Real-time Air Quality Index Monitoring and Alert System using IoT Technology

Akhil Mathew Mohan(*Student*)
Computer Science
Amal Jyothi College of Engineering
Kottayam, India
akhilmathew990@gmail.com

Alan Maria George (*Student*)
Computer Science
Amal Jyothi College of Engineering
Kottayam, India
alanmaria2001@gmail.com

Arathy Baby (*Student*)
Computer Science
Amal Jyothi College of Engineering
Kottayam, India
arathybaby01@gmail.com

Gopika S (*Student*)
Computer Science
Amal Jyothi College of Engineering
Kottayam, India
gopika.s45@gmail.com

Syam Gopi (*Guide*)
Computer Science
Amal Jyothi College of Engineering
Kottayam, India
syamgopi@amaljyothi.ac.in

Abubeker K.M (*Co-Guide*)
Electronics and Communication
Amal Jyothi College of Engineering
Kottayam, India
kmabubeker@amaljyothi.ac.in

***Abstract*— Air pollution is one of the biggest problems of our time because it not only contributes to climate change but also has a negative influence on public and individual health, which raises morbidity and mortality rates. The general comfort and health of a building's occupants are significantly influenced by the indoor air quality (IAQ). Numerous detrimental health outcomes, such as allergies, headaches, and respiratory issues, can be brought on by poor IAQ. An IoT-based indoor air quality monitoring system can be used to solve this problem. We suggest a three-phase air pollution monitoring system to address the issues with current systems. With the help of gas sensors and a Raspberry Pi 4, an IoT kit was created. This device can actually be put into different rooms to monitor air pollution. The gas sensors collect information from the atmosphere and transmit it to the Raspberry Pi 4. The Wi-Fi module on the raspberry pi4 sends the data to the cloud. Users can get pertinent cloud-based air quality data via an android app that has been built. In order to efficiently monitor air quality and foresee the negative effects that prolonged exposure to these pollutants may have, our project aims to develop a real-time air monitoring system.**

Keywords—sensors; raspberry pi; thinkspeak; IAQ; air quality; real-time monitoring

I. INTRODUCTION

According to the World Health Organization (WHO), air pollution is a major issue for 99% of the global population. According to the recommendations of the central pollution control board and the air quality model, 92% of the world's population lives in areas where air quality levels are above WHO-recommended safety limits. The suggested architecture for data collection and transmission will be used by the cloud-based network to monitor air quality. We are now able to monitor people's working and living environments at any time because of the steady progress of Internet of Things (IoT), sensors, and information and communication technology (ICT).

An Internet of Things (IoT)-based indoor air quality monitoring system is a device or network of devices that uses sensors and linked technologies to continually monitor and measure the quality of the air inside a building or structure. These systems can be utilized in a variety of settings, including homes, offices, schools, and hospitals, to assist guarantee that the air people breathe is safe and healthy. Temperature, humidity, and the presence of contaminants like mould, carbon monoxide, and volatile organic compounds can all have an impact on indoor air quality. These contaminants can cause allergies, respiratory problems, and even cancer.

Sensors are used by IoT-based indoor air quality monitoring systems to measure the temperature, humidity, and presence of different pollutants in the air inside a structure. These sensors gather data, which is then sent via a network to a hub or server where it can be processed and used to spot any possible issues or patterns.Some IoT-based indoor air quality monitoring systems offer features like alarms, warnings, and automatic controls that can help to minimize any problems found in addition to monitoring air quality. For instance, the system may automatically shut off any gas-burning equipment or notify building occupants to leave if excessive amounts of carbon monoxide are found.Overall, an IoT-based indoor air quality monitoring system can help to improve people's health and safety by continually monitoring and measuring the air they breathe and offering alarms and controls to mitigate any identified concerns.

II. Literature Survey

Air pollution is a major issue in India, which is having a negative impact on both the economy and the environment. The sources of air pollution include congested traffic, emissions from vehicles and industries, and the burning of fireworks, among others. These factors are not only affecting human life, but also the well-being of plants and animals.
In [1] a new environmental monitoring system that uses a combination of physical and communication redundancies to improve its quality. The system uses multiple sensor motes to monitor the same parameters and incorporates an energy -efficient control algorithm. The system has been tested in laboratory conditions and in real-world air quality monitoring, with results showing good correlation and high fault tolerance. The system has potential for use in microclimate analysis for cities and is a promising solution for low-cost air pollution assessment.

