

6.1.2 Alternative parameters for sludge settleability

The zone settling velocity test is not particularly suitable for routine use at waste water treatment plants because it is very tedious and time consuming. For this reason many research workers have tried to find alternative ways to express sludge settleability in quantitative terms.

The Sludge Volume Index or SVI (Mohlman, 1934) is probably the best known and most widely applied test for sludge settling. In this test, a certain volume of mixed liquor (for example 1 litre) is placed in a calibrated cone or cylinder. After a set time (for example 30 minutes) the sludge volume is read off and, after determination of the initial sludge concentration, the volume of settled sludge per gram of solids is calculated. This number expresses the sludge volume index (SVI or SVI_{30}). As this test is extremely simple to carry out it has found wide application. Unfortunately, it is not a very useful test for quantitative work. Its principal shortcoming is that the numerical value of the test depends on the initial sludge concentration. A true parameter for sludge settleability should be independent of the sludge concentration.

In an attempt to eliminate the influence of sludge concentration, Stobbe (1964) developed the diluted sludge volume index or DSVI. This test is based on the observation that, when the sludge volume after settling is less than about 25 percent of the initial volume, the calculated SVI value is practically constant and does not depend on the initial sludge concentration. Thus Stobbe (1964) suggested diluting sludge batches until the volume of the diluted suspension, after settling, has a volume of 200 ml or less per litre initial volume.

White (1975) developed the stirred sludge volume index (SSVI), defined as the volume of a unit mass of suspended sludge solids after 30 min of settling in a cylinder while gentle stirring is applied. The SSVI is almost independent of the initial sludge concentration, unless the zone settling velocity is extremely low ($< 1 \text{ m.h}^{-1}$). To quantify settleability for these poorly settling sludges, White suggested using a standard concentration of 3.5 g.l^{-1} , thus defining $SSVI_{3.5}$. Stofkoper and Trentelman (1982) determined both $SSVI_{3.5}$ and DSVI values in 25 activated sludge processes in The Netherlands. A proportional relationship between the two parameters was found such that:

$$I_{ssv} = c_p \cdot I_{dsv} \quad (6.3a)$$

Where $I_{ssv} = SSVI_{3.5}$ and $I_{dsv} = DSVI$

c_p = proportionality constant (the average value of c_p was determined to be $2/3$)

Catunda et al (1989) used sludge with a varying fraction of active sludge and showed that the value of the proportionality constant c_p depends on the active fraction of the volatile sludge f_{av} :

$$c_p = 1 - 0.35 \cdot f_{av} \quad (6.3b)$$

Pitman (1984) developed an empiric relationship between the constants of Vesilind's equation and I_{ssv} . Analysing his data obtained during six years of full-scale investigation, the following correlation was established:

$$v_0/k = 68 \cdot \exp(-0.016 \cdot I_{ssv}) \quad (6.4)$$

Ekama and Marais (1986) analysed their data and that of others (White 1975, Rachwall et al. 1981, Koopman and Cadee, 1983) and concluded that Pitman's empiric expression gave a good description for all. They also verified that there was a relationship between v_0/k and k :

$$k = 0.88 - 0.393 \cdot \log(v_0/k) \quad (6.5)$$

Knowing the k -value, v_0 can now be calculated with the aid of Eqs. (6.4 and 6.5):

$$v_0 = (v_0/k) \cdot k \quad (6.6)$$

Catunda et al (1989) observed that by rearranging Eqs. (6.4, 6.5 and 6.6), it is possible to express k and v_0 explicitly as a function of I_{ssv} . By substituting Eq. (6.4) in Eq. (6.5) one has:

$$k = 0.16 + 2.7 \cdot 10^{-3} \cdot I_{ssv} \quad (6.7)$$

Substitution of Eqs. (6.6 and 6.7) in Eq.(6.4) results in:

$$v_0 = (10.9 + 0.18 \cdot I_{ssv}) \cdot \exp(-0.016 \cdot I_{ssv}) \quad (6.8a)$$

In the range of I_{ssv} values that are of practical interest for the activated sludge process, Eq.(6.8) is almost linear and in good approximation can be expressed as:

$$v_0 = 11.2 - 0.06 \cdot I_{ssv} \quad (6.8b)$$

Equations (6.7 and 6.8) can be used to calculate the constants k and v_0 directly from the I_{ssv} value, without carrying out the zone settling velocity test. The constants can also be calculated from I_{dsv} data using Eq. (6.3). It must be remembered that the empiric relationships of this section are all based on experimental work with municipal sewage as waste water. It is possible that the relationships do not hold for predominantly industrial waste waters.

Catunda et al (1989) carried out an experimental investigation to evaluate the influence of sludge concentration and composition of activated sludge generated from municipal waste water on the values of the settleability constants: k , v_0 , I_{dsv} and I_{ssv} . The investigation was carried out on a pilot scale, by operating an aerated lagoon ($R_s = 2$ d) and a series of 4 aerobic digesters digesting the excess sludge from the aerated lagoon. The active sludge fraction in the sludge was varied between 83 percent (in the aerated lagoon) and 14 percent (in the last digester of the series). The main results of investigation are listed below:

$$(1) \quad I_{ssv} = 25 + 25 \cdot f_{av} + 5 \cdot X_t \quad (6.9a)$$

$$(2) \quad I_{ssv} / I_{dsv} = 1 - 0.35 \cdot f_{av} \quad (6.9b)$$

$$(3) \quad k = 0.16 + 0.003 \cdot I_{ssv} \quad (6.9c)$$

$$(4) \quad v_0 = 16 - 0.1 \cdot I_{ssv} \quad (6.9d)$$

When the results by Catunda et al (1989) and those from Ekama and Marais (1986) are compared, the following is concluded:

- The relationships between k and I_{ssv} (Eqs. 6.7 and 6.9c) and v_0 and I_{ssv} (Eqs. 6.8 and 6.9d) found by Catunda et al (1989) do not differ significantly from those suggested by Ekama and Marais (1986);
- The relationship between I_{ssv} and I_{dsv} as described by Van Haandel and Catunda (1992) is comparable with the results by Stofkoper and Trentelman (1982), when the active sludge fraction is high ($f_{av} \rightarrow 1$). This is not unexpected, as in the period between 1970 and 1985 nutrient removal was not yet required and most activated sludge processes in Holland were therefore operated at a short sludge age;
- The sludge concentration and composition influence the values of the settleability constants. While the influence of the sludge concentration is small, the sludge composition (active fraction) has a very marked effect on I_{ssv} and hence on the values of k and v_0 : a lower active sludge fraction results in a decrease in sludge settleability.