Case Study: Toxic Air Pollution and Human Health: Story of a Southeast Houston Neighborhood

This case study addresses the problems caused by emissions from petrochemical processing and their effects on nearby residents, particularly children. Studies demonstrated that the areas near the Houston Ship Channel and the petrochemical plants along it were releasing benzene and 1,3-butadiene, and those areas with highest concentrations had the highest incidence of childhood leukemia. Since the residents moved in after the plants were built, and the plants are within legal limits of emission, it presents a difficult legal and ecological problem and an interesting source for discussion, as would the fact that Texas has no air standards for toxins emitted by the petrochemical industry.

Chapter 8

ENVIRONMENTAL HEALTH AND TOXICOLOGY

8.1 SOME BASICS

● Environmental Health

Environmental health is a broad field encompassing factors of the environment that can cause or promote disease. Disease is an impairment of an individual's well being and ability to function. The incidence of a disease depends on several factors, including the physical and biological environments and lifestyle. A "gray zone" of sub-optimum health exists between total health and full-blown disease; exposure to pollutants, such as in Houston in the Case Study, may produce ill effects without leading to a demonstrable disease in strict medical terms. Symptoms such as headache, which can be caused by chemical exposure, are nonspecific and can be attributed to other causes.

The common assumption that natural waters, air, and soil are healthful and incapable of causing disease is false. Environmental risks are both anthropogenic and natural. Natural sources of pollution such as the Lake Nyos CO_2 release in Cameroon in 1986 killed more than 1,800 people and is an example of how risky nature can be. (This was the subject of the television show Nature Shock: Death Fog.)

● Terminology

Pollution refers to the occurrence of an unwanted environmental change caused by the introduction of harmful materials, such as dioxins, or the production of harmful conditions, such as heat; contamination implies making something unfit for use by the introduction of undesirable materials; toxicology is the science that studies chemicals that are known to be or could be toxic; a carcinogen is a toxin that increases the risk of cancer.

● Synergism

A synergism is an interaction between two or more substances such that the combined effect differs from that of either substance alone. Research into synergistic effects is hampered by its sheer magnitude as well as difficulty in standardizing doses and exposures.

● Point, Area, and Mobile Sources

Point sources of pollution can be isolated to a specific point, such as a sewer pipe outflow, while nonpoint sources are multiple and scattered, such as litter and oil runoff from roads. Mobile sources of pollution include trains, airplanes, cars, and others.

As a point source example, the text discusses the smelters that refine nickel and copper ores at Sudbury, Ontario. New regulations in 1969 forced the operators of Sudbury smelters to improve local air quality, which

was accomplished by raising the heights of the smokestacks (dilution is the answer to pollution). However, the SO_x emissions were carried over great distances and caused acid rain. As a result of years of pollution, nickel has been found to contaminate soils 50 km from the stacks. This and the acid rain have devastated the surrounding vegetation. The Ontario government then set standards to reduce emission to about 14% of earlier levels. The environment now is recovering, and this is a positive example of pollution reduction.

● Toxic Pathways

Toxins can make their way into the human body through numerous pathways. These can involve biomagnification. The two main categories of substances that biomagnify are persistent organic pollutants, such as DDT, and metals, such as cadmium and lead.

Mercury in aquatic systems provides a specific example of biomagnification. Hg is present in coal in small amounts and is released into the atmosphere when coal is burned. The Hg is then deposited onto the land surface and makes its way into rivers and lakes. The Hg is methylated by bacteria in sediments and in this form is far more toxic than elemental mercury. Methyl mercury enters the food chain and biomagnifies at each tropic level. Several major incidents of methyl mercury poisoning have been recorded, including the famous Minamata Bay case, discussed in A Closer Look 8.1.

8.2 CATEGORIES OF POLLUTANTS AND TOXINS

● Infectious Agents

Diseases classified as infectious are those that involve living organisms or viruses invading or colonizing the body. These diseases may involve ingestion of the organisms themselves or of toxins released by such organisms into food or other materials. Control of disease vectors, prevention of infection, and the use of antibiotics and vaccines are important control mechanisms. Emerging diseases such as hantavirus and West Nile virus pose serious potential for epidemics. Global climate change may increase spread of tropical diseases such as dengue fever and malaria to a wider range of areas.

Diseases that can be controlled by manipulating the environment are classified as environmental health concerns. In developing countries the greatest mortality is from infectious disease, not from toxins or carcinogens. Some examples of environmentally transmitted diseases are legionellosis (Legionnaires' disease), giardiasis (protozoan), salmonella, malaria, Lyme borreliosis, cryptosporidiosis (protozoan) and anthrax (a past and future terrorist threat).

● Toxic Heavy Metals

The major heavy metals that pose health hazards to people and ecosystems include mercury, lead, cadmium, nickel, platinum, bismuth, arsenic, selenium, vanadium, chromium and thallium. Heavy metals often have direct physiological toxic effects. Some are stored in living tissue, particularly fatty tissue and bone, the quantity of which is called a body burden. Students generally "enjoy" examining a list of metals and pesticides found in their bodies!

> A Closer Look 8.1: Mercury and Minamata, Japan
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> A number of people died from consuming tainted fish from the bay where chemical maker Chisso Corporation, a vinyl chloride factory, used Hg in its production processes and discharged Hg into the Minamata Bay for years. The Hg was methylated by bacteria in the sediments and entered the marine food chain. Fish from the bay was an important part of the local diet. In the end and estimated 3,000 people were affected and almost 1,800 died. This case illustrates four factors that must be considered in evaluating toxins: (1) individuals vary in the response to exposure; (2) pollutants may have a threshold; (3) some effects are reversible; and (4) the chemical form of a pollutant, its activity, and its potential to cause health problems may be changed by ecological and biological processes.

