



# Definition of Acid Rain

- ◆ Precipitation that has a pH of less than that of natural rainwater (which is about 5.6 due to dissolved carbon dioxide).
- ◆ It is formed when sulphur dioxides and nitrogen oxides, as gases or fine particles in the atmosphere, combine with water vapour and precipitate as sulphuric acid or nitric acid in rain, snow, or fog.

# Causes of Acid Rain

## ◆ Natural Sources

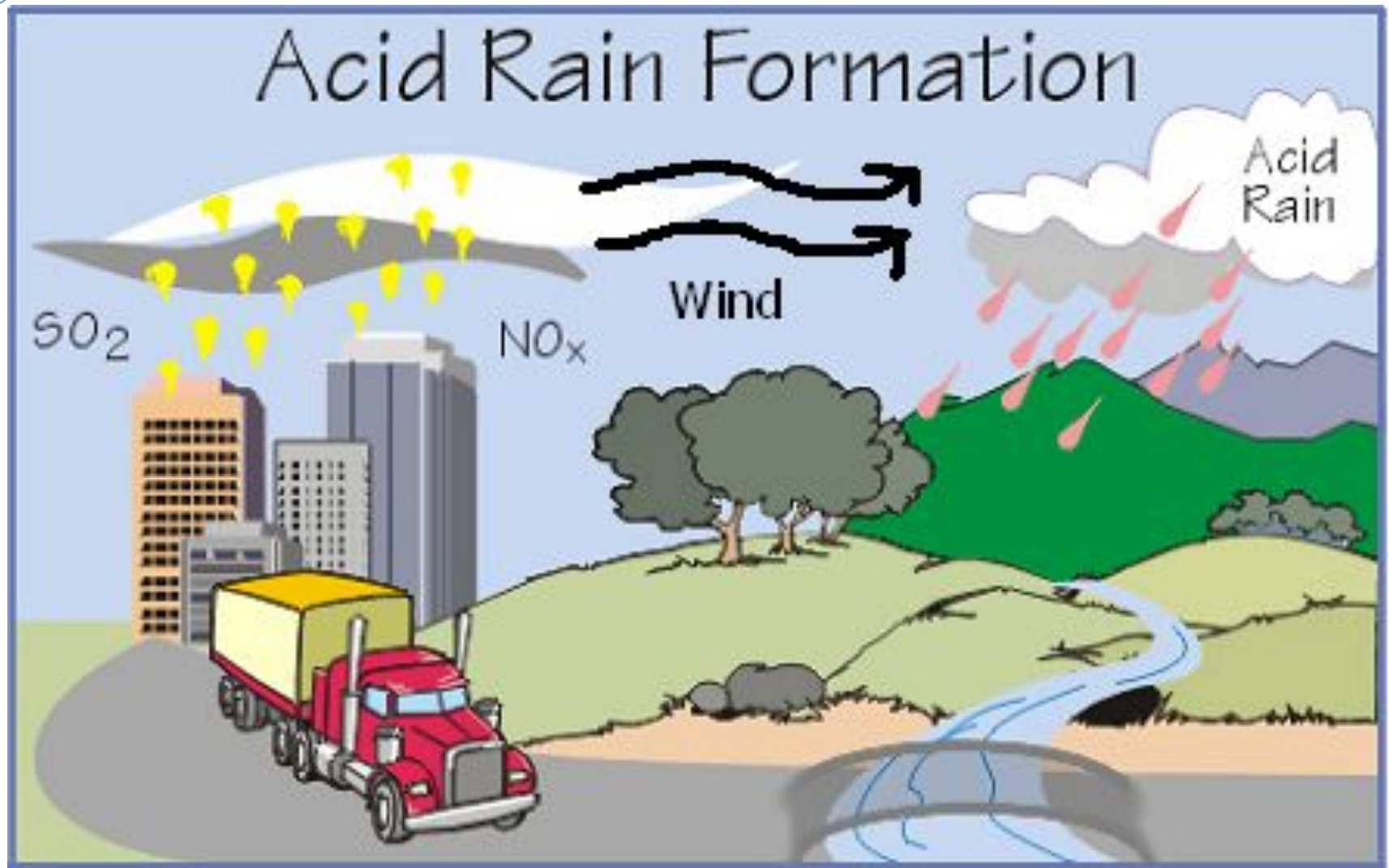
- Emissions from volcanoes and from biological processes that occur on the land, in wetlands, and in the oceans contribute acid-producing gases to the atmosphere
- Effects of acidic deposits have been detected in glacial ice thousands of years old in remote parts of the globe

