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# Acid Rain-The Major Cause of Pollution: Its Causes, Effects and Solution

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**Abstract**

Acid rain refers to a mixture of deposited material, both wet and dry, coming from the atmosphere containing more than normal amounts of nitric and sulfuric acids. Simply put, it means rain that is acidic in nature due to the presence of certain pollutants in the air due to cars and industrial processes. Acid rain can occur in form of rain, snow, fog or dry material that settle to earth. Acidity is determined on the basis of the pH level of the water droplets. Normal rain water is slightly acidic with a pH range of 5. 3-6. 0, because carbon dioxide and water present in the air react together to form carbonic acid, which is a weak acid. When the pH level of rain water falls below this range, it becomes acid rain.

It occurs due to natural and human activities. Erupting volcanoes contains some chemicals that can cause acid rain. Apart from this, burning of fossil fuels, running of factories and automobiles due to human activities are few other reasons behind this activity.

**Keywords:** sulphuric, Deposition, nitrogen, pollutants

## Introduction

Since the beginning of civilization, human beings have used various natural resources for their benefit. To make their life easier, they have produced facilities that use many of the Earth's energy resources. On one side this kind of development makes our lives easier, but on the other hand it results into pollution by release harmful substance into environment. Acid rain is the most serious environmental problems emerged due to air pollution. Acid rain is particularly damaging to lakes, streams and forests, and the plants and animals that live in these ecosystems. Acid rain is a widespread term used to describe all forms of acid precipitation (rain, snow, hail, fog, etc. ). Atmospheric pollutants, particularly oxides of sulphur and nitrogen, can cause precipitation to

become more acidic when converted to sulphuric and nitric acids, hence the term acid rain. Acid deposition, acid rain and acid precipitation all relate to the chemistry of air pollution and moisture in the atmosphere. Scientists generally use the term acid deposition but all three terms relate to the same issue. The term acid rain was first used by Robert Angus Smith, a scientist working in Manchester in the 1870s. The problem of acid rain is hence not a new one but the nature of the problem has changed from being a local problem for towns and cities to being an international problem. In Smith's time, acid rain fell both in towns and cities whilst today pollutants can be transported thousands of kilometres due to the introduction of tall chimneys dispersing pollutants high into the atmosphere. Precipitation is naturally acidic because of carbon dioxide in the atmosphere. The burning of fossil fuels (coal, oil and gas) produce sulphur dioxide and nitrogen oxides which can increase the acidity of rain or other precipitation. Sources of sulphur dioxide and oxides of nitrogen may be natural such as volcanoes, oceans, biological decay and forest fires, or may arise from combustion sources. The increasing demand for electricity and the rise in the number of motor vehicles in recent decades has meant that emissions of acidifying pollutants have increased dramatically from human sources, particularly since the 1950s. Emissions of such pollutants are heavily concentrated in the northern hemisphere, especially in Europe and North America, Sweden, Norway, and Germany. In addition, some amount of acid deposition is found in parts of South Asia, South Africa, Sri Lanka, and Southern India. As a result, precipitation is generally acidic in these countries.

**Forms of Acid Rain**

There are two forms in which acid deposition occurs – wet and dry. Both are discussed below:

- Wet Deposition – When the wind blows the acidic chemicals in the air to the areas where the weather is wet, the acids fall to the ground in the form of rain, sleet, fog, snow or mist. It removes acid from the atmosphere and deposit them on the earth's surface. When this acid flows through the ground, it affects large number of plants, animals and aquatic life. The water from drain flows into rivers and canals which is them mixed up with sea water, thereby affecting marine habitats.
- Dry Deposition – If the wind blows the acidic chemicals in the air to the areas where the weather is dry, the acidic pollutants slip into dust or smoke and fall to the ground as dry particles. These stick to the ground and other surfaces such as cars, houses, trees and buildings. Almost 50% of the acidic pollutants in the atmosphere fall back through dry deposition. These acidic pollutants can be washed away from earth surface by rainstorms.

