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Acid Rain-The Major Cause of Pollution: Its Causes, Effects and Solution

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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.
Keywords: sulphuric, Deposition, nitrogen, pollutants

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. . On one side this kind of development makes our lives easier, but on the other hand it results into pollution by release harmful substance into environment**.** Acid rain is the most serious environmental problems emerged due to air pollution. Acid rain is particularly damaging to lakes, streams and forests, and the plants and animals that live in these ecosystems.

Rain is one of the most essential ingredients for human and animal life. The water provided by rain allows all life on Earth to survive. Although rain is naturally acidic, it is being increasingly acidified by pollution from homes, factories, power stations and cars. The term used to describe this problem is "acid rain". **Acid rain** hasn't just occurred in the last twenty to thirty years. This was over 100 years ago.

For years ever since most of the world has been industrialized, the effects of pollution have plagued nations alike. Acid rain is one of the largest contributors to this industrialized form of pollution. The devastating effects to the environment caused by acid rain will be given along with what is being done to stop it. Acid rain is made when pollutants arise from the use of coal in the production of electricity, from base- metal smelting and from fuel combustion in vehicles. Once the sulfur and nitrogen oxides from these man made causes are released into the air they are caught by wind currents and are blown hundreds of miles away. The gas pollutants drift along with clouds until the rain eventually converts the sulfuric dioxide into sulfuric acid, and the nitrogen oxide into nitric acid.

Some air pollution as a matter of fact comes from natural sources, but most is human made. The burning of oil and coal by plants and factories, homes and cars, is the main source of chemicals that cause acid rain. Power stations and factories emit large amounts of sulphur dioxide and also nitrogen oxides, whilst car exhausts contain large amounts of nitrogen oxides. When volcanoes erupt, they emit various gases which have been trapped under the ground, including sulphur dioxide. This can cause air pollution, which can then be made much worse by the addition of human-made emissions. The air in many towns and cities is overfull of harmful pollutants.

New Delhi adds 1,400 poorly regulated new cars to its roads every day, so it's no wonder that the city is choking on auto exhaust. Asian air pollution kills 2 million people every year. Tough emissions laws in the U.S. explain why we're breathing better, despite adding cars, population and miles traveled.

Acid rain is also called acid deposition because this term includes other forms of acidic precipitation such as snow.It is two types of deposition:

1.Wet deposition 2.Dry deposition

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.

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.

Causes of acidification

Acid deposition can occur via natural sources like volcanoes but it is mainly caused by the release of sulfur dioxide and nitrogen oxide during fossil fuel combustion. When these gases are discharged into the atmosphere they react with the water, oxygen, and other gases already present there to form sulfuric acid, ammonium nitrate, and nitric acid. These acids then disperse over large areas because of wind patterns and fall back to the ground as acid rain or other forms of precipitation.

The gases responsible for acid deposition are normally a byproduct of electric power generation and the burning of coal. As such, it began entering the atmosphere in large amounts during the Industrial Revolution and was first discovered by a Scottish chemist, Robert Angus Smith, in 1852. In that year, he discovered the relationship between acid rain and atmospheric pollution in Manchester, England.

Although it was discovered in the 1800s, acid deposition did not gain significant public attention until the 1960s and the term acid rain was coined in 1972. Public attention further increased in the 1970s when the New York Times published reports about problems occurring in the Hubbard Brook Experimental Forest in New Hampshire.

Chemical reaction during acid rain formation:

Acid rain" is a popular term referring to the deposition of wet (rain, snow, sleet, fog, cloud water, and dew) and dry (acidifying particles and gases) acidic components. A more accurate term is "acid deposition". Distilled water, once carbon dioxide is removed, has a neutral pH of 7. Liquids with a pH less than 7 are acidic, and those with a pH greater than 7 are Alkaline. "Clean" or unpolluted rain has a slightly acidic pH of about 5.2, because carbon dioxide and water in the air react together to form carbonic acid, but unpolluted rain also contains other chemicals.

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

Carbonic acid then can ionize in water forming low concentrations of hydronium and carbonate ions:

$2\ H_2O\ (l) + H_2CO_3\ (aq) \rightarrow\ CO_3^{2-}\ (aq) + 2\ H_3O+\ (aq)$

The chemical reaction that results in the formation of acid rain involves the interaction of SO_2, NOx and O_3. When the pollutants are vented into the atmosphere by tall smoke stakes, molecules of SO_2 and NOx are caught up in the prevailing winds, where they interact in the presence of sunlight with vapours to form sulphuric acid and nitric acid mists. These acids remain in vapour state under the prevalent high temperature conditions. When the temperature falls, condensation takes the form of aerosol droplets, which owing to the presence of unburnt carbon particles will be black, acidic and carbonaceous in nature. This matter is called "acid smut". The presence of oxidizing agents and the characteristics of the reaction

Acid reactions involving O3:

$O_3 \rightarrow O_2 + O$

$O + H_2O \rightarrow OH^-$ (hydroxyl radical)

$OH^- + SO_2 \rightarrow HSO_3$

$HSO_3 + OH^- \rightarrow H_2SO_4$

$OH^- + NO_2 \rightarrow HNO_3$

Coal is especially rich in sulphur. As coal is burned, its component get oxidized

$S + O_2 \rightarrow SO_2$

The oxidation of sulphur to SO_2 occur directly in the flame;therefore SO_2 is discharged in to atmosphere from the smoke As SO_2 is swept along by the prevailing wind, it is slowly oxidized at ordinary temperature to SO32- Oxidant property of atmosphere plays an important role in conversion of SO_3^{2-} to SO_4. Sulphur dioxide oxidation is most common in clouds and especially in heavily polluted air where compounds such as ammonia and O_3 are in abundance. These catalyst help to convert in to sulphuric acid.

