Global Air Pollution - The Ozone Layer & Acid Rain

Introduction

The Royal Commission on Environmental Pollution (1984) defined pollution as :

"The introduction by man into the environment of substances or energy liable to cause hazards to human health, harm to living resources and ecological systems, damage to structures or amenity, or interference with legitimate use of the environment."

In other words it involves **human activity** introducing **substances** into the environment which have a **harmful effect**. These substances can be present at varying levels:

- When such substances are present at low levels they may not be hazardous and are called **contaminants**.
- When they are present at higher levels they have a harmful effect and are called **pollutants**.

In modern industrial societies air pollution is a chronic problem resulting in:

- ailments such as sore throats, asthma, eye irritation
- poor growth or death of vegetation
- deterioration of buildings

The pollution is caused by a mixture of chemicals such as hydrocarbons, heavy metals, carbon monoxide, nitrogen oxides and sulphur compounds. These chemicals are pollutants in their own right but they can also combine in the atmosphere to form even deadlier secondary contaminants.

Sulphur and nitrogen oxides mix with sunlight, oxygen and water vapour to form dilute sulphuric and nitric acids which then fall as **acid rain**. Hydrocarbons and nitrogen oxides combine in the presence of sunlight to form ozone and other oxidants in the form of **smog**.

Ozone is a form of oxygen which has three atoms instead of two. It is highly toxic near ground level contributing to both smog and acid rain. It is created when ultraviolet radiation from the Sun meets oxygen in the atmosphere.

However, ozone forms a protective layer in the upper atmosphere. The ozone layer occurs between 10 and 40 km above the surface of the Earth. It acts as a shield, preventing more than 95 per cent of the dangerous ultraviolet radiation reaching the Earth from the Sun.

Acid Rain

Acid rain is rain that is polluted mainly by sulphuric acid and nitric acid. The main cause of acid rain is the burning of fossil fuels (coal, oil and gas). When fossil fuels are burnt in factories, power stations and car engines, sulphur dioxide and nitrogen oxides are released in large quantities.

These gases combine with water vapour in the air making dilute sulphuric and nitric acids. These are carried in clouds by the wind until they fall to the ground as acid rain. Acid rain often falls to the ground a long distance from where it is produced. The United Kingdom gives off gases which fall as acid rain in Sweden and Norway.

Acid rain was first noticed in Scandinavia in the 1950's when many freshwater fish were found to be dying. It was found that their habitat contained abnormally high levels of acid.

About 70 percent of acid rain comes from sulphur dioxide (SO_2), which dissolves into the water to form sulphuric acid. The rest comes from various oxides of nitrogen (mainly NO_2 and NO_3, collectively called NOx). These gases are produced almost entirely from burning fossil fuels, mainly in power stations and road transport.

The effects of acid rain include:

- **increase in acidity of lakes and rivers**

  In the short term this results in the death of aquatic species. However, the greatest threat is from long-term increases, which stop the fish reproducing. The acidity can also free toxic metals which are held in rocks, especially aluminium, which prevents fish from breathing. Single celled plants and algae in lakes also suffer from increased acid levels.

- **increase in acidity of soils**

  This causes damage to trees, particularly conifers and leads to a loss of production in crops. Many toxic metals are held in the ground in compounds and acid rain can break down some of these compounds, freeing the metals and washing them into water sources such as rivers. This pollution of water supplies results in a human health hazard.

  As the water becomes more acidic, it can react with lead and copper water pipes, contaminating drinking water supplies. Copper can cause diarrhoea in young children, and can damage livers and kidneys.

- **erosion of buildings, bridges and statues**

  Acid rain also causes damage to certain construction materials, particularly limestone and marble. The acid dissolves the calcium carbonate in the stone, and this solution evaporates, forming crystals within the stone. As the crystals grow, they cause the stone to crumble.

Acid Rain

Most European countries add acid to the air, Britain being one of the main culprits. However, only about a third of Britain's pollution actually lands on British soil. Some falls in the North Sea while the remainder falls on Scandinavia. Scandinavia is one of the least polluting countries in Europe.

Acid rain is, therefore, a global problem as it easily crosses national frontiers. As such it requires global co-operation and management. Trees and buildings can be sprayed to wash off the acid and lime can be added to water to reduce acidity. However, these solutions are only short term and are not sustainable.

The solution must be the reduction and eventual prevention of pollution. In Britain over 60% of the pollutants causing acid rain come from burning fossil fuels.

Many of the measures to control pollution are expensive and will have to be enforced by laws. Organisations like Greenpeace and Friends of the Earth have been working for many years to open our eyes to the damage pollution does to our planet. They have also pressured Governments into doing something about it.

