



## The Role of Environmental Agencies in Air Quality Monitoring: A Technological Approach to Sustainable Education

Septi Almiyanti<sup>1\*</sup>, Delika Dinar Maulia Rahman<sup>1</sup>, Amar Amrullah<sup>1</sup>

<sup>1</sup>Department of Physics Education, Universitas Garut, Garut, Indonesia.

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Corresponding Author:

Author Name\*: Septi Almiyanti

Email\*: [septialmiyanti@gmail.com](mailto:septialmiyanti@gmail.com)

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**Abstract:** This study aims to examine the role of the Environmental Agency (*Dinas Lingkungan Hidup*, DLH) in monitoring and managing air quality in Garut, West Java. The research focuses on understanding the challenges faced by the DLH, as well as the impact of their initiatives on air quality improvement. A qualitative descriptive approach was employed, utilizing semi-structured interviews with DLH personnel and document analysis. The findings indicate that while air quality in Garut is generally categorized as "good," there has been a noticeable decline in the air quality index from 94% in 2023 to 85.6% in 2024. The primary sources of air pollution identified were motor vehicle emissions and open burning of waste. The DLH's efforts, such as air quality monitoring, public education campaigns, and tree planting initiatives, have helped raise awareness, but challenges such as limited monitoring equipment and insufficient technical personnel persist. The study concludes that to improve air quality management, Garut needs to invest in advanced monitoring technology, strengthen human resources, and enforce stricter regulations. These findings have important implications for local environmental policy and suggest that integrated approaches involving technology and community engagement are essential for sustainable air quality management.

**Keywords:** Air quality, environmental agency, Garut, pollution sources, public education

### Introduction

Air quality is a significant indicator of environmental health and directly influences the well-being of communities (Bacos et al., 2024; W. Guo et al., 2021; Lal et al., 2020). In recent years, Indonesia has seen a noticeable increase in air pollution levels due to rapid urbanization, population growth, and industrial activities (Rahman et al., 2024). These factors, compounded by the growing number of motor vehicles and the open burning of waste, have led to a deterioration in air quality in several urban areas (*Kementerian Lingkungan Hidup dan Kehutanan*, 2024). As urban environments expand, it is crucial to evaluate the role of local environmental agencies in monitoring and managing air quality. This study explores how the involvement of agencies, particularly the *Dinas Lingkungan Hidup* (DLH) or Environmental Agency, can be enhanced through technology, providing a sustainable solution to the challenges posed by air pollution.

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Air quality in urban areas is measured by monitoring pollutants such as particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), carbon monoxide (CO), nitrogen dioxide (NO<sub>2</sub>), and sulfur dioxide (SO<sub>2</sub>), all of which have detrimental effects on human health, particularly on the respiratory system (Nyayapathi et al., 2025; Sharma et al., 2024). In Indonesia, major cities have witnessed significant increases in the concentrations of these pollutants, posing severe health risks, including respiratory illnesses and impaired lung function. For instance, in the city of Garut, West Java, studies have shown a significant rise in vehicle emissions and a lack of adequate green spaces to absorb pollutants, exacerbating the urban air quality crisis (Alamsyah et al., 2021). These environmental challenges underscore the need for more effective monitoring systems that can detect pollution levels accurately and offer timely interventions.

The role of environmental agencies, especially in local government units such as Garut, is central to addressing these challenges. These agencies are tasked with implementing policies, monitoring air quality, and raising public awareness about the health risks of pollution. However, despite the significance of their roles, there remains a gap in the technological resources and infrastructure necessary for continuous, real-time monitoring. Inadequate equipment for measuring air pollutants, such as PM<sub>2.5</sub> and CO levels, limits the effectiveness of current monitoring systems. Additionally, the shortage of skilled technical staff hampers the ability to sustain year-round air quality surveillance (Alamsyah et al., 2021).

The introduction of technological innovations in monitoring air quality has the potential to bridge this gap. With advancements in sensor technologies, remote sensing, and data analytics, environmental agencies can enhance their monitoring capabilities and provide more accurate, real-time data (Chen et al., 2022; Chibueze Izah, 2025). This technology can also support educational campaigns aimed at raising public awareness and encouraging proactive measures to reduce air pollution. For example, the use of mobile applications and online platforms for air quality reporting can empower local communities to engage with and contribute to monitoring efforts. By integrating these technologies into educational programs, the DLH can help foster a culture of environmental responsibility and sustainability in the population.

In Garut, as in many other cities, public awareness campaigns have made some progress in educating residents about the dangers of air pollution. However, there is still much work to be done in terms of ensuring that these educational efforts are continuous and effective. Technological tools, such as interactive online resources and mobile apps, could play a critical role in sustaining public engagement over time (Amarulloh & Irvani, 2025a; Berigüete et al., 2024; Caputo et al., 2023). Moreover, they could serve as a platform for sharing real-time air quality data, allowing individuals to make informed decisions about their daily activities, such as avoiding areas with high pollution levels. These efforts, combined with educational outreach, can encourage community participation in mitigation actions, such as reducing vehicle emissions and adopting environmentally friendly waste disposal methods.

