

Analysis of Acid Rain: A Global Perspective

Anadya A. Nair

Preface

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Thesis Statement

Acid rain is a major environmental issue that is caused by human activities such as burning fossil fuels and has far-reaching impacts on ecosystems, including pollution levels, geographical and ornithological effects, and the potential to disrupt the food chain. To mitigate these impacts, it is necessary to understand the causes of acid rain, the chemistry of precipitating acids, how to identify it, and its historical and mythological mentions. Public perception, including the opinions of common people, farmers, artisans, and scientists, plays an important role in creating awareness and implementing preventive measures. Images of acid rain impacts serve as a reminder of the devastating effects of human activities on the environment. Without adequate preventive measures, acid rain could worsen and lead to further environmental degradation, highlighting the urgent need for governments and individuals to take action and implement sustainable practices to prevent further damage.

What is Acid Rain?

When rains show a drastic amount of shift in their pH level^[1] (descending at 5.6 or less), they deposit acid through precipitating^[2] mixture comprising dry and hydrated acidic ingredients. This is what is understood and known as acid rain.

Acid rain may precipitate from the atmosphere, in a solid, liquid or gaseous state, mainly in the form of dust, fog, cloud water, rain, dew, sleet, snow and hail; this index includes both wet and dry conditions of the above-mentioned acidic components.

Terminologies:

[1] The level of hydrogen ion concentration on a pH scale. pH is generally measured from 0 (highly acidic, lowly alkaline{basic}) to 14 (highly alkaline{basic}, lowly acidic), which signifies the nature of a solution.

[2] Condensed water vapour rises and falls on the earth's surface under gravity.

Influence of Acid Rains on health, geography and pollution levels

Acid rain can severely influence its effects on the environment. Despite the deteriorating effects of unpolluted rain on entities, acid rain speedily promotes corrosion^[3], decay, breakdown and

deterioration of buildings, monuments & memorials, statues and several other entities and zones which come under its rainfall domain.

It increases pollution levels in an ecosystem^[4] and can be the potential to be the destroyer of the same. Acid rain is a cause of rusting^[5], and tarnishing^[6] of metals and also increases their corrosion rates, in particular, Steel, Iron, Bronze, Copper, Aluminium and other heavy metals.

Pollutants such as sulphur dioxide and nitrogen oxides can cause respiratory diseases or exacerbate them. Asthma and chronic^[7] bronchitis can make breathing challenging for people. Barring producing acid rain, pollution can also have minuscule particles. Particles and ozone obscure vision and make the air hazy. If these particles penetrate the lungs, they can either cause health tribulations or aggravate existing illnesses. Moreover, nitrogen oxides produce ground-level ozone. Ground-level ozone causes respiratory problems like bronchitis and pneumonia and it can even result in permanent damage to the lungs.

Acid rain has a clear ecological impact in aquatic environments, such as marshes, streams and lakes, where fish and other wildlife may be adversely affected. Rainwater that contains acid leeches^[8] aluminium from soil clay particles flows into streams and lakes. The greater the portion of acid presented, the greater the amount of aluminium unleashed.

Overall, acid rain can have a wide-ranging and long-term impact on soil, terrains, water and ecosystems. It is crucial to take measures to reduce the amount of sulphur dioxide and nitrogen oxides released into the atmosphere to mitigate the effects of acid rain and safeguard our environment.

Terminologies:

[3] Corrosion is the gradual chemical or electrochemical breakdown of a material, typically metal, caused by exposure to the environment or other external factors.

[4] An ecosystem is a community of living and non-living things that interact with each other in a specific environment. It includes all the organisms living in a particular area, as well as the physical environment that they live in, such as the air, water, and soil.

[5] Rusting is the process of corrosion of iron and steel caused by the reaction of these metals with water and oxygen in the presence of air or other oxidizing agents. Rust is the common name for a substance that forms when iron and oxygen react in the presence of water.

[6] Tarnishing is the process of discolouration and corrosion that occurs on the surface of metal objects over time, caused by exposure to air, moisture, and other environmental factors. Tarnishing can make metal objects appear dull, faded, or discoloured, and can also weaken the structure of the metal, making it more prone to damage.

[7] Chronic refers to a condition or disease that is persistent or long-lasting, typically lasting for several months or longer.

[8] A leeching action refers to the act of obtaining resources or benefits without contributing anything in return.

Ornithological impact of Acid Rain *Severely impacts the food chain*

The ornithological impact of acid rain refers to the consequences of acid rain on bird populations and their habitats. Acid rain can have an expansive range of unfavourable impacts on birds, which can lead to population downfalls and even extinction. One of the main ways acid rain affects birds is by damaging their habitats^[9].

