Seasonal variability of SVI in the secondary sedimenter of an Italian WWTP

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This study presents a number of empirical evidences suggesting that the Sludge Volume Index (SVI) in an Italian WWTP (Fusina, Venice), operating at high sludge age to allow, nitrification, is strongly affected by Mixed Liquor Suspended Solids (MLSS) concentrations. The dependence of SVI on MLSS is detected only within peculiar periods of the year (winter-spring), and seems not to be affected by the use of Al^{3+} to counteract the growth of *Microtrix parvicella*, as this filament type is substituted by type 0041. It is shown that because of this time-varying dependence between SVI and MLSS, the manager of the WWTP gains more meaningful information from SVI than from diluted SVI (DSVI), which could hide the effects of MLSS on the performance of the secondary settling tanks.

1. Introduction

The Sludge Volume Index (SVI) is an indicator of the sludge settleability in the final clarifier; although not supported theoretically, SVI is a useful test that indicates changes in the sludge settling characteristics and quality, on which failure of WWTPs commonly depends. Generally, non-flocculent or non-settling microbial growth is the result of conditions favorable to filamentous micro-organisms (i.e., bacteria, fungi or actinomycetes, etc.) which cannot be readily settled. Low wastewater temperatures (12-15°C) and high sludge ages are considered as favouring factors to the abundant development of *Microthrix parvicella*, which is the most frequently occurring filamentous micro-organism in sludge (Knoop and Kunst, 1998). Therefore, the settling efficiency of the activated sludge in WTTPs affected by *M. parvicella*, shows a typical seasonal pattern, which is observed in a distinct increase of the SVI index up to critical values under massive growth of the filaments. In order to counteract the growth of *M. parvicella*, dosage of aluminium-based chemicals (e.g. $AlCl_3$) has proved very effective (Roels et al., 2002), although restricted to times of anticipated massive growth.

This study aims to assess the role of the seasonal factor in the temporal evolution of the SVI parameter at the WWTP at Fusina (Venice, Italy) (for details see: Busetti et al., 2005).

2. Data

The Fusina WWTP works at sludge age = 12 days and at low feed/biomass ratios to support nitrification. The WWTP suffers of massive grow of filamentous bacteria during winter and spring seasons, notwithstanding the dosage of Al^{3+}. In fact, the Al^{3+} dosage (0.8-1.0 $g_{Al}/Kg_{MLSS}d$) which started in 2002 has proven to be effective to massively reduce the *M. parvicella* population and counteract filamentous bulking until 2004. Across 2004, filamentous micro-organism type 0041 became the dominant filaments and bulking events resumed. Both filament types M. parvicella and 0041 are typical in MLSS of WWTPs working at low feed/biomass ratios (Graveleau et al., 2005).

The dataset used in this study is the following:

1. Weekly-average time series of SVI, Mixed Liquor Suspended Solids (MLSS), temperature (T), volatile percent of total solids (%Vol) measured at the Fusina WWTP spanning the period 2000-2006;
2. Weekly-average time series of diluted SVI (DSVI) and diluted MLSS (DMLSS), temperature (T) at the Fusina WWTP spanning the period 2005-2006 only;
3. Weekly microbiological data collected at the Fusina WWTP during the period 2000-2006, to detect the dominant filament type.

At the time of investigation, temperature ranged between 9°C and 24°C, SVI ranged between 35 mL/mg and 202 mL/mg, MLSS ranged between 3470 mg/L and 6330 mg/L, and %Vol showed to range between 52% and 73%.

3. Results and discussion

According to the change in the dominant filament (*M. parvicella* was the most abundant filament in 2000-2004 while filament type 0041 was the most abundant in 2005-2006), the original data are divided into two subset series: before 2004 and after 2004. Figures 1-2 show the temporal evolution of the measured parameters.

