



# DP IB Environmental Systems & Societies (ESS): SL



## Acid Deposition

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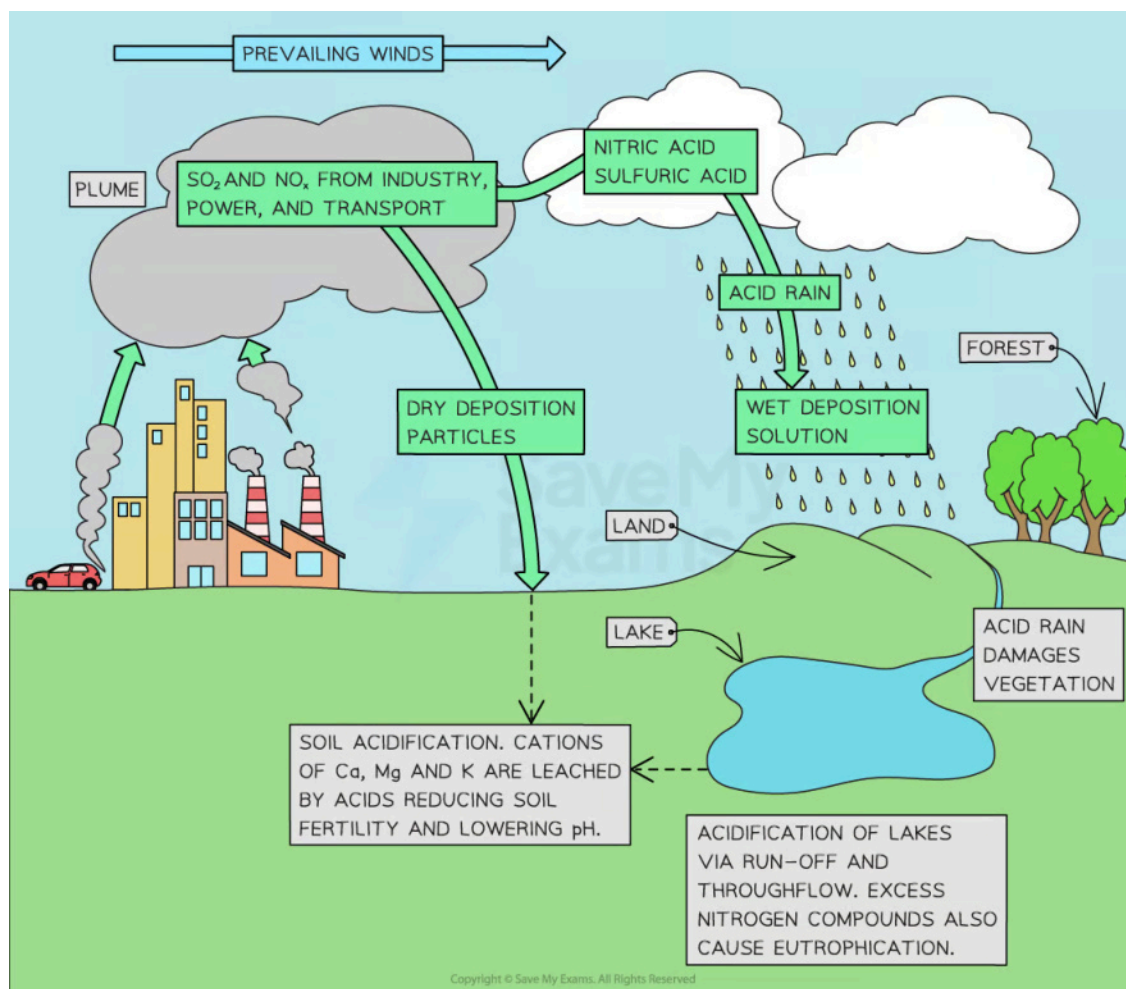
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## Acid Deposition: Causes & Effects

# Acid Deposition: Causes

## Acid Deposition

- Acid deposition is a significant environmental issue caused by **human activities**
- It occurs when **sulfur dioxide** and **nitrogen oxides** are released into the atmosphere primarily from the **combustion of fossil fuels**
- These gases can undergo chemical reactions and transform into secondary pollutants, resulting in both **dry** and **wet** acid deposition



### Causes of acid deposition



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## Primary Pollutants from the Combustion of Fossil Fuels

- Fossil fuel combustion in power plants, industrial processes, and motor vehicles releases sulfur dioxide ( $\text{SO}_2$ ) and nitrogen oxides ( $\text{NO}_x$ ) into the atmosphere
  - **Power plants** that burn coal, oil, or natural gas are major contributors to  $\text{SO}_2$  emissions, while  $\text{NO}_x$  emissions primarily come from **vehicle exhausts**
  - Sulfur dioxide is released when fossil fuels containing sulfur compounds are burned and contributes to the formation of **acid rain** directly
  - Oxides of nitrogen are produced through high-temperature combustion processes, such as those occurring in vehicle engines and industrial furnaces

