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IMPACTS OF ACID RAIN ON ENVIRONMENT

Dr. S.R.Ali*

*Professor,
Department of Civil Engineering, Faculty of Engineering,
Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, INDIA
Email id: drsrali.engineering@tmu.ac.in

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ABSTRACT

Acid rain is one of the important environmental threats and occurs due to the presence of certain acids in the atmosphere. Acidification of the rainwater is identified by the presence of sulphuric and nitric acids. Interaction of acid rain with environmental components results in their degradation. Acid rain reduces the soil fertility resulting in an adverse impact on the growth of the forest and crop fields. Acidification of the water bodies (lake/ponds) affects aquatic flora and fauna adversely. Acid rain also has some deleterious effects on human health, building and materials. The acid rain is responsible for the disturbance of several abiotic and biotic components of the ecosystem. Thus, the present review focuses on the causes, impacts and possible solution for the acid rain.

KEYWORDS: *Acid rain, Causes, Effects, Acidification, Control strategies.*

1. INTRODUCTION

Reduced reproduction of aquatic fish species, plant dieback and stunted growth, accumulation of toxic aluminum and heavy metals in soil and water bodies, biodiversity loss including corals and shellfish, and degradation of manmade structures have all been observed as a result of acidification around the world. Acid rain is produced by the release of SO2 and NOX into the atmosphere from different sources, which dissolve in atmospheric water and form acids in rainwater. SO2 does not react much with atmospheric chemicals, but it may travel longer distances faster and generates SO3 when it comes into touch with ozone or hydrogen peroxide, which is extremely soluble in water and forms sulphuric acid. Volcanic eruptions, marine spray, planktons, decaying plants, and forest fires all generate sulphur dioxide naturally. Sources of anthropogenic pollution, sulphur dioxide emissions from industrial combustion (point sources), household heating (firewood and coal) (area or non-point sources), and transportation (3.7 percent) account for 69.4 percent, 3.7 percent, and 3.7 percent, respectively (mobile sources).

It is also released from the manufacture of sulphuric acid during the production of disinfectants, bleaching agents, and fumigants, as well as from the smelting of metal ore, production of iron and steel, process pure metal (obtaining pure metals of Zn, Ni, and Cu), oil refinery, domestic and industrial boilers, and it is released from the manufacture of sulphuric acid during the production of disinfectants, bleaching agents, and fumigants. Natural sources of NOX include lightning, bacterial activity, forest fires, and volcanoes; man-made sources include cars (43%), fertilizer factories, power plants, and other industrial combustion (32 percent)The acid rain is

considered as one of the Global ecological problems. It is considered as the precipitation of low pH water (pH range: 4.2-4.7) in the form of rain, snow, fog, hail or even dust. The term acid rain is first used by Robert Angus Smith in 1872 to describe the nature of rain around the industrial town of Manchester, UK.

Wet deposition such as cloud water, rain, snow, hail, dew, fog or sheet) and dry deposition (SO2, NOx, other acid gas and particles) of acid components are responsible for the acid rain. Sulphuric and Nitric acids are considered as the major causes behind acidic rain whereas the formation of sulphuric acid and nitric acid in the atmosphere are the results of the atmospheric transformation reactions of the oxides of sulphur (SO2) and oxides of nitrogen (NOx) respectively. Nitrate levels in soil rise as a result of acid rain, resulting in nitrogen saturation. Excess nitrogen is removed from the soil by nitrate ions, which also remove extra calcium and magnesium. Several industries, motor vehicles, oil refineries and burning of fossil fuel are the important sources responsible for the generation of acid rain precursors. In the wet atmospheric conditions, these precursor gasses are converted in to sulphuric acid and nitric acid[1-3].

