Batch and automated SVI measurements based on short-term temperature variations

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Abstract

Effects of short-term temperature variations on the sludge volume index (SVI) are evaluated with batch and automated mixed liquor suspended solids (MLSS) settling tests. The test-cylinder environment and meteorological conditions have a direct influence on the MLSS sample temperature (T_s). A T_s change of 4.3°C over the 30 min settling test duration results in an inverse SVI change of 63.0 mℓ/g, at an average SVI decrease of 14.8 mℓ/g per 1°C T_s increase. T_s compensation or control during routine SVI tests is not common practice, partially due to a lack of temperature-controlled equipment and an absence of T_s-based MLSS settling models. A practical solution is found to reduce T_s variations experienced before and during batch MLSS settling tests. An automated MLSS settling meter is used to demonstrate a semi-continuous on-line method to determine SVI at the operational reactor temperature (T_r) of a full-scale plant. Basic and best-fit SVI models are obtained from the SVI data generated over diurnal periods, based on MLSS concentration and T_r fluctuations. These SVI models confirm the inverse dependence of SVI on temperature for the site-specific conditions. A diurnal T_r fluctuation of 1.8°C results in an SVI change of 26.6 mℓ/g, at an average -14.8 mℓ/g SVI change per 1°C T_r variation.

Keywords: activated sludge, mixed liquor suspended solids (MLSS), model, sludge volume index (SVI), settleability, temperature, wastewater

Nomenclature

BNR	=	biological nutrient removal
MLSS	=	mixed liquor suspended solids (mg/ℓ)
p value	=	probability value
R^2	=	coefficient of multiple determinations
SVI	=	sludge volume index (mℓ/g)
SV_{30}	=	settled sludge volume after 30 min settling in a 1 ℓ cylinder (mℓ/ℓ)
t-ratio	=	ratio of estimated parameter value to estimated parameter standard error
T_a	=	ambient temperature (°C)
T_r	=	reactor MLSS temperature (°C)
T_s	=	MLSS sample temperature (°C)
T_{s30}	=	MLSS sample temperature after 30 min settling (°C)
x, x_1, x_2	=	horizontal axis coordinates representing dependable variables
y	=	vertical axis coordinate representing response variable
α, β, γ	=	regression coefficients
ε	=	random error
σ^2	=	error variance

Introduction

At times biological nutrient removal (BNR) processes suffer from activated sludge or mixed liquor suspended solids (MLSS) settleability problems (Grady and Filipe, 2000) that disturb the BNR treatment efficiency. Short-term (diurnal) temperature variations in reactor temperature (T_r) have been observed as having an effect on MLSS settleability (Wilén et al., 2006). Scherfig et al. (1996) showed that T_r fluctuations are very dependent on local meteorological factors, such as ambient temperature (T_a), wind, sunshine and cloud cover. Where MLSS settling properties are traditionally determined batch-wise in 1 ℓ size cylinders (Gernaey et al., 1998), it is to be expected that unless special care is taken, these meteorological factors will have an effect on the sample temperature (T_s). T_s is usually not reported in batch MLSS settling evaluations that are used to represent BNR MLSS settleability (Ekama et al., 1997).

Jin et al. (2003) confirm that the traditional sludge volume index (SVI) is still the most widely used index to quantify MLSS settleability for routine operational and design tasks. The SVI has several shortcomings, which prompted Ekama and Marais (1984) and Daigger (1995) to encourage the adoption and use of stirred and diluted indexes. These alternative indexes attempt to standardise the SVI test conditions (Tandoi et al., 2006), but the simplicity of the SVI test procedure ensures its continued general use. Bye and Dold (1998) stated that the main criticism of the SVI is that there is no consistent relationship between SVI and the MLSS concentration, as was experimentally confirmed by Mines and Horn (2004). Dick and Vesilind (1969) noted that this relationship was sensitive to MLSS sample conditions, with container size (width and height), stirring conditions, and temperature considered as key contributors to SVI test result discrepancies. In addition, they cited a study by Rudolphs and Lacy, dated as far back as 1934 (when the SVI test was developed), where T_s increases were identified as having a considerable and positive influence on MLSS settling and SVI.

