

10.1.3 Performance objectives

The objective of constructing an activated sludge system is in general to produce an effluent with a certain desired quality at minimum total investment and operational costs. In general the desired effluent quality is specified by environmental legislation, setting limits to operational parameters such as the concentration of suspended solids, organic material and nutrients. In the case of industrial waste water, other parameters such as temperature, pH, oil, grease and fats and floating material could be important as well. In many developing countries effluent standards with respect to nutrient concentrations do not yet exist or are not yet applied or maintained. However, even if no legal requirements exist, it will be advantageous to apply tertiary treatment for the following reasons:

- Removal of nutrients (and particularly of nitrogen) is a necessary condition to obtain good operational stability, especially in regions with a hot climate;
- The oxygen consumption will be reduced because of the recovery of equivalent oxygen by denitrification;
- The tendency of environmental legislation is to become stricter in time, making it very probable that nutrient removal will be required within the expected lifetime of the activated sludge system to be constructed.

During the last three decades in Europe and the US, huge investments have been made to upgrade existing activated sludge systems, first to achieve nitrogen removal and later to achieve phosphorus removal as well.

In developing countries, the lessons learned can be immediately applied to the design of nutrient removal systems. Apart from legislation, an important consideration to define the type of treatment is the final destination of the effluent. Many cities are located in coastal zones, in which case the effluent of waste water treatment plants will be discharged directly into the sea (often by means of a pipeline outfall). The beneficial effects of nutrient removal (particularly phosphorus) may not be very significant, as the discharged nutrients will be instantly diluted and therefore do not significantly alter the existing background concentration. However, if the effluent is discharged into a surface water (such as lakes or rivers) or into a bay, nutrient removal can be extremely important to maintain the quality of the receiving water. The following examples from Brazil will clarify the issue of final effluent destination.

In the case of São Paulo, the largest Brazilian city with a population of 15 million inhabitants and an enormous industrial complex, a large part of the treated effluent ends up in the rivers Tietê and Paraíba, originating in the metropolitan area. The rivers run through hundreds of kilometres of land before reaching the sea and in doing so serve as a major source of potable water in many cities (for instance Rio de Janeiro). It is easy to see that maintaining and improving the quality of these rivers is of great importance, and for this reason tertiary treatment of all waste waters in the São Paulo metropolitan area is necessary.

In Rio de Janeiro, a large part of the sewage generated by its 6 million inhabitants and one of the largest industrial complexes in the country is discharged directly into the Bay of Guanabara. As a result a large part of the Bay, which in the past was an important area for fishing and tourism now has a septic aspect and a very low dissolved oxygen level. In this case, waste water treatment without nutrient removal will not resolve the problem as the load of nitrogen and phosphorus (estimated at 50 ton TKN.d⁻¹ and 10 ton P.d⁻¹) results in eutrophication of the bay and still seriously limits the use for fishing and tourism. Therefore, in this case tertiary treatment will also be necessary.

In the city of Salvador da Bahia (2.5 million inhabitants) a waste water collection system is in place which directs almost all sewage produced in the city to a primary treatment unit, from which it is sent into the Atlantic Ocean by means of a 5 km subsurface pipeline outfall. The primary treatment is applied to protect the outfall from accumulation of solids. Various studies have shown that the quality of the beach water is not significantly influenced by the discharge of the pre-treated sewage in the sea. It is concluded that in the case of Salvador, the subsurface disposal of sewage in the sea is a viable solution from an environmental viewpoint, although the initial investment cost were very high and a more economic alternative could have been implemented.

The city of Manaus in the heart of the Amazon Region is located at the bank of the Rio Negro, just upstream of the confluence with the Amazon River. The average flow of the Amazon River is $100,000 \text{ m}^3 \cdot \text{sec}^{-1}$. Assuming the population of Manaus (1.1 million inhabitants) produces a waste water flow of $160,000 \text{ m}^3 \cdot \text{d}^{-1}$ or approximately $2 \text{ m}^3 \cdot \text{sec}^{-1}$, the discharge of raw sewage in the river will dilute the sewage with a factor $100,000/2 = 50,000$. The pollutants will therefore automatically be diluted to a very low concentration, possibly even lower than the existing background concentration in the river. As there is a legal requirement to reduce the concentration of suspended solids and of biodegradable organic material, in the case of Manaus it may be considered to only install an efficient anaerobic treatment unit such as a UASB reactor (especially taking into account that the average water temperature in the region approaches 30°C year round), which will easily remove more than 80% of these pollutants.

The above examples clearly show that the geographical and demographical conditions have a decisive influence on the decision on the nature of the treatment to be applied and the required effluent quality.