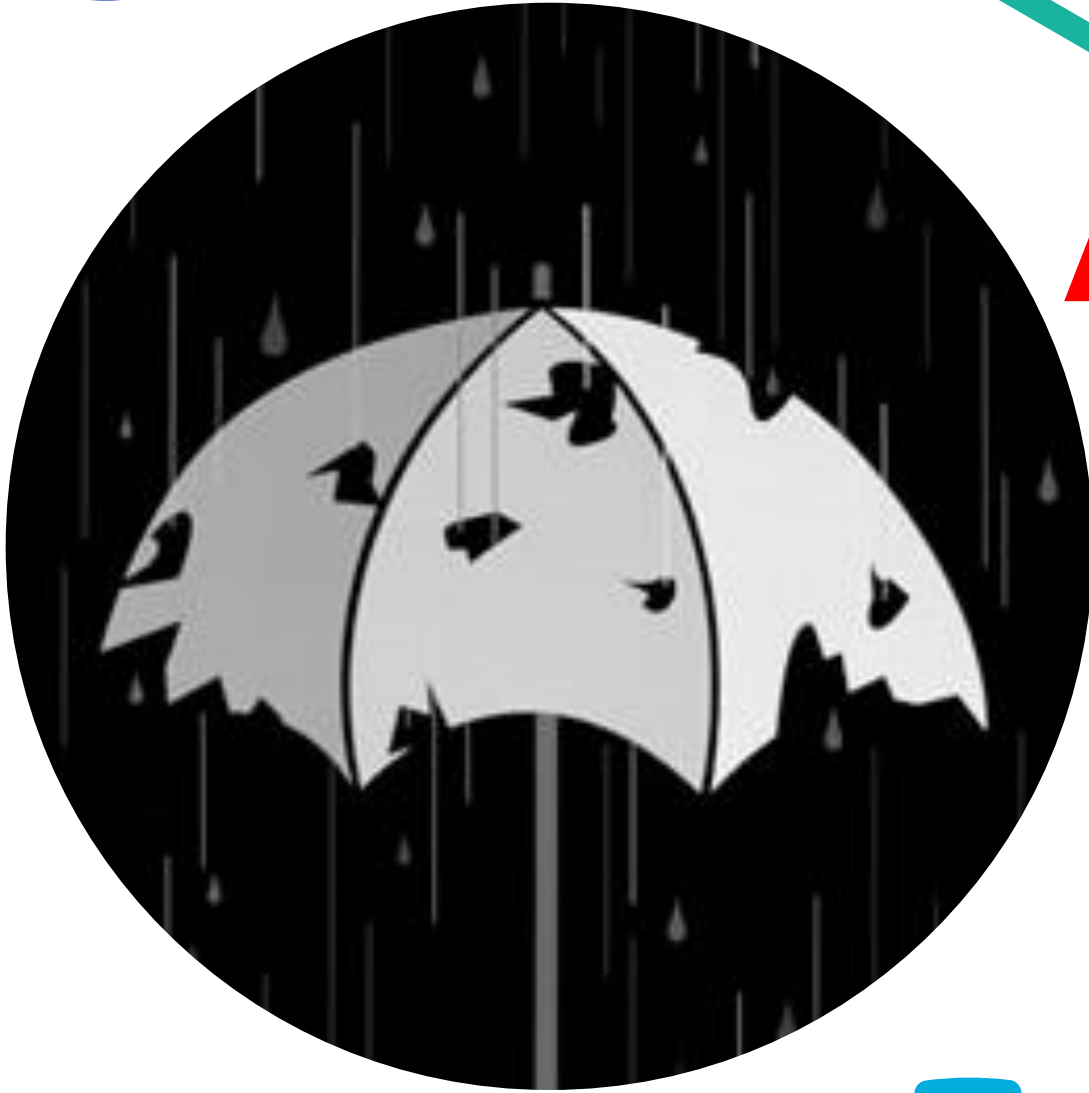


ACID RAIN



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Do Now

- What does pH scale measure?
- What pH value is considered “neutral”?
- Which pH values are “acidic”?
- Which pH values are “basic” or “alkaline”?



What is the pH of rain?

- Pure water has a **pH of 7** – neutral (neither an acid nor a base)
- Normal **precipitation** is slightly **acidic** (pH =5.6) because carbon dioxide (**CO₂**) in the air mixes with rain water to form a weak acid called **carbonic acid**.
- $\text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{H}_2\text{CO}_3$



Introduction to acid rain

Normal rain water is always slightly acidic because CO_2 present in atmosphere. get dissolved in it form carbonic acid. Normal acidity of rain water is 5.6



Because of SO_2 & NO_2 gases as pollutants in atmosphere. The pH of rain is further lowered to as 2.4 & this type of Precipitation is called as ACID RAIN.

Acid rain is combination of H_2SO_4 , HNO_3 and HCl is third

History

Since industrial revolution, emissions of SO_2 & NO_2 in atmosphere have increased.



In 1852 ROBERT ANGUS SMITH was first to show relation b/w acid rain & atmosphere pollution in Manchester (England)



Term acid rain was generated by SMITH in 1972.



Problem of acid rain has not only increased with population & industrial growth but has become widespread.

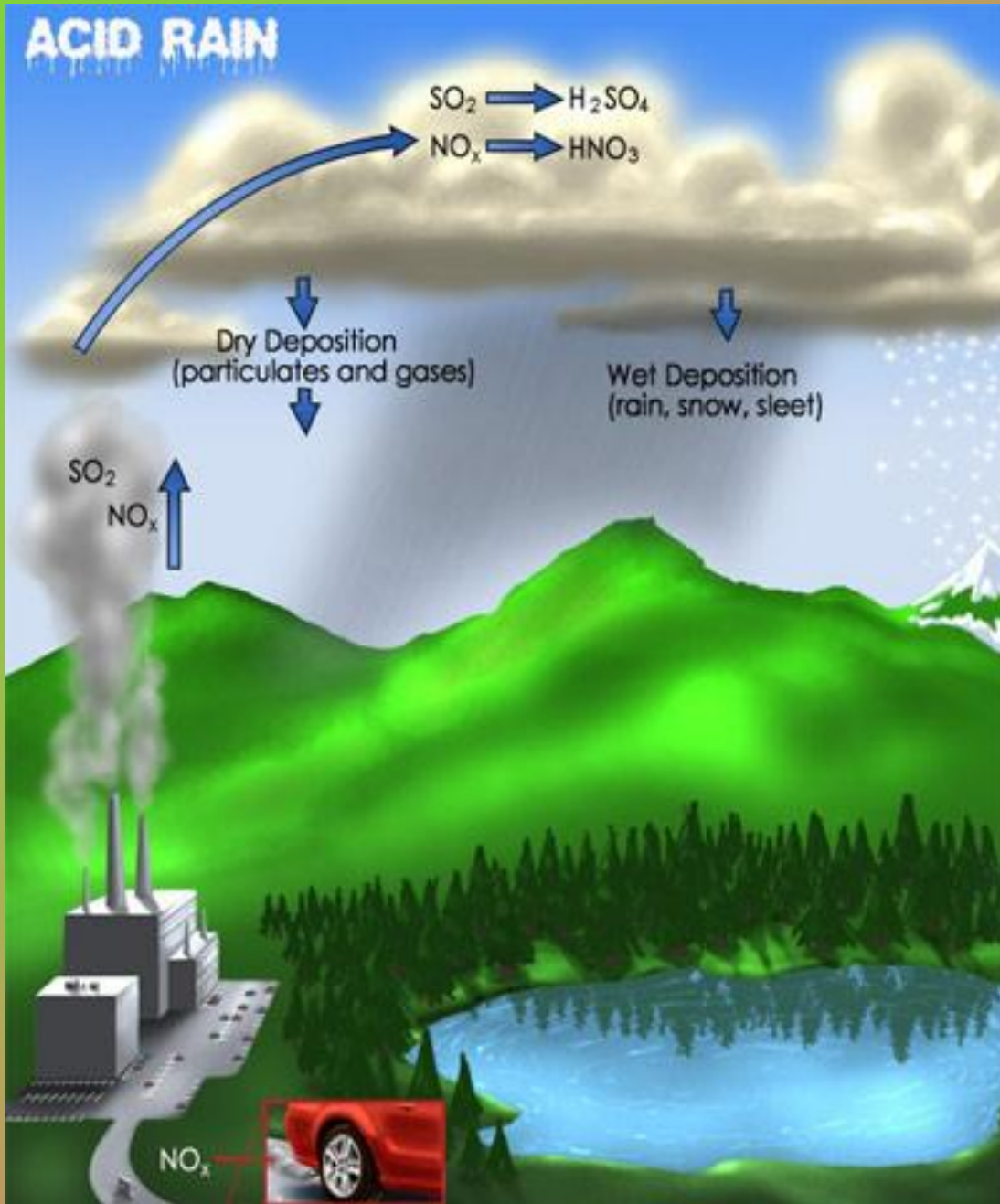
History

- The corrosive effect of polluted, acidic city air on limestone and marble was noted in the 17th century by John Evelyn, who remarked upon the poor condition of the Arundel marbles. Since the Industrial Revolution, emissions of sulphur dioxide and nitrogen oxides into the atmosphere have increased. In 1852, Robert Angus Smith was the first to show the relationship between acid rain and atmospheric pollution in Manchester, England.
- Though acidic rain was discovered in 1853, it was not until the late 1960s that scientists began widely observing and studying the phenomenon. The term "acid rain" was coined in 1872 by Robert Angus Smith, A Scottish chemist. Canadian Harold Harvey was among the first to research a "dead" lake. At first the main focus in research lay on local affects of acid rain. the chemical-laden clouds themselves know no borders and have the potential to float over a large area.

- Waldemar Christofer Brøgger was the first to acknowledge long-distance transportation of pollutants crossing borders from the United Kingdom to Norway. This became a media issue in the early 1980's. By this time most of the countries started noticing changes in the wildlife, population of fish and trees. Public awareness of acid rain in the U.S increased in the 1970s after The New York Times published reports of the deleterious environment. Occasional pH readings in rain and fog water of well below 2.4 have been reported in industrialized areas.
- In 1980, the U.S. Congress passed an Acid Deposition Act. This Act established an 18-year assessment and research program under the direction of the National Acidic Precipitation Assessment Program (NAPAP). NAPAP looked at the entire problem from a scientific perspective. Subsequent Reports to Congress have documented chemical changes in soil and freshwater ecosystems, nitrogen saturation, power plant pollution, decreases in amounts of nutrients in soil, episodic acidification, regional haze, and damage to historical monuments.

