THE SCIENCE OF WASTEWATER TREATMENT

MICROBIOLOGY AND BIOCHEMISTRY. The activated sludge environment is aquatic. The constant aeration, agitation, and sludge recirculation create an ideal environment for the numerous microorganisms present, while inhibiting the growth of larger organisms. Bacteria, fungi, protozoa, and rotifers are commonly found in activated sludge, though all may not exist in any single system. Nematodes are sometimes present. Despite the presence of other microorganisms, the bacteria are the significant organisms consuming the organic matter in wastewater. Algae rarely exist in mixed liquor because of their need for light.

Microbiology. From a microbiological standpoint, the predominant species of microorganism depend on the characteristics of the influent wastewater, environmental conditions, process design, and the mode of plant operation. The success of an activated sludge plant depends on cultivating a biological community that will remove and consume (assimilate) waste material, flocculate together, settle well to produce a concentrated sludge for recycling, and produce a clear effluent.

While the community of microorganisms in activated sludge is dominated by aerobic bacteria that require organic compounds to supply their carbon and energy (heterotrophic bacteria), there are also substantial populations of fungi and protozoa. Nitrifying bacteria that have the ability to use inorganic compounds for cell growth (autotrophic bacteria) are present in varying amounts depending on the mode of operation and nitrogen and carbon concentrations. Rotifers are most frequently found in systems with long aeration periods (6 to 30 hours) or, more properly, with SRTs longer than 10 days.

Biochemistry. The qualitative biochemical reaction for the stabilization of organic matter in the activated sludge process may be expressed as follows:

Inert matter **+** Organic matter **+** Oxygen **+** Nutrients **+** Microorganisms→
New microorganisms **+** Carbon dioxide **+** Water **+** Additional inert matter

The overall reactions occurring in the activated sludge process are determined by the composite metabolism of all the microorganisms in the activated sludge.

The metabolic process consists of the separate yet simultaneously occurring reactions of synthesis and respiration. Synthesis is the use of a portion of the waste matter (food) for the production of new cells (protoplasm); respiration is the coupled release of energy through the conversion of food material to lower energy-containing compounds, generally CO_2, H_2O, and possibly the various oxidized forms of nitrogen. The precise nature of the products formed depends to some extent on process design, including reaction time, temperature, and process loading.

The synthesis of protoplasm is reversible because the cells can also use their own protoplasm as food (substrate) to provide the energy needed to maintain life. This is known as endogenous respiration. Maintenance energy requirements exist independent of the presence of substrate outside the cell. When endogenous respiration predominates, the growth of the microorganisms does not cease, but is exceeded by cellular degradation. This results in a net decrease in the mass of microbial cells. The extended aeration process is one example of a process variation that can successfully operate in endogenous respiration.