Misconceptions About Stirred SVI

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Abstract

•Settling characteristics of mixed liquor were evaluated in 1-L and 5-L, stirred and unstirred, plastic settling columns.

•MLSS concentrations ranged from approximately 1,200 to 9,400 mg/L.

•Two-tailed, paired comparison, statistical analyses at the 5% level of significance indicated there was a significant difference between the SVIs obtained from the stirred and unstirred 1-L and 5-L settling columns.

•Two-tailed, paired comparison, statistical analyses performed at the 5% level of significance indicated there was a significant difference between the zone settling velocities observed in the stirred and unstirred 1-L and 5-L settling columns.

• Surface areas based on stirred settling column analyses may result in areas that are 33% to 238% smaller then those predicted from unstirred settling column analyses.

•In the design of full-scale, secondary clarifiers, a scaling factor of 1.5 – 2.0 should be applied to the limiting solids flux values obtained from stirred settling column analyses.

Introduction

- The literature has promoted stirred sludge volume index (sSVI) over the traditional unstirred SVI (uSVI) as a design parameter for enhancing the design and operation of secondary clarifiers.
- Performed this study to corroborate previous work published on SVI.
- And point out misconceptions about using uSVIs versus stirred SVIs.

Settling Velocity Equations

$V_i = 7.80\, e^{-[0.148 + 0.00210\,(uSVI)]MLSS}$	Daigger and Roper (1985)
$V_i = \left(15.3 - 0.0615\left(sSVI\right)\right) e^{-\left[0.426 + 0.00384(sSVI) - 0.0000543\,(sSVI)^2\right]MLSS}$	Wahlberg and Keinath (1988)
$V_i = 1.871\, e^{-[0.1646 + 0.001586\,(uSVI)]MLSS}$	Daigger (1995)
$V_i = 7.27\, e^{-[0.0281 + 0.00229\,(uSVI)]MLSS}$	Mines et. al. (2001)

Settling Column Apparatus

Results

Date	MLSS (g/L)	1-L sSVI (ml/g)	1-L uSVI (ml/g)	5-L sSVI (ml/g)	5-L uSVI (ml/g)	1-L sZSV (m/h)	1-L uZSV (m/h)	5-L sZSV (m/h)	5-L uZSV (m/h)
10/22/02	1.220	61	90	86	102	0.290	0.297	0.827	0.809
10/22/02	2.595	77	96	95	104	0.280	0.257	0.787	0765
10/17/02	4.820	79	114	106	131	0.271	0.230	0.653	0500
10/14/02	5.710	65	96	100	122	0.266	0.215	0.533	0.388
10/14/02	6.630	72	129	104	142	0.240	0.084	0.387	0.076
10/14/02	7.410	75	119	106	128	0.206	0.074	0.252	0.057
10/17/02	9.360	71	98	94	101	0.156	0.046	0.142	0.061

Paired Comparisons

Paired Comparison of Stirred and Unstirred Zone Settling Velocities.

