ACID RAIN AND ITS ENVIRONMENTAL IMPACTS: A REVIEW

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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.

Key words: - Acid rain, Causes, Effects, Acidification, Control strategies

1. Introduction

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 (Smith, 1872). Wet deposition such as cloud water, rain, snow, hail, dew, fog or sheet) and dry deposition (SO_2, NO_x, 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 (SO_2) and oxides of nitrogen (NO_x) respectively. 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 (as mentioned in the eq.1 and eq.2).

$SO_2 + H_2O = H_2SO_4$ (Sulphuric Acid)....................... (1)

$NO_x + H_2O = HNO_3$ (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 SO_2 (fossil fuel combustion and metal smelter) and NO_x (released from the vehicular sources, industrial and power plant) 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 sub soil in the presence of acid rain (Sonwani and Maurya, 2018). 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.

2. Causes of Acid Rain

Figure 1 shows the cause and mechanism of the acid rain formation. Both natural and anthropogenic causes are responsible for the formation of acid rain in the atmosphere. But the combustion of the fossil fuel releases sulphur dioxide (SO_2) and nitrogen oxides (NO_x) which are significantly responsible for the formation of acid rain in the atmosphere (Sonwani and Maurya, 2018).

2.1 NATURAL SOURCES

Volcanic eruption is one of the main sources for the acid rain formation. Volcanoes release a large amount of gases responsible for the formation of the acid rain and other forms of precipitation (fog and snow) affecting the environment adversely. Forest fire, degrading vegetation and biological activities also release significant quantities of gasses producing acid rain. Dimethyl sulphide (C_2H_6S) is a major biological contributor to sulphur containing elements into the atmosphere. Anaerobic biological reactions in the soil/water and photochemical destructions are the important sources for the formation of atmospheric oxide of nitrogen in the atmosphere. Lightening activity produces nitric oxide (N_2O) which reacts with the water to form nitric acid which is an important constituent of acid rain.

2.2 ANTHROPOGENIC SOURCES

Several industries, (chemical, petrochemicals, pulp and paper) oil refineries, thermal power plant and emissions from the motor vehicles are the important sources that release the precursor gasses such as oxides of sulphur and oxide of nitrogen responsible for the formation of the acid rain (Saxena and Sonwani, 2019) The coal combustion used in the electricity generating plants is one of the biggest contributors for the production of gasses responsible for the acid rain. In the urban area, gaseous emissions from the industries and motor vehicles are the major sources for the acid rain formation. Such gasses react with the water, oxygen and other atmospheric chemicals to form several compounds such as sulphuric acid and nitric acid which result in the formation of acid rain. Under the influence of the meteorological parameters (such as wind speed, wind directions, temperature, relative humidity and mixing height) these atmospheric gasses transport at a larger distance and participate in the atmospheric transformation reactions responsible for the acid rain (Fig.1).