Effects of Acid Rain

After studying the Hubbard Brook Forest and other areas today, there are several important impacts of acid deposition on both natural and man-made environments. Aquatic settings are the most clearly impacted by acid deposition though because acidic precipitation falls directly into them. Both dry and wet deposition also runs off of forests, fields, and roads and flows into lakes, rivers, and streams

Effects of acid rain on Health

Acid rain looks, feels, and tastes just like clean rain. The harm to people from acid rain is not direct. Walking in acid rain, or even swimming in an acid lake, is no more dangerous than walking or swimming in clean water. However, the pollutants that cause acid rain sulfur dioxide (SO_2) and nitrogen oxides (NO_x) do damage human health.

These gases interact in the atmosphere to form fine sulfate and nitrate particles that can be transported long distances by winds and inhaled deep into people's lungs. Fine particles can also penetrate indoors. Many scientific studies have identified a relationship between elevated levels of fine

particles and increased illness and premature death from heart and lung disorders, such as asthma and bronchitis.

Decreases in NO_x emissions are also expected to have a beneficial impact on human health by reducing the nitrogen oxides available to react with volatile organic compounds and form ozone. Ozone impacts on human health include a number of morbidity and mortality risks associated with lung inflammation, including asthma and emphysema.

acid rain harms trees

Acid rain does not usually kill trees directly. Instead, it is more likely to weaken trees by damaging their leaves, limiting the nutrients available to them, or exposing them to toxic substances slowly released from the soil. Quite often, injury or death of trees is a result of these effects of acid rain in combination with one or more additional threats.

acid rain harms other plants

Acid rain can harm other plants in the same way it harms trees. Although damaged by other air pollutants such as ground level ozone, food crops are not usually seriously affected because farmers frequently add fertilizers to the soil to replace nutrients that have washed away. They may also add crushed limestone to the soil. Limestone is an alkaline material and increases the ability of the soil to act as a buffer against acidity.

Effects in the forest

Over the years, scientists, foresters, and others have noted a slowed growth of some forests. Leaves and needles turn brown and fall off when they should be green and healthy. In extreme cases, individual trees or entire areas of the forest simply die off without an obvious reason.

Effects on Stone Buildings and Monuments in Acid Rain

Marble and limestone have long been preferred materials for constructing durable buildings and monuments. . Marble and limestone both consist of calcium carbonate ($CaCO_3$), and differ only in their crystalline structure. Limestone consists of smaller crystals and is more porous than marble; it is used more extensively in buildings. Marble, with its larger crystals and smaller pores, can attain a high polish and is thus preferred for monuments and statues. Although these are recognized as highly durable materials, buildings and outdoor monuments made of marble and limestone are now being gradually eroded away by acid rain.

calcium carbonate and sulfuric acid (the primary acid component of acid rain) results in the dissolution of $CaCO_3$ to give aqueous ions, which in turn are washed away in the water flow.

$$CaCO_3 + H_2SO4 \rightarrow Ca^{2+}(aq) + SO_4^{2-} + H_2O + CO_2$$

This process occurs at the surface of the buildings or monuments; thus acid rain can easily destroy the details on relief work (*e.g.*, the faces on a statue), but generally does not affect the structural integrity of the building. The degree of damage is determined not only by the acidity of the rainwater, but also by the amount of water flow that a region of the surface receives. Regions exposed to direct downpour of acid rain are highly susceptible to erosion, but regions that are more sheltered from water flow (such as under eaves and overhangs of limestone buildings) are much better preserved.

When the water dries, it leaves behind the ions that were dissolved in it. When a solution containing calcium and sulfate ions dries, the ions crystallize as $CaSO_4.2H_2O$, which is gypsum. Gypsum is soluble in water, so it is washed away from areas that receive a heavy flow of rain. However, gypsum accumulates in the same sheltered areas that are protected from erosion, and attracts dust, carbon particles, dry-ash, and other dark pollutants. This results in blackening of the surfaces where gypsum accumulates.

An even more serious situation arises when water containing calcium and sulfate ions penetrates the stone's pores. When the water dries, the ions form salt crystals within the pore system. These crystals can disrupt the crystalline arrangement of the atoms in the stone, causing the fundamental structure of the stone to be disturbed. If the crystalline structure is disrupted sufficiently, the stone may actually crack. Thus, porosity is an important factor in determining a stone's durability.

What's Being Done?

Because of these problems and the adverse effects air pollution has on human health, a number of steps are being taken to reduce sulfur and nitrogen emissions. Most notably, many governments are now requiring energy producers to clean smoke stacks by using scrubbers which trap pollutants before they are released into the atmosphere and catalytic converters in cars to reduce their emissions. Additionally, alternative energy sources are gaining more prominence today and funding is being given to the restoration of ecosystems damaged by acid rain worldwide.

Acid rain solutions

Take action as individuals

It may seem like there is not much that one individual can do to stop acid deposition. However, like many environmental problems, acid deposition is caused by the cumulative actions of millions of individual people. Therefore, each individual can also reduce their contribution to the problem and become part of the solution. Individuals can contribute directly by conserving energy, since energy production causes the largest portion of the acid deposition problem. For example, you can:

- Turn off lights, computers, and other appliances when you're not using them.
- Use energy-efficient appliances: lighting, air conditioners, heaters, refrigerators, washing machines, etc.
- Only use electric appliances when you need them..
- Insulate your home as best you can.
- Carpool, use public transportation, or better yet, walk or bicycle whenever possible
- Buy vehicles with low NO_x emissions, and properly maintain your vehicle.
- Be well informed.

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