What are Environmental Technologies?

Any technology whose use is less environmentally harmful than alternatives is called an environmental technology. Wind turbines, solar panels and wave machines are environmentally friendly because they use renewable energy sources. Technologies that improve our environment are also included in this definition. Examples here include waste-management systems; recycling and clean transport systems that make use of fuel cells, hybrid engines or biofuels. Sustainable construction is also included.

Houses can be built from environmentally friendly materials, or built so that they do not produce pollution. Such a house is called a passive house. Information and communications technology (ICT) can also help as it can be used to improve energy use or reduce pollution from industrial processes.

Environmental technologies play a key role in many sectors of our economy, including:
- Agriculture
- Construction
- Energy
- Industrial processes
- Waste and Resources Management
- Resources management
- Transport

In this lesson we examine some of the main technologies that help us to protect our environment.

Pollution Control Technologies

Humans cause serious damage to our own environment by producing pollution. We do this when we introduce substances that contaminate the environment and harm human, animal or plant life. Technology can help us to avoid this in two ways.
- It can improve industrial process so that little or no waste is produced.
- It can treat pollution after it has been generated. Technologies that do this are called end of pipe technologies.

We will now look at some examples of these pollution control technologies.

Water sanitation/purification is the process of removing undesirable chemicals, materials, and biological contaminants from raw water. The goal is to produce water fit for a specific purpose, such as human consumption.

Urban waste water treatment systems deal with the effluent from houses and businesses before it goes into rivers or the sea. Any such effluent can have a significant impact on water quality. The most recent estimate is that about 82% of waste water produced now receives secondary treatment. The construction of many secondary treatment facilities around the country is at an advanced stage due to major investment in recent years.

Gases from a fireplace, oven, furnace, boiler or steam generator flow into an exhaust pipe called a flue. The gases that come through it are called flue gases and these can contain pollutants. The composition of the gases depends on what is being burned. Usually there will be nitrogen (N₂) (typically more than two thirds) derived from the combustion air, carbon dioxide (CO₂) and water vapour as well as excess oxygen (O₂), also derived from the combustion air. There will usually be a small percentage of pollutants such as carbon monoxide (CO), nitrogen oxides (NOₓ) and sulfur oxides.

At power plants, flue gas is often treated with a series of chemical processes and scrubbers, which remove pollutants. Electrostatic precipitators or fabric filters remove small particles of matter. Desulphurisation captures the sulfur dioxide (SO₂) produced by burning fossil fuels, particularly coal. Where possible the combustion process is modified to avoid the production of nitrogen oxides. If this is not possible, then high temperature or catalytic reaction with ammonia or urea is used to produce nitrogen instead of the oxide.

What is Environmental Remediation?

Remediation means ‘to rectify or improve’. Two major means of improving the environment are bioremediation and phytoremediation. (The Greek word ‘phyto’ means plant.) Bioremediation is a remediation process that uses bacteria to degrade contaminating material. Phytoremediation is the use of plants to control or absorb pollutants. For example, plants capable of accumulating toxic metals such as cadmium, nickel and thallium have been identified.

Many plants would be poisoned by zinc levels greater than 1000 ppm (0.1%) but certain members of the cabbage family can not only survive but can accumulate the metal to levels of 30,000 ppm (i.e. 3%), so removing it from the soil. In the case of many metals combustion of the dry plant material after phytoremediation yields the metal oxides in commercially useful quantities. This process is called phytoextraction.

Resource Management Technologies

Some technologies assist directly with energy conservation. Energy sources such as solar power create fewer problems for the environment than traditional sources of energy like coal and petroleum. Other technologies are being developed that help the environment by reducing the amount of waste produced by human activities. We are all familiar with the fact that waste materials can be recycled.

In addition, there are two other widely used waste management technologies – thermal treatment and biological treatment.

Landfill

Disposing of waste in a landfill involves burying the waste. This is a common practice in most countries. A properly designed and well-managed landfill can be a hygienic and relatively inexpensive method of disposing of waste materials. A common by-product of
landfills is gas (mostly composed of methane \((CH_4)\) and carbon dioxide \((CO_2)\). This is a greenhouse gas and can also create odour problems and kill surface vegetation. Many landfills have landfill gas extraction systems installed to extract the gas. The gas is pumped out of the landfill, using perforated pipes, and flared off or burnt in a gas engine to generate electricity.

**Biological Treatment**

Waste materials that are organic in nature, such as plant material, food scraps, and paper products, can be recycled using biological composting (or anaerobic digestion) processes to decompose the organic matter. The resulting organic material is then recycled as mulch or compost for agricultural or landscaping purposes. In addition, the waste gas from the anaerobic digestion process (such as methane \((CH_4)\) can be captured and used for generating electricity. The intention of biological processing in waste management is to control and accelerate the natural process of decomposition of organic matter. A gardener’s compost heap is a simple example.

