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Modeling and characterization of primary settlers

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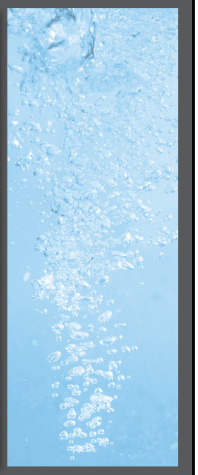

Technical Sessions

Modelling and characterisation of primary settlers in view of whole plant & resource recovery modeling

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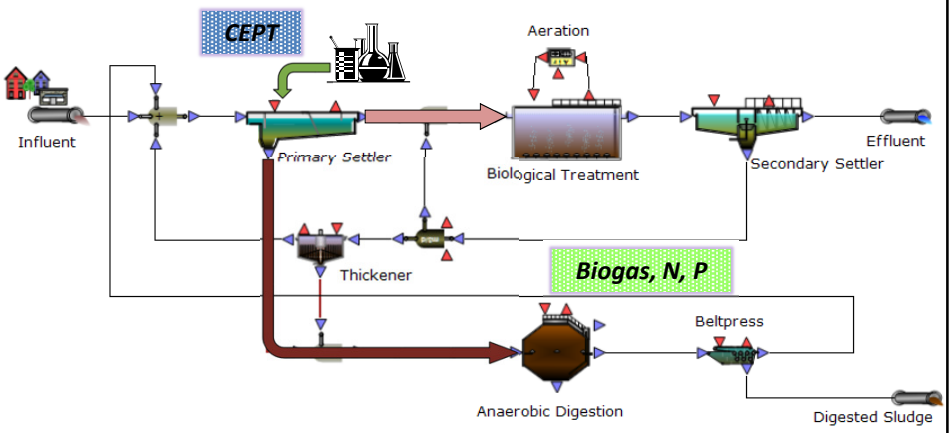
Overview

- ✓ Background
- ✓ Core of the work:
  - i. Particle Settling Velocity Distribution (PSVD) characterisation and modelling for primary settling tanks (PSTs)
  - ii. PSVD for Chemically Enhanced Primary Treatment (CEPT) characterisation and modelling
  - iii. Simple model for CEPT
- ✓ Conclusions

Background



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Background

- PST efficiency affects primary effluent and sludge waste
- **CEPT** may be pursued to enhance PST
- Simple models may be insufficient to describe PSTs

i. Particle Settling Velocity Distribution (PSVD) model for primary settler

PSVD model – Starting point

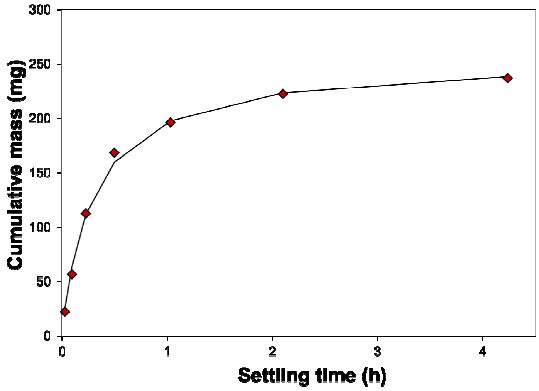
- ✓ Existing settling models based on a single settling velocity for all particles
- ✓ Reality ≡ Heterogeneity

Stokes: $V_s = \frac{g(\rho_p - \rho_w) \cdot d_p^2}{18\mu}$

- ✓ Distribution of settling velocities (ViCAs)
- ✓ PSVD model based on particle classes

