CHAPTER 7
HUMAN IMPACT ON ECOSYSTEMS

7.1 POLLUTION

Pollution is the addition of harmful substances to the environment.

Many of our activities are disrupting the **natural cycles** of nature and are damaging the environment. Our pollution affects the atmosphere, fresh water, sea and land. The lives of all organisms in an ecosystem are **interconnected** and so every organism is likely to be affected by our pollution.

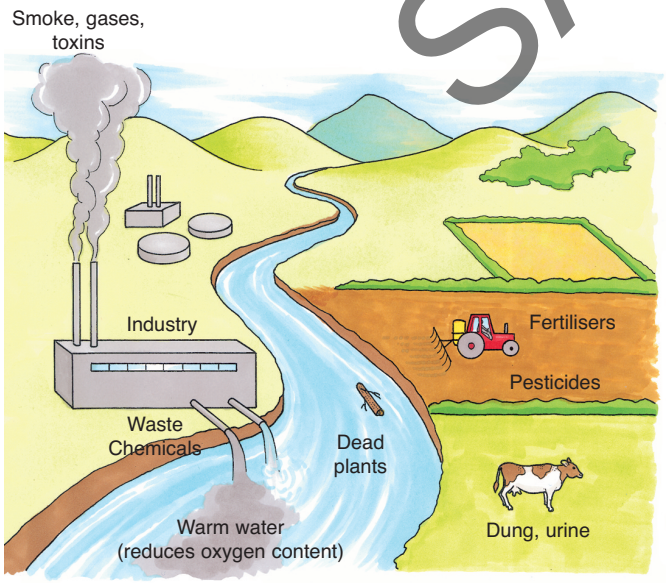


Fig. 1 Pollution – air, water and land

Domestic Pollution

In natural ecosystems, one organism's waste serves as food and nutrition for others, so the by-products of life are cycled through the system.

In the **developing** countries of the world, many resources are scarce (food, fresh drinking water, fuel for cooking, materials for homes). People **conserve** what they can and throw away very little.

In **developed** countries, like Ireland, many people use something once, discard it, then buy another. The traditional method of disposal is by dumping the rubbish in **landfill sites**. An alternative is to burn the wastes in **incinerators**, but many object to the pollutants that these release into the atmosphere, and no one wants an incinerator near their home. **Sewage** is another household waste that must be disposed of safely – digested by **microorganisms** in treatment plants, before being released into rivers or seas, or spread on the land.

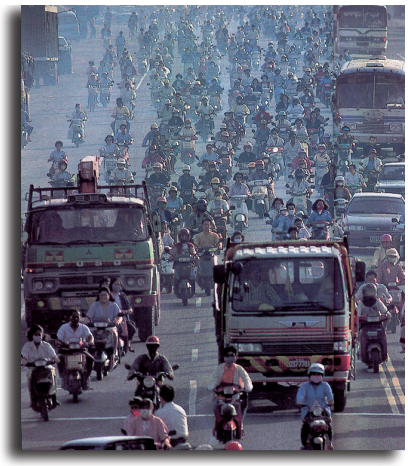


Fig. 2 Pollution in some cities poses a real threat to human health as well as the environment

Agricultural Pollution

A major purpose of agriculture is to produce food for human consumption. The efficiency and the intensity of **food production** are being increased all the time to meet the demands of a growing population. Our machine-based agriculture requires massive inputs of **fertilisers**, **pesticides**, and **water** for irrigation to grow high-yield crops – if these chemicals leak from the land and flow into rivers and lakes, they can lead to pollution of these ecosystems. Our agriculture also uses large amounts of **fossil fuel energy** to drive the machines – these add poisonous gases to the atmosphere.

Pesticides are chemicals used to kill pests – e.g. insects that eat crops, weeds that compete with crops, and fungi that cause disease. Without the use of pesticides, 50% of a crop could be lost. These chemicals have also saved millions of lives by killing the insects that spread malaria, and other diseases. But pesticides can be dangerous if they get into food chains, including our own, as the poison builds up along the **trophic levels**.

