



## SUSTAINING ENVIRONMENTAL QUALITY

### Chapter 18

### Environmental Hazards and Human Health



**“It’s A Small World After All”**

#### **Outline**

##### **Risk and Hazards**

- A. A risk is a measure of your likelihood of suffering harm from a hazard.
  - 1. Such a hazard may cause injury, disease, economic loss, or environmental damage.
  - 2. Risk assessment is projected as a probability: a mathematical statement about how likely it is that harm will result from a hazard. It gives the estimate of an event’s actually happening.
  - 3. Risk management involves deciding whether or how to reduce a particular risk to a certain level and at what cost.
- B. There are four major types of hazards.
  - 1. Biological hazards come from more than 1400 pathogens (bacteria, viruses, parasites, protozoa, and fungi) that can infect humans
  - 2. Chemical hazards from harmful chemicals in air, water, soil and food.
  - 3. Physical hazards such as fire, earthquake, volcanic eruption, flood, tornado, and hurricane.
  - 4. Cultural hazards such as smoking, unsafe working conditions, poor diet, drugs, drinking, driving, criminal assault, unsafe sex, and poverty.

##### **Biological hazards: disease in developed and developing countries**

- A. Diseases not caused by living organisms do not spread from one person to another, while those caused by living organisms such as bacteria and viruses can spread from person to person.
  - 1. Non-transmissible disease tend to develop slowly, have multiple causes, are not caused by living organisms, and do not spread from one person to another. Examples are cancer, diabetes, asthma, malnutrition and blood vessel disorders.
  - 2. Transmissible disease is caused by a living organism and can spread from on to another. Infectious agents/pathogens are spread in air, water, food, body fluids, by some insects and by vectors.
  - 3. The World Health Organization estimates that each year the world’s seven deadliest infectious diseases kill 13.6 million people-most of them poor people in developing countries. This amounts to about 37,000 mostly preventable deaths every day.
  - 4. There is concern about bioterrorism, which involves the deliberate release of disease-causing bacteria or viruses into the air, water supply, or food supply of concentrated urban populations.
  - 5. Mixed news is that death from infectious diseases has decreased, but many bacteria have developed immunity to widely used antibiotics.
- B. Rapidly producing infectious bacteria are becoming genetically resistant to widely used antibiotics.
  - 1. The bacteria can transfer this resistance to nonresistant bacteria.
  - 2. Human travel and trade spread bacteria rapidly across the globe.
  - 3. Doctors overuse antibiotics.
  - 4. The availability of antibiotics in many countries without a prescription.
  - 5. Resistance to antibiotics has increased because of antibiotics being used in livestock and dairy animals to control disease and promote growth.
  - 6. Overuse of pesticides increases pesticide resistant insects and other carriers of bacterial diseases.
  - 7. Public pressure has caused some phasing out of antibiotic use in cattle.
  - 8. Each year, some 2 million people pick up preventable infections while they are in U.S. hospitals.
- C. Tuberculosis kills 1.7 million people per year and could kill 25 million more people by 2020.
  - 1. Tuberculosis is a silent global epidemic since many people do not know that they have been infected.
  - 2. Several factors account for the recent increase in TB:
    - a. lack of screening, and control programs, especially in developing countries where 95% of the new cases occur
    - b. increased population growth, urbanization, and air travel means greater contact between

