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Acid rain and its environmental impacts

Research project
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for the degree of Bachelor science in Chemistry.

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Abstract:

Acid rain is a form of precipitation that contains high levels of sulfuric and nitric acids, primarily resulting from the combustion of fossil fuels. This phenomenon has raised significant environmental concerns due to its detrimental effects on ecosystems, water bodies, infrastructure, and human health. In this review, we explore the sources and mechanisms of acid rain formation, its distribution and prevalence globally, and its environmental impacts. Acid rain has been linked to the acidification of soil and water bodies, leading to the decline of aquatic life, damage to forests, and corrosion of buildings and infrastructure. Moreover, it poses risks to human health through the contamination of food and water sources. Various strategies have been proposed and implemented to mitigate the impacts of acid rain, including the reduction of sulfur and nitrogen emissions, use of alternative energy sources, and restoration of affected ecosystems. Understanding the complexities of acid rain and its environmental impacts is crucial for developing effective policies and practices to address this pressing environmental issue.

Keywords: Acid rain,Acid deposition , Effects and Control Strategies of acid rain

1-Introduction

Acid rain is a major problem facing the environment today. It is formed through both natural and anthropogenic sources. Industrial emissions are anthropogenic sources, and a volcano eruption is an example of a natural source. One of the most direct effects of acid rain is on aquatic ecosystems. Acid rain is the term given to increased acidity of rain due to the effects of gases (from industrial and natural processes) which dissolve in rainwater to form various acids. Acid rain forms when certain atmospheric gases (primarily carbon dioxide, sulphur dioxide, and nitrogen oxides) come in contact with water in the atmosphere or on the ground and are chemically converted to acidic substances. Oxidants play a major role in several of these acid-forming processes. Carbon dioxide dissolved in rain is converted to a weak acid (carbonic acid). Other gases, primarily oxides of sulphur and nitrogen, are converted to strong acids (sulphuric and nitric acids). Although rain is naturally slightly acidic because of carbon dioxide, natural emissions of sulphur and nitrogen oxides, and certain organic acids, human activities can make it much more acidic. (Prashant mehta,2010)

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 (Saurabh sonwani et al.,2020)

Also it is rain with a higher concentration of positively charged atomic particles (ions) than normal rain.. “Normal” or unpolluted rain has an acidic pH, but usually no lower than 5.7, because carbon dioxide and water in the air react together to form carbonic acid, (Nazih K. shammas et al.,2023)

Acid rain affects human life in a variety of ways. It can acidify soil and surface waters, bringing about a series of ecological changes such as hampering the growth of forests and agricultural crops and threatening animal spe- cies. For example, freshwater shrimp cannot sur- vive at a PH level of 6.0 or below. At a PH level of 5.5, bottom-dwelling bacterial decomposers begin to die, causing non-decomposed leaf litter and other organic debris to lie on the bottom and depriving plankton of a food supply. At a PH level of 4.5 or below, all fish and most frogs and in- sects die (Nagase and Silva, 2007).

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.(Saurabh sonwani et al ,2020)