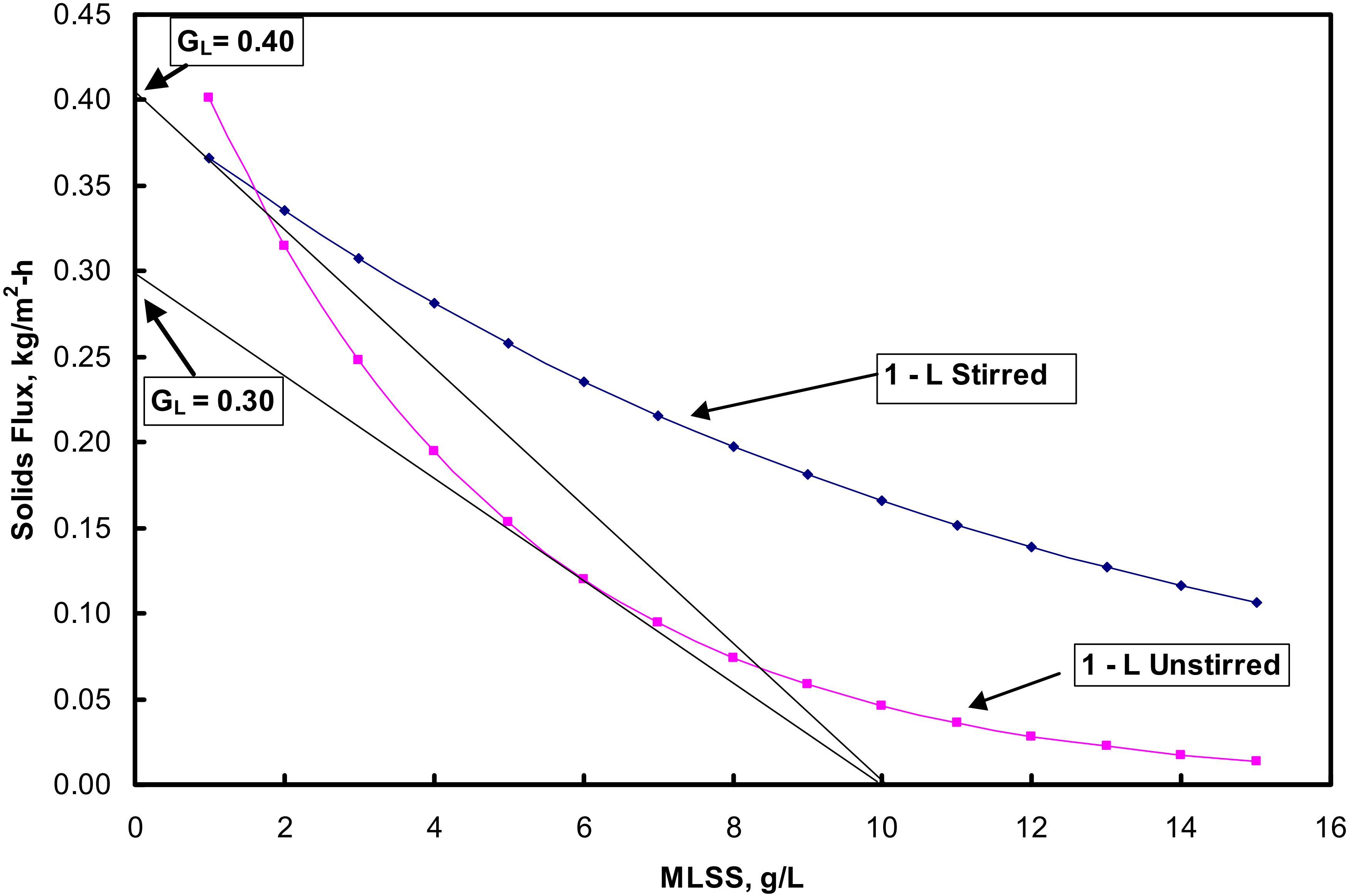
	1-L Columns	5-L Columns
α	0.05	0.05
df	6	6
t	3.17	3.37
$t_{(0.025)}$	2.45	2.45

Paired Comparison of Stirred and Unstirred SVIs.

	1-L Columns	5-L Columns
α	0.05	0.05
df	6	6
t	-7.32	-4.99
$t_{(0.025)}$	2.45	2.45

Example Problem #1

As an example, design a secondary clarifier to handle a flow of 7,570 m^3/day (2 MGD) at a MLSS concentration of 3,000 mg/L. A recycle ratio of 0.43 will be used and the underflow suspended solids concentration is 10,000 mg/L. An surface overflow rate of 27 m^3/d-m^2 will be used. From Figure 1, the limiting solids flux was 0.30 kg/m^2-h based on the 1-L unstirred settling column analysis and 0.40 kg/m^2-h based on the 1-L stirred settling column analysis. Clarifier surface areas based on clarification, Equation (2) and thickening, Equations (3) and (4) are presented below:



G_L= 0.40
G_L = 0.30
1 - L Stirred
1 - L Unstirred
Solids Flux, kg/m^2-h
MLSS, g/L
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
2
4
6
8
10
12
14
16

Figure 1.

