

# AIR QUALITY MONITORING SYSTEM

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## Abstract

Air pollution is a critical environmental challenge affecting public health and overall ecosystem stability. Traditional air quality monitoring methods are often expensive, stationary, and limited in coverage. Air pollution is the presence of excessive amounts of undesirable and unsafe solid or gaseous substances such as Carbon Monoxide, Lead, Nitrogen Oxide, Ozone, Particulate Matter, Sulfur Dioxide, etc., atmosphere. Air pollution has become an increasingly hazardous problem over the past few years. This factor is directly related to human health. Other effects of air pollution also include various diseases like lung cancer, ischemic heart disease, asthma attacks, etc. This research presents the design and implementation of a cost-effective, real-time Air Quality Monitoring System (AQMS) that utilizes Internet of Things (IoT) technology to measure key pollutants such as PM<sub>2.5</sub>, PM<sub>10</sub>, CO, CO<sub>2</sub>, NO<sub>2</sub>, and temperature-humidity parameters. The system integrates low-cost sensors with a microcontroller-based platform and transmits data to a cloud-based server for analysis and visualization. Machine learning techniques are employed to predict air quality trends and provide actionable insights. The proposed AQMS offers a scalable and accessible solution for urban and rural areas, enabling policymakers and the public to make informed decisions regarding air pollution mitigation. Experimental results demonstrate the system's accuracy and efficiency in detecting pollution levels compared to conventional monitoring stations. This study highlights the potential of IoT and AI-driven solutions in enhancing environmental monitoring and sustainability efforts.

**Keywords:** Air Quality Monitoring, IoT, Pollution Detection, Machine Learning, Environmental Sustainability.

## Introduction

Air pollution has become one of the most pressing environmental and public health concerns globally. Rapid urbanization, industrialization, and vehicular emissions have significantly contributed to the degradation of air quality, leading to severe health risks such as respiratory diseases, cardiovascular disorders, and environmental hazards. Accurate and continuous air quality monitoring is essential for assessing pollution levels, identifying pollution sources, and formulating effective mitigation strategies. However, traditional air quality monitoring systems are often expensive, require significant infrastructure, and have limited spatial coverage, making them inaccessible for many regions, particularly in developing countries.

To address these challenges, advancements in Internet of Things (IoT) technology and low-cost sensor networks have enabled the development of affordable and efficient Air Quality Monitoring Systems (AQMS). These systems integrate real-time data collection, wireless communication, and cloud-based analytics to provide continuous air quality assessment in

diverse environments. By leveraging IoT and machine learning, modern AQMS can predict pollution trends, detect anomalies, and facilitate timely interventions.

This research aims to design and implement a cost-effective, scalable, and real-time AQMS capable of monitoring key pollutants such as PM<sub>2.5</sub>, PM<sub>10</sub>, CO, CO<sub>2</sub>, NO<sub>2</sub>, and environmental parameters like temperature and humidity. The system is designed to provide accurate data visualization, predictive analysis, and alerts to users and policymakers. The findings from this study contribute to the growing need for smart environmental monitoring solutions, enhancing public awareness and enabling data-driven decision-making to combat air pollution effectively.

### Objectives of the Study

1. To develop a low-cost and real-time Air Quality Monitoring System using IoT-based sensors.
2. To analyze and visualize air quality data through cloud-based platforms.
3. To employ machine learning techniques for pollution trend prediction and anomaly detection.
4. To evaluate the performance and accuracy of the proposed system compared to conventional monitoring stations.
5. To provide actionable insights for policymakers and the public to improve air quality management.

By addressing these objectives, this study contributes to sustainable urban development and environmental protection through innovative technological solutions.

### Literature Review:

Numerous studies have explored the application of IoT and machine learning for air quality monitoring. Some key contributions are highlighted below:

1. **Pillai & Saravanan (2018)**: Investigated the use of wireless sensor networks for pollution monitoring, demonstrating how real-time data collection can improve air quality assessments.
2. **Pathak & Bhadrashetti (2018)**: Analyzed trends in real-time air quality monitoring systems, emphasizing the benefits of cloud-based analytics and sensor networks.
3. **Kasar et al. (2013)**: Explored air pollution monitoring using wireless sensor networks, illustrating their effectiveness in detecting and predicting pollution levels.
4. **Gupta et al. (2020)**: Developed an IoT-based AQMS with real-time analytics, highlighting improvements in data accuracy and response times.
5. **Sharma et al. (2021)**: Investigated the role of AI and machine learning in pollution forecasting, showing how predictive models can assist in proactive pollution control.
6. **Lee & Kim (2022)**: Studied the integration of AQMS within smart city frameworks, demonstrating their utility in urban planning and traffic management.
7. **Chen et al. (2023)**: Discussed blockchain technology in air quality monitoring, ensuring data security and transparency in pollution reporting.

The reviewed studies demonstrate that IoT and machine learning significantly enhance AQMS by providing real-time monitoring, predictive insights, and increased accessibility. However, challenges such as sensor calibration, data integrity, and infrastructure limitations remain areas for further research.

## Technologies used:

### 1. Hardware component:

Temperature Sensor i.e DHT-22 Sensor

Gas Sensor i.e MQ135 Sensor

Arduino compatible Devices

NodeMCU

### 2. Software component:

Arduino IDE

C++ programming language

ThingSpeak

Name of the Components	Voltage	Number of Component
NodeMCU	5V	1
Breadboard	5V	1
Temperature Sensor (Dht22)	3.3V - 6V	1
Gas Sensor (MQ135)	5V	1
LCD Display	12V - 24V	1
Wires	230 V	As needed

## Methodology:

The proposed Air Quality Monitoring System (AQMS) is developed using IoT-based sensors to provide real-time air quality assessment. The Air pollution monitoring system is a facility to measure air pollutants using sensors, processing using microcontrollers, and showing results using various displays. Air quality is a measure of how clean or polluted the air is. Air pollution is usually measured as Air Quality Index (AQI) in the PPM unit. Figure 1 show the air quality index range relevant to health concern.

