ACID RAIN – ITS CAUSES AND EFFECTS

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ABSTRACT

Acidification of rain-water is identified as one of the most serious environmental problems of transboundary nature. Acid rain is mainly a mixture of sulphuric and nitric acids depending upon the relative quantities of oxides of sulphur and nitrogen emissions. Due to the interaction of these acids with other constituents of the atmosphere, protons are released causing increase in the soil acidity. Lowering of soil pH mobilizes and leaches away nutrient cations and increases availability of toxic heavy metals.
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INTRODUCTION

Human beings have been using various natural resources to their advantage ever since the beginning of time. To make their lives easier, they have developed facilities that use the Earth's energy resources. Unfortunately, this kind of development can lead to pollution since harmful substances are released into the environment. Air pollution is known to have a significant impact on the environment, and acid rain is one of the most common problems. It can harm the ecosystems that are home to various animals and plants, such as streams and lakes. Rain is vital to the survival of all life on Earth. The pollution from cars, factories, and homes is known as acid rain. It has been around for over a hundred years now, and it's not just happening in the past couple of decades. Nations have been affected by this issue ever since the industrialized world began.

In New Delhi, over 1,500 new cars are added to the roads every day, and this contributes to the city's air pollution. Each year, around 2 million people in Asia die due to air pollution. The US has tough emissions laws that help explain why people are breathing better even though they're adding more cars to the roads. Acid rain, also referred to as acid deposition, is a type of acidic precipitation. It is two types of deposition:

1. Wet deposition
2. Dry deposition

Wet Deposition

When acid compounds in the air are blown into wet regions, such as areas where snow, rain, and fog form, they can release acids that can then fall to the ground. This acidic water can affect various animals and plants.

Dry Deposition

Areas that are dry may experience the formation of dust or smoke, which then falls to the ground. This can stick to the ground and houses, as well as trees and other structures. As a result of this, rainstorms can wash away the deposited particles and gases, which can lead to increased runoff.

Causes of acidification

The main causes of acid rain are the presence of sulphur dioxide and oxides of nitrogen in the atmosphere. These reactants interact with other elements and contribute to the deposition of acid. The natural sources for sulphur pollutants are the oceans and volcanic eruptions. Fossil fuels such as petroleum and coal are the main sources of SO2 emissions. Other sources include the production of sulphuric acids and the activities of industrial processes. In addition, the use of zinc and copper ores and the smelting of iron are also contributing factors to the increase in acid rain production. Although NOx emissions are small compared to those of SO2, they are still contributing to the growth of acid rain.

The degree of acidity is measured by pH value, it is shorthand version of potential hydrogen. The pH of normal rainwater is also acidic; the reason is that water reacts to a slight extent with atmospheric carbon dioxide (CO2) to produce carbonic acid.

$$CO2 + H2O \longrightarrow H2CO3 \text{ (carbonic acid)}$$

In addition to lightening storms, nitric acid can also contribute to the reduction of the acidity of rainwater. This occurs due to the oxidation of nitrogen in the water.

$$2\ N2 + 5O2 + 2H2O\ 4 \longrightarrow HNO3 \text{ (nitric acid)}$$

Rain that presents a concentration of H+ ion greater than 2.5 µeq-1 and pHvalue is less than 5.6 is considered acid (Evans,1984). Galloway et al. (1982) proposed a pH of 5.0 as a limit of natural contribution.

The formation of acid rain is caused by the interaction of various chemicals, such as NOx, O3 and SO2. When pollutants are released into the atmosphere, they interact with the sunlight and form nitric acid mists and sulphuric acid. Under the conditions of high temperature, the acids will remain in a vapour state. When the temperature drops, the droplets will condense and turn into carbonaceous, black, and acidic matter.

Acid reactions involving O3:

$$O3- \longrightarrow O2 + O$$
$$O+H2O \longrightarrow OH\bullet \text{ (hydroxy radical)}$$
$$OH\bullet+S02 \longrightarrow HSO3$$
$$HSO3-+ OH \longrightarrow H2SO4$$
$$OH+NO2- \longrightarrow HNO3$$
$$HSO3 + O2- \longrightarrow SO32-+ HO\bullet2 \text{ (peroxy radical)}$$

Peroxy radicals react with formaldehyde, acetaldehyde and form formic and acetic acids and some other organic acids, contributing to 5-20% acidity in total acid rain load.

