

Acid Rains: Causes, Effects and Remedy

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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. Energy is mainly produced by burning fuels such as coal, oil and natural gases. On one side this kind of development makes our lives easier, but on the other hand it results into pollution by release of harmful substances into the environment. Acid rain is one of the most serious environmental problems emerged due to air pollution. Acid rain is a broad term that describes several ways through which acid falls out from the atmosphere. Acid rain includes acidic rain, fog, hail and snow. Acid rain is a global problem that is gradually affecting environment. This communication briefly reviews the causes, effect and remedies of acid rain.

Chemistry of acid rain

The degree of acidity is measured in pH units, which indicate the concentration of hydrogen ions. The pH scale vary from 14 (most basic) to 0 (most acidic). Distilled water is neutral because it is in the middle of the pH scale i.e. pH 7. A decrease of 1pH unit means increasing of hydrogen ion concentration. Unusually normal rain water is also slightly acidic because carbonic acid is formed from carbon dioxide in the atmosphere. "Acid Rain," or more precisely acidic precipitation, is the term used to describe rainfall that has a pH level of less than 5.6--a pH of 7 being neutral.

Acid rain is formed by a chemical reaction that begins when compounds like sulphur dioxide and nitrogen oxides are released into the air. The two primary sources of acid rain are Sulphur dioxide (SO₂), and oxides of nitrogen (NO_x). Sulphur dioxide is a colorless gas released as a by-product of combusted fossil fuels containing Sulphur variety of industrial processes, such as the production of iron and steel, utility factories, and crude oil processing produces this gas. Sulphur dioxide can also be emitted into the atmosphere by natural disasters or means. This accounts for ten percent of all Sulphur dioxide emission, coming from volcanoes, sea spray, plankton, and rotting vegetation. Overall, 69.4 percent of

Sulphur dioxide is produced by industrial combustion. Only 3.7 percent is caused by transportation. The other chemical that is also chiefly responsible for the make-up of acid rain is nitrogen oxide. Oxides of nitrogen are a term used to describe any compound of nitrogen with any amount of oxygen atoms. Nitrogen monoxide and nitrogen dioxide are all oxides of nitrogen. Sulphur dioxide reacts with water vapour and sunlight to form sulphuric acid and nitrogen oxides form nitric acid in the air. This reaction takes hours or even days during which polluted air may move hundreds of kilometer. Thus acid rain can fall far from the source of their formation. Acid rains contain not only sulphur dioxide and nitrogen oxides but also heavy metals, carbon monoxide and photo chemical oxidants. Reactions between these substances strengthen their effect. See the ecological consequences of rain water at internationally in general and in India in particular in table 1-2.

Table - 1: Rainwater pH values in different regions of the world (modified from Khemani *et al.*, 1994)

Countries	Range of pH
Japan	4.7
Europe	4.1 - 5.4
China acid rain area	4.1 - 4.9
China non - acid rain affected area	6.3 - 6.7
US north west	5.1 - 5.2
US west- middlewest	5.0 - 5.5
US north west	4.1 - 4.2

Table - 2: Range of rainwater pH in different parts of India (modified from Khemani, 1993)

Regions	Cities	pH
Coastal area	Trivendrum	5.3
Industrial area	Chembur	4.8
Power plant	Inderprasth	5.0
	Koradi	5.7
	Singrauli*	5.8*
Urban area	Pune	6.3
	Delhi	6.1
Non urban area	Sirur	6.7
	Muktsar	7.3
	Goraur	5.3

Causes and Effects

Human activities are the main cause of acid rain over the past few decades. Humans have released so many different chemicals into the air that they have changes the composition of the gases in the air. Industrial factories, power plants release the majority of sulphur

dioxide and much of the nitrogen oxides when they burn fossil fuels such as natural gas, coal to produce electricity. Another cause is vehicles that burn petrol, diesel, kerosene etc. The exhaust emitted by burning these fuels contains sulphur dioxide and nitrogen oxides

The word “environment” relates to surroundings. It includes virtually anything. Indeed Einstein once remarked: “The environment is everything that is not me”. We can also define “environment” as anything which may be treated as covering the physical surroundings that are common to all of us, including air, space, waters, land, plants and wild life. Acid raining is harming the environment. Figure 1-2 is the diagrammatic representation showing cause of acid rain and its effect.