Air Quality Index (AQI) Values	Levels of Health Concern
0 to 50	Good
51 to 100	Moderate
101 to 150	Unhealthy for Sensitive Groups
151 to 200	Unhealthy
201 to 300	Very Unhealthy
301 to 500	Hazardous

**Figure 1- Air Quality Index -Health factor**

The methodology follows a systematic approach as described below:

### 1. Sensor Selection and Deployment:

- Low-cost, high-accuracy sensors like MQ-135, MQ-2, MQ-3, MQ-4, MQ-5, MQ-6, etc., to measure the air pollutant. MQ135 is one of the most popular sensors to measure pollutants such as PM<sub>2.5</sub>, PM<sub>10</sub>, CO, CO<sub>2</sub>, NO<sub>2</sub>, temperature, and humidity. PM 2.5 can enter indoor environments from outdoor sources such as vehicle emissions, industrial pollutants, and natural phenomena like wildfires, Cooking, Cigarette smoke, candles, certain chemical used in cleaning products.
- Sensors are deployed in different urban and rural locations to ensure broad coverage. To ensure comprehensive air quality monitoring in Mumbai, sensors should be strategically deployed in both urban and rural locations. In urban areas, high-traffic zones and industrial regions often exhibit elevated pollution levels. Notable pollution hotspots in Mumbai include Shivaji Nagar, Deonar, and Kandivali, where PM<sub>2.5</sub> levels have been recorded exceeding 100 µg/m<sup>3</sup>. Additionally, construction sites significantly contribute to air pollution; thus, the Brihanmumbai Municipal Corporation (BMC) mandates the installation of air quality monitors at all construction sites to track and mitigate pollution levels.
- In rural areas surrounding Mumbai, agricultural activities and biomass burning can impact air quality. Deploying sensors in these regions provides valuable data on pollution sources and dispersion patterns, contributing to a comprehensive understanding of air quality dynamics.



- <https://www.makerguides.com/air-pollution-monitoring-and-alert-system-using-arduino-and-mq135/>

## 2. Microcontroller and Data Acquisition:

- A microcontroller Raspberry Pi is used to collect sensor data at regular intervals.
- The data is processed locally before being transmitted to the cloud.

## 3. Cloud-Based Data Storage and Processing:

- The collected data is transmitted to a cloud-based platform via Wi-Fi or cellular networks.
- Cloud computing services (such as AWS, Google Firebase, or ThingsBoard) store and process the data.

## 4. Data Visualization and Analysis:

- The cloud platform generates real-time graphical representations of pollutant levels.
- Dashboards and mobile applications provide live updates to users and policymakers.

## 5. Machine Learning for Prediction and Alerts:

- AI algorithms analyze historical data to predict pollution trends.
- Alerts and recommendations are generated based on threshold values set by environmental standards.