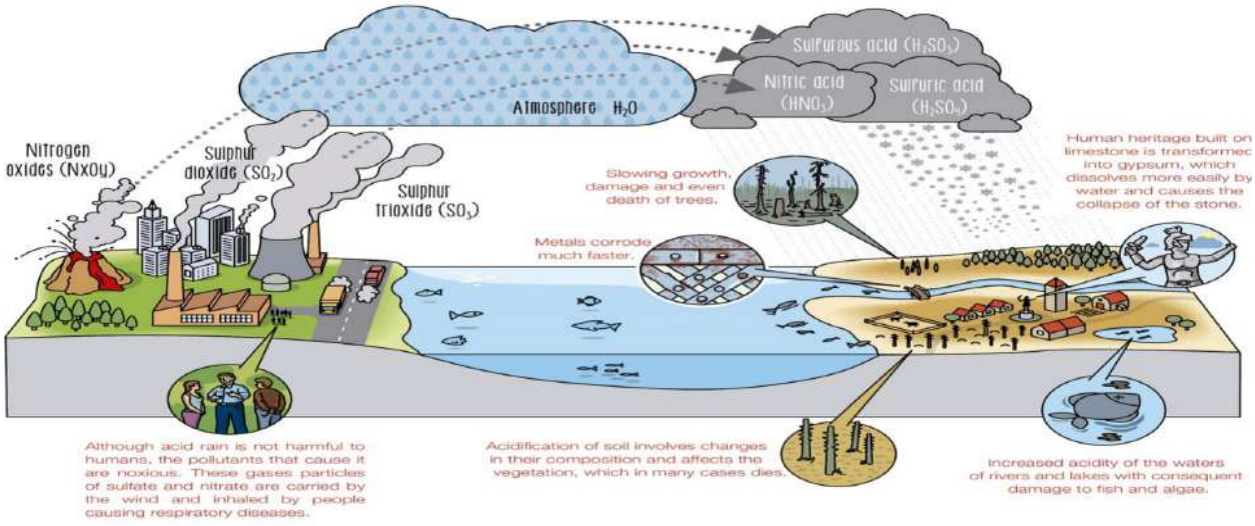

Figure. 1(Formation & Effect of acid rain)

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 source

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.

Figure. 2 (Volcanic eruptions)

2.2.Human source

Several industries, (chemical, petrochemicals, pulp and paper) oil refineries, thermal p wind energy, tidal energy, hydrothermal and geothermal energy)ower 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

Figure. 3 (Human source of acid rain)

3.Chemical reaction

Acid rain is the term given to increased acidity of rain due to the effects of gases (from industrial and natural processes) which dissolve in rainwater to form various acids. Acid rain forms when certain atmospheric gases (primarily carbon dioxide, sulphur dioxide, and nitrogen oxides) come in contact with water in the atmosphere or on the ground and are chemically converted to acidic substances. Oxidants play a major role in several of these acid-forming processes. Carbon dioxide dissolved in rain is converted to a weak acid (carbonic acid), (Mohajan and Haradhan,2018);

$H_2O\ (l) + CO_2\ (g) \rightarrow H_2CO_3\ (aq)$.

Acid rain is caused by the emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x; mainly nitric oxide NO and nitrogen dioxide NO_2) through the combustion of fossil fuel, which react with the water molecules in the atmosphere (oxidation) to produce H_2SO_4 and HNO_3 acids respectively (Schwartz, 1989). The procedures of formation of these two acids are as follows:

Formation of sulfuric acid (H_2SO_4):

Sulfur in coal burns in oxygen to form SO_2. Typically, less than 5% of the sulfur is dissolved into SO_2;

$S\ (\text{from coal}) + O_2(g) \rightarrow SO_2(g)$.

This SO_2 reacts with O_2 in atmosphere to form sulfur trioxide (SO_3);

$SO_2(g) + O_2(g) \rightarrow SO_3(g)$.

This SO_3 reacts with moisture in the atmosphere (water) to form H_2SO_4;

$SO_3\ (g) + H_2O(l) \rightarrow H_2SO_4(aq)$.

In the presence of sunlight (hυ), SO_2 and OH^- combine to form H_2SO_4;

$SO_2(g) + 2OH^- + h\upsilon \rightarrow H_2SO_4(aq)$.

Formation of nitric acid (HNO_3):

Nitric oxide (NO) can react with oxygen (O_2) to form nitrogen dioxide (NO_2), which can be broken down again by sunlight ($h\upsilon$) to produce NO and an oxygen radical O_2^-;

$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$,

$NO_2(g) + h\upsilon \rightarrow NO(g) + O_2^-$.

This O_2^- reacts with O_2 to create ozone (O_3);

$O_2^- + O_2(g) \rightarrow O_3(g)$.

In the presence of O_3, NO forms more NO_2;

$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$.

The O_2^- reacts with H_2O to produce hydroxyl radical $(OH)^-$;

$O_2^- + H_2O(l) \rightarrow 2OH^-$.