In the study conducted in [2] , the Air Quality Monitoring System is integrated between Connectionless sensor networks and Internet of Things based on the ThingSpeak cloud and the aim is to have completed remote monitoring in the air quality of the indoor environment. Here, the MQTT lightweight protocol is implemented for IoT-based system connection. In [3] a system which can monitor air quality is made. Various types of sensors such as Gas sensors and particulate matter sensors are used to create this system. Gas sensors are used to detect various types of gases such as sulfur dioxide, nitrogen dioxide, methane, carbon monoxide and particulate matter sensors used to detect the dust which presents in the environment of a crowded city. Sensing units sense the data from the environment and transfer the data wirelessly to the microcontroller. It analyzes the data and sends it to the cloud. If the pollution level crosses its normal limit then it will display in android phones or computer screen. In [4] a network for monitoring air pollution is implemented. To implement this a system of the sensor nodes are connected and placed in an environment where the data is to be collected. The aim of this paper is to aid in reducing respiratory problems due to industrial activities and to monitor the level of air pollution. The paper's main focus is on finding solutions to the increasing problem of harmful gasses amounting from industrial practices in the country.

Advancements in AI have led to the creation of AI sensors, which have the ability to transform the Internet of Things (IoT) industry. These sensors are capable of providing precise and trustworthy real-time data for various purposes. [5] describes the design and development of a prototype for an IoT-enabled IAQ monitoring system, with a custom app for data logging and user recommendations. An IAQI has been proposed to present a measure for air quality to the user. The data can be viewed in real-time or reported as an hourly or daily average.The paper [7] provides valuable insights into the current state of the technology and its future prospects, making it an important resource for researchers, practitioners, and anyone interested in the development and deployment of AI-based sensors for IoT applications.

In [8] device proposed uses sensors to identify the dangerous gases that are harmer for the human lifestyle. By sending the input to the sensors to the monitor. When the smoke parameter is above the normal range, the analogue values will be produced after code execution. The sensor updates the values every 30s by air sensing. The proposed air pollution monitoring kit along with the integrated mobile application in [9] can be helpful to people suffering from respiratory diseases. The app had following features, indices of air quality for a specific city using real-time computation, air quality daily forecasts, timing outdoor activities for different recommendations of generation, air quality dips related to health risks, specific reports for air quality measures based on locations, air quality maps generation.

The paper [11] presents a low cost and portable air pollution monitoring system (APMD) prototype. The APMD consists of an on-board PM sensor and other sensors to measure different

DOI:

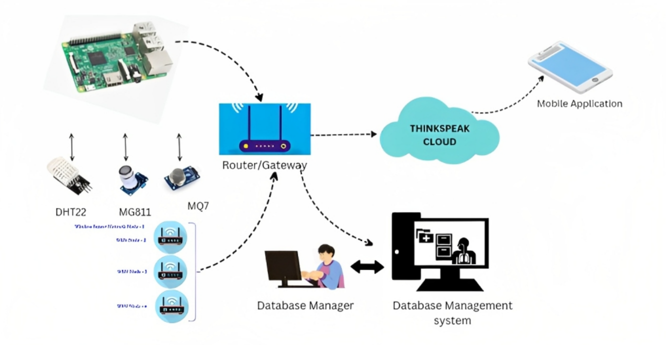
ambient pollutants. The system uses cloud-based service to create realtime high-resolution pollution maps of a large area. The system in [12] focused on air quality monitoring in the Pakila district of Helsinki, specifically on the health effects of indoor and outdoor air pollution.The use of low-cost air quality sensors allowed for the identification of outdoor air pollution hotspots and creation of real-time air pollution maps for citizens.The study faced challenges such as accidental damage to sensor devices and usability issues, but was able to overcome these with replacements and user feedback.The data was presented in diurnal cycles and heatmap plots to show the distribution of pollutants in space and time, and to provide personalized exposure information on an individual. The proposed system described in [13] was able to successfully collect and analyze air quality data using a combination of an Arduino microcontroller, Wi-Fi module, MQ135 gas sensor, and an LCD screen. The data was sent to a remote server called ”Thing-speak” for analysis and displayed in the form of scatter line graphs or bar charts. The system was able to update the air quality data regularly and provide a visual representation of the data for users to access at any time.