The standard methods (*Standard Methods*, 1998) prescribe that T_s should be kept at T_r during an SVI test. To ensure that T_s is stable during an SVI test, and not affected by convection, Simon

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et al. (2005) recommend a maximum 2°C difference between T_s and T_a for MLSS settling tests. These reports indicate that the traditional SVI test is temperature dependent, in addition to the well-known MLSS concentration dependence. This temperature dependence of SVI is not linear (Wilén, 1999), therefore empirical SVI correlations are only valid for the relevant experimental T_s ranges.

There are insufficient guidelines available to describe suitable methods and equipment to control T_s, or to compensate for the differences between T_r and T_s during an SVI test. In practice, the SVI test will become more laborious and time-consuming if the MLSS sample must be heated or cooled to T_r before each test, as well as maintained at T_r during the test. Clements (1976) manufactured settling columns fitted with insulation material to stabilise T_s for SVI tests, while Parker et al. (2000) mentioned that settling columns were used in a temperature-controlled water bath to manage T_s during MLSS settling tests. Sezgin (1982) reported on the dual use of laboratory-scale reactors as settling vessels to perform SVI tests *in situ*, which ensured that T_s was identical to T_r. From the literature survey, no additional details could be found of suitable equipment to manage T_s during SVI tests. Wilén (1999) noted the shortage of temperature-related MLSS settling studies. This survey confirms the lack of information on temperature-controlled MLSS settling equipment and methods.

The authors evaluated an on-line semi-continuous SVI determination method that incorporates temperature variations. A custom-designed automated MLSS settling meter was commissioned at a BNR reactor outlet to provide MLSS settling profiles and SVI data at the operational T_r. Vanrolleghem et al. (2006) regard the use of on-line MLSS settling meters as a suitable technique to generate MLSS settling profiles at full-scale plant reactors. Technological progress makes the future development of reliable MLSS settling meters more commonplace (Gernaey et al., 1998), after Sekine et al. (1989) commissioned an automated MLSS settling and SVI meter about 20 years ago to perform batch settling tests. Vanderhasselt et al. (1999) developed an on-line MLSS settling meter to provide semi-continuous settling profiles for settling velocity studies. These on-line MLSS settling profiles and associated SVI values will follow the diurnal MLSS concentration fluctuation in the reactor.

This MLSS concentration fluctuation is created due to the diurnal reactor inflow and return activated sludge solids concentration fluctuations (Härtel and Pöpel, 1992). The T_r follows in similar fashion a diurnal sinusoidal profile related to the T_a profile, as modelled by Makinia et al. (2005). Hence, on-line SVI determinations will ensure that the SVI profile reflects operational reactor conditions, not only in terms of MLSS concentration, but also with regard to T_r.

The purpose of this paper is to demonstrate that an automated MLSS settling meter can effortlessly incorporate temperature in SVI tests. This paper comprises three main components. Firstly, the extent of T_s variations during batch SVI tests is examined in terms of the MLSS sample environment. Secondly, an MLSS settling meter is used to obtain SVI profiles, according to diurnal MLSS concentration and T_r fluctuations in a full-scale reactor. Finally, a basic model is developed that represents an improved temperature-based SVI correlation.

Experimental

Grab MLSS samples were sourced during winter from the outlet of a full-scale BNR reactor. Batch MLSS settling tests commenced on plant location within minutes of sampling. This ensured that fresh MLSS samples were used with minimal changes in T_s. Two 1 ℓ and two 2 ℓ graduated polypropylene cylinders (61.0 and 77.0 mm diameter, 342.5 and 429.5 mm height respectively) were filled with MLSS samples and placed next to each other to create similar environmental conditions (T_a and solar radiation). To change these environmental conditions, the cylinders were moved into direct sunlight or shade. The settled MLSS volume was noted periodically, starting at every minute up to 10 min, then every second minute up to 20 min, and finally every 5 min up to 30 min. These 17 data points created a 30 min MLSS settling profile. To obtain a 30 min settled volume (SV_{30}) based on a 1 ℓ MLSS sample, the final settled volume in the 2 ℓ cylinder was divided by 2. The SVI was calculated by dividing this SV_{30} (mℓ/ℓ) by the initial MLSS concentration (g per ℓ) (*Standard Methods*, 1998) from each settling profile.

