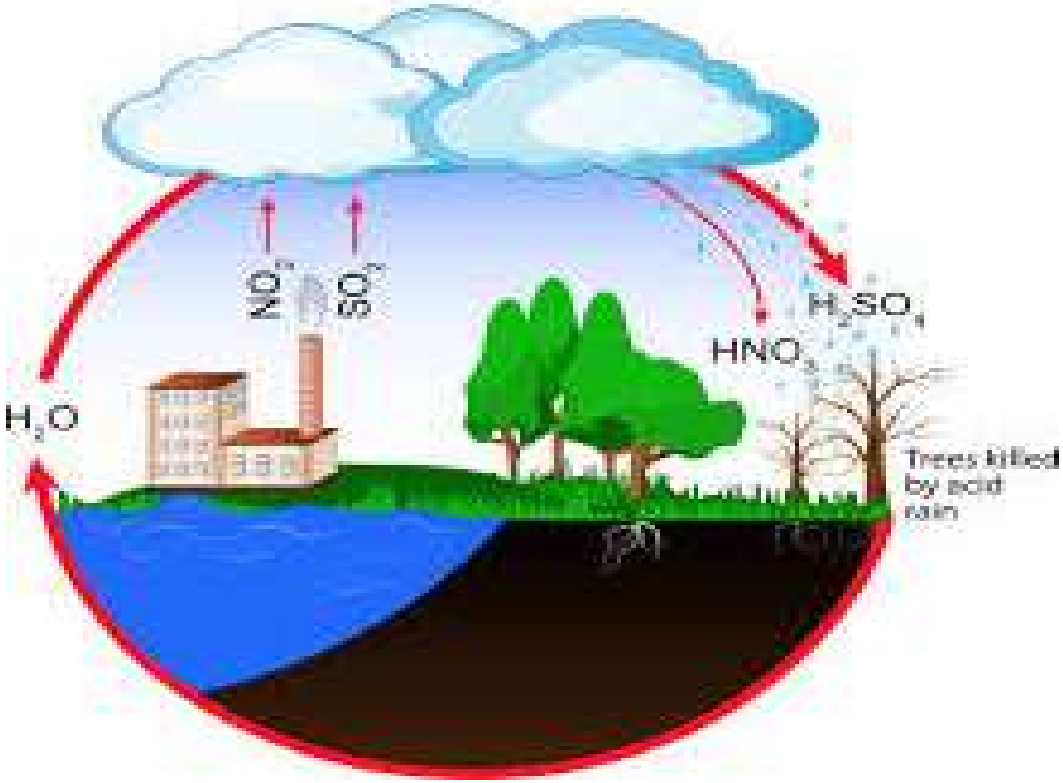
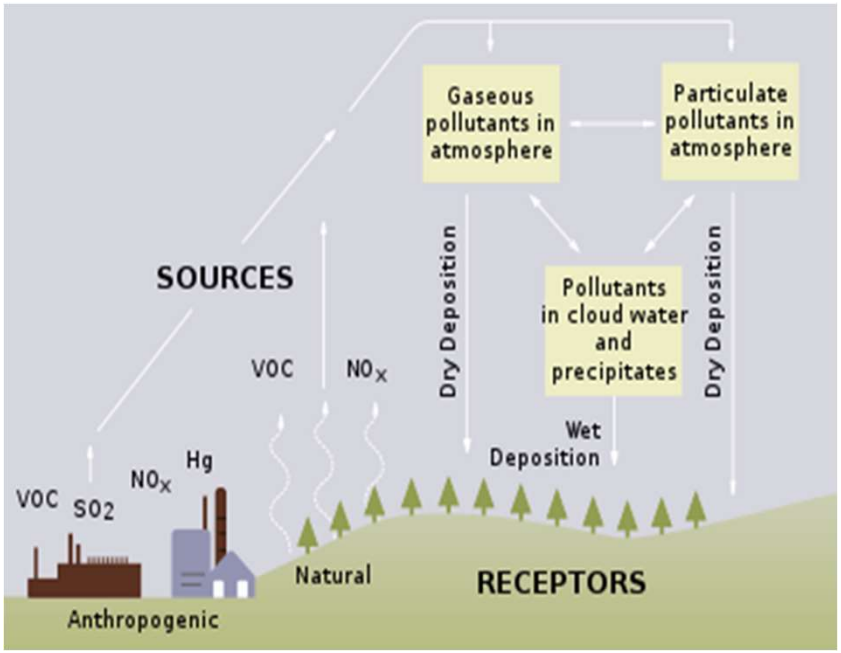
ACID RAIN



The phrase acid rain was first used in 1852 by Scottish chemist **Robert Angus Smith** during his investigation of rainwater chemistry near industrial cities in England and Scotland. The phenomenon became an important part of his book **Air and Rain**: Acid rain was recognized as a regional environmental issue affecting large areas of western Europe and eastern North America. Acid rain also occurs in Asia and parts of Africa, South America, and Australia.

