What are the aspects of the beast's anger?

Modelling wet weather impact on the WRRF

Peter A. Vanrolleghem

[1)] model*EAU*, Université Laval, Québec, Canada

4th IWA/WEF Wastewater Treatment Modelling Seminar
Spa, Belgium, March 30th – April 2nd 2014

Introduction

Based on forthcoming WEF publication

- *Facility Wet Weather Design and Operation*

and in particular:

Chapter 9: Modeling for Wet Weather

by P.A. Vanrolleghem, L. Benedetti, S. Moisio and N. Sahni

Introduction

What we should be modelling to describe wet weather impacts:

- *Influent flow and composition*
- *Wastewater fractionation*
- *Unit processes*
- *Mixing*
- *Aeration*
- *Settling and clarification*

Influent flow and composition

Graz measurement station under WW:

Influent flow and composition

See presentations:

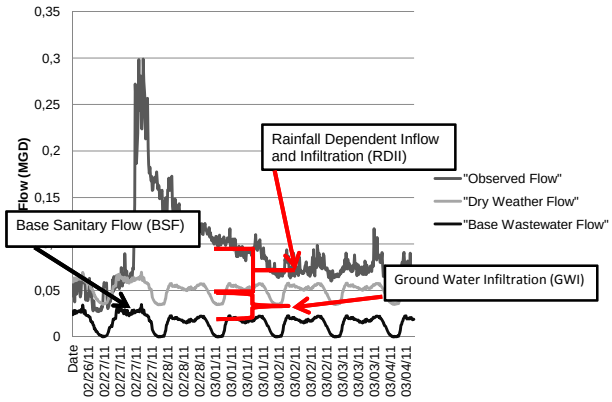
- *Martin & Vanrolleghem (this workshop)*
- *Talebizadeh et al. (Monday)*

Extensions to be considered:

- *Separate versus combined system*
- *Separate system:*
  - *Rainfall-dependent Inflow & Infiltration (RDII)*
  - *Cross connections*

Influent flow and composition

Separate system response on rainfall



Contents

What we should be modelling to describe wet weather impacts:

- *Influent flow and composition*
- *Wastewater fractionation*
- *Unit processes*
- *Mixing*
- *Aeration*
- *Settling and clarification*

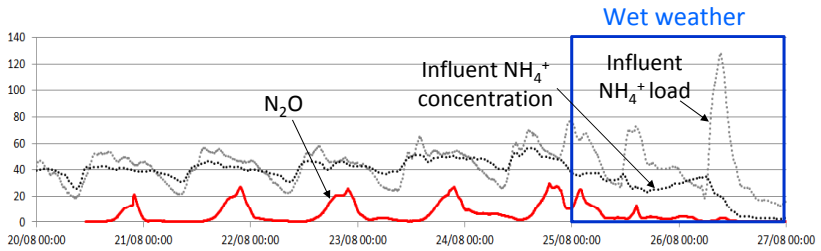
Wastewater fractionation

Wet weather induces changes in wastewater fractionation

- *Run-off*
  - *From roads, lawns, parking lots, roofs, …*
  - *Heavy metals, PHAs, oil, nutrients, pesticides, …*
- *Oxygen presence (> 1 mgO_2/L)!*
- *Dry weather plug flush-out (NH_3-peak)*
- *Resuspension of material accumulated in the sewer system (first flush)*