# Causes of Acid Rain

- ◆ The principal cause of acid rain is from human sources
  - Industrial factories, power-generating plants and vehicles
  - Sulphur dioxide and oxides of nitrogen are released during the fuel burning process (i.e. combustion)



# Formation of Acid Rain



# Formation of Acid Rain

- ◆ When water vapour condenses, or as the rain falls, they dissolve in the water to form sulphuric acid ( $\text{H}_2\text{SO}_4$ ) and nitric acid ( $\text{HNO}_3$ ).
- ◆ While the air is cleaned of the pollutants in this way, it also causes precipitation to become acidic, forming 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 of Acid Rain

- ◆ Harmful to aquatic life
  - Increased acidity in water bodies
  - Stops eggs of certain organisms (e.g. fish) to stop hatching
    - ◆ Changes population ratios
    - ◆ Affects the ecosystem



# Effects of Acid Rain

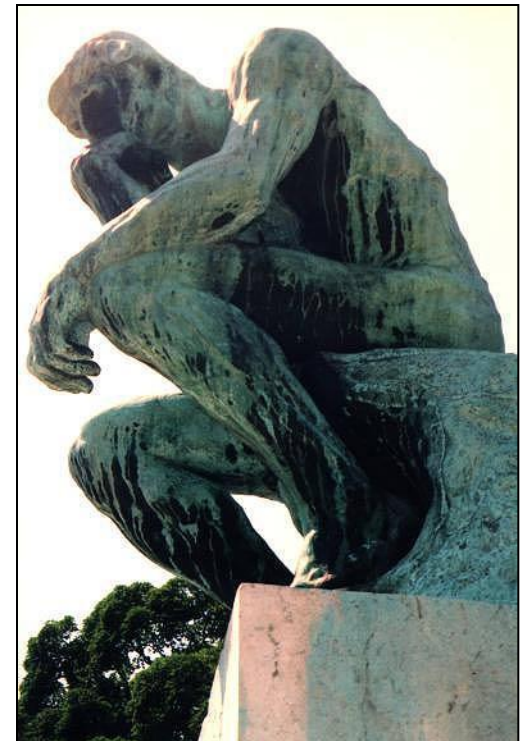
- ◆ Harmful to vegetation
  - Increased acidity in soil
  - Leeches nutrients from soil, slowing plant growth
  - Leeches toxins from soil, poisoning plants
  - Creates brown spots in leaves of trees, impeding photosynthesis
  - Allows organisms to infect through broken leaves

# Effects of Acid Rain



# Effects of Acid Rain

- ◆ Accelerates weathering in metal and stone structures
  - Eg. Parthenon in Athens, Greece; Taj Mahal in Agra, India



# Effects of Acid Rain

## ◆ Affects human health

- Respiratory problems, asthma, dry coughs, headaches and throat irritations
- Leeching of toxins from the soil by acid rain can be absorbed by plants and animals. When consumed, these toxins affect humans severely.
- Brain damage, kidney problems, and Alzheimer's disease has been linked to people eating "toxic" animals/plants.

# Preventive Measures

- ◆ Reduce amount of sulphur dioxide and oxides of nitrogen released into the atmosphere
  - Use less energy (hence less fuel burnt)
  - Use cleaner fuels
  - Remove oxides of sulphur and oxides of nitrogen before releasing
    - ◆ Flue gas desulphurization
    - ◆ Catalytic Converters

# Preventive Measures

- ◆ Use cleaner fuels
  - Coal that contains less sulphur
  - "Washing" the coal to reduce sulphur content
  - Natural Gas

# Preventive Measures

- ◆ Flue Gas Desulphurisation (FGD)
  - Removes sulphur dioxide from flue gas (waste gases)
  - Consists of a wet scrubber and a reaction tower equipped with a fan that extracts hot smoky stack gases from a power plant into the tower
  - Lime or limestone (calcium carbonate) in slurry form is injected into the tower to mix with the stack gases and reacts with the sulphur dioxide present

# Preventive Measures

- Produces pH-neutral calcium sulphate that is physically removed from the scrubber
- Sulphates can be used for industrial purposes



Scrubber at work



# Preventive Measures

- ◆ Use other sources of electricity (i.e. nuclear power, hydro-electricity, wind energy, geothermal energy, and solar energy)
  - Issue of cost



# Reducing the effects of Acid Rain

## ◆ Liming

- Powdered limestone/limewater added to water and soil to neutralize acid
- Used extensively in Norway and Sweden
- Expensive, short-term remedy