This OH^- reacts with NO to produce nitrous acid (HNO_2), and reacts with NO_2 to produce nitric acid (HNO_3);

$NO(g) + OH^- \rightarrow HNO_2(aq)$,

$NO_2(g) + OH^- \rightarrow HNO_3(aq)$.

4. Type of deposition

Acid rain is a type of acidic deposition, which can take many different forms. They are broadly divided into two main categories: wet deposition and dry deposition. Rain, sleet, snow, or fog that has been more acidic than usual is referred to as wet deposition. Dry deposition refers to acidic gas and particles. The wind has the ability to transport deposits, both wet and dry, sometimes over very great distances. Both wet and dry acid deposition can cause lakes to become acidic and fall on things like buildings, cars, and trees. People who breathe in dry acid deposits may experience health issues as a result.

4.1.Wet deposition

Wet deposition refers to acidic rain, fog, and snow. If the acid chemicals in the air are blown into areas where the weather is wet, the acids can fall to the ground in the form of rain, snow, fog, or mist. As this acidic water flows over and through the ground, it affects a variety of plants and animals. The strength of the effects depends on several factors, including how acidic the water is; the chemistry and buffering capacity of the soils involved; and the types of fish, trees, and other living things that rely on the water. the process of wet deposition of acidic compounds In particular, acidic deposition has adverse effects on vegetation. This is mainly due to soil acidification and the uptake of substances, which disturb the pH levels within plant cells that may lead to the evolution of reactive radicals(Rennenberg H and Gessler A ,2001)

4.2.Dry deposition

in areas where the weather is dry, the acid chemicals may become incorporated into dust or smoke and fall to the ground through dry deposition, sticking to the ground, buildings, homes, cars, and trees. Dry deposited gases and particles can be washed from these surfaces by rainstorms, leading to increased runoff. This runoff water makes the resulting mixture more acidic. About half of the acidity in the atmosphere falls back to earth through dry deposition.(Baedecker, P.A. et al.,1992)

5-Effect of acid rain

5.1. Effect on terrestrial plant life

1. Both natural vegetation and crops can be affected.
2. It can alter the protective waxy surface of leaves, lowering disease resistance.
3. It may inhibit plant germination and reproduction.
4. It accelerates soil weathering and removal of nutrients.
5. It makes some toxic elements, such as aluminum, more soluble. High aluminum concentrations in soil can prevent the uptake and use of nutrients by plants

.Over the years, scientists have noticed that some forests have been growing more and more slowly without reason. Trees do not grow as fast as they did before. Leaves and pines needles turn brown and fall off when they are supposed to be green. Acid rain does not kill trees immediately or directly. Instead, it is more likely to weaken the tree by destroying its leaves, thus limiting the nutrients available to it. Or, acid rain can seep into the ground, poisoning the trees with toxic

substances that are slowly being absorbed through the roots. When acid rain falls, the acidic rainwater dissolves the nutrients and helpful minerals from the soil. These minerals are then washed away before trees and other plants can use them to grow.

Not only does acid rain strip away the nutrients from the plants, they help release toxic substance such as aluminum into the soil. This occurs because these metals are bound to the soil under normal conditions, but the additional dissolving action of hydrogen ions causes rocks and small bound soil particles to break down. When acid rain is frequent, leaves tend to lose their protective waxy coating. When leaves lose their coating, the plant itself is open to any possible disease. By damaging the leaves, the plant can not produce enough food energy for it to remain healthy. Once the plant is weak, it can become more vulnerable to disease, insects, and cold weather which may ultimately kill it.(Prashant Mehta,2010)

. Acid rain damages trees by dissolving the calcium in the soil and in the leaves of trees. This hurts the tree, because calcium is a mineral that trees need to grow. Once the calcium is dissolved, the rain washes it away so the trees and other plants cannot use it to grow. Acid rain washes other minerals and nutrients from the soil in a similar fashion, causing

Nutrient deficiency . This is why acid rain can cause trees to grow more slowly. (Guide,2008)