PSVD model – ViCAs Methodology

ViCAs (*Settling Velocity in Sanitation*), Chebbo&Gromaire, 2009



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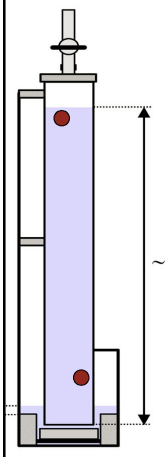
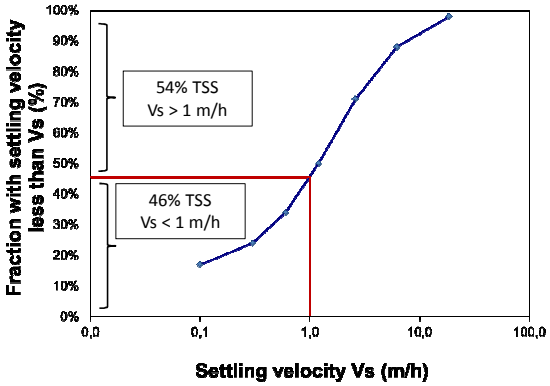
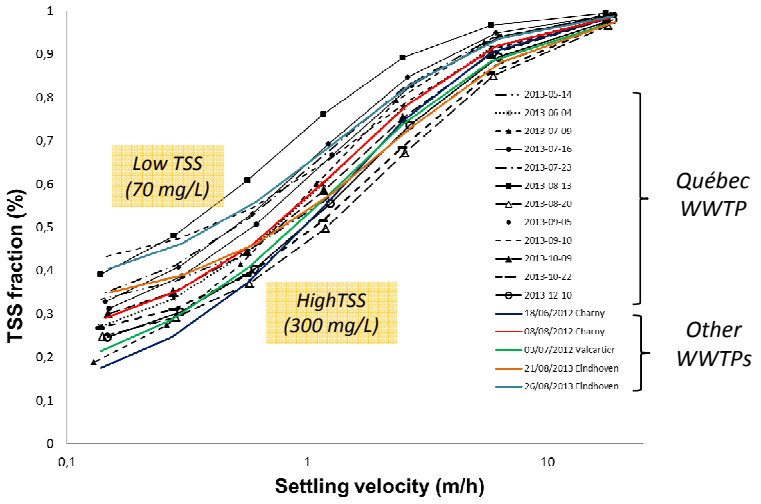
PSVD model – ViCAs Methodology

Not all particles settle over the same column height→
Mass not directly associated to a class of velocity

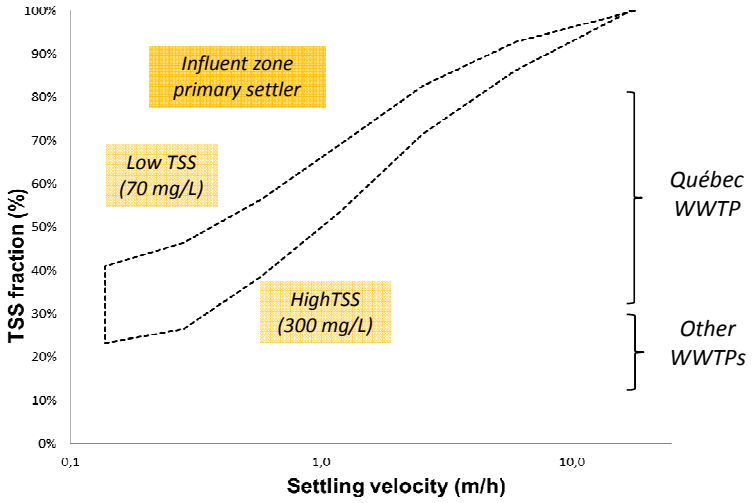




PSVD model - ViCAs zone for influent



PSVD model - ViCAs zone for influent



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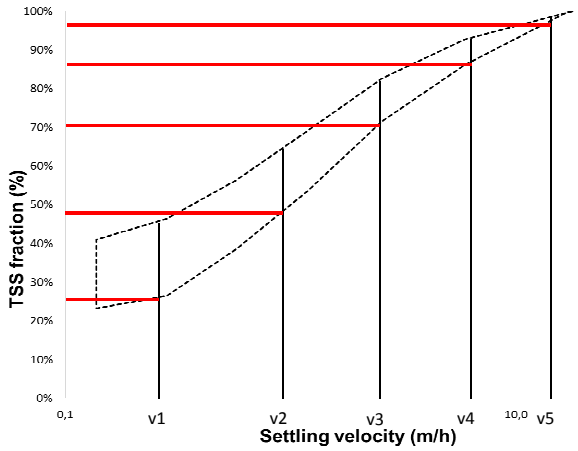
PSVD model - ViCAs interpolation