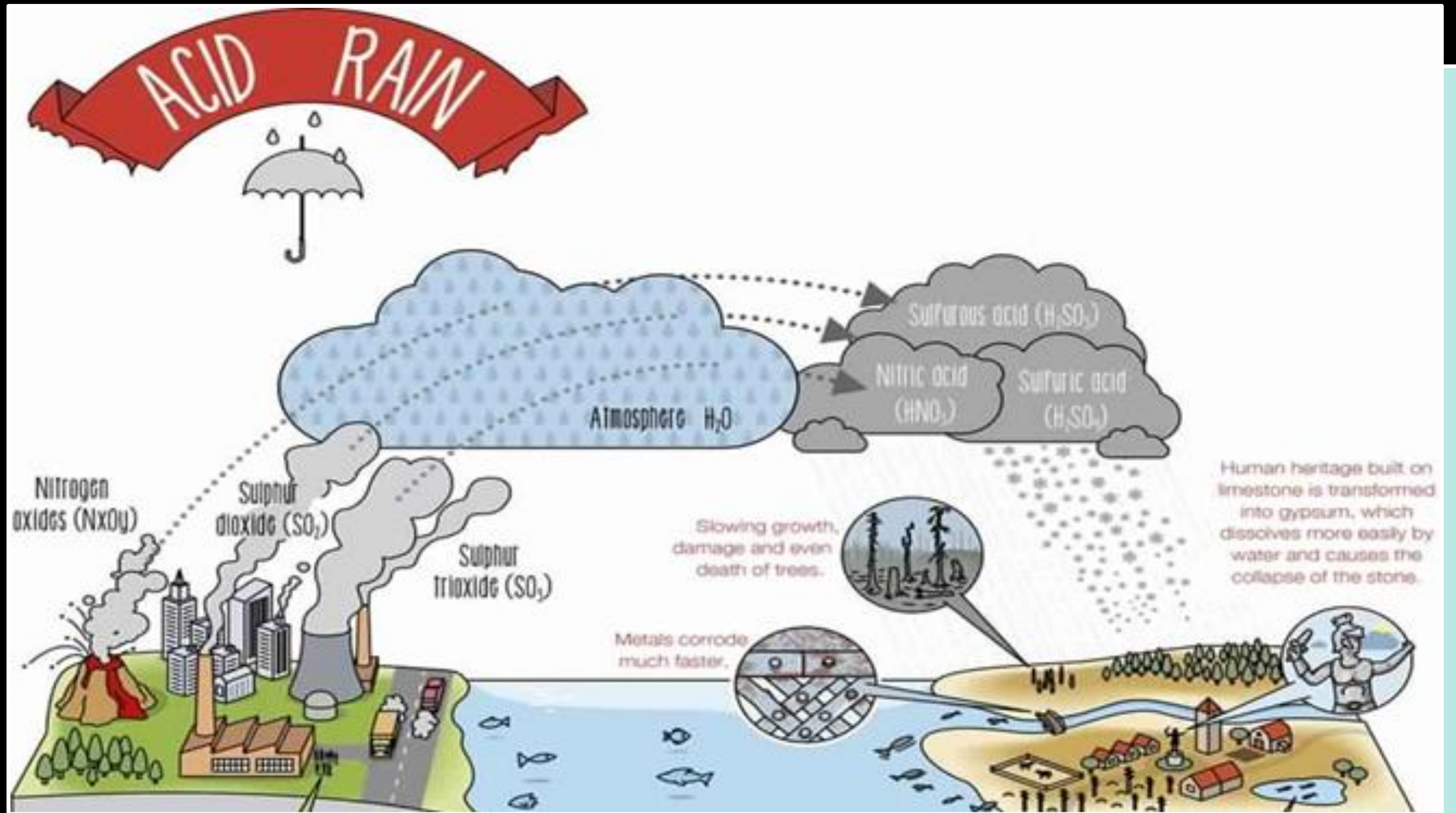


Since 1998, Harvard University wraps some of the bronze and marble statues on its campus, such as this "Chinese stele", with waterproof covers every winter, in order to protect them from corrosion caused by acid rain and acid snow.

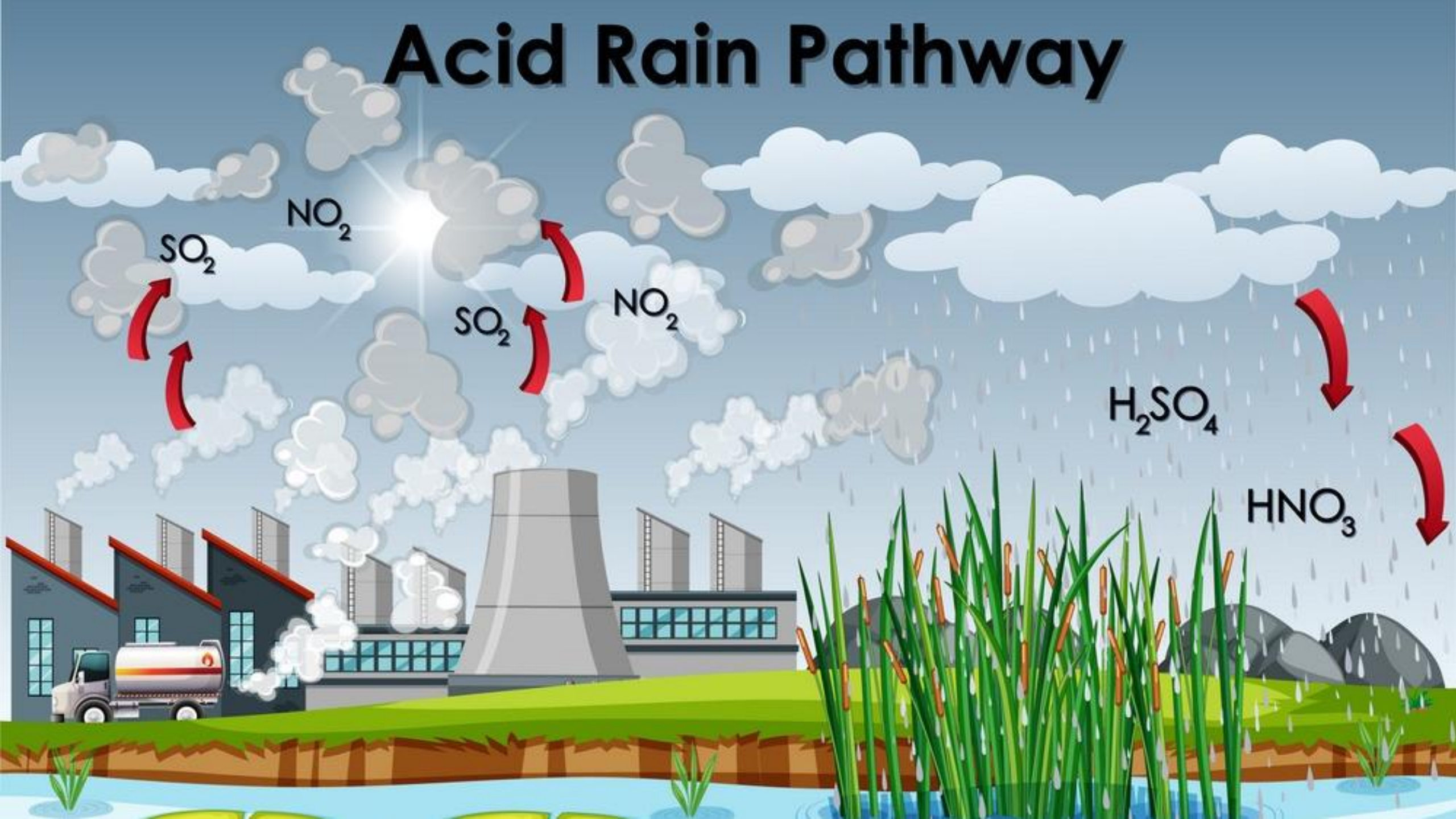


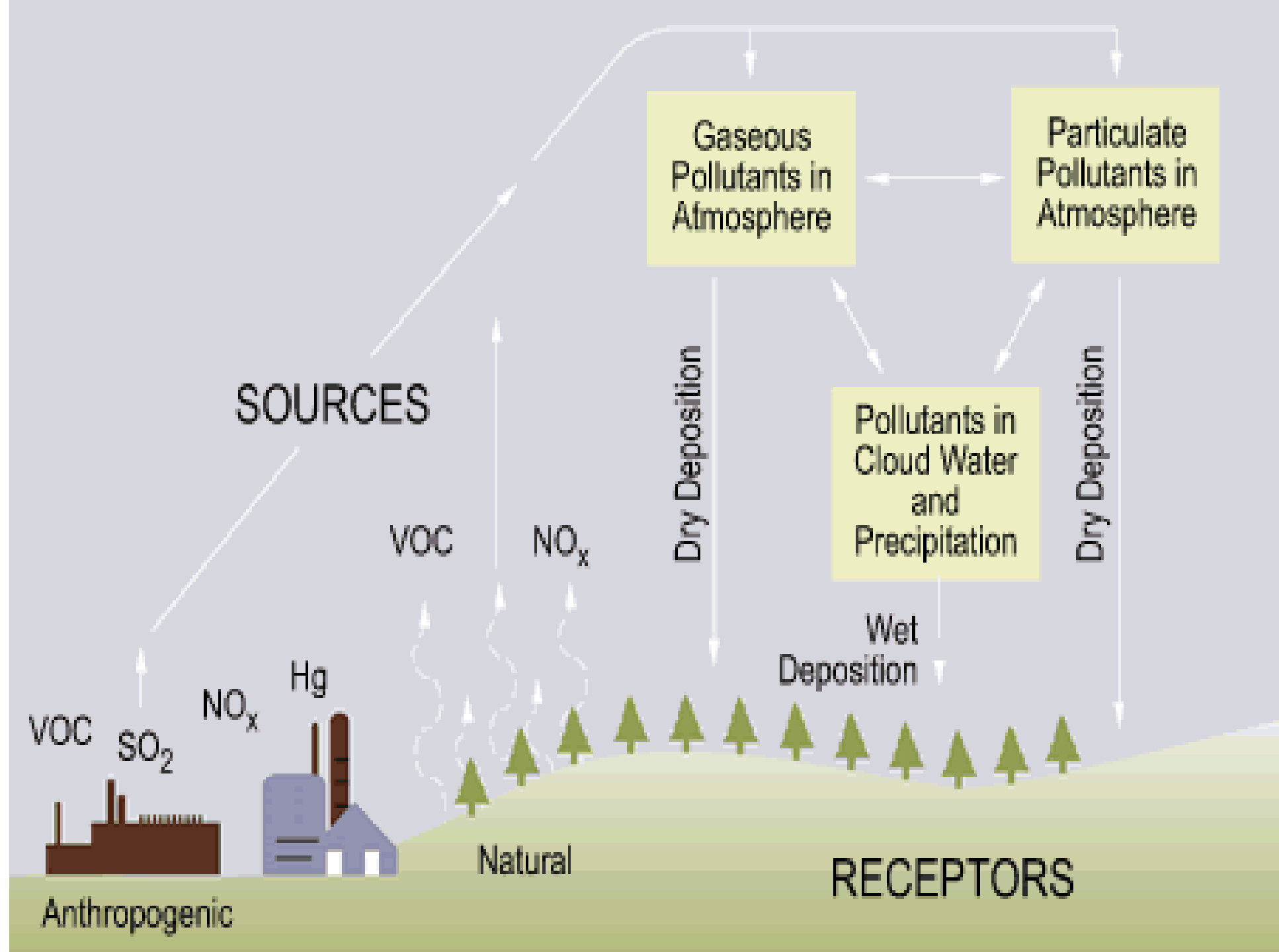
Acid Rain Formation

Emissions of sulfur dioxide and nitrogen oxides react with water vapor in the atmosphere to create sulfuric and nitric acids.