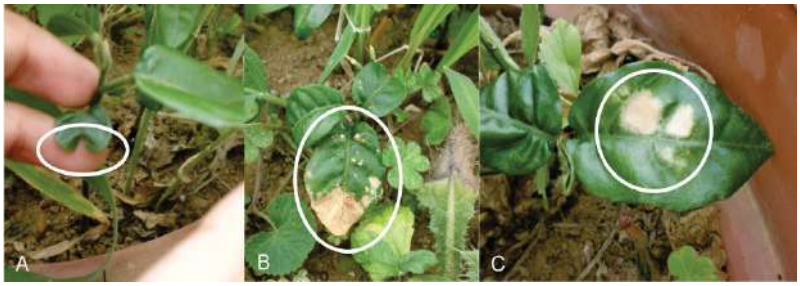

Figure. 4 (alter the protective waxy surface of leaves)

Figure. 5 (Weakening and destruction of trees)

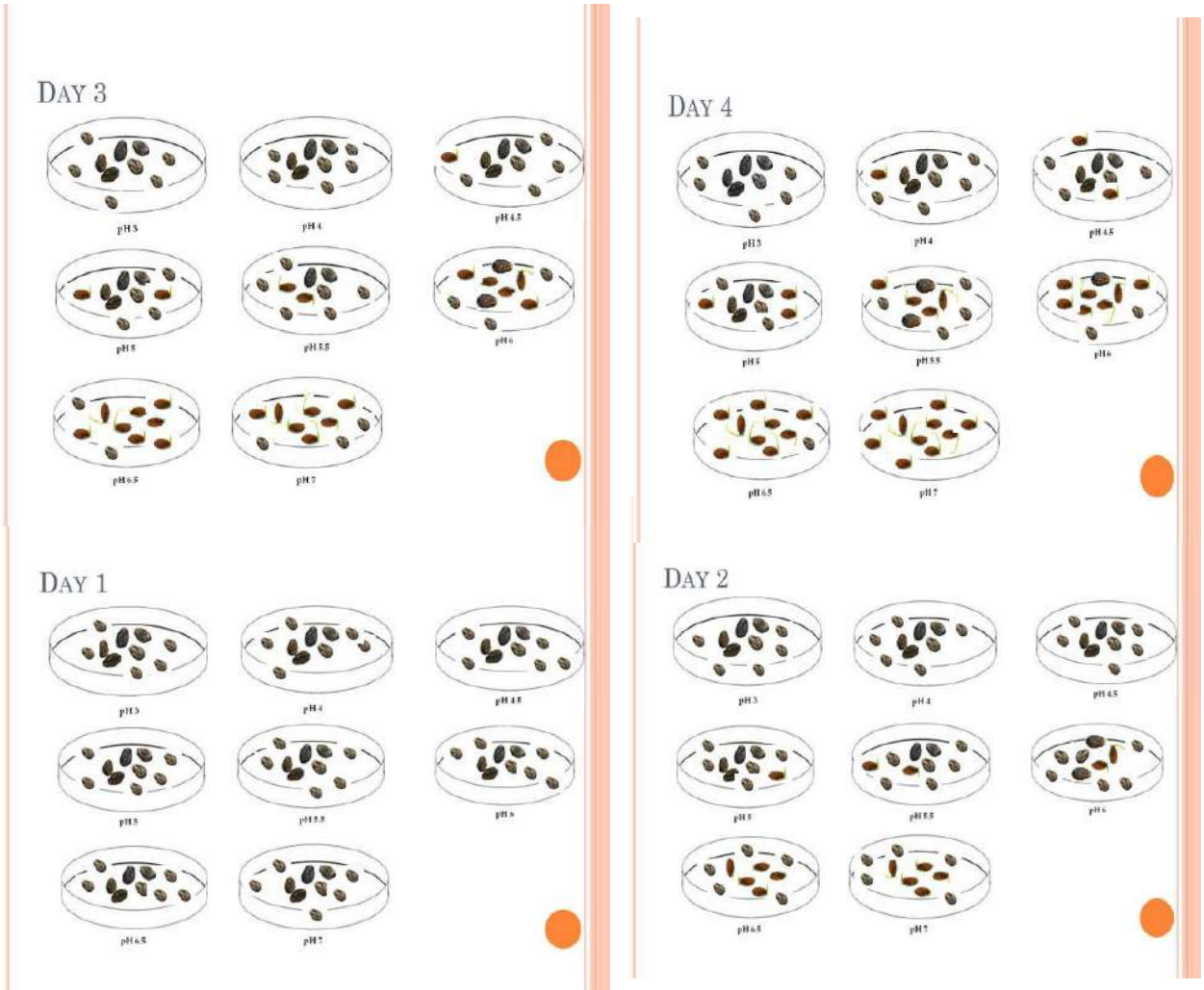

Figure.6 (inhibit plant germination and reproduction)