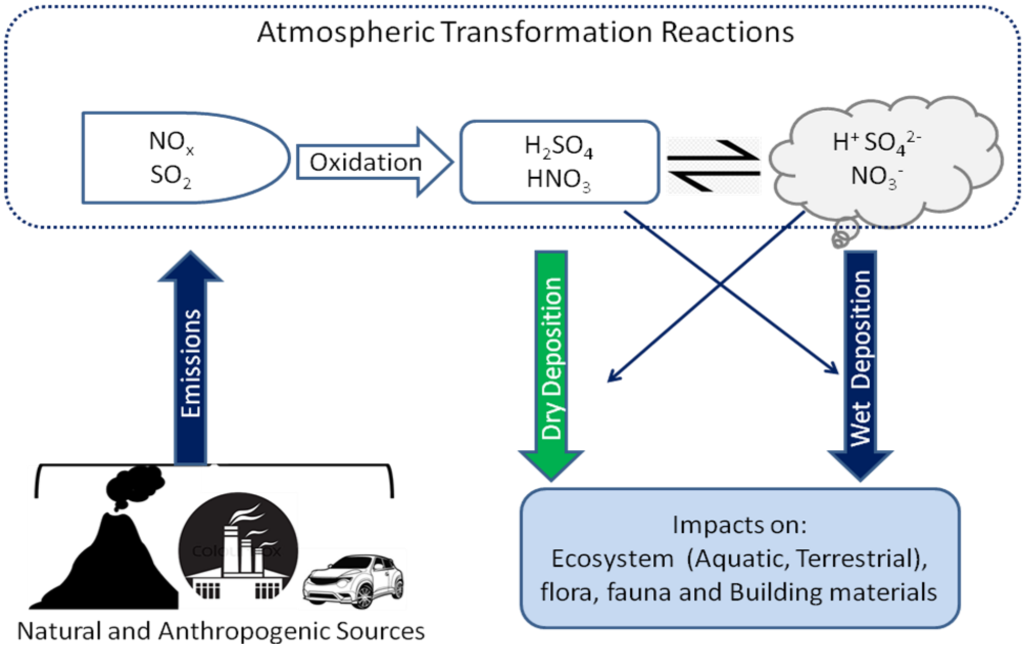

Fig. 1 Causes, formation mechanism and environmental impacts of the acid rain (Adapted from Sonwani and Maurya, 2018)

3. Effect of acid rain

In today's world due to rapid industrialization and to cope up with the demand of this exponentially growing population we have completely ignored the consequences of such actions on nature which ultimately resulted in causing serious damage to our environment. Acid rain is one such phenomenon caused due to acidification of rainwater by gases like sulphur dioxides and oxides of nitrogen and ozone to some extent. Such gases are not only released as a by-product from the burning of fossil fuels but also from motor vehicle exhausts (releasing NO_x) and smelters (releasing SO_2). These oxides react with each other and form hazardous substances in both dry and wet form which carried along with rainwater droplets and cause acid rain. Acid rain is a common term used for acid deposition in the form of rain, snow, hail etc. This acid precipitation has several profound effects on almost everything ranging from plants, soil to non-living objects like buildings. Here we will only discuss it's the effect on plants and crop fields.

In plants, acid precipitation causes foliar damage, create disturbance in plant physiological pathways like photosynthesis, nitrogen and sulphur metabolism, leaching of essential nutrients from leaves, cause hindrance in germination. (Varshney et al., 1979). Moreover, this acid precipitation causes soil acidification, improper nutrient supply etc.

The acidity of the rainwater is measured using a pH scale as low pH can damage biological membranes, electron transport system and other crucial phenomena essential for the survival of the plant.

3.1 EFFECTS ON CROP FIELD

Several studies mentioned the impacts of the acid rain on crop field (Singh and Agrawal, 2007, 2004). A wide range of responses are shown by crop plants in response to acidic rain. Table 1 showing the age wise changes in morphological characteristics in Simulated Acid Rain (SAR) treated *Triticum aestivum* var. *M213 & Sonalika* plants. Singh and Agarwal, (2004) conducted a field experiment in which they studied the effects of simulated acid rain of different pH i.e. 5.6 (control), 5.0, 4.5, 4.0, 3.0, using two cultivars of wheat (*Triticum aestivum*) *Malviya 213* (*M213*) and Sonalika. They used a split-plot design with cultivars as whole plots and SAR treatment was used as subplots. Five treatments of SAR were given (after 15 days of germination) i.e. 5.6, 5.0, 4.5, 4.0, and 3.0 within a time interval of 9:00-11:00 a.m. twice a week for 75 days. After 75 days six monoliths of 10x10x20cm^3 with intact roots were taken out. Two growth days i.e. 45 and 75 were taken and the samples were then thoroughly washed and several observations like leaf area (calculated using leaf area meter), shoot and root lengths, number of leaves, total biomass were made for each pH value. They found a significant reduction in root and shoot length at pH 3.0, the difference between both varieties is that *M213* showed a reduction in shoot length at both ages while Sonalika showed reduction at 75 days age. Whereas 13% and 15.5% root length reduction reported for *M213* and *Sonalika* respectively at pH 3. Similarly, leaf area declined at pH 4.0 & 3.0 in *M213* while 75 days age in *Sonalika* similar trend was observed in case of total biomass. Hence the magnitude of reduction was higher in *M213* as compared to that of *Sonalika*. Thus, different cultivars respond differently to different pH values of acid rain.

