The use and misuse of The Sludge Volume Index

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The Sludge Volume Index (SVI), first developed in 1934, is a simple test for measuring the day-to-day changes in sludge settling properties in sewage treatment plants. Over the years, through wide usage by plant operators, research workers and design engineers, this test has assumed a meaning and validity which differs significantly from the original. The purpose of this discussion is to define the limitations of the SVI and to suggest the applications for which the SVI is and is not well suited.

The popularity of the SVI is due mainly to its simplicity. The test consists of settling one liter of sludge in a graduated cylinder for 30 minutes and reading the height of the sludge-water interface in milliliters (ml). After measuring the initial sludge suspended solids concentration, in grams per liter (gm/l), the SVI is calculated as

$$SVI = \frac{\text{ml of sludge in cylinder after 30 minutes settling}}{\text{sludge suspended solids concentration in gm/l}}$$

An activated sludge that has a SVI of 100 or less is usually considered to be a well settling sludge.

This test, perhaps because of its simplicity, has several serious limitations. It is not, for example, necessarily indicative of the sludge settling characteristics. Consider the settling curves of the two sludges shown on Figure 1. Both of the curves pass through the 200 ml mark at 30 minutes, and if both sludges have the same suspended solids concentration, the SVI values must also be equal. The settling characteristics (the shapes of the settling curves), however, are not at all the same.

Although inclusion of the suspended solids concentration in the SVI calculation is intended to make the SVI independent of concentration, this does not usually occur in practice, as shown by some typical data on Figure 2. The increase in the SVI at higher solids concentrations is due to the inability of the sludge to «agglomerate» in small cylinders. Under favorable conditions, concentrated biological sludge can form large floc particles, accompanied by large voids. If settling of a concentrated sludge is to occur, the trapped water in the

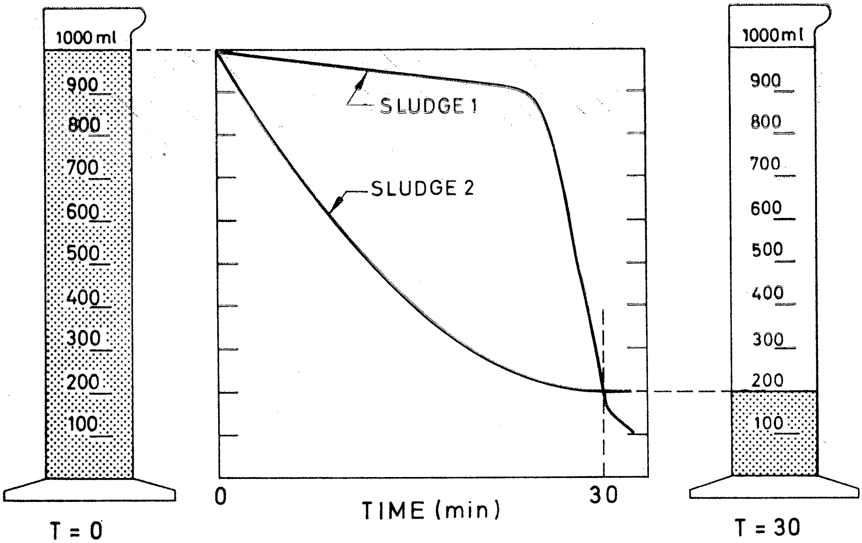

Figure 1:
At the beginning of the test ($T = 0$), the volume of both sludges is 1000 ml. At the end of the test ($T = 30$ minutes), the volume of both sludges is 200 ml. If the initial suspended solids concentration of both Sludge 1 and Sludge 2 is 2000 mg/l, (2 gm/l), for example, the SVI for both sludges is $200/2 = 100$. Even though the SVI's are identical, the sludges obviously have quite dessimilar settling characteristics.

sludge bed must escape. The rate of this escape is faster (and hence settling is faster) if large void spaces are formed. The process by which sludge forms the large flocs and corresponding large void spaces is called agglomeration. Agglomeration is enhanced by many variables, including cylinder-diameter and solids concentration. A small cylinder diameter and high solids concentration can both seriously inhibit agglomeration, and create artifically low settling velocities. The absence of agglomeration at higher concentrations caused the increases in the SVI values on Figure 2. Because of this process, as well as some other complicating factors, the SVI cannot therefore be considered to be independent of the concentration.

Although this might be a serious limitation in research work, it may not be as serious in the daily analysis of an activated sludge in a treatment plant, where the mixed liquor suspended solids may vary over a limited range, perhaps from 2000 to 2500 mg/l. The SVI may in this case be relatively insensitive to changes in concentration and this test may very well be able to detect variations in the sludge settling properties and thereby in plant performance.

