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Acid Rain & Its Effect on Environment

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Abstract: Acidification of rain-water is identified as one of the most serious environmental problems of trans boundary nature. Acid rain is mainly a mixture of sulphuric and nitric acids depending upon the relative quantities of oxides of sulphur and nitrogen emissions. Due to the interaction of these acids with other constituents of the atmosphere, protons are released causing increase in the soil acidity. Lowering of soil pH mobilizes and leaches away nutrient captions and increases availability of toxic heavy metals. Such changes in the soil chemical characteristics reduce the soil fertility, which ultimately causes the negative impact on growth and productivity of forest trees and crop plants. Acidification of water bodies causes large scale negative impact on aquatic organisms including fishes. Acidification has some indirect effects on human health also. Acid rain affects each and every components of ecosystem. Acid rain also damages man-made materials and structures. By reducing the emission of the precursors of acid rain and to some extent by liming, the problem of acidification of terrestrial and aquatic ecosystem has been reduced during last two decades. Present study focus on the effects of Acid rain and measures to control that effect.

Keywords: Acid rain, Human Health, Aquatic Organisms, Ecosystem, Acidification.

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. 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. Burning of fossil fuels in industries and transport sector, industrialization and urbanization have led to increase in concentrations of gaseous and particulate pollutants in the atmosphere leading to air pollution (Tripathi and Gautam, 2007; Dwivedi and Tripathi, 2007). 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. Robert Angus Smith first used this term in 1872 to describe the acidic nature of rain around industrial town of Manchester, U.K. in a paper entitled "The air and rain beginning of chemical climatology". Scientists often refer to "acid deposition" as a more accurate term for acid rain. Along with the wet deposition there are also dry depositions of acids, which can be transformed into salts in the soil and cause the same environmental damage, as do the wet deposits. Dry deposition generally occurs close to the point of emission. Wet deposition, however, may occur thousands of kilometers away from the original source of emission.

Acid Rain History:

First observation of acid rain was recorded in the mid-19th century in Europe. Signs of leaf deterioration were found in forest located downwind of large industrial areas. In 1872 an English

Scientist Robert Angus Smith introduced the term "acid rain" as he noticed that acid precipitation damages the leafs. First attempt to reduce the acid rain was took place in 1936 at Battersea plant in London, UK, however after 1970 the severity of the issue had been increased. Increased utilization of coal fuel has resulted in elevated levels of SO2 concentrations in the atmosphere, thus, after 10 years of continuous National Acidic Precipitation Assessment Program (NAPAP), US congress has passed acid deposition act in 1980. This enlarged the monitoring site network for dry deposition and the effects of acid rain on monuments, fresh water, terrestrial ecosystem and buildings. Funded studies were carried out on atmospheric process and potential control programs. According to NAPAP's first assessment report in 1991 on acid rain, about 5% of New England's (in USA) lakes were acidic and issues such as changes biochemical pattern in soil, fresh water bodies and damages to the manmade structures were observed.

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.

Effects of acid rain on soil: Soil is one of the most important ecological factors. Every plant depends on it for their nutrient and water supply. Soil system is very complex and dynamic. Acid rain results into acidification of soil, which increases the exchange between hydrogen ion and nutrient cat ions like potassium (K), magnesium (Mg) and calcium (Ca) in the soil. These cat ions are liberated into soil and can be rapidly leached out in soil solution along with sulphate from acid input (Van Breeman et al., 1984)

Effects of acid rain on aquatic ecosystem: Acid rain makes the water bodies acidic. Streams and lakes normally show clear signs of acidification as these have less prospect of buffering acid inputs than do soils and plants. The acidic deposition changed the lake chemistry in the Adirondack region of New York . A survey report of Adirondack lake during 1991-1994 showed that 41% of lake either chronically acidic or susceptible to episodic acidification (Driscoll et al., 2001).

Effects of acid rain on lower plants: The lower plants including algae, fungi and lichen are also negatively affected by acid rain. Various microorganisms and microbial processes get affected because of changes in soil properties due to acid rain (Strayer et al., 1981; Johnson and Reuss, 1984). There were several reports on the impact of acid rain on mycorrhiza. These include negative influence on mycorrhizal association in Betula papyrifera (Kaene and Manning, 1988) and Picea rubens (Machara et al., 1993). Lichens are more sensitive to acidification of soil. They provide a sensitive biological litmus indicator (Ferry et al., 1973). Nitrogen fixation performed by lichen, Peltigera sp was found to be sensitive at pH 2.4 (Gunther, 1988). Photosynthetic activity was also found to be decreased at pH 3.0 in Cladina stellaris (Lechowiez, 1982). It has been found that species of diatoms and golden brown algae are also sensitive to change in water chemistry and hence can be used as indicator of acidity of water (Smol and Glew, 1992). With acidification of lakes, golden brown algal species are replaced by other chlorophycean

like Chlorella mucosae (Findlay and Kasian, 1986).