Table 1 Age wise changes in morphological characteristics in SAR treated *Triticum aestivum* var. *M213 & Sonalika* plants

Sonalika plants

Parameters	Age (Days) 45					Age (Days) 75				
	C	T1	T2	T3	T4	C	T1	T2	T3	T4
Root Length (cm)	9.83^a	8.97^a	8.97^a	8.25^a	8.08^a	10.45^a	9.58^a	9.25^a	9.17^a	8.73^b
	±0.68	±0.32	±0.21	±0.41	±0.35	±0.22	±0.47	±0.28	±0.40	±0.59
Shoot Length (cm)	19^a	18.37^a	18.22^a	17.8^a	17.58^a	79.45^a	78.67^a	76.33^a	73.17^{ab}	71.33^b
	±0.74	±0.44	±0.54	±0.64	±0.40	±1.11	±1.26	±1.38	±1.28	±1.34

M213 Plants

Parameters	Age (Days) 45					Age (Days) 75				
	C	T1	T2	T3	T4	C	T1	T2	T3	T4
Root Length (cm)	9.17^a	9.08^a	8.37^a	8.33^a	7.92^a	9.75^a	9.33^a	9.42^a	8.75^a	8.47^b
	±0.44	±0.27	±0.33	±0.28	±0.52	±0.38	±0.31	±0.31	±0.50	±0.51
Shoot Length (cm)	23.75^a	22.22^a	20.58^a	20.22^a	17.92^a	80.67^a	76.73^a	76.17^a	74.67^{ab}	70.5^b
	±0.81	±0.69	±1.04	±0.64	±0.72	±2.68	±0.52	±0.91	±1.15	±0.76

C= control; T1= pH 5.0; T2=pH4.5; T3= pH4.0; T4= pH3 (Table modified from Singh and Agarwal, 2004)

Acid rain can severely affect foliar parts of a plant. There are few crop plants which are resistant towards acid rain and noticed with profitable yield. In an experiment, some major crops of United States were allowed to grow in field chambers and exposed with simulated acid rain (pH 3.0, 3.5, 4.0 & control of pH 5.6) to identify the effects of acid rain on their yield, growth and foliar injury (Lee et al., 1981). Total above-ground portion and roots are usually determined at the time of harvest. Studies found that the acid rain unexpectedly increases the yield of crops (tomato, green pepper, strawberry, alfalfa, timothy, orchard grass). It was also mentioned that a group of monocotyledons are generally more affected than dicotyledons and different species showed different tolerance to acidified water (Lee et al., 1981; Singh and Agrawal, 2007; Lal, 2016).

3.2 IMPACT ON FOREST TREES

Effects of acid deposition on forest can be studied at two levels, firstly acid rain will damage foliar parts of the plant which will include direct damage to plant tissues like chlorosis, necrosis etc. and secondly through roots which is responsible for the stunted growth of tree including reduced canopy size (Tomlinson, 1983). It is worth mentioning that apart from the negative effects, acid rain also has some positive aspects in the forest ecosystem (Abrahamsen, 1984; Cowling and Dochinger, 1980). The positive and negative effects of the acid rain to forest ecosystem determine on the basis of the high/low productivity of the forest. Acid rain is considered as beneficial if it supports the productivity and vice versa.