The educational approach to air quality management is not only about raising awareness but also about integrating environmental responsibility into everyday practices (Altassan, 2023; Kousar et al., 2022). By using technology, the DLH can provide accessible educational materials, such as webinars, workshops, and digital courses, which can be targeted at schools, businesses, and local communities. This will ensure that air quality issues are not only understood but actively addressed by all sectors of society. Furthermore, it will build capacity within local governments to respond effectively to air quality issues and equip residents with the knowledge they need to make sustainable choices.

In conclusion, the role of environmental agencies in monitoring air quality is crucial, and technological innovation offers an effective path forward. By adopting advanced monitoring tools and integrating them into educational programs, local governments can improve both the quality of air and public awareness. This holistic approach, combining technology and education, can pave the way for a more sustainable and healthy future. As Garut's case study demonstrates, while challenges remain, the continuous enhancement of environmental policies through technology and public engagement will lead to tangible improvements in air quality management.

## Method

This research utilizes a qualitative descriptive approach, aiming to explore the role of the Environmental Agency (*Dinas Lingkungan Hidup*, DLH) in air quality monitoring in Garut. The qualitative method was chosen because it allows for a detailed examination of the perceptions and experiences of key stakeholders, particularly those directly involved in air quality management (Amanda et al., 2025; Amarulloh & Irvani, 2025b; Creswell & Creswell, 2017). This approach is particularly useful for understanding complex social phenomena such as the effectiveness of governmental policies, the impact of public education campaigns, and the challenges faced by local authorities in managing air quality.

The research design employed is a case study, focusing on the DLH of Garut as the central agency responsible for air quality management. Case study methodology enables the researcher to delve deeply into the unique context of Garut, investigating the practical aspects of air quality monitoring, regulatory implementation, and public engagement in this specific locale. By focusing on one city, this study provides an in-depth understanding of how local environmental policies are implemented and the challenges that arise from them.

Data collection for this research was conducted through a combination of semi-structured interviews and document analysis. Semi-structured interviews were chosen to allow for flexibility in obtaining rich, detailed data from key informants within the DLH. These interviews were guided by a set of open-ended questions that encouraged participants to discuss the policies, strategies, and challenges related to air quality management. The participants were selected using purposive sampling, ensuring that individuals with significant knowledge and experience in air quality monitoring and environmental policies were included in the study. Key informants from the DLH were chosen for their roles in implementing air quality control measures, managing public outreach programs, and monitoring air pollution levels in Garut.

In addition to interviews, document analysis was also employed to supplement and triangulate the data. The documents reviewed included reports from the DLH on air quality monitoring, data on the air quality index (IKU), and other relevant local environmental policies. This allowed the researcher to cross-check information from interviews with official records and reports, providing a comprehensive understanding of the air quality situation and management strategies in Garut.

Data analysis was conducted using thematic analysis, which involves identifying and analyzing recurring patterns or themes within the data. The thematic analysis process was carried out in several stages. First, the data from interviews and documents were transcribed and coded. During the coding process, initial themes were identified based on the key issues discussed by the interviewees, such as pollution sources, monitoring practices, and community engagement efforts. After the coding process, the researcher grouped similar codes into broader categories and refined the themes through multiple iterations. The final step involved interpreting the themes and drawing conclusions about the effectiveness of the DLH's role in managing air quality and the challenges faced in the implementation of air quality management strategies.

## Result and Discussion

The results of this research reveal a significant decline in air quality in Garut, particularly in urban areas. According to the air quality index (IKU) data, the air quality in Garut was recorded at 94% in 2023, categorized as "good." However, in 2024, the air quality index dropped to 85.6%, although it still remained in the "good" category. This decline indicates an increase in pollution levels, which can be attributed to rising vehicular emissions and open waste burning in certain areas (Alamsyah et al., 2021). The major sources of air pollution identified in Garut include emissions from motor vehicles and the open burning of household waste. The increasing number of vehicles in urban areas, coupled with limited waste management systems, contributes significantly to the deterioration of air quality (Wallington et al., 2022; Zhang et al., 2022).