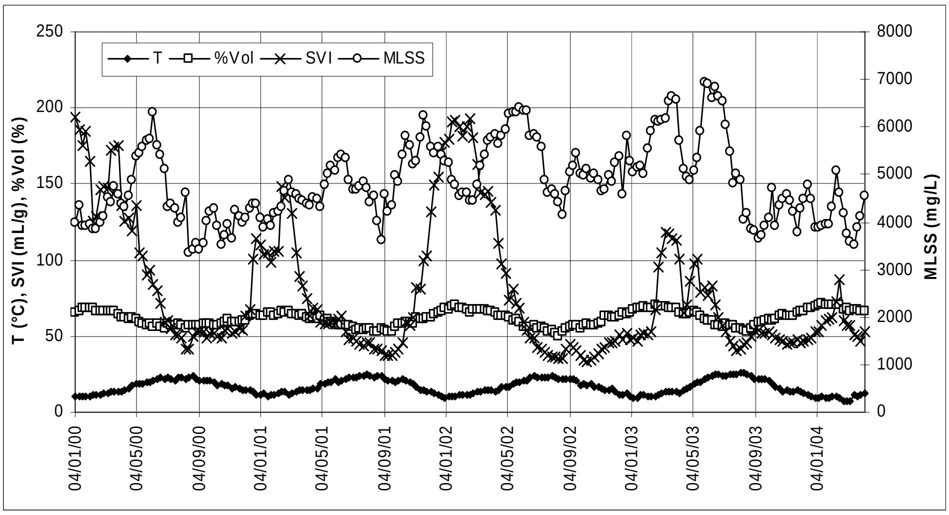

Figure 1 – Temporal evolution of the parameters T, %Vol, SVI and MLSS measured at Fusina WWTP during 2000-2004

From figures 1-2, it emerges that there exists a robust dependence of %Vol on T, and that the increasing phases in the SVI patterns are synchronic with winter-spring periods, undependently on the prevailing filament type.

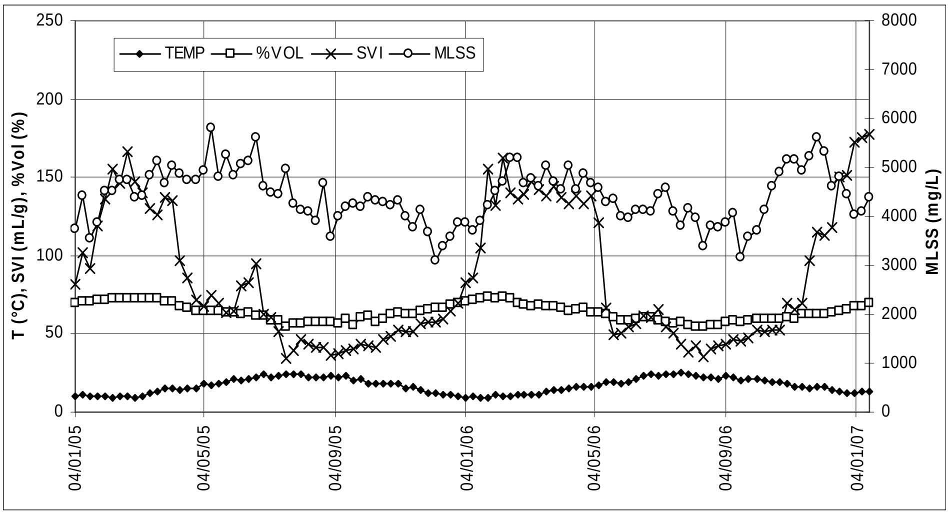

Figure 2 – Temporal evolution of the parameters T, %Vol, SVI and MLSS measured at Fusina WWTP during 2005-2006

Figure 3 compares the SVI and DSVI patterns across the period 2005-2006. It emerges that there exists an evident alternation of periods in which SVI does (or does not) depend on MLSS, i.e., there is (or is not) a distinct evolution of SVI and DSVI patterns. Notably, the differentiation between SVI and DSVI is observed in winter-spring, when also filament bulking generally occurs. These results support the hypothesis that the evolution of sludge settleability properties shown by SVI is similar to that of sludge rheological parameters. In fact, also rheological parameters have been shown to strongly depend on MLSS when filamentous bacteria prevail; conversely, they practically do not depend on MLSS as long as MLSS<10 g/L when floc-forming bacteria proliferate (Battistoni, 1997, Foster, 2002, Tixier et al., 2003).