An on-line and a hand-held MLSS concentration meter (Royce models 9100D and 711) supplied the reactor and sample MLSS concentrations. The built-in temperature sensor of an on-line dissolved oxygen concentration meter (Royce 7011A) and an electronic data logger (Fourier, MicroLogPlus) measured and recorded the T_r data. This logger had a limited 0.3°C increment storage facility. The T_s was measured with a hand-held digital thermometer (Testo 925). This meter was fitted with a 0.6 m long immersion probe that could reach the centre of the MLSS sample inside the test cylinder. The T_a was measured during batch SVI tests in sunshine and in shade with a hand-held dissolved oxygen concentration meter (YSI, Model 550A), equipped with a built-in thermometer. The on-line T_a was recorded with a second logger equipped with an internal temperature sensor. The on-line MLSS concentration data were recorded every 5 min with a third logger (MC Systems, Alog MCS131LCD). MLSS concentration meter sensors were cleaned daily and calibrated on a regular basis.

An automated MLSS settling meter (2 ℓ perspex cylinder, 84.0 mm diameter, and 360.9 mm height) was commissioned at a full-scale BNR reactor. The settling meter generated 85 MLSS settling profiles and associated SVI readings over 2 d. The SVI data points were combined with the initial MLSS concentration and average T_r over 30 min settling periods, and fitted with Microsoft Excel, as well as a statistical software package (DataFit, 2005). DataFit contains 242 predefined non-linear regression models, up to 10-parameter polynomial functions. Polynomial functions trend data points with sinusoidal wave profiles, as found in diurnal T_a (Scherfig et al., 1996) and T_r (Makinia et al., 2005) fluctuations. From the shape of the profile, the amplitude (height of wave) and wavelength (distance between wave crests) illustrate the diurnal fluctuations.

The statistical significance of a model, to account for the fraction of the variation among the data points represented by the model, is illustrated by the coefficient of multiple determinations (R^2). Researchers have used R^2 as a general indicator of the statistical significance of settleability models (Daigger, 1995; Ekama et al., 1997), based on batch SVI data sets. The following 3-parameter 1st order polynomial function was chosen as the fitted regression model for SVI, based on R^2 and formula simplicity:

$$y = \alpha + \frac{\beta}{x_1} + \frac{\gamma}{x_2} + \varepsilon, \qquad \varepsilon \approx n(0, \sigma^2)$$

where:

y is the SVI (mℓ/g)
x_1 is the MLSS concentration (mg/ℓ)
x_2 is the T_r (°C)
α, β, γ are regression constants
ε is the random error
σ^2 is the error variance

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TABLE 1
Effect of batch MLSS settling cylinder environment on T_{s30} and SVI

Cylinder size (ℓ)	Placement	Parameter	Sample 1	Sample 2	Sample 3	Average	SVI change
		MLSS concentration (mg/ℓ)	4 210	3 930	4 470	4 203	
		T_r (°C)	18.0	19.7	21.0	19.6	
		T_a (°C)	16.9	17.5	19.4	17.9	
1	Shade	SVI (mℓ/g)	181	170	172	174	- 66 mℓ/g·4.4°C or -15.0 mℓ/g·1°C
		T_{s30} (°C)	17.0	19.5	20.9	19.1	
1	Sunshine	SVI (mℓ/g)	105	104	116	108	
		T_{s30} (°C)	21.5	23.8	25.2	23.5	
2	Shade	SVI (mℓ/g)	195	137	181	171	- 60 mℓ/g·4.1°C or -14.6 mℓ/g·1°C
		T_{s30} (°C)	17.0	19.5	20.7	19.1	
2	Sunshine	SVI (mℓ/g)	109	106	119	111	
		T_{s30} (°C)	20.9	23.6	25.1	23.2	

Results and discussion

Batch SVI dependence on environment and T_s

Three sets of manual batch MLSS settling tests, at an average sample MLSS concentration of 4 203 mg/ℓ, were completed at an average T_r and T_a of 19.6 and 17.9°C respectively. Table 1 indicates that a T_s increase of 4.3°C, due to cylinder placement in sunshine during the 30 min test, caused an average SVI decrease of 63 mℓ/g. The T_s of the 1 ℓ and 2 ℓ cylinders increased, from 19.1°C at the start of the settling test, to 23.5 and 23.2°C respectively after 30 min (T_{s30}). The corresponding SVI in the 1 ℓ and 2 ℓ cylinders decreased from 174 and 171 mℓ/g to 108 and 111 mℓ/g respectively.