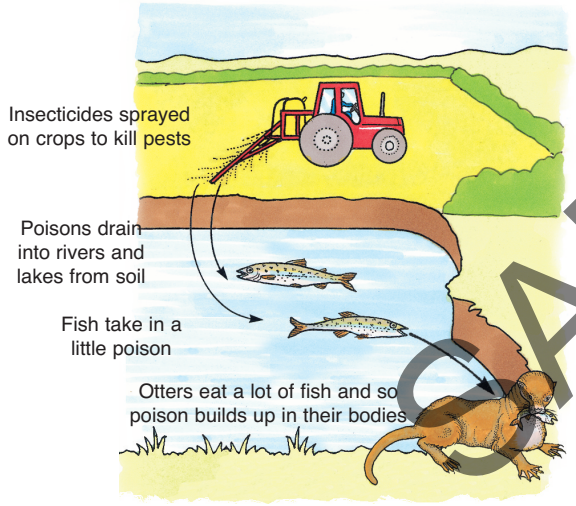


Fig. 3 How poison accumulates along a food chain

The N Cycle and Eutrophication

Eutrophication is any activity that increases the concentrations of dissolved nutrients in an aquatic ecosystem.

Humans are altering the cycling of nitrogen in natural ecosystems. With each **harvest**, nitrogen is taken away from the fields in the tissues of the **crop** plant. Soil **erosion** and **leaching** removes more. These losses must be replaced in the form of fertilisers. **Slurry** (the dung of animals) is spread on fields as a **natural fertiliser**. The decomposers in the soil break it down to release nitrates and other nutrients.

Intensive agriculture relies on the application of **artificial fertilisers**, rich in nitrogen (N), phosphorus (P), and potassium (K). To make these fertilisers requires huge amounts of fuel energy.

But **excess fertiliser** can cause water **pollution**.

- Fertiliser can be washed through the soil into rivers and streams.
- There it provides the nutrients for weeds and algae to grow rapidly (in a process called **eutrophication**).
- These plants eventually die and fall to the lake or river bed.
- **Decomposers** like bacteria thrive on all the extra dead matter.
- Their numbers increase quickly and they soon use up all the **oxygen** in the water.
- The river may become so low in oxygen that fish and other small animals die.

Water Pollution and Indicator Species

The population levels of different animal species vary according to the level of oxygen in the water, and this makes them useful **indicator species** for measuring pollution. **Tubifex worms** are the most tolerant of low oxygen levels and can therefore survive close to a sewage outfall; further downstream, as oxygen levels rise, other species (e.g. **midge larvae**) are able to survive. A continuing rise in oxygen levels, further from the outfall, results in clean-water species, like the **freshwater shrimp** appearing again.

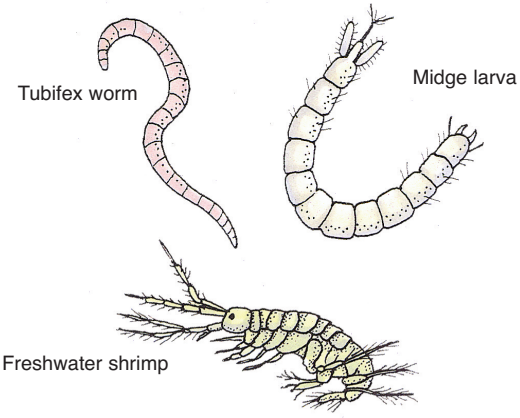


Fig. 4 Indicator species for detecting water pollution

Air Pollution and Indicator Species

The tolerance of **lichen** and **moss** species to sulfur dioxide is very variable and makes them useful indicator species for measuring **sulfur dioxide** pollution. As you move from the centre of an industrial city, the concentration of sulfur dioxide falls rapidly and the number of species of lichen and moss increases.

Fig. 5 Lichens, like this type, flourish where the air is clean

Industrial Pollution

Industrial pollution includes **air pollution**, **hot water** (from cooling processes), **poisons** (cyanide, lead, and other metals), **oil** spillages, and **radioactive waste**. These can poison organisms directly or build up in food chains.

Air Pollution

The main pollutant gases are **sulfur dioxide**, **nitrogen oxides**, **ozone**, **carbon monoxide** and **carbon dioxide**.