This can be understood easily by taking an example consider a forest that is deficient in nitrogen (N) and sulphur (S) in that case moderate acid deposition will enrich the land with nitrogen and sulphur thereby causing productivity to increase. Similarly, if the land is already enriched with nitrogen and sulphur then acid deposition will lead to decrease in productivity (Johnson, 1982). An experiment was conducted where researchers sprayed acidic mist of pH 2.5 to a canopy of Sitka spruce which provided an overall of 48 Kg nitrogen and 50 Kg sulphur per hectare per year for three years. They observed a continuous decrease in the wood growth which is primarily due to the leaching of calcium ion causing membrane destabilization and foliar injury. Morphology and chemical composition of the soil is another important factor which decide the impact of the acid rain onto the forest and its productivity.

3.3 EFFECT ON SOIL

Soil is one of the essential ecological factors responsible to supply water and nutrients to the plants. Acid deposition adversely affects the soil quality by changing its pH levels, which ultimately disturb the soil nutrients concentration. Thus, acid deposition indirectly affects the ecosystem by changing soil chemistry. Increasing soil acidity negatively affects soil microflora population, accountable for the breakdown of soil organic matter into simple nutrients. Thus, acid rain harms the soil quality. Importantly, three important impacts of acid rain on soil reported are: (1) acid rain entering in the soil may be neutralized by the presence of the free bases such as $CaCO_3$ or Na_2CO_3, but during episodic acidification (melting snow or heavy rain downpour brings higher quantity of acidic deposition in soil) soil losses its buffering capacity (2) Acid rain removes the essential nutrients and minerals from the soil that are required for the plant growth (3) Acid rain leaches aluminium from the soil, which may be injurious to flora and fauna.

Due to the soil acidification cation (potassium, calcium and magnesium) exchange also happen under the influence of the hydrogen ions of acid rain. The dissolution of the soil minerals and salts resulting in the leaching of these minerals and salts from top soil to sub soil surface cause the mineral and salt deficiency in the top soil. This deficiency of the soil minerals and salts affect the soil fertility, which ultimately effects the growth of plants.

3.4 EFFECT ON AQUATIC ECOSYSTEMS

Aquatic ecosystem has wide range of abiotic and biotic components (autotrophs and heterotrophs). Acid rain lowers the acidity of the water bodies as water has low acid buffering capacity than soil, thus acid rain changes the chemistry of the lake. Thus, acid rain increases the acidity of the water bodies such as lakes and streams due to low buffering capacity of water and surrounding soil. Acid rain also releases aluminium from soil to the lakes and streams which is highly toxic to aquatic life including producers (algae, mosses and phytoplankton) and consumers. Phytoplankton is an important source of food for filter-feeding crustaceans and rotifers. Many of them are very sensitive to low pH level and thus disappear from water bodies after acid rain.

3.5 ACIDIFICATION OF LAKES/PONDS

Lakes are one of the important aquatic ecosystems supporting water life. Each abiotic and biotic component in any ecosystem has an important role and can affect directly or indirectly other related things in the ecosystem. Acid rain is one of the results of various anthropogenic activities which harm the environment. Lakes and pond have buffering capacity to balance their fluctuating pH levels which supports their aquatic life. So, the influx of acid in lakes/ponds can be maintained up to some extent. But when acid rain is precipitated in lakes/ponds for a long time, the concentration of nitrogen and sulphur compound increases in water resulting in loss of their buffering capacity and slowly its water becomes acidic there by resulting in the death of aquatic life and lakes both. The country like Norway has been suffering from acidification of lakes which has also reduced their freshwater availability. Most of the European countries, US and Canada are also suffering from these problems.

3.6 EUTROPHICATION OF LAKE

Eutrophication can be defined as the over enrichment of mineral and nutrients in the water bodies such as lakes and ponds. This excessive growth of algae in the lake called algal bloom which covers lake surfaces with green blanket. Eutrophication depletes the dissolved oxygen and increases the biochemical oxygen demand of water. It also blocks the sunlight and gaseous exchange from the lake water resulting in loss of underwater plant and animal species. Excess accumulation of the nitrogen, phosphate and organic compounds are the major causes responsible for the eutrophication of lake, whereas acid rain is another important reason behind eutrophication in lake. As acid rain reaches to the ground it easily solubilises several available nutrients present in the soil which ultimately reaches the nearby water bodies. Due to this continuous flow of such water leads to nutrient enrichment and cause eutrophication in lakes.