The cylinder size played a minor role in SVI variations, as the larger 2 ℓ cylinder heated up more slowly to 23.2°C, against a T_{s30} of 23.5°C for the smaller 1 ℓ cylinder. The T_s difference, due to cylinder size, was reflected in the slightly higher SVI of 111 mℓ/g in the colder 2 ℓ cylinder, against 108 mℓ/g in the warmer 1 ℓ cylinder. The SVI change in the 1 ℓ and 2 ℓ cylinders was an average 15.0 mℓ/g and 14.6 mℓ/g SVI decrease respectively per 1°C T_s increase, leading to an average 14.8 mℓ/g SVI decrease per 1°C T_s increase.

Solar radiation is the main energy source for heat gain in quiescent water bodies (Gillot and Vanrolleghem, 2003). Atmospheric radiation, surface convection, and wall convection/conduction are additional energy contributors in an MLSS sample heat balance (Makinia et al., 2005). The effects of these energy sources on T_s and SVI over the 30 min test period were clearly demonstrated in the experimental results in Table 1.

These observations illustrate the importance of recording proper reference conditions during MLSS settling and SVI tests. In this study, experimental conditions were limited to a narrow T_r and T_s range on a short-term basis to simulate conditions at an operational plant. The T_s adjusts towards the T_a of the immediate environment in which the tests are performed, such as outdoors at the T_a of a plant reactor, or indoors at the T_a in a laboratory. The T_s could vary considerably from the T_r (colder or warmer), depending on T_a, the sample environment, as well as the time delay between MLSS sampling and sample testing.

Dick and Vesilind (1969) concluded that an SVI reading was only meaningful when supplied with the MLSS concentration, as the MLSS concentration exerted the largest influence on the SVI. Bye and Dold (1998) proposed that the dimensions of the settling vessel be included in MLSS settling test results. These improved settleability reporting methods could be further enhanced by recording information about temperature (T_r, T_s, and T_a) and environmental conditions during MLSS settling and SVI tests.

On-line SVI dependence on MLSS concentration and T_r

The direct relationship between MLSS concentration and SVI is illustrated in Fig. 1 (next page) for a 48 h period, based on on-line data. The MLSS concentration fluctuation follows a sinusoidal wave profile, in accordance with profiles observed by Härtel and Pöpel (1992). This cyclic MLSS concentration fluctuation of between 4 489 and 4 923 mg/ℓ is mirrored without significant lag by the SVI fluctuation of between 97 and 203 mℓ/g. MLSS concentration and SVI fluctuate in a matching diurnal relationship with fluctuations of 434 mg/ℓ and 106 mℓ/g respectively.

The mathematical relationships between settleability parameters are approximated as basic polynomial functions, to show trends that adequately describe MLSS settleability behaviour. The MLSS concentration data points over the 2 d period are thus represented by a polynomial function, as shown in Fig. 1, with an amplitude of about 217 mg/ℓ and R^2 = 0.90. The separate slope change over the first 6 h of the MLSS concentration profile, representing a change of about 200 mg/ℓ, can be attributed to experimental conditions. The SVI data points are described by a similar polynomial function, with an amplitude of about 53 mℓ/g and R^2 = 0.91.

The MLSS concentration and SVI relationship can be represented in Fig. 2 by a linear and a polynomial function, with comparable R^2 values of 0.67 and 0.68 respectively. Large scatter of SVI data points around average values is evident for both trends. The data scatter is in agreement with earlier observations of experimental MLSS settling data and calculated SVI data ranges, as presented in models by Daigger and Roper (1985) and Catunda and Van Haandel (1992). There are therefore other significant factors present that are not incorporated in the traditional SVI regression models based only on MLSS concentration. Ambient and reactor temperature fluctuations, and the related change in sample temperature, are such factors which can account for some of the scatter in SVI data.

The relationship between T_a and T_r at the assessed reactor is shown in Fig. 3 over a 48 h period. T_r follows the cyclic wave shape of T_a, with a lag of about 8 h. The characteristic sinusoidal profile of the T_a data consists of successive warming and cooling stages during day- and night-time, as modelled by Makinia et al. (2005). The T_r response to T_a fluctuations can be adequately presented by polynomial trends.