5.2. Effect on human being

Most importantly, acid rain can affect health of a human being. It can harm us through the atmosphere or through the soil from which our food is grown and eaten from. Acid rain causes toxic metals to break loose from their natural chemical compounds. Toxic metals themselves are dangerous, but if they are combined with other elements, they are harmless. They release toxic metals that might be absorbed by the drinking water, crops, or animals that human consume. These foods that are consumed could cause nerve damage to children or severe brain damage or death. Scientists believe that one metal, aluminum, is suspected to relate to Alzheimer's disease. One of the serious side effects of acid rain on human is respiratory problems. The sulphur dioxide and nitrogen oxide emission gives risk to respiratory problems such as dry coughs, asthma, headaches, eye, nose, and throat irritation. Polluted rainfall is especially harmful to those who suffer from asthma or those who have hard time breathing. But even healthy people can have their lungs damaged by acid air pollutants. Acid rain can aggravate a person's ability to breathe and may increase disease which could lead to death.(Prashant mehta,2010)

Figure.7 (Effect on human being)

5.3. 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 aluminum 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.(Sorabh sonwani,2020)

Figure.8 (Effect on soil)

5.4 Effect on aquatic ecosystems

Acid rain affects ponds, rivers, streams, lakes, gulfs, seas, oceans, etc. by increasing their acidity. As a result fish and other aquatic creatures can no longer live (Ekmekyapar et al., 2009). Acid rain affects on fishes directly or indirectly. Direct effects are the alteration of blood chemistry, retardation of egg development, etc. Indirect effects are the reduction in the kinds and supply of food available to fish, the creation of toxic to fishes, etc. Some lakes in Sweden have become so acidic that they are no longer able to support fish life (EPA, 2004). At pH, lower than 5 most fish eggs will not hatch, and also kill adult fishes. At pH 6, freshwater shrimp cannot alive and at pH< 4.5, all fish die. Snails, crayfish, and certain other invertebrate animals are very sensitive to acid and may rapidly disappear if acidity increases. Some microorganisms, plankton, insects, and blue-green algae are the food of fishes; these are affected by acid rain, ultimately fishes are declined due to the lack of food (Mohajan and Haradhan,2018)

Figure.9 (reduced reproduction and mortality of fish)

5.5 Effect on buildings and monuments (Heritage structures)

Acid rain does not only damage the natural ecosystems, but also man-made materials and structures. Buildings have always been subject to attack by weathering; the effects of rain, wind, sun, and frost. Acid rain can accelerate the rate of this damage. Throughout the world, emissions of sulphur dioxide and nitrogen oxides contribute to the international problem of acidification. Acid deposition affects most materials to some degree. Limestone, marble and sandstone are particularly vulnerable, whilst granitic-based rocks are more resistant to acidity. Other vulnerable materials include carbon-steel, nickel, zinc, copper, paint, some plastics, paper, leather and textiles. Stainless steel and aluminum are more resistant metals. Structural damage to underground pipes, cables and foundations submerged in acid waters

can also occur, in addition to damage to buildings, bridges and vehicles above ground. Whilst dry deposition contributes to the corrosion of materials, in most areas with substantial rainfall it is the effect of wet deposition on building surfaces which is more damaging. Building stone can be damaged when calcium carbonate in stone dissolves in acid rain to form a crust of calcium sulphate or gypsum. The sulphated layers are more readily washed away by rainfall or removed by the action of frost and other weather conditions, resulting in more stone being exposed. This permanent alteration of stone surfaces by the action of acid deposition is known as sulphation.

