Research Article

Acid Rain-A Specific type of Pollution: Its concept, causes, effects and tentative solutions

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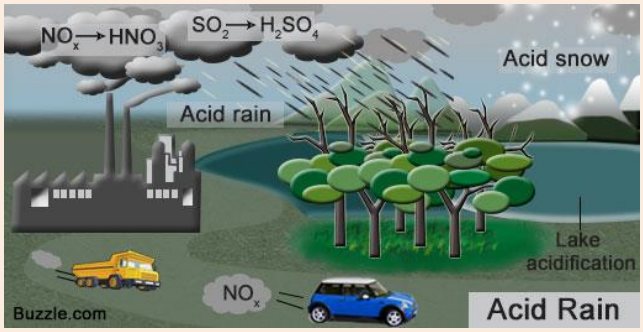
Abstract

Acid rain is one of the most dangerous and widespread forms of pollution. Sometimes called 'the unseen plague' acid rain can go undetected in an area for years. Technically, acid rain is rain that has a larger amount of acid in it than what is normal. The acidity of rain in parts of Europe and North America has dramatically increased over the past few decades. It is now common in many places for rain to be ten to seventy times more acidic than unpolluted rain. Many living and non-living systems become harmed and damaged as a result of acid rain. Acid deposition has many harmful effects, especially when the p^H falls below 5.1 for terrestrial and below 5.5 for aquatic system.



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Introduction

The term acid rain was first used by Robert Angus Smith in 1852. It refers to the presence of excessive acids in rain water. Smith defined acid rain as 'a condition of environment in which natural precipitation becomes acidic after reacting chemically with pollutants in the air. It refers to all precipitation which is more acidic than normal. Generally, clean rain is slightly acidic as it dissolves varying amounts of naturally occurring carbon dioxide from the atmosphere. The lowest p^H level which can be produced by carbon Dioxide or carbonic acid is 5.6. Therefore, the precipitation or rain is said to be clean rain up to a pH of 5.6, which is the natural background p^H of rain water.

$$CO_2 + H_2O \Longrightarrow H_2CO_3$$

Hence, acid rain, on precipitation, is defined as the one which has a p^H less than 5.6.It results when gaseous emissions of oxides of sulpher (SO_X) and oxides of nitrogen(NO_X) interact with water vapour and sunlight, and are chemically converted to strong acidic compounds such as sulphuric ,sulphurous,nitric and nitrous acids. When these compounds are carried to the earth's surface by precipitation (raindrops, snow, fog or dew), it is referred as acid rain.

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 whilst today pollutants can be transported thousands of kilometers due to the introduction of tall chimneys dispersing pollutants high into the atmosphere. Precipitation is generally acidic because of carbon di oxide in the atmosphere. The burning of fossil fuels produces sulpher dioxide and nitrogen oxide which can increase the acidity of rain or other precipitation.

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 Southern India. As a result, precipitation is generally acidic in these countries.

Causes of Acid Rain

Acidification of environment is a phenomena caused by human activities. Acid deposition is more precise term for acid rain. It (Acid deposition) may be either wet or dry. Wet form of deposition – is Rain, snow, dew fog, frost and mist. Dry deposition – is settling of dust particles containing sulphates and nitrates on earth. Wet deposition is a more common occurrence**.**

Form of acid Rain

There are two forms in which acid deposition-wet and dry. Both are discussed in Figure1.

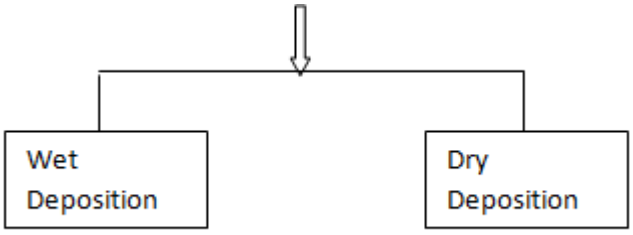


Figure 1 Forms of Acid Rain

Wet Deposition: Wet deposition of acids occurs when any form of precipitation (rain, snow, and so on.) removes acids from the atmosphere and delivers it to the Earth's surface. This can result from the deposition of acids produced in the raindrops (see aqueous phase chemistry above) or by the precipitation removing the acids either in clouds or below clouds. Wet removal of both gases and aerosols are both of importance for wet deposition.