Acid rain can acidify lakes and rivers, making them uninhabitable for aquatic birds such as loons and ducks. It can also damage the leaves of trees and other plants, making them negligibly nutritious for birds that feed on them. This can lead to a decline in the general health of bird populations and can make it more challenging for them to find food and shelter.

Acid rain can also have a direct impact on birds by making them more susceptible to disease and other health problems. The acidity of acid rain can damage the feathers of birds, making them less waterproof and more vulnerable to the elements. This can lead to hypothermia^[10] and other health problems in birds, which can further lessen their populations.

Another way in which acid rain can affect birds is by modifying the pH levels of their nesting sites. Acid rain can acidify the soil and make it more difficult for birds to nest and raise their young. This can lead to a decline in the reproductive success of bird populations, which can further decline their numbers.

Acid rain can also disrupt the food chain that birds rely on, killing off fish and other aquatic life and making plants less nutritious. This can usher in reduced populations of birds that feed on these organisms, which can additionally disrupt the ecosystem.

Overall, acid rain can have a wide-ranging and long-term impact on bird populations and their habitats. It is crucial to take measures to reduce the amount of sulphur dioxide and nitrogen oxides released into the atmosphere to mitigate the influences of acid rain and protect bird species and their habitats.

Terminologies:

[9] A habitat is a place where an organism or species naturally or normally lives and grows, providing the resources it needs to survive.

[10] Hypothermia is a medical emergency in which an individual's body loses heat faster than it can produce heat, causing a dangerously low body temperature.

Causalities of Acid Rain

Acid rains are caused by the emission of sulphur dioxide (SO_2) and nitrogen oxides (NO_x) into the atmosphere. These pollutants react with the atmosphere to form sulphuric acid and nitric acid, which then precipitate. There are several origins of these emissions, including power plants, factories, and vehicles. Power plants that burn coal and oil for energy, release substantial amounts of SO_2 and NO_x into the atmosphere. These plants are liable for up to 70 per cent of total SO_2 emissions. Factories that produce goods through chemical procedures also emit these pollutants, as do vehicles that burn fossil fuels. In addition, the usage of fertilizers in agriculture also contributes to the formation of nitric acid (HNO_3).

The outcomes of acid rain are across-the-board and can have profound environmental consequences and biohazards^[11]. Acid rain can cause soil and water pollution, leading to the death of fish and other aquatic life. It can also damage crops and forests, leading to decreased biodiversity. Acid rain can also have harmful effects on human health, causing respiratory problems and increasing the risk of cancer.

Various measures have been taken to reduce the causalities of acid rain, including introducing emissions control technology in power plants and vehicles and promoting alternative energy

sources such as wind and solar power. Governments have also introduced laws and regulations to limit the emission of SO_2 and NO_x from industrial and transportation sources.

In conclusion, acid rain is a serious environmental problem caused by human activities such as burning fossil fuels, industrial processes, and agriculture. To protect the environment and human health, it is important to continue to reduce the emission of pollutants that cause acid rain and to promote the use of clean and renewable energy sources.

Terminologies:

[11] Biohazards are biological substances or organisms that pose a threat to human health and safety, such as bacteria, viruses, toxins, or pathogens. These substances can cause serious diseases and infections and can be spread through contaminated food, water, air, or bodily fluids.

Chemistry of acid rain

The chemistry of acid rain concerns the chemical reaction of sulphur dioxide (SO_2) and nitrogen oxides (NO_x), originating from multiple factors such as lightning, volcanic eruptions, industrial activities, and manufacturing of acids and usage in various operations. They react within the atmosphere to form sulphuric acid (H_2SO_4) and nitric acid (HNO_3), which ultimately precipitate as acid rain.

Normal rainwater is slightly acidic due to its reaction with atmospheric carbon dioxide (CO_2), forming carbonic acid. Normal rainwater's acidity is also attributed to a small amount of nitric acid produced by the oxidation of nitrogen in the presence of water during lightning storms. Winds transport pollutants from smokestacks^[12] to form sulphuric and nitric acid mists with sunlight and vapours. At high temperatures, these acids remain as vapours and condense as "acid smut"^[13] at lower temperatures. The rate of acid formation is affected by oxidising agents and reaction properties.