Acid Rain Pathway





Causes Of Acid Rain

➤ NATURAL CAUSES:-

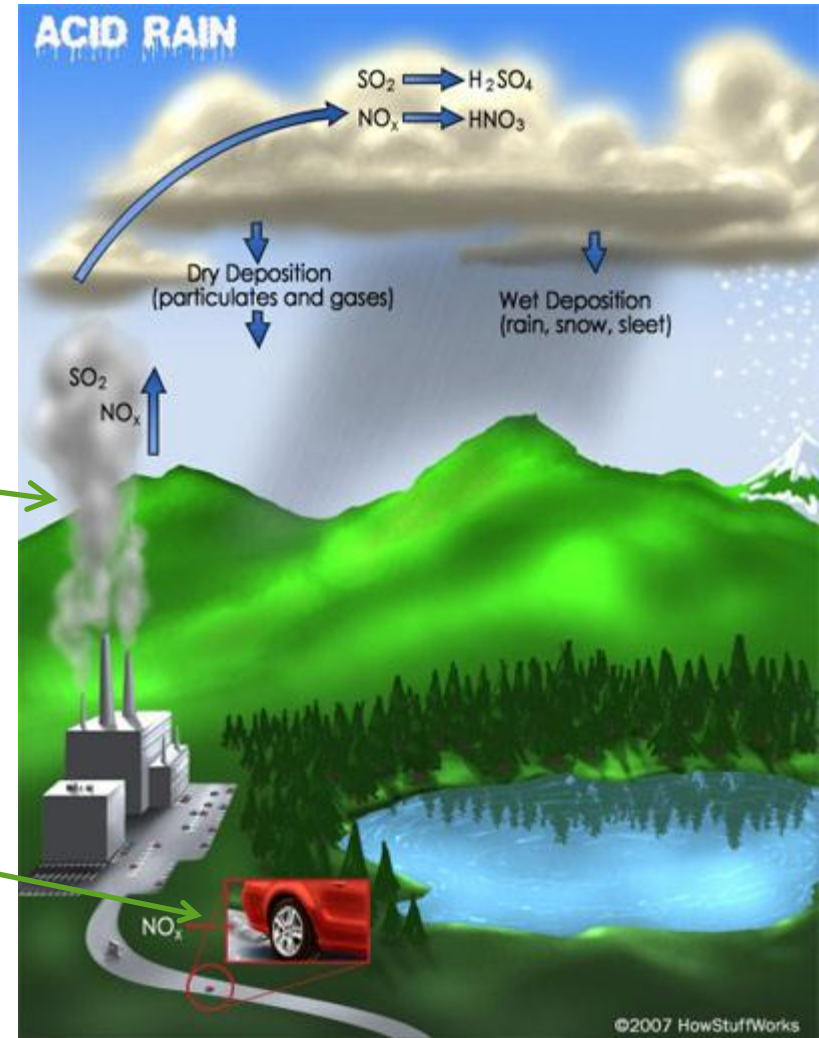
- ❖ Volcanic emissions.
- ❖ Biological processes.
- ❖ Lightning.

➤ ANTHROPOGENIC CAUSES:-

- ❖ Factories (industrialization)
- ❖ Motor vehicles, automobile exhaust.
- ❖ Coal based power plants.
- ❖ Domestic fires.
- ❖ Smelters.

How does acid rain form?

- Factories that burn fossil fuels release sulfur dioxide(SO_2) and nitrous oxides(NO_x)
- Cars that burn fossil fuels release nitrous oxides. (NO_x)

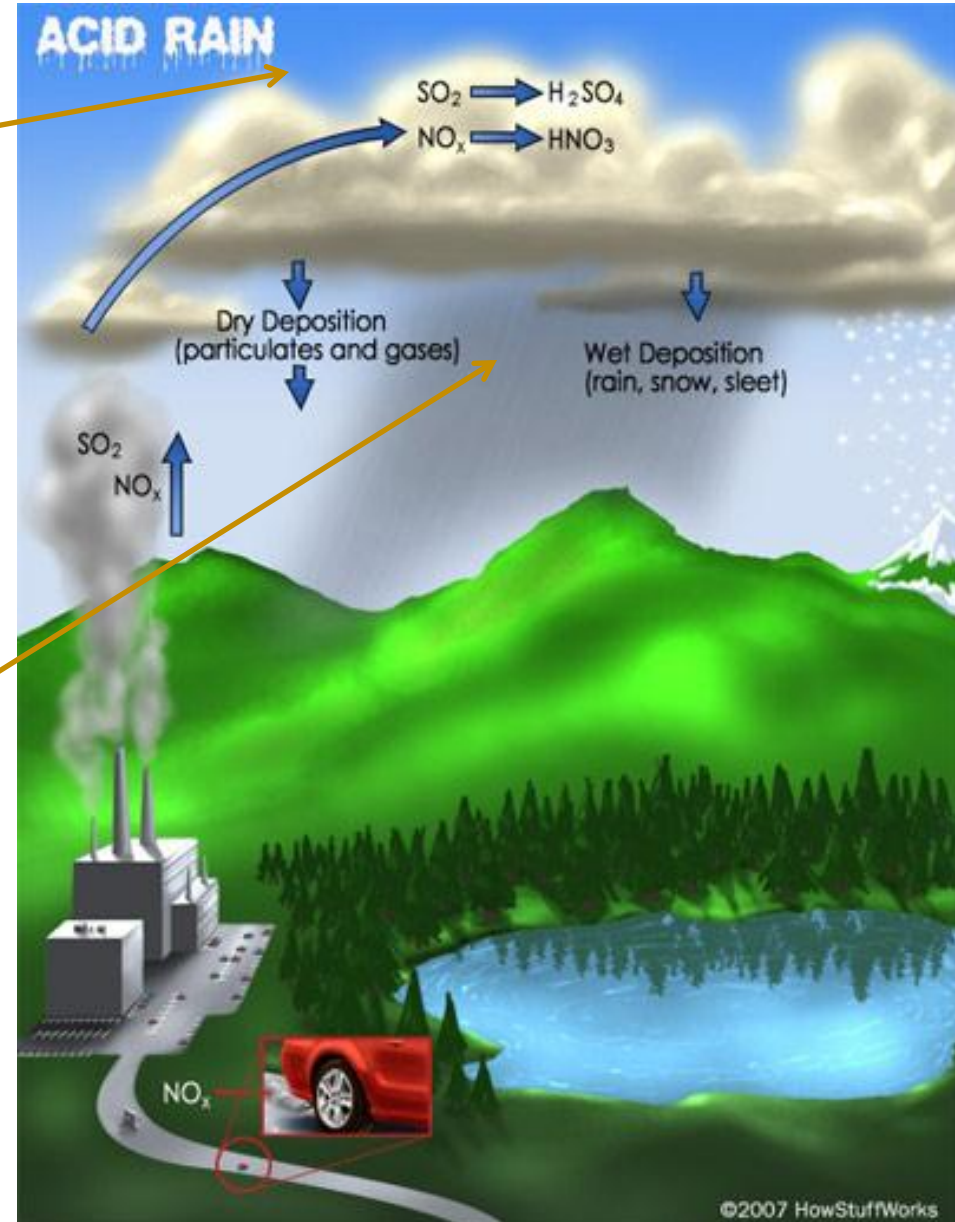


How does acid precipitation form?

- Sulfur and nitrous oxides combine with water in the atmosphere to form sulfuric acid and nitric acid

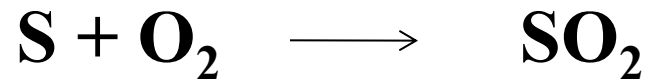


- These strong acids lower the pH of rain more than H_2CO_3

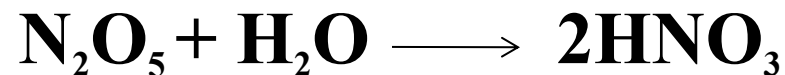
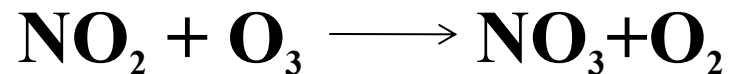
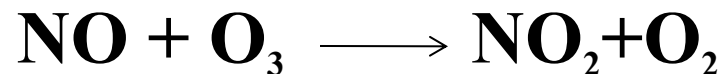


Chemical Processes Involved In acid rain

Formation Of Sulphuric Acid

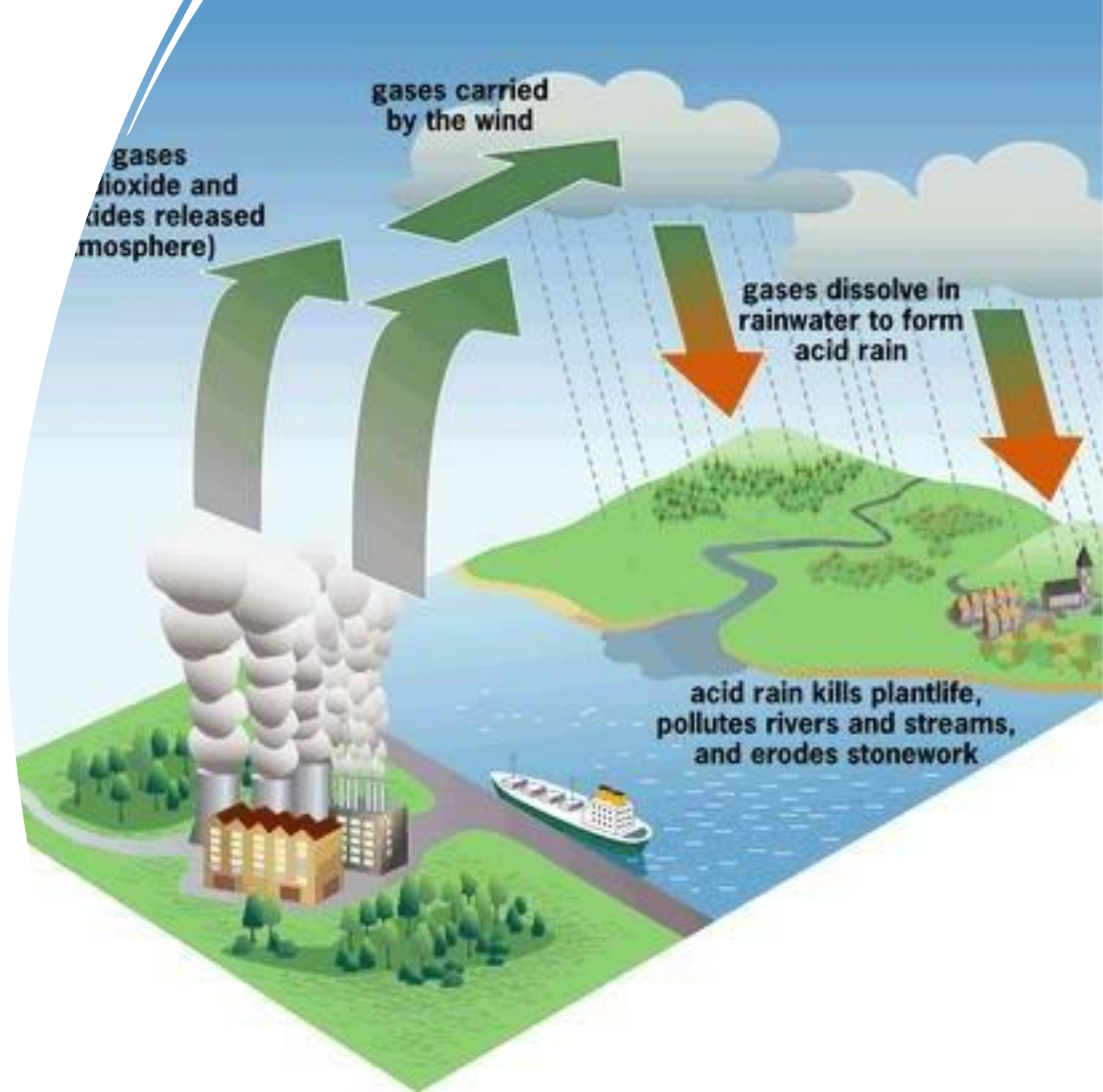


Reaction Involving Formation Of Nitric Acid



problems!!!