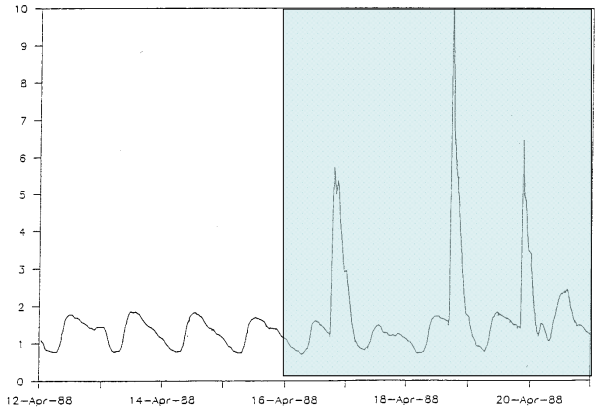
Wastewater fractionation

Dry weather plug flush-out



Wastewater fractionation

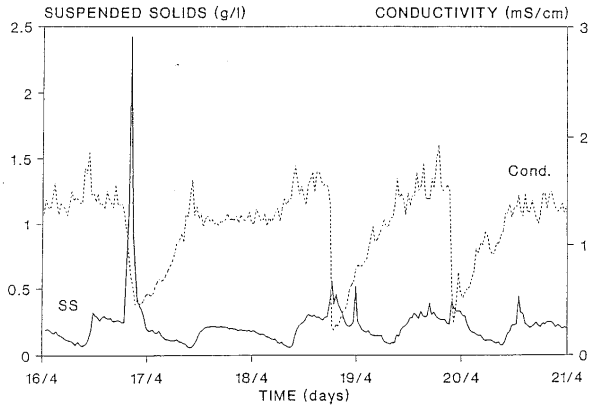
First flush



Wastewater fractionation

First flush

Verbanck M. (1995) Variabilité des charges solides en suspension à l'exutoire des réseaux de collecte. Journée d'étude CB-IAWQ, 31 May 1995, Liège, Belgium (in French).



Wastewater fractionation

Wet weather generates changes in wastewater fractionation

- *Run-off*
- *Oxygen presence (> 1 mgO_2/L)!*
- *Dry weather plug flush-out (NH_3-peak)*
- *Resuspension of material*
  - *Inorganic Suspended Solids (ISS) increases*
  - *Organics with lower biodegradation rate*

Contents

What we should be modelling to describe wet weather impacts:

- *Influent flow and composition*
- *Wastewater fractionation*
- *Unit processes*
- *Mixing*
- *Aeration*
- *Settling and clarification*

Contents

Unit Processes

- *Preliminary treatment*
- *Primary treatment*
- *Biological treatment*
- *Physical and chemical treatment at WRRFs*
- *Disinfection*
- *Residuals processing*

Unit Processes

Preliminary treatment

- *Screens and grit chambers*
- *Often not modelled*
  at best empirical efficiency relationships
- *Screens clog*
- *Grit chambers overloaded,*
  reduced removal efficiency

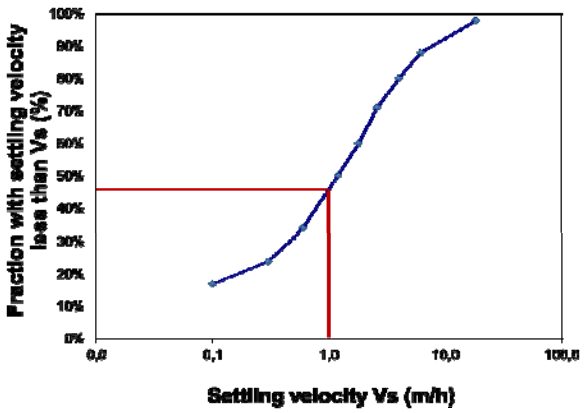
Unit Processes

Primary treatment

- *Point settler with Q-dependent efficiency (Otterpohl – BSM)*
- *Layer model + scouring under hydraulic load*
- *Particle settling velocity distribution (PSVD) (Giulia Bachis et al., Tuesday presentation)*
- *Chemically enhanced primary treatment (CEPT)*