The DLH (*Dinas Lingkungan Hidup*) of Garut has been actively involved in monitoring air quality through various initiatives. These include strategic air monitoring at key locations such as city centers, markets, and transport hubs. The DLH also runs public awareness campaigns aimed at educating the

community about the health risks associated with pollution and the importance of maintaining clean air. Programs such as tree planting and greening initiatives have also been implemented, particularly in urban areas and schools, to reduce the impact of pollution. Despite these efforts, the DLH faces several challenges in the form of inadequate monitoring equipment, including a shortage of tools for accurately measuring pollutants such as PM<sub>2.5</sub> and CO levels. Additionally, there is a shortage of technical human resources, which hinders the DLH's ability to carry out air quality monitoring continuously throughout the year (*Kementerian Lingkungan Hidup dan Kehutanan, 2024*).

The findings of this research align with previous studies that have highlighted the impact of urbanization and industrialization on air quality in Indonesian cities. As noted by Husen (Husen et al., 2025), urban areas in Indonesia face increasing levels of pollution due to growing vehicular traffic and inadequate waste management systems. Similar to Garut, other cities such as Jakarta and Bandung have also experienced rising levels of pollutants, particularly PM<sub>2.5</sub>, which poses significant health risks to the population. The research by Guo et al. (J. Guo et al., 2023) supports this, stating that exposure to high concentrations of particulate matter can lead to respiratory diseases and long-term health complications, particularly among vulnerable groups such as children and the elderly.

The decline in Garut's air quality is primarily driven by two key factors: increased vehicle emissions and open burning of waste. The rise in vehicle emissions is directly correlated with the growth of urban population and economic activities, which leads to greater demand for transportation (Pratama et al., 2021). This situation mirrors findings from other studies in Southeast Asia, where similar trends have been observed. Previous research emphasizes that as the number of motor vehicles increases in urban areas, so does the level of pollution, especially in cities with limited public transportation infrastructure (Sun et al., 2022). Moreover, the practice of open burning, often a result of inadequate waste management services, exacerbates the air pollution problem (Alamsyah et al., 2021).

One of the most notable aspects of the DLH's efforts in Garut is its public outreach programs, which aim to increase awareness about the consequences of air pollution and encourage responsible behaviors, such as reducing car usage and proper waste disposal. These efforts are in line with research by Fadhullah et al. (Fadhullah et al., 2022), which underscores the importance of community participation in environmental management. Education and awareness programs are essential for fostering a culture of environmental responsibility, and technological innovations such as mobile apps and online platforms could further enhance public engagement in air quality monitoring and mitigation efforts (Abdillah, 2024).

However, despite the DLH's active involvement in air quality management, several challenges persist. The limited availability of monitoring equipment and technical personnel are significant obstacles to effective air quality monitoring. The lack of proper monitoring tools in many regions impedes the ability to track air pollution levels accurately, making it difficult to respond in a timely manner (Kumari et al., 2025). Additionally, as identified in this study, the shortage of skilled technical staff is a major limitation in Garut, preventing the DLH from conducting regular and comprehensive air quality assessments. To address these issues, there is a need for investment in both technology and human resources, as well as improved coordination between local authorities and national agencies to ensure more effective monitoring and regulation of air quality.

Furthermore, while the DLH's initiatives, such as tree planting programs and green space development, contribute positively to improving air quality, they are not sufficient on their own. Expanding and maintaining green spaces is crucial, but it must be accompanied by stricter regulations on emissions and waste management. Studies by Fahru et al. (Fau & Akliyah, 2013) emphasize that comprehensive policies, including stricter enforcement of emission standards and better waste management infrastructure, are essential to curbing pollution and improving urban air quality in the long run.

The research highlights that the DLH of Garut plays a vital role in air quality management, but it faces significant challenges related to limited resources and infrastructure. While public education efforts and green initiatives have had positive effects, more technological support and regulatory enforcement are necessary to effectively address the root causes of air pollution. By integrating advanced monitoring technologies and strengthening human resource capacity, Garut can improve its

air quality management practices, contributing to a healthier and more sustainable urban environment.

## Conclusion

This study highlights the important role of the Environmental Agency (DLH) in managing air quality in Garut, particularly through monitoring and public education efforts. While the overall air quality in Garut remains in the "good" category, the observed decline in the air quality index from 94% in 2023 to 85.6% in 2024 signifies a growing environmental concern, driven primarily by increased vehicle emissions and the open burning of waste. The DLH's initiatives, including air monitoring, public awareness campaigns, and greening programs, are crucial steps in mitigating pollution. However, the agency faces significant challenges, including limited monitoring equipment and a shortage of technical personnel, which hinder the effectiveness of air quality management efforts.

To improve air quality management in Garut, it is essential to enhance technological infrastructure and human resource capacity within the DLH. Investing in advanced monitoring technologies and training staff will ensure more accurate and continuous air quality assessments. Furthermore, stricter regulatory enforcement and comprehensive waste management solutions are necessary to address the root causes of pollution. By addressing these challenges, Garut can improve its air quality and promote a healthier, more sustainable environment for its residents.

## Conflicts of Interest

The authors declare no conflict of interest.

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