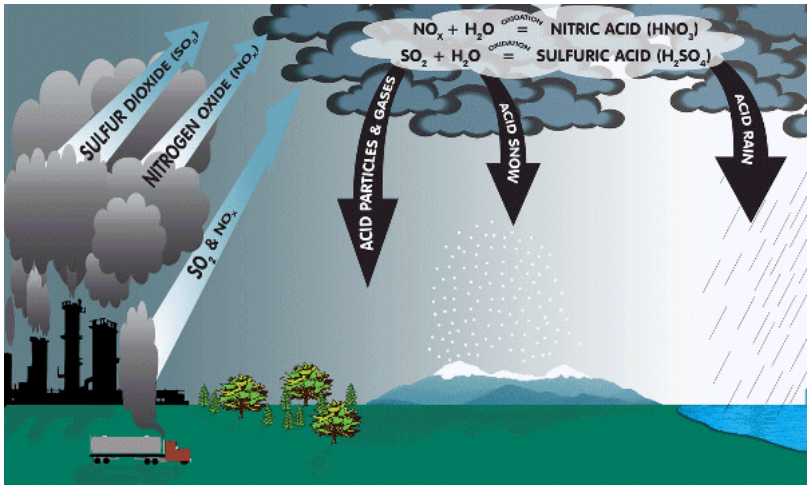
**Causes of Acid Rain-**

Both natural and man-made sources are known to play a role in the formation of acid rain. But, it is mainly caused by combustion of fossil fuels which results in emissions of sulfur dioxide (SO2) and nitrogen oxides (NOx). Natural sources such as erupting

volcanoes, rotting vegetation and sea sprays produce sulfur dioxide and fires, bacterial decomposition and lightening generate nitrogen dioxide. The chemicals released by natural sources gets mixed up with water and oxygen and are disperse over large areas because of wind patterns. Man-made sources include emission of sulfur dioxide and nitrogen oxides due to combustion of fossil fuels. Roughly two-thirds of all sulfur dioxide and one-fourth of all nitrogen oxides come from generation of electricity through burning of fossil fuels such as coal. These gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds such as sulfuric acid, ammonium nitrate, and nitric acid. The existing winds blow these acidic compounds over large areas across borders and they fall back to the ground in the form of acid rain or other forms of precipitation. Upon reaching the earth, it flows across the surface, absorbs into the soil and enters into lakes and rivers and finally gets mixed up with sea water. The gases sulfur dioxide (SO2) and nitrogen oxides (NOx) are primarily gases occurring from electric power generation by burning coal and responsible for acid rain.

**Natural Acidity of Rainwater-**

Pure water has a pH of 7. 0 (neutral); however, natural, unpolluted rainwater actually has a pH of about 5. 6 (acidic). [Recall from Experiment 1 that pH is a measure of the hydrogen ion ($H^+$) concentration. ] The acidity of rainwater comes from the natural presence of three substances ($CO_2$, NO, and $SO_2$) found in the troposphere (the lowest layer of the atmosphere). As is seen in Table I, carbon dioxide ($CO_2$) is present in the greatest concentration and therefore contributes the most to the natural acidity of rainwater. Carbon dioxide reacts with water to form carbonic acid (Equation 1). Carbonic acid then dissociates to give the hydrogen ion ($H^+$) and the hydrogen carbonate ion ($HCO_3^-$) (Equation 2). The ability of $H_2CO_3$ todeliver $H^+$is what classifies this molecule as an acid, thus lowering the pH of a solution.