$F_{class}(\%) = f(TSS_{influent})$

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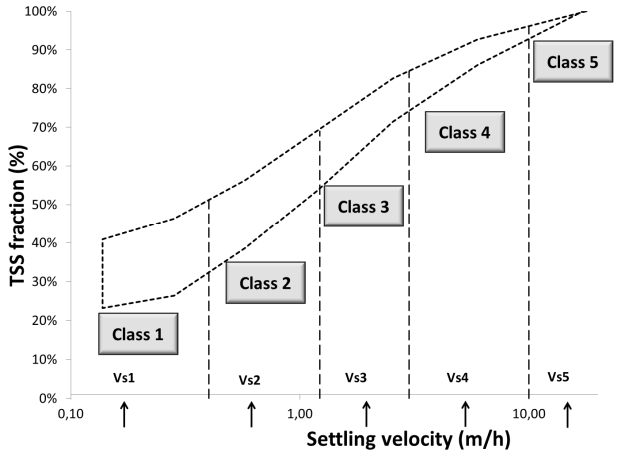
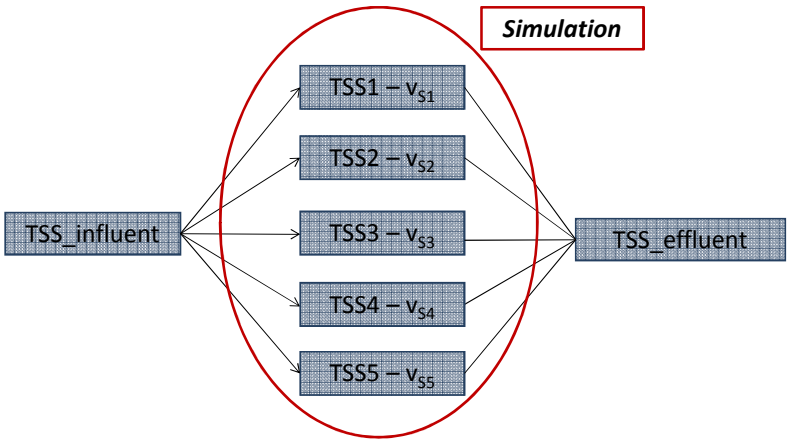
PSVD model - ViCAs interpolation



PSVD model - TSS fractionation



PSVD model - Primary settler data

Eastern WWTP of Québec (full-scale and 5 m^3 pilot PST)

PSVD model - Simulation

Two series of data available

- Full-scale influent and effluent TSS
  (3 days – dry/wet weather - Δt=1h)
- Pilot-scale online turbidity/TSS in influent and effluent
  (1 day - dry weather - Δt=10s)

Calibration

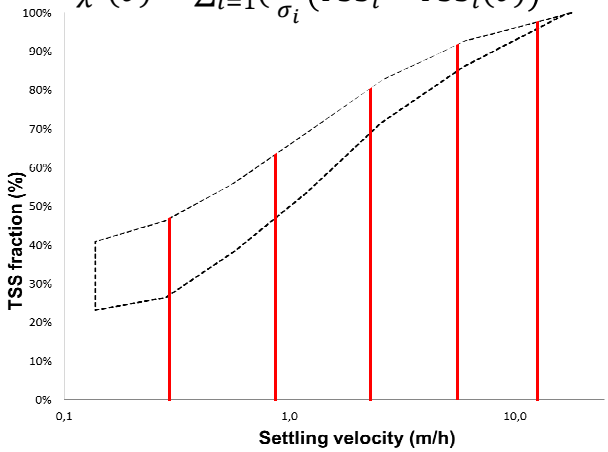
➢ 2 days (full-scale data)