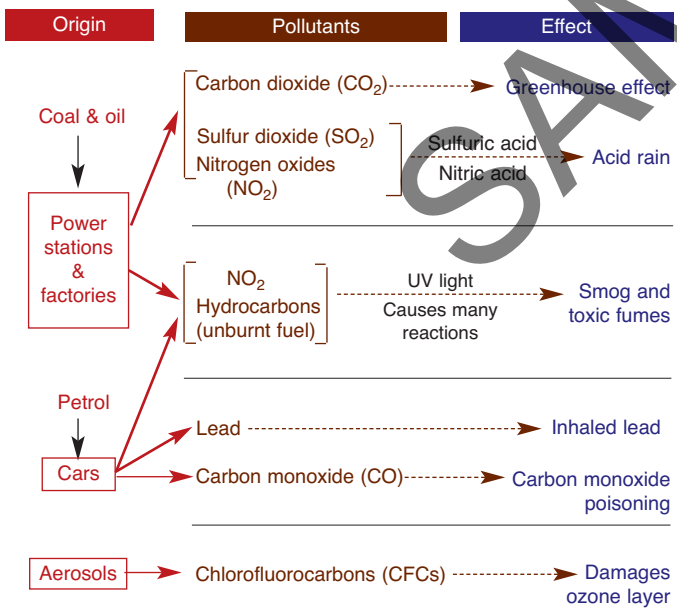


Fig. 6 Air pollutants

- **Exhaust fumes** from cars contain lead, carbon monoxide, nitrogen oxides and unburnt hydrocarbons – all poisons to living organisms.
- Carbon dioxide (CO_2) is given off when we burn fossil fuels like coal and oil. Its build-up in the atmosphere is contributing to **global warming**.

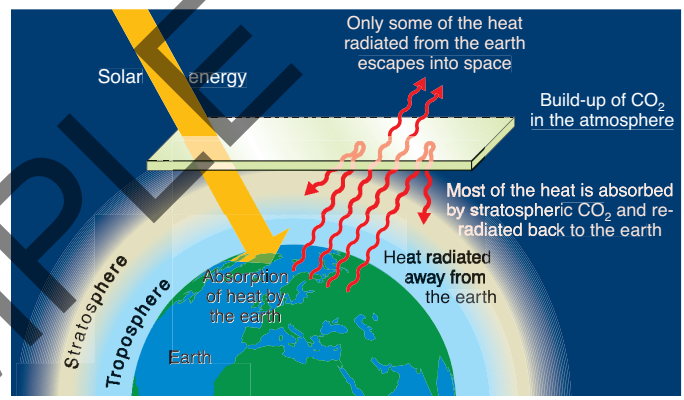


Fig. 7 How CO_2 and other gases keep the earth warm (Greenhouse Effect)

- CFCs (chlorofluorocarbons) are used in spray cans, refrigerators and in making plastic foam and are damaging the protective ozone layer above the earth.
- Sulfur dioxide from fossil fuels, plus nitrogen oxides, cause acid rain.

Fig. 8 Waste gases from industry can pollute the atmosphere

Acid Rain – SO_2 and NO_2

If sulfur dioxide and nitrogen oxide gas are in the air, they dissolve in rain to form acid solutions. These make the rain much more acidic than normal (pH 3 or 4), and this is what we refer to as 'Acid Rain'.

Where do the SO_2 and NO_2 come from? These pollutants come from **car exhausts** and **factory chimneys** (as we burn fossil fuels for energy).

Possible effects of acid rain

- Damage to stone and metal in buildings.
- Disruption of photosynthesis, especially in conifers.
- Killing of fish and other organisms in lakes, as the pH drops to 4.5.

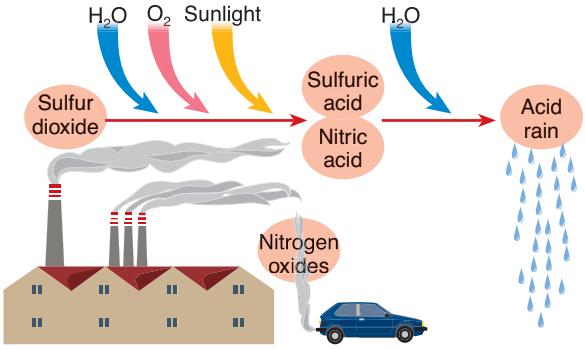


Fig. 9 Sources of acid rain

The only satisfactory solution is to reduce the amount of pollution from burning fossil fuels, and to change over to **renewable energy sources** (e.g. wind, solar, hydroelectric).

