

1 Pollution and Human Health

2 Biological Hazards



READING WARM-UP

Before you read this chapter, take a few minutes to answer the following questions in your *EcoLog*.

1. What are two ways that environmental conditions can affect human health?
2. How does environmental change affect the transfer of diseases like malaria?

This woman is washing a pot in a polluted river in Kathmandu, Nepal. Pollution is only one way the environment affects our health.

Pollution and Human Health

If you have ever coughed from breathing car exhaust, you have experienced a mild health effect of air pollution. Pollution of air, water, and soil is frequently in the news. Because people in the United States are so concerned about pollution, our country enjoys a relatively clean environment. But this situation is also due to the efforts of scientists who have studied the relationship between pollution and human health. Scientists are also beginning to understand the broader relationships between health and the environment.

Environmental Effects on Health

Pollution causes illness in two main ways. First, it may cause illness directly by poisoning us, as in the cases of lead poisoning and lung cancer. Second, pollution may cause illness indirectly because many infectious diseases spread in polluted environments. Examples of these diseases include cholera and river blindness, diseases caused by organisms found in polluted water.

The World Health Organization (WHO) has begun to collect data on how the environment affects human health. **Figure 1** shows the WHO's estimate of poor health by world region. Poor health is measured by the estimated number of days of healthy life lost to death and disease. The WHO graph shows that, in general, people in developed countries suffer fewer health impacts due to environmental causes than people in developing countries do. The main factor behind this situation is the enormous role of infectious diseases, such as tuberculosis and cholera, which are more common in crowded areas with poor sanitation.

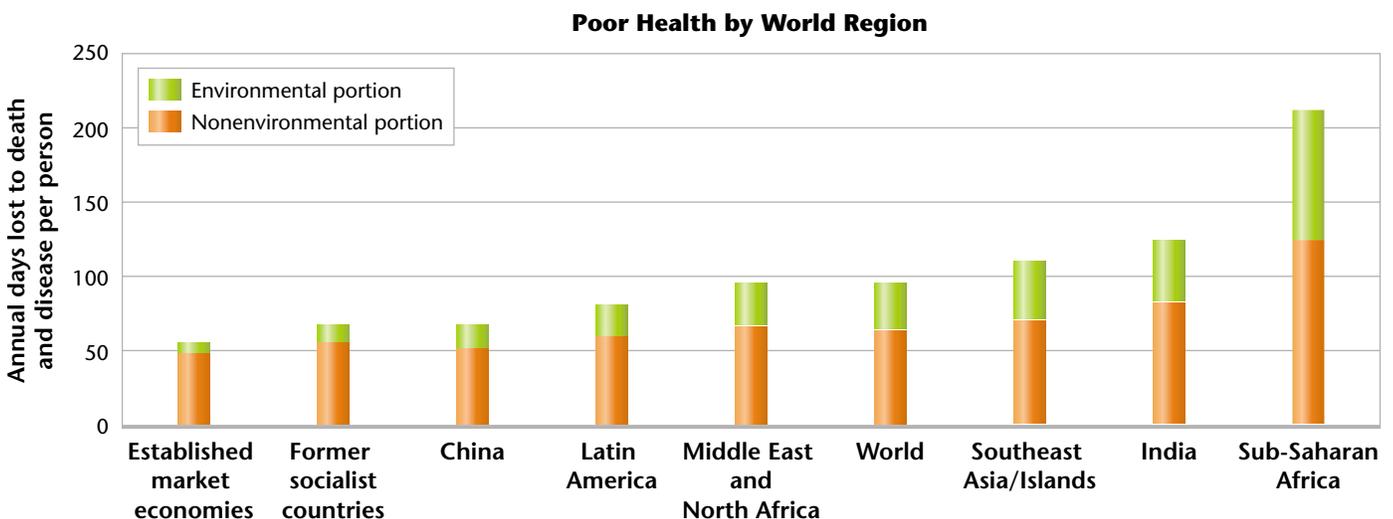
Objectives

- ▶ List five pollutants, their sources, and their possible effects on human health.
- ▶ Explain how scientists use toxicology and epidemiology.
- ▶ Explain how pollution can come from both natural sources and human activities.
- ▶ Describe the relationship between waste, pollution, and human health.