$SO2 + H2OH2SO4$ (Sulphuric Acid) ..... (1)

$NOx + H2O \longrightarrow HNO3$ (Nitric Acid).....(2)

Acid rain is also known for its role in environmental damage and trans-boundary air pollution. Acid rain is a result of emission of SO2 (fossil fuel combustion and metal smelter) and NOx forming sulphuric and nitric acid in precipitation. Acid rain has several adverse effects on ecological aspects (it harms flora and fauna both), biogeochemical cycles, soil quality due to nutrient leaching from top soil to sub soil and below subs soil in the presence of acid rain. Apart from the above mentioned, acid rain also has several adverse impacts on human health such as itching, skin burn, respiratory problems (asthma, dry cough and irritation in throat), headache, brain damage and kidney problems. Degradation in building material (historical monument and sculpture all over the world), yellowing and weakening of fabrics are also results of acid rain exposure. Acid rain is the main reason for corrosion of several metals and structure made from it. It is also responsible for the loss of carved details and corrosion of copper, zinc etc. Acid rain is toxic to many aquatic organisms because it releases aluminum from the soil into lakes and streams. As the pH goes below 5, 75 percent of lakes and 50 percent of streams in the United States get acidified, according to natural surface effects of deposition.

Acid precipitation on vegetation reduces the photosynthesis and growth also increase the susceptibility to draught and disease, process called ‘dieback’ it causes browning of leaf and fall off, in addition, effects such as thinning of annual growth ring and reduction in biomass (due to reduced growth), it also damages the fine root system, affect root mycorrhiza. Man-Made Structures Effects Because nitric acid, sulphuric acid, and sulphuric acid concentrated in dew or rain deposited on automobile coatings cause paint fading, contemporary car manufacturers employ acid to coat their vehicles. Phosphorus deficiency decreases fruit output, while toxic elements like zinc and aluminum accumulate. Aluminum toxicity slows root development and causes chlorophyll loss.

Effects on the ocean surface Acid rain is harmful to many aquatic creatures because it transfers aluminum from the earth into lakes and streams. As the pH goes below 5, 75 percent of lakes and 50 percent of streams in the United States get acidified, according to natural surface effects of deposition. Similarly, 14,000 lakes in eastern Canada were found to be acidic. Acidification is

more likely in soft waters with low alkaline metal ions. Acidification causes granite rocks to release more aluminum. Aluminum causes chronic stress, which causes fish to lose weight or shrink in size, making them less effective in fighting for food and habitat. Furthermore, most eggs may not hatch, some adult fish may die, and partly sensitive animals like snails and clams cannot survive pH levels below.

However, certain species, such as frogs, can survive lower pH, but their prey species, such as mayflies, cannot, and a reduction in the prey population leads to a fall in the frog population. The ecosystem is affected by the food chain's interconnections and interdependencies. Toxic heavy metal ions such as copper, cadmium, nickel, chromium, cobalt, lead, and zinc released into the water decrease fish development and growth. Acidic conditions combined with heavy metal toxicity decreased fish development and increased stress, making the fish less immune and therefore more vulnerable to illnesses, killing eggs and larval stages, and reducing spawning and reproductive success. Another significant cause of episodic acidification is nitrogen dioxide deposition in water bodies; approximately 10-45 percent of nitrogen dioxide reaching water bodies is airborne, and it is mostly delivered to the atmosphere by human causes.

Similarly, 14,000 lakes in eastern Canada were found to be acidic. Acidification is more likely in soft waters with low alkaline metal ions. Acidification causes granite rocks to release more aluminum. Aluminum causes chronic stress, which causes fish to lose weight or shrink in size, making them less effective in fighting for food and habitat. Furthermore, most eggs may not hatch, some adult fish may die, and partly sensitive animals like snails and clams cannot survive pH levels. However, although certain species, such as frogs, can survive lower pH, their prey species, such as mayflies, cannot, resulting in a reduction in the prey population. Acid rain is toxic to many aquatic organisms because it releases aluminum from the soil into lakes and streams. As the pH goes below 5,75 percent of lakes and 50 percent of streams in the United States get acidified, according to natural surface effects of deposition. Similarly, 14,000 lakes in eastern Canada were found to be acidic. Acidification is more likely in soft waters with low alkaline metal ions. Acidification causes granite rocks to release more aluminum. Aluminum causes chronic stress, which causes fish to lose weight or shrink in size, making them less effective in fighting for food and habitat. Furthermore, most eggs may not hatch, some adult fish may die, and partly sensitive animals like snails and clams cannot survive pH levels below 5.5.However, although certain species, such as frogs, can survive lower pH, their prey species, such as mayflies, cannot, resulting in a reduction in the prey population[4], [5].