Sulphur dioxide is the main pollutant in respect to corrosion but others also take their toll, including nitrogen oxides, carbon dioxide, ozone (on organic materials) and sea salt from sea spray. Research has revealed that when nitrogen dioxide is present with sulphur dioxide, increased corrosion rates occur. This is because the nitrogen dioxide oxidises the sulphur dioxide to sulphite thereby promoting further

sulphur dioxide absorption. The interactions between building materials and pollutants are very complex and many variables are involved. Deposition of pollutants onto surfaces depends on atmospheric concentrations of the pollutants and the climate and microclimate around the surface. Once the pollutants are on the surface, interactions will vary depending on the amount of exposure, the reactivity of different materials and the amount

of moisture present. The last factor is particularly important because the sulphur dioxide that falls as dry deposition is oxidized to sulphuric acid in the presence of moisture on the surface. The effects of acid deposition on modern buildings are considerably less damaging than the effects on ancient monuments. Marble, limestone, and sandstone can easily be dissolved by acid rain. Metals, paints, textiles, and ceramic can effortlessly be corroded. Acid rain can downgrade leather and rubber. Man- made materials slowly deteriorate even when exposed to unpolluted rain, but acid rain helps speed up the process. Acid rain causes carvings and monuments in stones to lose their features(Prashant mehta , 2010)

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

5.5.1 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.

$CaCO_3$ + Acid (H_2SO_4, HNO_3 $\longrightarrow$ $CaSO_4$ +Ca $(NO_3)_2$ + CO_2 (Bubble off)

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

Figure.10 (marble and limestone)

5.5.2 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.

Figure.11 (change of concrete due to acid rain effects over time)

5.5.3 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.

$Fe(s) + H_2SO_4\ (aq) \longrightarrow FeSO_4\ (aq) + H_2$

$Zn(s) + H_2SO_4\ (aq) \longrightarrow ZnSO_4\ (aq) + H_2$ etc

5.5.4 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:

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

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.(Saurabh Sonawi et al., 2020)

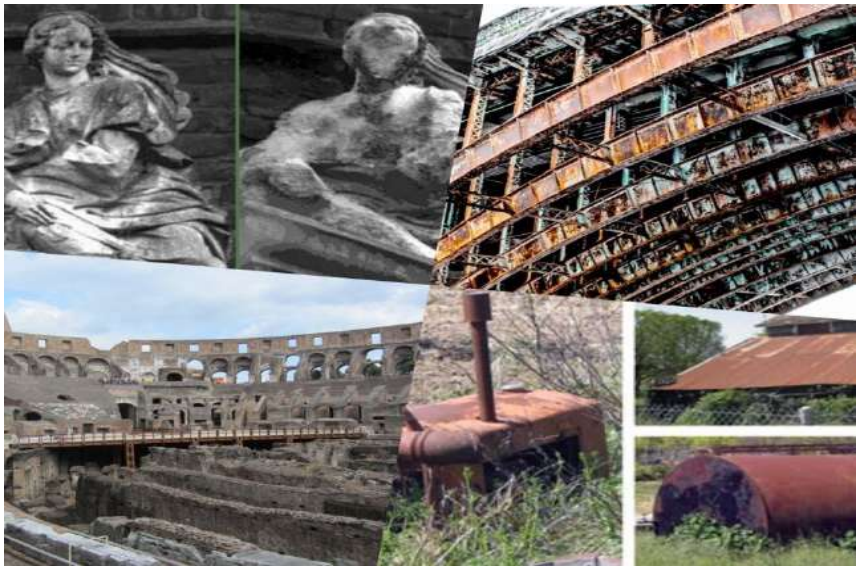

Figure.12 (effect on buildings and monuments (heritage structures))

6.Control acid rain

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.

6.1.Source emission strategies

6.1.1.Policy implications

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.

