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# The Interaction of Air Quality to Acid Rain: An Unexplored Nexus

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ABSTRACT

From an ethical standpoint, the intricate connection between acid rain and air quality—both of which are caused by human actions like burning fossil fuels—is examined. These environmental problems harm ecosystems and human health and have similar sources of pollution. The study aims to better understand the relationship of air quality to the occurrence of acid rain by taking this ethical point of view into account. In this study, we employed a comprehensive literature review spanning various academic papers and sources surrounding areas of acid rain and air pollution. The finding shows that acid rain is primarily linked to subpar air quality, marked by increased levels of pollutants like PM2.5, NOx, and VOCs. The reduction in air pollution during holidays suggests a significant contribution of human activities to the resulting PM2.5 concentration, which is characteristic of Acid Rain. However, other factors also contribute to acid rain such as location, methodology, or other natural events. Although seasonal factor also plays a role in acid rain, some areas that have heavy city traffic shows elevated H+ levels, during both the dry and wet seasons. On the flip side, acid rain worsens air pollution by harming water sources and releasing specific chemicals into the atmosphere, highlighting the connection between environmental and health issues.



## Introduction

The narratives surrounding acid rain and inadequate air quality have predominantly been shown as separate issues within the broader context of environmental challenges confronting humanity in the 21st century. Both of these problems, stemming from the rapid industrialization, urbanization, and globalization of the preceding century, pose substantial difficulties that have had a lasting influence on human welfare, economies, and ecosystems. Nevertheless, the complex correlation between acid rain and air quality, a connection that remains largely unexplored, offers a more nuanced understanding of the many impacts that these variables exert on our environment. This research paper aims to examine the connection between acid rain and air quality by looking at it through the perspective of environmental ethics and by doing so, the research raises questions and inquiries on the underlying ethical responsibilities associated with our collective behaviors and failures to act.

Recent studies have shown that both natural and man-made emissions are responsible for the precipitation's acidity. However, previous works have not comprehensively considered the air quality caused by human activities in acid rain. According to data on acid rain from recent decades, the primary cause of acid rain is the emission of sulfur dioxide (SO2) and nitrogen oxide (NOx), which come from various human activities such as burning fossil fuels, burning waste in cars, and operating thermal power plants (US EPA, 2015).

The phenomenon of acid rain has been studied for several decades, and its detrimental effects on ecosystems and human health are well-documented in many research from decades ago. Acid rain occurs when sulfur dioxide and nitrogen oxides are released into the atmosphere and react with water vapor to form sulfuric acid and nitric acid. These acids then fall to the ground as acid rain, snow, or dry deposition, leading to a range of ecological and environmental problems, including the acidification of lakes and rivers, damage to forests, and corrosion of buildings and infrastructure (Mehta, 2015)

Similar to water quality issues, air quality issues have drawn a lot of interest because of their direct and indirect effects on human health and well-being. Poor air quality, which is frequently characterized by high levels of pollutants including particulate matter (PM2.5 and PM10), ground-level ozone (O3), carbon monoxide (CO), and volatile organic compounds (VOCs), is associated with respiratory and cardiovascular diseases, a shortened life expectancy, and financial costs from medical expenses and lost productivity (Cohen et al., 2017). Although both acid rain and poor air quality have been studied separately, there is an increasing understanding of how both environmental problems are interrelated. Sulfur dioxide and nitrogen oxide emissions, which are the main causes of acid rain, are also important in the production of other pollutants like ground-level ozone and fine particulate matter in the atmosphere (Sivaramanan, 2015). This overlap in emission sources highlights the need for a deeper comprehension of the connection between acid rain and air quality, as well as the moral implications of our responses to these problems.

Investigating the linkages between acid rain and air quality from an ethical perspective will help us better understand environmental issues. The intricacy of these issues is shown by looking at the shared sources of pollutants and the environmental effects of human activity, which also highlights the moral obligations that guide decisions and policies. A deeper comprehension of this link can aid in the creation of more potent mitigation measures for acid rain and better air quality, eventually protecting the health of current and future generations.

By investigating the relationships between acid rain and air quality from an ethical perspective, this research article aims to close the gap between the two environmental issues that initially appear to be distinct. We can better understand the complexity of these difficulties and the moral obligations that drive our decisions and policies by looking at the shared sources of pollutants and the environmental effects of human actions. A deeper comprehension of this link will enable us to create more efficient plans to reduce acid rain and enhance air quality, eventually ensuring the health of current and future generations.

## Method

The research conducted in this study involved a comprehensive literature review spanning various academic papers and sources. Specifically, the research falls into the category of a paper review, where the primary approach is to synthesize and gather existing data from previously published works by various authors to draw meaningful conclusions for the current research. To ensure a robust and thorough review, the study utilized a combination of national Indonesian and international proceedings and journals accessed through prominent academic search engines such as Google Scholar and Elicit.

Moreover, we also utilize the data collected from real-time air quality information platforms to provide real-time data for this research.