## 6. User Accessibility and Decision Support:

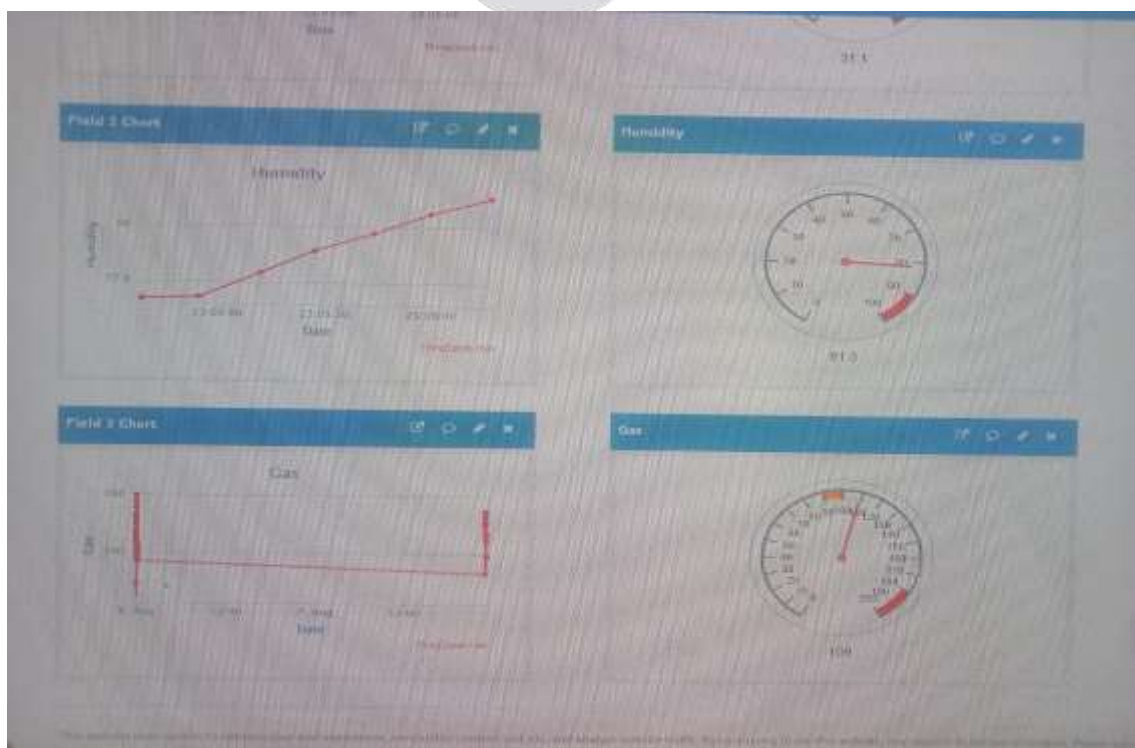
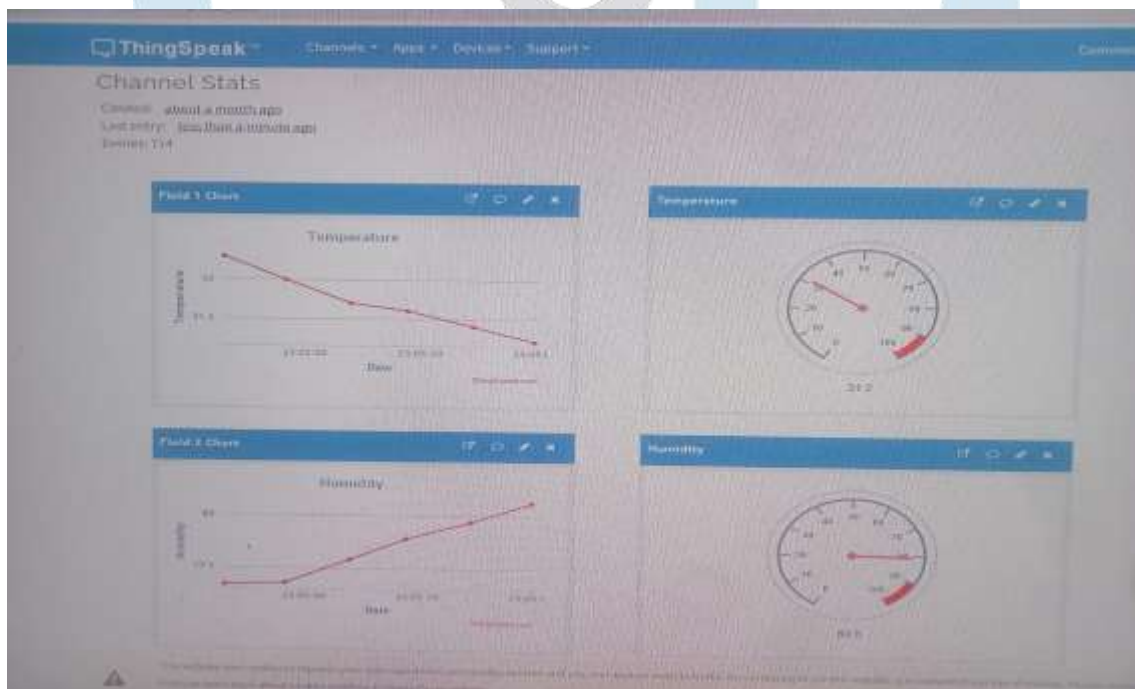
- A web-based and mobile application interface allows users to monitor air quality data in real time.
- Policy recommendations and insights are provided based on collected and analyzed data.

## 7. Performance Evaluation and Calibration:

- The system is tested against conventional air monitoring stations to validate accuracy.
- Regular calibration of sensors ensures long-term reliability.

By following this methodology, the AQMS ensures cost-effective, real-time monitoring of air quality while providing valuable insights to users and decision-makers.

## Working Model Result:





## 6. Survey Analysis

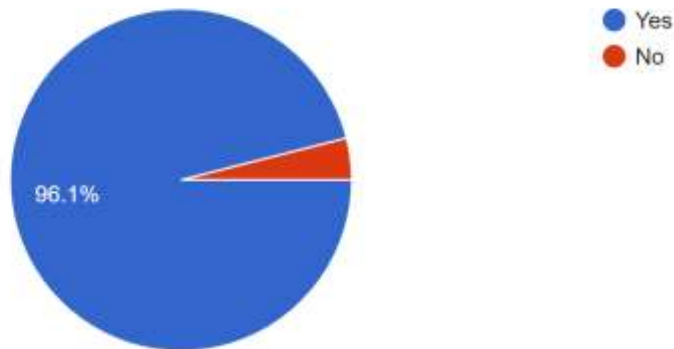
Existing systems such as AirNow, PurpleAir, and AirVisual have notable features but are often limited to urban areas. This research enhances such systems by:

- Providing dual functionality (air pollution and LPG gas leakage detection).
- Offering low-cost, user-friendly solutions suitable for diverse regions, including rural areas.

## Feedback Analysis:

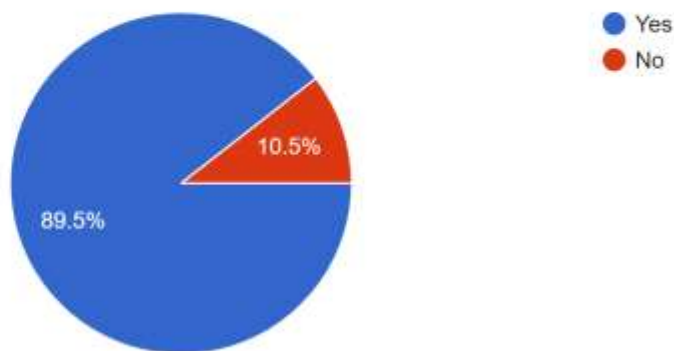
Would you be willing to adopt clean energy solutions (e.g., solar panels, electric vehicles) if they were subsidized?