Acid reactions involving sulphur:

Coal is especially rich in sulphur. As coal is burned, its component get oxidized

$$S + O2 \longrightarrow SO2$$

The oxidation of sulphur to SO2 occurs directly in the flame; therefore SO2 is discharged to the atmosphere from the smoke stacks. As SO 2 is swept along by the prevailing wind, it is slowly oxidized at ordinary temperature to SO32-

$$2\ SO2 + O2 \longrightarrow 2\ SO32-$$
$$SO3\ 2-+ H2O \longrightarrow H2SO4$$
$$SO2 + H \longrightarrow H2SO3\ (H+\ HSO3)$$
$$HSO3 + O3 \longrightarrow SO42++\ H+ + O2$$

Oxidant property of atmosphere plays an important role in conversion of SO3 2- to SO4. Sulphur dioxide oxidation is most common in clouds and especially in heavily polluted air where compounds such as ammonia and O3 are in abundance. These catalysts help to convert more SO2 into sulphuric acid.

$$H2\ O2 + HSO3 \longrightarrow -\ HSO4- + H2O$$

Acid reactions involving nitrogen:

$$NO2 + OH\bullet \longrightarrow HNO3$$ Nitric Acid
$$NO2 + O \longrightarrow NO3$$
$$NO2 + NO3 \longrightarrow N2O5$$
$$N2O5+ H2O \longrightarrow 2HNO3$$ Nitric Acid

Effects of Acid Rain

Following the study of the Hubbard Brook Forest, it has been revealed that acid deposition can have a significant impact on both man-made and natural environments. Acid deposition can directly affect aquatic settings, as acidic precipitation falls into them. Both wet and dry deposition can run off of fields, forests, roads, and streams.

Effects of acid rain on Health

Although acid rain can taste and look similar to clean water, its effects on people are not direct. While it's no more dangerous than swimming in a lake or walking in it, the pollutants that can cause acid rain, such as nitrogen oxides and sulfur dioxide, can cause health problems. These gases interact with one another in the atmosphere to create nitrate and fine particles, which can be transported by winds and inhaled into one's lungs. According to scientific studies, elevated levels of these particles can lead to premature death and heart disease.

Acid rain harms other plants

Trees can be harmed by acid rain, just like other plants. Although food crops can also be negatively affected by other air pollutants, such as ground-level ozone, farmers typically add nutrients to their soil to help nourish their crops.

Effects in the forest

Some forests have slowed down their growth, and scientists have noted that the leaves and needles of trees would turn brown and fall off as they should be healthy and green. In extreme cases, entire forests have died off.

Effects on Stone Buildings and Monuments in Acid Rain

Marble and limestone have long been preferred materials for constructing durable buildings and monuments. . Marble and limestone both consist of calcium carbonate (CaCO3), and differ only in their crystalline structure. Limestone consists of smaller crystals and is more porous than marble; it is used more extensively in buildings. Marble, with its larger crystals and smaller pores, can attain a high polish and is thus preferred for monuments and statues. Although these are recognized as highly durable materials, buildings and outdoor monuments made of marble and limestone are now being gradually eroded away by acid rain calcium carbonate and sulfuric acid (the primary acid component of acid rain) results in the dissolution of CaCO3 to give aqueous ions, which in turn are washed away in the water flow.

$$CaCO3 + H2SO4 \rightarrow Ca2+(aq) + SO42- + H2O + CO2$$

Acid rain can affect the surface of buildings and monuments, but it does not usually affect their structural integrity. For instance, it can easily destroy details on relief work.

What's Being Done?

Due to the harmful effects of air pollution on human health, various steps have been taken to reduce the emissions of nitrogen and sulfur. One of these is the use of scrubbers on smokestacks. These devices are designed to trap pollutants before they can be released into the atmosphere.

Control of acid rain:

This can be achieved by following ways:

Liming:

Adding lime can help prevent the damage caused by acidified water to lakes. Various chemicals, such as sodium carbonate, caustic soda, and slacked lime, are commonly used to raise the pH level of water. Liming can remove some of the harmful effects of acidification, but it is not a cure.

Policy Intervention

Acid rain's effects on ecosystems and natural resources became a major public concern during the 1970s and 1980s. In response to this issue, Canada's Ontario Province and several northeastern states sued the EPA in 1980. The EPA was then tasked with controlling the emissions of acid precursor gases from the state governments. The US Congress established the National Acid Precipitation Assessment Programme (NAPAP) in 1980. It aims to conduct a comprehensive study of the issue of acid rain over a decade. The purpose of the study was to inform public policy by providing information on:

1. Specific regions and resources affected by acidic deposition.
2. How and where acid precursor emissions are transformed and distributed?
3. Whether the effects are extensive and require mitigation?
4. What emission control technologies and mitigation options are

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