Water Pollution*

The Transmission of Infectious Diseases. Water that moves below the ground's surface undergoes a filtering that removes most microorganisms. For this reason, water from springs and deep wells is generally of good quality. The most dangerous form of water pollution occurs when feces enter the water supply. Many diseases are perpetuated by the fecal–oral route of transmission, in which a pathogen is shed in human or animal feces, contaminates water, and is ingested. The Centers for Disease Control and Prevention (CDC) estimates that in the United States 900,000 people become ill each year from waterborne infections. Globally, it is estimated that waterborne diseases are responsible for over 2 million deaths each year, mostly among children under the age of 5. This is the equivalent of 20 jumbo jets crashing every day and represents about 15% of all child deaths in this age group.

Examples of such diseases are typhoid fever and cholera, caused by bacteria that are shed only in human feces. About 100 years ago, the *Journal of the American Medical Association* reported that the typhoid fever mortality rate in Chicago had declined from 159.7 per 100,000 people in 1891 to 31.4 per 100,000 in 1894. This advance in public health had been accomplished by extending the city water supply intake pipes in Lake Michigan to a distance of 4 miles from shore. The medical journal commented that this diluted the sewage contaminating the water supply, which at that time was not treated further. This same article speculated on the need to remove microorganisms that caused specific diseases. They suggested the use of sand filter beds, already widely used in Europe at the time. Sand filtration mimics the natural purification of spring water. ***Figure 1*** illustrates the effect of the introduction of such filtration of water supplies on the incidence of typhoid fever in Philadelphia.

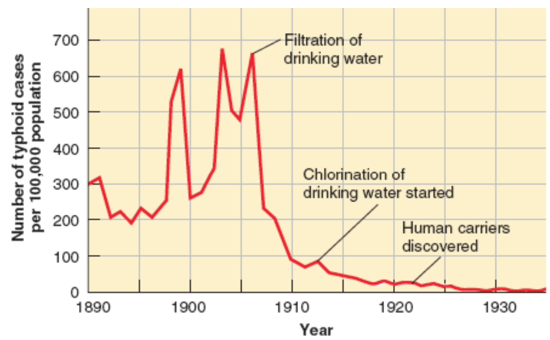

Figure 1*. The incidence of typhoid fever in Philadelphia, 1890–1935. This graph clearly shows the effect of water treatments on incidence of typhoid. Why did the incidence of typhoid fever decrease?*

Chemical Pollution. Preventing chemical contamination of water is a difficult problem. Industrial and agricultural chemicals leached from the land enter water in great amounts and in forms that are resistant to biodegradation. Rural waters often have excessive amounts of nitrate from agricultural fertilizers. When ingested, the nitrate is converted to nitrite by bacteria in the gastrointestinal tract. Nitrite competes for oxygen in the blood and is especially likely to harm infants.

A striking example of industrial water pollution involved mercury in wastewater from paper manufacturing. The metallic mercury was allowed to flow into waterways as waste. It was assumed that the mercury was inert and would remain segregated in the sediments. However, bacteria in the sediments converted the mercury into a soluble chemical compound, methyl mercury, which was then taken up by fish and invertebrates in the waters. When such seafood is a substantial part of the human diet, the mercury concentrations can accumulate with devastating effects on the nervous system. The U.S. Food and Drug Administration (FDA) advises that pregnant or nursing women not eat certain fish, including swordfish and shark, that are likely to contain high levels of mercury. Bioremediation efforts using bacteria to detoxify mercury were used in one wildlife refuge in Louisiana.

Another example of chemical pollution is the synthetic detergents developed immediately after World War II. These rapidly replaced many of the soaps then in use. Because these new detergents were not biodegradable, they rapidly accumulated in the waterways. In some rivers, large rafts of detergent suds could be seen traveling downstream. These detergents were replaced by biodegradable synthetic formulations.

Biodegradable detergents, however, still present a major environmental problem because they often contain phosphates. Unfortunately, phosphates pass almost unchanged through sewage systems and can lead to **eutrophication,** which is caused by an overabundance of nutrients in lakes and streams.

To understand the concept of eutrophication, recall that algae and cyanobacteria get their energy from sunlight and their carbon from carbon dioxide dissolved in water. In most waters, only nitrogen and phosphorus supplies, therefore, remain inadequate for algal growth. Both of these nutrients can enter water from domestic, farm, and industrial wastes when waste treatment is absent or inefficient. These additional nutrients cause dense aquatic growths called **algal blooms.** Because many cyanobacteria can fix nitrogen from the atmosphere, these photosynthesizing organisms require only traces of phosphorus to initiate blooms. Once eutrophication results in blooms of algae or cyanobacteria, the eventual effect is the same as adding biodegradable organic matter. In the short run, these algae and cyanobacteria produce oxygen. However, they eventually die and are degraded by bacteria. During the degradation process, the oxygen in the water is used up, killing the fish. Undegraded remnants of organic matter settle to the bottom and hasten the filling of the lake.

Red tides of toxin-producing phytoplankton (***Figure 2***) are probably caused by excessive nutrients from oceanic upwellings or terrestrial wastes. In addition to eutrophication effects, this type of biological bloom can affect human health. Seafood, especially clams or similar mollusks, that ingest these plankton become toxic to humans.

Figure 2. *A red tide. These blooms of aquatic growth are caused by excess nutrients in water. The color is from the pigmentation of the dinoflagellates.*
What is the primary energy source of the dinoflagellates that cause such aquatic blooms?

Municipal waste containing detergents is likely to be the main source of phosphates in lakes and streams. As a result, phosphate-containing detergents and lawn fertilizers are banned in many places.

Coal-mining wastes, particularly in the eastern United States, are very high in sulfur content, mostly from pyrite (FeS_2). In the process of obtaining energy from the oxidation of the ferrous ion (Fe^{2+}), bacteria such as *Thiobacillus ferrooxidans* convert the FeS_2 into sulfate. The sulfate enters streams as sulfuric acid, which lowers the pH of the water and damages aquatic life. The low pH also promotes the formation of insoluble iron hydroxides, which form the yellow precipitates often seen clouding such polluted waters.

Questions

1. Use Figure 1 to explain how waterborne diseases can best be eliminated.
2. Algae are important in the aquatic food chain and produce most of the O_2 that we breathe, so how can algae kill fish?
3. Why are phosphates banned in detergents in California?

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* G. Tortora, B. Funke, C. Case. 2010. *Microbiology: An Introduction*. San Francisco: Benjamin Cummings.