3.6

Pollution

For thousands of years, Aboriginal peoples lived in relative harmony with their environment. Without modern synthetic materials, they produced little waste compared with modern civilizations. Two factors have changed the relationship humans have with their environment. First, human population size has drastically increased. There are more of us around to create waste. Second, many toxic and persistent chemicals have been invented to support our lifestyle. As a result, each of us has a greater impact than did a single individual of the past.

pollution harmful contaminants released into the environment

When released into the environment, toxic materials are called **pollution** (Figure 1). Some polluting materials, such as pesticides and fertilizers, have a specific purpose. Others, such as automobile exhaust and product packaging, are by-products of our consumer society. Even natural, biodegradable products can pollute when put into the environment in high concentrations. In this section, we look at examples of air and water pollution.



Figure 1 Examples of land, water, and air pollution

Acid Precipitation

Sulfur dioxide and nitrogen oxides are two damaging air pollutants. They are produced in industrial processes and from burning fossil fuels, such as coal and petroleum. Sulfur dioxide and nitrogen oxides combine with water vapour in the atmosphere to form acids. Acids move through the water cycle, sometimes over very long distances, before returning to Earth in the form of **acid precipitation**.

acid precipitation precipitation that has been made more acidic than usual by the combination of certain chemicals in the air with water vapour

The Effects of Acid Precipitation

Acid precipitation, also called acid rain, impacts aquatic and terrestrial ecosystems. As rivers and lakes become more acidic, species decline in numbers and may disappear. For example, microscopic photosynthetic plankton that are at the bottom of the aquatic food web are negatively impacted. Crayfish, clams, and the fish that eat plankton are disappearing as their food supply decreases.

neutralize counteract the chemical properties of an acid

Not all rivers and lakes are equally impacted by acid precipitation. Certain minerals, particularly limestone, are able to **neutralize**, or counteract, acid. Limestone deposits near lakes tend to neutralize acid rain. The Canadian Shield, which is formed of granite, does not neutralize acid. For this reason, acid precipitation causes more damage in northern and southeastern Ontario than in southwestern Ontario.

In terrestrial ecosystems, acid rain chemically changes the soil by depleting the nutrients needed by plants. This damages the vegetation and results in slower growth. Acid rain has affected the soils in parts of Ontario, Quebec, and the Atlantic provinces. Figure 2 shows the effects of acid precipitation on terrestrial and aquatic ecosystems.

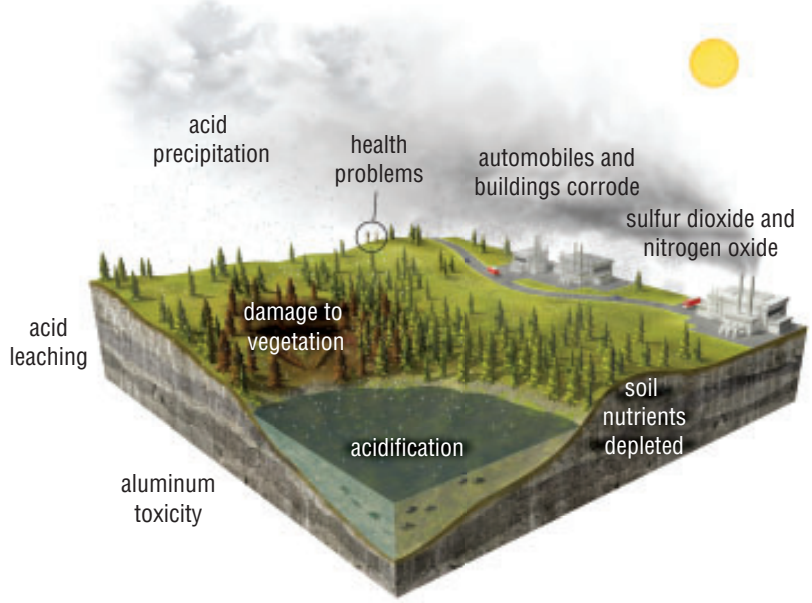

Figure 2 The release of sulfur dioxide and nitrogen oxides into the air causes acid precipitation.