7.2 WASTE MANAGEMENT

The wastes we produce and release into the environment are causing problems in ecosystems all around us. Toxic chemicals, incineration fumes, disease-causing microorganisms, eutrophication, unsightly litter and unpleasant smells all demand solutions.

The Problem of Waste Disposal

The traditional method of waste disposal is the dumping of rubbish in **landfill sites** such as disused quarries and gravel pits, and dumping liquid waste into rivers, lakes and seas. This causes a number of **problems**.

1. There are insufficient landfill sites to take all the rubbish. What happens when the space around cities and towns runs out, which is what is happening right now?
2. The compacted rubbish decays in the absence of air, producing **methane gas** which contributes to the 'greenhouse gases' and in some places has caused explosions.
3. Harmful substances may leak from the landfill site into groundwater supplies (e.g. wells, lakes).
4. Plants and animals in rivers and lakes are killed through direct poisoning or **eutrophication**.

Options for Waste Management

1. Minimisation

- This means using as little material as possible (e.g. in packaging) and producing as little waste as possible. The attitude should be '**Reduce, Reuse and Recycle**'.
- If reusable materials are first separated out, then the remainder may be converted to **pellets of fuel** that can be incinerated, producing ash that is easy to bury in landfill.
- The **heat** produced during the incineration can be used to generate electricity or in central heating systems. However, many object to incinerators because of poisonous fumes produced during the burning process.

2. Recycling

- Items such as bottles, cans, paper, cardboard and some plastics are collected and used as the ingredients to make new versions of those same items, saving on material costs and energy, as well as saving on their disposal.

Fig. 10 Recycling centres are crucial in helping reduce waste

3. Use of microorganisms

- About a third of our household rubbish is kitchen and garden waste. We can put this in a **compost** heap or bin, and allow bacteria and fungi to feed on the waste and decompose it, and then use the **humus** as natural fertiliser in our gardens.
- Our **sewage** can be decomposed by microorganisms in fermenters (anaerobic digestion) and the methane **gas** (biogas) produced during this process can be used to generate electricity.
- Bacteria can **digest** oil spills from ships at sea, instead of spraying the oil with detergents (which may be even more harmful than the oil).
- Plastics used in packaging are a major pollutant. Scientists have developed a type of **biodegradable** plastic that can be broken down by microbes in the soil.

7.3 CONSERVATION

Conservation is the wise management of existing resources.

Examples of conservation practices are:

- **Recycling** natural resources (glass, metal, paper and plastics) to limit environmental damage.
- Encouraging **organic farming** so that living things are not harmed by agricultural chemicals, e.g. pesticides, herbicides, artificial fertilisers.
- Limiting the release of pollutants by **reducing** the use of fossil fuels, and by improving existing laws.
- Preventing the destruction of important ecosystems by giving them **legal protection**, e.g. as national parks, nature reserves, etc.

Fig. 11 Glendalough – part of Wicklow Mountains National Park

The main aim of conservation should be to preserve the balance of nature and use natural resources wisely and economically. Conservation involves us all taking responsibility, not just governments and industry. You must become conservation minded and apply the principles of ecology to improve your environment.

A clean environment is a vital resource for a good quality of life, and in terms of Ireland's green image, it supports tourism, agriculture and fisheries.

NOTE: The following sections outline good conservation practices in the areas of agriculture, forestry and fisheries. You need only study **one** section.

Agriculture and Conservation

Sustainable agriculture provides high-quality food from a high-quality environment. This can be achieved by a variety of methods.

Fig. 12 Preparing land for crop growth

- **Mixed farming** – Keep animals along with growing crops, so that any wastes produced can be used as fertilisers on the land again.
- **Crop rotation** – Grow different crops on the same land in successive years without manuring each year. The two harvested crops have different mineral requirements and often obtain them from different soil depths. In the 'fallow year', **legumes** (e.g. clover), are grown and then ploughed back into the soil to restore nitrogen compounds to the soil.
- **Biological controls** – Use natural predators to get rid of pests and disease rather than relying on pesticides or herbicides, which eliminate pests but also kill harmless organisms and poison food chains. **Examples**: Introduce ladybirds to eat aphids; spray a solution containing bacteria onto plant leaves to kill caterpillars. Only the pest is affected, while the crop and other animals are unharmed. It is not as rapid as using chemicals, but is a better long-term solution.