Effect on plants: Acid rain seeps in to the earth, poisons plants and trees by dissolving toxic substances in the soil such as aluminum which get absorbed by the roots. Acid rain also dissolves the beneficial minerals and nutrients in the soil, which are washed away before the plants and trees have a chance of causing them in order to grow. When there is frequent acid rain, it corrodes the waxy protective coating of leaves. When this protective coating on the leaves is lost, it results in making the plant susceptible to disease. When the leaves are damaged, the plant loses its ability to produce sufficient amount of nutrition for it to survive. Then plants become vulnerable to the cold weather, insects and diseases.

Effect on aquatic Life: Acid rain damages every thing over a period of time because it makes the living things in the environment die. Acid rain also affects the life in the water. It is almost worse in water than on land. All rain water contains some level of acidity. All the sea life will die when the water that they swim gets to be acidic. If the water goes below a pH of 4.5 all fishes including frogs, insects etc will die. With a pH of 5.5 all of the bottom-dwelling bacterial decomposes, animals that eat the remains will die. Aquatic plants will grow the best in a pH between 7 and 9.2. If acid rains get to be more of a problem then all of the sea life will die.

Effect on human Health: Acid rains effects to the human health also in many ways. It has the ability of harming us via the atmosphere as well as the soil. Acid rain results in toxic metals breaking from the chemical compounds they occur in naturally while toxic metals may be dangerous. Once acid rain causes these toxic metals to be released they can infiltrate into the drinking water, the animals or crops that human uses as source of food. The contaminated food can damage the nerves in children or result in severe brain damage or even death. Scientists suspected that Alzheimer’s disease is also associated with acid rain. Another

adverse health effect of acid rain on human is the respiratory problems it causes. The emissions of nitrogen oxides and sulphur dioxide causes respiratory problem like throat, nose, eye irritation, headache, asthma and dry coughs. It is particularly very harmful for those who have difficulty in breathing or suffer from asthma. In fact even the lungs of healthy people can be damaged by the pollutants in the acid rain.

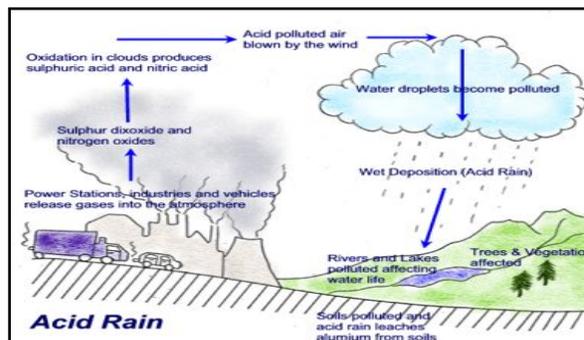


Figure 1: Diagrammatic representation showing cause of acid rain and its effect on vegetation and aquatic system.

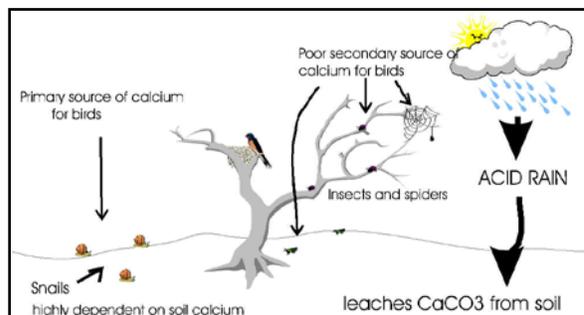


Figure 2: Diagrammatic representation effect of acid rain on animals.