Acid pollution also impacts humans. Sulfur dioxide is toxic and aggravates respiratory problems such as asthma and bronchitis. Acid precipitation speeds up the corrosion of metal, causing automobiles and iron structures to rust. It also dissolves concrete, marble, and limestone, damaging statues and buildings (Figure 3). Acid pollution causes billions of dollars in medical and economic costs each year. Ironically, acid lakes are sometimes considered desirable for recreation because they appear clear and clean (Figure 4).

Figure 3 Acid precipitation dissolves statues.

Figure 4 Acid lakes are clear because few organisms live in them.

Reducing Acid Precipitation

Even if acid emissions were eliminated, it could take hundreds of years for ecosystems to recover. Until then, forests in affected areas must rely on poorer soils. This situation threatens the long-term sustainability of our forests. According to Environment Canada, "If current levels of acid rain continue into the future, the growth and productivity of ~ 50 % of Canada's eastern boreal forests will be negatively affected."

DID YOU KNOW?

Sudbury's Green Solution to Pollution

In Sudbury, Ontario, extensive forestry has removed the area's trees, and emissions from smelting plants have contaminated the soil. In the 1980s, the city undertook a massive re-greening campaign. Lime was applied to neutralize the soil, and trees were planted. The City of Sudbury has won numerous awards for its efforts.

At one time, "the solution to pollution was dilution." Using this reasoning, the concentration of pollutants in the environment was decreased by mixing them with a large volume of air or water. One strategy employed tall superstacks to disperse pollutants over great distances. The result was that rather than the effects being severe and local, the effects were less acute but spread over a greater area. Fortunately, attitudes have changed and progress has been made (Figure 5).

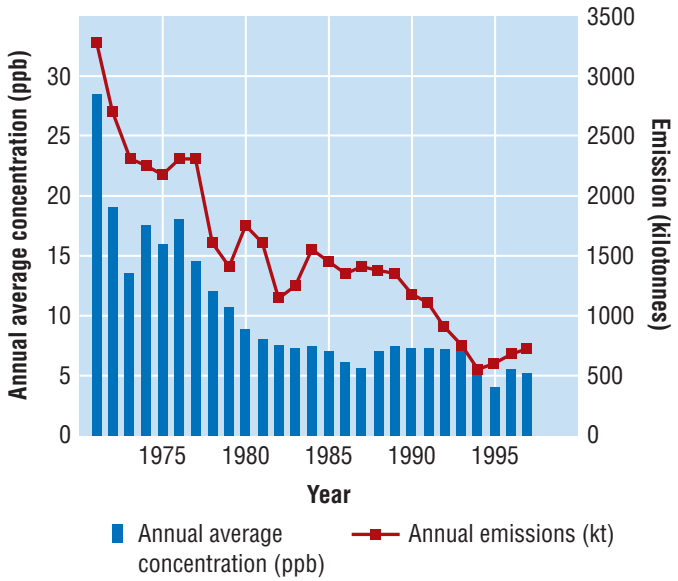

Figure 5 Sulfur dioxide emissions in Ontario have been steadily decreasing since the 1970s.

In eastern Canada, emissions of sulfur dioxide declined by over 60 % between 1980 and 2001. However, even today, the rain in the Muskoka–Haliburton area of Ontario is still 40 times more acidic than natural rain. Furthermore, while Canada has adopted new technologies, much of our acid precipitation comes from the United States, where high-sulfur coal is still widely used.

To learn more about acid precipitation,
GO TO NELSON SCIENCE

Now, humans are even changing the acidity of the world's oceans. As you learned in Section 2.6, the burning of fossil fuels is releasing large amounts of carbon dioxide into the atmosphere. Much of this carbon dioxide eventually dissolves in ocean water, where it forms carbonic acid. There is now enough carbonic acid forming to alter the chemistry of the world's largest bodies of water.

RESEARCH THIS OCEAN ACIDIFICATION

SKILLS: Researching, Communicating

SKILLS HANDBOOK 4.B.

Human activities have caused acid precipitation damage to thousands of lakes in Ontario.

1. Research the changes that are occurring to the acidity of the ocean. The pH scale is between 0 (highly acidic) and 14 (basic). Acidic water has a pH below 7 (neutral).
2. Research how these changes threaten marine ecosystems.

GO TO NELSON SCIENCE

A. How much has the pH of the ocean changed over the past 100 years? T/I

B. Explain how pH influences marine organisms by considering the following questions: T/I

(i) What kinds of organisms have shells and external mineral skeletons?