As a global environmental issue, it is frequently overshadowed by climate change. Although the problem of acid rain has been significantly reduced in some areas, it remains an important environmental issue within and downwind from major industrial and industrial agricultural regions worldwide.

Acid rain, or acid deposition, is a broad term that includes any form of precipitation that contains acidic components, such as sulfuric acid or nitric acid, according to the Environmental Protection Agency (EPA).



The precipitation is not necessarily wet or liquid; the definition includes dust, gasses, rain, snow, fog and hail. The type of acid rain that contains water is called wet deposition. Acid rain formed with dust or gasses is called dry deposition.

What is Acid Rain?

Acid rain is a rain or any other form of precipitation that is unusually acidic, meaning that it has elevated levels of hydrogen ions (low pH). It can have harmful effects on plants, aquatic animals, and infrastructure. Acid rain is caused by emissions of sulfur dioxide and nitrogen oxide, which react with the water molecules in the atmosphere to produce acids. Some governments have made efforts since the 1970s to reduce the release of sulfur dioxide and nitrogen oxide into the atmosphere with positive results. Nitrogen oxides can also be produced naturally by lightning strikes, and sulfur dioxide is produced by volcanic eruptions. Acid rain has been shown to have adverse impacts on forests, freshwaters, and soils, killing insect and aquatic life-forms, causing paint to peel, corrosion of steel structures such as bridges, and weathering of stone buildings and statues as well as having impacts on human health.

"Acid rain" is a popular term referring to the deposition of a mixture from wet (rain, snow, sleet, fog, cloudwater, and dew) and dry (acidifying particles and gases) acidic components. 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 an acidic pH, but usually no lower than 5.7, because carbon dioxide and water in the air react together to form carbonic acid, a weak acid according to the following reaction:

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

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

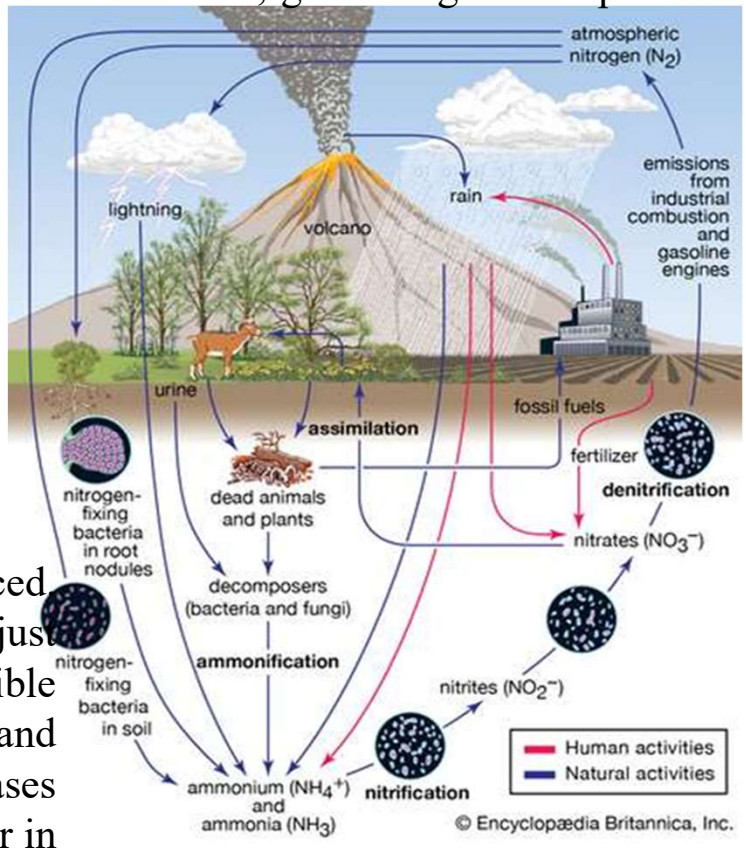
$$H_2O\ (l) + H_2CO_3\ (aq) \rightleftharpoons HCO_3^-\ (aq) + H_3O^+\ (aq)$$

Unpolluted rain can also contain other chemicals which affect its pH (acidity level). A common example is nitric acid produced by electric discharge in the atmosphere such as lightning.[4] Acid deposition as an environmental issue (discussed later in the article) would include additional acids other than H_2CO_3.