Solution to Problem #1

$$A_{clarification} = \frac{7570\ m^3/d}{27\ m^3/d-m^2} = 280\ m^2 \qquad (2)$$

$$A_{thickening(1-L\,unstirred)} = \frac{(7570+3255)(3000)(1000)\left(1/10^6\right)}{0.30\,(24)} = 4510\ m^2 \qquad (3)$$

$$A_{thickening(1-L\,stirred)} = \frac{(7570+3255)(3000)(1000)\left(1/10^6\right)}{0.40\,(24)} = 3383\ m^2$$

Solution to Problem #1 Continued

The area based on thickening will control the design of the clarifier however, a 33% larger clarifier will have to be constructed if the limiting solids flux based on the unstirred settling column analysis is used in the design, Equation (4). Applying a scaling factor of 1.5 to the limiting solids loading rate of 0.40 kg/m^2-h results in a surface area of 5,074 m^2 that is closer to the surface area predicted by using the unstirred 1-L settling column data, Equation (3).

Example Problem #2

This example is the same as example 1. The only difference is that the limiting solids flux data from Figure 2 is used. These figures are based on the stirred and unstirred 5-L settling column analyses. The limiting solids flux values are 0.40 kg/m^2-h for the 5-L unstirred settling column analysis and 0.95 kg/m^2-h for the 5-L stirred settling column analysis. Areas based on clarification, Equation (6) and thickening, Equations (7) and (8) are presented below:

