Effects of Use and Disposal of Pure Substances and Mixtures on the Environment

Here is a summary of what you will learn in this section:
- Careless use and disposal of pesticides has a harmful effect on the environment.
- The release of raw sewage has a negative effect on waterways.
- Disposal of industrial substances and mixtures, as well as by-products of industrial processes, has a negative impact on the environment.

The headlines screamed, “Raw sewage streams into Toronto creeks.” Of course, everyone was concerned and wondered how this could happen. Raw sewage can make people sick and it can also damage the environment. Upon further investigation, it was revealed that cities across Canada treat their sewage differently. Partially treated sewage is regularly discharged into the waterways around many large urban centres in Canada.

C42 Starting Point

Dilution versus Pollution

Many pure substances and mixtures have very little impact when they occur at very low levels. For example, chlorine can be diluted to allow people to swim safely in a pool. However, other substances retain the ability to harm even in very small concentrations.

Starting with blue food colouring that is 87 percent blue dye by volume, do the following:
- Add 1 mL of blue food colouring to 99 mL of tap water (Figure 9.16).
- Collect 1 mL of the resulting solution and add it to another 99 mL of tap water.
- Repeat the process until you can no longer see the blue colour.

Consider This

1. After how many dilutions can you no longer see the blue colour?
2. Some substances are toxic at levels of less than one part per million. If the blue dye were toxic, do you think dilution with water would be an effective treatment method?

Figure 9.16 The blue food colouring represents a toxic substance.
Sewage and Waste Water Treatment

Sewage is the liquid waste water from toilets, baths, showers, and sinks. The water may also contain run-off from roofs, urban green spaces, and roadways, and liquid waste from industries. It is treated at a waste water treatment plant, and the treated water is eventually returned to the environment. Figure 9.17 illustrates that waste water treatment usually involves a three-stage process that includes mechanical, biological, and chemical treatments.

Primary, Secondary, and Tertiary Treatment

Water flowing into the treatment plant is full of solids that must be removed before further processing. Primary treatment involves separation of a mechanical mixture, including removal of suspended solids, rocks, sand, and grit. It allows heavy matter in the mixture to settle to the bottom of a sedimentation tank before moving on to secondary treatment. The solid matter that settles at the bottom of the tank is called sludge.

Secondary treatment is a biological process involving aeration, which mixes waste water and sludge with large volumes of air. Living organisms, such as bacteria and protozoa, help to break apart larger clumps. This finer material then drops to the bottom of retention tanks and is removed.
Tertiary treatment involves application of chemicals, such as chlorine, to disinfect and kill remaining germs, and to remove phosphates. Other treatments include exposure to high-intensity ultraviolet (UV) light and treatment with ozone gas, which also kill germs.

Any sludge remaining at the end of the process must be disposed of. This can involve bacterial action, burial, or incineration (burning).

**Environmental Impact**

In Canada, completely treated waste water is usually safe to return to the environment. However, during periods of heavy use or very rainy weather, water treatment plants become overwhelmed and waste water is not retained long enough to ensure purity. This commonly leads to the release of contaminated water. Recent upgrades to waste water treatment plants in Ontario have greatly increased the capacity to store and treat waste water effectively.

**Pesticides**

As you learned at the beginning of this chapter, farmers use pesticides, such as insecticides and herbicides, to protect their crops. Home-owners often use insecticides to maintain their lawns and gardens. Farmers use herbicides to control weeds to enable the maximum growth of crops (Figure 9.18). However, the widespread use of pesticides has had a significant impact on the environment.

**Residues**

According to environmental studies, almost every lake, river, and stream in the more populated areas of North America contains varying levels of pesticide residues. These are chemicals that come from pesticides.

Residue levels are very low in some areas, but in waterways that flow into the Great Lakes, the level of pesticide contamination is significant. The Ontario Ministry of the Environment recommends that, “Women of childbearing age and children under 15 should restrict their consumption of most sport fish caught in Ontario waters and some freshwater fish should not be consumed at all.”
It is difficult to prevent pesticides from entering our water supply. Figure 9.19 shows ways that pesticides can move into water supplies. For example, some chemicals are introduced through percolation where they seep into the ground and later enter a water supply. As the liquid chemicals move through the ground, leaching may occur. Leaching is a process in which soluble parts of a substance are separated out. Another example is pesticide drift. When pesticides are sprayed over an area, the wind can carry the chemical particles out over water. When they settle in the water, they may build up in harmful concentrations that can damage the environment for years.