Causes

- **Manmade pollutants** are currently affecting most acidic precipitation, natural disasters can be a factor as well. For example, volcanoes can cause acid rain by blasting pollutants into the air. These pollutants can be carried around the world in jet streams and turned into acid rain far from the volcano. After an asteroid supposedly wiped out the dinosaurs 65.5 million years ago, sulfur trioxide was blasted into the air. When it hit the air, it turned into sulfuric acid, generating a downpour of acid rain, according to a paper published in 2014 in the journal Nature Geoscience.

- **Sulfur dioxide (SO_2) and nitrogen oxides (NO_x) released** into the air by fossil-fuel power plants, vehicles and oil refineries are the biggest cause of acid rain today, according to the EPA. Two thirds of sulfur dioxide and one fourth of nitrogen oxide found in the atmosphere come from electric power generators. A chemical reaction happens when sulfur dioxide and nitrogen oxides mix with water, oxygen and other chemicals in the air. They then become sulfuric and nitric acids that mix with precipitation and fall to the ground. Precipitation is considered acidic when its pH level is about **5.2 or below**, according to Encyclopedia Britannica. The normal pH of rain is around **5.6**.



- **Air pollution**. When any type of fuel is burnt, lots of different chemicals are produced. The smoke that comes from a fire or the fumes that come out of a car exhaust don't just contain the sooty grey particles that you can see - they also contains lots of invisible gases that can be even more harmful to our environment. Power stations, factories and cars all burn fuels and therefore they all produce polluting gases. Some of these gases (especially nitrogen oxides and sulphur dioxide) react with the tiny droplets of water in clouds to form sulphuric and nitric acids. The rain from these clouds then falls as very weak acid - which is why it is known as "acid rain".

Other reasons

- Acid rain results when sulfur dioxide (SO_2) and nitrogen oxides (NO_X) are emitted into the atmosphere and transported by wind and air currents. The SO_2 and NO_X react with water, oxygen and other chemicals to form sulfuric and nitric acids. These then mix with water and other materials before falling to the ground.
- While a small portion of the SO_2 and NO_X that cause acid rain is from natural sources such as volcanoes, most of it comes from the burning of fossil fuels. The major sources of SO_2 and NO_X in the atmosphere are:
- Burning of fossil fuels to generate electricity. Two thirds of SO_2 and one fourth of NO_X in the atmosphere come from electric power generators.
- **Vehicles and heavy equipment.**
- **Manufacturing, oil refineries and other industries**.
- Winds can blow SO_2 and NO_X over long distances and across borders making acid rain a problem for everyone and not just those who live close to these sources.

Forms of Acid Deposition

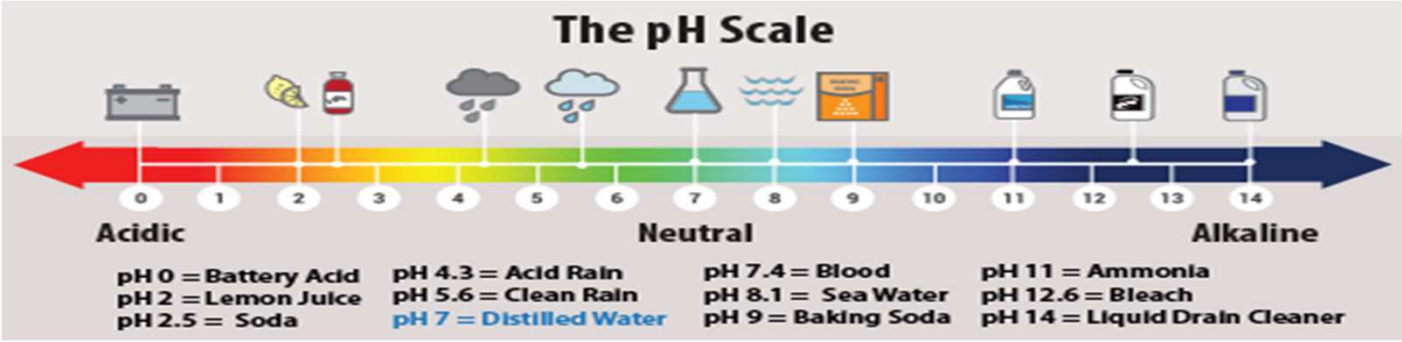
❖ **Wet Deposition**

Wet deposition is what we most commonly think of as acid rain. The sulfuric and nitric acids formed in the atmosphere fall to the ground mixed with rain, snow, fog, or hail.

❖ **Dry Deposition**

Acidic particles and gases can also deposit from the atmosphere in the absence of moisture as dry deposition. The acidic particles and gases may deposit to surfaces (water bodies, vegetation, buildings) quickly or may react during atmospheric transport to form larger particles that can be harmful to human health. When the accumulated acids are washed off a surface by the next rain, this acidic water flows over and through the ground, and can harm plants and wildlife, such as insects and fish.