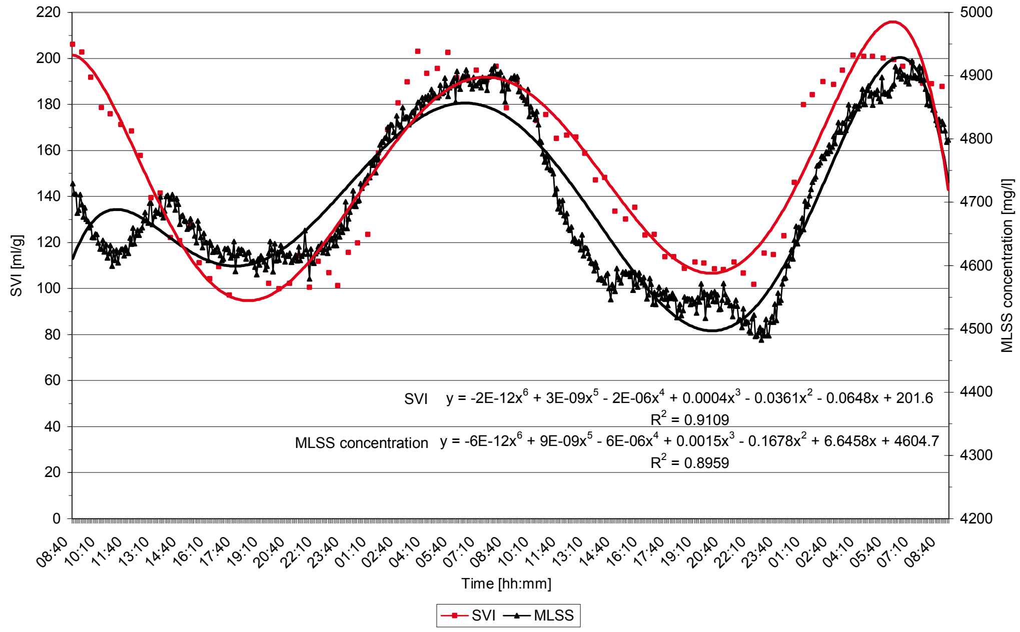

Figure 1
Experimental data and fitted curves of temporal variations in MLSS concentration and SVI