2. DISCUSSION

Biological consequences of acid rain are mostly visible in aquatic areas like streams, lakes, and marshes, where it can harm fish and other species. Acidic rain water can drain aluminium from soil clay particles as it passes through the soil and into streams and lakes[6]–[9]. Aluminum is discharged in greater quantities when more acid is added into the ecosystem. Acidic waters with moderate quantities of aluminium are tolerable to some plants and animals. Others, on the other hand, are acid-sensitive and will perish as the pH drops. Acid rain-affected regions are littered with dead or dying trees. Aluminum is leached from the soil by acid rain. Aluminum may be detrimental to both plants and animals. Acid rain also depletes the soil of minerals and nutrients that trees require to thrive. Acidic fog and clouds at high elevations may drain nutrients from tree foliage, leaving brown or dead leaves and needles. As a result, the trees are less able to absorb

sunlight, making them fragile and susceptible to cold conditions. Acidic deposition isn't always moist. It's possible for dust particles to become acidic as well, which is known as dry deposition. The nitric and sulfuric acid that makes acid rain and dry acidic particles acidic can drop on sculptures, buildings, and other built objects, causing damage to their surfaces.

The acidic particles damage metal and accelerate the deterioration of paint and stone. They also make buildings and other structures, like as monuments, filthy. The costs of this harm can be substantial. Humans are no more at risk from walking in acid rain or swimming in acidic lakes than they are from walking in normal rain or swimming in non-acidic lakes. When pollutants that produce acid rain are present in the air, such as SO2 and NOX, as well as sulfate and nitrate particles, they may be hazardous to people. Fine sulfate and nitrate particles are formed when SO2 and NOX combine in the environment, which humans may inhale. Many scientific investigations have shown a link between these particles and effects on heart function, such as heart attacks that end in mortality in individuals who have a higher risk of heart disease, and impacts on lung function, such as breathing problems in people who have asthma. Acid precipitation on vegetation reduces photosynthesis and growth, increasing susceptibility to draught and disease. A process known as ‘dieback' causes browning of leaves and fall off as well as other effects such as thinning of annual growth rings and reduction in biomass (due to reduced growth). It also damages the fine root system, affecting root morphology. During the monitoring phase. The National Acid Deposition Program (NADP) uses wet and dry deposition collectors to monitor acid deposition The container on the left collects rain water, while the container on the right measures dry deposition[1], [2], [5], [10]–[12].

Acidification has an impact on shell-forming mollusks, shell fish, coral reefs, sea grass beds, and aquatic creatures in their juvenile stages. In an acidic climate, the calcareous shell or skeleton of shellfish and corals dissolves. Acid tolerant organisms, such as bacteria and protozoa, thrive in low pH environments. Acid rain isn't the only source of acidification; certain swamps, bogs, and marshes have pH levels that are naturally low. Furthermore, acid water drainage from coal mines may reach surface water bodies, resulting in fish deaths in Pennsylvania, West Virginia, and Virginia surface waterways in the United States and Canada, respectively.

The causative agents of acid rain, SO2, SO3 and NOx, may have a negative impact on health, especially SO2 & SO3's influence on asthma and emphysema patients, as well as a rise in the incidence of asthma and emphysema. Particles smaller than PM 2.5 may enter the bloodstream via the lungs and produce adverse consequences such as lung cancer. Because nitric acid, sulphuric acid, and sulphuric acid, which are concentrated in dew or rain and deposited on automobile coatings, cause the paint to fade, contemporary vehicle manufacturers cover with acid. Impairment of vision in the eastern United States, acid fog, especially sulfur dioxide and sulfur trioxide particles, decreases vision by 50-70 percent. Scrubbing can take the form of electrostatic precipitators, in which positively charged sulphur particles are attracted to a negatively charged plate, or chemical means, such as wet scrubbing (injecting water or a chemical solution like flue gas desulphurization (FGS), which removes SO2 at a rate of 80-95 percent, or dry scrubbers like lime injection Multi stage burning (LIMB) or fracking. To decrease NOx, techniques such as the selective catalytic reduction process (SCR), which reduces NOx by up to 80% by injecting reactive chemicals such as ammonia, which interacts with NOx and converts it to N2 and O2, altering the air-to-fuel ratio, and modifying the combustion temperature are used. Catalytic converters, such as three-way catalytic converters that convert

