



Environmental Health Risk Analysis of Water and Air Pollution

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Abstract

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Environmental pollution is a global issue that has a significant impact on human health, particularly through water and air. This study aims to analyze health risks resulting from exposure to chemical and biological contaminants using an environmental health risk analysis approach. A qualitative method was employed, utilizing secondary scientific data from various publications over the past five years obtained through an online literature search. The results indicate that water pollution caused by heavy metals and pathogenic microorganisms contributes to an increased risk of infectious diseases and vital organ disorders. Meanwhile, air pollution resulting from particulate matter and hazardous gases is associated with an increase in respiratory and cardiovascular diseases. The environmental health risk analysis approach provides a systematic overview of the risk levels faced by the public. Furthermore, the integration of various environmental media demonstrates that the impacts of pollution are complex and mutually interactive. Therefore, comprehensive and sustainable control efforts are required to minimize health risks and improve environmental quality and community well-being.

1. Introduction

Environmental pollution is one of the global problems that continues to increase and has a significant impact on human health. Deteriorating environmental quality, especially in water and air media, has been associated with an increase in various diseases, both infectious and non-infectious. Exposure to pollutants, both chemical and biological contaminants, can trigger complex and ongoing health problems. Globally, environmental pollution has even been identified as one of the main factors causing the burden of disease and death, especially in developing countries with suboptimal environmental management systems (Livingston et al., 2024). In addition, the development of industrialization, rapid urbanization, and population growth have also increased pressure on the environment and increased potential exposure to hazardous substances (Fuller et al., 2022).

Water quality is one of the important aspects in determining the degree of public health. Water used for daily use, including drinking water and clean water, is particularly susceptible to contamination by various pollutants. Heavy metals such as arsenic, nitrates, and manganese can enter the water system through industrial, agricultural, and domestic waste activities, and have the potential to cause serious health impacts if exposed in the long term (Khan et al., 2020). In addition to chemical contamination, biological pollution is also a major concern, especially the presence of pathogenic bacteria such as *Escherichia coli* which is an indicator of fecal pollution. Microbiological contamination in drinking water has been shown to contribute to the high incidence of diarrheal diseases and gastrointestinal infections in various regions (Owho & Ndakara, 2022).

In addition to water, air quality also has an important role in influencing human health. Air pollution caused by fine particulate matter (PM₁₀), as well as harmful gases such as nitrogen dioxide (NO₂) and sulfur dioxide (SO₂), have been linked to an increased risk of respiratory, cardiovascular, and other health disorders. Long-term exposure to air pollutants can cause respiratory system damage and worsen chronic disease conditions, especially in vulnerable groups such as children, the elderly, and individuals with certain health conditions (Pozzer et al., 2023). Furthermore, air pollution also contributes significantly to the global burden of disease, making it one of the urgent public health issues to be addressed (Lee et al, 2021).

To understand the relationship between exposure to environmental pollutants and their impact on human health, a systematic and measurable scientific approach is needed. One of the widely used approaches is environmental health risk analysis. This approach includes hazard identification, exposure analysis, as well as risk characterization that allows for an assessment of the level of health risk due to exposure to specific pollutants. Environmental health risk analysis provides a comprehensive framework for evaluating potential health impacts and serves as a basis for decision-making related to environmental management (Emmanuel et al., 2022).

Although there have been many studies that discuss environmental pollution and its impact on health, there are still limitations in studies that integrate different types of contaminants and environmental media simultaneously. Most studies tend to focus on one type of pollutant or one environmental medium alone, so it does

not provide a comprehensive picture of the complexity of the interactions between various environmental factors and human health. In addition, studies linking exposure levels to population characteristics, especially vulnerable groups, are still relatively limited.

Therefore, research is needed that is able to integrate the analysis of chemical and biological contaminants in various environmental media, as well as comprehensively evaluate their impact on human health. This approach is expected to provide a deeper understanding of the relationship between environmental quality and health risks, as well as support effective pollution prevention and control efforts. This study aims to analyze health risks due to exposure to chemical and biological contaminants in environmental media, especially water and air, using an environmental health risk analysis approach.