The amount of acidity in the atmosphere that deposits to earth through dry deposition depends on the amount of rainfall an area receives. For example, in desert areas the ratio of dry to wet deposition is higher than an area that receives several inches of rain each year.



Measuring Acid Rain

Acidity and alkalinity are measured using a pH scale for which 7.0 is neutral. The lower a substance's pH (less than 7), the more acidic it is; the higher a substance's pH (greater than 7), the more alkaline it is. **Normal rain has a pH of about 5.6**; it is slightly acidic because carbon dioxide (CO_2) dissolves into it forming weak carbonic acid. Acid rain usually has a pH between 4.2 and 4.4.

Policymakers, research scientists, ecologists, and modelers rely on the National Atmospheric Deposition Program's (NADP) National Trends Network (NTN) for measurements of wet deposition. The NADP/NTN collects acid rain at more than 250 monitoring sites throughout the US, Canada, Alaska, Hawaii and the US Virgin Islands. Unlike wet deposition, dry deposition is difficult and expensive to measure. Dry deposition estimates for nitrogen and sulfur pollutants are provided by the Clean Air Status and Trends Network (CASTNET). Air concentrations are measured by CASTNET at more than 90 locations.

When acid deposition is washed into lakes and streams, it can cause some to turn acidic. The Long-Term Monitoring (LTM) Network measures and monitors surface water chemistry at over 280 sites to provide valuable information on aquatic ecosystem health and how water bodies respond to changes in acid-causing emissions and acid deposition.

Normal rainwater is weakly acidic because of the absorption of carbon dioxide (CO_2) from the atmosphere—a process that produces carbonic acid—and from organic acids generated from biological activity. In addition, volcanic activity can produce sulfuric acid (H_2SO_4), nitric acid (HNO_3), and hydrochloric acid (HCl) depending on the emissions associated with specific volcanoes. Other natural sources of acidification include the production of nitrogen oxides from the conversion of atmospheric molecular nitrogen (N_2) by lightning and the conversion of organic nitrogen by wildfires. However, the geographic extent of any given natural source of acidification is small, and in most cases it lowers the pH of precipitation to no more than about 5.2.

ROLE OF WINDS IN ACID RAIN

The oxides of S and N are swept up into the atmosphere and can travel thousands of kilometres. The longer they stay in the air, the more likely they are to be oxidised into acids. For example, SO_2 molecule may remain in the atmosphere upto 40 hours while a sulphate particle may remain for three weeks. Hence these molecules may be wind transported to several kilometres. This has been observed in southern Norway and Sweden which receive a heavy load of pollutants from industrial areas of Europe including UK.

Acid Fog. The process that lead to the formation of nitric and sulphuric acids in rain also occur in fogs. The liquid water content in fog is of the order $0 \cdot 1\ g^3$ whereas in clouds it is larger. Fogs are observed after days of dense haze. It suggests that condensation and evaporation of water vapour on pre-existing aerosols were the major processes controlling the water concentrations. High concentrations of SO_4^{2-}, NO_3^- and NH_4^+ ions may have adverse effects on man, animals and plants.

Snow. Snow frequently remains on the ground for extended periods so it is affected by dry and wet deposition processes. The trace amounts of ions like H_3O^+, Na^+, K^+, Mg^{2+}, Ca^{2+}, NH_4^+, Cl^-, NO_3^- and SO_4^{2-} in freshly fallen snow in Antarctic region is probably due to the fact that it is remote from anthropogenic sources of these ions. Snow undergoes metamorphosis during winter season and form larger grains.

Effects

- Acid rain affects nearly everything. Plants, soil, trees, buildings and even statues can be transformed by the precipitation.

- Acid rain has been found to be very hard on trees. It weakens them by washing away the protective film on leaves, and it stunts growth. A paper released in the online version of the journal of Environmental Science and Technology in 2005 showed evidence of acid rain stunting tree growth.

- Acid rain can also change the composition of soil and bodies of water, making them uninhabitable for local animals and plants. For example, healthy lakes have a pH of 6.5 or higher. As acid rain raises the level of acidity, fish tend to die off. Most fish species can't survive a water pH of below 5. When the pH becomes a 4, the lake is considered dead, according to National Atmospheric Deposition Program.

- It can additionally deteriorate limestone and marble buildings and monuments, like gravestones.

- Acid rain can be carried great distances in the atmosphere, not just between countries but also from continent to continent. The acid can also take the form of snow, mists and dry dusts. The rain sometimes falls many miles from the source of pollution but wherever it falls it can have a serious effect on soil, trees, buildings and water.