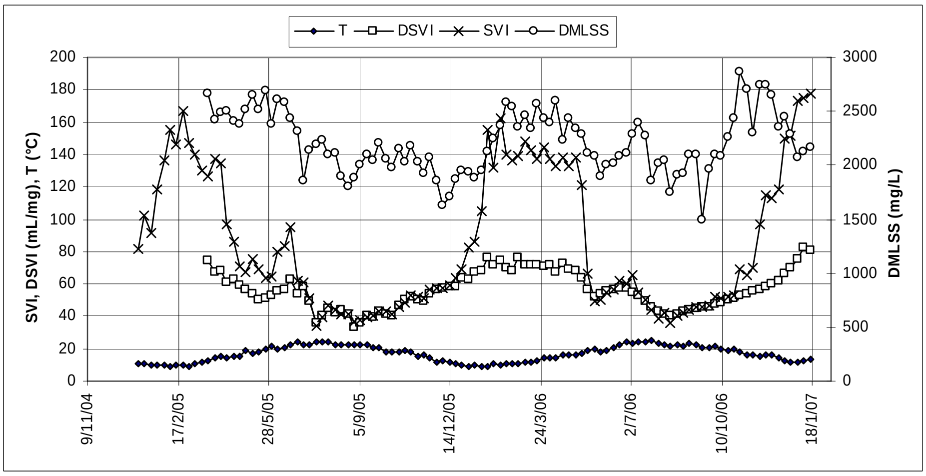

Figure 3 – Temporal evolution of DSVI and DMLSS measured in the WWTP at Fusina during the period 2005-2006

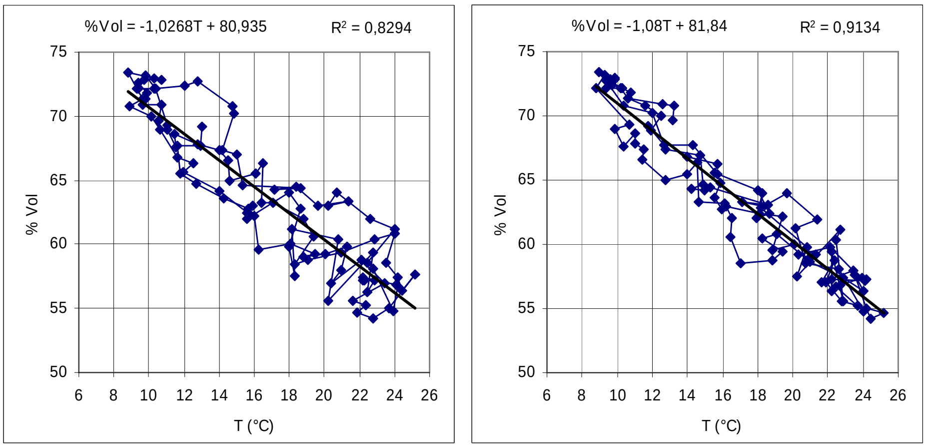

Figure 4 – Scatterplot of weekly-average values of temperature (T) and volatile percent of total solids (%Vol) during the period 2004-2006 without (left panel) and with (right panel) a delay of 3 weeks between the data. Equations of linear regression and R^2 *values are also shown.*

Although the seasonal effect of temperature on modulating the MLSS/settleability relationship stands up from the figures, the linking mechanism is hardly describable. Nonetheless, the prolonged period during winter-spring 2005-2006, when SVI (DSVI) was practically near to 140 (70) mL/mg, provides an opportunity to evaluate the dependence of SVI on MLSS in that period: $(\mathrm{SVI})_{\mathrm{MLSS}=4700} = 2\cdot\cdot\,(\mathrm{SVI})_{2350}$