6.1.2. 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

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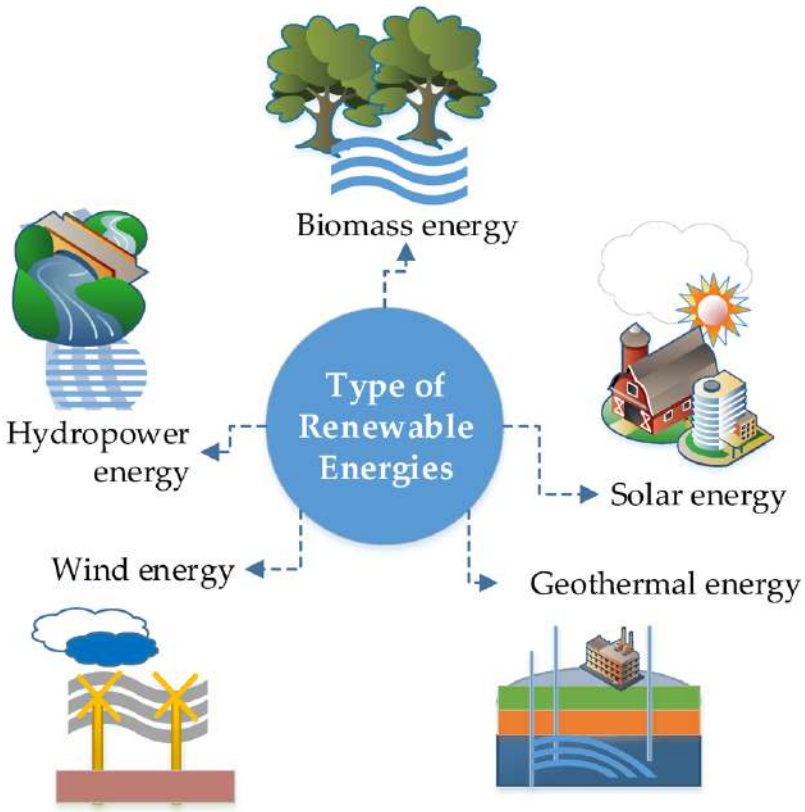

Figure.13 (Type of renwable energies)

6.1.3. 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.

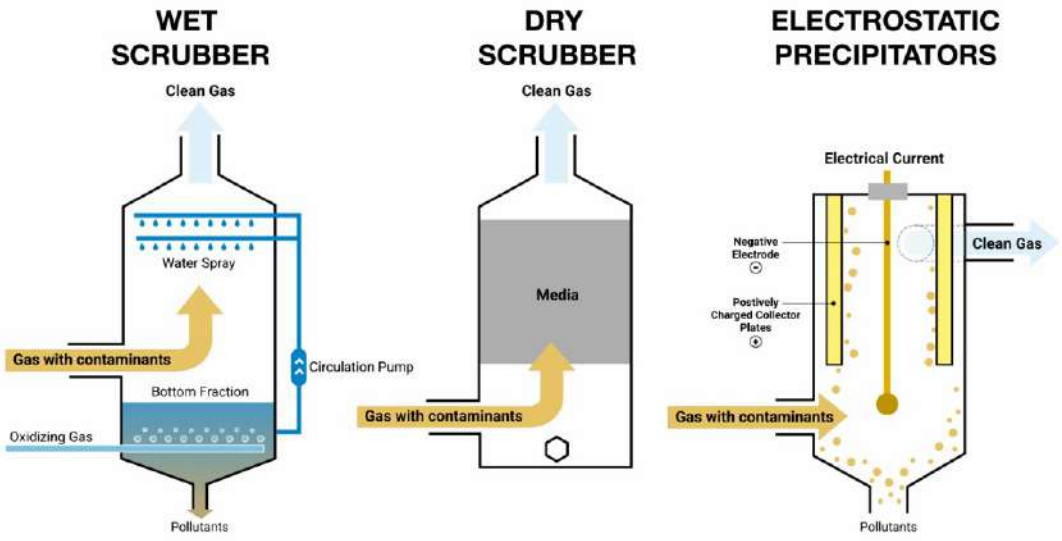

Figure.14 (type of scrubber)

6.1.4.Pre combustion cleaning of fuel

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).

6.2. 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).

6.2.1. 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.