Key Terms

toxicology
dose
dose-response curve
epidemiology
risk assessment
particulates

Figure 1 ▶ This bar graph shows the environment's contribution to disease in different parts of the world. Regions that suffer from poor health generally also suffer more from environmental causes of poor health, such as infectious diseases.



Source: *Epidemiology*.

Table 1 ▼

| Pollutant Types and Effects | | |
|-----------------------------|--|---|
| Pollutant | Source | Possible effects |
| Pesticides | use in agriculture and landscaping | nerve damage, birth defects, and cancer |
| Lead | lead paint and gasoline | brain damage and learning problems |
| Particulate matter | vehicle exhaust, burning waste, fires, and tobacco smoke | respiratory damage (asthma, bronchitis, cancer) |
| Coal dust | coal mining | black lung disease |
| Bacteria in food | poor sanitation and poor food handling | gastrointestinal infections |

Toxicology

The word *toxic* means poisonous. **Toxicology** is the study of the harmful effects of substances on organisms. Table 1 lists some important pollutants and their toxic effects.



Toxicity: How Dangerous Is It? We are exposed to small amounts of chemicals every day, in food, in the air we breathe, and sometimes in the water we drink. Almost any chemical can be harmful if taken in, or *ingested*, in large enough amounts. The question is whether the concentration of any particular chemical in the environment is high enough to be harmful.

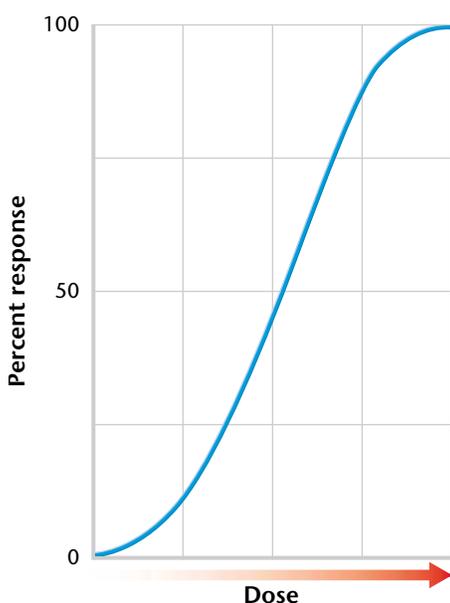
To determine the effect of a pollutant on health, we need to know several things. We need to know how much of the pollutant is in the environment and how much gets into the body. Then we need to determine what concentration of the toxin damages the body. The amount of a harmful chemical to which a person is exposed is called the **dose** of that chemical. The damage to health that results from exposure to a given dose is called the *response*.

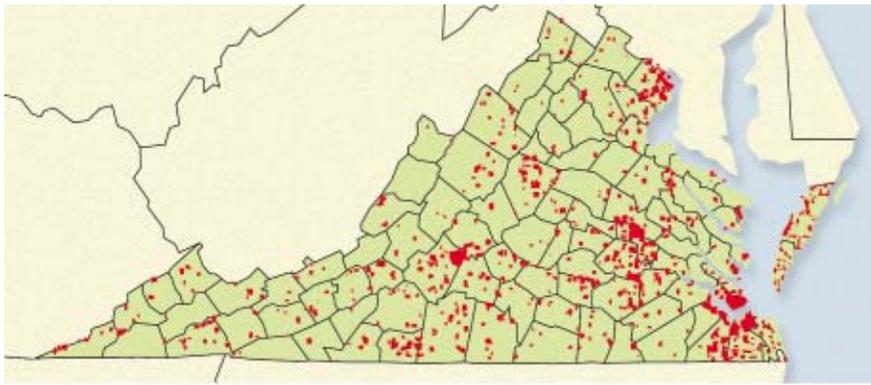
Whether a chemical has a toxic effect depends in part on the dose. The response also depends on the number of times a person is exposed, the person's size, and how well the person's body breaks down the chemical.

A persistent chemical is a chemical that breaks down slowly in the environment. The pesticide DDT is an example of a persistent chemical. Persistent chemicals are dangerous because more people are likely to come into contact with them, and these chemicals are more likely to remain in the body.

