Activated sludge settling Part I: Experimental determination of activated sludge settleability

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Abstract

Several methods to quantify sludge settleability are reviewed and interrelationships between the zone settling velocity (as defined by Vesilind's (1968) equation), the stirred sludge volume index and the diluted sludge volume index are derived from empirical equations. An experimental investigation showed that activated sludge composition had a marked influence: Sludge settleability increased with increasing sludge age, i.e. as the fraction of active sludge (living organisms) in the sludge decreased.

Introduction

Due to a high suspended solids concentration, sedimentation of mixed liquor occurs in a fashion quite different from that of more dilute solutions like raw sewage. In dilute suspensions, the velocity of a particular floe or particle is determined by the resulting force of gravity and frictional shear. In concentrated suspensions, a matrix of interlinked particles is formed and these settle all with the same velocity: the zone settling velocity (ZSV). The magnitude of ZSV is determined by the total force on the interlinked particles. The minimum total suspended solids (TSS) concentration for zone settling to develop is 0,5 to 1,0 *g/l;* below this range floes are dispersed and tend to settle individually. As activated sludge systems are operated with a TSS concentration in the range of 2 to 5 *g/l,* invariably in final settlers zone settling will occur.

The value of sludge settleability and its eventual fluctuations are of great importance for design and operation of activated sludge systems. Both the system reactor/final settler and the system thickener/sludge digester can be optimised only if the sludge settleability is known. In day-to-day operation of an activated sludge system, variations of sludge settleability are an important indicator to detect at an early stage the onset of sludge bulking, allowing the operator to take measures that may avoid operational problems, or at least reduce these considerably.

In this paper three experimental methods are compared to quantify activated sludge settleability, viz. the determinations of:

- zone settling velocity (ZSV);
- stirred sludge volume index (SSVI); and
- diluted sludge volume index (DSVI).

Empirical relationships are presented to relate the values of these three parameters.

An experimental investiqation was carried out to establish the influence of sludge composition on settleability. The experimental results showed that, as the fraction of active (i.e. life organism) sludge increases, settleability tends to become poorer. It was possible to derive expressions to describe quantitatively the influence of sludge composition on sludge settleability.

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Experimental methods to determine sludge settleability

Determination of the zone settling velocity (ZSV).

Zone settling can be observed conveniently in an apparatus described by White (1975) and represented schematically in Fig. la. This apparatus consists of a vertical transparent cylinder, in which a batch of activated sludge is placed. The sludge is gently stirred by a vertical rod, connected to a central axis, driven by a low-speed motor. When a batch of sludge is placed in the cylinder, the following behaviour is observed (Fig. lb):

- A short time (a few minutes) after introducing the sludge, a clearly visible interface is formed between settling sludge in the lower section and a clear supernatant, essentially free of suspended solids, at the upper section.
- In the bottom section the particles settle with a uniform and constant rate and the interface moves downwards with this same velocity.
- Simultaneously, at the bottom of the cylinder, settled sludge with a higher concentration accumulates and, as settling continues, a steadily increasing fraction of the solids is incorporated in this more concentrated part of the sludge.
- After some time, all the suspended solids will be part of the settled sludge. On approaching this moment, the velocity of interface displacement will gradually decrease.

Figure lb shows a typical curve of the interface level as a function of settling time. The zone settling velocity (ZSV) is defined as the displacement rate of the interface at the linear (or linearised) section of the curve.

Figure 2 shows a more elaborate version of White's apparatus, which allows the determination of ZSV of six batches simultaneously. If, for example, batches of one sludge with different concentrations are used, then the influence of the concentration on ZSV can be evaluated (of course it is also possible to use one cylinder with sequential batches of sludge with different concentrations).

ZSV is influenced by several factors, but the most important is the initial sludge concentration. Several research workers have investigated the relationship between ZSV and the initial sludge concentrations. The best known models to describe the relationship are those by Vesilind (1968) and by Dick (1972),