## Formation of Secondary Pollutants

- $\text{SO}_2$  and  $\text{NO}_x$  gases can undergo **chemical reactions** with other compounds already present in the **atmosphere**, such as oxygen, water vapor, and various pollutants
  - These reactions lead to the formation of secondary pollutants, including **sulfuric acid** and **nitric acid**

## Dry Deposition of Secondary Pollutants

- Sulfuric acid and nitric acid can combine with ash and other particles present in the air, forming **dry particles**
  - Dry deposition occurs when these particles settle on surfaces, including **vegetation, buildings, and soil**, causing damage over time

## Wet Deposition of Secondary Pollutants

- Sulfuric acid and nitric acid can dissolve in **rainwater** or **snowflakes**, forming **acidic precipitation**
  - Wet deposition occurs when this acidic precipitation falls to the ground, affecting surface water and soils
- These processes of conversion from primary pollutants to secondary pollutants contribute to the phenomenon of acid deposition
- Understanding the **causes** of acid deposition is crucial in developing effective strategies to reduce emissions, mitigate its environmental impacts, and promote sustainable practices

## Acid Deposition: Effects

- Acid deposition has significant environmental effects that can impact various ecosystems and regions

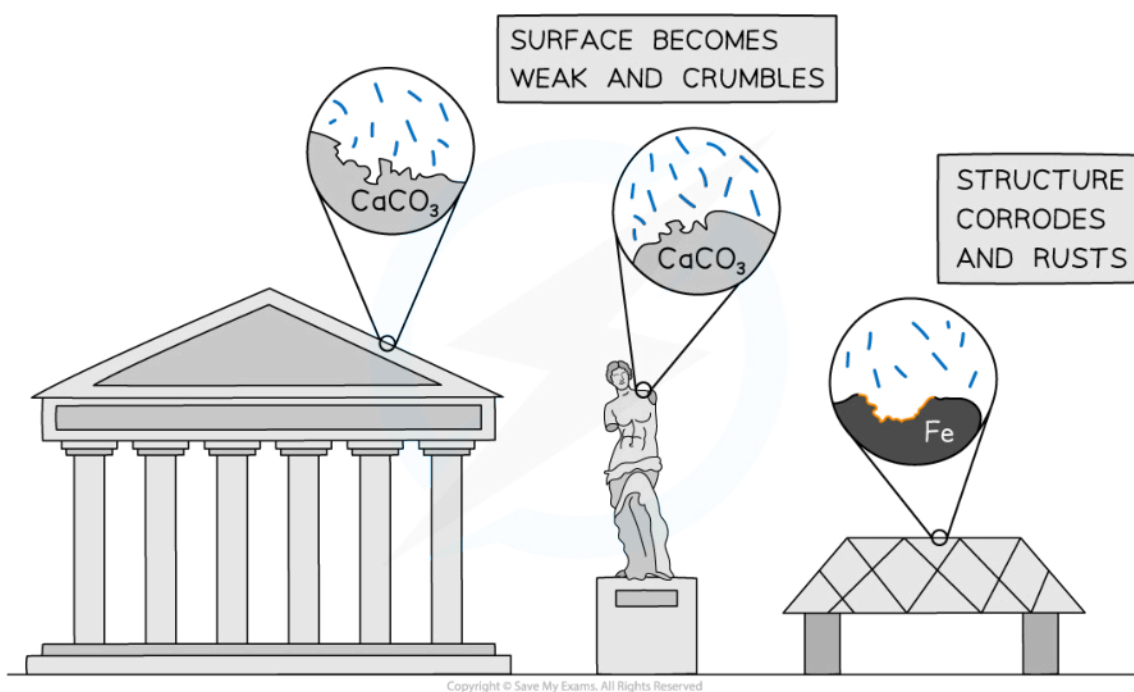


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- The effects of acid deposition are diverse and can have **direct** and **indirect** consequences on aquatic organisms, forests, and nutrient cycling