The central focus of this research was to investigate the correlation between acid rain and air pollution. In doing so, the research team limited their scope to scientific papers published from 2014 onwards. Papers published before 2014 were excluded from consideration. To capture a broad spectrum of information and insights, the researchers also included less prestigious journals in their review process, providing a more holistic perspective on the subject matter. It is important to note that the researchers placed a particular emphasis on peer-reviewed materials that were based on empirical research, thus ensuring the reliability and credibility of the sources used to support their findings.

In the context of this study, the literature review was narrowed down to encompass all aspects related to textiles, textile waste, textile production, and the various impacts associated with textile waste. The research culminated in a noteworthy discovery – despite the inherent disadvantages, the practice of reusing and recycling textiles can yield a range of positive outcomes. These benefits span from environmental conservation, where the reduction of textile waste contributes to a healthier planet, to economic advantages, such as the creation of new job opportunities within the recycling and upcycling industries. Thus, the research underscores the potential for sustainable practices within the textile industry to not only mitigate negative environmental effects but also foster economic growth.

## Result and Discussion

The literature review process collected data surrounding the area of air quality, in this case, the literature used in specific regions of Indonesia. According to IQAir regarding the data on Air Quality in Jakarta, especially on the pollutant PM2.5 (Particulate Matter Pollution), conclude that Indonesia's average PM2.5 concentration in 2022 is 6.1 times the WHO annual air quality guideline value. The presence of PM2.5 pollutants in the atmosphere not only poses risks to human health, including respiratory and cardiovascular issues but also contributes to the formation of acid rain. As stated by a study conducted in the eastern United States, the increasing sulfur deposition, a characteristic of acid rain, was associated with higher PM2.5 concentrations (Yim et al., 2019). When emitted into the atmosphere, PM2.5 particles can interact with water vapor, sulfur dioxide (SO2), nitrogen oxides (NOx), and other chemicals to form acidic compounds. These compounds, when deposited back onto the Earth's surface through precipitation, result in acid rain. This effect further exacerbates air quality issues and leads to detrimental impacts on ecosystems and infrastructure.

Other studies also reveal that air pollution affects acid rain, but varies depending on several factors such as location, methodology, or other natural events. One study analyzing the rainwater pH in various areas in Jakarta found that the rainwater pH showed a diurnal fluctuation with a low value during the night and morning, but a high value in the afternoon (Turyanti & Chaerunnisa, 2017). Since most of the public activities are done in the afternoon, this indicates how human activities impact the acidity of rain in the afternoon. Moreover, Turyanti & Chaerunnisa highlighted the impact of seasonal changes on the occurrence of acid rain, while also noting that vehicular traffic could play a role in acid rain incidents. This is evident from the elevated H+ levels found at Bundaran HI during both the dry and wet seasons. Using a different method, another study analyzed the particulate matter pollution (SPM, PM10, and PM2.5) during the feast of Ied Al Fitr in 2016 and 2017 indicating a further decrease in PM2.5 due to highly reduced inner-city traffic (Kusumaningtyas et al., 2018). These two research studies showed proof of how the quality of air affects the acidity of rain.

Moreover, the intricate relationship between the quality of the air and the occurrence of acid rain goes beyond immediate health concerns. It carries wider ecological and environmental repercussions. Research has shown that acid rain can be detrimental to aquatic ecosystems, particularly impacting freshwater environments like lakes and rivers. The acids present in acid rain can lower the pH levels of these water bodies, which in turn affects the aquatic life residing within them. This concern is particularly relevant in Indonesia, where regions experiencing acid rain coincide with areas abundant in freshwater resources. Acid rain can have many negative impacts on aquatic ecosystems, including the reduction of biodiversity of all structural elements due to the disappearance of species that were sensitive to acidification, modification of trophic structure, and decrease of fish stock (V. Patel, 2019). It is imperative to conduct in-depth assessments to fully comprehend the extent of acid rain's ecological influence on aquatic ecosystems and to formulate strategies for both mitigation and conservation. Additionally, recognizing the interconnectedness of air quality, acid rain, and their consequences underscores the necessity for comprehensive policies and practices that holistically address these environmental challenges. Approaching issues related to air quality and acid rain simultaneously presents an opportunity to adopt a more efficient and integrated strategy for safeguarding both human well-being and the environment.

## Conclusion

The findings of our study reveal that acid rain is primarily linked to subpar air quality, marked by increased levels of pollutants like PM2.5, NOx, and VOCs. The reduction in air pollution during holidays suggests a significant contribution of human activities to the resulting PM2.5 concentration, which is characteristic of Acid Rain. However, other factors also contribute to acid rain such as location, methodology, or other natural events. Although seasonal factor also plays a role in acid rain, some areas that have heavy city traffic shows elevated H+ levels during both the dry and wet seasons. On the flip side, acid rain worsens air pollution by harming water sources and releasing specific chemicals into the atmosphere, highlighting the connection between environmental and health issues. Our study stresses the effectiveness of addressing the root causes of both acid rain and poor air quality simultaneously. Solutions encompass implementing renewable energy sources, promoting urban sustainability, executing public awareness initiatives, enhancing digital tracking systems, and formulating comprehensive regulations.

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