Dose-Response Curves The toxicity of a chemical can be expressed by a dose-response curve, as shown in Figure 2. A **dose-response curve** shows the relative effect of various doses of a drug or chemical on an organism or organisms as determined by experiments. Sometimes, we find that there is a *threshold dose*. Exposure to any amount of chemicals less than the threshold dose has no adverse effect on health. Exposure to levels above the threshold dose usually leads to worse effects.

Figure 2 ▶ A dose-response curve shows the response of an organism to different concentrations of a substance.





Source: Virginia Department of Health.

Figure 3 ▶ This map shows the location of cases of mercury poisoning in Virginia. Patterns point scientists toward areas of mercury pollution.

Epidemiology

When an epidemic occurs, such as a widespread flu infection, health officials use their knowledge of epidemiology to take action. **Epidemiology** (EP uh DEE mee AHL uh jee) is the study of the spread of diseases. Epidemiologists collect data from health workers on when and where cases of the disease have occurred. This information can be used to produce a map like the one in **Figure 3**.

Then scientists trace the disease to try to find its origin and how to prevent it from spreading. For example, in a case of mercury poisoning, health officials may ask questions such as: What did the people with mercury poisoning have in common? Were they all exposed to the same chemicals?

Risk Assessment In order to safeguard the public, health officials determine the risk posed by particular pollutants. Recall that risk is the probability of a negative outcome. In the case of human health, risk is the probability of suffering a disease, injury, or death.

Scientists and health officials work together on risk assessments for pollutants. A **risk assessment** is an estimate of the risk posed by an action or substance. During the process of risk assessment, scientists first compile and evaluate existing information on the substance. Then they determine how people might be exposed to it. **Figure 4** shows a diagram, created by a computer model, of how air pollutants might travel through a city area. The third step is determining the toxicity of the substance. Finally, scientists characterize the risk that the substance poses to the public. Risk assessments may lead to government regulations on how and where the substance can be used. In the United States, the Environmental Protection Agency (EPA) formulates these regulations.

Figure 4 ▶ Air flow models like this one help scientists predict the path that air pollutants may follow through a city. The bright orange areas are receiving the most pollutants.

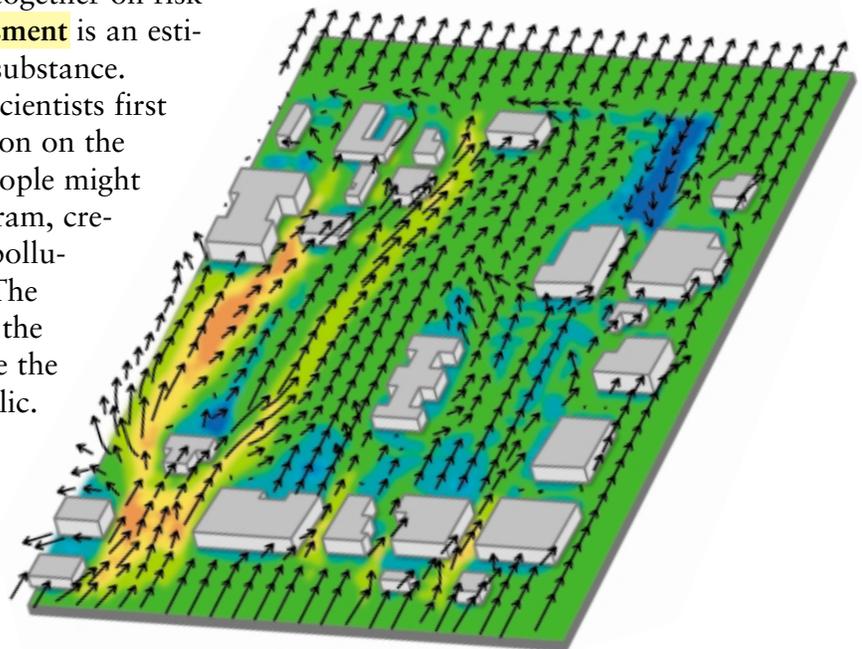




Figure 5 ▶ A dust storm descends upon Marrakesh, Morocco, in the photo above. Dust is perhaps the most common natural pollutant.

