

5.2.4 Resolving operational problems

Activated sludge systems designed for biological phosphorus removal are among the most sophisticated technologies available in the field of waste water treatment. However, in practice there are several factors that may reduce the efficiency and reliability of the treatment system.

The first factor refers to operational stability: it should be realised that the PAO in the activated sludge system are in fact a large reservoir of phosphorus. Under adverse conditions this phosphate can be released to the liquid phase. Such a situation might occur, for instance, when aeration is interrupted for several hours. In this case, phosphate will still only be released in the anaerobic zone (as it requires the availability of VFA). However, the absorption of the released phosphate will cease in the normally aerated zone, as the uptake of phosphorus is linked to utilisation of stored PHB and such a process requires either anoxic- or aerobic conditions. While the decrease in oxygen concentration in the aerobic reactor in the event of the interruption of aeration is obvious, the nitrate concentration will also decrease in time since nitrification will cease.

In the anaerobic zone the concentration of released phosphorus will be equal to fifty percent of the mass of VFA taken up by the PAO. Thus for a typical domestic sewage containing $100 \text{ mg COD}\cdot\text{l}^{-1}$ of VFA, an interruption of the air supply for a couple of hours could result in several tens of milligrams per litre of phosphorus in the effluent. Under these conditions it may be preferable to by-pass the anaerobic zone with the influent, so that no VFA becomes available for the PAO.

A similar problem might occur when toxic shock loads are introduced into the system, which might reduce the OUR and thus also the phosphorus absorption rate. In the same context, it is important to notice that an inadequate aeration capacity will also jeopardise the efficiency of the phosphorus removal process. If the utilisation of PHB in the aerobic zone is incomplete due to lack of an oxidant, the amount of energy generated by the PAO will be insufficient to completely regenerate the polyphosphate released in the anaerobic zone, resulting in the discharge of phosphorus in the effluent.

However, the problem most frequently encountered in bio-P systems is that the capacity for biological phosphorus removal is insufficient to produce an effluent with a low phosphorus level. In the earlier sections it was explained that it is important to protect the anaerobic zone against introduction of nitrate. In some cases oxygen is introduced, for example due to some form of pre-treatment involving aeration (e.g. aerated sand traps or dissolved air flotation for removal of oil and fats). This oxygen will then be used to oxidise part of the VFA in the waste water, reducing the fraction of PAO in the system and thus the phosphorus removal capacity.

However, in most cases when biological phosphorus removal capacity is insufficient, this is due to an unfavourable ratio between phosphorus in the influent and VFA present or generated in the anaerobic zone. In this case it should be attempted to increase the easily biodegradable material in the influent. The three main alternatives, which are all technically feasible, but will result in additional operations and/or costs, are:

- Addition of an easily biodegradable carbon source (such as acetate or methanol);
- Pre-treatment of the influent using acid fermentation, generating additional VFA from the proteins, fats and carbohydrates present in the waste water;
- Treatment of the excess primary sludge with acid fermentation (without subsequent methanogenesis) and recirculation of the generated VFA to the anaerobic reactor.

Another problem in the operation of systems with bio-P removal is the handling of the biological excess sludge. During anaerobic sludge digestion, a large part of the PAO will be hydrolysed. As a consequence, the internally stored polyphosphate is also released from the cell and this can result in a very high phosphate concentration in the digester effluent (up to 200 mg P.l⁻¹). The phosphorus present in this stream can amount to more than half of the phosphorus load in the influent: of the other half, part of the phosphorus precipitates in chemical complexes and another (very small) part will be present in the stabilised anaerobic excess sludge.

Direct recirculation of the anaerobic digestion water to the activated sludge system is not practical, as this would overload the system with phosphorus: prior to recirculation to the activated sludge process the phosphorus will have to be removed. An alternative would be to stabilise the sludge with aerobic digestion, as in this process less phosphate is released to the liquid phase during decay of the PAO. However, in general physical-chemical treatment methods are used to eliminate the phosphate from the liquid phase of the digested sludge.