2. Literature Review

2.1. Environmental Pollution and Its Impact on Health

Environmental pollution is a condition for the entry of substances, energy, or other components into the environment that causes a decrease in environmental quality and negatively impacts human health. In recent decades, increased industrial activity, urbanization, and population growth have accelerated the degradation of environmental quality, especially in water and air media. The impact of this pollution is not only local, but has also become a global problem that affects various aspects of human life. Studies show that environmental pollution contributes greatly to the

global burden of disease, including respiratory, cardiovascular, and digestive system disorders (Livingston et al., 2024).

Water pollution, for example, is often caused by the entry of domestic, industrial, and agricultural waste that contains harmful chemicals and pathogenic microorganisms. The presence of heavy metals such as arsenic, nitrates, and manganese in drinking water can have toxic effects on the human body if exposed in the long term (Khan et al., 2020). In addition, microbiological contamination such as *Escherichia coli* bacteria is the main indicator of fecal contamination that can cause diarrheal diseases and gastrointestinal infections (Owho & Ndakara, 2022).

On the other hand, air pollution is also an important factor that affects public health. Exposure to air pollutants such as fine particulate matter (PM₁₀) and toxic gases such as nitrogen dioxide (NO₂) has been linked to an increased risk of respiratory and cardiovascular diseases. Research shows that air pollution contributes significantly to the global death rate, especially in regions with high pollution levels (Pozzer et al., 2023). Therefore, understanding the impact of environmental pollution on health is important as a basis for prevention and control efforts.

2.2. Environmental Health Risk Analysis (ARKM)

Environmental Health Risk Analysis (ARKM) is a scientific approach used to assess potential health impacts due to exposure to pollutants in the environment. This method involves several main stages, namely hazard identification, exposure analysis, dose-response analysis, and risk characterization. This approach allows researchers to measure the level of risk that individuals or populations may

experience as a result of exposure to certain contaminants in the environment (Emmanuel et al., 2022).

In the context of environmental pollution, ARKM is often used to evaluate health risks due to exposure to heavy metals, air pollutants, and microbiological contamination. Through this approach, risk values such as *Risk Quotient* (RQ) can be calculated which indicates whether an exposure is within safe limits or has the potential to cause health impacts. The use of this method is very important in providing a quantitative picture of the level of risk faced by the community due to environmental pollution.

In addition, ARKM also plays an important role in supporting *evidence-based decision-making*. The results of risk analysis can be used as a basis for the formulation of environmental policies, the determination of quality standards, and the planning of mitigation strategies. Studies show that an integrated approach in risk analysis, which includes a variety of environmental media such as water and air, can provide a more comprehensive understanding of the impact of pollution on human health (Zhang et al., 2024).

However, the implementation of ARKM still faces several challenges, such as limited exposure data, variability of individual characteristics, and complexity of interactions between contaminants. Therefore, it is necessary to develop a more comprehensive and integrative method so that environmental health risk analysis can provide more accurate and relevant results in supporting public health protection efforts.

3. Methods

This research uses a qualitative approach by utilizing scientific data available online through various reliable sources. The qualitative approach was chosen because it was able to provide a deep understanding of the phenomenon of environmental pollution and its impact on human health based on the interpretation of various scientific findings that have been published. The data used in this study are secondary data obtained from scientific journal articles, reports of international organizations, as well as academic publications relevant to the topic of environmental pollution and health risk analysis. Data sources are selected based on certain criteria, namely published in the last five years, namely 2020 to 2024, have relevance to the research topic, and come from journals or institutions that have high credibility.

The data collection process is carried out through literature search using academic search engines such as Google Scholar, Elsevier, ResearchGate, and other journal databases. Keywords used in the search included terms related to water pollution, air pollution, microbiological contamination, and environmental health risk analysis. After the search process is carried out, the next stage is the selection of literature based on the suitability of the topic, the quality of the sources, and the completeness of the information presented. Literature that did not meet the criteria or had significant data limitations was not included in the analysis.

The data that has been collected is then analyzed using qualitative descriptive analysis techniques. This analysis is carried out by identifying, grouping, and interpreting the information contained in each source to find patterns, relationships,

and differences between research findings. The focus of the analysis is directed at the relationship between environmental quality, type of contaminants, exposure levels, and potential health risks posed. In addition, this study also pays attention to the integration aspect between various environmental media, such as water and air, in influencing human health.