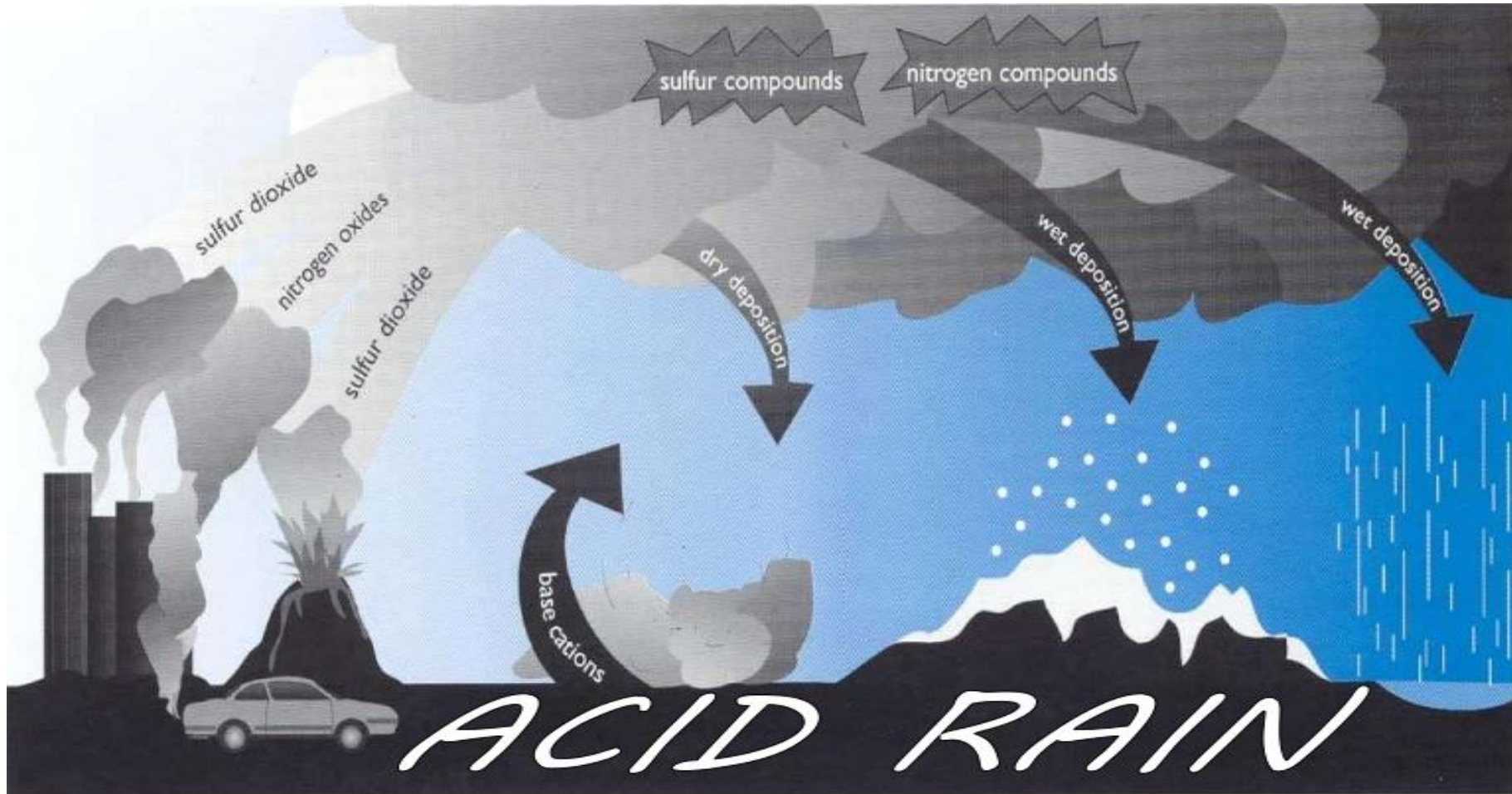
- Acid rain can travel long distances.
- Often it doesn't fall where the gas is produced. Winds blow them great distances before they dissolve and fall to Earth as rain.
- E.g. gases produced in India and China can result in acid rain in Pakistan or Afghanistan.



Forms of Acid Deposition

1. Wet Deposition

2. Dry Deposition



Wet Deposition

Where the weather is wet, the acids fall to the ground in the form of rain, sleet, fog, snow or mist. It removes acid from the atmosphere and deposit them on the earth's surface. The acidic water flows over and through the ground, and can harm flora and fauna.



