9.6: Wastewater Treatment

Although there are many kinds of wastewater depending upon where the water has been used, the most common wastewater treatment is applied to sewage consisting of water that has been through a municipal water distribution system. The most common contaminant of municipal wastewater consists of biodegradable organic matter, abbreviated $\{CH_2O\}$, usually biological material from human wastes or biomass flushed down the drain by garbage disposal grinders. When this biodegradable matter gets into the receiving waters where sewage effluent ultimately ends up, its biodegradation consumes dissolved oxygen as shown in Reaction 9.3.1. As noted in Section 9.3, biochemically degradable matter in water is said to exert a biochemical oxygen demand, BOD. The main objective of municipal wastewater treatment is reduction of BOD.

There are three main categories of sewage treatment: (1)primary treatment to remove solid objects, grit, and grease, (2) secondary treatment to reduce BOD, and (3) tertiary treatment to further refine the quality of the effluent water. Primary treatment is essentially self-explanatory and tertiary (advanced) treatment is addressed in more detail in Section 9.6 which discusses treatment of wastewater for recycling. The following is a brief discussion of secondary wastewater treatment.

Normally biological treatment with microorganisms is employed to remove BOD in secondary wastewater treatment. In fixed film bioreactors this is accomplished with a film of bacteria and protozoa immobilized on a support so that the microorganisms are alternatively exposed to wastewater and to air. One way in which this is done is with a trickling filter consisting of rocks coated with microorganisms onto which wastewater is drained from a rotating pipe with holes along the bottom edge. A second means is with microorganism-coated disks that rotate on a shaft so that half of each disk is immersed in water and the other half exposed to air at any given time.

The most widely used means of secondary wastewater treatment is the **activated sludge process** shown in Figure 9.7. In this process, biomass is degraded in a tank containing a relatively large mass of microorganisms kept suspended by air pumped into the bottom of the tank. This air serves as a continually renewed source of dissolved molecular oxygen in the water. In the aeration tank biodegradable organic material is acted upon by the microorganisms to produce biomass and carbon dioxide. As part of this process organically bound nitrogen, sulfur, and phosphorus are largely converted to simple inorganic species, such as NH_4^+ from organic nitrogen. The treated wastewater exits the tank after an appropriate residence time and goes to a settling basin in which the suspended mass consisting largely of bacterial and protozoal biomass called sewage sludge(now often given the less offensive term of biosolids) settles and the treated water is discharged. The settled sewage sludge is then pumped back to the front of the aeration tank to provide a constant high population of biodegrading organisms in the tank. As the process progresses, the mass of sewage sludge increases and the excess is transferred to an anoxic digester where it remains for some time and generates methane (CH_4) by anoxic fermentation in the absence of oxygen. The methane is used as a fuel and can be employed to run engines that power the plant. Spent sludge accumulates in the anoxic digester and requires disposal. The “greenest” means of disposal is to spread it onto farmland as fertilizer. Often it is incinerated, which requires significant amounts of supplemental fuel because the sludge has such a high water content.