**Thermal Treatment**

A well-known form of thermal treatment is incineration, which involves combustion of the waste material. Incinerators convert waste materials into heat, gas, steam, and ash. It is used to dispose of solid, liquid and gaseous waste. It is recognised as a practical method of disposing of certain hazardous waste materials such as biological medical waste. Incineration is a controversial method of waste disposal, due to issues such as emission of gaseous pollutants.

The **Environmental Protection Agency (EPA)** is an independent public body established under the Environmental Protection Agency Act, 1992. The EPA regulates and polices activities that might otherwise cause pollution. It ensures there is solid information on environmental trends so that necessary actions are taken. The EPA’s priorities are protecting the Irish environment and ensuring that development is sustainable. It employs over 340 people who work in ten locations throughout the country.

The other main instruments from which it derives its mandate are the Waste Management Act, 1996, and the Protection of the Environment Act, 2003. The EPA has a wide range of functions to protect the environment. Its primary activities include:

- environmental licensing and permitting
- enforcement of environmental law
- resource and waste management
- environmental planning and guidance
- regulating Ireland’s greenhouse gas emissions
- monitoring and reporting on the environmental status of air, water, waste, noise, sand and soil and
- environmental research and development: under the programme the EPA fund research and demonstration projects that support environmental technologies.

The EPA’s function is to protect and improve the natural environment for present and future generations, taking into account the environmental, social and economic principles of sustainable development.

You can find out more about the work of the Environmental Protection Agency on www.epa.ie
Syllabus References
The appropriate syllabus references are:

**Leaving Certificate Biology**
1.4.9 Human impact on an ecosystem

**Leaving Certificate Chemistry**
6.2 Rates of reaction (catalytic converters)
9.3 Water treatment
1B.3 Carbon dioxide
1B.4 Atmospheric pollution
1B.5 The ozone layer

**Leaving Certificate Physics**
4, 5 The nucleus

**Junior Certificate Science**
1C7 Ecology
2C5 Hydrocarbons, acid rain

Learning Outcomes
On completion of the lesson students should be able to:

- Be able to identify threats to the environment.
- Be aware of existing and potential methods of controlling land and water degradation.
- Realise that air pollution can be reduced by technology.
- Know that progress in environmental protection technology is ongoing.
- Understand that prevention is better than cure.

General Learning Points
The following points can be used to inform discussion on the lesson.

- Human activity has impacted adversely on the environment in many ways.
- Water pollution can be alleviated through sewage treatment, ion-exchange and proper disposal of industrial waste.
- Pollution of land and water can be dealt with through bioremediation, natural and artificial. Phytoremediation offers a means of dealing with metal pollution. These techniques may also provide an environmentally sensitive method of mining.
- GM technology may allow land to be used more efficiently.
- CO$_2$ production can be reduced by improving existing technology and better waste treatment procedures. New energy sources may replace fossil fuels.
- Buildings can be designed to reduce energy requirements.
Student Activities

1. Compare the fuel consumption rates of cars today with those of 10, 20, 30 years ago. Verify that modern cars use less fossil fuel and emit less CO\textsubscript{2}. Compare the fuel consumption of different types of vehicle.
   (To help you compare mile/gallon with km/litre, 1 mile = 1.6 km. 1 imperial gallon = 4.57 litres. 1 U.S. gallon = 3.78 litres)

2. What are hybrid vehicles? What advantages do they have for the environment? Make a list of hybrid cars currently on sale in Ireland.

3. Find out how regenerative braking, flywheels and ultracapacitors could or can be used in vehicles to promote energy efficiency.

4. To show that electricity can be produced from chemicals, connect a copper and zinc rod together through a galvanometer. Now dip the rods in a beaker of vinegar and look at the galvanometer. Try different variations such as carbon and zinc rods or maybe try orange juice instead of vinegar.

5. A garden compost heap can be your low-tech way of protecting the environment. Keep it well aerated by using a well-ventilated composter or compost tumbler, or by simply agitating the compost regularly. In that way, you prevent the anaerobic decomposition which releases methane into the atmosphere.

True or False

a) Diesel engines are efficient because they burn fuel in excess oxygen and this leads to more complete combustion.  
   T  F

b) Radioisotope thermal generators provide electricity from radioactivity. They have powered space probes, lighthouses and remote sensors.  
   T  F

c) Burning CH\textsubscript{4} fuel produces CO\textsubscript{2}, replacing a greenhouse gas with one that has less greenhouse effect.  
   T  F

d) Algae are ineffective absorbers of NO\textsubscript{x} gases from power stations.  
   T  F

e) Well-aerated garden compost generates CO\textsubscript{2} rather than CH\textsubscript{4}.  
   T  F

f) Adding excess fertilisers to farmland carries no environmental risk.  
   T  F

g) Using closed recirculation systems in fish farming would mean that effluents could be better controlled.  
   T  F

h) Farming of predatory fish has involved the harvesting of wild fish in large quantities for fishmeal.  
   T  F

i) Catalytic converters in cars operate extremely well at low temperatures.  
   T  F

j) Using CFC substitutes in aerosol propellants reduces damage to the Earth’s ozone layer.  
   T  F

Check your answers to these questions on www.sta.ie.