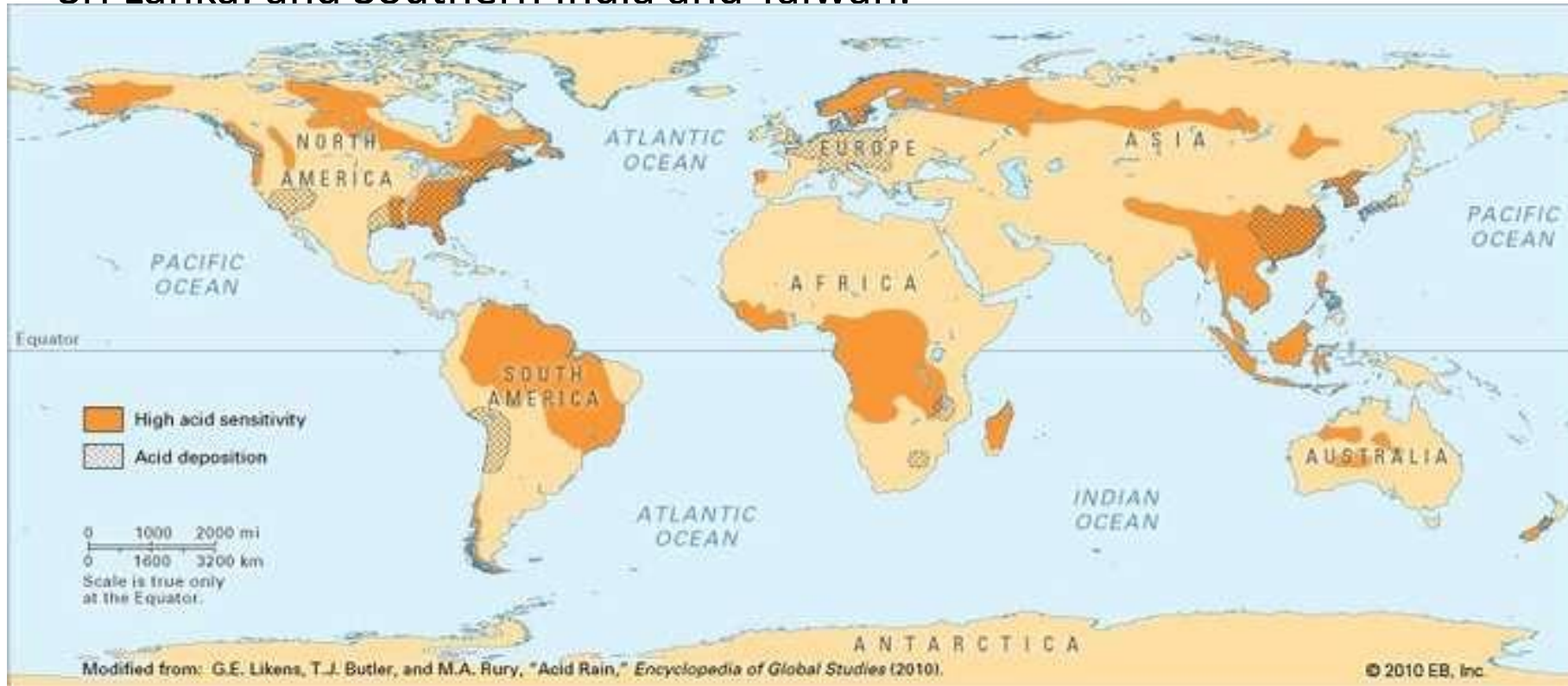
Dry Deposition

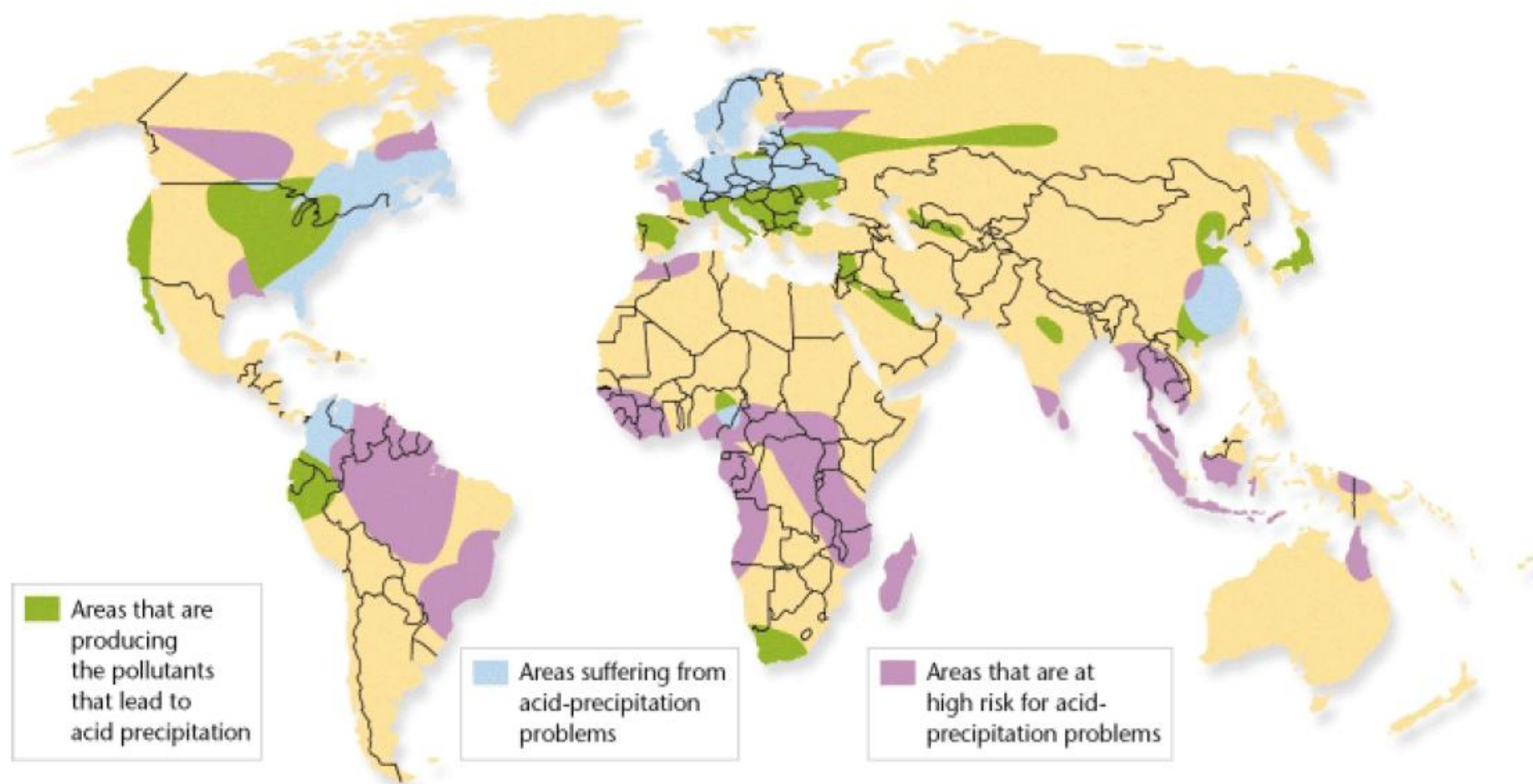
- Where the weather is dry, the acidic pollutants slip into dust or smoke and fall to the ground as dry particles. These stick to the ground and other surfaces such as cars, houses, trees and buildings. Almost 50% of the acidic pollutants in the atmosphere fall back through dry deposition. These acidic pollutants can be washed away from earth surface by rainstorms.
- Unlike wet deposition, dry deposition is difficult and expensive to measure. Dry deposition estimates for nitrogen and sulphur pollutants are provided by the Clean Air Status and Trends Network (CASTNET).



Affected Areas

Places significantly impacted by acid rain around the globe include most of eastern Europe from Poland northward into Scandinavia, the north eastern of the United States, and southeastern Canada. Other affected areas include the southeastern coast of China South Asia, South Africa, Sri Lanka. and Southern India and Taiwan.





Affected Areas

- Canada
 - Acid rain is a problem in Canada
 - Water and soil systems lack natural alkalinity such as lime base
 - Cannot neutralize acid
 - Canada consists of susceptible hard rock such as granite
 - Do not have the capacity to effectively neutralize acid rain

Affected Areas

- Industrial acid rain is a substantial problem in China, Eastern Europe and Russia and areas down-wind from them.
- Acid rain from power plants in the Midwest United States has also harmed the forests of upstate New York and New England.
- This shows that the effects of acid rain can spread over a large area, far from the source of the pollution



Effects

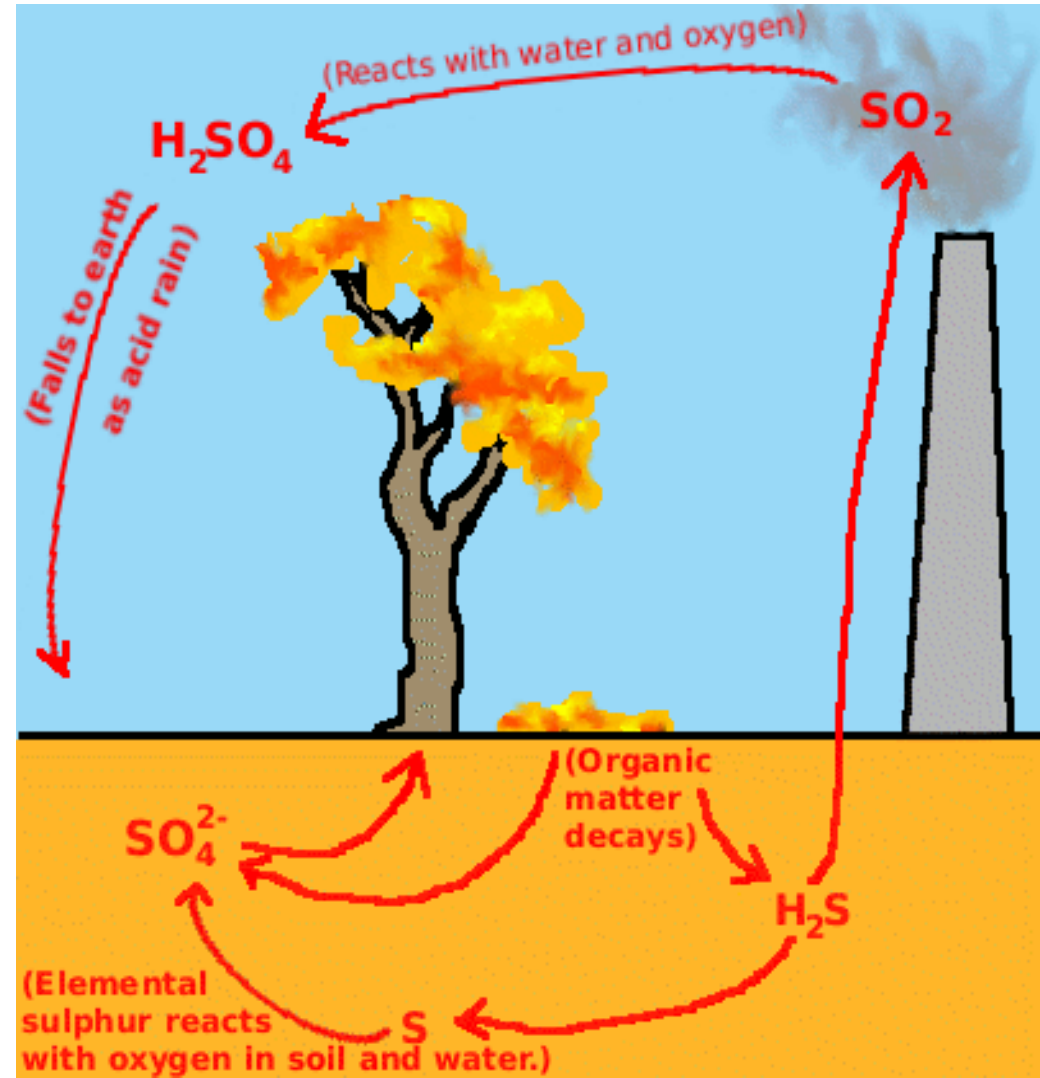


Plant

- Direct effect on plant growth due to toxification of soil
- It takes away soil nutrients causing stunted growth.
- Block stomatal pores of leaves.
- Electron transport system, biochemical reactions dominated by pH are effected.
- Degradation of plant chlorophyll.



So what does acid rain damage in plants look like?



b. Soil

- Acid rain damages soil biology and chemistry
- Microbes not able to tolerate low pH and die
- Upper fertile layer of soil is affected as essential nutrients are leached away from soil



Acidification of soils

- Soils with lime frequently lose their fertility by acidification.
- Leads to loss of nutrients like Potassium, Phosphorous, Calcium and Magnesium.
- Spoils the metals like Al, Zn, Mn, etc. from soils.
- Affects agricultural production so greatly.



Acidification of lakes and rivers

Kills aquatic animals, plants and fishes.

Affects aquatic eco-system.

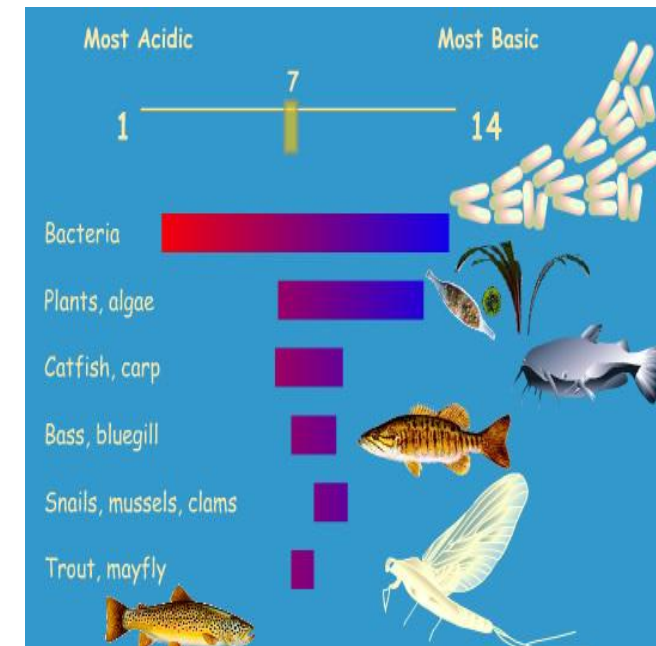
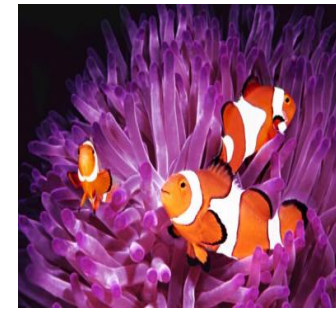
Kills bacteria, green algae and other biota.

Leads to water pollution.

Improves concentrations of heavy metals like lead, cadmium, copper and zinc in water bodies.

Aquatic Life

- Acid rain is a threat to the aquatic life. If the pH level or the acidity is below 5 or 4.8, the fishes die.
- The calcium level and the reproductive ability of the fish decreases due to acid rain. As a result the bones become weak and deformed resulting in death. The sensitivity of the eggs increases and young fishes die.
- A high amount of sulphuric acid in the seawater interferes with the ability of fish to take in nutrients, salt, and oxygen.
- As far as freshwater fish is concerned, in order to stay alive, they need to balance the amount of minerals and salts in their tissues. The molecules of acid result in mucus forming in their gills, which prevents them from absorbing oxygen in adequate amounts. Thus, this decreases the population of different species of fish resulting in their extinction.





Surface Water And Aquatic Animals

- Acid rain causes lower pH & high aluminum conc. in surface water that causes damages to fish and aquatic animals.
- Biodiversity of water body is reduced.
- Lakes, rivers are fragile ecosystems where each species depend on other to survive ,if one disappears other too disappears.