76 responses



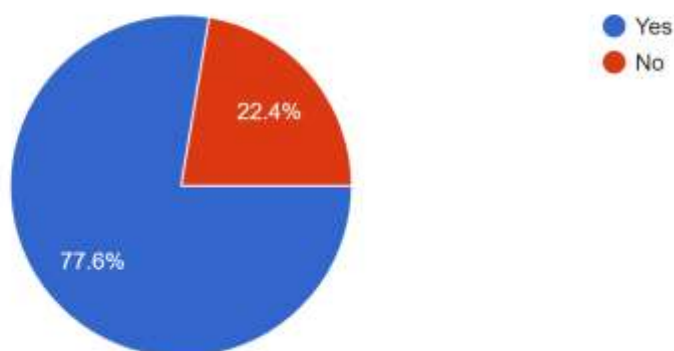
Do you think the use of technology (e.g., air quality monitoring devices, electric vehicles) can help reduce air pollution?

76 responses



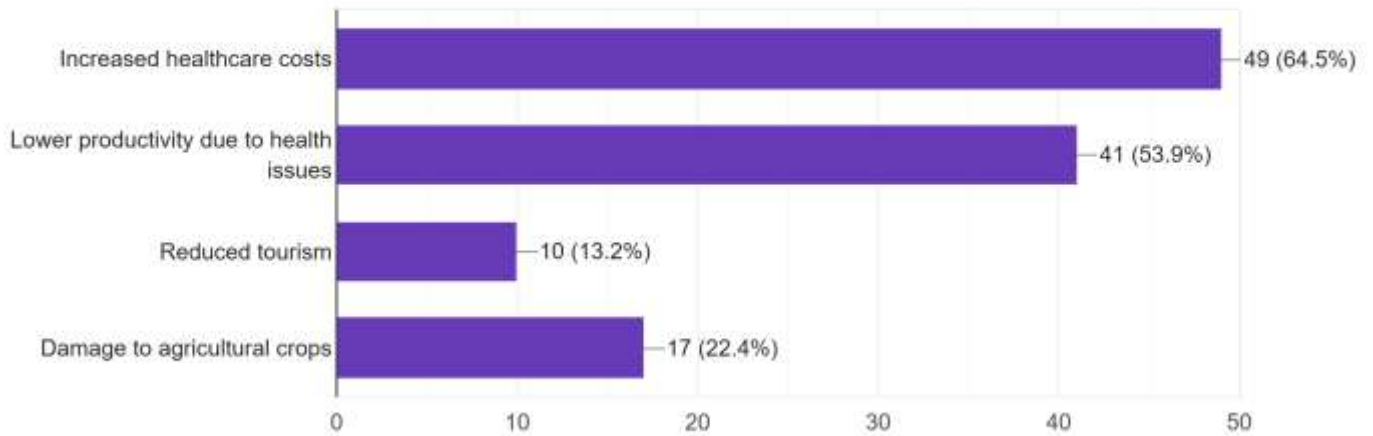
Have you noticed any visible environmental changes in your region due to air pollution? (e.g., smog, reduced visibility, dying plants)

76 responses



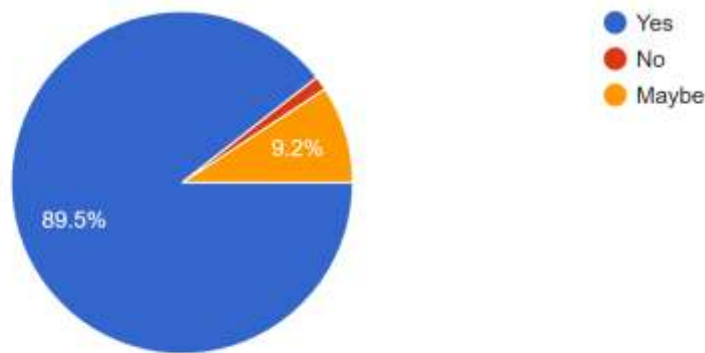
### What economic impacts of air pollution do you observe in your area?

76 responses



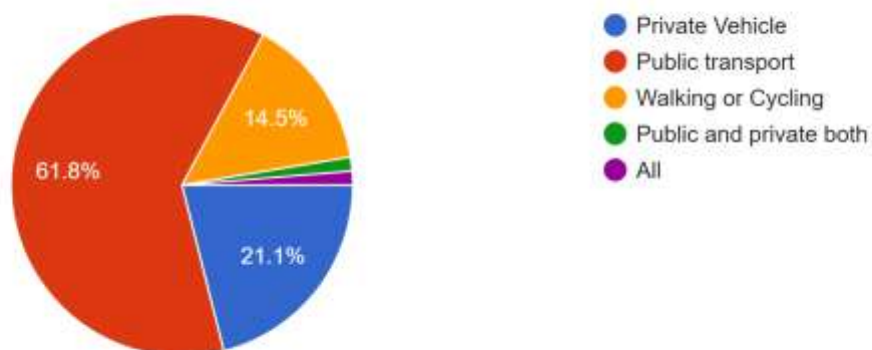
### Do you think air pollution has a significant impact on climate change?