- Forests all over the world are dying, fish are dying. In Scandinavia there are dead lakes, which are crystal clear and contain no living creatures or plant life. Many of Britain's freshwater fish are threatened, there have been reports of deformed fish being hatched. This leads to fish-eating birds and animals being affected also. Is acid rain responsible for all this? Scientists have been doing a lot of research into how acid rain affects the environment.

Forests

It is thought that acid rain can cause trees to grow more slowly or even to die but scientists have found that it is not the only cause. The same amount of acid rain seems to have more effect in some areas than it does in others.

As acid rain falls on a forest it trickles through the leaves of the trees and runs down into the soil below. Some of it finds its way into streams and then on into rivers and lakes. Some types of soil can help to neutralise the acid - they have what is called a "buffering capacity".

Other soils are already slightly acidic and these are particularly susceptible to the effects of acid rain.

Acid rain can effect trees in several different ways, it may:

• dissolve and wash away the nutrients and minerals in the soil
which help the trees to grow.

• cause the release of harmful substances such as aluminium into the soil.

• wear away the waxy protective coating of leaves, damaging them
and preventing them from being able to photosynthesise properly.

A combination of these effects weakens the trees which means that they can be more easily attacked by diseases and insects or injured by bad weather. It is not just trees that are affected by acid rain, other plants may also suffer.

Lakes and Rivers

It is in aquatic habitats that the effects of acid rain are most obvious. Acid rain runs off the land and ends up in streams, lakes and marshes - the rain also falls directly on these areas.

As the acidity of a lake increases, the water becomes clearer and the numbers of fish and other water animals decline. Some species of plant and animal are better able to survive in acidic water than others. Freshwater shrimps, snails, mussels are the most quickly affected by acidification followed by fish such as minnows, salmon and roach. The roe and fry (eggs and young) of the fish are the worst affected, the acidity of the water can cause deformity in young fish and can prevent eggs from hatching properly.

The acidity of the water does not just affect species directly, it also causes toxic substances like aluminium to be released into the water from the soil, harming fish and other aquatic animals.

Lakes, rivers and marshes each have their own fragile ecosystem with many different species of plants and animals all depending on one another to survive. If a species of fish disappears, the animals which feed on it will gradually disappear too. If the extinct fish used to feed on a particular species of large insect, that insect population will start to grow, this in turn will affect the smaller insects or plankton on which the larger insect feeds.

Buildings

Every type of material will become eroded sooner or later by the effects of the climate. Water, wind, ice and snow all help in the erosion process but unfortunately, acid rain can help to make this natural process even quicker. Statues, buildings, vehicles, pipes and cables can all suffer. The worst affected are things made from limestone or sandstone as these types of rock are particularly susceptible and can be affected by air pollution in gaseous form as well as by acid rain.

Effects of Acid Rain on Aquatic Biota.

Acid rain creates complex problems and its impacts are far reaching. It declines productivity of fish, plankton and amphibians, causes skeletal deformities and increased fish mortality. There are 15,000 fishless lakes in Sweden and 100 such lakes in the Adirondack region of USA because of increased acidity of lakes. About 237 lakes in Adirondack have a pH below 5.

- Different species of fish react differently to acidified lakes. Adult fish can survive in more acidic water than fry fish. **Brook trout** is most acid tolerant while rainbow trout the least. Juvenile fish, small and large mouth bass and walleyes are extremely sensitive and unable to reproduce at pH levels 5·4 to 5·7. Northern pike and chain pickerel are quite tolerant to low pH levels. Some non-sport species and succumb can survive in this water.
- Many bacteria and blue green algae are killed due to acidification, disrupting the whole ecological balance. Acidic water can also leach aluminium from the soil. This run-off carry dissolved aluminium to lakes, rivers and streams. It causes death of fish by clogging its gills and deprives it of oxygen.
- Acidification of a lake or stream results in disruption of the **food web.** Nutrient cycles are disrupted and as a result soil bacteria and fungi die. Acidophilic algae, mosses grow abundantly and litter accumulates in the bottom of the lake because decomposers are absent.
- Fresh water lakes are fairly alkaline with Ca^{2+}, Mg^{2+} and HCO_3^- as the dominant ions. Phytoplankton and zooplankton are affected by acidity of water.
- In winter, acid rain accumulates as acid snow. When it melts it gives a jolt of acid water to lakes. This acid jolt is most damaging to young fish, algae and insects.
- Snails, clams, oysters etc. having their shells of calcium carbonate are among the first animals to perish in acidic lakes.
- Black flies, mosquitoes, deer flies, dragon fly and other worms grow abundantly and flourish in acidic lakes.