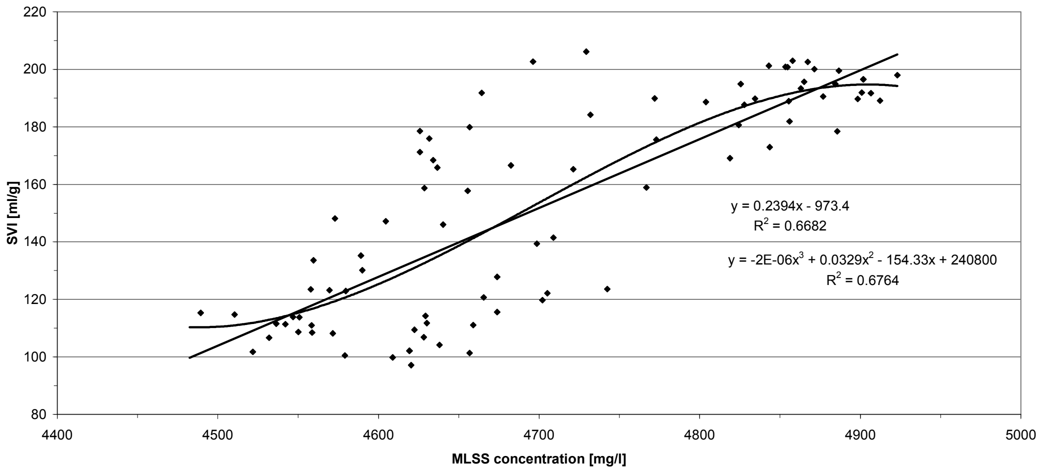

Figure 2
SVI and reactor MLSS concentration relationship

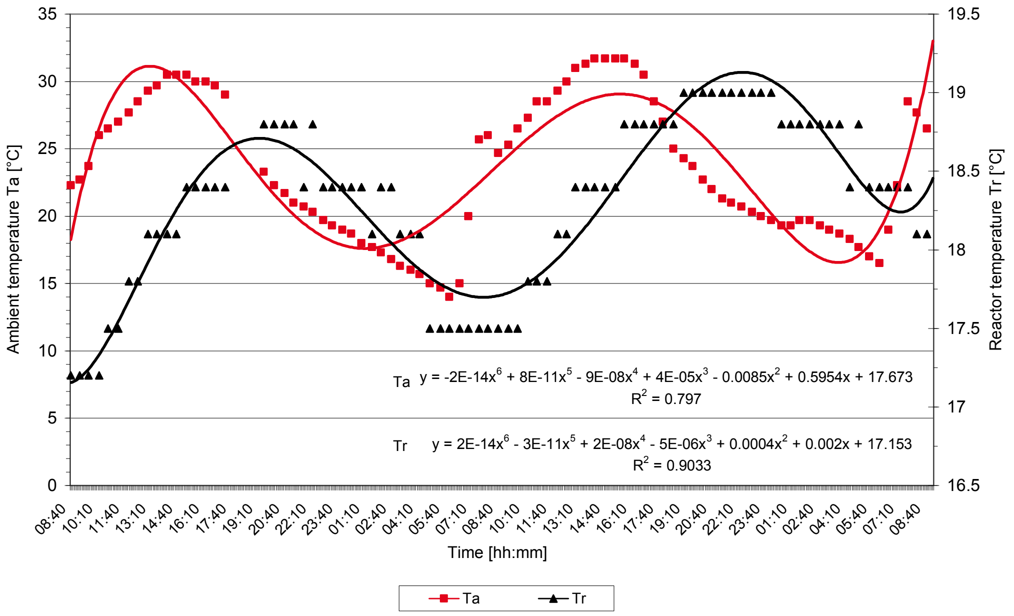

Figure 3
Experimental data and fitted curves of temporal variations in T_a and T_r

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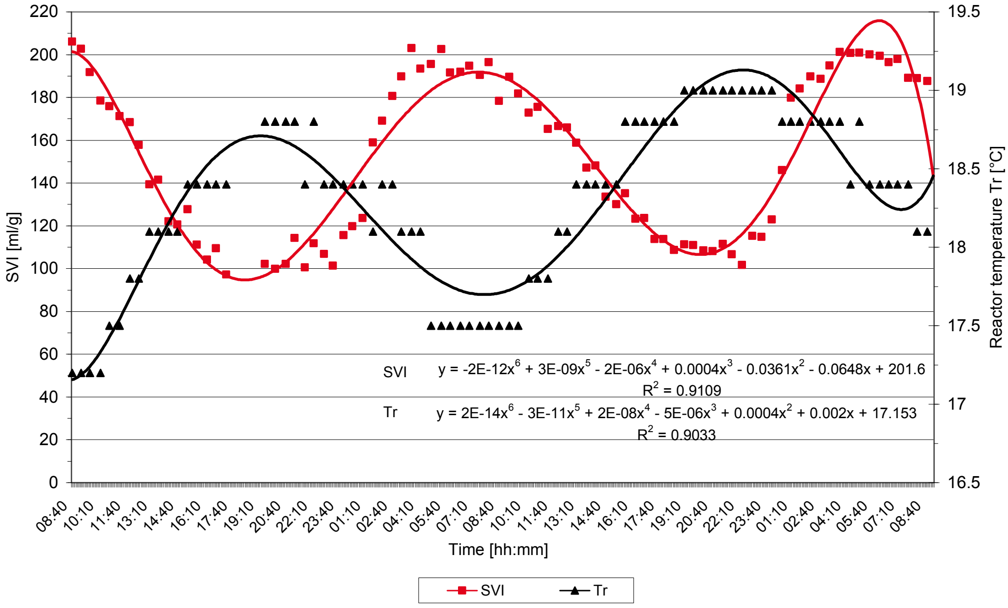

Figure 4
Experimental data and fitted curves of temporal variations in SVI and T_r

T_a fluctuates between 14.0 and 31.7°C, and T_r follows with a fluctuation of between 17.2 and 19.0°C. The T_a data points over 2 d are represented by a polynomial function with an amplitude of about 8.9°C and $R^2 = 0.80$. The response from T_r is described by a similar polynomial function with an amplitude of about 0.9°C and $R^2 = 0.90$.

The on-line SVI and T_r profiles, as shown in Figs. 1 and 3 respectively, are combined in Fig. 4. The cyclic fluctuation of SVI inversely follows the T_r fluctuation profile, without significant lag. The extended horizontal portions of the T_r profile are formed by the limited 0.3°C recording increments of the data logger.

It has been demonstrated that the SVI follows direct and inverse relationships with the MLSS concentration and T_r respectively, confirming the results of earlier studies (Dick and Vesilind, 1969). The periodic cyclic fluctuations of SVI, MLSS concentration and T_r are related to the diurnal T_a cycle.

The experimental MLSS concentration and T_r data obtained from the MLSS settling meter, as illustrated in Figs. 1 and 4, are summarised in Table 2. These data represent the modelled SVI range, as well as the corresponding MLSS concentration and T_r limits of this SVI model.