Dry Deposition: Acid deposition also occurs via dry deposition in the absence of precipitation. This can be responsible for as much as 20 to 60% of total acid deposition. This occurs when particles and gases stick to the ground, plants or other surfaces.

The dry particles 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.

Major causes of acid rain include burning of fuels and use of nuclear weapons, which cause emission of a large amount of sulphur dioxide and nitrogen dioxide. Sulphur dioxide oxidized in the in atmosphere which then reacts with rain water to form sulphuric acid.

Frost: - deposit of white ice crystals formed on surface when temp tolls below freezing freeze.
Mist: - Cloud of tiny water drops.

Similarly, the oxides of nitrogen react in air to produce nitric acid (HNO3). Both those acids are very strong and when present in the atmosphere dissolve in water droplets to fall on earth as acid rain. Acid rain is measured using a scale called scale. Normal rain is slightly acidic because carbon dioxide dissolves in to it and hence it has of about 5.5. The lower a substance's the more acidic it is.

Scientists have discovered that air pollution from burning of fossil fuels is the major cause of acid rain. The main chemicals in air pollution that create acid rain are sulfur dioxide (SO2) and nitrogen (NOx). Acid rain usually forms high in the clouds where sulfur dioxide and nitrogen oxides react with water, oxygen, and oxidants. This mixture forms a mild solution of sulfuric acid and nitric acid. Sunlight increases the rate of most of these reactions. Rainwater, snow, fog and other forms of precipitation containing mild solutions of sulfuric acids and nitric acids fall on earth as acid rain. Acid rain does not account for all of the acidic particles and gases onto buildings, cars, home, and trees. In some instances, these gases and particles can eat away the things on which they settle. Dry deposited gases and particles are sometimes washed from trees and other surfaces by rainstorms. When that happens, the runoff water

adds those acids to the acid rain, making the combination more acidic that the falling rain alone. The combination of acid rain plus dry deposited acid is called acid deposition.

Table 1 Stoichiometric equations for the formation of sulphuric acid

Burning of fossil fuels emits sulphur dioxide.	S (in coal) + O2◆SO2
Sulphur dioxide reaches the atmosphere; it oxidizes to first form a sulphate ion.	2 SO2 + O2◆ 2 SO3
The sulphate ion joins with hydrigen atoms in the air and becomes sulphuric acid. This then falls back down to earth as "acid rain"	SO3 + H2O◆ H2SO4

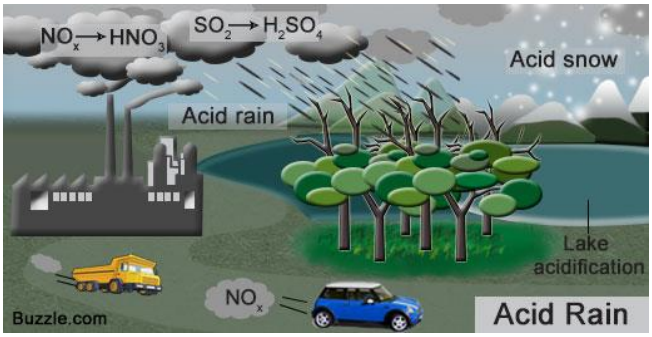
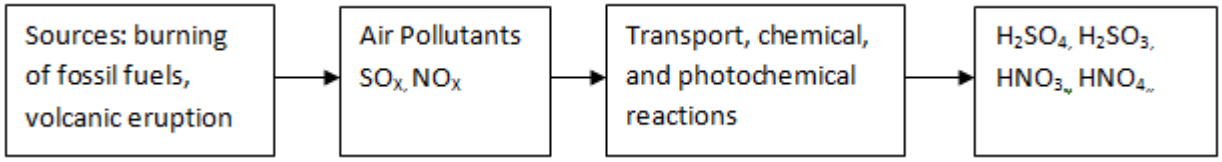


Figure 2 Acid Rain

Effects of Acid Rain: The acid rain problem is fast spreading in the developing world. The adverse effect of acid rain are discussed below



Effects on Human Beings: Acid rain has been found to be very dangerous to human beings.It may laed to skin burning,skin blisters, graying of hair .Acid rain is also affects the human nervous system,respiratory system etc.This also causes irritation to eyes.

