Aquatic Microbiology and Sewage Treatment

Aquatic Microorganisms

Aquatic microbiology refers to the study of microorganisms and their activities in natural waters, such as lakes, ponds, streams, rivers, estuaries, and the sea. Large numbers of microorganisms in a body of water generally indicate high nutrient levels in the water. Water contaminated by inflows from sewage systems or from biodegradable industrial organic wastes is relatively high in bacterial counts. Similarly, ocean estuaries (fed by rivers) have higher nutrient levels and hence higher microbial counts than other shoreline waters.

In water, particularly in water with low nutrient concentrations, microorganisms tend to grow on stationary surfaces and on particulate matter. In this way a microorganism has contact with more nutrients than if it were randomly suspended and floating freely with the current. Many bacteria whose main habitat is water have appendages and holdfasts that attach to various surfaces. One example is *Caulobacter* (see Figure 11.15a). Some bacteria also have gas vesicles that they can fill and empty to adjust buoyancy.

FRESHWATER MICROBIAL FLORA

Figure 27.6 shows a typical lake or pond that serves as an example to represent the various zones and the kinds of microbial flora found in a body of fresh water. The **littoral zone** along the shore has considerable

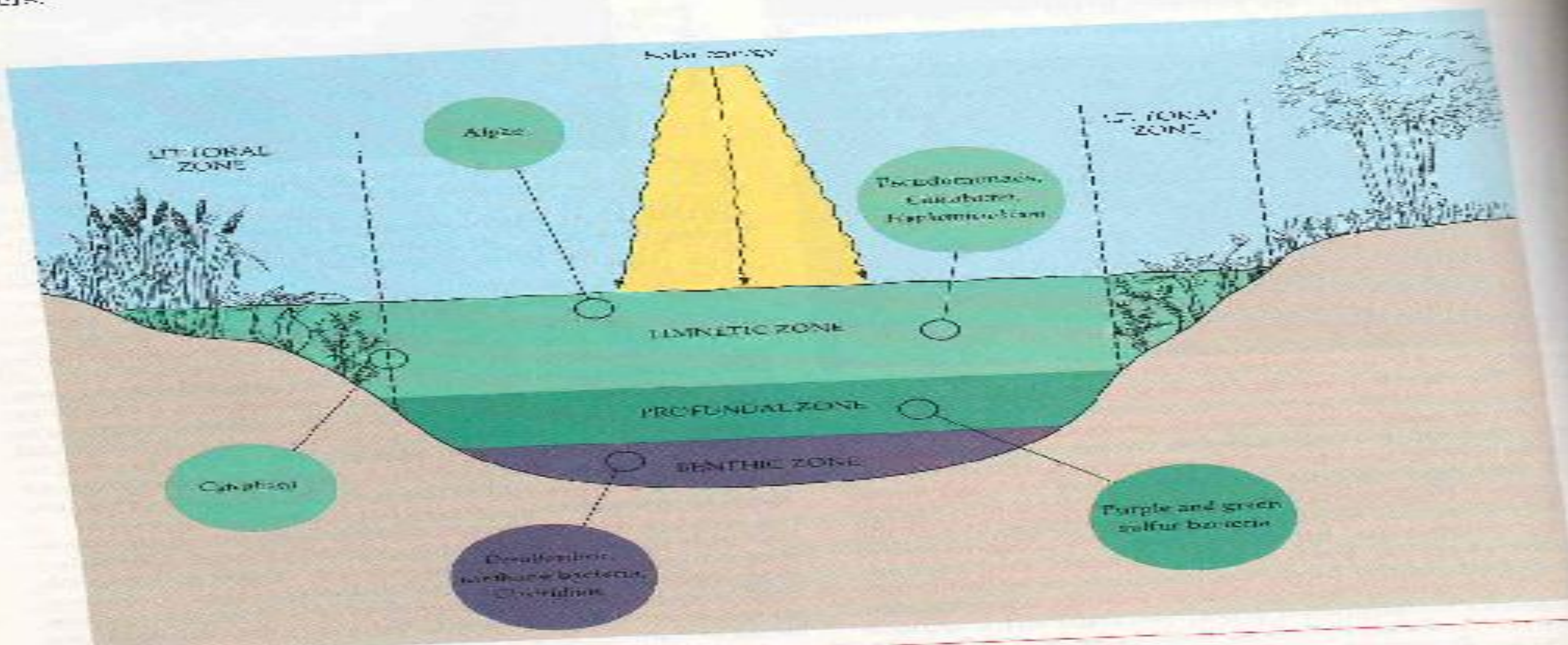

FIGURE 27.6 The zones of a typical lake or pond and some representative microorganisms of each zone. The microorganisms fill niches that vary in light, nutrients, and oxygen availability.

TABLE 27.2 Waterborne Disease Outbreaks in Public Water Systems, 1986 to 1988

AGENT	NUMBER OF OUTBREAKS	NUMBER OF CASES
Shigella spp.	4	2733
Salmonella spp.	2	70
Campylobacter spp.	1	250
Giardia lamblia (cyst-forming protozoan)	9	1169
Cryptosporidium spp. (sporeforming protozoan)	1	13,000
Acute gastrointestinal illness of unknown etiology	24	2975

Source: *Surveillance Summaries, MMWR* 39:SS-1 (March 1990).

water supply. Many diseases are perpetuated by the fecal–oral route of transmission, in which a pathogen shed in human feces contaminates water or food and is later ingested (see Chapter 25). Typical of these diseases are typhoid fever and cholera, which are caused by bacteria, and hepatitis A, which is caused by a virus. An especially troublesome waterborne disease is diarrhea caused by ingestion of cysts of the protozoan *Giardia lamblia*. This protozoan is a problem not only in municipal water systems but also in mountain streams, which are contaminated by beavers and other animals. Mollusks that feed by filtering tend to concentrate waterborne viruses and bacteria in their tissues, so mollusks from polluted water may be dangerous to eat.