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- people
- c. there are genetically resistant strains of TB to almost all effective antibiotics
- d. the spread of AIDS weakens the immune system and allows the TB bacteria to multiply
- 3. There must be early detection and treatment of people with active TB to slow the spread of the disease.
- D. Flu, HIV, and hepatitis B viruses infect and kill many people each year than highly publicized West Nile and SARS viruses.
  - 1. The influenza or flu virus is the biggest killer. It is responsible for the deaths of about 1 million people a year.
  - 2. The second biggest killer is HIV, transmitted in a variety of ways. (See the Core Case Study on p. 418 for facts regarding the global HIV/AIDS epidemic). Globally it infects about 4.9 million new people a year. The resulting complications from AIDS kill about 3 million people annually. The World Health Organization has suggested a five-point strategy to slow the spread of HIV/AIDS.
    - a. Shrink the number of people capable of infecting others by quickly reducing the number of new infections below the number of deaths.
    - b. Concentrate on the groups that are most likely to spread the disease such as truck drivers, sex workers and soldiers.
    - c. Provide free HIV testing
    - d. Use mass advertising and education for adults and schoolchildren
    - e. Provide free or low-cost drugs to slow the progress of the disease.
  - 3. The third largest killer is the hepatitis B virus (HBV) that damages liver and kills about 1 million people each year. It is transmitted by the same methods as HIV.
  - 4. Health officials are concerned about the emergence of West Nile virus and severe acute respiratory syndrome (SARS) in recent years.
- E. Malaria kills about 2 million people per year and has probably killed more people than all of the wars ever fought. Malaria is caused by a parasite that is spread by the bites of certain mosquitoes.
  - 1. It is caused by four species of protozoan parasites in the genus *Plasmodium*.
  - 2. The parasite circulates from mosquito to human and back to mosquito.
  - 3. The cycle repeats until immunity develops, treatment is given, or the victim dies.
  - 4. During the 1950s and 1960s, the spread of malaria was sharply curtailed by draining of swamplands and marshes, spraying breeding areas with insecticides, and using drugs to kill the parasite in the bloodstream. Since 1970, however, malaria has come roaring back as most species of the *Anopheles* mosquito have become genetically resistant to most insecticides.
  - 5. Researchers are currently working to develop new anti-malarial drugs, vaccines, and biological controls for the mosquitoes.
  - 6. Currently prevention is the best method to control its spread. Methods include fixing leaking water pipes, using mosquito netting; cultivate fish that feed on mosquito larvae, plant trees that soak up water in marshy areas and use zinc and vitamin A supplements to boost resistance in children.
- F. There are a number of ways to reduce the incidence of infectious diseases if the world is willing to provide the necessary funds and assistance.
  - 1. Global death rate dropped by about 2/3rds between 1970 and 2000. The number of children immunized between 1971 and 2000 went from 10% to 84% and saved an estimated 10 million lives a year.
  - 2. To reduce the incidence of infectious disease, we now use oral rehydration therapy to replace water in victims of diarrheal diseases, which cause about one-fourth of all deaths of children younger than age 5.
  - 3. Only about 10% of global medical research and development money is spent on preventing infectious diseases in developing countries, even though more people worldwide suffer and die from these diseases than all other diseases combined. .
- G. Mostly because of human activities, infectious diseases are moving at increasing rates from one animal species to another and from one animal species to humans.
  - 1. Infectious diseases that are transmitted from wild and domesticated animals to humans include avian flu, SARS, West Nile virus, Hantavirus, and Lyme disease.

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2. Ecological or conservation medicine is a new field devoted to tracking down these connections between wildlife and humans.
3. The clearing and fragmentation of forests has played a major role in exposing humans to new types of infectious disease.
4. Understanding the connections between human activities and ecosystem functioning is a key to preventing or slowing the spread of infectious organisms from wild and domesticated animals to humans.