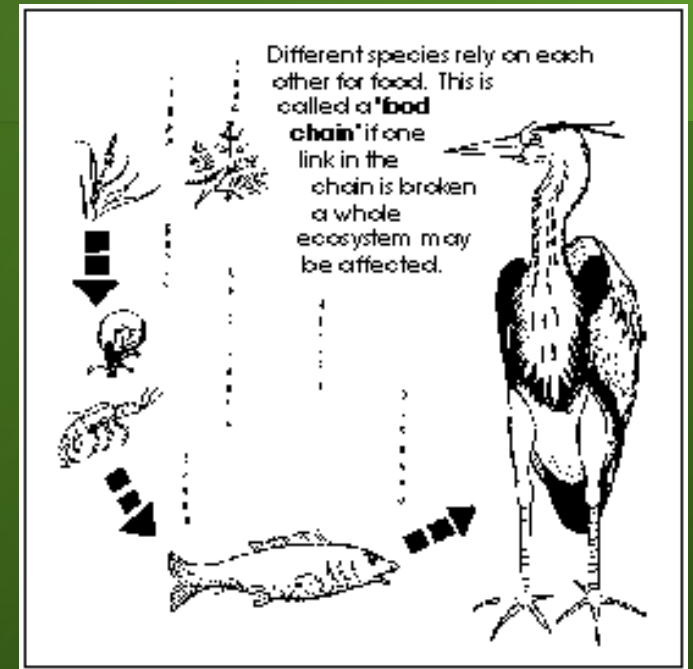


How does acid rain affect fish and other aquatic organisms?

	PH 6.5	PH 6.0	PH 5.5	PH 5.0	PH 4.5	PH 4.0
TROUT						
BASS						
PERCH						
FROGS						
SALAMANDERS						
CLAMS						
CRAYFISH						
SNAILS						

- Acid rain causes harm or kill fish, reduce fish population numbers, completely eliminate fish species from a water body, and decrease biodiversity. As acid rain flows through soils in a watershed, aluminum is released from soils into the lakes and streams located in that watershed. So, as pH in a lake or stream decreases,
- aluminum levels increase. Both low pH and increased aluminum levels are directly toxic to Aquatic Organisms. In addition, low pH and increased aluminum levels cause lower body weight and smaller size and fish lose their ability to reproduce.

What does acid rain damage in these ecosystems look like?



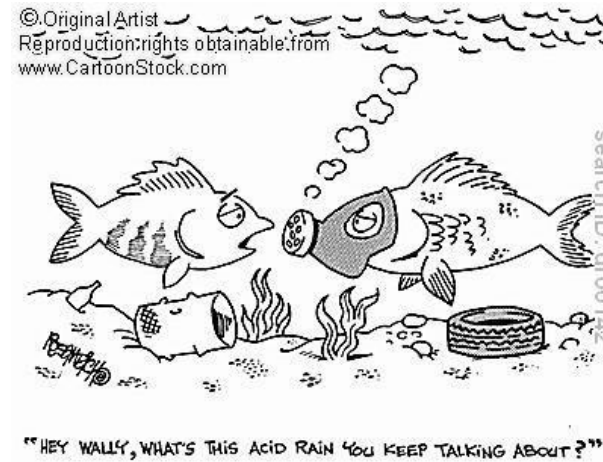
Acid Precipitation and Aquatic Ecosystems

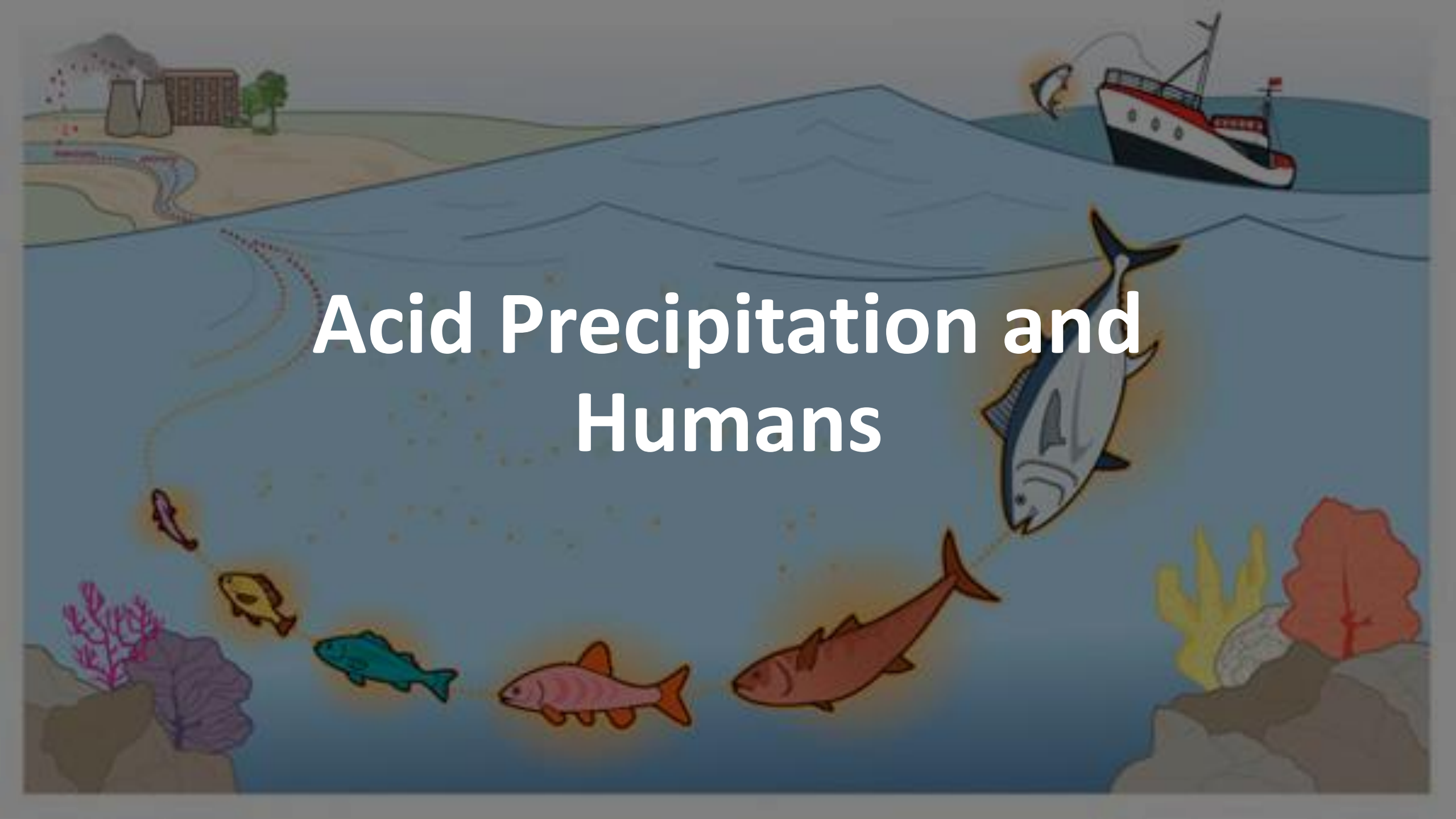
Acid precipitation can cause aluminum to leach out of the soil surrounding a lake.

The aluminum accumulates in the gills of fish and interferes with oxygen and salt exchange.

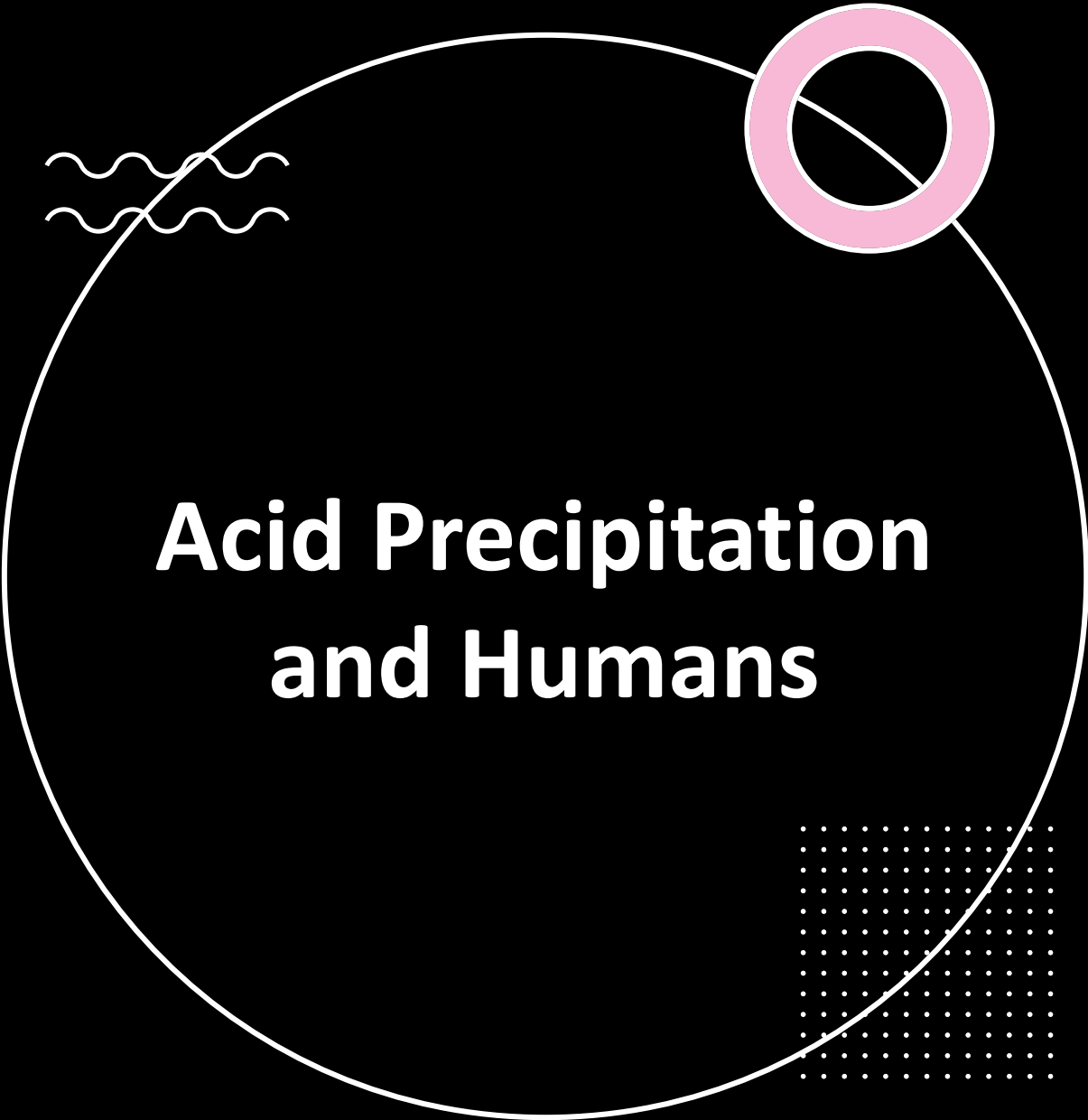
As a result, fish are slowly suffocated

If acid precipitation falls on a lake and changes the water's pH, it can kill aquatic plants and animals.



An illustration depicting the environmental impact of acid precipitation. In the upper left, a factory with two large cooling towers and smokestacks is shown on a shoreline, with smoke rising from the stacks. A river flows from the factory into a body of water. In the upper right, a fishing boat is on the water. The central text 'Acid Precipitation and Humans' is overlaid on the water. In the lower half, a variety of fish are shown swimming in the water, including a large blue fish, a red fish, a pink fish, a green fish, a yellow fish, and a small purple fish. The bottom corners show rocky shorelines with colorful coral or seaweed in shades of purple, yellow, and red. The overall scene suggests the contamination of water bodies by industrial waste and acid rain, affecting marine ecosystems.