To ensure the validity of the data, this study uses the source triangulation technique, which is by comparing information obtained from various different references. This approach aims to improve the accuracy and reliability of the analysis results by reducing the bias that may arise from one particular source. In addition, the data interpretation process is carried out systematically and objectively so that the results of the research can provide a comprehensive picture of health risks due to environmental pollution.

Using this method, the research is expected to produce an in-depth and integrated analysis of the relationship between environmental pollution and its impact on human health, as well as provide a solid basis for the development of further research and the formulation of science-based policies.

4. Results

Based on the results of analysis of various scientific sources that have been studied, it was found that environmental pollution, both in water and air media, has a significant relationship with increased health risks in humans. Various types of contaminants, both chemical and biological, play a major role in degrading the quality of the environment and triggering various health problems. The results of

the study show that exposure to pollutants is not only influenced by the concentration of contaminants, but also by the duration of exposure, individual characteristics, and environmental conditions (Emmanuel et al., 2022).

In water media, pollution is generally caused by the presence of heavy metals, harmful chemical compounds, and pathogenic microorganisms. Heavy metals such as arsenic, nitrates, and manganese are found in various water sources due to industrial, agricultural, and domestic waste activities. Long-term exposure to these metals can lead to serious health problems, including nervous system damage, kidney disorders, as well as an increased risk of cancer (Khan et al., 2020). In addition, poor water quality is also often associated with high levels of microbiological contamination, particularly indicator bacteria such as *Escherichia coli*, which indicate the presence of fecal contamination (Owho & Ndakara, 2022).

Microbiological contamination in water has a direct impact on public health, especially in the form of gastrointestinal infectious diseases. Data show that the consumption of water contaminated with pathogenic microorganisms can increase the incidence of diarrhea, especially in vulnerable groups such as children and the elderly. In addition, inadequate sanitation conditions contribute to worsening water contamination levels and increasing the risk of exposure (Ahmed et al., 2020). This shows that water pollution is not only related to environmental aspects, but is also influenced by social factors and people's behavior.

On the other hand, air pollution also contributes greatly to health risks. Fine particulates such as PM10 and harmful gases such as nitrogen dioxide (NO₂) and sulfur dioxide (SO₂) are the main components of air pollutants that have a significant

impact on the respiratory system. Exposure to air pollutants can cause respiratory tract irritation, decreased lung function, as well as an increased risk of chronic diseases such as asthma and chronic obstructive pulmonary disease (Lee et al., 2021). In addition, long-term exposure to air pollution is also associated with an increased risk of cardiovascular disease and premature death (Pozzer et al., 2023).

The results of the analysis also show that the impact of air pollution is not evenly distributed throughout the population. Vulnerable groups such as children, the elderly, as well as individuals with certain health conditions have a higher level of vulnerability to exposure to air pollutants. Factors such as age, health status, and activity level also affect the level of exposure and the impact it causes. This suggests that health risk analysis needs to consider specific population characteristics to produce a more accurate assessment (Fuller et al., 2022).

In addition, the results of the study show that overall environmental pollution contributes greatly to the global burden of disease. The combination of water and air pollution leads to more complex and interinteracting health impacts. For example, individuals who are exposed to air pollution in the long term may also have a decreased immune system, making them more susceptible to infections caused by water contamination (Livingston et al., 2024). The interaction between these different types of pollutants shows the importance of an integrated approach in analyzing the impact of the environment on human health.

In the context of environmental health risk analysis, the results of the study show that this approach is able to provide a quantitative picture of the level of risk faced by individuals or populations. Through the calculation of parameters such as

Risk Quotient (RQ), it can be known whether an exposure is within safe limits or has the potential to cause health impacts. Studies show that an RQ value greater than one indicates the presence of significant potential health risks and requires control measures ((Zhang et al., 2024)). This approach is important in supporting evidence-based decision-making in environmental management.