Some notable and essential chemical compositions of the details as mentioned above, and more:

1. Sulphuric acid (H_2SO_4)
2. Nitric acid (HNO_3)
3. Carbonic acid (H_2CO_3)

4. Hydrochloric acid (HCl)
5. Phosphoric acid (H_3PO_4)
6. Acetic acid (CH_3COOH)
7. Formic acid ($HCOOH$)
8. Methanesulfonic acid (CH_3SO_3H)
9. Oxalic acid ($C_2H_2O_4$)
10. Citric acid ($C_6H_8O_7$)
11. Lactic acid ($C_3H_6O_3$)
12. Malic acid ($C_4H_6O_5$)
13. Succinic acid ($C_4H_6O_4$)
14. Tartaric acid ($C_4H_6O_6$)
15. Nitrogen oxides (NO_x)
16. Sulphur dioxide (SO_2)
17. Carbon monoxide (CO)
18. Ammonia (NH_3)
19. Chlorofluorocarbons (CFCs)
20. Volatile organic compounds (VOCs)

Terminologies:

[12] A smokestack, also known as a chimney or flue, is a tall vertical structure that is used to vent exhaust gases and smoke from industrial and power generation facilities. The primary purpose of a smokestack is to release the byproducts of combustion into the atmosphere at a high enough elevation to minimize their impact on the surrounding environment.

[13] Smut is a plant disease caused by various species of fungi that belong to the order Ustilaginales. The disease affects cereal crops, such as wheat, barley, corn, and oats, as well as other grasses.

How to identify acid rain?

Acid rain is a dangerous environmental phenomenon that can cause significant harm to our planet. The identification of acid rain is crucial to prevent further damage to the environment. One of the most apparent indicators of acid rain is the presence of acidic deposits on outdoor surfaces such as cars, buildings, and statues. These deposits can be seen as rust-like stains, discolouration, or erosion, and are particularly noticeable on surfaces made of limestone or marble. Acid rain can also cause the leaves of trees and other vegetation to turn yellow or brown and fall off prematurely.

Another way to detect the presence of acid rain is to look for changes in water quality. Acid rain makes lakes and rivers more acidic, which can harm aquatic life and cause the death of fish and other organisms. A visible sign of this change in water quality is cloudy, murky^[14], or discoloured water. Acidic water can harm the ecosystem, which can cause irreversible damage.

Air pollution is another indicator of acid rain. Pollutants such as sulphur dioxide and nitrogen oxides can contribute to the formation of acid rain. If you smell a strong odour of sulphur or other chemicals in the air, it may be a sign that acid rain is present in the environment. Therefore, monitoring air quality is crucial to detect and prevent the formation of acid rain.

Finally, monitoring the pH levels of soil and water is a reliable method to identify the presence of acid rain. Acid rain can lower the pH of soil and bodies of water, making them more acidic. By testing the pH levels of soil and water, it is possible to determine whether they have been affected by acid rain. Low pH levels severely impact the growth of crops and other vegetation, causing harm to the environment and the ecosystem.

In conclusion, identifying acid rain is essential to prevent further harm to the environment. The detection of acidic deposits on surfaces, changes in water quality, air pollution, and monitoring pH levels in soil and water are reliable methods to identify the presence of acid rain. I urge you to take prompt action and help in reducing the pollution that causes acid rain and protect our planet from the harmful effects of this phenomenon.

Terminologies:

[14] Murky is an adjective used to describe water or other liquids that are cloudy, turbid, or unclear in appearance. It is a term that is often used to describe water that is polluted or contains suspended particles or sediment.

What if acid rains do not stop?

Acid rain can have significant economic consequences, particularly in industries that rely on natural resources such as tourism and agriculture. When forests and water bodies are damaged by acidic precipitation, it can impact the tourism industry as visitors may be deterred^[15] from visiting areas with damaged natural resources. This can result in decreased revenue for local businesses and governments.

Similarly, the agriculture industry can be severely impacted by acid rain. Acidic soil can lead to reduced crop yields, affecting food production and supply. This can lead to increased food prices and food insecurity, particularly in areas where agriculture is a primary source of income and food production.

Acid rain can also damage buildings and infrastructure, leading to costly repairs and maintenance. Buildings made of materials such as limestone and marble are particularly vulnerable to acid rain as the acidic compounds can cause the material to dissolve and crumble over time. This can result in expensive repairs and restoration work, particularly for historical and cultural landmarks that cannot be easily replaced.

In addition to these economic impacts, acid rain can also have indirect economic consequences. For example, the health impacts of acid rain can result in increased healthcare costs and decreased worker productivity. Acid rain can also lead to increased energy consumption as people turn to air conditioning and other technologies to combat the impacts of air pollution.

The economic impacts of acid rain can be significant and far-reaching, affecting industries and communities across the globe. It is essential to continue efforts to reduce air pollution and address the issue of acid rain to prevent these economic consequences from becoming even more severe in the future.