Acid Precipitation and Humans



Acid Precipitation and Humans

Fisherman can't fish
because the number of fish
is decreased because by
acidification of lakes

The Forestry industry is also
affected because trees are
damaged by acid
precipitation.

Birds

Acid rain has affected the bird population to an extent. Certain bird studies conducted have proved the extinction of certain species of birds around the globe. The breeding habits have considerably declined. The calcium levels have also decreased so the eggs become unhealthy.



Health effects



Causes skin cancer and other skin diseases.



Can enter very deep in lungs and causes lung cancer.



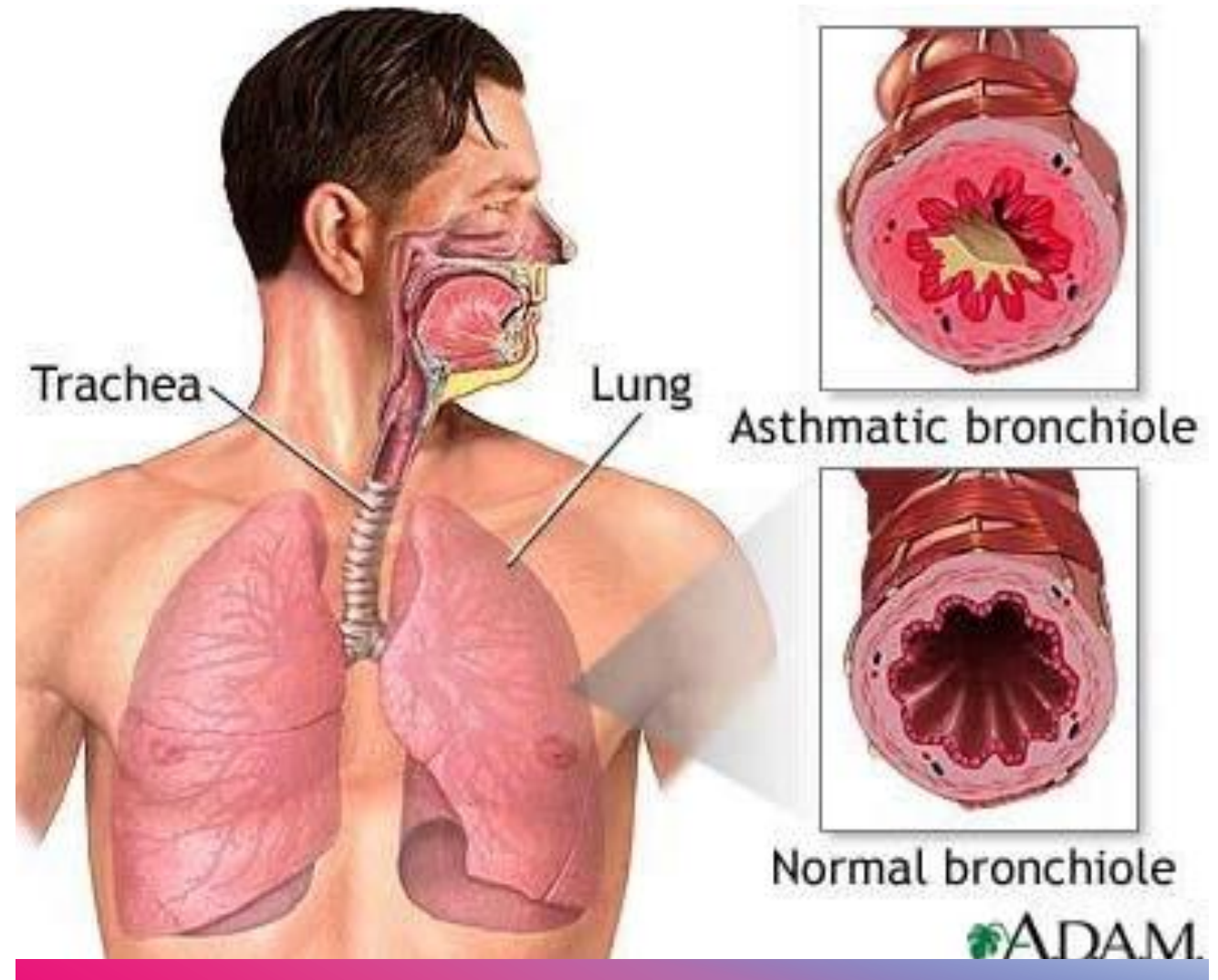
Increased acidity in water, air, soil and plants. So, automatically the food produced will become so dangerous.



➤ Aerosol mist of sulfuric acid has very serious respiratory effects.

➤ Acidification play havoc with human nervous system ,respiratory system and digestive system.

- Since acid rain can kill aquatic animals, weaken trees and dissolve stone, it seems like it could also burn animals, but it doesn't affect people in the same way as it does fish or plants.
- Acid rain feels the same as regular rain -- it's even safe to swim in an acidic lake. But the sulfate and nitrate particulates of dry deposition can cause asthma & bronchitis problems.





Acid rain can affect both plants (through soil and/or direct contact) and animals (from things they eat and/or direct contact). When humans eat these plants or animals, the toxins inside of their meals can affect them. Kidney problems, skin cancer & different diseases have been linked to people eating "toxic" animals/plants.

Effects on materials



Cause physical damage to buildings, monuments, bridges and other structures by corrosion.



Causes erosion of stones.



Undergo chemical reactions with limestone.



Causes weathering of surfaces of sand stone.



Affects several items like paper, fabrics, leather and wood very badly.

Effect On Buildings

Causes extensive damage to buildings, structural materials of marble ,limestone, slate etc.



In Greece and Italy invaluable stone statues have been partially dissolved by acid rain.

Taj Mahal in Agra is also suffering due to acid fumes from Mathura refinery.

Acid Rain Effects on Sculptures



E. M. Winkler Stone, Schmidt-Thomsen

1908

1969



The Supreme Court ordered 292 industries in the vicinity to either adopt pollution control measures or to shut down. It also made it mandatory for these units to either switch over to eco-friendly fuels like natural gases or shift out of the area. As a result of this plan, the industries situated inside the trapezium had switched over to the use of liquefied petroleum gas or natural gas in the place of coal or oil.



Deterioration of Taj Mahal



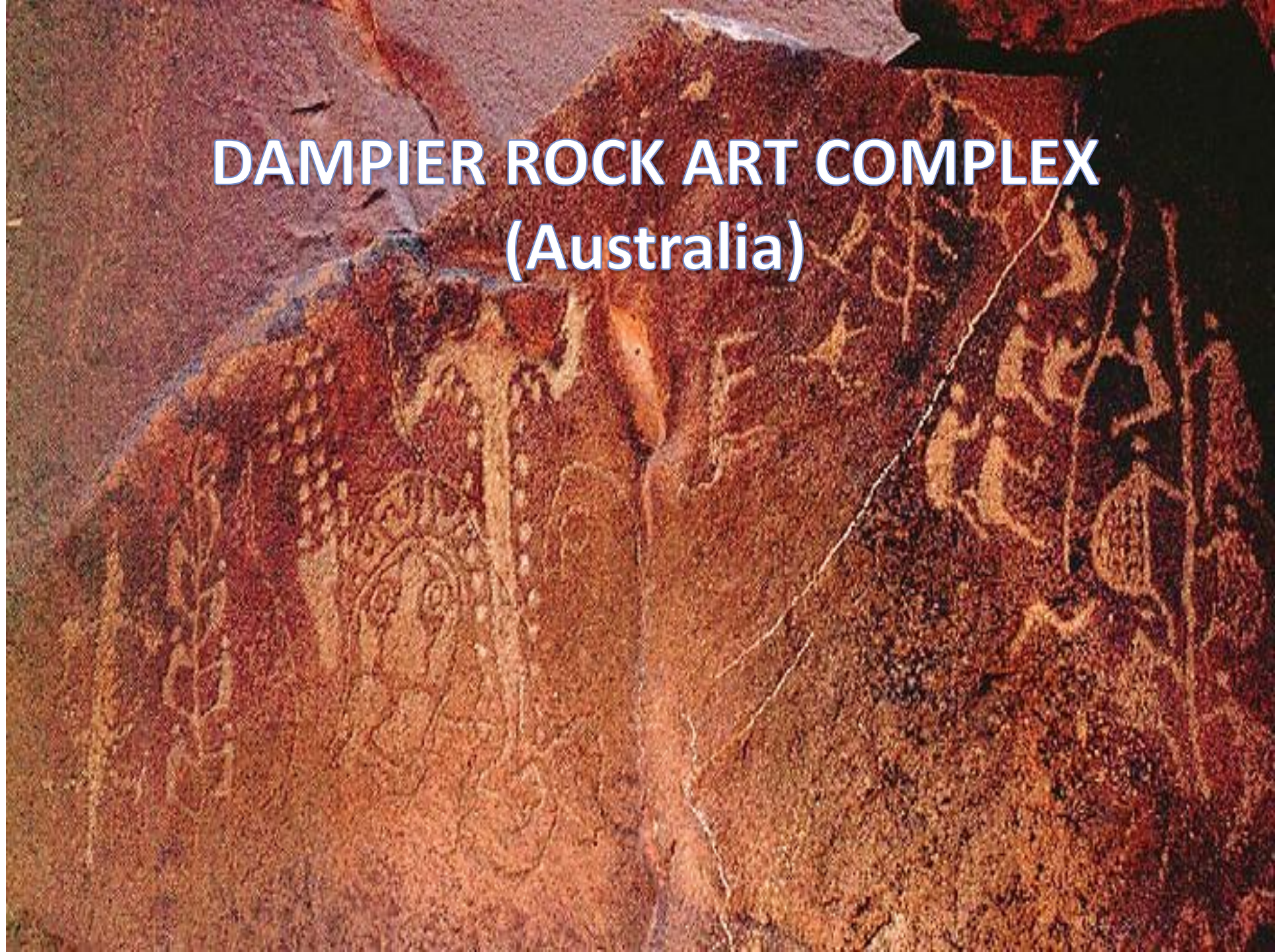
- Taj, the seventh wonder of world getting deteriorated because of emissions of Mathura oil refinery which lies 40 km away from Taj
- The oil refinery emits 25-30 tones of SO_2 daily in spite of using low sulphur fuels.



LONGMEN GROTTOES (China)



DAMPIER ROCK ART COMPLEX (Australia)





**LESHAN GIANT BUDDHA,
MOUNT EMEI (China)**

A photograph of the Propylaea, the monumental gateway to the Acropolis of Athens. The structure is made of dark, weathered stone and features a central section with four tall Doric columns supporting a triangular pediment. Below this, a large semi-circular archway is visible, through which the Parthenon can be seen in the distance. The sky is a clear, bright blue.

ACROPOLIS OF ATHENS (Greece)

Transport



- Currently, both the railway industry and the aeroplane industry are having to spend a lot of money to repair the corrosive damage done by acid rain.
- Also, bridges have collapsed in the past due to acid rain corrosion.
- Repainting is the only way to fix a car finish disfigured by acid rain



According to a Research

Research carried out in North America in 1982, revealed that sulphur pollution killed 51,000 people and about 200,000 people become ill as a result of the pollution.

