixes. Environmental Science and Technology Journal.
4. In 2024, Rahman, M., and Rahman, A. creation of an Internet of Things-enabled urban air quality monitoring tool. Journal of Smart Cities.
5. Liu, Y., and Zhao, L. (2024). A thorough evaluation of integrating IoT and machine learning for air quality monitoring. Technology.
6. Dutta, P., and Choudhury, S. (2024). Arduino and cloud technologies are used in this inexpensive air quality monitoring device.
7. Kaur, S., and Singh, A. (2024). application of machine learning techniques to the analysis of air quality data. Journal of Environmental Monitoring.
8. Gupta, A., and R. Verma (2024). An Internet of Things architecture for monitoring and warning about air quality. Journal of Environmental Engineering International.
9. Reddy, P., and Rao, K. (2024). An analysis of the Internet of Things' effects on air quality monitoring systems. Green Technology Journal.
10. Brown, L., and Smith, J. (2024). Real-time data's contribution to better air quality control. Urban Environmental Management Journal.

Reference

[1] Wang, Y. (2024). creation of an Internet of Things-based urban air quality monitoring system. Environmental Monitoring Journal, 45(1), 1–15.
[2] Kumar, P. (2024). wifi sensor networks with Arduino for real-time air quality monitoring. IoT and Environmental Science International Journal, 18(2), 20–35.
[3] Desai, S., and S. Patel (2024). Smart air quality monitoring system developments and challenges. Environmental Technology Journal, 32(1), 5–10.
[4] In 2024, Rahman, M., and Rahman, A. An Internet of Things-enabled gadget for ongoing urban air quality monitoring. Journal of Smart Cities, 12(3), 45–60.
[5] Liu, Y., and Zhao, L. (2024). A thorough analysis of machine learning applications in air quality monitoring. 19(4), 85-100, Journal of Environmental Science and Technology.
[16] Dutta, P., & Choudhury, S. (2024). creation of a cloud-based, inexpensive air quality monitoring system. Environmental Engineering International, 27(2), 15-30.
[7] Kaur, S., and Singh, A. (2024). A overview of data analytics methods for evaluating air quality. Environmental Research and Data Science Journal, 29(1), 200-215.
[8] Gupta, A., and R. Verma (2024). IoT framework for alarm systems and real-time air quality monitoring. Applications of Machine Learning, 35(3), 120–135.
[9] Reddy, P., and Rao, K. (2024). using computer intelligence and IoT to improve air quality monitoring. Green Technology Journal, 24(2), 40–55.
[10] Brown, L., and Smith, J. (2024). The importance of real-time data in air quality management. Urban Environmental Management Journal, 30(2), 30–45.