3.2.4.5 F/M ratio

In the development of the simplified model, the sludge age appeared as the fundamental process variable. In practice a different parameter is amply used in design and analysis of activated sludge systems: the F/M ratio. This parameter seeks to express the ratio between the influent organic material (F for "food") and the bacterial mass available to metabolise it (M for "micro-organism mass"). Usually the parameter F is taken as the influent COD mass, whereas M is taken to be equal to the volatile sludge mass, so that the F/M ratio is expressed as kg COD.kg^{-1} VSS.d^{-1}. In the terminology of the simplified model one has:

$$F/M = MS_{ti}/MX_v = 1/mX_v. \tag{3.64}$$

Hence, the F/M ratio can also be expressed as a function of the sludge age:

$$F/M = 1/mX_v = 1/[(1-f_{ns}-f_{np})\cdot(1+f\cdot b_h\cdot R_s)\cdot C_r + f_{np}\cdot R_s/f_{cv}] \tag{3.65}$$

In Fig. 3.12 the F/M ratio is plotted as a function of the sludge age for raw sewage and settled sewage. Fig. 3.12a. has been calculated for long sludge ages (R_s from 4 to 20 days) and Fig. 3.12b for short sludge ages (0 to 4 days). When Fig. 3.12 is analysed, it can be noted that the F/M ratio is an ambiguous parameter: for the same sludge age it exhibits very different values for different f_{np} values.

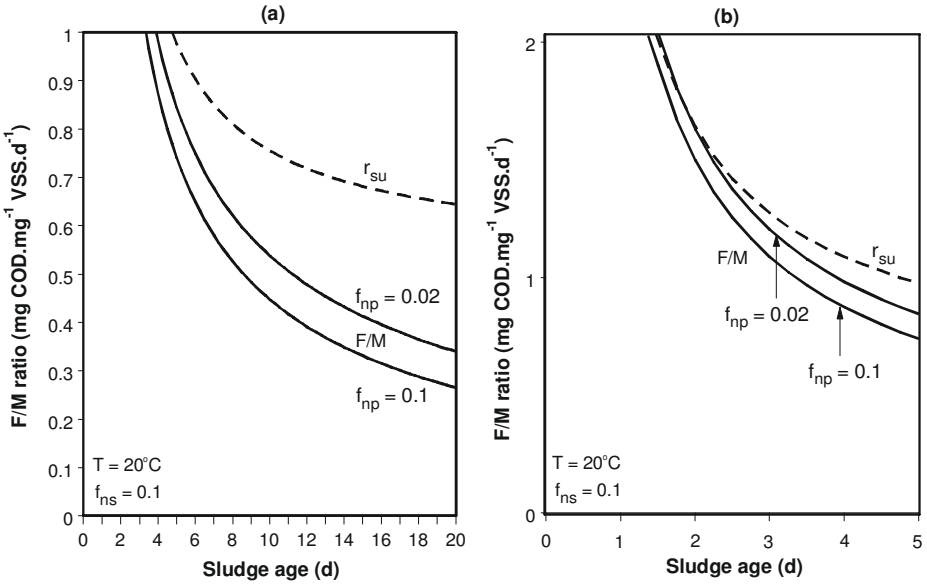

Figure 3.12 F/M ratio and specific utilisation rate r_{su} as a function of the sludge age

Hence the fact that different systems have the same F/M ratio does not mean that the sludge ages are equal or that these processes are otherwise comparable. In this context it would be more meaningful to define an alternative parameter, indicating the ratio between the mass of daily applied biodegradable material and the available active sludge concentration.

This parameter would represent the specific utilisation rate of biodegradable organic material by the sludge, or in other words, the metabolised COD mass per unit mass active sludge per day:

$$r_{su} = MS_{bi}/MX_a = (1+b_h \cdot R_s)/(Y \cdot R_s) = 1/C_r \quad (3.66)$$

Where:

r_{su} = specific utilisation rate of biodegradable influent organic material by the active sludge (mg COD.mg^{-1} X_a.d^{-1}).

The r_{su} value has also been plotted as a function of the sludge age in Fig. 3.12. Note that this parameter is independent of the composition of the influent in terms of f_{ns} and f_{np}. Another important aspect that can be observed especially in Fig. 3.12b, is that the F/M ratio and r_{us} increase as the sludge age decreases. In reality the values of F/M or r_{su} will have an upper limit, because of the limited capacity of the bacteria to metabolise organic material.

Hence, there is a minimum sludge age such, that if an activated sludge system is operated at a shorter sludge age than this minimum, it will not be possible for the bacteria to metabolise all the influent organic material. The simplified model only has validity for sludge ages above this minimum where the ideal behaviour is approached.

In Section 3.4 the non-ideal active sludge process will be discussed and a kinetic model is presented, allowing the determination of the minimum sludge age for substantially complete utilisation of the influent biodegradable material.