Nitric oxide (NO), which also contributes to the natural acidity of rainwater, is formed during lightning storms by the reaction of nitrogen and oxygen, two common

atmospheric gases (Equation 3). In air, NO is oxidized to nitrogen dioxide ($NO_2$) (Equation 4), which in turn reacts with water to give nitric acid ($HNO_3$) (Equation 5). This acid dissociates in water to yield hydrogen ions and nitrate ions ($NO_3^-$) in a reaction analagous to the dissociation of carbonic acid shown in Equation 2, again lowering the pH of the solution.

$$CO_2 + H_2O \longrightarrow H_2CO_3 \quad (1)$$

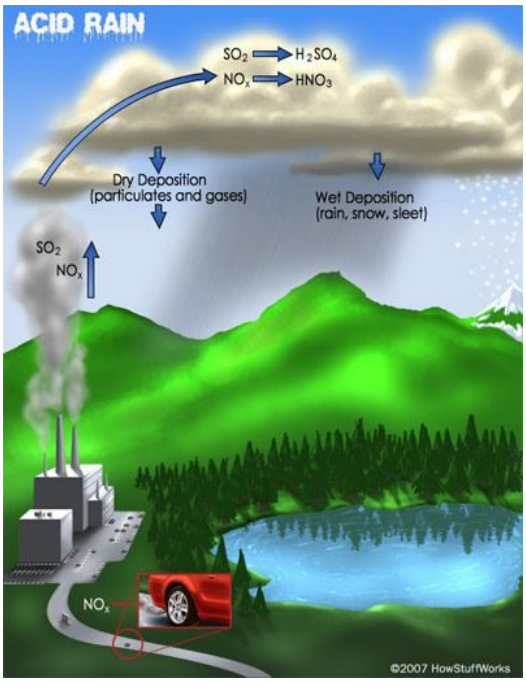
$$H_2CO_3 \longrightarrow H^+ + HCO_3^- \quad (2)$$

$$N_{2(g)} + O_{2(g)} \xrightarrow{\text{lightning}} 2NO_{(g)} \quad (3)$$

$$NO_{(g)} + \tfrac{1}{2}O_{2(g)} \longrightarrow NO_{2(g)} \quad (4)$$

$$3NO_{2(g)} + H_2O \longrightarrow 2HNO_{3(aq)} + NO_{(g)} \quad (5)$$

$$SO_{2(g)} \xrightarrow{O_2} SO_{3(g)} \xrightarrow{H_2O} H_2SO_4 \quad (6)$$




What about the other 75% of the acidity of rain? Most is accounted for by the presence of sulfuric acid ($H_2SO_4$) in rainwater. Although sulfuric acid may be produced naturally in small quantities from biological decay and volcanic activity (Figure 1), it is produced almost entirely by human activity, especially the combustion of sulfur-containing fossil fuels in power plants. When these fossil fuels are burned, the sulfur contained in them reacts with oxygen from the air to form sulfur dioxide ($SO_2$). Combustion of fossil fuels accounts for approximately 80% of the total atmospheric $SO_2$ in the United States. The effects of burning fossil fuels can be dramatic: in contrast to the unpolluted atmospheric $SO_2$ concentration of 0 to 0. 01

ppm, polluted urban air can contain 0. 1 to 2 ppm $SO_2$, or up to 200 times more $SO_2$! Sulfur dioxide, like the oxides of carbon and nitrogen, reacts with water to form sulfuric acid (Equation 6)Sulfuric acid is a strong acid, so it readily dissociates in water, to give an $H^+$ ion and an $HSO_4^-$ion (Equation 7). The $HSO_4^-$ion may further dissociate to give $H^+$ and $SO_4^{2-}$(Equation 8). Thus, the presence of $H_2SO_4$causes the concentration of $H^+$ ions to increase dramatically, and so the pH of the rainwater drops to harmful levels.

$$H_2SO_4 \longrightarrow HSO_4^- + H^+ \quad (7)$$

$$HSO_4^- \longrightarrow SO_4^{2-} + H^+ \quad (8)$$

**Effects of Acid Rain-**

Acid rain has significant effects on the world environment and public health.