III. Methodology

This chapter discusses in detail the proposed implementation.As mentioned, the basic architecture of indoor air quality monitoring system consists of
three parts:

1) Sensing Module
2) Cloud Storage
3) Application Interface(API)

From the extensive literature survey conducted, we have identified the following architecture for the initial prototype.



IV.

Fig. 1. Basic Architecture of Proposed System

The MQ-7, DHT-22, and MG-811 sensors are used as part of an IoT-based indoor air quality monitoring system to measure various parameters that are relevant to indoor air quality. The Raspberry Pi 4 is used as a microcontroller to collect data from the sensors and transmit it to the cloud using the ZigBee protocol.

In this implementation, the Raspberry Pi 4 would be connected to the MQ-7, DHT-22, and MG-811 sensors using appropriate wiring and circuitry as shown in figure 1. The Raspberry Pi 4 would also be connected to a Xbee module, which would be responsible for transmitting the sensor data to the cloud using the ZigBee protocol. The cloud platform that is used in this implementation is ThingSpeak, an open-source IoT platform. ThingSpeak provides tools for storing, managing, and analyzing data from sensors and other devices, as well as providing a user interface for accessing and visualizing the data.

The Raspberry Pi 4 would be responsible for sending the sensor data to ThingSpeak via the ZigBee module, where it would be stored and made available for analysis. ThingSpeak can also be configured to trigger alarms or take other actions based on the data, such as optimizing the building’s HVAC system to maintain comfortable and healthy indoor air.

V. Expected Outcome

The expected outcomes of an indoor air quality monitoring system using a Raspberry Pi are

- Real-time monitoring: The system will provide real-time measurement of various air quality parameters, allowing for continuous monitoring of indoor air quality.
- Improved air quality: By continuously monitoring air quality, the system can help identify areas that need improvement, and assist in taking steps to improve air.
- Early warning system: The system can be configured to trigger alarms or notifications when the air quality crosses a certain threshold level, alerting people to take action to improve air quality.
- Data analysis: The collected data can be analyzed to identify trends, patterns, and correlations, providing insights into the factors that influence indoor air quality.
- Customizable: The system can be customized to meet specific needs, such as monitoring specific pollutants or integrating with other home automation systems .The threshold values are updated automatically.

DOI:

VI. RESULTS

The results of the designed monitoring system are discussed in this section. The system measurements are compared with the threshold values described by WHO as shown in figure 2

Pollutant	Averaging Time	2005 AQGs	2021 AQGs
$PM_{2.5}$, μg/m³	Annual	10	5
	24-hour[a]	25	15
PM_{10}, μg/m³	Annual	20	15
	24-hour[a]	50	45
O_3, μg/m³	Peak season[b]	-	60
	8-hour[a]	100	100
NO_2, μg/m³	Annual	40	10
	24-hour[a]	-	25
SO_2, μg/m³	24-hour[a]	20	40
CO, mg/m³	24-hour[a]	-	4

Fig. 2. AQG level by WHO

The figure 3 presents the temperature variation and figure 4 presents the CO level in the current atmosphere.