Terminologies:

[15] To make somebody decide not to do something, especially by telling the person that it would have bad results.

Preventions of Acid Rain

Preventing acid rain requires addressing the root cause of the problem. One effective prevention strategy is to reduce emissions of sulphur dioxide and nitrogen oxides by using cleaner energy sources, such as wind and solar power, and by implementing stricter environmental regulations for industrial processes and transportation. Governments can also offer incentives for companies to adopt cleaner technologies and penalise those who fail to comply with regulations.

In addition to reducing emissions, several other prevention strategies can be implemented to mitigate the impact of acid rain. For example, treating acidic soil can help neutralise acidity and improve soil quality. This can be achieved through the use of liming^[16] materials such as limestone or by adding nutrients to the soil to counteract the negative impact of acid rain.

Another prevention strategy is to implement measures to protect water bodies from the effects of acid rain. This can include reducing nutrient pollution from agricultural runoff, restoring wetlands and other natural filters, and implementing programs to control and reduce the amount of acid rain that reaches water bodies.

In urban areas, prevention strategies can include planting trees and other vegetation to absorb pollutants and reduce the amount of acid rain that reaches the ground. Additionally, green roofs^[17] and walls can be installed on buildings to help absorb rainwater and reduce runoff.

Education and awareness campaigns can also play a critical role in preventing acid rain. By raising public awareness about the negative impact of air pollution and acid rain, individuals can be encouraged to adopt sustainable practices and support policy changes aimed at reducing emissions.

Finally, international cooperation is essential for preventing acid rain on a global scale. Many pollutants that cause acid rain are released across national borders, making it necessary for countries to work together to reduce emissions and address the issue. Organizations like the United Nations and the World Health Organization can facilitate international cooperation and provide technical assistance to countries that are working to address the problem of acid rain.

By implementing prevention strategies at the local, national, and international levels, we can reduce the impact of acid rain and protect the environment and human health for generations to come.

Terminologies:

[16] Liming is the application of calcium(Ca) and magnesium(Mg) rich materials in various forms, including marl, chalk, limestone, burnt lime or hydrated lime to soil In acid soils, these materials react as a base and neutralise soil acidity.

[17] Green roofs, also known as vegetative or living roofs, are roof structures that are partially or completely covered with vegetation, soil, and other components such as drainage layers and irrigation systems.

Images of acid rain impacts (may disturb some people, viewer's discretion advised)



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Opinions of common people, farmers, artisans and scientists on the incidence of acid rain

Acid rain is a phenomenon that has been a cause of concern for various groups of people such as common people, farmers, artisans, and scientists. The opinions of these groups on acid rain are based on their individual experiences and knowledge.

Common people, in general, are aware of the harmful effects of acid rain. They often see the visible effects of acid rain on the environment such as the destruction of buildings, plants, and aquatic life. They are concerned about the impact of acid rain on their health and the health of

their families. Common people also understand the need for government action to address the issue of acid rain.

Farmers, on the other hand, are particularly affected by acid rain as it can have a significant impact on their crops and livestock. Acidic soil can harm crops and reduce yields, leading to economic losses. Farmers, therefore, view acid rain as a serious problem that can have a direct impact on their livelihoods. They often advocate for government action to reduce the levels of acid rain in the environment.

Artisans, particularly those who work with materials such as marble and limestone, are also significantly affected by acid rain. Acid rain can corrode these materials, leading to damage and decay. Artisans, therefore, view acid rain as a significant threat to their craft and heritage. They often call for measures to protect cultural artefacts and buildings from the effects of acid rain.

Scientists, who study the environment and the effects of acid rain, have a deep understanding of the impact of acid rain on the environment. They view acid rain as a complex issue that requires comprehensive solutions. Scientists often advocate for a multi-pronged approach to addressing acid rain, including reducing emissions of sulphur dioxide and nitrogen oxides, as well as implementing measures to protect vulnerable ecosystems.

The Indian government has taken several steps and enacted various policies to mitigate the impact of acid rain on the environment.

1. Implementation of the National Clean Air Programme (NCAP): The NCAP is a comprehensive program launched by the government in 2019 to address air pollution, including acid rain. The program aims to reduce air pollution by 20-30% in the next five years by implementing measures such as reducing industrial emissions, improving transportation, and promoting clean energy.
2. Enforcing Emission Standards: The Central Pollution Control Board (CPCB) has set emission standards for industries, vehicles, and power plants to reduce the release of sulphur dioxide and nitrogen oxides. The government has also imposed a ban on the use of old and polluting vehicles in major cities.
3. Promoting Renewable Energy: The Indian government has set a target of achieving 175 GW of renewable energy capacity by 2022. This includes the promotion of solar and wind power, which do not emit harmful gases and thus do not contribute to acid rain.
4. Implementation of Forest Conservation Measures: The Indian government has implemented several measures to conserve forests, which play a crucial role in reducing acid rain. These measures include afforestation, preventing deforestation, and promoting sustainable forestry practices.