DAL JHEEL is the one of the famous lakes in Srinagar capital of Jammu & Kashmir. It is slowly dying due to eutrophication. Main reason for the eutrophication in Dal Lake is the disposal of 15 major drains of city containing sewage and organic waste of the city in lake which decreases the oxygen level and causes the algal bloom in the lake. Thus the fresh water availability for the cities as well as the aquatic life forms has decreased in the lake.

3.7 EFFECT ON BUILDING MATERIALS

Mainly the materials used in the buildings are marble, limestone, wood, cement, and metals (iron, aluminium, bronze etc). Acid rain affects these materials through two processes: **Dissolution** in which acid solubilises other solids or metals in to it and **Alteration** in which acid rain breaks or alters the solid physically.

3.7.1 Effect on marble and limestone

Acid rain has permanent effect on the marble and limestone because they are made up of calcium carbonate mainly called calcite. Such materials easily dissolve in the acid rain through the dissolution and form sulphates and nitrate of calcium which are highly soluble in water.

$$CaCO_3 + \text{Acid } (H_2SO_4, HNO_3) \rightarrow CaSO_4 + Ca(NO_3)_2 + CO_2 \text{ (Bubble off)}$$

They are later washed out by the rain water which leads to the degradation of limestone

3.7.2 Effect on cement and concrete

Acid rain effects cemented or concrete structures directly through the process of alteration, making the structures porous due to low pH (~3) and exposed to the moisture and leads to deterioration of the structure. Carbonation is the process through which acid rain affects the cemented structure which leads to corrosion, weakening and cracks in concrete which are very harmful for a building.

3.7.3 Effect on metals

Acid is very reactive towards metals. It easily corrodes or damages the surface of several metals such as iron, copper and zinc. Under the influence of acid rain, the acid reacts slowly and forms a corrosive layer on metal surface. This corrosion damages metal and reduces its strength and durability. Steel, bronze, zinc and nickel are some of the most vulnerable metals towards acid rain.

$$Fe(s) + H_2SO_4\,(aq) = FeSO_4\,(aq) + H_2 \text{ .... (4)}$$

$$Zn(s) + H_2SO_4\,(aq) = ZnSO_4\,(aq) + H_2 \text{ etc .... (5)}$$

3.7.4 Effect on Sculptures

Acid rain has significant effect on the monuments and sculptures made up of rocks, stones, wood, fabric and metals. Acid rain leads to the loss of many art sculptures every year. Acid rain affects sculptures in two ways:

Dry Acid– During dry conditions fumes of sulphuric acid deposit at the marble or limestone structure that are exposed to rain as well as shaded area and forms black crust over the surface which is called as gypsum. When it is washed with water, it leads to loss of material and weakening of that sculpture. The area which is protected from water this gypsum can be seen.

Wet Acid– Under normal weather conditions in acid mixes with rain water and reacts with calcite present in calcium carbonate which leads to corrosion of the materials.

Fig.2 Effects of the acid rain on Sculptures (Source: https://en.wikipedia.org/wiki/Acid_rain)

Some major monuments that are affected by acid rain are:

(a) Taj Mahal, Agra: Taj Mahal is one of the cultural UNESCO World Heritage Site and situated on the bank of the river Yamuna in Agra, India. It is also known as one of the Seven Wonders of the World. But under the influence of acid rain, the colour of the Taj Mahal is turning yellow day by day which leads to loss of its beauty. It's due to the presence of nitric acid and sulphuric acid in the rain deposited in the vicinity of Agra. These acids are the results of the transformation of atmospheric oxides of nitrogen and sulphur dioxide into nitric acid and sulphuric acid respectively. Such types of gases released by several industries located in the vicinity of Agra and Mathura. Vehicular emission also contributed to a large amount of the oxide of nitrogen into the atmosphere. The acid rain reacts with the calcite of marble resulting in yellowing of white marble of Taj. Due to continuous exposure marble loses its texture, broken spot and yellow tint form over the marble over time. Taj Trapezium case is linked to the Taj and the petition of this case was filled by M.C. Mehta, who mentioned that oil refinery at Mathura and industries located at Agra, emit a large amount of the toxic gasses responsible for the acid rain in the Agra region resulting in yellowing of white marble of Taj.

