Al-Mustaqbal University

College of Science

Department of Medical physics

3th stage \ 2024 - 2025

Environmental Pollution

6th Lecture

Acid Rain

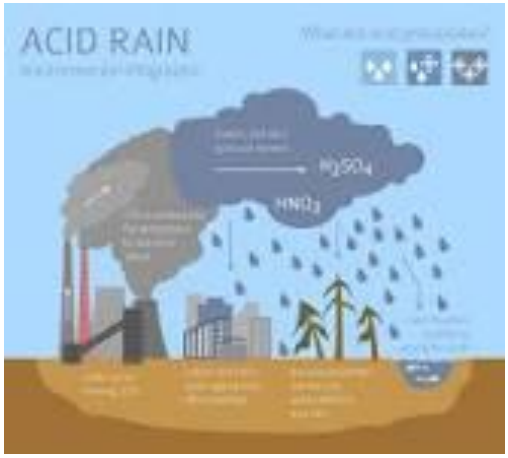
Acid Rain

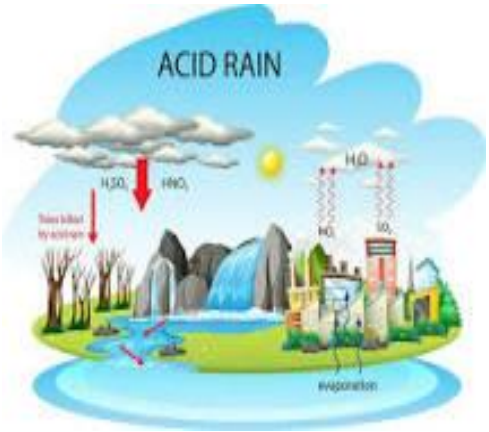
Virtually all rain in nature, before the Industrial Revolution, was acid. The relatively recent term "acid rain" refers to the additional acidity in rain as a result of the emissions of sulfur dioxide (primarily from coal-burning utility plants) and nitrogen oxides (dominantly from vehicles). To define acidity the chemist uses a "pH scale," in which each unit of pH x represents a tenfold difference in acid concentration. A pH of 7 means a solution is neutral, a pH of 14 is highly basic, and a pH of 1 is highly acid. Preindustrial (natural background) rain over forested areas in the temperate zone has an average pH of about 5.0, while the most polluted rain that falls in western Pennsylvania is about eight times more acid at a pH of 4.2 . Note also that fogs and clouds carry higher concentrations of pollutants than does accompanying rain. Although individual rains and parts of rains differ in their acidity, the seasonal average is generally the most important indicator of effects. The area having the highest acidity (lowest pH) in rain western Pennsylvania, eastern Ohio, southwestern New York, and northern West Virginialies about one day's travel time downwind from the Ohio River valley, the region with the highest concentration of uncontrolled coal-burning plants. West of the Mississippi valley, in northern Maine, and in southern Florida the acidity of rain approaches that of the preindustrial, unpolluted level (that is, a pH of 5.0). In the western United States, aside from the heavily polluted Los Angeles basin, the average annual pH of rain is greater than 5.0 because the alkaline dust in the air neutralizes the acid. Also, in the western United States the amount of emissions is much smaller than in the eastern part of the country. This general pattern of acid rain distribution has not changed in the past decade or so.

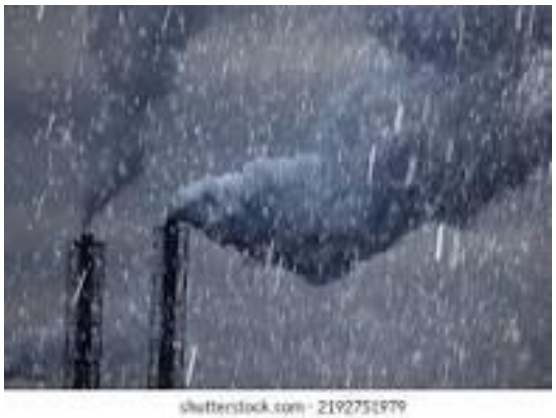
Causes of Acid Rain

The bulk of the acidity in rain comes from the reaction of sulfur dioxide (SO_2) with hydrogen peroxide in clouds, a reaction that produces sulfuric acid. This is the

important mechanism in the summer, when most acid rain falls. The hydrogen peroxide is formed from the photochemical reactions of volatile organic compounds derived from such divergent sources as trees and automobile exhaust. In the eastern United States in the summer the hydrogen peroxide in clouds is commonly sufficient to convert all of the SO2 to sulfuric acid. In the winter, however, the hydrogen peroxide concentration is considerably lower so that much of the emitted SO2 goes out to the Atlantic Ocean without reacting. Therefore, controlling SO2 emissions in the summer would be more effective than in the winter. A minor fraction of the sulfuric acid responsible for acid rain is formed by the reaction of SO2 with ozone or other.







oxidants in the air (not clouds). Since we cannot control the emission of volatile organic compounds from natural sources, we can decrease the sulfuric acid component of rain only by reducing SO2 emissions. While nitric acid, formed by the oxidation of nitrogen dioxide, also contributes to the acidity of rain, its role is minor compared with that of sulfuric acid. In fact, in the case of crops and forests, nitric acid generally provides beneficial fertilization. Therefore, the primary target in reducing the acidity of rain must be control of the SO2 emissions from large coal-burning utility plants that contribute over 70 percent of the emissions from all sources. Control of nitrogen oxide emissions from these plants would make only a secondary contribution to either acid rain or ozone reduction.

Effects of Acid Rain

Over the observed range of acidic deposition, acid rain has had clearly demonstrable negative effects only on surface waters and atmospheric visibility. There is clearly no negative effect on crops. Some minor effects on forests, building materials, and health have been hypothesized, but not quantified. Further, to assess the significance of the effects of acidity on any of the categories of concern, it is important to distinguish results obtained in experiments where much higher acidities were used from the potential or actual effects under ambient (current) conditions.