Examination Questions

Leaving Certificate Biology (HL) 2008, Q. 10

(a) (i) What does an ecologist mean by competition?  
   T  F

(ii) Distinguish clearly between contest competition and scramble competition.  

(b) Read the following extract, study the graph below and answer the questions that follow.

“The application of pesticides to strawberry plants in an attempt to destroy cyclamen mites that were damaging the strawberries killed both the cyclamen mites and the carnivorous mites that preyed on them. But the cyclamen mites quickly re-invaded the strawberry fields while the mites that preyed on them returned much more slowly. The result was that the cyclamen mites rapidly increased in density and did more damage to the strawberries than if the pesticide had never been applied.” (Adapted from W.T. Keeton and J. L. Gould. Biological Science. New York: W.W. Norton & Co., 1993)

(i) Which graph, A or B represents the carnivorous mites? Explain your answer.

(ii) What term is used to describe the relationship between the cyclamen mites and the carnivorous mites?

(iii) Suggest two reasons why the cyclamen mite managed to quickly re-invade the strawberry fields.

(iv) Suggest an alternative to the use of pesticides for controlling the cyclamen mite population.

(v) Draw a pyramid of numbers to include each of the organisms mentioned in the extract above.

(vi) Apart from competition and the factor illustrated in the above example, state another factor that limits population growth.

(c) (i) Waste management is a matter of growing concern in Ireland as the population expands. Outline three problems associated with waste disposal.

(ii) Give an example of waste produced in agriculture or fisheries or forestry and describe how it is managed.

(iii) Suggest two methods of waste minimisation.

(iv) Give one example of the use of micro-organisms in waste management.
**Did you know?**

1. Fuel cells consist of electrolytes sandwiched between layers of catalysts (possibly enzymes in the future). They convert chemical energy to electricity as long as fuel, usually hydrogen, is supplied. They are silent and non-polluting. A car has been developed which runs on fuel cells. In another project, electricity produced by solar panels splits water to release hydrogen which is then used by a fuel cell. The problem is in producing sufficient hydrogen to make fuel cells widely usable. It has been suggested that intermittent wind-generated electricity could be used for this purpose.

2. In the 1930s, scientists discovered that an alga – pond scum – sometimes produced hydrogen. More recently, it has been noticed that depriving the alga of sulfur and oxygen induces the process. However, the algae need sulfur to make protein. Research is ongoing.

3. Biosensors are biological materials (enzymes, microorganisms, antibodies) coupled to microelectronic devices. They can be used to detect pollutants in air, soil and water.

4. In 1899/1900, electric cars outsold all other types of cars in America.

**Revise the Terms**

Can you recall the meaning of the following terms? Reviewing terminology is a powerful aid to recall and retention.

- ammonia
- anaerobic digestion
- biofuel
- biological composting
- biological treatment
- bioremediation
- cadmium
- carbon dioxide
- carbon monoxide
- catalytic reaction
- combustion air
- compost heap
- effluent
- electrostatic precipitator
- end of pipe
- end-of-pipe technologies
- environmental technology
- fabric filter
- flared off
- flue
- flue gases
- fossil fuel
- fuel cell
- gas engine
- gas extraction systems
- hybrid engine
- incineration
- methane
- nickel
- nitrogen
- nitrogen oxides ($NO_x$)
- oxygen
- passive house
- phytoextraction
- phytoremediation
- pollution
- power plant
- ppm
- recycled
- recycling
- renewable energy
- scrubber
- solar panel
- solar power
- sulfur dioxide
- sulfur oxides
- technology
- thallium
- thermal treatment
- urea
- waste-management
- water vapour
- wave machine
- wind turbine
- zinc

Check the Glossary of Terms for this lesson at [www.sta.ie](http://www.sta.ie).

**Biographical Notes**

**Rudolf Diesel**

Born 1858 to German parents. He grew up in Paris but was deported at the outbreak of war in 1870. His interests were varied but much of his life was devoted to building an internal combustion engine that would approach the efficiency of the Carnot cycle. He initially experimented with a machine that used ammonia. In 1892 he obtained the German development patent for the engine that now bears his name. It was an immediate success. Today we have low-emission diesel cars which make more efficient use of diminishing fossil fuels. Rudolf Diesel drowned at sea on his way to London in 1913.