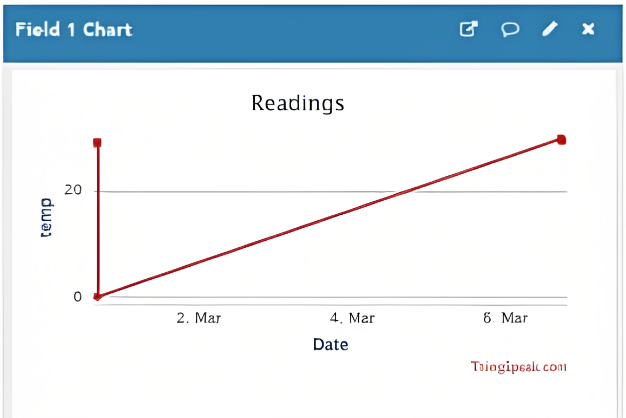


Fig. 3. Temperature data collected

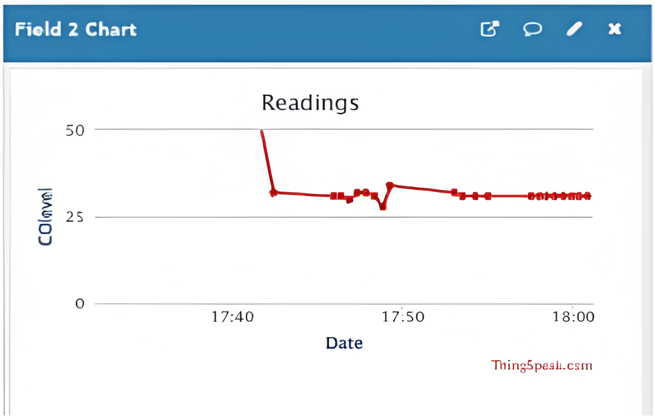


Fig. 4. CO data collected

VII. CONCLUSION

In the past, pollution was hardly noticeable. However, at the moment, pollution is getting worse by the day due to a number of factors, including industrial development and the development of automobiles. Therefore, this air pollution kit was created to let a person identify, monitor, and test air pollution in a specific location in order to lower the level of pollution from such sources and to safeguard persons and the environment from hazardous gases.The drawbacks and performance of each of the methodologies were discussed and the following conclusions can be drawn:

- High cost
- High power consumption
- Security issues

The air pollution issue, which has both social and economical implications, could be addressed with IoT. Asthma and other respiratory conditions may be triggered by carbon dioxide, ground-stage ozone, and particle matter. One of the most difficult aspirations of modern society is to monitor the air quality in critical areas. So, using a Raspberry PI, we attempt to develop an intelligent method of tracking various environmental requirements. The IoT concept affects temperature, humidity, noise levels, and air quality. The monitoring technique is economical, dependable, and effective. The evaluation of complex patterns is aided by the observation of the accumulated data in cloud storage, which in turn informs the public.

DOI:

Acknowledgment

First of all we sincerely thank the Almighty GOD for giving us knowledge and courage.

We express our gratitude to Dr. Juby Mathew, HOD, Department of Computer Science and Engineering for his kind cooperation in all aspects of our Project. We express our sincere thanks to our internal guide, Mr.Syam Gopi,Associate Professor and our co guide, Mr. Abubeker K.M, Assistant Professor and our Project Coordinators Ms. Shiney Thomas, Associate Professor & Dr.Sinciya P O,Associate Professor for their encouragement and motivation during the project. We are indebted to our beloved teachers for their cooperation and suggestion throughout the project which helped us a lot.

We also thank all our friends and classmates for their interest, dedication and encouragement.We convey hearty thanks to our parents for their moral support, suggestion and encouragement to make this venture a success.

References

[1] H. A. D. Nguyen and Q. P. Ha, "Wireless Sensor Network Dependable Monitoring for Urban Air Quality," in IEEE Access, vol. 10, pp. 40051-40062, 2022, doi: 10.1109/ACCESS.2022.3166904.

[2] S. Faiazuddin, M. V. Lakshmaiah, K. T. Alam and M. Ravikiran, "IoT based Indoor Air Quality Monitoring system using Raspberry Pi4," 2020 4th International Conference on Electronics, Communication and Aerospace Technology (ICECA), 2020, pp. 714-719, doi: 10.1109/ICECA49313.2020.9297442.

[3] S. Jiyal and R. K. Saini, "Prediction and Monitoring of Air Pollution Using Internet of Things (IoT)," 2020 Sixth International Conference on Parallel, Distributed and Grid Computing (PDGC), 2020, pp. 57-60, doi: 10.1109/PDGC50313.2020.9315831.

