

3.2.5 Selection and control of the sludge age

In the previous sections it has been established that the most important operational parameter of the activated sludge system is the sludge age. Therefore attributing the correct value to this parameter is of great importance. A short sludge age as used in the so called high-rate processes ($F/M > 1$ to $2 \text{ g COD} \cdot \text{g}^{-1} \text{ VSS} \cdot \text{d}^{-1}$, i.e. $R_s < 1.5$ to 2 days) may allow almost complete utilisation of biodegradable material at higher temperatures, but the solids retention time is too short for extensive decay and associated endogenous respiration. Hence, the oxygen consumption in these processes will be low, whereas the sludge production is high (Fig. 3.4) and the fraction of active (biodegradable) sludge is also high (Fig. 3.8). For this reason, in high-rate processes the units for sludge treatment are large, whereas the reactor itself is relatively small (see also Chapter 8).

A disadvantage of a very short sludge age is that the predators of free bacteria (those not aggregated to flocs) do not have sufficient residence time to develop, so that the effluent quality is not very high: part of the active sludge will be discharged as free bacteria in the effluent. For that reason both BOD and VSS concentrations in the effluent will be relatively high. At longer sludge ages (above 5 to 8 days), the predators of free bacteria will develop and BOD and VSS concentrations can be very small (< 5 to $10 \text{ mg} \cdot \text{l}^{-1}$), if the final settler works properly.

In Europe and the United States many activated sludge systems were designed for operation at a very short sludge age in the 1970's and 1980's, even though the final effluent had a somewhat inferior quality. If the removal of organic material is the only or principal objective of an activated sludge system in regions with a warm climate, there is a very solid argument for using a short sludge age. The main disadvantage of a short sludge age is the high sludge production, but in tropical regions this can be used as an advantage: using anaerobic digestion (which can be applied at environmental temperatures), the large and highly biodegradable excess sludge mass can be converted into methane, which in turn may be used for power generation. This energy can then be used to cover the energy needs of the aeration process. Hence, it becomes possible to use the chemical energy of the organic material in the waste water in the treatment process. In principle the activated sludge process may even become independent of external energy sources. The quantitative aspects of this process are discussed in Chapter 8.

However, often the sludge age is not determined by considerations concerning the removal of organic material alone. Due to stricter legislation, in general the activated sludge system will also have to remove nutrients (nitrogen and phosphorus) and the removal of these constituents requires a certain minimum operational sludge age for the activated sludge system. In Chapters 4 and 5 the theory will be presented to determine this minimum sludge age. Once the sludge age has been selected, it is important to maintain the chosen value by an adequate discharge of excess sludge. This discharge can be directly from the reactor (so called hydraulic control of the sludge age) or from the return sludge flow. The latter option is much applied in practice, because the return sludge is always more concentrated than the mixed liquor in the reactor. Hence a smaller flow needs to be discharged to withdraw the same mass of solids.

The potential advantage of withdrawing sludge from the return sludge flow is non-existent when the sludge is thickened before being introduced to the unit of sludge treatment, as will be very often the case in practice. The thickened sludge concentration is independent of the influent concentration, so that the same concentration will be obtained after thickening from both mixed liquor and return sludge (Chapter 6).

On the other hand, hydraulic sludge age control has an important advantage over control by discharging from the return sludge flow. Due to variations in the influent flow, the flow of mixed liquor to the settler and the sludge mass in the settler vary considerably.

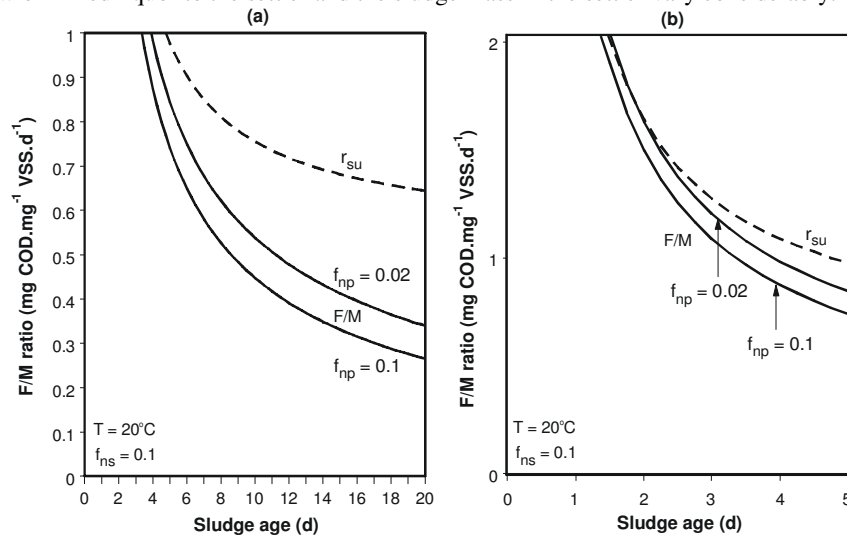


Figure 3.13 Typical daily profiles of the mixed liquor- and the return sludge concentration in an activated sludge system.

As an example, in Fig 3.18 typical profiles of the sludge concentrations in the mixed liquor and the return sludge are presented as a function of time (WRC, 1984). In the example above, the mixed liquor concentration oscillates around an average of 4.5 g.l⁻¹, whereas the maximum value of the return sludge concentration is more than twice as high as the minimum value. Hence the sludge mass in a unit volume of return sludge is highly variable and consequently precise sludge age control is difficult. The sludge concentration in the reactor is much less variable and largely independent of influent flow fluctuations. Thus sludge age control by direct discharge of excess sludge from the reactor is much more reliable.