The following simplified regression model, with $R^2 = 0.71$, provides the SVI response relationship with MLSS concentration and T_r variations:

$$SVI = 872.4 - \frac{4624176.1}{MLSS} + \frac{4823.4}{T_r} \quad (\text{m}\ell/\text{g}) \qquad (1)$$

The regression variable results are summarised in Table 3, including the standard error and the 95% confidence intervals. The large *t*-ratios confirm that all parameters are significant, with MLSS concentration having the largest influence in the model. The low *p* values indicate that none of the parameters can be removed from the model without affecting the regression model accuracy, with a smaller than 1% chance that T_r is zero. A calculated correlation coefficient of 0.512 between the estimates of β and γ shows that the effect of MLSS concentration or T_r on SVI can not be independently determined with the present data set to provide similar model accuracies.

The plot of this model, valid only within the experimental data ranges listed in Table 2, is presented in Fig. 5. The three-dimensional graph illustrates the model, where the colour-coded surface areas represents the regression results, colour bands represent SVI changes of about 15 mℓ/g, and the bullets represent the experimental data points. The x_1-axis represents the MLSS concentration range of 4 489 to 4 923 mg/ℓ, the x_2-axis represents the T_r range from 17.2 to 19.0°C, and the *y*-axis represents the modelled SVI from 96 to 214 mℓ/g. The modelled SVI range slightly exceeds the experimental SVI range of 97 to 203 mℓ/g.

TABLE 2
Modelled SVI range, with experimental MLSS concentration and T_r limits

Parameter	Unit	Lowest SVI, minimum MLSS concentration, Maximum t_r	Intermediate SVI, Minimum MLSS concentration, Minimum t_r	Intermediate SVI, Maximum MLSS concentration, Maximum t_r	Highest SVI, Maximum MLSS concentration, Minimum t_r
SVI	(mℓ/g)	96	118	187	214
MLSS concentration	(mg/ℓ)	4489	4489	4923	4923
T_r	(°C)	19.0	17.2	19.0	17.2

TABLE 3
Regression variable results

Variable	Value	Standard error	Lower limit	Upper limit	t-ratio	p value
α	872.4	159.1	555.9	1188.9	5.48	0.0000
β	-46241761	445895.9	-5511196.8	-3737155.4	-10.4	0.0000
γ	4823.4	1611.6	1617.5	8029.3	2.99	0.0037

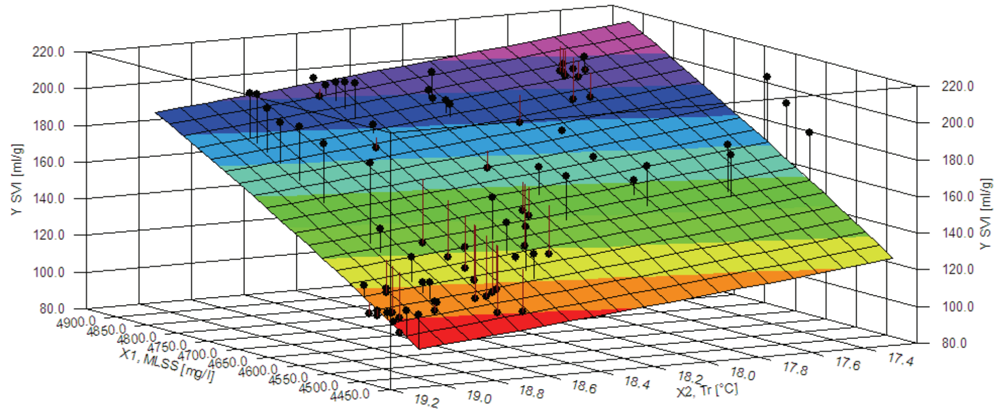

Figure 5
Experimental data points and modelled three-dimensional response surface of SVI (y) over the dependable variables MLSS concentration (x_1) and T_r (x_2)

The SVI dependence on the full-scale T_r can be illustrated with a simulation. The SVI decrease, due to a T_r increase from 17.2 to 19.0°C, is calculated with the simplified SVI-model (Eq. (1)). The SVI decreases at a constant MLSS concentration of 4 500 mg/ℓ by 26.5 mℓ/g, from 125 to 98.5 mℓ/g, for the corresponding 1.8°C T_r increase. Under these conditions, the inverse SVI relationship with T_r is averaged at -14.8 mℓ/g SVI per 1°C T_r variation. This relationship is also correlated by a best-fit 10 parameter 10th order polynomial function, with R^2 = 0.84.