## Direct Effects

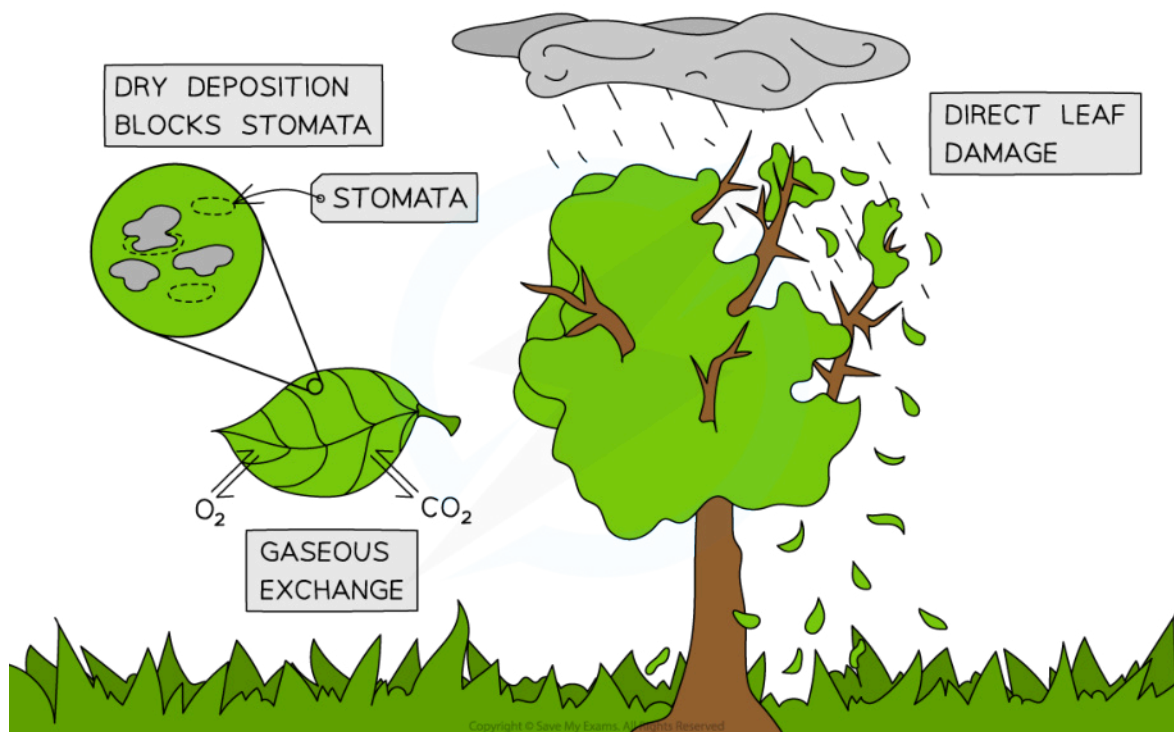
- Acid deposition can react with metals and rocks (such as limestone) damaging buildings and statues
  - Limestone and marble both contain calcium carbonate ( $\text{CaCO}_3$ )
  - The calcium carbonate reacts with sulfuric acid or nitric acid causing stonework to corrode and weaken



***The impact of acid deposition can be seen on buildings, statues and metallic structures, particularly in polluted cities***

- Acidic deposition, particularly in bodies of water, directly affects aquatic organisms such as fish, amphibians, and invertebrates
  - Acidic deposition **lowers** the **pH** of the water, making it difficult for some species to survive and reproduce
- As well as acid deposition directly falling on leaves, causing leaf damage and eventually killing plants, acid particulates can also block stomata (plant pores), preventing gaseous exchange
- Coniferous forests, such as those composed of pine or spruce trees, are sensitive to acid deposition due to their shallow root systems and thin bark

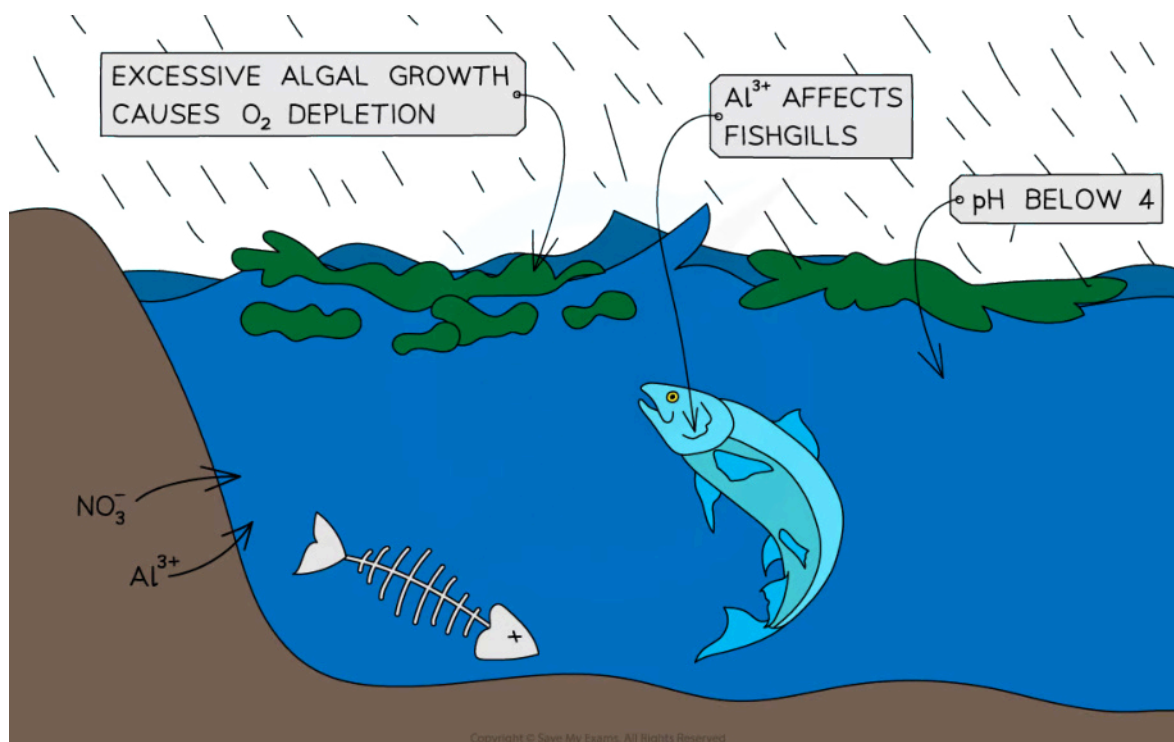
- Acid rain also damages their foliage and inhibits nutrient absorption