(ii) How could a more acidic environment affect these organisms?

(iii) How might the loss of these species impact marine food webs?

Laying Waste to Water

Water is our most precious renewable resource. We drink water and use it to grow and cook our food. We use it to generate power and in many industrial and commercial processes. Water is a valuable natural resource, and it is important that we protect it from contamination. Acid precipitation pollutes water from above. Other wastes directly enter and threaten Earth's surface and groundwater.

DID YOU KNOW?

Orange Peels Fight Pollution

A recent study suggests that orange peel is capable of removing toxic industrial dyes from waste water. It could be a natural alternative to more expensive chemical processing. Orange peel is readily available.

Oil Spills

The most dramatic water pollution events are large oil spills. Oil tankers navigate the world's oceans. Inevitably, accidents happen. When they do, the results are devastating (Figure 6). Oil is toxic, slow to break down, and difficult to clean up. It forms large slicks that cover the ocean, beach, and seabed.

Figure 6 High-pressure steam was used to wash crude oil from the *Exxon Valdez* spill off the rocky coastline of Prince Edward Sound, Alaska, in 1989. More than 40 million litres of crude oil was spilled.

Sea birds and seals are particularly vulnerable to oil spills. When sea birds get oil on their wings, they remove and ingest it while cleaning themselves. The ingested oil damages their digestive tract, liver, and kidneys. When covered with oil, the feathers of birds and fur of seals lose their ability to insulate. The animals lose too much body heat and die of the cold.

Following an accident, a variety of methods can be used to capture, break down, or disperse any oil that cannot be recovered:

- Skimming/vacuuming. Floating oil may be contained and skimmed or vacuumed up into a recovery vessel. This method is used only if sea conditions permit.
- **Bioremediation.** Some micro-organisms are capable of feeding on oil. Scientists are currently studying ways to speed up the rate at which these bacteria are able to break down the oil. The addition of inorganic nutrients is one technique that has shown promise.

bioremediation the use of micro-organisms to consume and break down environmental pollutants

Figure 7 Spilled oil is often burned.

- Burning. Oil floating at the surface is sometimes lit on fire so that it burns away. This prevents oil from sinking or washing up on shore. While this may solve the water pollution problem, it pollutes the air (Figure 7).
- Dispersal agents. Oil may be broken up into small droplets using detergents. This technique allows the droplets to be more easily washed out to sea and dispersed. However, the smaller droplets will spread over a larger area and can be taken in more readily by even more organisms.

Plastics at Sea

On Midway atoll, an island between the United States and Japan, about 500 000 albatross chicks are born each year. About 40 % of them die from dehydration or starvation. Why are so many chicks dying? Researchers have found that the stomachs of chicks that die from these causes are twice as likely to contain plastic as chicks that die from other causes. Where are the albatross getting plastic they feed to their chicks?

Plastic is an extremely useful material. It is inexpensive, lightweight, and strong. The qualities that make the plastic industry so successful also make plastic a harmful part of our waste. Because it does not chemically degrade, plastic that is disposed of today may remain in the environment for hundreds or thousands of years.

Each year, over a billion kilograms (1 million tonnes) of plastics are produced worldwide. Only a tiny fraction is recycled. Most of this plastic ends up in landfills, but some enters waterways and oceans. It may be blown there by the wind, washed into storm sewers, or intentionally dumped from ships. Large plastic commercial fishing nets also break loose and drift through the oceans, unintentionally trapping fish, turtles, birds, and marine mammals like dolphins and whales.

The North Pacific Ocean contains one of several large areas of slowly rotating ocean surface water. Floating debris slowly accumulates in these areas, forming massive mats of plastic trash. The so-called Great Pacific Garbage Patch is twice the size of Texas and is up to 100 m deep (Figure 8).