- **Gene banks** – Use varieties of crops or animals that grow well and are disease resistant, so that the product is naturally produced without needing artificial fertilisers or pesticides.

Forestry and Conservation

Sustainable forestry improves the natural environment, ensures a supply of timber and supports the quality of rural life by providing employment and amenities. This can be achieved in a number of ways.

Fig. 13 Wood is a renewable source of energy and material

- **Re-planting** – Whenever trees are felled for timber, new stock is planted, and even former bogland and poor farmland can be reclaimed for forestry. Wood, a renewable fuel, can satisfy some of our energy needs.
- **Broadleaf/conifer mix** – 80% of Irish forests are made up of conifer trees. These softwoods give rapid growth and quick returns on investment, but do not support as rich a variety of plant or animal life as broadleaved forests. Therefore, more deciduous (hardwood) trees should be planted alongside the conifers.

As well as providing a valuable timber crop and employment, forests provide important **recreational resources**, are home to wildlife, and can assist in preventing soil erosion and controlling landslips. They also play an important role in the carbon cycle, as they have the ability to absorb large quantities of carbon dioxide from the atmosphere.

Fisheries and Conservation

Modern fishing methods involve large factory ships, capable of travelling thousands of kilometres and catching huge hauls of fish, which can be processed and frozen on board. This has resulted in **over fishing** in much of the world, including the seas around Ireland.

Fig. 14 Lack of fish stocks threatens the livelihood of fishermen

It takes many years for such stocks to recover. Unfortunately, attempts by the EU to limit the size of fishing fleets, the mesh size of nets or the numbers of days spent at sea have been less than successful, because fishermen are reluctant to reduce or limit their income.

Larger net sizes, **fish quotas** and **restocking** are conservation measures that try to ensure that enough fish are left in the sea to allow fish populations to recover.

- **Net size** – If the mesh is sufficiently large, then the smaller and younger fish escape capture, grow larger and, more importantly, are able to reach sexual maturity. These fish can then spawn and reproduce, so replacing the stock.
- **Quotas** – Some controls now exist and international agreement has been reached on the total weight of fish that any country can take each year. These quotas are often bitterly disputed and the difficulty of enforcement has led to many quotas being ignored, which is not good for the next generation of fishermen.
- **Re-stocking** – Young fish are grown in captivity and reintroduced into areas where their numbers have become depleted, so allowing a population to grow and breed in the area again.

7.4 THE FUTURE

Sustainable development means development that meets the needs of the present generation and allows future generations do the same. **Environmental awareness** in Ireland must be improved so that, in our daily lives, we are sufficiently informed and committed that we will take the environment into account in the way we manage our homes and our businesses, use transport and make consumer choices. Our present **choices**, both as a society and as individuals, determine the quality of the environment that we will hand on to future generations.