Increasingly, governments are passing laws and setting requirements designed to control pollution. They issue information on the effects of air pollutants and the techniques available for controlling them. They set goals called air quality standards for achieving clean air. They then must enforce control measures to meet the goals. Governments may act directly against polluters if they fail to obey the regulations.

The control measures include emission standards, which restrict the amount of pollution from factories and other sources of pollution. Governments also set emission standards for motor vehicles. In many countries, to meet these emission standards, new cars must be equipped with catalytic converters.

To reduce acid rain, the amount of NOx and SO_2 being released into the atmosphere should be reduced. Fitting a catalytic converter to a car can reduce the emissions of NOx by up to 90 percent. However, they are very expensive, and cause more carbon dioxide to be released, which contributes to the greenhouse effect.

All members of the EEC are now committed to reducing emissions of sulphur dioxide by specified amounts by the year 2003. From 1993, all new cars sold in the EEC were fitted with catalytic converters.

SO_2 emissions from power stations can be reduced by using a fuel with a low sulphur content (such as North Sea gas or oil). However, low sulphur fuels are more expensive because they are in greater demand, and although high sulphur fuels can be treated to reduce their sulphur content, this is very expensive.

Alternatively, the SO_2 created during combustion can be absorbed by suitable chemical ,such as limestone, if it is present as the fuel burns. Once the fuel has been burned, the SO_2 can be removed from the exhaust gases. Most systems spray a mixture of limestone and water onto the gases. This mixture reacts with the SO_2 to form gypsum, a useful building material used to make plasterboard.

Another option is not to burn fossil fuels, but to use alternative energy sources.

What can individuals do to help reduce acid rain emissions

Sulphur dioxide and nitrogen oxides are the main pollutants that cause acid rain. These pollutants are emitted largely by the combustion of fossil fuels in coal and oil fired power stations. Reducing the amount of electricity required will, therefore, help to reduce these emissions. The following are some suggestions on what you, as an individual, can do:

- **In the home**
  - Have showers instead of baths
  - Run dishwashers and washing machines only with a full load.
  - Hang dry the laundry.
  - Buy energy efficient appliances.
  - Turn out the lights in empty rooms and when away from home.
  - Installing low wattage fluorescent instead of high wattage incandescent bulbs.
  - Turn off the hot water heating when going away for extended periods of time.
  - Install additional insulation on the hot water tank and pipes.
  - Insulate and draft proof your basement and loft.
  - Weather-strip doors and windows.
  - Fit thermostatic valves to central heating radiators
  - Don't use sink waste disposal units.

- **At the shops**
  - Look for products bearing the EcoLogo. They minimise the use of environmentally hazardous substances and maximise energy efficiency and the use of recycled materials.
  - Buy locally produced or grown items from local stores and businesses. They don't require the transportation energy of imported products.

- **Transportation**
  - Walk, ride your bike or take a bus to work.
  - Share a car with a friend or co-worker.
  - Have your car serviced regularly.
  - Check your car tyre pressures regularly.
  - Avoid unnecessary idling.
  - Reduce the number of trips you make in your car.
  - Drive at moderate speeds.
  - Take the train or bus on long trips.

The ozone layer

The ozone layer occurs in the stratosphere, between 10 and 40 km above the surface of the Earth. It acts as a shield, preventing more than 95 per cent of the dangerous ultraviolet radiation reaching the Earth from the Sun.

Since the 1970s, scientists have observed that the ozone layer above the Arctic and Antarctic has thinned. During the Antarctic spring, which is at the same time as our autumn, a hole appears in the ozone layer over the Antarctic pole.

The hole is as big as North America. Rather than being an actual hole through the layer, the ozone hole is a large area of the stratosphere with extremely low amounts of ozone.

In addition, research has shown that ozone depletion occurs over the latitudes that include North America, Europe, Asia, and much of Africa, Australia, and South America. Thus, ozone depletion is a global issue and not just a problem at the South Pole.

Many scientists believed the ozone hole is caused by the use of chlorofluorocarbons (CFCs). CFCs are chemicals that are used in aerosols, refrigerators, air conditioners and plastic foam insulation.

In the early 1970s, scientists began to investigate the effects of various chemicals on the ozone layer, particularly CFCs, which contain chlorine. They also examined the impacts of other chlorine sources, such as chlorine from swimming pools, industrial plants, sea salt, and volcanoes.

Chlorine compounds from these sources readily combine with water and research shows that they rain out of the troposphere very quickly. On the other hand, CFCs are very stable and do not dissolve in rain. Thus, there are no natural processes that remove the CFCs from the lower atmosphere.

CFC's can take several years to drift upwards to reach the ozone layer. Once there, they will take about a hundred years to be broken down. As breakdown occurs they release chlorine which reacts with the ozone converting it into ordinary oxygen.