Not all pathogens must be ingested to cause disease. For example, the helminthic disease schistosomiasis is spread among persons who swim or wade in waters contaminated by human wastes. The pathogens are not usually ingested but are in the form of swimming cercaria that bore through the skin.

As good sanitation practices have nearly eliminated a few diseases, such as typhoid fever and cholera, in the United States, attention has focused on other waterborne diseases. Note in Table 27.2 that most outbreaks of waterborne bacterial diseases are now caused by *Shigella* species, which cause shigellosis (bacterial dysentery). There is some anxiety about pathogens such as *Legionella*, the cause of a pneumonia often spread by inhalation of water aerosols. *Mycobacterium* spp., *Pseudomonas* spp., and other opportunistic pathogens that are dangerous to immunosuppressed individuals are being found more and more often in tap water.

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. Many of these chemicals become biologically concen[illegible] trated in some of the organisms in the food chain.

A striking example of industrial water pollution involved mercury, used in the manufacture of paper. 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.

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 waters. In some rivers, large rafts of detergent suds could be seen traveling downstream; in some cities, a small head of bubbles might appear on the surface of a glass of water. These detergents were replaced in 1961 by new biodegradable formulations.

The new detergents, however, brought new problems. Substantial amounts of phosphates were added to many of these detergents to improve their effectiveness. Unfortunately, phosphates pass virtually unchanged through most sewage treatment systems and can cause eutrophication (*eu* means well, *troph* means nourish) of lakes and streams— an overabundance of nutrients, resulting in overgrowth of algae or cyanobacteria and the eventual death of other organisms.

To understand how phosphate pollution leads to eutrophication, we must first consider the nutritional requirements of algae and cyanobacteria. These organisms get their energy from sunlight and their carbon from carbon dioxide dissolved in the water. Most waters contain adequate amounts of the minerals required for algal growth, except for nitrogen and phos[illegible]