Example 3.2

An activated sludge system treats raw sewage (f_{ns} = 0.14 and f_{np} = 0.10) and is operated at a sludge age of 20 days. It is required to increase the organic load by 50 percent from 10 to 15 ton COD per day without increasing the sludge mass in the system. What will be the new maximum sludge age? How much does the fraction of influent COD wasted as excess sludge change? How much will the oxygen consumption increase?

Solution*:*

From Fig. 3.7a it is determined that mX_v (the organic sludge mass per unit mass of daily applied influent COD) for the given sludge age of 20 days is equal to 3.6 mg $VSS.mg^{-1}$ $COD.d^{-1}$. Hence the maximum sludge mass in the system is:

$MX_v = mX_v \cdot MS_{ti} = 3.6 \cdot 10 = 36$ ton VSS

After the load increase, the total sludge mass is not to increase, so that the sludge age must be reduced. For the new sludge age the mX_v value is given as:

$mX_v = MX_v/MS_{ti} = 36/15 = 2.4$ mg $VSS.mg^{-1}$ $COD.d^{-1}$

Again using Fig. 3.7, it is noted that for $mX_v = 2.4$ the sludge age is 12 days. Hence it is concluded that the sludge age must be reduced from 20 to 12 days, due to the increase of the organic load. The change of the active sludge fraction can be evaluated with the aid of Fig. 3.8: for R_s = 20 days one has $f_{av} = 0.33$ while for R_s = 12 days the value of $f_{av} = 0.45$.

To evaluate the influence of the load increase and the consequential sludge age reduction on the oxygen consumption, first the fractions mS_{xv} and mS_o are calculated for the original load and for R_s = 20 days:

$mS_{xv} = f_{cv} \cdot mX_v/R_s = 1.5 \cdot 3.6/20 = 0.27$

$mS_o = 1 - 0.14 - 0.27 = 0.59$

For R_s = 12 days one has:

$mS_o = 1 - 0.14 - 1.5 \cdot 2.4/12 = 0.56$

Hence, the oxygen demand increases from $0.59 \cdot 10 = 5.9$ ton $O_2.d^{-1}$ before the load increase to $0.56 \cdot 15 = 8.4$ ton $O_2.d^{-1}$, i.e. the increase of the load by 5 ton $COD.d^{-1}$ results in an increase of the oxygen consumption of 8.4 - 5.9 = 2.5 ton $O_2.d^{-1}$. At the same time, there is an increase of the effluent load from $0.14 \cdot 10 = 1.4$ ton COD/d to $0.14 \cdot 15 = 2.1$ ton $COD.d^{-1}$. Hence it is calculated that the COD mass discharged as excess sludge increases from its initial value of $MS_{xv} = MS_{ti} - MS_o - MS_{te} = 10 - 5.9 - 1.4 = 2.6$ ton $COD.d^{-1}$ to $MS_{xv} = 15 - 8.4 - 2.1 = 4.5$ ton $COD.d^{-1}$, so that the sludge production is $4.5/f_{cv} = 3.0$ ton $VSS.d^{-1}$.

Due to the load increase and the sludge age reduction, the sludge production increases by 67 percent from 1.8 to 3.0 $ton.d^{-1}$. It can be verified that the daily sludge production is ME_t = 4.5/1.5 = 3.0 ton $VSS.ton^{-1}$ $COD.d^{-1}$ = 1/12 MX_v, as could also have been calculated from the sludge mass and the sludge age.