● Organic Compounds

These include molecules containing carbon and hydrogen atoms, and may be natural or synthetic. Synthetic organics are used for many purposes such as pharmaceuticals, pesticides, and food additives. They also include the HAAs that were discussed earlier. Humans have produced over 20 million synthetic chemicals, and new ones are appearing at a rate of about 1 million per year, though most of these are not produced commercially.

Persistent organic pollutants (POPs) have the following characteristics: they often contain a highly reactive chlorine atom, they are usually synthetic, they do not easily or quickly degrade, they are polluting and toxic, they are fat soluble, and they occur in forms that allow them to be transported by wind, water and sediments. Polychlorinated biphenyls (PCBs) once used in the electronics industry is a notorious example of a toxic POP that has made its way into the food chain, biomagnifies, and is still present years after its production was stopped.

Dioxin is a colorless chlorinated hydrocarbon that is very toxic. Dioxin is produced as a byproduct of several industrial processes, including the production of chlorinated herbicides. Dioxin is an expected carcinogen, but its actions in the human body are not well known. Studies of animals suggest that fish, birds and other animals are extremely sensitive to its effects. The EPA has set an acceptable intake of dioxin at 0.006 pg/kg/day, though this level is controversial. Dioxin is stable, long-lived, and is accumulating in the environment. There is no known remediation technology that is economical, safe and reliable.

● Hormonally Active Agents (HAAs)

The HAAs deserve closer inspection and further study. These chemicals enter the body and mimic or obstruct natural hormones, making them extremely disruptive to body functions and cycles. Pesticides, including herbicides, are found in alarming concentrations in the environment and in the tissues of all organisms, including humans. Plastics that are chlorine-based leak plasticizers (phthalates) are also suspect, and little is known about them.

There is evidence that these compounds are affecting the reproductive systems of numerous organisms. The data on declining sperm counts in humans, possibly linked to exposure to HAAs, is controversial and not conclusive. These compounds are also suspected of playing a role in breast cancer.

> Case Study: Demasculinization and Feminization of Frogs
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> This is a case study of freak abnormalities beginning to appear in common species around us. A variety of pollutants are the suspected causative agents. In the case of the leopard frogs in the Midwest, 10-92 percent of male frogs exhibit gonadal abnormalities that are thought to be caused by the common herbicide atrazine. The atrazine is believed to activate a gene that turns testosterone to estrogen. Atrazine is one of a growing group of chemicals that are referred to as xenoestrogens, or compounds that mimic or alter the activity of estrogen, also known as hormonally active agents (HAAS). This example dramatizes the importance of evaluating the role of human-made chemical in the environment.

● Nuclear Radiation

Nuclear Radiation is a class of pollutant that is discussed in more detail in later Chapters.

● Thermal Pollution

The release of hot water from thermal power plants can raise the temperature of the aquatic environment and have adverse effects on the biota. Thermal pollution occurs when heat released into water or air produces undesirable effects such as disturbances to fish spawning, depleted dissolved oxygen, and fish kills. The release can be acute or chronic. Solutions to thermal pollution from power plants include cooling ponds and towers.

● Particulates

Particulates are small particles of dust (such as soot) released by natural or anthropogenic sources. The EPA estimates that the Clean Air Act's reduction of airborne particulates has prevented over 160,000 cases of health complications (http://www.epa.gov/oar/sect812/prospective2.html).

● Asbestos

Asbestos is a term applied to several fibrous minerals that have been used for decades as a fire retardant and as insulation. Breathing asbestos fibers can cause inflammation as well as mesothelioma, a rare lung cancer. About 95% of the asbestos is white asbestos from the mineral chrysolite, which is not particularly dangerous, and the movement to remove it from buildings and homes at great expense was probably an overreaction. In contrast, exposure to crocidolite asbestos (blue asbestos) is quite harmful. There are additional harmful forms of asbestos, including contamination of other products such as vermiculite.

● Electromagnetic Fields

The radiation from electromagnetic fields (EMFs) deserves further study. Despite the many studies that have evaluated relationships between cancer and exposure to EMFs the jury is still out if there is a correlation.

● Noise pollution

The intensity of the energy carried by sounds waves is measured in units of decibels (dB). The threshold for human hearing is 0 dB, the average level in a home is 45 dB, an automobile is 70 dB, and a jet aircraft taking off is about 120 dB. A 10-fold increase in the strength of a sound adds 10 dB. The decimal field is logarithmic. Noise pollution can range from annoying to physically damaging, as permanent loss of hearing can result from

extended exposure to 110 dB (the strength of amplified music) as well as from sudden traumatic exposure such as an explosion. Quieter sounds, while not being directly destructive, can result in sleep loss and irritability.

Critical Thinking Issue: Is Lead in the Urban Environment Contributing to Antisocial Behavior?

Lead (Pb) is one of the most common and oldest forms of pollution. A study of children concluded that attention deficit disorder, aggression and delinquency were related to the concentration of Pb in bones. The study controlled for factors such as maternal intelligence, socioeconomic status, and the quality of child rearing. The implication of the study is that Pb toxicity may play a role in urban crime.
Are there other factors besides those mentioned that might explain the effect of Pb? What are the assumptions and are they reasonable?