Validation

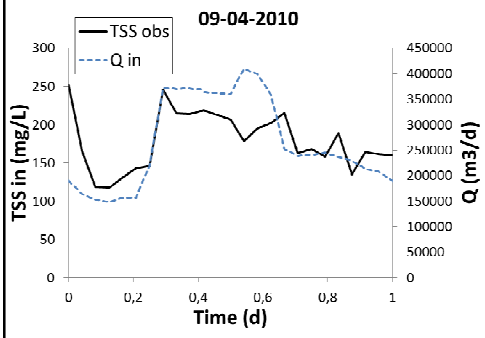
➢ 1 day (full-scale data) + 1 day (pilot-scale data)

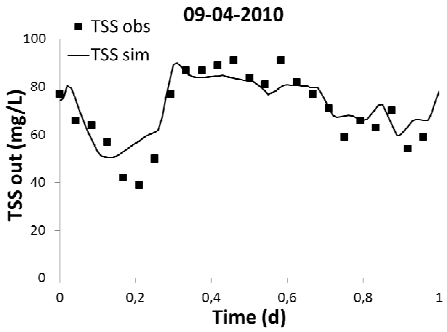
PSVD model - Calibration

$$\chi^2(\theta) = \sum_{i=1}^{n}\left(\frac{1}{\sigma_i}\left(TSS_i - \widehat{TSS}_i(\theta)\right)\right)^2$$



PSVD model – Calibration results





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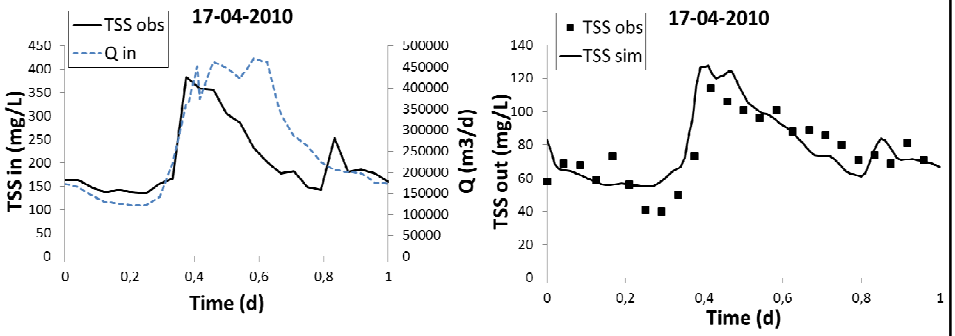