Effects of Acid Rain on Terrestrial Ecosystem.

Acid precipitation causes damage to crops, forests and soil. Potential impact of acid deposition on plant include : Damage to leaf cuticle, interference with normal stomata, metabolism, germination, flowering, photosynthesis, interference with nitrogen fixation by inhibiting microbial or fungal activities, possible synergistic interactions with other environmental stress factors.

- Acid deposition falling on plant canopies of forests is modified during its transport from canopy to soil. Organic compounds such as amino acids, carbohydrates and hormones are leached from leaves through rain water. The nature of leachate depends on tree characteristic, leaf structure, morphology, stem density, composition and rate of precipitation. An enrichment of inorganic ions in water fall after contact with vegetation take place, but as H^+ ion concentration increases, cations loss increases.

- Demineralisation of soil occurs. Cations like Ca^{2+}, Mg^{2+}, Na^+, K^+ are leached away and replaced by acid cations such as M^+, Al^{3+} ions.
- The capacity of nitrifying bacteria to fix nitrogen diminish rapidly below pH 6. Average number of nodules containing nitrogen fixing bacteria or beans and soyabeans decreases with the increasing concentration of SO_2.
- Acidification of soil adversely affects soil fauna and leads to reduced forest productivity.
- Acid rain has retarded the growth of vegetables such as pea, beans, raddish, spinach, broccoli and carrots etc.
- Acid deposition weakens the trees like pine, spruce, birch which can be attacked by pathogens and droughts. Soils in these regions have little buffering capacity and are subjected to leaching of minerals.
- Acid rain in **Japan** has damaged 5000 sq. kms of **cedar** trees in Kanto plain which lies to the north of Tokyo. Elsewhere Sweden's 85000 lakes were killed by deluge, plant and fish life were damaged. In Canada trees and lakes are also being killed by acid rain, 60% of which originates from USA.

Injury to Vegetation by Acid Rain.

Sulphur dioxide injures the vegetation by initial disruption of cellular integrity which usually appears in the spongy parenchymal cells affecting palisade layer. These areas first appear water soaked, then become dry and papery and bleach to a light ivory or tan colour. The final effect is a pattern of light coloured blotches, mainly interveinal.

- Continuous chronic/exposure to low levels of acidic water causes diffuse chlorosis in the leaves of plants.
- Acidic water containing SO_2 affects the functional cells near the stomata. Apparently the cells have capacity to detoxify SO_2 or SO_3^{2-} by conversion to SO_4^{2-}. If the concentration of SO_2 is in large excess, the sulphite ions build up, the water relation of the cell are disrupted and plasmolysis occurs.
- **Aluminium Concentration.** Waters affected by acid deposition increase aluminium concentration. Aluminium hydroxide is common in soils, solubility of which increases with the increase in H^+ level. The Al^{3+}, Fe^{3+} and Mg^{2+} cations neutralise negative charge carried by organics. Thus Al^{3+} and organic compounds precipitate in soil. Excess of Al^{3+} ions are released from the soil and enter the water percolating into streams and lakes. These Al^{3+} ions are highly toxic to aquatic biota at 90 to 270 ppm level.

Effects of Acid Rain on Buildings.

Acid rain causes extensive damage to buildings and structural materials of marble, limestone, slate and mortar etc. The attack of acid on marble is termed as **stone leprosy.**

$$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + CO_2$$

- Acid rain corrodes houses, monuments, statues, bridges, fences and railings that cost the world 1450 million dollar a year. British Parliament building also suffered enough damage due to acid rain. Much of the falling snow in Britain is highly acidic. If it does not melt it may turn into a pollution time bomb.

Advantages of Acid Rain

- Concentrated Sulphuric acid is used as a drying agent.
- Nitric acid is used in preparation of fertilizers.
- Sulphuric acid is used in domestic drainage cleaner.
- Sulphuric acid is used as an electrolyte in lead acid batteries.
- It makes holes in limestone below ground, which creates caves and places to store groundwater, as well as providing habitat for some species.
- But the new study shows that sulfuric in acid rain may have benefits, limiting global warming by counteracting the natural production of methane gases by microbes in wetland areas.

Solutions

There are several solutions to stopping manmade acid rain.

- **Regulating the emissions coming from vehicles and buildings** is an important step, according to the EPA. This can be done by restricting the use of fossil fuels and focusing on more sustainable energy sources such as solar and wind power.

Also, each person can do their part by reducing their vehicle use. Using public transportation, walking, riding a bike or carpooling is a good start, according to the EPA. People can also reduce their use of electricity, which is widely created with fossil fuels, or switch to a solar plan. Many electricity companies offer solar packages to their customers that require no installation and low costs.