As the CFCs destroy the ozone layer, more ultraviolet radiation reaches the surface of the earth. This causes :

- an increase in skin cancer by suppressing the immune system
- eye cataracts - a cause of blindness in approximately 30 million people world-wide
- damage to many plant species thus affecting food production
- reduction in fish species due to the adverse effect on marine life such as plankton

In 1987, many countries signed an agreement called the Montreal Protocol. They promised to half the production of CFCs by the year 2000.

Summary

Acid rain

About 70 percent of acid rain comes from sulphur dioxide (SO_2), which dissolves into the water to form sulphuric acid. The rest comes from various oxides of nitrogen (mainly NO_2 and NO_3). These gases are produced mainly in power stations and road transport.

- The effects of acid rain include:
  - increase in acidity of lakes and rivers
  - increase in acidity of soils
  - erosion of buildings, bridges and statues

Acid rain is a global problem as it easily crosses national frontiers. As such it requires global co-operation and management. All members of the EEC are now committed to reducing emissions of sulphur dioxide by specified amounts by the year 2003. From 1993, all new cars sold in the EEC were fitted with catalytic converters.

SO_2 emissions from power stations can be reduced by using low sulphur fuel. Alternatively, the SO_2 created during combustion can be absorbed by suitable chemical ,such as limestone, if it is present as the fuel burns.

Another option is not to burn fossil fuels, but to use alternative energy sources.

Ozone depletion

Stratospheric ozone has decreased by over 5% since 1980 in winter and spring. Every spring, more than 60% of the ozone is destroyed over Antarctica. Human activity has caused a six fold increase in stratospheric chlorine and a smaller amount of bromine.

These emissions have been caused by the use of chlorofluorocarbons (used as propellants for aerosols, air conditioning fluids and refrigerants), halons (used as fire retardants) and solvents such as carbon tetrachloride.

Assuming full compliance with the Montreal Protocol and subsequent amendments, the ozone layer should recover by 2050.

Stratospheric depletion of ozone leads to :

- an increase in skin cancer
- eye cataracts
- damage to many plant species
- reduction in aquatic species

The production and consumption of chlorofluorocarbons, carbon tetrachloride and halons has been banned in developed countries since 1996 and is to be banned in developing countries by 2010.

Assessment

The Ozone Layer & Acid Rain

Questions 1 to 5 - Select the correct response for the following questions :

1. At what height does the ozone layer occur ?

   A between ground level and 1 km above the surface of the Earth
   B between 1 km and 5 km above the surface of the Earth
   C between 5 km and 10 km above the surface of the Earth
   D between 10 km and 40 km above the surface of the Earth

2. What is the main pollutant contained in acid rain ?

   A heavy metals
   B chlorofluorocarbons
   C sulphur and nitrogen oxides
   D ozone

3. How much of Britain's acid rain causing pollutants come from burning fossil fuels ?

   A 10%
   B 20%
   C 40%
   D 60%

4. By how much are a car's pollutants reduced by fitting a catalytic converter ?

   A 90%
   B 70%
   C 50%
   D 30%

5. By how much did the countries who agreed to the Montreal Protocol promise to reduce production of CFC's by the year 2000?

   A 70%
   B 50%
   C 30%
   D 20%

Questions 6 to 10 - Decide whether each of these statements is True (T) or False (F).

6. i) When such substances are present at low levels they may not be hazardous and are called contaminants.
   ii) When they are present at higher levels they have a harmful effect and are called pollutants.

   Which option best describes the two statements?

   A i) T ii) T
   B i) T ii) F
   C ii) F ii) T
   D ii) F ii) F

7. i) Sulphur and nitrogen oxides mix with sunlight, oxygen and water vapour to form dilute sulphuric and nitric acids which then form smog.
   ii) Hydrocarbons and nitrogen oxides combine in the presence of sunlight to form ozone and other oxidants in the form of acid rain.

   Which option best describes the two statements?

   A i) T ii) T
   B i) T ii) F
   C i) F ii) T
   D i) F ii) F

8. i) The production of acid rain is a purely local problem affecting only the country that causes it.
   ii) Scandinavia is one of the least polluting areas in Europe.

   Which option best describes the two statements?

   A i) T ii) T
   B i) T ii) F
   C i) F ii) T
   D i) F ii) F

9. i) Since the 1970s, scientists have observed that the ozone layer above the Arctic and Antarctic has thinned.
   ii) Ozone depletion occurs only over the North and South poles.

   Which option best describes the two statements?

   A i) T ii) T
   B i) T ii) F
   C i) F ii) T
   D i) F ii) F

10. i) CFC's will take about 100 years to be broken down in the stratosphere.
    ii) Stratospheric ozone depletion leads to an increase in skin cancer and cataracts.

    Which option best describes the two statements?

    A i) T ii) T
    B i) T ii) F
    C i) F ii) T
    D i) F ii) F