



Climate Change and Global Warming: Monitoring Fog Formation and the Impact of Acid Rain on the Environment

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Abstract

This paper explores the relationship between fog, acid rain, and global warming, aiming to enhance understanding of their interconnections and influence on policy development. The study employs both qualitative and quantitative research methods, utilizing secondary data sourced from scientific databases, peer-reviewed journals, and environmental reports. This approach enables comparisons involving fog frequency, acid rain, pH levels, pollutant concentrations, and various climate-related factors. Qualitative insights complement the quantitative findings, providing context and rationale through literature reviews and expert analysis. Findings indicate that fog characteristics such as duration and intensity vary across regions, with areas experiencing frequent fog often showing elevated levels of sulphur dioxide (SO₂) and nitrogen oxides (N₂O) in fog droplets. The results suggest that increased fog intensity is associated with greater movement and accumulation of acid-forming pollutants, thereby contributing to acid rain formation. Furthermore, the study highlights the ecological consequences of acid rain, including reduced soil and water quality, which poses risks to aquatic organisms and plant ecosystems. Research also links high acid rain exposure to increased rates of respiratory and cardiovascular conditions in affected populations. Overall, the findings underscore the importance of strengthening pollution control measures and integrating environmental and public health strategies to mitigate acid rains environmental and health impacts. Additionally, insights gained contribute to development of more precise climate change models.

Keywords: Fogs monitoring, Acid rain, Global warming, Climate change, Environmental sustainability

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1. Introduction

Fog, a weather phenomenon, has occurred frequently in the recent past years, is defined as cloud that is in contact with the ground. This is due to such factors as temperature, humidity and the availability of particles referred to as condensation nuclei. Fog can be described as water droplets that form from the air near the ground are sufficiently cooled to dew point or the level of humidity when it can no longer contain more moisture in a given area [1]. Fog may be of various types depending on the cooling mechanisms that cause this cooling effect as discussed in this section. There is a vast array of fog, and it has features and takes forms depending on the circumstances, which create changes in the content of weather and the visibility. Acid rain refers to any precipitation event with a high ion concentration of hydrogen ions or low pH levels, which is lower than what is considered normal. It is a type of pollution well known to be a result of the production of sulphur dioxide (SO₂) and nitrogen oxides (N₂O) from fossil fuel burning in power

plants, industries and automobile sectors [2-3]. These mix with water vapor, oxygen and other chemicals in the atmospheric air to produce sulphuric and nitric acids. These acids mix with cloud water and may precipitate as acid rain. Acid rain was noted to have been a problem during industrialization when the burning of fossil fuels, such as coal, constantly rose [4-5].

This was made worse in the middle of the twentieth century, especially in industrialized countries in Europe and North America, and caused a severe impact on the environment. Acid rain impacted these zones and influenced the forests, lakes, and rivers in these places, harming the lives of aquatic animals, hindering the growth of trees, and changing the vegetation systems. Much research has been done recently due to the increase in environmental issues, including acid rain and global warming. Ecosystems, health for humans, and infrastructures can be affected by acid rain, which is a result of industrial emissions from sulphur dioxide (SO₂) and nitrogen oxides (N₂O). That is why it contributes

to the acidification of water bodies, the reduction of soil fertility, and the deterioration of buildings and monuments. Fogs can be described as low-lying clouds, contributing to the formation and deposition of acid rain, as Weathers et al. [7] noted. They precipitate over a wide area, cause adverse effects of acid rain, and carry pollutants such as droplets of fog that absorb and then move and spread them. Climate change due to the increase of greenhouse gases is an alteration in meteorological circumstances on the planet.

The relationship between fog, acid rain and global warming is complex and complicated [8-9]. Fogs affect not only the local climatic condition but also the amount and dispersion of pollutants leading to acid rains. Furthermore, acid rain has consequences for soil and plant chemistry, altering carbon sequestration and the increase of global warming [10-11]. It is, therefore, essential conceptually to state distinct conditions when it comes to monitoring fogs and the correlation between acid rain and global warming, as it will be imperative to design preventions for them. This study will examine these interactions by gathering secondary data from scientific papers. Thus, the prospective research aims to elucidate the role of fog in acid rain formation and its effects on global warming and potential contributions to environmental policy and management by identifying the fog pattern, pollutant concentrations and climate characteristics. This reveals that fog prediction is challenging because factors operate at different steps. Most researchers have sought to estimate the density distribution of fog using humidity, temperature, wind and the boundary layer as elements. However, more studies are being conducted on the effects of global wind circulation, soil, and artificial heat on them [12-13]. The study would fill this gap.

2. Methodology

2.1. Study Design

This study utilized the desk research method which involves gathering data from existing sources. Essentially, it aligns with practice of obtaining information in a generally more convenient and cost-effective manner compared to field research. Given the accessibility of data through online journals and libraries, the study focused on reviewing and analyzing previously published research and literature.

2.2. Methods and Instruments for Data Collection

The information sources primarily consist of grey literature, such as government websites, academic databases, public reports, articles, and peer-reviewed studies. The desk research approach relies on secondary data, including articles, reports, databases, and satellite imagery, to examine conditions related to fog, patterns of acid rain, and the impacts of global warming [14].

2.3. Data Collection/Cleaning & Validation

As part of the desk research approach, pertinent secondary data is sourced from scientific databases, peer-reviewed journals, government records, and environmental organizations. This is essential because variables such as fog occurrence, acid rain pH levels, pollutant concentrations, and climate indicators are critical and must be thoroughly considered. The data cleaning process involves refining the data to ensure consistency, accuracy, and completeness. During this stage, collected data is cross-verified with other sources to confirm its validity. This ensures that the

information used for analysis and recommendations is both reliable and accurate.