Acid Rain: an international problem

The pollutants that cause acid rain are carried by wind (travelling 1000-2000 km within the atmosphere in 3-5 days). They are therefore easily transported across international boundaries. This means that a country suffering the effects of acid rain is not necessarily responsible for its creation. Many forests and lakes in Scandinavia for example have been damaged by pollution which has travelled from Britain. Therefore international co-operation is essential to solve the problems caused by acid rain.

Remedy measures

There are certain remedies measures which may be adopted against acid rain problem are as follows:

1. **Use of low sulphur coal:** The amount of sulphur dioxides emitted by power plants can be reduced by burning coal with a low percentage of sulphur present.

2. *Use of scrubbers:* Power plant and factory chimney can be fitted with scrubbers that release 90 to 95 % sulphur free smoke and also produce sludge from which gypsum, a building material can be produced. This problem can also be solved by enforcing tight emission standards of vehicles that burn gas and diesel. An another solution is fitting devices such as catalytic converter into car exhaust pipes to minimize the amount of sulphur-dioxide car can exhaust. Additionally alternative energy sources are gaining more prominence and funding is being given to the restoration of ecosystems damaged by acid rain world wide.
3. *Fluidized Bed Combustion:* In the system known as atmospheric fluidized-bed combustion, a turbulent bed of pulverized coal and limestone is suspended by an upward blast of air. The combustion chamber has many boiler tubes which convert water into steam. The turbulent mixing of coal and air allows the combustion to occur at a lower temperature which reduces the formation of nitrogen oxides. The limestone captures the Sulphur oxides by converting them to calcium sulfate which is a solid rather than a gas. This process also burns the coal more efficiently by about 5 %. This process removes 90 % of the Sulphur oxides and 15-35 % of the nitrogen oxides.
4. *Limestone Injection - Multistage Burner:* Limestone injection multiple burning is still in the development and testing stages. Crushed limestone is injected into a boiler burning powdered coal at lower than normal temperatures. The limestone combines with Sulphur dioxide to produce a solid ash (mostly gypsum, calcium sulfate). This process removes 70 % of both Sulphur and nitrogen oxides.

Reports on acidic episodes

The first incidence of acid rain seems to have coincided with onset of the industrial revolution in the mid 19th century. Gorham, 1958 observed acid rain problem in England then as a regional phenomenon in Scandinavia in the late 1960's [1]. By 1965, the pH of rainwater in Sweden was about 4 or less and it was reported in 13th UN conference on the Human Environment held at Stockholm in 1972. This was the beginning of acid rain research. It was suggested that rain and snow in many industrial regions of the world are between five and thirty times as acidic as would be

expected in an unpolluted atmosphere [2]. In 1974, over the northeast United States, the pH of rain and snow was found to be around 4.0 [5]. Until the mid 1970s, the problem of acid rain was mainly confined to north America and Scandinavia, but thereafter pH of precipitation well below 4.5 in much of central and northern Europe and it was recorded. American records include a rain of pH 2.7 at Kane in Pennsylvania and a rain of pH 1.5 falling over wheeling in West Virginia in 1979 [3]. At Banchory in northeast Scotland, the pH of rain was sometimes as low as 3.5 [4].

Acid rain in context to India

India Meteorological Department has found increasing acidity in rain samples from Pune and Nagpur. The samples were acidic with pH values less than 5 pH is a measure of the acidity or alkalinity of a solution.

Taj Mahal, one of the wonders of the world and the pride of India was facing serious threat from pollution caused by Mathura Refinery, iron foundries, glass and other chemical industries. As a result of very high toxic emissions from these industries, the Taj Mahal and 255 other historic monuments within the Taj trapezium were facing serious threat because of acid rain. The Petition was filed in the year 1984. The Supreme Court of India delivered a historic Judgment in December 1996. The apex Court gave various directions including banning the use of coal and coke and directing the industries to switch over to Compressed Natural Gas (CNG).

In sum, there are ways to reduce acid rain, but all ranging from societal changes to individual action.

References

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