*The impacts of acid deposition on plant life*

## Indirect Toxic Effects on Fish

- Acid deposition can **increase the solubility of metals** like aluminium in water bodies
  - High levels of **aluminium ions** become toxic to fish, affecting their respiratory systems, impairing growth, and even causing mortality



*The impact of acid deposition on waterways*

## Indirect Nutrient Effects

- Acidic deposition accelerates the **leaching** of essential **nutrients** from soil, such as calcium, magnesium, and potassium
  - Leaching of nutrients reduces their availability for plants, leading to **nutrient deficiencies** and impacting plant growth and overall ecosystem **productivity**

## Geographic and Transboundary Impacts

- The impacts of acid deposition are not confined to the immediate vicinity of emission sources
  - Areas **downwind** of major industrial regions are more likely to experience the adverse effects of acid deposition
  - It is also possible for the impacts of acid deposition to extend across **national boundaries**, affecting regions in different countries than the source of emissions
- These effects of acid deposition highlight the environmental risks associated with high levels of sulfur dioxide and nitrogen oxides emissions

- Efforts to reduce acid deposition involve emission control measures, such as the use of cleaner technologies and regulations on industrial and transportation emissions
- **International cooperation** and **agreements** are also necessary to address transboundary impacts



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## Pollution Management Strategies for Acid Deposition

# Pollution Management Strategies for Acid Deposition

- Acid deposition requires effective pollution management strategies to **mitigate** its harmful effects on the environment and human health
  - These strategies involve altering human activities, regulating pollutant release, and implementing clean-up and restoration measures

### Altering Human Activity

- Reducing the consumption of fossil fuels is a key strategy to minimise acid deposition
  - Encouraging the use of alternative energy sources, such as **renewable energy**, can significantly reduce emissions of sulfur dioxide and oxides of nitrogen
- International agreements and national governments play a vital role in promoting sustainable practices, supporting the development of clean technologies, and lobbying for emission reduction

### Regulating and Monitoring Pollutant Release

- Government regulations and **monitoring systems** are essential to **control** and **reduce** the release of pollutants that contribute to acid deposition
  - Coal-burning power plants and vehicles are major sources of sulfur dioxide and nitrogen oxides emissions
  - Installing pollution control devices such as **scrubbers** and **catalytic converters** can effectively remove these pollutants from emissions

### Clean-up and Restoration Measures

- In areas heavily affected by acid deposition, clean-up and restoration measures may be implemented to mitigate the damage caused
  - For example, **spreading ground limestone** or **lime** in acidified lakes and rivers can **neutralise acidity** and restore the water's pH balance
- Restoring damaged ecosystems can also be achieved through recolonisation efforts, such as **planting acid-tolerant vegetation**
  - This can help to restore some measure of ecological balance to these damaged ecosystems

### Limitations

- While clean-up and restoration measures have shown some success, their scope is limited



- Applying ground limestone or recolonising ecosystems can be extremely **expensive** and logistically challenging, making it difficult to address acid deposition on a large scale
- Prevention through **emission reduction** is more effective and sustainable in the long term
- Implementing these pollution management strategies for acid deposition requires a combination of international cooperation, national regulations, technological advancements, and public awareness
- By reducing the emissions of sulfur dioxide and nitrogen oxides, and implementing measures to restore affected ecosystems, the adverse effects of acid deposition can be minimised



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