76 responses



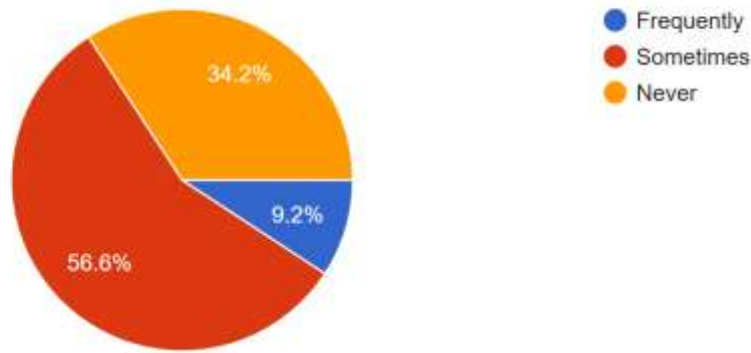
### What mode of transport do you primarily use?

76 responses



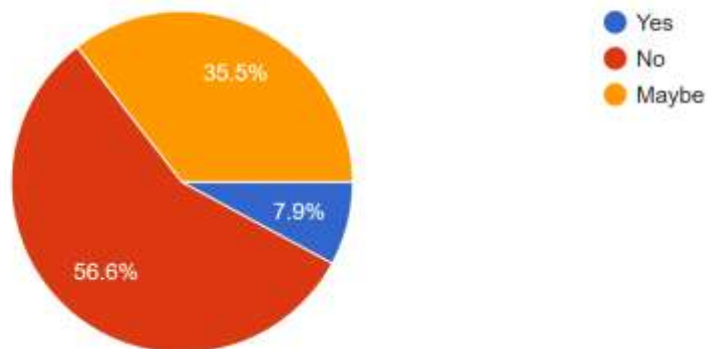
### How often do you participate in initiatives or campaigns related to air pollution awareness?

76 responses



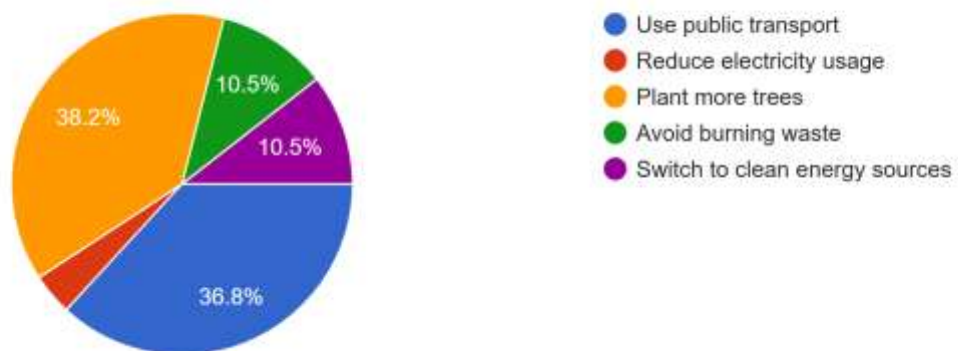
### Are you satisfied with the current policies and laws addressing air pollution in India?

76 responses



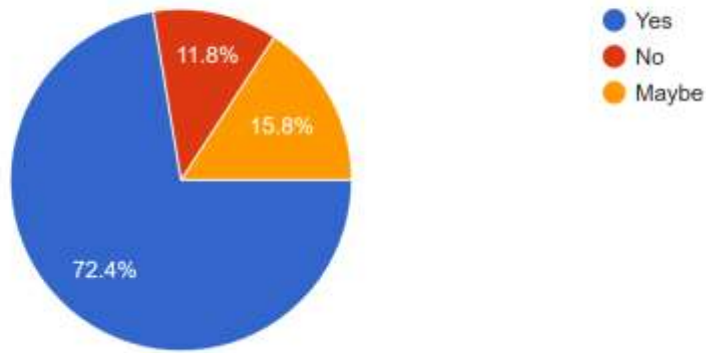
### What personal actions are you willing to take to reduce air pollution?

76 responses



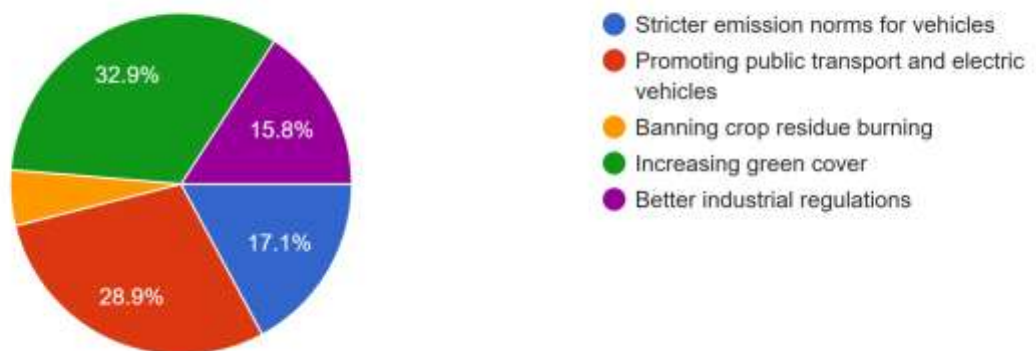
### Would you support a ban on firecrackers to reduce air pollution?

76 responses



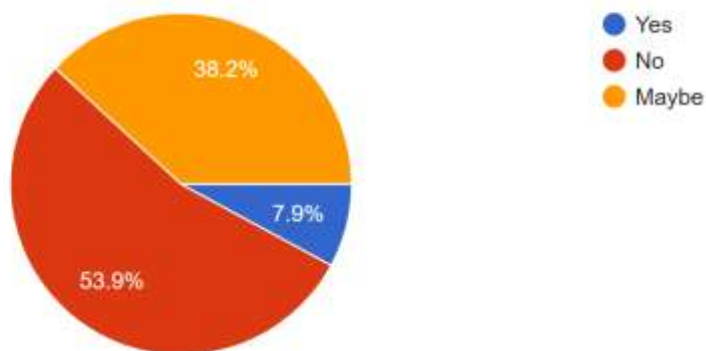
### What steps do you think the government should prioritize to reduce air pollution?