In addition, the results of the analysis show that the integration between different types of contaminants in a single analytical framework provides more comprehensive results compared to an approach that focuses only on one type of pollutant. An integrated approach allows for a more comprehensive identification of interactions between contaminants and their impact on human health. This is in line with research findings that suggest that risk analysis spanning a wide range of environmental media can improve accuracy in health risk assessment (Chen et al., 2021).

Another factor that also affects health risks due to environmental pollution is the level of exposure affected by daily activities. Individuals who live in environments with high levels of pollution or have activities that increase exposure, such as working in industrial settings, are at greater risk for health problems. In addition, access to clean water and sanitation quality are also important factors in determining the level of public health risk (Wolf et al., 2023).

The results of the study also show that efforts to control environmental pollution still face various challenges, both in terms of technical and policy. Limited data, lack of sustainable environmental quality monitoring, and low public awareness are inhibiting factors in pollution control efforts. Therefore, a more comprehensive

and collaborative approach is needed between the government, the community, and the industrial sector in managing environmental quality.

The results of this study show that environmental pollution has a significant impact on human health and requires serious attention in control and prevention efforts. The environmental health risk analysis approach has proven to be effective in identifying and evaluating the level of risk posed by different types of pollutants, and can be used as a basis for more effective and evidence-based policy formulation.

5. Discussion

The results of the study show that environmental pollution has a strong relationship with increased human health risks, both through water and air media. These findings are in line with various studies that state that exposure to environmental contaminants is one of the main factors contributing to the global burden of disease (Livingston et al., 2024). In this context, pollution not only has a direct impact on health, but also interacts with other factors such as social, economic, and behavioral conditions of the community.

In water pollution, the presence of heavy metals and microbiological contamination has been proven to be the main risk factor for health problems, especially in the digestive system and vital organs. These findings support the results of previous studies that suggest that long-term exposure to heavy metals can lead to serious toxic effects, including impaired organ function and an increased risk of chronic disease (Khan et al., 2020). In addition, microbiological contamination such as *Escherichia coli* also shows a strong link with the incidence of infectious diseases,

especially diarrhea, which is still a public health problem in various regions (Owho & Ndakara, 2022).

On the other hand, air pollution shows a significant impact on the respiratory and cardiovascular systems. Exposure to air pollutants such as fine particulate matter and harmful gases has been shown to increase the risk of chronic diseases as well as premature death. This is consistent with findings that air pollution is one of the main risk factors for non-communicable diseases at the global level (Pozzer et al., 2023). In addition, vulnerable groups such as children and the elderly show a higher level of vulnerability to these exposures, thus requiring special attention in health protection efforts.

The environmental health risk analysis approach used in this study is proven to provide a systematic framework in evaluating the impact of pollution on health. Through this approach, the level of risk faced by individuals and populations can be identified, allowing the formulation of more effective control strategies. Previous studies have also shown that an integrated approach in risk analysis can improve accuracy in assessing health impacts due to exposure to different types of contaminants ((Zhang et al., 2024)).

However, this study also shows that there are still various challenges in managing environmental pollution, such as limited data, lack of continuous monitoring, and low public awareness. Therefore, collaborative efforts are needed between various parties to improve the quality of the environment and reduce the health risks posed. Thus, the results of this study not only reinforce previous

findings, but also provide a basis for the development of more comprehensive and scientifically evidence-based policies.

6. Conclusion

Environmental pollution, whether in water or air, is a major factor contributing to increased risks to human health. Research findings indicate that the presence of chemical contaminants such as heavy metals and biological contaminants such as pathogenic microorganisms can degrade environmental quality and trigger various health issues, ranging from infectious diseases to chronic conditions. Additionally, air pollution caused by particulate matter and hazardous gases has been shown to have significant impacts on the respiratory and cardiovascular systems. The environmental health risk analysis approach provides a systematic framework for identifying, analyzing, and evaluating the level of risk posed by exposure to pollutants. Through this approach, a more comprehensive understanding of the relationship between environmental quality and its impact on human health can be obtained. Integrating analyses across various environmental media is essential for understanding the complexity of interactions among different types of pollutants. This study underscores the importance of integrated and sustainable efforts to control environmental pollution. Collaboration among various stakeholders and increased public awareness are necessary to maintain environmental quality. Thus, health risks from pollution can be minimized, and the quality of life for the community can be sustainably improved.

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