- **Reduce emissions:**

• Burning fossil fuels is still one of the cheapest ways to produce electricity so people are now researching new ways to burn fuel which don't produce so much pollution.
• Governments need to spend more money on pollution control even if it does mean an increase in the price of electricity.
• Sulphur can also be 'washed' out of smoke by spraying a mixture of water and powdered limestone into the smokestack.
• Cars are now fitted with catalytic converters which remove three dangerous chemicals from exhaust gases.

- **Find alternative sources of energy**

• Governments need to invest in researching different ways to produce energy.
• Two other sources that are currently used are hydroelectric and nuclear power. These are 'clean' as far as acid rain goes but what other impact do they have on our environment?
• Other sources could be solar energy or windmills but how reliable would these be in places where it is not very windy or sunny?
• All energy sources have different benefits and costs and all theses have to be weighed up before any government decides which of them it is going to use.

➢ Conserving Resources

• Greater subsidies of public transport by the government to encourage people to use public transport rather than always travelling by car.
• Every individual can make an effort to save energy by switching off lights when they are not being used and using energy-saving appliances - when less electricity is being used, pollution from power plants decreases.
• Walking, cycling and sharing cars all reduce the pollution from vehicles

➢ Restoring the Damage done by Acid Rain

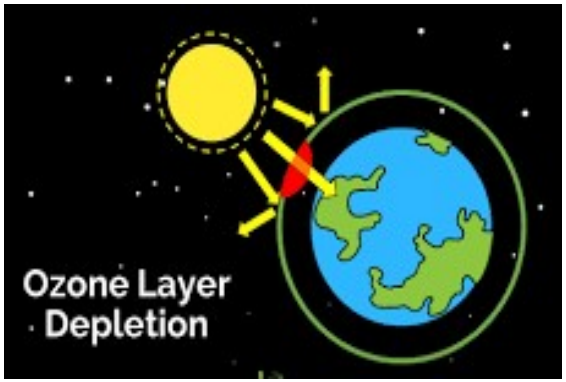
Lakes and rivers can have powdered limestone added to them to neutralise the water - this is called "liming". Liming, however, is expensive and its effects are only temporary - it needs to be continued until the acid rain stops. The people of Norway and Sweden have successfully used liming to help restore lakes and streams in their countries. A major liming programme is currently taking place in Wales.

OZONE LAYER DEPLETION

The ozone layer is found in the lower portion of the earth's atmosphere. It has the potential to absorb around 97-99% of the harmful ultraviolet radiations coming from the sun that can damage life on earth. If the ozone layer was absent, millions of people would develop skin diseases and may have weakened immune systems.

However, **Joe Farman, Brian Gardiner and Jonathan Shanklin** have discovered a hole in the ozone layer over the Antarctic in 1985. This has focussed their concern on various environmental issues and steps to control them.

The main reasons for the ozone hole are **chlorofluorocarbons, carbon tetrachloride, methyl bromide and hydrochlorofluorocarbons.**



"**Ozone layer depletion is the gradual thinning of the earth's ozone layer in the upper atmosphere caused due to the release of chemical compounds containing gaseous bromine or chlorine from industries or other human activities."**

Ozone depletion consists of two related events observed since the late 1970s: a steady lowering of about four percent in the total amount of ozone in Earth's atmosphere (the ozone layer), and a much larger springtime decrease in stratospheric ozone around Earth's polar regions. The latter phenomenon is referred to as the ozone hole. There are also springtime polar tropospheric ozone depletion events in addition to these stratospheric events.

What is Ozone Layer Depletion?

- Ozone layer depletion is the thinning of the ozone layer present in the upper atmosphere. This happens when the chlorine and bromine atoms in the atmosphere come in contact with ozone and destroy the ozone molecules. One chlorine can destroy 100,000 molecules of ozone. It is destroyed more quickly than it is created.
- Some compounds release chlorine and bromine on exposure to high ultraviolet light, which then contributes to the ozone layer depletion. Such compounds are known as Ozone Depleting Substances (ODS).
- The ozone-depleting substances that contain chlorine include chlorofluorocarbon, carbon tetrachloride, hydrochlorofluorocarbons, and methyl chloroform. Whereas, the ozone-depleting substances that contain bromine are halons, methyl bromide, and hydro bromofluorocarbons.
- Chlorofluorocarbons are the most abundant ozone-depleting substance. It is only when the chlorine atom reacts with some other molecule, it does not react with ozone.
- The main cause of ozone depletion and the ozone hole is manufactured chemicals, especially manufactured halocarbon refrigerants, solvents, propellants, and foam- blowing agents (chlorofluorocarbons (CFCs), HCFCs, halons), referred to as ozone-depleting substances (ODS). These compounds are transported into the stratosphere by turbulent mixing after being emitted from the surface, mixing much faster than the molecules can settle. Once in the stratosphere, they release atoms from the halogen group through photodissociation, which catalyze the breakdown of ozone (O_3) into oxygen (O_2). Both types of ozone depletion were observed to increase as emissions of halocarbons increased.
- Montreal Protocol was proposed in 1987 to stop the use, production and import of ozone-depleting substances and minimize their concentration in the atmosphere to protect the ozone layer of the earth.