Effects on plants:Acid rain damages the plants the plant cell and hence adversely affects the growth of trees.The various damages caused b acid rain to the plant cell are-Membrane damage,chlorophyll destruction and plasmolysis.

Effects on aquatic life-The effect on acid rain on aquatic life is quite serious.Acidification of lakes affects aquatic animals and plants.Green algae ,bacteris etc which are essential to aquatic systems,will be killd due to acidity.The fish population is also reduced due to acid rain.

Effects on fertility of soil: Soil is slightly alkaline in nature.Because f acid rain the alkalinity of the soil will reduce and te siol becomes acidic which in turn reduces th fertility of the soil.Hence world,s food production will drastically be affected.

Effects on buildings and monuments: Marble, limestone, slate, cement etc. are the ingredients of buildings and monuments. Acid rain causes extensive damage to these materials by pitting. The pitting materials get weakened mechanically as the soluble suphates are leached out b rain water.

$$CaCO_3 + H_2SO_4 \longrightarrow CaSO4 + CO_2 + H_2O$$

Effects on metals on alloys: Acid reacts vigorously with metals. The metallic structures (made up of iron, zinc and aluminum) undergo corrosion in acid rain which reduce their strength gradually and ultimately lead to the failure to the structure.

$$Fe \longrightarrow Fe^{+2} + 2e$$

$$2H^{+} + 2e \longrightarrow H_2$$

$$Fe + 2H^{+} \longrightarrow Fe^{++} + H_2$$

Effects on Architecture: Architecture and artwork can be destroyed by acid rain. Acid particles can land on buildings, causing corrosion. When sulpher pollutants fall on the surfaces of buildings (especially made out of limestones or sandstones), they react with the minerals in the stone to form a powdery substances that can be washed away by rain.

Control Measures: It is very expensive to practice the remedial measures. Thus it becomes necessary to control the pollutants that actually cause the acid rain.
a) Energy Conservation: Energy conservation can be done through improved thermal insulation and ore efficient fuel use.
b) Desulphurization and Denitrifition helps to introduce new technology that reduces the SO_2 and NO_X emission.
c) Substitution for fossil fuels by other alternative energy form.
d) The effective and simplest method to control the acid rain depositions is to neutralize the acid with lime but this is effective only for short term control and where small amount of acid has to be neutralized.
e) A small steps 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. - Acid rain is causing damage to many famous buildings and monuments across the world.

Eg. 1 Taj Mahal in Agra

(ii) British parliament building is also suffered due to Acid rain.
(iii) Through Europe and Greece many famous buildings monuments and art treasures have deteriorated at an alarming rate.

The Taj Mahal: A Case Study
The Taj Mahal –one of the seven wonders of world-has withstood the onslaught of natural elements for elements for centuries, but now it is the increasing danger of being destroyed by the constituents of a polluted atmosphere, especially due to pollutants released from the nearby Mathura Refinery. The refinery in spite of using low sulpher fuels emits about 25 to 30 tonnes of sulpher dioxide daily. The emitted SO_2 results in acidic precipitation under conditions of low wind speeds combined with humidity, in the surrounding areas. The other sources of pollutants, which also contribute to acidic precipitation, is the heavy traffic in Agra. The acid deposition reacts with calcium carbonate in the marble to form calcium sulphate which causes deterioration.

Some of the visible signs of deterioration of the Taj Mahal include discolouration of the white marble surface i.e. appearance of yellowish or yellow grey or brown rust like stains ,especially in the niches and arches,chipping and breaking og the edges of the marble slabs, and formation/appearance of cracks in marbles.

To save this magnificent historical monument ,the Government has taken many steps,such as development of a green belt of 1 to 5 km around the Taj ,closing down of two thermal power plants at Agra ,cleaning of emissions from stacks of the Mathura Oil Refinery ,providing an outer road to restrict traffic and establishment of pollution monitoring stations inside the Taj Mahal complex and Mathura and Agra.

Possible Solutions:

The numbers 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 acid 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.

Acid rain is one of the biggest environmental hazards that we are facing today, and strong measures must be taken to prevent it, before it is too late. The government of all the nations needs to take notice, and do much more than what they are already doing. Acid rain is adversely affecting plants, animals, and human beings. It is our duty towards ourselves, and towards our fellow human beings, to do all that we can, to prevent and reduce the presence of acid rain in our environment.

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