10.2.5 System C2: Tertiary treatment with N and P removal

In order to effect biological removal of phosphorus, it is required to incorporate a completely anaerobic zone in the system configuration. Based on the analysis made in Chapter 5 (Figs. 5.6 and 5.7), it was concluded that a relatively small anaerobic zone is sufficient and that preferably the sludge age is low.

On the other hand, the necessity to remove nitrogen as well, requires a relatively long sludge age. There is no analytical solution for this problem: one has to find an optimised solution iteratively while using expert judgment regarding the values of several operational and design variables.

These are: (1) the size of the anaerobic sludge fraction, (2) the recirculation rate from the anoxic zone to the anaerobic zone "r", (3) the hydraulic regime characterised by the number of completely mixed reactors in series in the anaerobic zone N, and (4) the sludge age. With regard to these parameters, a value of $N > 2$ only increases performance marginally, while experience has shown that the value of r generally should be about 1.
The optimised design procedure can be summarised as:

1. Select adequate values for N and r (e.g. $N = 2$, $r = 1$);
2. Select a value for the anaerobic sludge mass fraction, e.g. $f_{an} = 0.10$;
3. Determine the value of the sludge age that permits removal of both phosphorus and nitrogen. For phosphorus removal use the procedure described in Section 5.1.3. For nitrogen removal refer to the earlier example shown in Section 4.4;
4. Adapt the values of f_{an} and possibly also of N and r and determine the minimum sludge age that permits removal of the nutrients. This value of the sludge age will then be used in the optimisation of the activated sludge system, which follows the procedure explained in Example 10.5;
5. If it is not possible to comply with both the effluent phosphorus and nitrogen limits, optimise the system for compliance to the nitrogen limits and apply supplementary simultaneous precipitation for removal of the excess phosphate (as demonstrated in Example 5.4).