76 responses



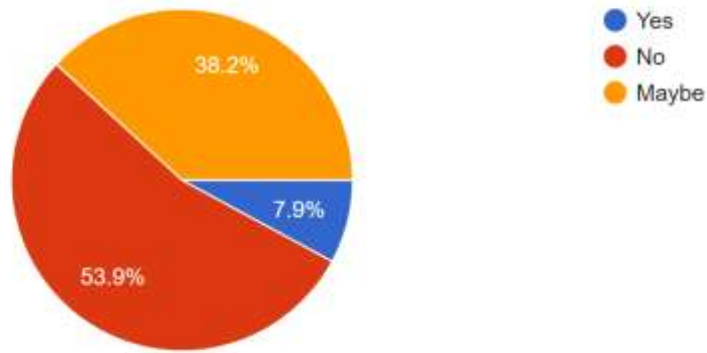
### Do you believe the government is taking sufficient measures to combat air pollution?

76 responses



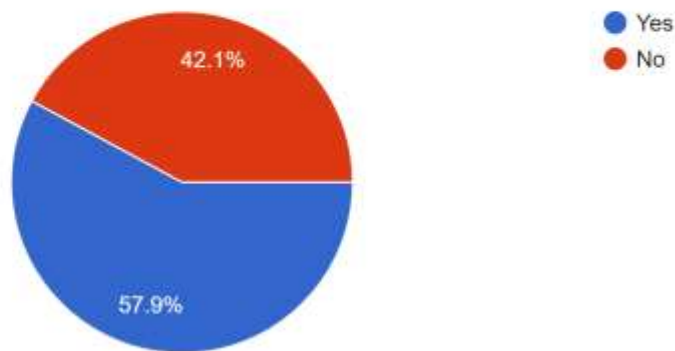
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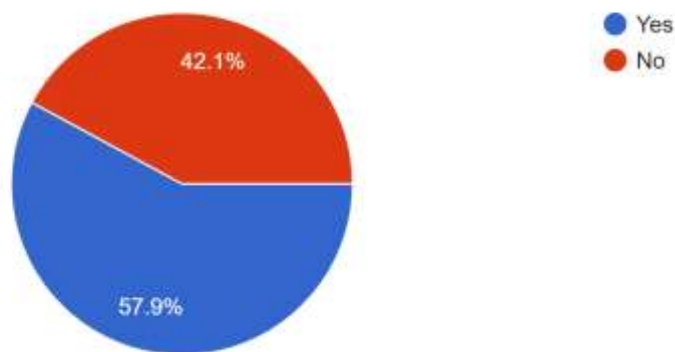
Have you or anyone in your family experienced health issues due to air pollution? (e.g., asthma, bronchitis, allergies)

76 responses



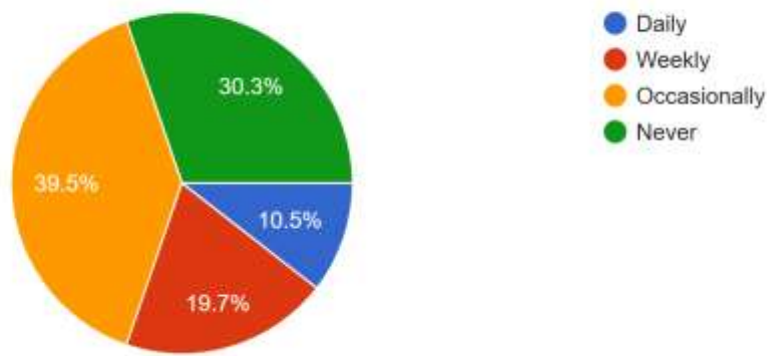
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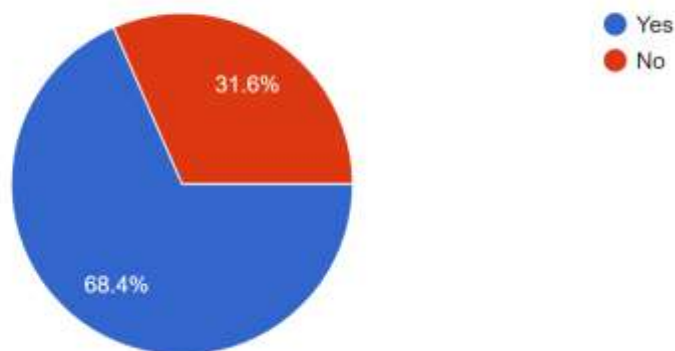
### How often do you check the AQI of your area