Figure 6 ▶ A town is coated with ash after the 1991 eruption of Mount Pinatubo, in the Philippines.



Pollution from Natural Sources

You may think of pollution as being entirely caused by people, but some pollutants occur naturally in the environment. Naturally occurring pollutants usually become hazardous to health when they are concentrated above their normal levels in the environment. One example is the radioactive gas radon. In some areas, radon from granite bedrock may seep into buildings, where it becomes concentrated. Because it is an odorless gas, people may unknowingly breathe it in. Radon causes an estimated 5,000 to 20,000 cancer deaths every year in the United States.

Particulates The most common pollutants from natural sources are dust, soot, and other particulates. **Particulates** (pahR TIK yoo lits) are particles in the air that are small enough to breathe into the lungs. These particles become trapped in the tiny air sacs in our lungs and cause irritation. This irritation can make lung conditions, such as chronic bronchitis and emphysema, worse. **Figure 5** shows particulate pollution from a dust storm, whereas **Figure 6** shows pollution from a volcanic eruption. Wildfires also produce large amounts of particulates.

Heavy Metals Another important type of pollution from natural sources are the so-called *heavy metals*. Dangerous heavy metals include the elements arsenic, cadmium, lead, and mercury. These metals occur naturally in rocks and soil. Most of these elements cause nerve damage when they are ingested beyond their threshold dose. Selenium, also found naturally in many soils, is actually a beneficial element when taken in very small quantities. But larger doses pose health risks to humans.

Pollution from Human Activities

Human activities release thousands of types of chemicals into the environment, but we know surprisingly little about the health effects of most of them. Only about 10 percent of commercial chemicals have been tested for their toxicity, and about 1,000 new chemicals are introduced every year. **Figure 7** shows the introduction of pollutants into the environment by human activities.

Recent Improvements In the United States, regulations have helped reduce our exposure to pollutants. Most vehicles and factories now have pollution-control devices. As a result, people living in the United States contain lower levels of some toxic chemicals in their bodies, on average, than they did in the recent past. In 2001, the U.S. Centers for Disease Control and Prevention (CDC) released a study on chemical residues in 3,800 people. Levels of nicotine (from smoking), lead, and several other toxic chemicals were considerably lower in these peoples' tissues than they had been 10 years earlier.

Because we know so little about the effects of chemicals on our health, new health risks are discovered frequently. For example, scientists now think that chemical pollution may be at least part of the cause of Parkinson's disease and Alzheimer's disease.

Burning Fuels Despite the very real advances in public health resulting from pollution control, air pollution is still a major health problem. Burning fuels in vehicles, home furnaces, power plants, and factories introduces enormous amounts of pollutants into the air. These pollutants include the gas carbon monoxide and many kinds of particulates. Gasoline and coal burning contribute to the many premature deaths each year from asthma, heart disease, and lung disorders. In fact, it may be possible to predict an area's death rate based on the amount of pollution. A recent study found that long-term exposure to air contaminated with soot particles raises a person's risk of dying from lung cancer or other lung and heart diseases.



FIELD ACTIVITY

Sources of Pollution Walk around your neighborhood, and record potential sources of pollution. Suggest ways in which the amount of pollution from each source might be reduced. Write your observations, suggestions, and any evidence that supports your analysis in your **EcoLog**.