NOx into N2 and O2, and conversion of CO into CO2, are used to reduce NOx emissions in automobiles. Hydrocarbon conversion to CO2 and water.

During the years 1985 to 1987, each plant was granted a number of "allowances" based on yearly SO2 emissions. The program also promoted the use of renewable energy and energy saving. Solar, wind, and geothermal facilities are also eligible for tax breaks. The Title V acid rain permit scheme required plant or industrial owners to apply to the relevant government for legal authorization. The acid rain program was divided into two phases: Phase I took place from 1995 to 2000, and Phase II began in 2009 to track general changes in SO2 and NOx emissions in New England. A similar initiative, the Regional Acidification Information and Simulation Programme, is being implemented in Asia, where the danger is growing in emerging nations as their energy demands rise (Hunt, 1992, as quoted in Kemp, 2004). From 2003 to 2008, the NOx Budget Trading Scheme (NBP) was a cap-and-trade program in which businesses in the eastern United States were obliged to reduce NOx emissions during the summer season.

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In 1991, the United States and Canada signed a bilateral air quality agreement to minimize the impacts of trans-boundary acid deposition, and an integrated atmospheric deposition network (IADN) was created to gather and manage data on the subject. Similarly, the US EPA has been enforcing the Cross State Air Pollution Rule and Litigation (CSAPR) since 2011, which substantially lowers emissions that cross state lines. Since the 19th century, acid rain has been a significant environmental concern. This article examines the US EPA's 2012 progress report and analyzes the problem from different environmental perspectives. The active implementation of the Clean Air Interstate Rule (CAIR), Acid Rain Program (ARP), and NOx budget training program has resulted in significant reductions in SO2, NOx emissions, and acid deposition (NBP). The US EPA's Cross State Air Pollution Rule and Litigation (CSAPR) has reduced wastewater cross-border flow between the US and Canada since 2011. Between 1980 and 2012, the national composite mean of average SO2 annual mean ambient concentration in the United States decreased by 85 percent.

3. CONCLUSION

Coal combustion is the primary source of SO2, as well as car emissions and NOx emissions from different fossil fuel-based power plants. By interacting with atmospheric water vapour, SO2 and NOx create sulphuric and nitric acid, respectively, and precipitate as wet deposition such as rain, snow, sleet, and fog, as well as dry deposition such as dangerous PM 2.5 particles. Acid rain causes yellowing and leaf fall in forest trees, fish mortality in acidified rivers and lakes, and the

loss of calcareous shell-forming species (mollusks). It also causes increased nitrification in soil microorganisms, which leads to eutrophication in water bodies and changes in biodiversity.

Coral reefs are also harmed by acid rain. It results in the leaching of metal ions, particularly harmful Aluminum and heavy metals like chromium, cadmium, and nickel, which has a negative impact on the soil microflora and aquatic biota. Acid rain corrodes metal buildings and fades paintwork, causing marble, stone monuments, and architecture to degrade. Liming is a process that is used to neutralize acidity in soil and water. Reduced sulphur content in fuels, scrubbers such as flue gas desulphurization (FGS), and lime injection multi stage burning (LIMB), or fluidized bed combustion (FBC or circulation dry scrubber) are all used to decrease SO2 and NOx emissions. To decrease NOx, techniques such as the selective catalytic reduction process (SCR), in which reactive chemicals such as ammonia are injected and react with NOx to convert it to N2 and O2, as well as altering the air-to-fuel ratio and the combustion temperature, are used. NOx is removed from automobiles using three-way catalytic converters.

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