The SVI relationship with T_r was not investigated over an extended temperature range outside the operational T_r and T_s variations. Several previous studies (Çetin and Sürücü, 1990; Krishna and Van Loosdrecht, 1999; Morgan-Sagastume and Allen, 2003; Zhang et al., 2006) reported poorer MLSS settling at elevated temperatures. SVI values increased (up to 540 mℓ/g) at long-term elevated temperatures as high as 35 to 45°C. These extreme temperature conditions usually result in the interruption of floc formation (Gerardi, 2002) and deflocculation. Wilén (1999) experimentally confirmed deflocculation and the resulting reduced MLSS settling properties at high T_s of 30 to 45°C, as well as at low T_s of 4°C. Some of the reported MLSS settling deteriorations at elevated temperatures could be attributed to industrial wastewater plant conditions or to long-term high temperature-based conditions, as well as to MLSS concentration variations.

Wilén (1999) confirms that activated sludge responds differently to different temperatures. The conflicting effects of temperature on SVI illustrate the importance of proper reference conditions during MLSS settling evaluations and SVI tests. In this study, experimental conditions were limited to the typical T_r and T_s variations on a short-term basis, mainly to exclude the influence of micro-organism population changes on MLSS settleability. These arrangements reproduced operational plant and laboratory conditions where MLSS settling and SVI improved at increased temperatures.

Dick and Vesilind (1969) cautioned against operational and research decisions that rely on batch SVI test results as the primary measurement of MLSS characteristics. The MLSS sample environment in small cylinders can create artificial experimental settling conditions (Sezgin, 1982). The sensitivity of the calculated SVI to environmental conditions of the MLSS sample, and specifically temperature, has been illustrated. The use of batch SVI test results, without considering these experimental conditions, may lead to over- or under-design, or the implementation of inappropriate process control measures at wastewater treatment plants.

Summary

In this paper, it is demonstrated that short-term temperature variations are an essential component of batch MLSS settling and SVI tests. The experimental results show that the SVI is highly dependent on MLSS sample conditions and experimental procedures. An inverse SVI variation of about 14.8 mℓ/g per 1°C temperature change has been established during batch and on-line MLSS settling tests, valid for the specific experimental conditions of this study. Solar radiation changes and diurnal T_r fluctuations created the variable temperature conditions investigated during the batch and automated on-line SVI tests respectively.

The SVI correlation with MLSS concentration at R^2 = 0.67 improves to R^2 = 0.71 when T_r is included in a simplified first order settling model. This model can be further improved to R^2 = 0.84 with a best-fit 10th order model. The traditional experimental procedures to establish these temperature-based batch MLSS settling correlations and related SVI data are laborious and time- consuming. Automated MLSS settling meters provide semi-continuous settling profiles and SVI data that reflect the operational diurnal T_r profile. The SVI data sets generated by such an MLSS settling meter are suitable for the development of empirical settling models for individual plant reactors.

Conclusions

The main conclusions drawn from this research are as follows:

- The rise in sample and reactor temperatures, during batch and on-line MLSS settling tests respectively, caused considerable SVI reductions. The average SVI decrease of 14.8 mℓ/g per 1°C increase is based on both batch and on-line SVI measurements. These SVI correlations are valid only for the experimental MLSS sample conditions, with regard to MLSS concentration, temperature, and experimental procedure. The SVI correlations should not be extrapolated outside experimental conditions, but rather redeveloped for site-specific operational conditions.
- A small, but statistically significant improvement is obtained when T_r is included in MLSS settling correlations. A multiple correlation between SVI and 1/MLSS concentration improves from R^2 = 0.67 to 0.71 when it is expanded to include $1/T_r$. A best-fit model between SVI, MLSS concentration, and T_r, confirms the improved correlation and benefit of T_r inclusion in SVI measurements, with R^2 increasing from 0.67 to 0.84.
- An automated MLSS settling meter is a valuable tool that calculates the temperature dependant SVI values automatically from the semi-continuous settling profiles. Time-consuming experimental work is avoided to manage T_s at the operational T_r during MLSS settling tests.

With the above conclusions, a suitable approach is provided to improve the reliability of SVI, as the effects of short-term

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temperature variations can be practically eliminated from SVI tests.

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