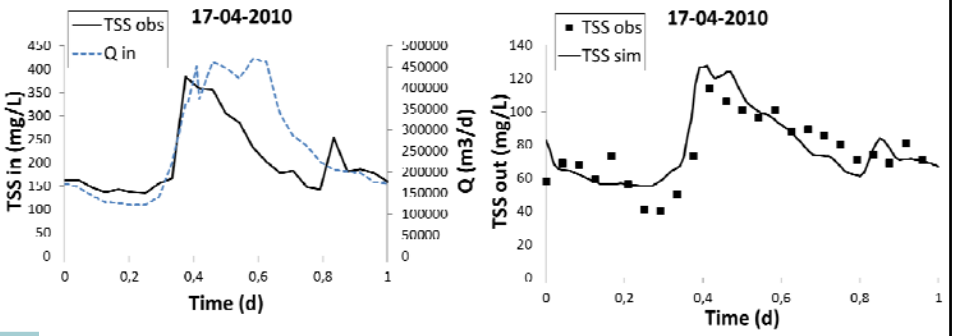
PSVD model

ViCAs experimental set-up



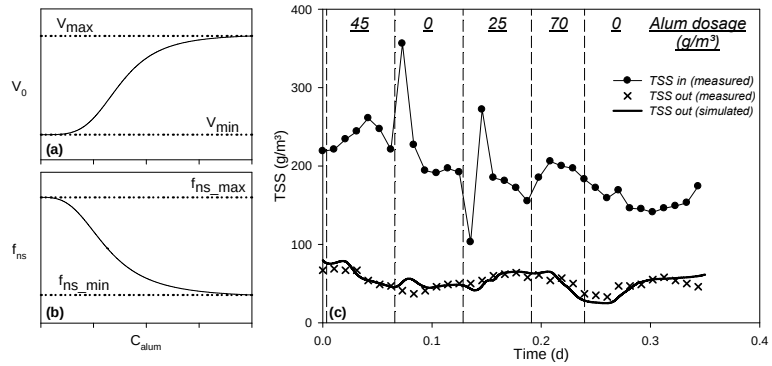
PSVD model

Model capability



CEPT

Tik et al. (ICA2013)



Tik et al. (2013) "Establishment of control strategies for chemically enhanced primary treatment based on online turbidity data."

Contents

Unit Processes

- *Preliminary treatment*
- *Primary treatment*
- *Biological treatment*
- *Physical and chemical treatment at WRRFs*
- *Disinfection*
- *Residuals processing*

Contents

Unit Processes

- *Preliminary treatment*
- *Primary treatment*
- *Biological treatment*
- *Physical and chemical treatment at WRRFs*
- *Disinfection*
- *Residuals processing*

Unit Processes

Physical and chemical treatment

- *Sandfilters, ozonation, activated carbon*
- *Often not modelled*
  at best empirical efficiency relationships
- *No wet weather impacts modelled*
  (clogging, reduced removal efficiency)

Unit Processes

Desinfection

- *Often not modelled*
- *Reduced efficiency under wet weather*

Unit Processes

Residuals processing

- *Traditional models fed with the additional load*
- *No adaptation to the difference in composition of the solids (inert fraction, particle size)*

Contents

Unit Processes

- *Preliminary treatment*
- *Primary treatment*
- *Biological treatment*
- *Physical and chemical treatment at WRRFs*
- *Disinfection*
- *Residuals processing*

Contents

What we should be modelling to describe wet weather impacts:

- *Influent flow and composition*
- *Wastewater fractionation*
- *Unit processes*
- *Mixing*
- *Aeration*
- *Settling and clarification*