Causes Of Ozone Layer Depletion

- **Chlorofluorocarbons**

Chlorofluorocarbons or CFCs are the main cause of ozone layer depletion. These are released by solvents, spray aerosols, refrigerators, air-conditioners, etc. The molecules of chlorofluorocarbons in the stratosphere are broken down by the ultraviolet radiations and release chlorine atoms. These atoms react with ozone and destroy it.

- **Unregulated Rocket Launches**

Researches say that the unregulated launching of rockets result in much more depletion of ozone layer than the CFCs do. If not controlled, this might result in a huge loss of the ozone layer by the year 2050.

- **Nitrogenous Compounds**

The nitrogenous compounds such as NO_2, NO, N_2O are highly responsible for the depletion of the ozone layer.

- **Natural Causes**

The ozone layer has been found to be depleted by certain natural processes such as Sun-spots and stratospheric winds. But it does not cause more than 1-2% of the ozone layer depletion.

- The volcanic **eruptions** are also responsible for the depletion of the ozone layer.

Ozone-Depleting Substances	Sources
Chlorofluorocarbons (CFCs)	Refrigerators, air-conditioners, solvents, dry-cleaning agents, etc.
Halons	Fire-extinguishers
Carbon tetrachloride	Fire extinguishers, solvents
Methyl chloroform	Adhesives, aerosols
Hydrofluorocarbons	Solvent cleaning, fire extinguishers, solvent cleaning

Effects Of Ozone Layer Depletion

- The depletion of the ozone layer has harmful effects on the human health, animals, environment and marine life.
- Studies demonstrate that an increase in UV-B rays causes a higher risk of skin cancer, plays a major role in malignant melanoma development, sunburns, quick ageing, eye cataracts, blindness and weekend immune system.
- Direct exposure to ultraviolet radiations also leads to skin and eye cancer in animals.
- UV-B rays negatively affect plants, crops. It may lead to minimal plant growth, smaller leaf size, flowering and photosynthesis in plants, lower quality crops for humans. And decline in plant productivity would in turn affect soil erosion and the carbon cycle.
- Planktons and zooplankton are greatly affected by the exposure to UV-B rays. These are higher in the aquatic food chain. If the planktons declines, it would likely have wide-reaching effects for all marine life in the lower food chain.
- Since ozone is a greenhouse gas, the breakdown and anticipated recovery of the ozone layer affects Earth's climate. Scientific analyses show that the decrease in stratospheric ozone observed since the 1970s has produced a cooling effect—or, more accurately, that it has counteracted a small part of the warming that has resulted from rising concentrations of carbon dioxide and other greenhouse gases during this period.
- Ozone depletion represents a radiative forcing of the climate system. There are two opposing effects: Reduced ozone causes the stratosphere to absorb less solar radiation, thus cooling the stratosphere while warming the troposphere; the resulting colder stratosphere emits less long-wave radiation downward, thus cooling the troposphere.

Solutions to Ozone Layer Depletion

- ✓ Montreal Protocol was proposed in 1987 to unite the world to cut out production and import of ozone-depleting substances. The Montreal Protocol phases down the consumption and production of the different ozone depleting substances (ODS) in a step-wise manner, with different timetables for developed and developing countries.
- ✓ Every individual should also take steps to prevent the depletion of the ozone layer. One should avoid using pesticides and shift to natural methods to get rid of pests instead of using chemicals. The vehicles emit a large amount of greenhouse gases that lead to global warming as well as ozone depletion. Therefore, the use of vehicles should be minimized as much as possible. Most of the cleaning products have chemicals that affect the ozone layer. We should substitute that with eco-friendly products. Maintain air conditioners, as their malfunctions cause CFC to escape into the atmosphere.
- ✓ A 2018 United Nations report estimated that the Antarctic ozone hole would close slowly and stratospheric ozone concentrations would return to 1980 values by the 2060s. The expected increases in ozone would be gradual primarily because of the long residence times of CFCs and other halocarbons in the atmosphere.
- ✓ New forest creation

World Ozone Day is observed on September 16 every year to spread awareness among people about the depletion of Ozone Layer. This year the slogan for World Ozone Day is 'Ozone For Life'.