

3.1.1 Organic material fractions in waste water

In this text COD will be used as the parameter for organic material measurement. Some advantages of its use over its alternatives BOD₅, BOD₂₀ and TOC have been mentioned already in the previous chapter. In Section 3.2 another important advantage will be presented: the possibility to verify if the organic material mass balance closes. The concentration and composition of the organic material depends on the origin of the waste water. For the purpose of modelling the activated sludge system, it is necessary to divide the influent organic material into four different fractions.

In Chapter 2 a first distinction was made between biodegradable and non-biodegradable material, the former being susceptible to metabolism by the bacterial mass, whereas the latter was not affected by the biochemical actions of the micro-organisms. For a more refined description of the activated sludge system, both the biodegradable and the non-biodegradable fractions are divided into a dissolved part and a particulate part. The subdivision takes into consideration the physical size of the organic material.

In most waste waters, the particles of the organic material show a large variation in size: part is present as a true solution, another part may be present as a colloidal suspension and the remainder as a suspension with macroscopic particles. With respect to the metabolism of organic material by the micro-organisms, a distinction is made between dissolved and particulate material (colloids and macroscopic particles), which is a simplification of a more complex reality. However, it will be shown that this simple approach leads to a surprisingly precise description of activated sludge behaviour, even under extreme operational conditions.

The activated sludge flocs act as a strong coagulant, resulting in the removal of particulate organic material by physical processes: the sludge flocs can capture the particles by screening, enmeshment or adsorption, making them part of the solid (sludge) phase. These physical processes remove both biodegradable- and non-biodegradable particles. This leads to the conclusion that the behaviour of organic material of the dissolved non-biodegradable fraction will be different from that of the particulate non-biodegradable fraction: the former will not be affected by the presence of sludge and will leave the process without modifications, whereas the latter will accumulate in the solid phase, until it is discharged as part of the excess sludge.

For the biodegradable organic material there is also a difference between the organic material of dissolved- and particulate origin. Due to the small size of the molecules in the dissolved fraction, these penetrate through the cell membranes and thus will be metabolised directly. In contrast, the particulate organic material can only be metabolised after several preparatory processes that may include flocculation, adsorption on the cell wall and hydrolysis of the adsorbed material with the consequential production of soluble organic material. It is concluded that the physical removal of the organic material occurs at a high rate, but in the case of particulate material, metabolism will not be immediate. In this chapter it will be shown that it may take several hours before organic influent material is actually metabolised in the activated sludge system. Thus a distinction can be made between easily (dissolved) and slowly (particulate) biodegradable materials.

As the division of the influent organic material in the four main fractions will be used frequently throughout this text, it is convenient that each be indicated by a separate symbol. Using S (substrate) as a generic symbol for organic material concentration (expressed as COD), the following parameters can be defined:

- S_{ti} = (total) influent COD concentration
 S_{bi} = biodegradable influent COD concentration
 S_{ni} = non biodegradable influent COD concentration
 S_{bpi} = biodegradable, particulate influent COD concentration
 S_{bsi} = biodegradable, dissolved influent COD concentration
 S_{npi} = non biodegradable, particulate influent COD concentration
 S_{nsi} = non biodegradable, dissolved influent COD concentration

From the above definitions one has:

$$\begin{aligned}
 S_{ti} &= S_{bi} + S_{ni} \\
 &= S_{bsi} + S_{bpi} + S_{nsi} + S_{npi}
 \end{aligned}
 \tag{3.1}$$

It will prove to be convenient to introduce the following fractions:

$$\begin{aligned}
 f_{ns} &= S_{nsi}/S_{ti} \\
 &= \text{non biodegradable, dissolved influent COD fraction}
 \end{aligned}
 \tag{3.1a}$$

$$\begin{aligned}
 f_{np} &= S_{npi}/S_{ti} \\
 &= \text{non biodegradable, dissolved influent COD fraction}
 \end{aligned}
 \tag{3.1b}$$

$$\begin{aligned}
 f_{sb} &= S_{bsi}/S_{bi} \\
 &= \text{fraction of the biodegradable COD that is dissolved (and easily biodegradable)}
 \end{aligned}
 \tag{3.1c}$$

Applying these definitions one has:

$$S_{ni} = (f_{ns} + f_{np}) \cdot S_{ti} \text{ and} \tag{3.2}$$

$$S_{bi} = (1 - f_{ns} - f_{np}) \cdot S_{ti} \tag{3.3}$$

Figure 3.1 is a graphical representation of Eqs. (3.1 to 3.3). The methods to experimentally determine the value of the different fractions will be discussed later in this chapter. The numerical values of the fractions may vary significantly for different waste waters, especially in the case of industrial waste waters. Table 3.1 shows some examples.

The division of the influent organic material in four fractions is a simplification of a more complex reality, but it is adopted since a more refined model does not lead to a better simulation of reality and thus would be an unnecessary sophistication for the purpose of developing a general description of the activated sludge behaviour.

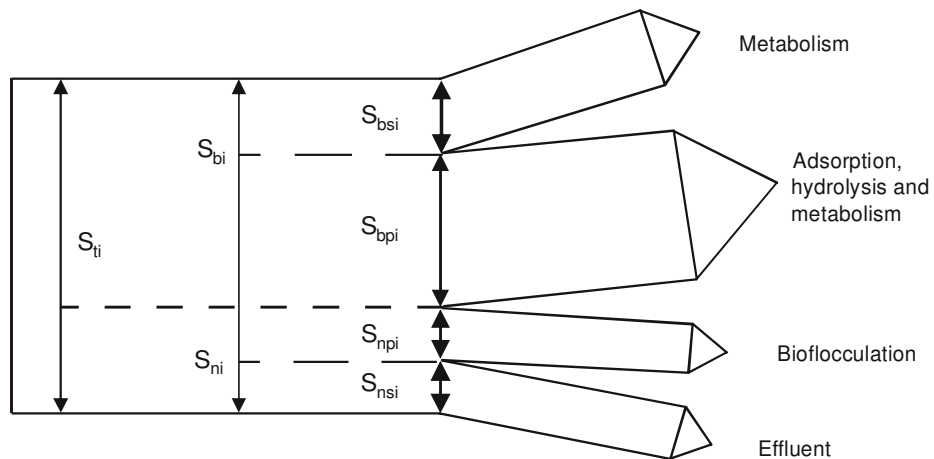


Figure 3.1 Characterisation of the influent COD in different fractions and their relation to the main processes in the activated sludge system

Table 3.1 Experimentally determined values of the influent organic material fractions for different types of waste water

Type of waste water	Fractions			Reference
	f_{ns}	f_{np}	f_{sb}	
Municipal sewage:				
- Campina Grande - Brazil (raw)	0.07	0.05	0.25	Coura Dias et al (1983)
- Cape Town - South Africa:				
- raw	0.09	0.12	0.25	Marais and Ekama (1976)
- settled	0.12	0.02	0.37	Marais and Ekama (1976)
- Burlington - Canada (raw)	0.12	0.25	---	Sutton et al (1979)
Industrial waste water:				
- Distillage (alcohol distillery)	0.02	0.02	0.80	(unpublished research)
- Black liquor (paper mill)	0.40	0.10	0.35	Macedo (1990)
- Petrochemical	0.20	0.06	0.25	Neto et al (1994)