Biological Treatment

Mixing

- *Flow affects mixing*
- *Number of tanks in series:*

$$N = 7.4\alpha \frac{L}{WH} Q_{in}$$

- *Computational Fluid Dynamics (CFD)*

Biological Treatment

Aeration

- *Composition affects aeration efficiency*

$$OTR = \alpha K_L a \left(\beta S_O^{sat} - S_O \right)$$

- *Effects on both α and β*

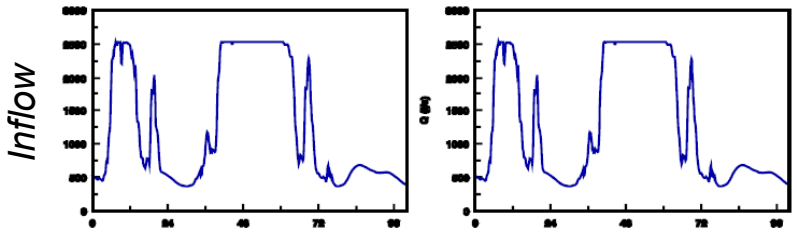
Biological Treatment

Secondary clarifier

- *Sludge inventory under wet weather*

Fixed Q_{ras} *Ratio Q_{ras}*

Inflow



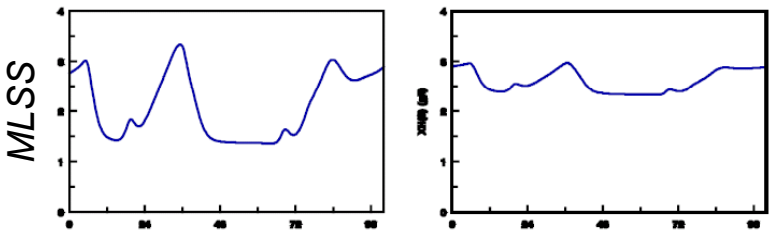
Biological Treatment

Secondary clarifier

- *Sludge inventory under wet weather*

Fixed Q_{ras} *Ratio Q_{ras}*

MLSS

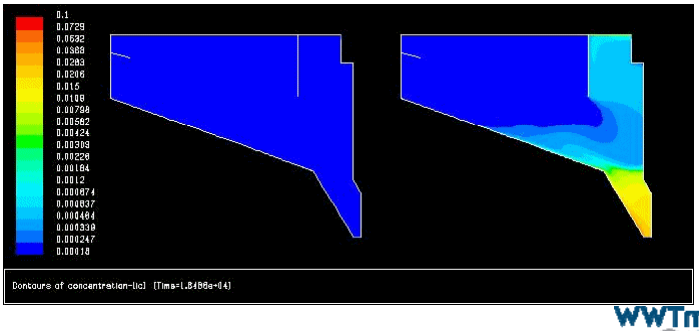


Biological Treatment

Secondary clarifier

- *Computational Fluid Dynamics*

Soluble tracer *TSS*



Biological Treatment

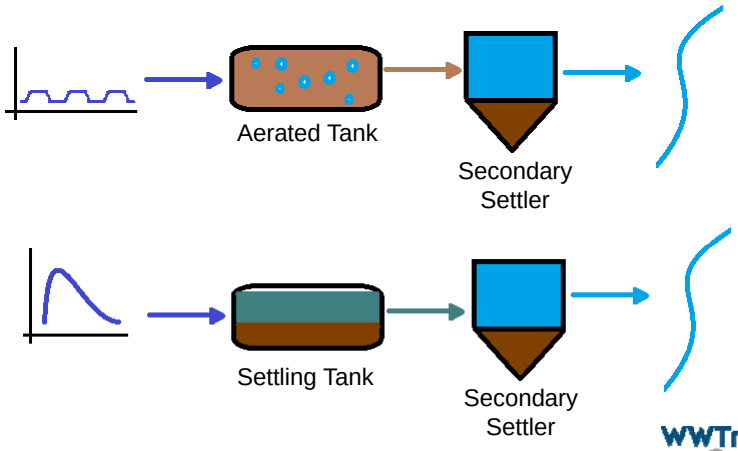
Aeration Tank Settling (ATS)

- *Temporarily using the bioreactor as a settler to store sludge and reduce sludge loading on the secondary clarifier (advanced step feed)*

Benedetti, L., Nyerup Nielsen, C. and Thirsing, C. (2011) Modelling for integrated sewer-WWTP operation with ATS in Copenhagen. In: Proceedings of the 12th Nordic Wastewater Conference, Helsinki, Finland, November 14-16 2011.

Biological Treatment

Aeration Tank Settling (ATS)



Conclusion

What we should be modelling to describe wet weather impacts:

- *Influent flow and composition*
- *Wastewater fractionation*
- *Unit processes*
- *Mixing*
- *Aeration*
- *Settling and clarification*