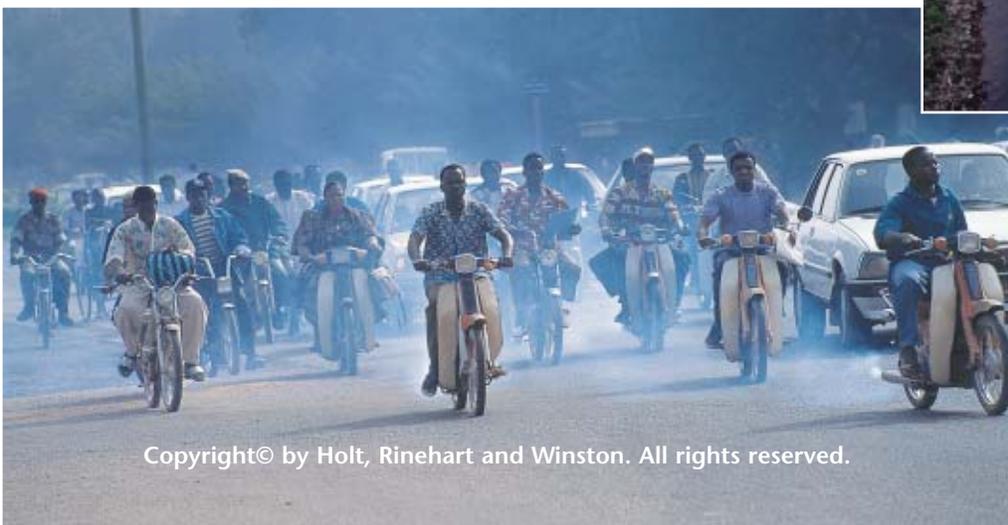


Figure 7 ► Human activities can pollute air and water. Paper mills contribute pollutants to rivers (above). Vehicle emissions cloud the air in urban areas worldwide (left).

MATH PRACTICE



Concentration Concentrations of chemicals in the environment are often expressed in parts per million (ppm) or parts per billion (ppb). One teaspoon of salt in two gallons of water produces a salt concentration of 1,000 ppm. What salt concentration, in ppm, would result from dissolving one teaspoon of salt in five gallons of water?

Pesticides *Pesticides* are chemicals designed to kill unwanted organisms such as insects, fungi, or weeds. Pesticides are beneficial in that they allow us to grow more food by reducing pest damage. Many of the increases in food production in the past 60 years are partly due to the development and use of more effective pesticides.

But because pesticides are designed to kill organisms, they are often dangerous to humans in large enough doses. Although we are exposed to pesticide residues on fruits and vegetables, the amounts consumed by most people pose little danger.

Most modern pesticides, such as most of those used in the United States, break down quickly in the environment into harmless substances. Widely used *organophosphate* pesticides have replaced more persistent pesticides, such as DDT. But organophosphates are very toxic, causing nerve damage and perhaps cancer. In 1999, U.S. poison centers reported more than 13,000 cases of organophosphate poisoning. Most cases of pesticide poisoning affect the people applying the chemicals.

Persistent chemicals are still used in many developing countries. Such pesticides pose the greatest risk to children, whose internal organs are still developing and who eat and drink more in relation to their body weight than adults do.

CASE STUDY

Chemicals That Disrupt Hormones

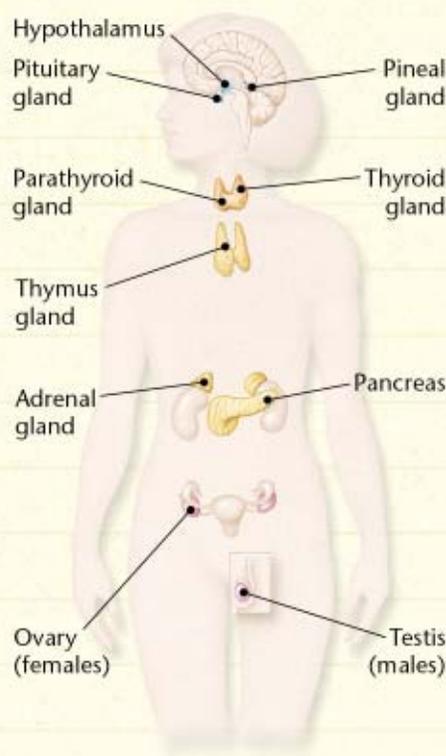
In recent years, scientists have collected evidence that many pollutants disrupt the endocrine system. The glands that make up the human endocrine system produce hormones. *Hormones* are chemicals that circulate in the bloodstream and control many life processes, such as the development of muscles and sex organs.

Some pollutants, called *hormone mimics*, behave like natural hormones. Other pollutants are *hormone disrupters*, which prevent natural hormones from functioning normally. Even low levels of these kinds of pollutants can affect developing embryos and infants.

Hormone mimics were first discovered in fish in Europe. Researchers in England and France found that male trout and eels downstream

from sewage treatment plants contained egg-yolk proteins usually produced only by females. Lab experiments showed that the water contained estrogen-like chemicals and that these chemicals induced the male fish to make proteins usually produced only by females. The chemicals are believed to have come from detergents and from the urine of women taking contraceptive pills.