Environmental Impact
The effects of pesticide use have been noted in farmers, in the environment, and in residues found in foods. Farmers have reported headaches, dizziness, and vomiting as a result of using pesticides that are considered safe. Long-term health problems include respiratory and digestive problems, memory disorders, and skin and eye problems.

Environmental contamination from pesticides has led to fewer kinds of living things in soil and waterways. This means that plants and animals that were native to an area are now either completely gone or greatly reduced in numbers. Also, many fruits (e.g., apples, oranges) and vegetables (e.g., lettuce, spinach) may contain pesticide residues or have residues present on their surfaces.

Using a Procedural/Sequential Pattern
List, in sequential order, all the pure substances and mixtures you have used since you woke up this morning. Much of what we use in a day produces some form of waste product, such as paper waste or water waste. Re-examine your list and think about ways you could reduce the amount of waste you produce. Use your ideas to write a procedural paragraph outlining an action plan that could reduce the waste products created at your school. Remember to include signal words appropriate to this type of writing.
Disposal of Pure Substances and Mixtures

Burlington Bay, located in the extreme west of Lake Ontario, is an example of the influence of industry on the landscape (Figure 9.20). The water, air, and environment have been polluted by steel manufacturers for years. An unknown amount of industrial waste material has been released into the environment by the steel industry since it began in Hamilton nearly 100 years ago. The amount of waste is surely very large, but we are still just learning about its effect on the environment and human health.

Sudbury is another example of an area damaged by the disposal of industrial waste mixtures. Much of the land has been damaged by acid rain, which is caused by sulphur released into the air (Figure 9.21). In addition, a by-product of nickel and copper smelting is slag (a mixture of waste rock), which was discarded over a large area of land in the greater Sudbury area. This damaged the natural environment.

Landfills

Household solid waste, including garbage and waste from lawns and gardens, is usually disposed of in large landfills (Figure 9.22). A landfill is an area where garbage is disposed of and buried under layers of soil. Many items pose no hazard with this type of storage. However, many hazardous liquids are not suitable for landfill and must be treated in another manner. For example, some oil-based paints contain lead, which is a very toxic pure substance. Latex paint does not contain lead and is safe for disposal in a regular landfill.

Hazardous chemicals must be stored in special sites for the disposal of hazardous wastes. Examples include mercury, a pure substance found in fluorescent light bulbs, and cadmium, a pure substance found in rechargeable batteries. Disposal sites for hazardous wastes are specially constructed to contain dangerous solid and liquid substances. These sites are sealed to prevent the movement of ground water, which could carry harmful liquids into wells and other drinking water sources.
Nuclear Energy and Uranium

Uranium is the fuel source most commonly used in generating electricity from nuclear power (Figure 9.23). The uranium is not burned like fossil fuels, so there is no release of air pollution or carbon dioxide. Instead, energy is released in a controlled nuclear reaction. However, the use of uranium as a fuel source for nuclear power has some significant social and environmental implications.

Uranium is not uncommon in Earth’s crust. In fact, it can be found in small amounts in most rocks, dirt, and in the oceans. However, to be used as a fuel source, uranium must be concentrated and purified. Uranium is radioactive. A radioactive substance releases energy in the form of radiation. This radiation can be harmful. Uranium fuel must be produced carefully to avoid harming workers and the environment.

Storage and Disposal

Typically, the uranium used as a fuel source can last for a period of about six years. The spent fuel must be stored temporarily in a large pool of water, where it cools and loses some of its radioactivity. After about five years in a spent fuel pool, the uranium is cool and stable enough for transportation to a reprocessing site. About 95 percent of the uranium can be reprocessed and used again as fuel. Unfortunately, the remaining 5 percent remains dangerously radioactive and must be prepared carefully for long-term storage.

Waste uranium material from nuclear power generation remains dangerously radioactive for a very long time. Some estimates suggest that spent nuclear fuel will pose a hazard for at least 10,000 years. Given that an average nuclear power plant produces up to 30 tonnes of waste fuel per year, the safe disposal of nuclear fuel is a very large problem. Some radiation and environmental experts recommend storage of spent nuclear fuel in deep underground deposits that can be monitored for leakage. The actual uranium fuel would first be sealed in dry storage casks made of steel and further encased in concrete containers, which would be moved to a final storage location, possibly kilometres underground.

Figure 9.23 Nuclear power plants generate electricity using uranium as fuel.