#### Chemical hazards

- A. Toxic and hazardous chemicals can harm or kill.
  1. A toxic chemical can cause temporary or permanent harm or death to humans or animals.
  2. A hazardous chemical can harm because it is flammable or explosive or because it irritates or damages skin or lungs or induces allergic reactions.
  3. There are three major types of potentially toxic agents.
    - a. Mutagens are chemicals or ionizing radiation that cause or increase the frequency of random mutations in the DNA molecules. It is generally accepted that there is no safe threshold for exposure to harmful mutagens.
    - b. Teratogens are chemicals that cause harm or birth defects to a fetus or embryo. Alcohol and thalidomide are examples of teratogens.
    - c. Carcinogens are chemicals or ionizing radiation that cause or promote cancer.
- B. Long-term exposure to some chemicals at low doses may disrupt the body’s immune, nervous, and endocrine systems.
  1. The immune system consists of specialized cells and tissues that protect the body against disease and harmful substances. It forms antibodies that make invading agents harmless.
  2. Neurotoxins are types of poisons that attack the nervous system that consists of the brain, spinal cord, and peripheral nerves.
  3. The endocrine system is a complex glandular system that releases small amounts of hormones into the bloodstream of vertebrates. Low levels of these chemicals turn on and off bodily systems controlling sexual reproduction, growth, development, learning ability, and behavior.
  4. There is concern that certain synthetic chemicals can mimic hormones and that low-level exposure to these hormonally active agents (HAAs) can disrupt the endocrine system.
  5. These HAAs may
    - a. disrupt human immune functions
    - b. have adverse reproductive and developmental effects on vertebrates exposed to them
    - c. act as thyroid disrupters and cause growth, weight, brain, and behavioral disorders
    - d. disrupt the human endocrine and nervous systems and cause or promote certain types of cancers
- C. The world’s worst industrial accident occurred in 1984 at a pesticide plant in Bhopal, India.
  1. An explosion in an underground storage tank released a large quantity of highly toxic methyl isocyanate (MIC) gas, used to produce carbamate pesticides.
  2. MIC was converted to the more deadly hydrogen cyanide gas in the atmosphere.
  3. Indian officials and other groups put the death toll between 15,000-20,000 people.
  4. A lawsuit relating to the Union Carbide plant in Bhopal still continues 20 years after the initial accident.

#### Toxicology: assessing chemical hazards

- A. Factors determining the harm caused by exposure to a chemical include the amount of exposure (dose), the frequency of exposure, the person who is exposed, the effectiveness of the body’s detoxification systems, and one’s genetic makeup.
  1. Toxicity measures how harmful a substance is in causing injury, illness, or death to a living organism. Several factors to consider are:
    - a. Dose, the amount of a substance a person is exposed to
    - b. Frequency of exposure
    - c. Age and size of the individual exposed

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- d. The health of the body’s detoxification system
- e. Genetic makeup of the individual is also important for determining sensitivity to a toxin.
2. Five major factors can affect the harm caused by a substance:
  - a. Solubility. Water-soluble toxins can move throughout the environment. Oil- or fat-soluble toxins (generally organic compounds) can penetrate the membranes surrounding an organism’s cells and accumulate in the body.
  - b. Persistence of a substance is also important. Some substances resist breakdown and remain in the environment a long time and can have long-lasting harmful effects.
  - c. Bioaccumulation is a third factor. Molecules are absorbed and stored in the body at higher than normal levels.
  - d. Biomagnification is where toxins accumulate at greater levels as they are moved up from one trophic level to the next higher one.
  - e. Chemical interactions can decrease or multiply the harmful effects of a toxin. An antagonistic interaction reduces the harmful effect while a synergistic interaction multiplies the harmful effects.
3. The effects of a chemical can be chronic or acute. An acute effect is immediate; a chronic effect is a long-lasting consequence from exposure to a harmful substance. The type and amount of health damage from exposure to a chemical is called the response.
4. The basic concept of toxicology is that any synthetic or natural chemical can be harmful if ingested in a large enough quantity.
5. The critical question is how much exposure to a particular toxic chemical causes a harmful response? It is different for each individual.
6. The body has three major mechanisms for reducing the harmful effects of some chemicals:
  - a. It can break down, dilute, or excrete small amounts of most toxins to keep them from reaching harmful levels.
  - b. Certain enzymes can sometimes repair damage to DNA and protein molecules.
  - c. Cells in certain parts of the body (skin, gastrointestinal tract, lungs and blood vessels) can reproduce fast enough to replace damaged cells.
7. A poison or toxin is a chemical that adversely affects the health of a human or animal by causing injury, illness, or death.
- B. Trace amounts of chemicals in the environment or your body may or may not be harmful. Should we be concerned about trace amounts of various chemicals in air, water, food, and our bodies? The honest answer is we do not know.
  1. Some scientists think that trace levels of most chemicals are not harmful.
  2. Other scientists feel we need to evaluate the long-term harm caused by exposure to low doses of many new synthetic chemicals.
  3. Natural chemicals in the environment are sometimes thought to be safe, but this is a false impression since nature has an arsenal of harmful chemicals for defense also.
- C. Under existing laws, most chemicals are considered innocent until proven guilty, and estimating their toxicity to establish guilt is difficult, uncertain, and expensive.
- D. Some scientists and health officials say that preliminary but not conclusive evidence that a chemical causes significant harm should spur preventative action but others disagree.
  1. Some scientists, especially those in European Union countries, are pushing for much greater emphasis on pollution prevention, which is based on the precautionary principle.
  2. In 2000, negotiators in the European Union agreed to a global treaty that would ban or phase out use of 12 of the most notorious persistent organic chemicals (POPs), also called the dirty dozen.
  3. Manufacturers and businesses contend that widespread application of the precautionary principle would make it too expensive and almost impossible to introduce any new chemical or technology.