- Effect on Aquatic Environment-Acid rain either falls directly on aquatic bodies or gets run off the forests, roads and fields to flow into streams, rivers and lakes. Over a period of time, acids get accumulated in the water and lower the overall pH of the water body. The aquatic plants and animals need a particular pH level of about 4. 8 to survive. If the pH level falls below that the conditions become hostile for the survival of aquatic life
- Effect on Forests-It makes trees vulnerable to disease, extreme weather, and insects by destroying their leaves, damaging the bark and arresting their growth. Forest damage due to acid rain is most evident in Eastern Europe especially Germany, Poland and Switzerland. acid rain can be extremely harmful to forests. acid rain that seeps into the ground can dissolve nutrients, such as magnesium and calcium, that trees need to be healthy. acid rain also causes aluminum to be released into the soil, which makes it difficult for trees to take up water. trees that are located in mountainous regions at higher elevations, such as spruce or fir trees, are at greater risk because they are exposed to acidic clouds and fog, which contain greater amounts of acid than rain or snow. the acidic clouds and fog strip important nutrients from their leaves and needles. this loss of nutrients makes it easier for infections, insects, and cold weather to damage trees and forests.
- Effect on Soil-As it falls on forest or field soil, it kills useful micro-organisms and leaches nutrients of soil. Many a times, this leads to calcium and other nutrient deficiency, producing infertile soils.
- Effect on Architecture and Buildings-Acid rain on buildings, especially those constructed with limestone, react with the minerals and corrode them away. This leaves the building weak and susceptible to decay. modern buildings, cars, airplanes, steel bridges and pipes are all affected by acid rain. irreplaceable damage can be caused to the old heritage buildings.
- Effect on Public Health-When in atmosphere, sulfur dioxide and nitrogen oxide gases and their particulate matter derivatives like sulfates and nitrates, degrades visibility and can cause accidents, leading to injuries and deaths.
- Effect on Lakes and Streams-Without pollution or acid rain, most lakes and

streams would have a pH level near 6. 5. Acid rain, however, has caused many lakes and streams in the northeast United States and certain other places to have much lower pH levels. In addition, aluminum that is released into the soil eventually ends up in lakes and streams. Unfortunately, this increase in acidity and aluminum levels can be deadly to aquatic wildlife, including phytoplankton, mayflies, rainbow trout, small mouth bass, frogs, spotted salamanders, crayfish, and other creatures that are part of the food web. excess nitrogen may cause eutrophication (over nourishment) in areas where rivers enter the ocean. this may lead to unwanted growth of algae and other nuisance plants. as much as 40% of the total nitrogen entering coastal bays on the atlantic and gulf coasts may come from atmospheric deposition.

**Possible Solutions**

The number of possible solutions are available to deal with air pollution and the resultant acid rain. However, what matters more is to consciously enforce these solutions on a wide scale. The most important thing is to educate people all over the world, and create awareness, about the causes and effects of acid rain. Solutions to this problem can only be successful through cooperation. Given below are a few solutions, which can greatly reduce the threat of acid rain, if strictly followed by a large number of people.

- One of the most fundamental solutions is to utilize fuels that burn more cleanly, or to burn coal more efficiently. This will greatly reduce the amount of acids released in the atmosphere.
- As far as industrial power plants are concerned, the best solution is to attach devices known as 'scrubbers' in the chimneys of these plants. These scrubbers reduce the amount of sulfur released through the smoke by 90-95%. Moreover, industries must regularly inspect and clean all their emission equipment, chimneys, pipes, etc. the scrubbers which can be used in chimneys produce sludge while reducing the sulfur content, and in this process, it also produces a building material called gypsum, which is used to make plaster of paris and cement.
- Cars and vehicles have a large contribution in polluting the environment, and causing acid rain. Using public transport, resorting to carpool, walking down to nearby places instead of driving, etc., can help us save fuel and gas, as well as reduce the adverse effects. it must be mandatory for vehicles and cars to comply with the efficient emission standards. fitting catalytic converters into the exhaust pipes of vehicles also reduces the amount of sulfur dioxide emitted into the atmosphere.
- A small step can be taken by turning off our lights, computers, and other electrical appliances, when not in use. While purchasing, we can buy appliances, which consume less energy. If everyone follows this, it can help to a huge extent.
- All these solutions will be pointless unless people are informed and educated about the ill-effects and harms of this rain. A widespread and nationwide

effort must be made to make people aware of the hazardous effects. Only after that is done, will all the solutions actually make a difference.

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