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REVIEW ARTICLE

Air pollution: the process of PM2.5 ingestion into the body and its impact on health

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Abstract

PM2.5 consists of fine particles with a size of less than 2.5 micrometers, which can be easily inhaled and enter the respiratory tract, causing various health problems. Transportation plays a major role in increasing PM2.5 levels in urban areas. Some things that can be done to minimize the impact of PM2.5 are the establishment of strict air quality standards, the development of environmentally friendly technologies for industry and transportation, and increasing public awareness of the impact of air pollution on health. In addition, government policies are also needed such as the use of public transportation and greening. So that the negative impact of PM2.5 on health can be minimized and air quality can be significantly improved.

Keywords: PM2.5, Air Pollution, Health, Control.

INTRODUCTION

Air pollution caused by Particulate Matter (PM2.5) has become a serious public health problem, especially in urban areas and near industrial sources. PM2.5 consists of fine particles with a size of less than 2.5 micrometers, which can be easily inhaled and enter the respiratory tract, causing various health problems. A study conducted in a residential area around the Steam Power Plant (PLTU) showed that the concentration of PM2.5 in the air reached 26.77 μg/m³ in the exposed group, much higher than 17.22 μg/m³ in the unexposed group. This finding shows a significant relationship between the level of PM2.5 exposure and increased health complaints, such as coughing (70%) and eye irritation (47%) in the exposed group (Arba, 2019).

Air pollution caused by Particulate Matter 2.5 (PM2.5) is a serious problem that impacts public health and environmental quality. Research in various cities, including Bogor and Bandung, shows that PM2.5 concentrations vary significantly depending on emission sources and weather conditions. In Bogor, analysis using the AERMOD model revealed that the highest PM2.5 concentration reached

85.5 μg/m³, while field measurements recorded a maximum value of 53.68 μg/m³. This suggests that the transportation sector plays a major role in increasing PM2.5 levels in urban areas, with factors such as temperature, humidity, and wind speed also contributing to variations in concentrations (Iriani and Pribadi, 2023).

In Bandung City, measurements show that although PM2.5 concentrations in some places are still below the standards set by the government, many days of measurements show PM2.5 levels that exceed the limits set by the World Health Organization (WHO). This raises concerns about the long-term health impacts for residents, especially related to the increasing cases of acute respiratory infections (ARI) related to exposure to this pollutant (Wellid et al., 2024). In general, data shows that PM2.5 pollution is influenced not only by human activities, such as vehicle traffic, but also by natural factors that can worsen or improve air quality.

MATERIALS AND METHODS

This study uses a literature review approach by collecting data from various previous studies to analyze air pollution caused by PM2.5. In this process, a number of relevant literature sources were accessed, including a search on Google Scholar, which is an effective platform for finding scientific articles and journals related to health and environmental issues. By utilizing this database, this study aims to provide a comprehensive understanding of how PM2.5 air pollution can enter the body and its control measures.

RESULTS AND DISCUSSION

Air pollution caused by Particulate Matter (PM) 2.5 is becoming an increasingly pressing public health problem, especially in densely populated urban areas. PM 2.5 consists of fine particles measuring less than 2.5 micrometers that can be easily inhaled and penetrate deep into the respiratory system, causing a variety of serious health problems (Schneider et al., 2020). When exposed to air pollution, PM2.5 particles can be inhaled and penetrate the lower respiratory tract until they reach the alveoli, which are the site of gas exchange between oxygen and blood. This process occurs because the very small size of PM2.5 allows them to evade the natural filtration in the upper respiratory tract. After reaching the alveoli, these particles can enter the bloodstream through the capillaries present there, triggering various reactions in the body (Ridayanti et al., 2022; Sembiring, 2020). Studies have shown that short-term exposure to PM 2.5 can trigger inflammatory reactions in the lungs, causing respiratory symptoms, and worsening cardiovascular conditions (Maksum and Tarigan, 2022). In addition, long-term exposure is associated with an increased risk of chronic obstructive pulmonary disease (COPD), decreased lung function, and potentially premature death (Wellid et al., 2024). In Indonesia, especially in big cities like Bandung and Jakarta, PM2.5 levels often exceed the limit set by WHO, which should not be more than 5 μg/m³. Research conducted in Bandung City shows that increased PM2.5 concentrations contribute to increased cases of acute respiratory infections (ARI) among children (Pertiwi et al., 2024).

