

### 10.2.8 Influence of the sludge age

In the optimised design procedure presented in the previous examples, it was always assumed that the selected sludge age is always equal to the minimum required sludge age required for proper functioning of the processes involved. The design procedure will now be used to demonstrate that this is in fact a correct assumption. For several sludge ages the system parameters will be calculated in order to determine the quantitative effect of the sludge age on system design and costs.

#### **Example 10.8**

Use the data of Tables 10.6 and 10.7 to estimate the optimal sludge age for system A1, conventional secondary treatment (without nitrification).

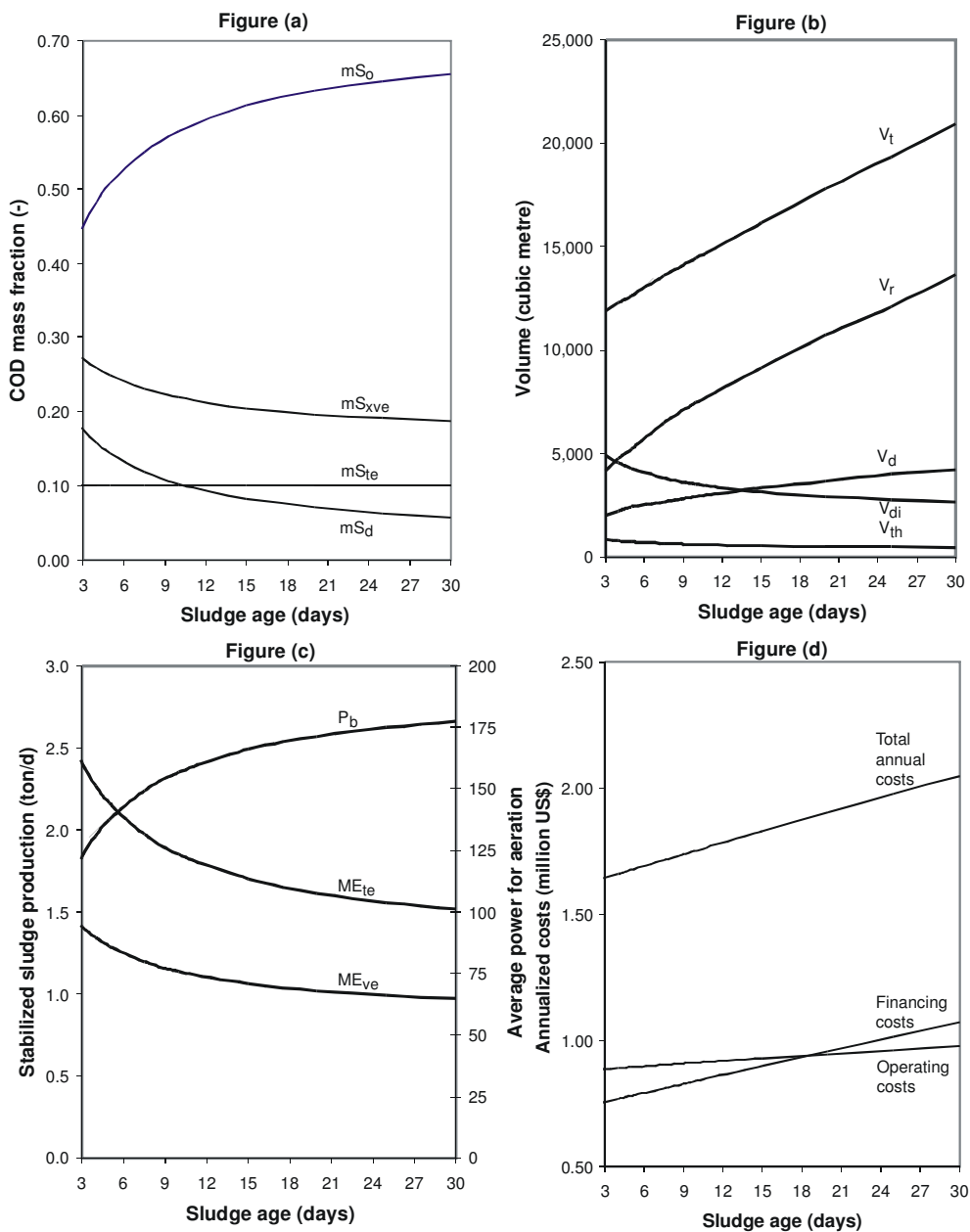
#### **Solution:**

The calculations made for the optimal sludge age are repeated for other values of the sludge age, in order to assess what the influence of this variable is on the performance and the costs of the system. In Fig. 10.15 the following parameters are plotted as a function of the sludge age:

- The volume of the treatment units and their total value (Fig. 10.15a);
- The fractions of influent organic material ending up in the effluent, the excess sludge and oxidised (Fig. 10.15b);
- The excess sludge production and the energy consumption (Fig. 10.15c);
- The estimated total costs of the treatment system (Fig. 10.15d). In the example, constant construction costs per unit volume have been used throughout the whole range of sludge ages. Furthermore personnel and operational costs have been fixed at the values for  $R_s = 3$  days.

A minimum sludge age of 3 days has been applied, knowing that at the selected temperature of 20°C the removal of organic material is essentially complete and a reasonable effluent quality will be achieved (refer to Appendix 3).

The figures show that the different parameters are significantly influenced by the value of the sludge age, although the effluent quality (at least theoretically) remains constant. At higher sludge age a higher proportion of the influent COD will be oxidised. Therefore the values of the parameters related to the oxidation of organic material (e.g.  $P_b$ ,  $V_r$ ) will increase as well. It can be observed that the annualised total costs gradually rise when the sludge age increases.



**Figure 10.15 Influence of the sludge age on activated sludge system performance and annualised treatment costs**

This cost increase may be smaller than expected (from 1.65 million US\$.yr<sup>-1</sup> at a sludge age of 3 days to 2.05 million US\$.yr<sup>-1</sup> at 30 days, or 25%). The reason is that the two subsystems of aerobic reactor - final settler, and of secondary excess sludge thickener - anaerobic digester, demonstrate opposing behaviour at increasing sludge age. While the reactor volume and installed blower capacity increase at higher sludge age, the amount of excess sludge produced will decrease, resulting in a smaller thickener-digester system and less costs for sludge disposal.

It is concluded that for waste water treatment plants with anaerobic sludge digestion, the minimum sludge age ensuring proper functioning of the system should be selected, as it will yield minimum total annualised costs.

In the example, the construction costs per unit volume have not been adapted at different sludge age values to reflect the effect that unit volume prices will decrease at higher volumes. While this would yield some additional accuracy, the decrease in volumetric costs for reactor and final settler is balanced by the increase in volumetric costs for thickener and anaerobic digester. The trend, i.e. increasing annualised total costs at higher sludge ages, would not have been different.