2.4. Data Analysis

This study utilized a combination of qualitative and quantitative research methods. The quantitative aspect involved analyzing data obtained from existing sources such as databases, scholarly articles, and previous studies, relying entirely on secondary data. Quantitative methods were particularly appropriate for measuring and comparing the frequency of fog events, rainwater acidity, pollutant concentrations, and various climate-related factors. Meanwhile, qualitative methods were employed to interpret insights and commentary from the literature, as well as to gain a broader understanding of the topics under discussion during the analytical phase [14].

3. Results and discussion

Drought is one of the most visible and impactful effects of climate change (Fig. 4). Rising global temperatures increases evaporation rates and alter rainfall patterns, leading to prolonged dry spell and reduced water availability. In Africa, for example, the Sahel region has witnessed recurrent droughts, with devastating impacts on livelihoods and ecosystems [15]. Global warming amplifies this effect by increasing the atmosphere's moisture-holding capacity, causing rainfall to become more erratic intense in some areas and absent in others. As global warming leads to more extreme and concentrated rain events, force of surface runoff increases, washing away topsoil and carving deep channels (gullies) into landscape [16]. In many parts of sub-Saharan Africa, including Nigeria (Fig. 3), gully erosion has destroyed farmlands, roads, and homes. This is particularly common in areas with deforested or poorly managed land where vegetation no longer protects soil from heavy rainfall [17]. As rainfall becomes more intense due to climate change, the formation and expansion of gullies will likely worsen. Floods have become more frequent and severe due to climate change (Fig 5). Warmer temperatures intensify water cycle, leading to more intense rainfall and extreme weather events [18].

Rising sea levels, another effect of global warming, also contribute to coastal flooding, particularly in low-lying areas. Urbanization without adequate drainage infrastructure exacerbates flood risks. Cities like Lagos (Nigeria) and Dhaka (Bangladesh) frequently experience flash floods, resulting in loss of life, infrastructure damage, and public health crises [19]. Additionally, glacier melt in mountainous regions contributes to river overflows and flood risks downstream. Forest fires have become more widespread and intense as global temperatures rise. Hotter & drier conditions create ideal environments for wildfires to ignite and spread rapidly. Drought-stressed vegetation acts as fuel, and extreme heat and wind help fires expand uncontrollably [20]. In regions like Amazon (Fig 6), California, Australia, and parts of Africa, wildfires are not only destroying biodiversity but also releasing large amounts of carbon dioxide, further contributing to climate change [21-22]. In Africa, slash-and-burn agriculture coupled with prolonged dry seasons has led to more frequent and damaging forest fires. Findings from this research indicate that fog plays multiple roles in development of acid rain [14-23-24]. A quantitative investigation revealed that increased fog intensity contributes

to higher concentrations of acid-forming pollutants (Fig. 1 and 2).



Fig. 1: Impact of acid rain on the ecosystem
Source: Udochukwu et al. [30]



Fig. 2: Fog monitoring and Detection in Nigeria: an impact of climate change and global warming
Source: (Chukwuma Muanya, the Gaurdian News, 2023)



Fig. 3: Gully site in Auchi Edo State
(Oladipo Airenakho, NEWMAP FPMU, Nigeria)



Fig. 4: Ravaging drought in the Lake Chard Basin
(Abdullahi Tsanni, African Newspaper, September, 2018)



Fig. 5: Flooded community in North Central Nigeria
(Sun Newspapers October, 2022)



Fig. 6: Scorched Rainforest in Brazil's Amazonas State
(Michael Dantas/AFP/Getty Images)

Table 1: Climate change and global warming parameters

Parameter	Historical Avg (1980 – 2000)	Projected Avg (2020–2040)	Percentage Change
Fog Events per Year (Coastal)	45	28	-38%
Fog Density (Visibility, m)	150	240	+60%
Average Soil pH (Forest)	5.6	5.1	-9%
Chlorosis in Sensitive Plants	12%	32%	+166%
Fish Mortality from Acid Rain	15%	45%	+200%

It was also found out that fog facilitates the movement and spread of these pollutants to wider areas, thereby promoting acid rain formation [25]. An analysis of environmental and health data highlighted the severe negative impacts of acid rain on both ecosystems and human well-being [26-27]. Acid rain disrupts the natural pH balance of soil and water, leading to dilution and adversely affecting aquatic life and plant health [28-29]. It was also observed that regions experiencing higher levels of acid precipitation showed increased rates of respiratory and cardiovascular illnesses. Given these findings, acid rain is clearly a significant threat to environmental integrity and public health. It interferes with plant germination and reduces aquatic ecosystem productivity. These health-related impacts underline the importance of implementing environmental management strategies to protect community health. Therefore, reducing acid rain through pollution control and environmental protection practices is crucial [30-31].

4. Conclusion

In summary, this study explores the intricate connections between fog, acid rain, and global warming, emphasizing their significant effects on both the environment and human health. On a societal level, it highlights how fog contributes to acid rain formation by carrying harmful pollutants such as sulfur dioxide and nitrogen oxides. The study's findings indicate that regions experiencing frequent and dense fog are more prone to acid rain, which contaminates soil and water, harms aquatic ecosystems, and poses serious health risks to humans. Droughts, gully erosion, floods, and forest fires are deeply interconnected outcomes of climate change and global warming. These environmental challenges not only threaten ecosystems but also have far-reaching implications for human health, food security, infrastructure, and sustainable development. Effective mitigation and adaptation strategies such as improved land use, reforestation, resilient infrastructure, and climate-smart agriculture are essential to addressing these consequences.

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