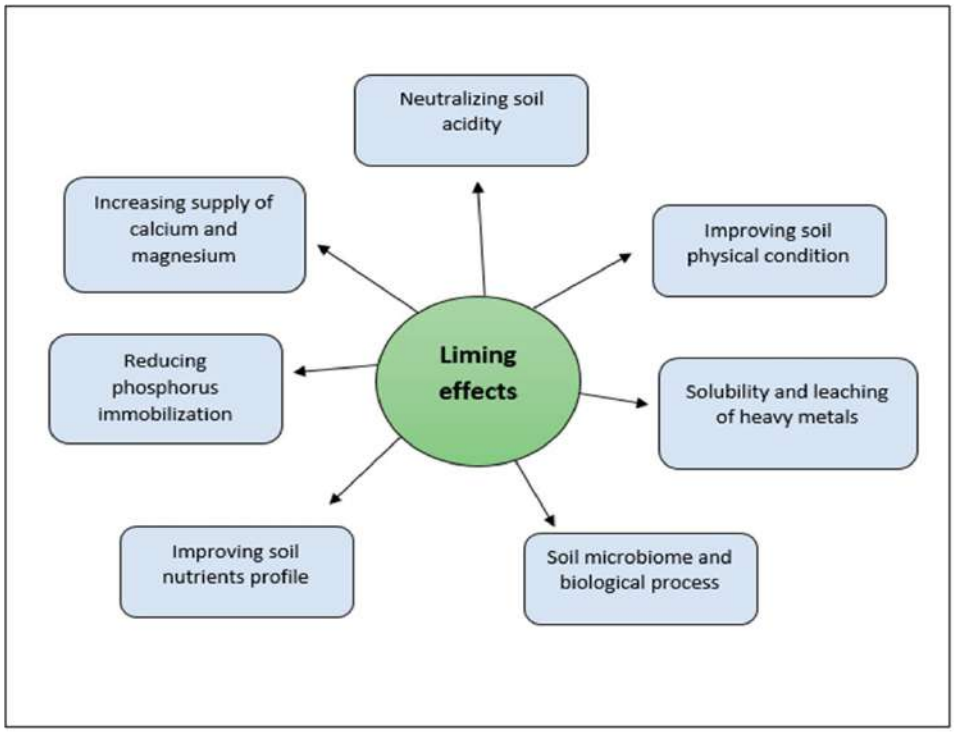

Figure.15 (Liming Effect)

6.2.1.1. 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

6.2.1.2. 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.

7. Conclusion

Acid rain is a significant environmental issue caused by the release of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) into the atmosphere, primarily from human activities such as burning fossil fuels. When these gases react with water, oxygen, and other chemicals in the atmosphere, they form acidic compounds that fall to the ground as acid rain, snow, fog, or dust.

The environmental impacts of acid rain are wide-ranging and serious. It can harm aquatic ecosystems by lowering the pH of lakes, rivers, and streams, which can be harmful to fish and other aquatic life. Acid rain can also damage forests by leaching essential nutrients from the soil and weakening trees, making them more susceptible to diseases, pests, and harsh weather conditions.

Additionally, acid rain can damage buildings, monuments, and statues made of limestone and marble, as the acidic compounds react with the calcium carbonate in these materials, causing them to deteriorate over time.

Reducing acid rain involves using cleaner fuels with less sulfur, installing scrubbers in industrial facilities, and using catalytic converters in vehicles. Regulations like the Clean Air Act and international cooperation are also important. Promoting renewable energy and raising public awareness are additional strategies.

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حکومەتی هەرێمی کوردستان-عێراق
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زانکۆی سلاحەدین-هەولێر
کۆلێژی زانست
بەشی کیمیا

ترشە باران و کاریگەرییەکانی لەسەر ژینگە

پرۆژەی دەرچونە :
پێشکەش بە بەشی کیمیا کۆلێژی زانستی زانکۆی سلاحەدین-هەولێر
وەک بەشێک لە پێداویستیاکانی بەدەستهێنانی بڕوانامەی
بەکالۆریۆس لە زانستی کیمیا

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