#### Risk analysis

- A. There are scientific ways to evaluate and compare risk, to decide how much risk is acceptable, and find affordable ways to reduce risk.
  1. Risk assessment involves identifying hazards and evaluating their associated risks.
  2. In terms of premature deaths per year and reduced life span, the greatest risk by far is poverty.

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3. Reducing poverty would improve human rights, provide more people with income to stimulate economic development, and reduce environmental degradation and the threat of terrorism.
4. Avoidance of cultural hazards also improves longevity of life.
- B. Estimation of risk for complex technology is difficult due to unpredictability of human behavior, human error, and sabotage.
  1.  $\text{System reliability (\%)} = \text{Technology reliability} \times \text{Human reliability}$ .
  2. One way to make a system more foolproof or failsafe is to move more of the potentially fallible elements from the human side to the technical side.
  3. Chance events can still cause problems.
- C. Most individuals are poor at evaluating the relative risks they face, mostly because of misleading information, denial, and irrational fears. Factors that impact our sense of evaluating risk include
  1. The degree of control we have.
  2. The fear of the unknown.
  3. If the risk is voluntary rather than forced we will have a different view of the risk itself.
  4. The catastrophic or chronic nature of the risk will also influence our perception of it.
  5. There is also concern over the unfair distribution of risks, such as the danger associated with putting a hazardous waste landfill or incinerator in or near their neighborhood.
- D. We can carefully evaluate or tune out of the barrage of bad news covered in the media, compare risks, and concentrate on reducing personal risks over which we have some control.
  1. Recognize that everything is risky.
  2. Recognize that the media often give an exaggerated view of risks.
  3. Compare risks and evaluate the risk of an action compared to other risks.
  4. Concentrate on the most serious risks to life and health and do not worry about the small risks and those over which you have little or no control.

#### **Summary**

1. Major types of hazards faced by humans include cultural, physical, chemical, and biological hazards.
2. Toxicology is the scientific field that measures the degree of harm a hazardous agent can cause. Scientists measure toxicity based on dosage, solubility, persistence, bioaccumulation, biomagnification, and chemical interactions.
3. Chemical hazards include agents that are flammable or explosive, damage or irritate lungs or skin, interrupt oxygen uptake, and cause allergies. Chemical hazards are defined by their toxicity, the person’s acute and chronic reactions to it, and its pervasiveness in the environment.
4. The types of disease threatening people in developing countries are primarily infectious diseases of childhood while those threatening people in developed countries tend to be chronic diseases of adults, such as heart disease, stroke, cancer, and respiratory conditions.
5. Risks can be estimated, managed, and reduced by identifying hazards, evaluating related risks (risk assessment), ranking risks (comparative risk analysis), determining alternative solutions, making decisions about reducing risks (risk management), and informing decision-makers about risk (risk communication).

#### **Objectives**

1. Define *risk*, *probability*, and *risk assessment*. List four general types of common hazards and give two examples of each. Describe the relationship between health and the American workplace.
2. Define *dose* and *response*. Distinguish among acute and chronic exposures. Distinguish among acute and chronic effects. Summarize three methods used to enhance our understanding of toxicity of chemicals.