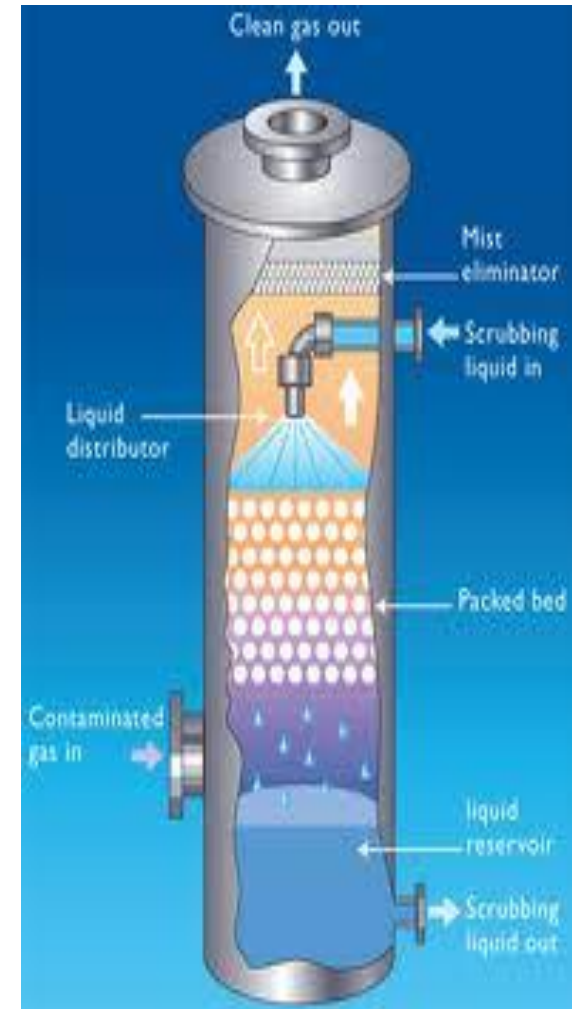
In Europe about 20% trees and in Germany about 60% trees have been damaged by acid rain. In some places acid rain had a pH level of 2.3, which was very acidic and destructive.

SOLUTIONS

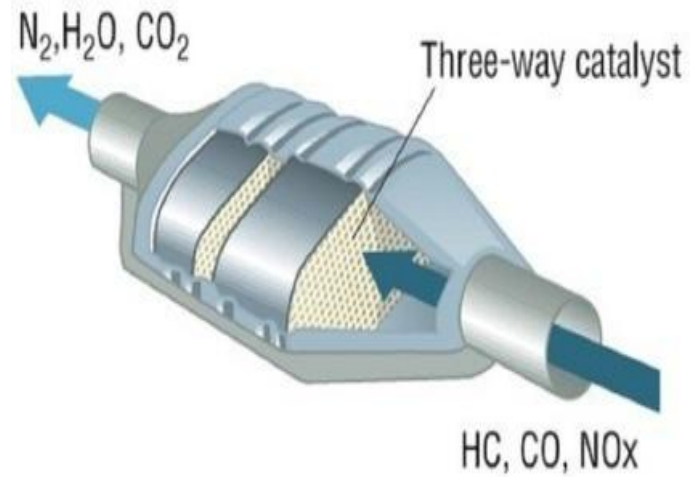
- **Use renewable energy** like wind power, solar panels , geothermal energy & hydro power.
- Limit the **number of vehicles** on the roads and increase public transport.
- **Plant a tree.** These are finally something we don't seem to have enough of. The tree will absorb some of the polluted air and put out clean, fresh oxygen.
- **Drive less:** Try to walk or bike instead.
- **Educate other people:** Now I have explained about causes of acid rain to you, you must aware other peoples who don't know about this problem.
- **Liming of lakes and soils**
- **Formulate the policy framework for reduction of sulfur dioxide and other acid rain causing gas emissions.**
- **Support a set of subproject that promote cleaner production, reduce acid rain and air pollution, improve the environment.**

Cleaning up Smokestacks

Most of the electric power supporting the modern-day energy requirements comes from combusting fossil fuels such as oil, natural gas, and coal. Washing coal, use of coal comprised of low sulphur, and use of devices known as “scrubbers” can provide technical solution to SO_2 emissions. “Scrubbing” also called flue-gas desulphurization (FGD) typically work to chemically eliminate SO_2 from the gases leaving smokestacks. It can eliminate up to 95% of SO_2 gases. The scrubbers produce sludge while reducing the sulphur content. It also produces a building material called gypsum, which is used to make plaster of Paris and cement, in the process. Power generation facilities can also shift to using fuels that emit much less SO_2 such as natural gas instead of burning coal.



Cleaner Automobiles



Cars and trucks are major sources of the pollutants that cause acid rain. Therefore, automobile manufacturers are required to reduce the amount of nitrogen oxides and other pollutants released by new cars. One type of technology used in cars is called a catalytic converter. Catalytic converters are fixed on the exhaust pipe system to reduce NO_x emission. This piece of equipment has been used for over 20 years to reduce the amount of nitrogen oxides released by cars. Some new cars can also use cleaner fuels, such as natural gas.

Restoring Damaged Environments

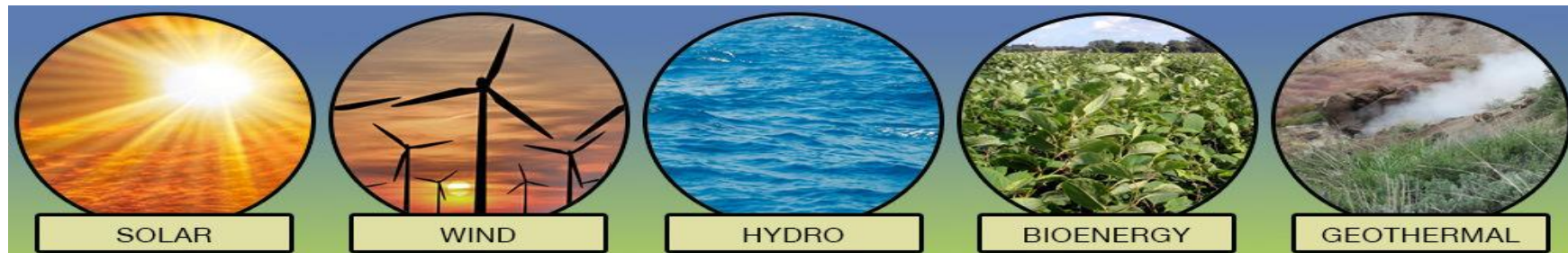


Use of limestone or lime, a process called liming, is a practice that people can do to repair the damage caused by acid rain to lakes, rivers and brooks. Adding lime into acidic surface waters balances the acidity. Furthermore, it only offers a short-term solution at the expense of solving the broader challenges of SO_2 and NO_x emissions and risks to human health. Nevertheless, it helps to restore and allow the survival of aquatic life forms by improving chronically acidified surface waters. The effect on food crops is minimized by the application of lime and fertilizers to replace lost nutrients. In cultivated areas, limestone may also be added to increase the ability of the soil to keep the pH stable.

Alternative Energy Sources



Besides fossil fuels, there is a wide range of alternative energy sources that can generate electrical power. These include wind energy, geothermal energy, solar energy, hydropower, and nuclear power. Harnessing these energy sources can offer effective electrical power alternatives instead of using fossil fuels. Fuel cells, natural gas, and batteries can also substitute use of fossil fuel as cleaner energy sources. As of today, all energy sources have environmental and economic costs as well as benefits. The only solution is using sustainable energy that can protect the future.



Responsibility of an individual

- Individuals can also help prevent acid rain by conserving energy. The less electricity people
- use in their homes, the a small number of chemicals power plants will emit. Vehicles are also major fossil fuel users, so drivers can reduce emissions by using public transportation, carpooling, biking, or simply walking wherever possible.

Individual, National/State, and International Actions



Millions of people directly and indirectly contribute to SO_2 and NO_x emissions. Mitigation of this challenge requires individuals to be more informed about energy conservation and ways of reducing emissions such as: turning off lights or electrical appliances when not using them; use public transport; use energy efficient electrical appliances; and use of hybrid vehicles or those with low NO_x emissions, walking down to nearby places instead of driving, etc., can help us save fuel and gas, as well as reduce the adverse effects.

Innovations

- The perils of plastic are nothing new to most of us. A lesser-known fact, however, is that plastic has a higher energy value than just about any other type of waste. To harness this energy while addressing the waste problem, Japanese company Blest has created a machine that converts several types of plastic into oil.
- Rather than burning the plastic, the machine uses a temperature-controlled electric heater to convert plastic into crude gas, which can then be used to power gas-based household appliances like stoves, boilers and generators or, if refined, can even be pumped into a car or motorcycle. Small yet highly efficient, the machine produces nearly one liter of oil – gasoline, diesel or kerosene – from every kilogram of plastic, requiring only 1 kilowatt of electricity for the conversion.



Plant a Garden

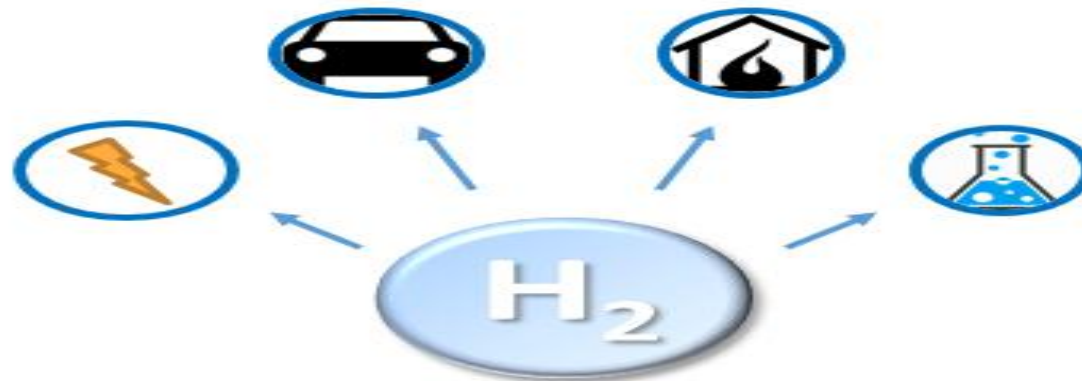
Not only is it great to add plants and trees to the planet that will help absorb carbon dioxide, but growing your own food will also further reduce your reliance on the fossil fuels associated with food transportation.



Hydrogen Economy



- One proposed way to meet the need for new energy sources is to burn hydrogen as a fuel in industry and power plants and possibly also in homes and motor. This proposal is referred to hydrogen economy. Dihydrogen releases large quantities of heat on combustion. Dihydrogen can release more energy than gasoline
- Burning of hydrogen in air or dioxygen not only liberates large amount of energy but yields water as the only product. Burning of hydrogen produces no pollutant like SO_2 that are responsible for acid rain ,nor carbon dioxide that is responsible for the greenhouse effect ,nor carcinogenic hydrocarbons nor lead compounds. But it should be used with proper precautions.



Liming



The process of adding a lime or calcium hydroxide (a base) to acidified lakes.

Use Energy Sources that Don't Produce Nitrogen or Sulfur Oxides

