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ACID RAIN - AN INVISIBLE THREAT

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Issue Definition :

Acid Rain is defined as precipitation (rain) that has a pH lower than 5.6, which is the pH expected in distilled water exposed to the atmosphere. (pH is a measure of the acidity or alkalinity of a water sample.) The pH of precipitation undoubtedly is affected by a variety of natural sources of acidic and alkaline materials (e.g. volcanic gases, gases from decomposing organic matter and soil dust). However it has recently become apparent that rain and snow in certain regions of the earth are consistently more acidic than expected. The European Atmosphere Chemistry Net Work first recognized that the pH of precipitation was declining in Scandinavia during the late 1960's. Current data indicates that the mean annual pH in this region was 5.0 - 5.5 in the late 1950's which declined to 4.2 - 4.4 in the mid 1970's. In Eastern North America precipitation is now more acidic than in Scandinavia. The median pH for 1978 - 1979 ranged from 4.0 to 4.4 in North Eastern U.S. and South Eastern Canada.

Although there is disagreement over the source and nature of acidic precipitation, the most widely accepted view is that the increased acidity is a result of the presence of increased quantities of sulphuric and nitric acids. These acids are believed to result from oxidation of sulphur and nitrogen oxide gases. Oxides of sulphur and nitrogen are produced from combustion of fossil fuels, metal smelting and various industrial processes. Although natural sources of these gases may be greater than anthropogenic sources, on a global scale, anthropogenic sources

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are concentrated in the Northern Hemisphere and far outweigh natural sources in populated areas. Transportation of these gases to distant locations is facilitated by the trend towards increasing height of smoke stacks and increasing use of particle precipitators. Tall stacks increase the dispersion of gases and particle precipitators reduce the quantity of particles that absorb and neutralize gases. The end result is long range transportation of gases which are transformed into strong acid precipitations in distant locations.

Heavy metals such as mercury and selenium and complex organic compounds, such as polychlorinated biphenyls and poly nuclear aromatic hydrocarbons are emitted to the atmosphere by fossil fuel combustion and industrial processes and have been detected in acidic precipitation. It is believed that sources and transport mechanisms are similar for acids, metals and organic compounds and these pollutants may interact with each other in the environment.

Impact on aquatic environments

The impact of acidic precipitation on an aquatic ecosystem is determined by geochemistry, geomorphology and hydro-dynamics of the system. These factors determine the buffering capacity - the ability to neutralize acids and resist changes in pH of soil and water. Decline in pH of surface waters and a low buffering capacity have been recorded in areas that received acidic precipitation. When buffering capacity of the water shed is exhausted, lakes and streams generally reflect the pH of the precipitation. Severe depression in lake and stream pH and increase in metal content have been associated with spring snow melt. Contaminants are stored in the snow pack until released by melting. The release rate of contaminants is not directly proportional to the amount of melting, but is greater during the early stages of melting.

The organic component of precipitation is poorly understood. Complex organic compounds of anthropogenic origin have been detected in lakes remote from any direct source. Compounds such as poly chlorinated biphenyls and poly nuclear aromatic hydrocarbons and pesticides such as toxaphene are known to be transported atmospherically and redetected in remote lakes, but the mechanism of transport and deposition are not known. Lake quality determines the vulnerability to acidification. Generally areas underlaid by insoluble bedrocks such as granite have overlying soil and surface waters that are low in buffering capacity. (Exclusive areas of Scandinavia and North America contain such terrains). Factors such as lake hydrology, water shed order or soil depth may also be important in controlling the vulnerability of a particular body to acidification.

Effect on fish, shell - fish and related organisms

Effect on fish have been widely reported probably because fishes are highly sensitive to acids and related contaminants and are the most visible components of the aquatic ecosystems. The observed effects include mortality, reproductive failure, reduced growth and skeletal deformities. The earliest recorded impacts of acidic precipitation were decline in populations of Atlantic Salmon in a few Southern Norway rivers, which were correlated with decline in river pH. Today nine rivers in Southern Norway are virtually devoid of Salmon where as no such declines have been observed in 79 rivers in Northern Norway which are not acidified. A survey of more than 2000 lakes in Southern Norway revealed that about one - third has lost their fish population, since previous survey in 1940's. Good fish populations are Seldom found in lake with pH5. Declines have been reported from Ontario, Adirondack mountain lakes of New York - where atleast 177 lakes totalling approximately 9000 acres have been acidified and have lost their fish population. Decline in salmon population was also reported from rivers of South Western Nova Scotia. Unfortunately no such studies and results are reported from our country.

Acute mortalities of adult fish have been observed, usually following a sudden spring melt or heavy rain. The cause of death may be either a decline in blood pH or loss of body sodium in response to increased external hydrogen ion concentration or acute toxicity of metals such as Aluminium or copper. The primary response of fish to acidic precipitation however appears to be reproductive failure. Several mechanisms have been reported including failure to produce and deposit viable eggs, failure of hatching and mortality of embryos. Thus early life history stages of fish are more susceptible to acidity and other pollutants. The severe conditions of spring melt coincide with the occurrence of sensitive life stages for some species especially salmonoids.

Sublethal effects such as reduced growth and skeletal deformities have also been observed in fishes of acidified lakes. Skeletal deformities are believed to be related to a reduction in body calcium levels in response to low pH. These fishes may also contain elevated levels of Hg which may render them unfit for human consumption.

All other biotic components of aquatic ecosystems may also be affected by acidic precipitation. Microbial decomposition of organic matter is depressed at low pH and methanogenic bacteria are replaced by sulphate reducers. Phyto plankton species composition shifts. Many species of macrophytes (Rooted plants) are displaced. The number of species of benthic invertebrates especially gastropods, May flies and Stone flies generally decline.

Need of the hour

Our knowledge of 'Acid Rain' is rather limited. A coordinated research effort to determine the source of strong acids responsible for increasing acidity in precipitation is necessary. Factors that govern susceptibility of different organisms to changes in pH are to be found out. Most water quality monitoring stations are located in high order water sheds that are affected by human activities such as agriculture and sewage disposal, which will mask acidification. Long term water quality monitoring stations must be located in low-order water sheds remote from human habitation. Traditional fixed endpoint alkalinity titrations over estimates true alkalinity. Colorimetric pH indicators over estimates true pH as much as 0.5 to 1.5 units in poorly buffered waters. So accurate pH meters and inflection - point alkalinity titrations must be adopted for poorly buffered surface water.

Reduction in emission of pollutants to atmosphere is an obvious solution for acid precipitation. Alternate solutions include neutralization of acidic lakes and streams by addition of basic substances and genetic selection of more acid tolerant strains of fishes. The discovery of acid rain gives us the opportunity to implement an equitable and effective solution to the problem massive deterioration of aquatic ecosystems may occur and widespread losses of fishery resources result.

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