

In the second method, activated sludge, the effluent from the primary tanks is mixed with a culture of organisms and then flows into aeration tanks, where the retention time is approximately six hours. The liquid is profusely aerated and agitated with compressed air. Instead of the bacterial growth clinging to a rock media and the water percolating through, as in the filtration process, the bacterial masses dispersed in the liquid grow rapidly and act as a coagulant for entraining the suspended solids. The same carbonaceous and nitrogenous cycles of reduction and oxidation take place here as in the filtration process.

The final stage of treatment is running the effluent from the filters or activated-sludge units through a final sedimentation tank to remove the settleable solids resulting from the previous processes. The effluent from this tank is chlorinated and discharged into the river or waterways.

It is very apparent that the processes of sewage treatment are basically bacteriological. Bacteria are specific. By that is meant that each type of bacteria has a specific function. For example, the various types of that break down protein to ammonia do nothing else. Other types are required to oxidize the ammonia to nitrites, and types entirely different from either of the two previously mentioned are required to oxidize the nitrites to nitrates. The same is true of the breakdown of the carbohydrates, and the subsequent oxidation of the carbonaceous compounds. In other words, each step in the biochemical process is caused by a specific type of organism. All microscopic organisms have their own limited range of environmental conditions under which they can thrive. When these conditions are not maintained, they either die or form spores, which are a dormant form. Fortunately, the undesirable, or disease-producing, bacteria are generally non-spore-forming bacteria and are easily killed when their environmental limitations are exceeded.

The two principle environmental factors are temperature and chemical. Bacteria that thrive best at 80 F are retarded at 60 F or 100 F. Those that thrive best at body temperature, 98.6 F, are grossly retarded at ± 10 deg, for example. They can, however, tolerate cold temperatures better than hot.

The story is about the same in a chemical environment. No bacteria can thrive in a strong acid or caustic environment. Most of them thrive best where the acidity, or alkalinity, is near the neutral point. Those that thrive best at a pH of 7.2 are retarded at a pH of 6.8, and vice versa. Considerable retardation of bacterial growth occurs at pH's of 6.6 and 7.6. A knowledge of the optimum pH range for the organisms being used is very important, because it provides the plant operator with an additional control parameter which may affect peak efficiency. The plant's efficiency is determined solely by maintaining the best possible conditions for growth of the organisms performing the treatment processes. Laboratory testing and control is necessary to attain this result. Bacteria can be killed in minutes, but it requires days and possibly weeks to restore the growth in the filters and aeration units.

With this basic background, let us try to apply it to the treatment of sewage on the average towboat.

TOWBOAT SEWAGE TREATMENT

Statistics indicate that the total number of people on boats on the inland waterways at any given time is approximately 55,000, with an average of eight per boat. The average amount of sewage is estimated at 30 gal. per person per day. This might be as high as 50 in some isolated instances, so, for the purpose of discussions let us use 40 gal per day per person.

Total flow per day, $8 \times 40 = 320$ gal per boat

$320 \text{ gal} \times 8.34 = 2669 \text{ lb}$ per boat

$\text{BOD} = 8 \times 0.25 = 2.0 \text{ lb}$ per boat

Solids $= 8 \times 0.2 = 1.6 \text{ lb}$ per boat

The average flow of the Ohio River at Cincinnati is 32,000 cfs, or 14.4 million gpm. The minimum is 6000 cfs, or 2.7 million gpm. At 2.7 million gpm, the dilution ratio is approximately 1:8450 if the entire 320 gal were pumped overboard within a minute. The BOD dilution ratio would be 1:11,259,000 (2 lb BOD/22,518,000 of water). If we assembled all 7000 boats on the inland waterways at Cincinnati, and they all discharged the daily accumulation of sewage simultaneously, 14,000 lb of BOD would represent a dilution ratio (based on the minimum river flow of 2,700,000 gal or 22,518,000 lb per minute) of 1:1608; under average flow conditions of 14,400,000 gpm, or 120,096,000 lb of water, it would be 1:8578. It