[4] A. Alshamsi, Y. Anwar, M. Almulla, M. Aldohoori, N. Hamad and M. Awad, "Monitoring pollution: Applying IoT to create a smart environment," 2017 International Conference on Electrical and Computing Technologies and Applications (ICECTA), 2017, pp. 1-4, doi: 10.1109/ICECTA.2017.8251998.

[5] S. Esfahani, P. Rollins, J. P. Specht, M. Cole and J. W. Gardner, "Smart City Battery Operated IoT Based Indoor Air Quality Monitoring System," 2020 IEEE SENSORS, 2020, pp. 1-4, doi: 10.1109/SENSORS47125.2020.9278913.

[6] S. C. Mukhopadhyay, S. K. S. Tyagi, N. K. Suryadevara, V. Piuri, F. Scotti and S. Zeadally, "Artificial Intelligence-Based Sensors for Next Generation IoT Applications: A Review," in IEEE Sensors Journal, vol. 21, no. 22, pp. 24920-24932, 15 Nov.15, 2021, doi: 10.1109/JSEN.2021.3055618.

[7] M. J. Shehab, I. Kassem, A. A. Kutty, M. Kucukvar, N. Onat and T. Khattab, "5G Networks Towards Smart and Sustainable Cities: A Review of Recent Developments, Applications and Future Perspectives," in IEEE Access, vol. 10, pp. 2987-3006, 2022, doi: 10.1109/ACCESS.2021.3139436.

[8] V. Sajjan and P. Sharma, "Analysis Of Air Pollution By Using Raspberry Pi-IoT," 2021 6th International Conference on Inventive Computation Technologies (ICICT), 2021, pp. 178-183, doi: 10.1109/ICICT50816.2021.9358535.

[9] S. Dhingra, R. B. Madda, A. H. Gandomi, R. Patan and M. Daneshmand, "Internet of Things Mobile–Air Pollution Monitoring System (IoT-Mobair)," in IEEE Internet of Things Journal, vol. 6, no. 3, pp. 5577-5584, June 2019, doi: 10.1109/JIOT.2019.2903821.

[10] S. P. Raja, "Green Computing: A Future Perspective and the Operational Analysis of a Data Center," in IEEE Transactions on Computational Social Systems, vol. 9, no. 2, pp. 650-656, April 2022, doi: 10.1109/TCSS.2021.3093702.

[11] P. Das, S. Ghosh, S. Chatterjee and S. De, "A Low Cost Outdoor Air Pollution Monitoring Device With Power Controlled Built-In PM Sensor," in IEEE Sensors Journal, vol. 22, no. 13, pp. 13682-13695, 1 July 1, 2022, doi: 10.1109/JSEN.2022.3175821.

[12] Pranvera Kortoçi, Naser Hossein Motlagh, Martha Arbayani Zaidan, Pak Lun Fung, Samu Varjonen, Andrew Rebeiro-Hargrave, Jarkko V. Niemi, Petteri Nurmi, Tareq Hussein, Tuukka Petäjä, Markku Kulmala, Sasu Tarkoma, Air pollution exposure monitoring using portable low-cost air quality sensors, Smart Health, Volume 23.

[13] Okokpujie, Kennedy \& Noma-Osaghae, Etinosa and Odusami, Modupe , John, Samuel , Oluwatosin, Oluga. (2018). A Smart Air Pollution Monitoring System. International Journal of Civil Engineering and Technology. 9. 799-809.

[14] Tran VV, Park D and Lee YC.,"Indoor Air Pollution, Related Human Diseases, and Recent Trends in the Control and Improvement of Indoor Air Quality," in *International journal of environmental research and public health* vol. 17,8 2927. 23 Apr. 2020,

[15] Mehzabeen Mannan and Sami G. Al-Ghamdi,"Indoor Air Quality in Buildings: A Comprehensive Review on the Factors Influencing Air Pollution in Residential and Commercial Structure," in *International journal of environmental research and public health ,22 March 2021*

[16] https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health

[17] https://www.ncbi.nlm.nih.gov/books/NBK138699/#:~:text=An%20annual%20average%20indoor%20nitrogen,meta%2Danalysis%20of%20indoor%20studies.

[18] https://www.who.int/news-room/questions-and-answers/item/who-global-air-quality-guidelines