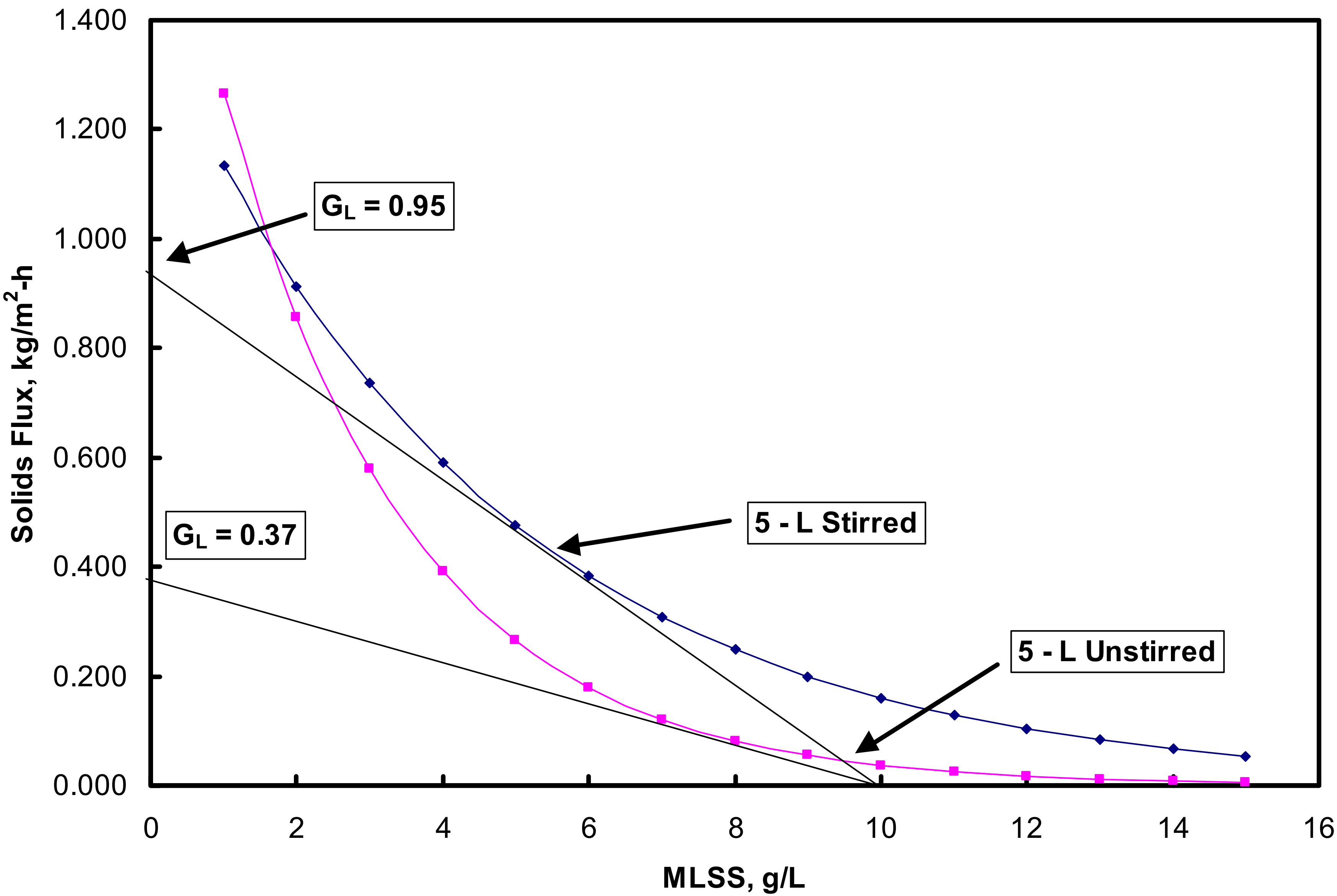

1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
Solids Flux, kg/m2-h
0
2
4
6
8
10
12
14
16
MLSS, g/L
GL = 0.95
GL = 0.37
5 - L Stirred
5 - L Unstirred

Figure 2.

Solution to Problem #2

$$A_{clarification} = \frac{7570\ m^3/d}{27\ m^3/d - m^2} = 280\ m^2 \qquad (6)$$

$$A_{thickening(\ 5-L\ unstirred\ )} = \frac{(7570 + 3255)(3000)(1000)(1/10^6)}{0.40\ (24)} = 3383\ m^2 \qquad (7)$$

$$A_{thickening(\ 5-L\ stirred\ )} = \frac{(7570 + 3255)(3000)(1000)(1/10^6)}{0.95\ (24)} = 1424\ m^2$$

Solution to Problem #2 Continued

Using the limiting solids flux data based on the unstirred, 5-L settling column data results in a clarifier surface area that is 238% larger than the area predicted using the stirred limiting solids flux from the 5-L column. Applying a scaling factor of 2.0 to the limiting solids loading rate of 0.95 kg/m^2-h (Equation 9) results in a surface area of 2,849 m^2, which is closer to the surface area predicted by using the unstirred 5-L settling column data (Equation 7).

$$A_{thickening(5-L\ stirred)} = \frac{(7570+3255)(3000)(1000)\left(1/10^6\right)}{(0.95/2)(24)} = 2849\ m^2$$

Conclusions

- Our work corroborate Wahlberg and Keinath [3] results showing that stirring has a significant impact on both the zone settling velocity and sludge volume index.
- Two-tailed, paired comparison analyses at the 5% level of significance indicated there is a significant difference between SVIs obtained from stirred and unstirred 1-L settling columns.

Conclusions continued

- Two-tailed, paired comparison analyses at the 5% level of significance indicated there is a significant difference between zone settling velocities obtained from stirred and unstirred 1-L settling columns.
- Two-tailed, paired comparison analyses at the 5% level of significance indicated there is a significant difference between SVIs obtained from stirred and unstirred 5-L settling columns.

Conclusions continued

- Two-tailed, paired comparison analyses at the 5% level of significance indicated there is a significant difference between zone settling velocities obtained from stirred and unstirred 5-L settling columns.
- A scaling factor (1.5 – 2.0) should be applied to the limiting solid flux values developed from stirred settling column analyses to enable clarifiers to handle peak solids loadings.

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