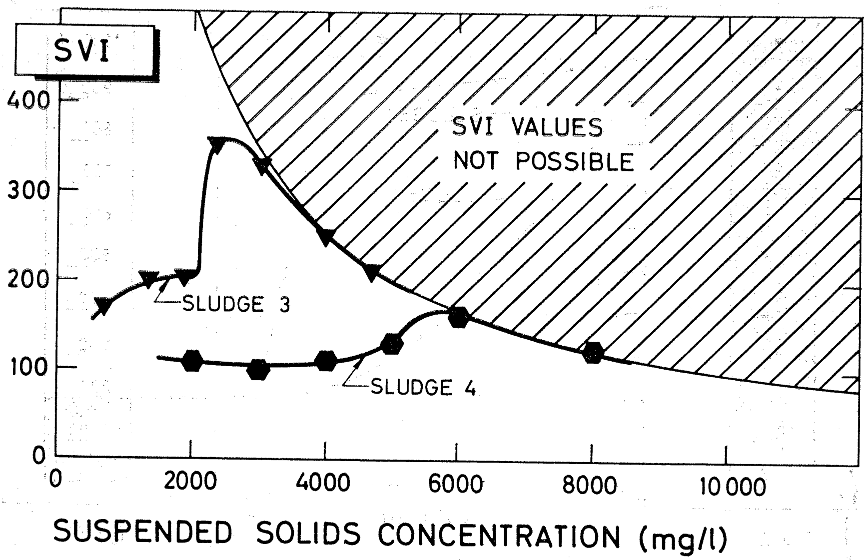

Figure 2:
Sludge 3 is not able to agglomerate at concentrations greater than 2000 mg/l, and the SVI increases rapidly to the maximum. SVI values at concentrations greater than about 2000 mg/l for this sludge are therefore meaningless. Sludge 4, however, has a fairly constant SVI up to about 5000 mg/l. The SVI value of any particular sludge is therefore dependent to a great degree on how the sludge behaves at different concentrations.

Another complication in the effect of solids concentration on the SVI is that the SVI has a maximum possible value at any specific concentration, as shown on Figure 2. Obviously, if a sludge of 10 gm solids per liter (10000 mg/l) does not settle at all in 30 minutes (the sludge volume at 30 minutes is 1000 ml) the SVI would still be:

$$SVI = \frac{1000 \text{ ml}}{10 \text{ gm/l}} = 100$$

Likewise, if a 8000 mg/l sludge does not settle, the SVI would still be only 125. It is impractical, therefore, to attempt to use the SVI for a concentrated sludge, such as return activated sludge for example, which may have a solids concentration of 10000 mg/l or more.

Although the variations in the settling properties of any one activated sludge may be adequately detected by the SVI, it is a questionable practice to compare the settling properties of different sludges by the SVI. Even if the suspended solids is included in the description (for example, „the SVI is 80 at a suspended solids concentration of 2000 mg/l"), the shapes of the SVI-solids concentration curves may be totally different, as in Figure 2, and the comparison would be almost meaningless.

Numerous other factors influence the results of a sludge settling test, including the method used to initially disperse the sludge (1), the cylinder diameter (2), and the initial sludge depth (1). All of these contribute toward making the results of a settling test in a liter cylinder quite unrepresentative of how the sludge would really behave in a large tank.

Settling tests in liter cylinders therefore cannot be safely used for design purposes unless proper correction factors are used. These correction factors, however, vary with the type of sludge as well as the sludge solids concentration, thereby making their application difficult. Better procedures than settling tests in liter cylinders are available for obtaining design criteria (3), and the use of liter cylinders is quite unwarranted.

What alternatives so do we have for measuring settling properties of a sludge in research work? We could, for example, measure the settling velocity of the sludge-water interface. Although the interface velocity is dependent on the concentration and may not necessarily be any more representative of the settling characteristics in a large tank, it would be far more sensitive to changes in sludge properties than the SVI. It may also be possible to use some fundamental measure of sludge, such as the viscosity, as a primary variable. Perhaps in some cases a microbiological parameter would be more appropriate. The choice, of course, depends on the objective of the research. The SVI, nevertheless, does not seem to be an appropriate variable, and its use in research work should be limited. If it is used, the researcher should be familiar with its limitations and should interpret the data accordingly.

In conclusion, it should be emphasized that I am not criticising the SVI test as it was originally conceived. Nor am I advocating its abandonment. I am merely suggesting that it be applied only for the original purpose, namely the day-to-day monitoring of treatment plant operation. It is my contention and experience, however, that the SVI has been misused, especially by research workers, and if the SVI is adopted as a primary variable and if its limitations are not fully understood, the experimental result can too often be misleading. Research engineers should, whenever possible, use a better tool, and relegate the SVI to its only proper role in sanitary engineering practice.

References.

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