Summary

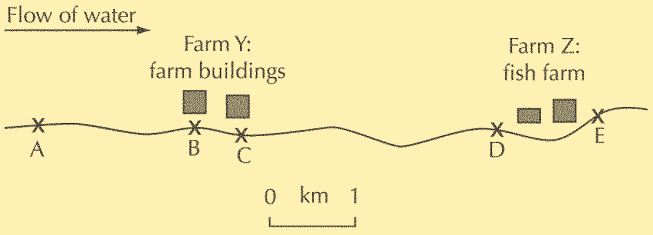
- Pollution is the addition of harmful substances to the environment.
- Most domestic waste is disposed of in landfill sites. An alternative is to burn the wastes in incinerators.
- Agricultural pollution is caused by the overuse of artificial fertilisers, slurry, pesticides, and water for irrigation – these can lead to pollution of surrounding ecosystems.
- Eutrophication is the addition of nutrients (e.g. fertilisers and slurry) to fresh water. This leads to bacterial growth, causing a lack of oxygen in the water, resulting in fish kills.
- Pesticides are chemicals used to kill pests, but can be dangerous if they get into food chains.
- The main pollutant gases in air are: exhaust fumes from motor engines, CO_2 , SO_2 and NO_2 from burning fossil fuels, and CFCs from spray cans and refrigerators.
- The tolerance of different worm and insect species to oxygen levels in water makes them useful indicator species for measuring water pollution.
- The tolerance of lichen and moss species to sulfur dioxide makes them useful indicator species for measuring air pollution.
- Rising levels of CO_2 from the increased burning of fossil fuels, may be causing 'global warming' due to an enhanced 'greenhouse effect'.
- Sulfur dioxide (SO_2) and Nitrogen Oxide (NO_2) from car exhausts and factory chimneys dissolve in rain to form 'acid rain'.
- Acid rain damages stone and metal in buildings, disrupts photosynthesis and kills organisms in lakes.
- Waste disposal involves dumping rubbish in landfill sites, or releasing liquid waste into rivers, lakes and seas. Problems resulting from waste disposal: full landfill sites, methane gas from rotting rubbish, harmful substances leaking into wells and lakes.
- Options for waste management are: (a) Minimisation, (b) Recycling and (c) Use of Micro-organisms.
- Conservation is the wise management of existing resources, so as to achieve a natural ecological balance in ecosystems.
- Conservation practices include:
  – protecting endangered species and giving important habitats legal protection,
  – recycling natural resources and limiting the release of pollutants by laws,
  – encouraging organic farming (with no use of pesticides, herbicides, artificial fertilisers),
  – reducing the use of fossil fuels (by increased use of renewable energy sources).
- A clean environment is a vital resource for a good quality of life, and in terms of Ireland's green image, it supports tourism, agriculture and fisheries.
- Conservation measures in agriculture include the use of: mixed farming, crop rotation, biological controls and gene banks.
- Conservation measures in forestry include: re-planting and establishing a better broadleaf/conifer mix.
- Conservation measures in fisheries include: using larger net sizes, applying fish quotas, and restocking.
- Sustainable development means development that meets the needs of the present generation and allows future generations do the same.

QUESTIONS

1. Explain each of these terms:
   1 Pollution
   2 Landfill site
   3 Incinerator
   4 Fertilisers
   5 Pesticides
   6 Fossil fuel
   7 Slurry
   8 Eutrophication
   9 Indicator species
   10 Radioactive waste
   11 CFCs
   12 Lichen
   13 Global warming
   14 Acid rain
   15 Ozone layer
   16 Waste minimisation
   17 Recycle
   18 Microorganisms
   19 Compost
   20 Sewage
   21 Fermenters
   22 Biogas
   23 Conservation
   24 Organic farming
   25 Renewable energy source
   26 Sustainable agriculture
   27 Mixed farming
   28 Crop rotation
   29 Biological controls
   30 Gene banks
   31 Sustainable forestry
   32 Over fishing
   33 Net sizes
   34 Fish quota

2. Distinguish between the following pairs of term:
   (a) Developed and developing country
   (b) Domestic and industrial pollution
   (c) Renewable and recycling
   (d) CO_2 and SO_2 and NO_2
   (e) Waste disposal and waste management
   (f) Irrigation and incineration

3. The map shows a river flowing through farms Y and Z.



Farmer Y changed from beef to dairy cattle. His herd no longer stayed all day in the fields, but came twice a day to the farm buildings to be milked. Farmer Z had a fish farm and kept his fish in tanks filled with water from the river. His fish began to die. Scientists analysed the river water at A, B, C, D and E along the river. Their results are shown in the table.

RIVER-WATER ANALYSIS			
	Total nitrogen in chemical compounds (parts per million)	pH	Dissolved oxygen (parts per million)
A	0.40	8.5	10.0
B	2.60	6.8	3.6
C	2300.00	4.0	10.0
D	0.76	7.8	1.2
E	0.66	7.8	4.0

(a) What factors could have caused the death of farmer Z's fish?
(b) What factor do you think is the most likely to have caused the death of farmer Z's fish? Why would this factor have caused the death of his fish?
(c) Suggest one explanation each for:
(i) The rise in nitrogen compounds between A and C.
(ii) The fall in nitrogen compounds between C and D.
(iii) The low pH at C.
(iv) The low oxygen content at D.
(d) Farmer Y's cows had polluted the river.
What is pollution?
Suggest one way in which pollution from the cows could be reduced.