To learn more about the Great Pacific Garbage Patch,
GO TO NELSON SCIENCE

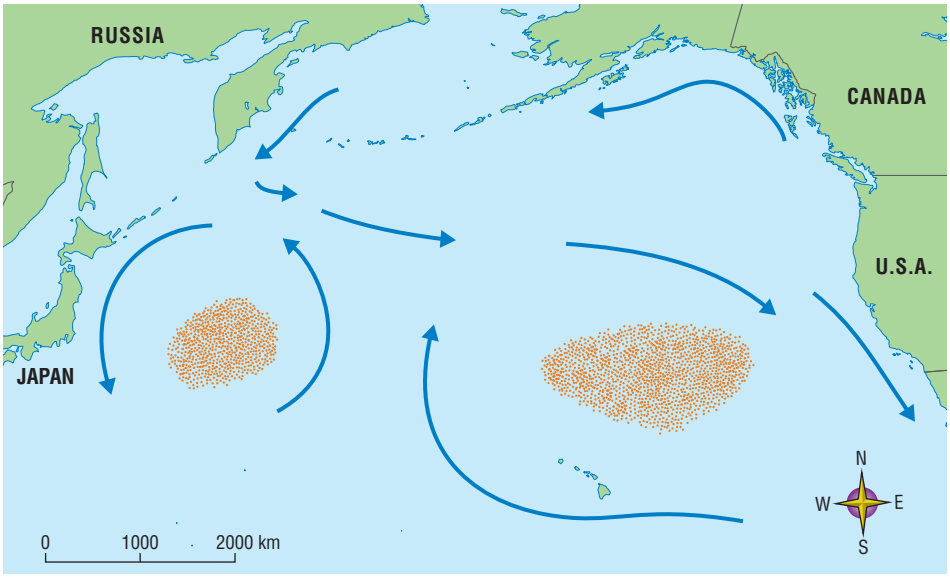

Figure 8 The Western and Eastern Pacific Garbage Patches are sometimes collectively called the Great Pacific Garbage Patch.

Plastics are responsible for significant ecological damage in marine ecosystems. Sunlight and wave action break the plastic into smaller and smaller pieces. These pieces become attractive bite-sized morsels for marine life. Sea turtles may mistake a piece of floating plastic bag for a jellyfish. Fish and sea birds may feed on brightly coloured plastic fragments. The plastic has no nutritional value and may block the digestive systems of the animals. Some animals become entangled in plastic bags or plastic rings (Figure 9).

As plastic gets broken down into smaller fragments, smaller organisms take them in. Scientists have found microscopic particles of plastic in the cells of plankton. Scientists believe that plastic absorbs chemicals from the environment. Proper recycling and disposal of plastics would reduce or eliminate this needless source of ocean pollution.

In addition to the threats they pose to our environment, the manufacturing of plastics creates pollution and results in the consumption of petroleum: a non-renewable resource. One way to avoid some of this waste is simply to use cloth bags when you shop!

Figure 9 Birds and other sea animals easily become entangled in plastic.

IN SUMMARY

- Acid precipitation is precipitation that has been made more acidic than usual by the combination of sulfur dioxide and nitrogen oxides with water vapour.
- Acid rain affects terrestrial and aquatic ecosystems as well as human health and infrastructure such as buildings.
- Acid precipitation can travel a long distance from its source through the atmosphere.
- Oil spills can be cleaned up using skimming, bioremediation, burning, and dispersal agents.
- Plastics cause significant damage to marine ecosystems, especially to aquatic organisms.
- Massive mats of floating plastic trash have formed in the oceans.
- The manufacturing of plastics causes pollution and consumes non-renewable resources.

CHECK YOUR LEARNING

1. Identify two factors that have changed the relationship between people and their environment, resulting in the production of pollution. K/U
2. Name two chemical pollutants that are responsible for acid precipitation. What are their main sources? K/U
3. Describe some of the negative impacts of acid precipitation on ecosystems. K/U
4. What minerals, found in rock formations, are able to neutralize the effects of acid? K/U
5. Explain how oil spills directly harm wildlife. K/U
6. List several methods that can be used to help clean up an oil spill. K/U
7. "The solution to pollution is dilution." T/I C
   (a) What does this mean in relation to pollution control?
   (b) Is it a good solution? Explain your answer.
8. Write a short paragraph on the relationship between plastics and ocean pollution. C A
9. Brainstorm a list of twenty items that you have used recently that contain plastics. Examine your list and consider what items, if any, were wasteful or unnecessary. T/I A
10. Do you think humans should attempt to clean up the Great Pacific Garbage Patch? Why do you think this might be difficult? A