(b) Giant Buddha Statue, China: The world's largest Buddha statue situated in Mount Emei, one of the four sacred Buddhist Mountains of China. The statue has great religious belief and made up of carving a face on a sandstone rock of 71-meter height. Now, it is suffering from the black spot due to acid rain. Acid rain has destroyed the beauty of the statue and surface of the statue has become rough and porous. The cause of this acid rain is due to coal power plants near Mount Emei.

(c) Silver Bridge, Ohio River, U.S.: Silver bridge located in U.S over the Ohio River is famous for its unique aluminium paint. It collapsed in 1967 after a life of 40 years. According to some

investigators, the indirect reason for collapsing of bridge is the acid rain which slowly corrodes its paints and its joints leading to the weakening of shackles or cables.

4. Acid Rain Control Strategies

Acid rain is a global environmental problem and cannot be solved without any proper strategy. It may take several years to solve the problem. Till today few under developing countries can't even figure out the source of emission and receptor for the acid rain. These strategies can be divided into two parts 1. Source emission strategies which include strategies to control the emission of acidic gases from the source, to examine the emission from the sources, to check the sources whether they are working under the policy or norms made by the government or not like stack height, etc. 2. Receptor recovery strategies which include recovering the sites which are affected by the deposition of acid rain example: soil liming, lake liming, etc.

4.1 SOURCE EMISSION STRATEGIES

4.1.1 *Policy Implication*

It is listed under source emission strategies. The first step in acid rain control is to spread awareness among the people rather to enhancing any financial support to use advanced technology (Abbasi et al., 2013) or implications of the policies like restriction on using high sulphur coal, setting a limit on sulphur emission. It even turns out to be an effective strategy when local and central government work together towards the implementation of a policy which holds ecological importance and is in nation's best interests (Hao et al., 2007). The government can also sign the agreement with the industrialists to generate their interest in these national policies that helps in controlling acid rain as it is not easy to control acid rain.

4.1.2 Fuel Switching

Fuel switching is one of the easiest methods to reduce emission from the coal (with high sulphur) combustion activities. The use of low sulphur coal or reducing the use of coal or a step towards renewable energy sources (wind energy, tidal energy, hydrothermal and geothermal energy) can be a better option to reduce toxic gases responsible for the acid rain (Sivaramanan, 2015). In vehicles, we can switch from petrol or diesel to CNG or even better renewable energy options.

4.1.3 Advance Technology

There are several methods by which we can control acid rain by spending at cheap rates than the available technology but these are at underdeveloped or at developing stage, for example, Limb Injected Multistage Burner (LIMB). It is a method in which sulphur dioxide and nitrogen oxide can be reduced significantly by directly introducing the lime in the chamber which absorbs a considerable amount of these (Fay et al., 1983). There are also other methods which are just in Developing Stage which need to be financed. It comes under source emission strategies.

4.1.4 Scrubber

Scrubbers are the device that is used to control pollution by controlling the emission of acidic gases in the environment (Kerr, 1998; Smock, 1990). Positively charged Sulphur particles are attracted by the negatively charged plate in electrostatic precipitators. Instead of the negatively charged plate, we can also use chemical methods (Sivaramanan, 2015) like in "Flue gas desulphurization" it involves bringing post-combustion gas in contact with an aqueous solution of lime. The Sulphur dioxide reacts with this aqueous solution and other alkaline additives in it to form gypsum (calcium sulphate) this method is also known as a wet-scrubber method. Dry scrubbers method includes Limb injected multistage burner (LIMB) (Fay et al., 1983). It comes under source emission strategies.