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3. Define a *dose-response curve*. Distinguish between a linear dose-response model and a threshold dose-response model. Describe the difficulty in deciding which model applies best when low doses are involved. Assess the limits of toxicological research.
4. List five principal types of chemical hazards and give two examples of each.
5. Define *mutagen*, *teratogen*, and *carcinogen*. Summarize current research implying chemical effects on the immune, nervous, and endocrine systems.
6. Distinguish between transmissible and nontransmissible diseases. Summarize current states of the fights against tuberculosis, malaria, and infectious bacteria.
7. Summarize steps to improve health in developing countries.
8. Summarize key questions to be answered in risk-benefit analysis, risk assessment, and risk management. What are the useful applications and limits of these analyses?
9. List several cases in which the public generally perceives that a technology or product has a greater risk than the risk estimated by experts.

Key Terms (**Terms are listed in the same font style as they appear in the text.**)

<i>acquired immune deficiency syndrome (AIDS)</i> (p. 418)	<i>conservation medicine</i> (p. 425)
<i>acute effect</i> (p. 430)	<i>cultural hazards</i> (p. 419)
<i>Anopheles</i> mosquito (p. 423)	<i>degree of control</i> (p. 436)
<i>antagonistic interaction</i> (p. 430)	<i>dirty dozen</i> (p. 433)
<i>bioaccumulation</i> (p. 430)	<b>dose</b> (p. 429)
<i>biological hazards</i> (p. 419)	<i>ecological medicine</i> (p. 425)
<i>biomagnification</i> (p. 430)	<i>endocrine system</i> (p. 426)
<i>bioterrorism</i> (p. 420)	<i>epidemic</i> (p. 420)
<b>carcinogens</b> (p. 426)	<i>gender benders</i> (p. 427)
<i>chemical hazards</i> (p. 419)	<i>genetic makeup</i> (p. 429)
<i>chemical interactions</i> (p. 430)	<b>hazardous chemical</b> (p. 426)
<i>chronic effect</i> (p. 430)	<i>hepatitis B virus (HBV)</i> (p. 422)
<i>comparative risk analysis</i> (p. 433)	<i>hormonally active agents (HAAs)</i> (p. 426)
<i>hormone blockers</i> (p. 426)	<i>Plasmodium</i> (p. 423)
hormone disrupters (p. 428)	<b>poison</b> (p. 431)
<i>hormone mimics</i> (p. 426)	<i>pollution prevention</i> (p. 432)
<i>hormones</i> (p. 426)	<i>possibility</i> (p. 419)
<i>human immunodeficiency virus (HIV)</i> (p. 418)	<i>precautionary principle</i> (p. 432)
<i>human immunodeficiency virus (HIV)</i> (p. 422)	<i>probability</i> (p. 419)
<i>immune system</i> (p. 426)	<b>response</b> (p. 430)
<b>infectious disease</b> (p. 419)	<b>risk</b> (p. 419)
<i>influenza (flu)</i> (p. 421)	<i>risk analysis</i> (p. 433)
<i>Kaposi’s sarcoma</i> (p. 418)	<b>risk assessment</b> (p. 419)
<b>metastasis</b> (p. 426)	<i>risk assessment</i> (p. 433)
methyl isocyanate (MIC) (p. 428)	<i>risk communication</i> (p. 433)
<i>multiple chemical sensitivity (MCS)</i> (p. 430)	<i>risk management</i> (p. 419)
<b>mutagens</b> (p. 426)	<u>Severe acute respiratory syndrome (SARS)</u>
mutations (p. 426)	<u>virus</u> (p. 423)
<i>nervous system</i> (p. 426)	<i>synergistic interaction</i> (p. 430)
<i>neurotoxins</i> (p. 426)	<b>teratogens</b> (p. 426)
	<i>thyroid disrupters</i> (p. 427)

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<b>nontransmissible disease</b> (p. 419) <i>oil (fat) soluble toxins</i> (p. 430) <i>oral rehydration therapy</i> (p. 425) <i>pandemic</i> (p. 420) <i>persistence</i> (p. 430) <i>persistent organic pollutants (POPs)</i> (p. 433) <i>phthalates</i> (p. 428) <i>physical hazards</i> (p 419)	<b>toxic chemical</b> (p. 426) <b>toxicity</b> (p. 429) <b>toxicology</b> (p. 429) <b>toxin</b> (p. 431) <b>transmissible (infectious) disease</b> (p. 419) <i>water-soluble toxins</i> (p. 430) <i>West Nile virus</i> (p. 423)
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