Lakes and Streams: All rock minerals are alkaline and therefore help neutralize acidic ground water. The degree of neutralization depends on the length of time in contact with the minerals and their individual rates of reactivity. The acidity of a lake or a headwater stream therefore depends on these factors and the acidity of the rainfall. Thus, for example, rain averaging a pH of 5.0 can produce lake or stream water with similar acidity if the water falls on a smooth granite surface and runs directly into the lake or stream. If the same water moves slowly through a soil rich in limestone fragments, however, the resulting stream or lake water may be completely neutralized and hence have a pH well above 7. Organic acids from humid layers in the forest soil, with a pH as low as 4, could increase the acidity of the resulting surface waters.

Visibility: The sulfuric acid produced from the emissions of SO2 reacts with alkaline compounds in the air to form fine particles of ammonium sulfate and calcium sulfate, among others. These particles produce haze, especially at high levels of humidity. This effect is particularly evident in the relatively clean air areas of the western states. In many of the National Park areas the sulfate creates 50 to 60 percent of the degradation in visibility. In the East it is closer to 70 percent, and the total haze is much greater. It is difficult to quantify the effect over short periods because of the many factors including humidity and carbonaceous and soil particles that contribute to the phenomenon. Nevertheless, historical studies on a regional basis suggest that decreased visibility is related to increased sulfate particle concentration in both the western and eastern United States.

Crops: Numerous controlled experiments in which crops of corn, oats, potatoes, and soybeans have been exposed over the growing season to simulated acid rain have established that current concentrations of acidity in rain observed in agricultural as do not retard growth. The experiments demonstrate that there is no significant effect on growth even at ten times the acidity now observed in the eastern United States. The nitrate component, and to a lesser extent the sulfate component, of acid rain actually benefit nearly all crops and forests because of their nutritional requirements. This fertilization reduces the amount the farmer or commercial forester must otherwise provide.

Forests: Controlled experiments exposing a wide range of tree species as seedlings to simulated acid rain over the current range of concentrations for up to three growing seasons have shown no effects on growth rates. Extensive surveys in natural forests and commercial plantations over the eastern and northwestern states have failed to identify any regional decline that could not be attributed to natural causes, with the possible exception of red spruce trees in the high elevations of the northeastern Appalachians. (These high-elevation red spruce forests above the cloud base or about 700 meters represent less than 0.01 percent of the forested area east of the Mississippi.)

Building Materials: Researchers have examined three types of building materials for damage by acid rain: galvanized steel, carbonate stone, and surface coatings. Since all of these materials are also affected by solar radiation, ozone, thermal cycling, moisture cycling, bacterial activity, natural organic acids, and carbonic acid in rain, it is difficult to determine the incremental degree of erosion or corrosion of these materials due to ambient levels of acid rain. The main effect of rain acidity on galvanized steel is the dissolution of a basic zinc carbonate corrosion product that occurs naturally. Although the acidity of rain contributes to the final removal of the zinc, the rate of corrosion depends on the sulfur dioxide, nitric acid, and formaldehyde already on dew-covered surfaces. Since the SO2 is 10 to 100 times greater in urban than in rural regional air, the economic damage from exposed galvanized steel occurs largely in cities. Although at present the relative contribution of the SO2 gas to corrosion is uncertain, the acidity of rain appears at worst to make only a secondary contribution.

Health: Researchers have not demonstrated indirect health effects from acid rain in drinking water. Where metal concentrations in untreated drinking water have exceeded drinking water standards, these concentrations have not been traceable to differential acidity in rainfall. For example, regardless of the acidity of the rain, cistern water is usually alkaline since it is normally stored in cement containers.

Control of acid rain: This can be achieved by following ways: Liming:- The damage to lakes and other water bodies can be eliminated by adding lime. Many chemicals such as caustic soda, sodium carbonate, slacked lime and limestone are most popular for raising pH of acidified water (Khemani

et al., 1985). Liming eliminates some of the symptoms of acidification; it is expensive and not real cure.