4.1.5 Pre Combustion Cleaning of Fuels

Coal can be washed before utilization. It involves physical washing by water which can reduce sulphur from about 30% to 20%. It is a very effective method as there will be less emission of Sulphur dioxide after coal utilization. We can also opt for coal that has low Sulphur content however, this low Sulphur coal is not that much famous because it has low calorific content (Fay et al., 1983).

4.1.6 Models

We can also establish different models to ascertain a relation between the source of emission and the region of deposition. Such approach will further help the government to make policies, which will be also helpful in redistribution of emission sources. It will also be helpful to get the idea about the cost assessment between the damage caused by the source and cost it will take to recover the damage. There are different models for that like box-model and atmospheric models which depict the ongoing scenario and the complications associated with it (Fay et al., 1983). These models also tell us about the point of source and point of damage, so that we can sum up the damage caused and make policies accordingly.

4.2 RECEPTOR RECOVERY STRATEGIES

Receptor recovery strategies are for the recovery of the sites affected like lakes, streams and forests etc. Soil liming can be done to reduce the acidity of the soil in an effort to make the soil suitable for the crop cultivation or for the plant growth. We can also grow species that are suitable for the acidic environment and are of economic importance. Although liming is very expensive and not affordable to all, it is also not a permanent solution as it can also kill species that live in acidic soil by turning the soil too basic (Fay et al., 1983).

4.2.1 Liming

It comes under receptor recovery strategies. Lime is added to the water to reduce its acidity. Calcium present in the lime acts as sustenance for the primary production in an aquatic system. Lime is also helpful in reducing the toxicity of heavy metals and it also helps in the regeneration of the locked nutrients in the water bodies (Sivaramanan, 2015). But liming is not a permanent solution (Singh and Agarwal, 2007) and it is not recommended as it increases the turbidity and cloudiness in water (Sivaramanan, 2015). There is a wide application of liming in lakes, streams, running water and forest soils.

(a) Liming lake & Streams: Adding lime directly to the surface of lakes provides a cheap and clear-cut method for raising pH and acid-neutralizing capacity (ANC) of lakes. It was reported that lakes appear to recover faster than streams (Gerson et al., 2016). Acidified streams have different liming challenges than lakes. However, fewer data are available on trends in stream chemistry than lake chemistry, but the limited data suggests that chemical recovery in streams may be weaker than in lakes. Moreover, stream water chemistry is temporally changeable than lake water chemistry, and more prone to intermittent acidification during high flows.

(b) Liming forest soils: Liming in the forest soil is used to recover depleted Ca level due to soil acidification. The terrestrial liming is done through helicopters or with spreaders pulled by tractors or skidders (Long et al., 1997). Liming in forest soil is also helpful to prevent the mobilization of toxic Al forms in soils and help to restore both terrestrial and aquatic ecosystems. Liming could also be used to balance ecosystem nutrient relationships. Liming also helps in the re-establishment of biogeochemical linking between terrestrial and aquatic ecosystems.

Conclusion

Acid rain is one of the global issues with several adverse impacts on the environment. Oxides of nitrogen and sulphur dioxide are major gasses behind the formation of acids in the atmosphere responsible for acid rain. Emissions from industries are major sources for sulphur dioxide whereas several fossil fuel combustion activities and vehicular emissions are the major cause for emission of oxides of nitrogen in the atmosphere. As a result of these gasses acid rain happens after the formation of nitric acid and sulphuric acid. Acid rain causes several environmental problems such as the impact on the forest, crop, building, material, soil/water acidification including health-related issues (respiratory disorder, irritation in eyes and skin infections). To reduce such type of global problems several strategies have been adopted to reduce the acid rain and its impact on the environment. The effect of acid rain can be lowered by spreading awareness among the people and by the implementation of policies. Using advanced technology that is cost-efficient and reliable may also decrease acid deposition. The government can make some more strict policies regarding the emission of sulphur dioxide and nitrogen oxide from the transports and industries.

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