Other information indicates that children are the most vulnerable group to the negative impacts of air pollution, where complaints such as shortness of breath and asthma increase significantly when PM2.5 concentrations are at high levels. Research conducted at green open space locations (RPTRA) showed a significant relationship between exposure to PM2.5 during the day and evening with respiratory complaints, including shortness of breath, runny nose, and sore throat (Inaku and Novianus, 2020).

PM2.5 particles can be easily inhaled and enter the respiratory tract, until they reach the alveoli in the lungs. Once in the alveoli, PM2.5 can penetrate the blood vessels through the diffusion process that occurs during gas exchange , potentially causing various health problems. In addition, PM2.5 can trigger oxidative stress and systemic inflammation associated with increased blood glucose and insulin levels. Research shows that long-term exposure to PM2.5 can cause insulin resistance and

increase the risk of diabetes mellitus. This disorder occurs due to the activation of macrophages that stimulate the release of pro-inflammatory cytokines such as TNF-α, which have a negative impact on the body's metabolism and can worsen overall health conditions. In addition, exposure to PM2.5 is also associated with increased levels of C-reactive protein (CRP), which is an indicator of inflammation in the body and indicates a greater inflammatory reaction due to exposure to these fine particles (Ramdhan et al., 2020).

Control Efforts

Pollution control caused by Particulate Matter (PM 2.5) is increasingly urgent, considering the serious impact it can have on public health. PM 2.5 is a fine particle with a size of less than 2.5 micrometers that can penetrate the respiratory system and enter the bloodstream. Exposure to these particles can cause various health problems, ranging from eye irritation, coughing, and shortness of breath, to increasing the risk of death (Arba, 2019).

Controlling air pollution, especially that caused by fine particles such as PM2.5, requires a series of coordinated and continuous efforts to protect public health. Based on Government Regulation No. 41 of 1999, preventive measures against air pollution include the establishment of Ambient Air Quality Standards (BMUA) and Non-Moving Source Emission Quality Standards (BMESTB), which aim to ensure that all activities that produce emissions comply with the established standards.

1. Pollution handling is done by requiring parties that produce pollution to routinely monitor and report emissions, and adopt environmentally friendly technology. In addition, one important step is to improve the public transportation system and increase green spaces in urban areas. The development of efficient and comfortable public transportation infrastructure can reduce dependence on private vehicles, which is one of the main factors causing exhaust emissions.
2. Another important step is to improve the public transportation system and increase green spaces in the city. By building effective and comfortable public transportation infrastructure, we can reduce dependence on private vehicles, which are one of the main factors causing exhaust emissions (Saly and Metriska, 2023).

Another effort in pollution control is the tree planting program, which plays a crucial role in filtering pollutants from the air and creating green spaces that can improve the quality of life in urban areas. In addition to technical and policy strategies, public education is also vital. Socialization about the use of Personal Protective Equipment (PPE), such as masks, in areas prone to pollution can help the community reduce direct exposure to PM2.5. Participatory approaches in environmental management, such as group discussions and skills training, can raise awareness and encourage changes in community behavior regarding the importance of maintaining air quality (Rivai et al., 2022).

CONCLUSIONS

Short-term exposure to PM2.5 can worsen existing health conditions, while long-term exposure has the potential to cause chronic diseases and premature death. According to WHO data, air pollution is responsible for millions of deaths each year, with PM2.5 being one of the main causes. To control PM2.5 pollution, various efforts need to be carried out in an integrated manner. This includes setting strict air quality standards, developing environmentally friendly technologies for industry and transportation, and increasing public awareness of the impacts of air pollution on health. In addition, government policies that support the use of public transportation and urban greening are also very important to reduce PM2.5 emissions. Public education on the use of personal protective equipment such as masks in areas with poor air quality is also an important step in protecting individual health from direct exposure to these hazardous particles. With this combination of strategies, it is hoped that the negative impacts of PM2.5 on health can be minimized and air quality can be significantly improved.

Author contributions

Josfirin Uding Rangga: Conceptualization, analysis, draft writing, and editing.

Conflict of Interest

There is no conflict of interest in this study.

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Data availability

Data related to the findings of this study are available at the corresponding author.

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