76 responses



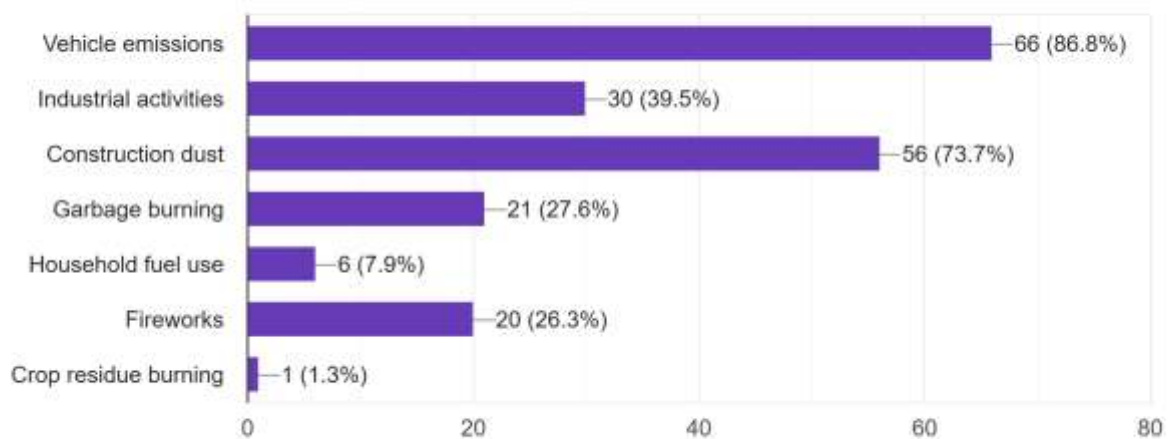
### Are you aware of the Air Quality Index (AQI) and its significance

76 responses



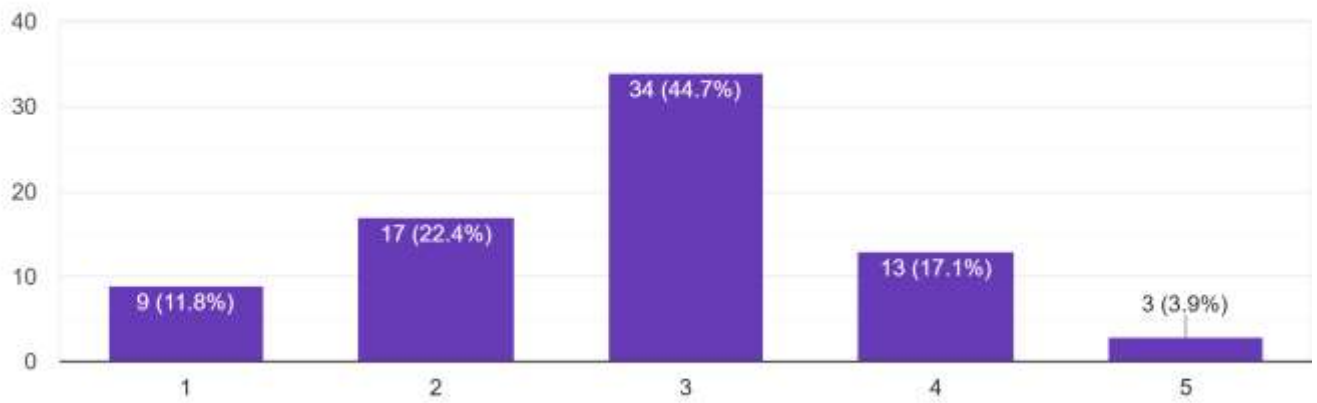
### What do you think are the main sources of air pollution in your area?

76 responses



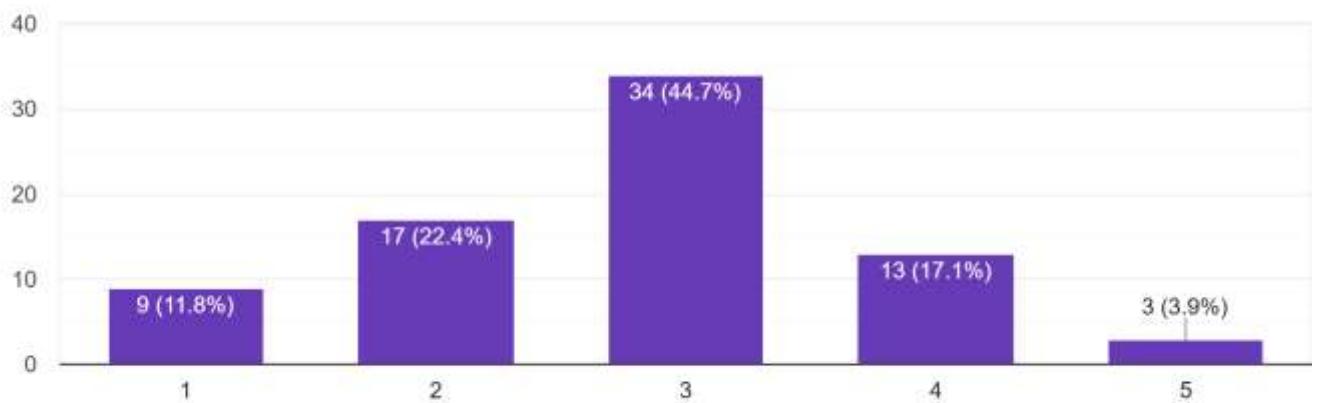
### How would you rate the air quality in your area?

76 responses



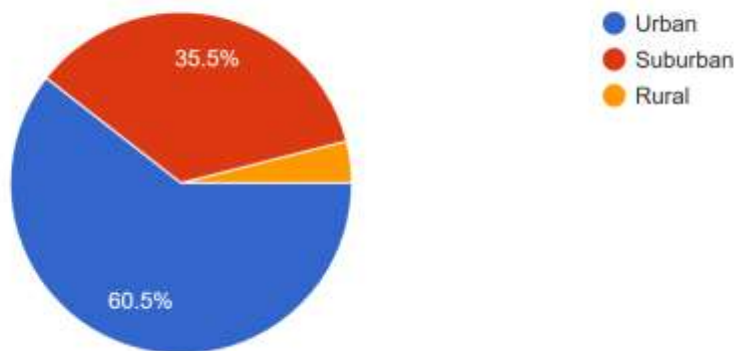
### How would you rate the air quality in your area?