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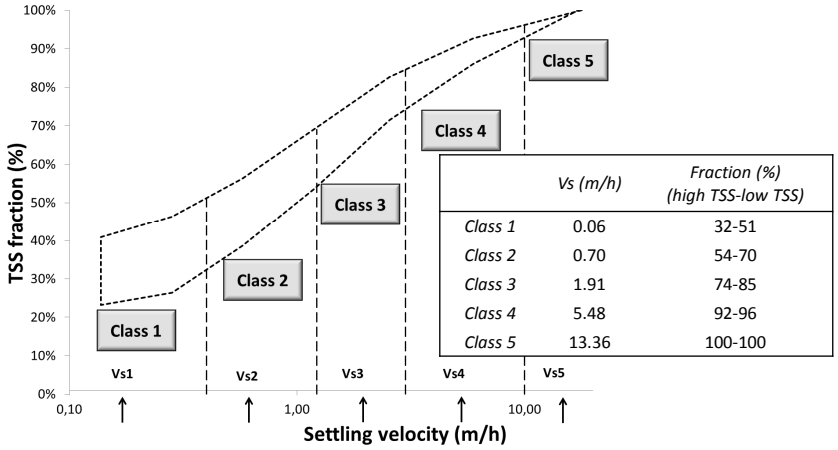
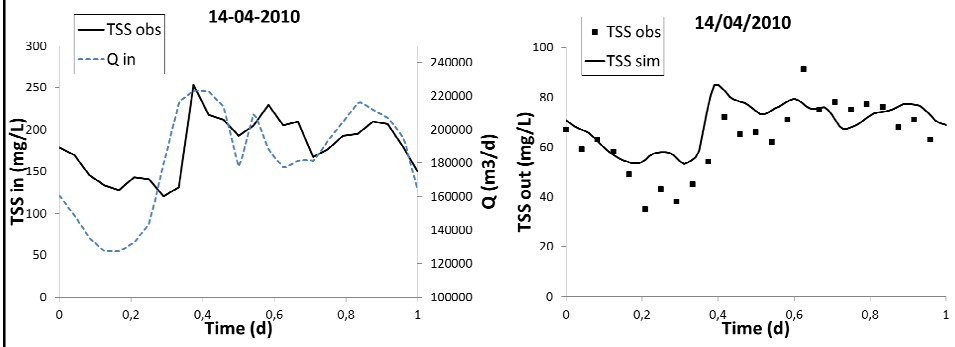
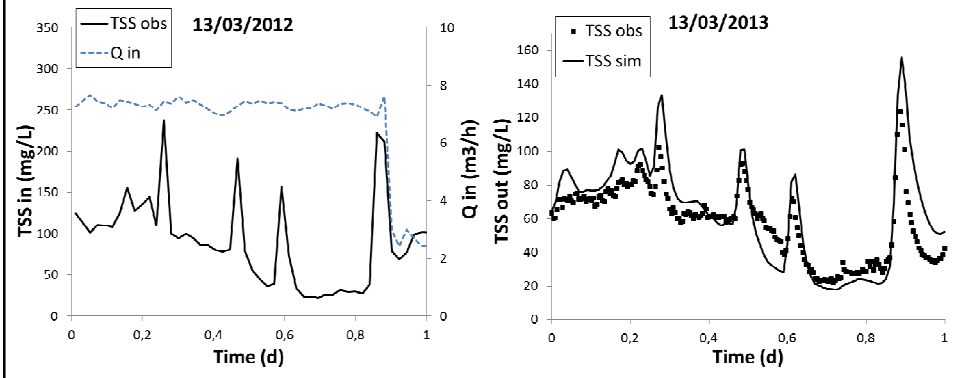


	Vs (m/h)	Fraction (%) (high TSS-low TSS)
Class 1	0.06	32-51
Class 2	0.70	54-70
Class 3	1.91	74-85
Class 4	5.48	92-96
Class 5	13.36	100-100

PSVD model – Validation results



PSVD model – Validation results



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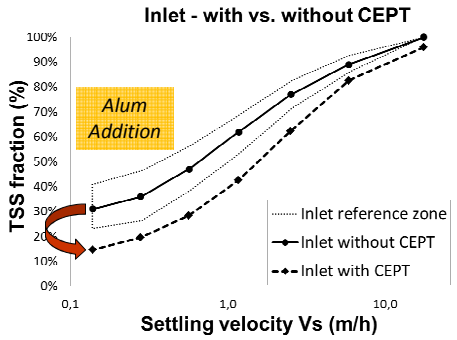
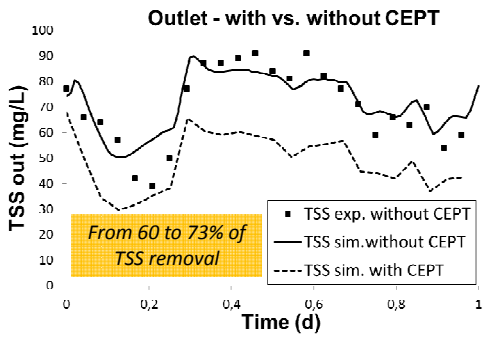
PSVD for CEPT