Most hormone disrupters interfere with the sex hormones. They prevent normal production of testosterone in males or increase the chances of sexual abnormality in females. Examples of hormone disrupters include phthalates, which are widely used in cosmetics, such as hair dyes and fingernail polish. Polychlorinated biphenyls (PCBs),



► The diagram above shows the major organs and glands of the human endocrine system.

Industrial Chemicals Railroad tankers carrying industrial solvents overturned near Rochester, New York, in 2002. Two solvents reacted to cause a fire that destroyed several houses. Several people were treated for breathing the fumes.

We are exposed to low levels of industrial chemicals every day, particularly inside new buildings that have new furnishings. Toxic chemicals are used to make building materials, carpets, cleaning fluids, and furniture. Older buildings, like the one shown in **Figure 8**, were often painted using lead-based paint. Lead is directly linked to brain damage and learning disabilities.

Often, industrial chemicals are not known to be toxic until they have been used for many years. For example, polychlorinated biphenyls (PCBs) are oily fluids that have been used for years as insulation in electrical transformers. PCBs do not break down in the environment. In 1996, studies showed that children exposed to PCBs in the womb can develop learning problems and IQ deficits. The waters of the Great Lakes are polluted by PCBs, and doctors warn pregnant women not to eat fish from these lakes. Studies have shown that adults with high concentrations of PCBs in their tissues have more memory problems than adults who do not.



Figure 8 ▶ Lead poisoning in children is most often due to direct exposure to lead-based paint.



▶ The fertility of American alligators, such as this one, has been reduced by their exposure to hormone disrupting pollutants.

some pesticides, lead, and mercury may also act as hormone disrupters.

Many cases of pollution by hormone disrupters have now been found in the United States. For example, alligators in a Florida lake that was polluted with local hazardous waste had such abnormally small penises and low testosterone levels that they could not

reproduce. In 2002, scientists reported that even small amounts of the widely used herbicide atrazine disrupt the sexual development of frogs.

During the past 50 years, there has been a large increase in cancers of the prostate, testicles, ovaries, and breasts in most industrialized countries. All of these forms of can-

cer can be accelerated by abnormal levels of sex hormones. A recent analysis of sperm counts among men in industrialized countries shows that sperm counts have fallen by 50 percent in the last 50 years.

Scientists do not yet have concrete evidence that hormone disrupters in the environment are actually causing these human health problems. Research into these questions has accelerated since an international conference on hormone disrupters was held in 1996.

CRITICAL THINKING

1. Reading Comprehension

Explain the difference between hormone mimics and hormone disrupters.

2. Analyzing Relationships If humans are increasingly exposed to these pollutants, what are some possible results?



Figure 9 ► Waste that is not disposed of properly can pollute beaches, where it can pose a threat to swimmers and sunbathers.

Waste Disposal Much of the pollution in our environment is a byproduct of inadequate waste disposal. **Figure 9** shows the pollution of a beach with solid waste. Wastewater from cities can carry oil and dozens of toxic chemicals into our waterways. Waste incineration plants can emit toxic products into the air, and mining can release toxic contaminants into streams and rivers.

One of the reasons that our air and water is less polluted in many areas than it was 50 years ago is that methods of disposing of waste have improved. However, problems remain. Many old landfills are leaking. And many communities still have sewage treatment plants that release raw sewage into a river or the ocean after heavy rains. In addition, laws regulating waste disposal are not always enforced.

The United States government has not decided how it will dispose of radioactive waste from nuclear power plants. Meanwhile, the waste remains in barrels at or near the plants, and small quantities of radioactive iodine, cesium, and other elements leak into nearby waterways.



SECTION 1 Review

1. **List** five pollutants, their sources, and their possible effects on human health.
2. **Explain** how pollution can arise from both natural sources and from human activities.
3. **Describe** the relationship between waste, pollution, and human health.

CRITICAL THINKING

4. **Making Comparisons** Write a short paragraph that explains the relationship between toxicology and epidemiology. **WRITING SKILLS**
5. **Analyzing Relationships** In what ways do human activities increase the health risks from natural pollutants?