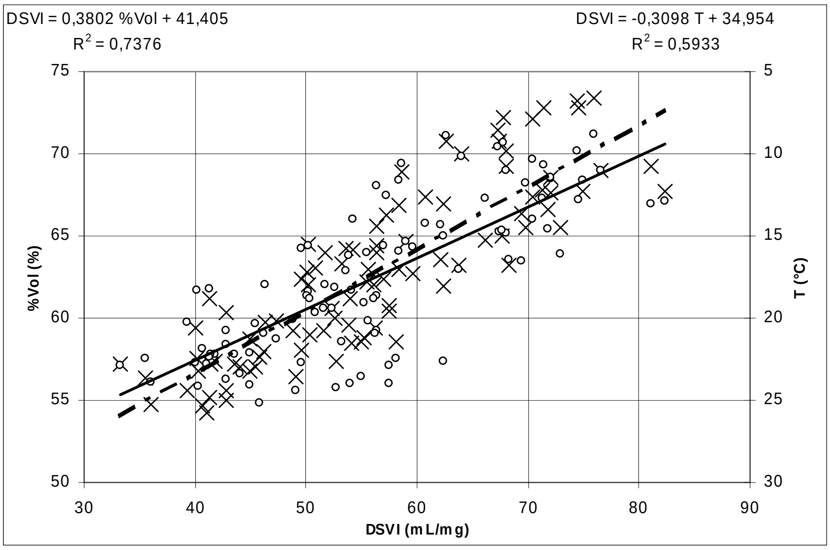

Figure 5 – Scatterplot of weekly-average values of diluted SVI (DSVI) versus volatile percent of total solids (%Vol, left axis) and temperature (T, right axis) during the period 2004-2006. Equations of linear regression and R^2 *values are also provided. Black (or dotted) line represents the linear best fit between DSVI and T (or DSVI and %Vol) data.*

Figure 4 shows the link between the annual patterns of %Vol and T. Notably, the highest coefficient of linear correlation between %Vol and T is evaluated when a delay of about 3 weeks is imposed on the response of %Vol to T. This might suggest that during temperature transient conditions there is a significant delay between temperature and its effect on sludge quality. Similarly, the correlation between DSVI and T which can be observed in Figure 3, is the highest when a delay of about 3 weeks is imposed on the response of DSVI to T. This means that the correlation between DSVI and %Vol is higher than the correlation between DSVI and T (see Figure 5). The strong linear dependence of DSVI on %Vol might suggest that %Vol is a dominant factor driving sludge settleability, which would be consistent with the known influence of Extracellular Polimeric Substances (EPS) and adsorbed organic material on settleability (Morgan-Sagastume et al., 2003). Actually this observation would be misleading, at least during the more critical period for the management of the nitrification process, as MLSS is evidently the dominant factor on settleabilty under filamentous bulking at Fusina WWTP.

4. Conclusions

The empirical evidences shown in this study suggest that SVI is strongly affected by MLSS concentrations only within peculiar periods of the year. Specifically, a strong dependence of SVI on MLSS is detected in the winter-spring period, even if Al^{3+}-based flocculant is adopted for counteracting blooms of *M. parvicella*, because this filament type is replaced by type 0041 which have comparatively similar effects on SVI. This would suggest that Al^{3+}-salts are satisfactorily effective in reducing *M. parvicella*, but not so effective in reducing other filaments, in particular type 0041.The fact that 2-3 years were necessary since Al^{3+}-salts dosing to MLSS in order that type 0041 not only could exceed *M. parvicella* as dominant filaments but also cause bulking, possibly suggests a time spending adaptation of type 0041 to Al^{3+}-salts effects. This hypothesis would merit further investigations.

The strenghten of the dependence of SVI on MLSS occurring under low temperature is associated to unfavourable conditions for nitrification. Hence, managers can not attempt to counteract decreasing nitrification rates by increasing MLSS concentrations, as this would affect sludge settleability and, consequently, deteriorate the performance of the secondary settling tanks up to an unacceptable increase of the suspended solids concentration in the effluent. Nowadays, flow rate reduction at the inlet of the WWTP is then the only option adopted by the Fusina WWTP manager who wants to warrant nitrification during the winter-spring critical period.

References

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