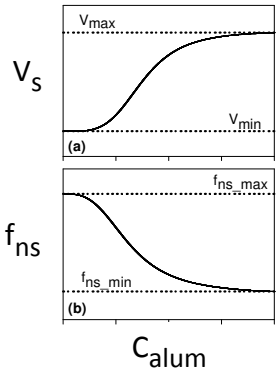




PSVD methodology allows characterisation of CEPT and may provide a useful tool for modelling its impact

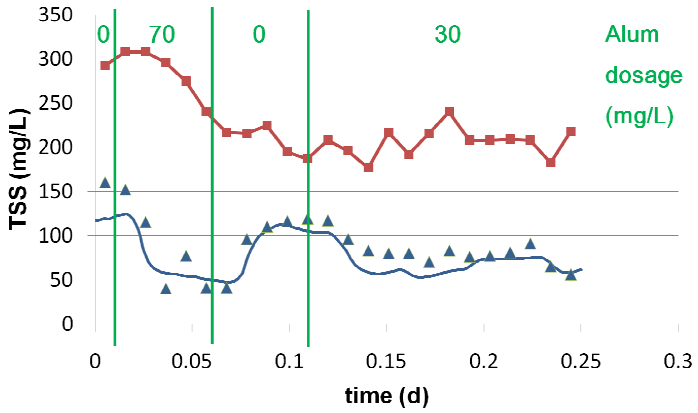
iii. Simplified CEPT model

Simplified CEPT model



Simplified CEPT model

- Model validation:

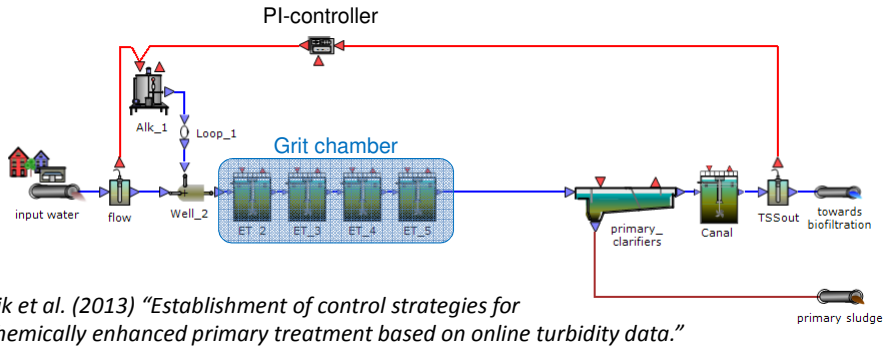


Simplified CEPT model

- Effect of alum addition represented by varying $\mathbf{V_0}$ and $\mathbf{f_{ns}}$
- Model sufficiently adequate for the development of a **control loop** using turbidity/flow as input signal

Simplified CEPT model

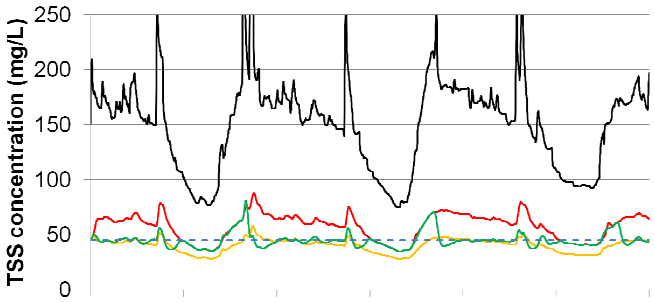
- Alum addition controller



Tik et al. (2013) "Establishment of control strategies for chemically enhanced primary treatment based on online turbidity data." Proceedings ICA2013, Narbonne, France, September 2013

Simplified CEPT model

- Controller performance



Controlled system uses 30% less alum than constant addition

Conclusions

- ✓ A new experimental and modeling approach based on particle settling velocity distribution is proposed
  - ✓ The PSVD model successfully predicts primary effluent TSS
  - ✓ The PSVD model seems useful for modelling PSTs under CEPT
- ✓ An alternative simple PST model allows the development of a CEPT controller using turbidity data

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VILLE DE QUÉBEC

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