PREVENTIVE MEASURE REDUCE EMISSIONS:

• Burning fossil fuels is still one of the cheapest ways to produce electricity so people are now researching new ways to burn fuel which don't produce so much pollution.

• Governments need to spend more money on pollution control even if it does mean an increase in the price of electricity.

• Sulphur can also be 'washed' out of smoke by spraying a mixture of water and powdered limestone into the smokestack.

• Cars are now fitted with catalytic converters which remove three dangerous chemicals from exhaust gases.

ALTERNATIVES SOURCES OF ENERGY:

• Governments need to invest in researching different ways to produce energy.

•Two other sources that are currently used are hydroelectric and nuclear power. These are 'clean' as far as acid rain goes but what other impact do they have on our environment?

• Other sources could be solar energy or windmills but how reliable would these be in places where it is not very windy or sunny?

• All energy sources have different benefits and costs and all these have to be weighed up before any government decides which of them it is going to use.

• Sulfur and nitrogen are mostly released into the atmosphere from the burning of fossil fuels (e.g. Coal).

CONSERVING RESOURCES:

• Greater subsidies of public transport by the government to encourage people to use public transport rather than always travelling by car.

• Every individual can make an effort to save energy by switching off lights when they are not being used and using energy-saving appliances - when less electricity is being used, pollution from power plants decreases.

• Walking, cycling and sharing cars all reduce the pollution from vehicles.

CONCLUSION:

The ecological effects of acid rain are most clearly seen in the aquatic, or water, environments, such as streams, lakes, and marshes. Acid rain flows into streams, lakes, and marshes after falling on forests, fields, buildings, and roads. Acid rain also falls directly on aquatic habitats .Acid rain affects each and every components of ecosystem. Acid rain also damages man-made materials and structures Acid rain is one of the most serious environmental problems emerged due to air pollution Sulphur dioxide (SO2) and oxides of nitrogen and ozone to some extent are the primary causes of acid rain. Acid rain causes a cascade of effects that harm or kill individual fish, reduce fish population numbers, completely eliminate fish species from a water body, and decrease biodiversity. These mobilized contaminants are dissolved in soil and water make their way to groundwater that is drunk by humans and contaminate the food (Fish, meat, and vegetables) eaten by humans .These heavy metals get accumulated in the body and resulted into various health problems like dry coughs, asthma, headache, eye, nose and throat irritations. Acid rain is one of the world's major environmental problems since 19th century. Coal burning is the major cause of SO2 production and also vehicle emission and various fossil fuel based power generation emits NOx. Both SO2 and NOx produces suplhuric and nitric acid respectively by reacting with atmospheric water vapour and precipitate as wet deposition such as rain, snow, sleet and fog and dry deposition including hazardous particles of PM 2.5. Acid rain affects forest trees causes yellowing and leaf fall, acidified rivers and lakes causes fish death, loss of calcareous shell forming species (mollusks), it also affects soil microorganisms causes increased nitrification which also leads to eutrophication in water bodies and changes in the biodiversity. Acid rain also destroys the coral reefs. It causes leaching of metal ions including toxicAluminum and heavy metals such as chromium, cadmium and nickel, which adversely affects the soil micro flora and aquatic biota. Acid rain deteriorates the marble, stone monuments and architectures, corrode metal structures and fading paints. Liming is used to neutralize the acidity in soil and aquatic bodies. Several methods are used to reduce the emission of SO2 and NOx such as reducing the sulphur content in fuels, using scrubbers such as flue gas desulphurization (FGS) lime injection multi stage burning (LIMB) or fluidized bed combustion (FBC or circulation dry scrubber). To reduce NOx

methods such as selective catalytic reduction process (SCR) where injection of reactive chemicals such as ammonia reacts with NOx and convert into N2and O2, changing air to fuel ratio and changing the combustion temperature. In automobile three way catalytic converters are used to get rid of NOx. By 1990 US congress has passed amendments to the Clean Air Act. Title IV of the amendment consist control measures to SO2 and NOx , implemented in 2 phases. In Asia, regional acidification information and simulation programme is conducted. NOx. Budget Trading program (NBP) operated from 2003 to 2008, For trans boundary acid deposition issue US and Canada have signed in a bilateral air quality agreement in 1991, an integrated atmospheric deposition network (IADN) was established and in 2011cross state air pollution rule and litigation (CSAPR) implemented by US EPA for the same.

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