5. International Cooperation: India has also collaborated with other countries to address the issue of acid rain. For instance, India is a member of the Acid Deposition Monitoring Network in East Asia, which aims to monitor acid deposition in the region and take steps to reduce its impact.

Overall, the Indian government has taken significant steps to address the issue of acid rain through various policies and programs. However, there is still a need for continued efforts to reduce emissions and promote sustainable practices to protect the environment from the harmful effects of acid rain, which will be possible even more efficiently when the citizens start taking part in the initiatives.

History of acid rains

The history of acid rain can be traced back to the Industrial Revolution in the 18th and 19th centuries when coal became the primary source of energy for industries. The burning of coal releases large amounts of sulphur dioxide (SO_2) and nitrogen oxides (NO_x) into the atmosphere, which react with water, oxygen, and other chemicals to form sulphuric acid (H_2SO_4) and nitric acid (HNO_3). These acids then fall back to the ground in the form of acid rain.

The earliest historical mentions of acid rain can be found in the writings of 17th-century English chemist Robert Boyle, who observed that acidic fumes from burning coal could corrode marble and limestone. In the early 19th century, scientists began to document the impact of acid rain on vegetation, particularly in areas with heavy industrialization such as Manchester and Glasgow in the UK.

However, it was not until the 1960s and 1970s that acid rain became a major environmental concern. The first scientific studies linking acid rain to environmental damage were published in the 1950s, and by the 1970s, acid rain was identified as a major problem in Europe and North America. In 1980, the US Congress passed the Acid Deposition Act, which authorized research and monitoring of acid rain and its impacts on the environment.

Since then, significant progress has been made in reducing the emissions of SO_2 and NO_x from industrial and transportation sources, leading to a decline in the prevalence of acid rain. However, acid rain remains a problem in many parts of the world, particularly in developing countries where air pollution controls are less stringent. The historical mentions of acid rain serve as a reminder of the importance of taking action to protect the environment from the harmful effects of human activities.

Mythological mentions of acid rain

There are several mythological mentions of acid rain, particularly in ancient civilizations where natural phenomena were often attributed to the actions of gods and goddesses. In some cultures, acid rain was seen as a punishment from the gods for human misdeeds or as a symbol of divine anger.

One example of a mythological mention of acid rain can be found in Hindu mythology, where the god Indra is often associated with rain and thunder. In some stories, Indra is depicted as a fierce warrior who battles against demons and other enemies of the gods. In one tale, Indra becomes angry with a group of people who have offended him and sends down a rain of acid that burns their skin and destroys their crops.

In ancient Greek mythology, acid rain was associated with the wrath of the goddess Hera, who was often portrayed as a vengeful deity who punished mortals who crossed her. According to some myths, Hera would send down a rain of sulphur and other acidic compounds as a way of punishing humans who had angered her. In one story, Hera punished the city of Sodom by raining down a shower of brimstone that destroyed the city and its inhabitants.

In Norse mythology, acid rain was sometimes associated with the god Thor, who was often associated with thunder and lightning. In some stories, Thor would use his hammer to create thunderstorms and rain down sulphuric acid on his enemies. In other tales, acid rain was seen as a sign of the impending apocalypse, a time when the gods would battle against each other and the world would be destroyed.

These mythological mentions of acid rain reflect the way that humans have long tried to understand and explain the natural world around them. While our scientific understanding of acid rain has advanced significantly in recent years, these ancient myths remind us of the enduring power of human imagination and storytelling.

Conclusion

In conclusion, the analysis of acid rain from a global perspective has revealed the complex interplay between human activities and the environment. It has been demonstrated that the primary causes of acid rain are anthropogenic, resulting from the combustion of fossil fuels and industrial activities. Acid rain has far-reaching impacts on ecosystems, including pollution levels, geographical and ornithological effects, and the potential to disrupt the food chain. I extend my appreciation to the academic community, the scientific community, and environmental activists

who have tirelessly worked towards creating awareness and advocating for sustainable practices to reduce the impact of acid rain.

References for drafting this document

*I express my sincere gratitude to the following sources,
that helped me in creating this research paper document:*

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