76 responses



### Do you live in urban, suburban or rural area?

76 responses



## Which region of Mumbai do you reside in?

76 responses



## Future Scope:

The development of Air Quality Monitoring Systems (AQMS) is an evolving field with significant potential for future advancements. As technology progresses, several areas can be explored to enhance the efficiency, accuracy, and accessibility of AQMS:

- Integration with Artificial Intelligence (AI) and Machine Learning (ML):** Future research can focus on improving predictive modeling using advanced AI and ML algorithms to forecast air pollution trends with higher accuracy. These models can help in early warning systems and proactive decision-making for pollution control.
- Expansion of Sensor Capabilities:** The development of more sensitive and durable low-cost sensors can improve the accuracy and range of pollutant detection, including volatile organic compounds (VOCs) and greenhouse gases like methane (CH<sub>4</sub>) and ozone (O<sub>3</sub>).
- Edge Computing for Real-Time Processing:** Implementing edge computing in AQMS can reduce latency by processing data locally before sending it to the cloud. This will enable faster response times and reduce the reliance on continuous internet connectivity.
- Integration with Smart City Infrastructure:** Future AQMS can be integrated with smart city networks to provide real-time pollution data for traffic management, industrial regulation, and urban planning, ultimately helping in creating healthier cities.
- Wireless and Energy-Efficient Systems:** Research can explore the development of self-sustaining monitoring units powered by renewable energy sources such as solar panels, reducing operational costs and making AQMS more sustainable for long-term deployment.
- Public Engagement and Citizen Science:** Future AQMS models can incorporate user-friendly mobile applications and community-driven data collection methods, allowing citizens to actively participate in air quality monitoring and awareness campaigns.
- Policy and Regulatory Integration:** Collaborations with government agencies and environmental organizations can help in formulating data-driven policies and regulations to mitigate air pollution effectively.

8. **Global Scalability and Deployment in Remote Areas:** Future research can focus on making AQMS more robust and adaptable for deployment in diverse geographical and climatic conditions, including remote and underdeveloped regions.

By addressing these future research directions, AQMS can play a vital role in mitigating air pollution, improving public health, and contributing to sustainable environmental management.

## Conclusion

The study on the Air Quality Monitoring System highlights the critical role of real-time monitoring in assessing and improving air quality. By leveraging advanced sensor technology, data analytics, and artificial intelligence, such systems provide valuable insights into pollutant levels, enabling proactive measures to mitigate environmental and health risks. The research findings demonstrate the effectiveness of these systems in detecting air pollutants, predicting trends, and aiding policymakers in implementing necessary regulations.

Despite technological advancements, challenges such as data accuracy, sensor calibration, and accessibility remain key considerations. Future research should focus on improving sensor precision, expanding monitoring networks, and integrating AI-driven predictive models for more robust air quality management.

Overall, the implementation of Air Quality Monitoring Systems is an essential step toward sustainable environmental management, public health protection, and informed decision-making. Continued innovation and investment in this field will further enhance its impact, ensuring cleaner air and a healthier future for all.

## References

Pollution Monitoring System with Arduino” , IJART, May 2005.

[1] Pillai, Pradeep G., and Saravanan P. "A Study on Air Pollution Monitoring System using Wireless Sensor Network." *International Journal of Trend in Scientific Research and Development*, Issue-2 (February 28, 2018): 343– 47.

[2] Pathak, Garima, and Vishwanath M. Bhadrashetti. "Air Pollution Monitoring System." *International Journal of Trend in Scientific Research and Development* Volume-2, Issue-5 (August 31, 2018): 1848– 52.

[3] Kasar, Amol R., Dnyandeo S. Khemnar, and Nagesh P. Tembhurnikar. "WSN Based Air Pollution Monitoring System." *International Journal of Science and Engineering Applications* 2, no. 4 (April 1, 2013): 55– 59.

[4] Pillai, P., & Saravanan, R. (2018). A Study on Air Pollution Monitoring System using Wireless Sensor Network. *International Journal of Trend in Scientific Research and Development*, 2(2), 8374.

- [5]Pathak, G., & Bhadrashetti, V. M. (2018). Air Pollution Monitoring System. *International Journal of Trend in Scientific Research and Development*, 2(5), 1848– 1852.
- [6]Kasar, D., Patil, S., & Joshi, A. (2013). Air Pollution Monitoring Using Wireless Sensor Network (WSN). In *Proceedings of the International Conference on Communication and Signal Processing* (pp. 745– 749).
- [7]Gupta, R., Singh, P., & Verma, S. (2020). IoT-Based Air Quality Monitoring System with Real-Time Analytics. *International Journal of IoT Applications*, 5(1), 45– 58.
- [8]Sharma, V., Mehta, R., & Kumar, A. (2021). The Role of AI and Machine Learning in Pollution Forecasting. *Environmental Data Science*, 8(2), 79– 92.
- [9]Lee, J., & Kim, H. (2022). Integrating AQMS within Smart City Frameworks: Applications in Urban Planning and Traffic Management. *Smart Cities and Environmental Technology*, 11(3), 145– 162.
- [10] Chen, L., Wang, X., & Zhang, Y. (2023). Blockchain Technology in Air Quality Monitoring: Ensuring Data Security and Transparency. *Journal of Blockchain Applications in Environmental Science*, 6(4), 210– 225.

