Les StaRRE – Stations de récupération des ressources de l'eau – Défis de modélisation et de contrôle

Atelier sur la récupération des ressources des eaux et déchets

Université Laval

7 mai 2015

Peter VANROLLEGHEM

Chaire de recherche du Canada en modélisation de la qualité de l'eau

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modelEAU

100 ans! Ça suffit!

Willy Verstraete, Lisbon, 25-Sep-2014
Chair IWA Resource Recovery Cluster

Davyhulme WWTP, Manchester, UK

WRRF's: Water Resource Recovery Facilities: Modelling and Control Challenges

Atelier sur la récupération des ressources des eaux et déchets

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May 7th 2015

Peter VANROLLEGHEM

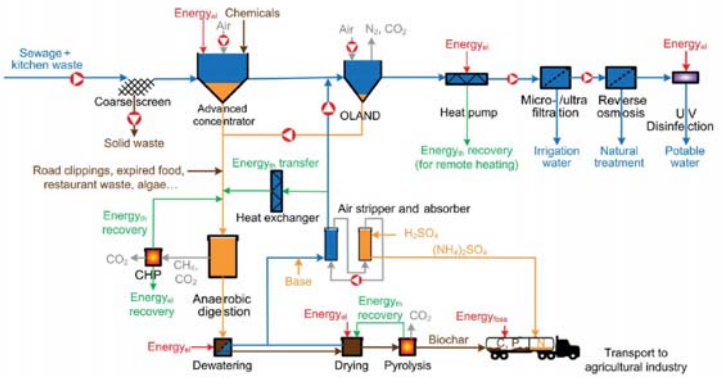
Canada Research Chair in Water Quality Modelling

Outline

- Water resource recovery
- Modelling challenges
- Control challenges
- Take home

"Wurfs"

- Water resource recovery facility (WRRF)



Verstraete & Vlaeminck (2011)
Int. J. Sust. Dev. World Ecol., 18, 253-264.

Resource recovery processes

- Stripping (NH_3, fatty acids)
- Air scrubbing (ammonium sulfate)
- Precipitation (struvite, Ca-phosphate)
- Filtering (paper fibers)
- Extraction (PHA)
- Ion exchange (NH_4^+)
- Reverse osmosis (H_2O, N-K concentrates)
- Phase separation (butanol)
- Pyrolysis, gasification, incineration (energy)
- Chemically enhanced primary treatment (COD)

All physico-chemical unit processes

Outline

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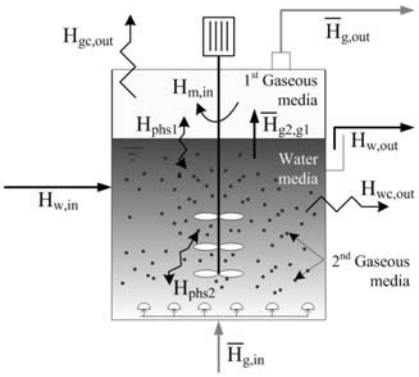
Modelling physicochemical processes

- We've done it simply:
  - Aeration: Kla (C_{sat}-C)
  - pH: f(pKa, TAN, Alk, …)
  - Precipitation: MeOH/MeP
  - Membrane: J = TMP/μ.(R_m+R_f+R_c)

Modelling physicochemical processes

- We have to do it differently:

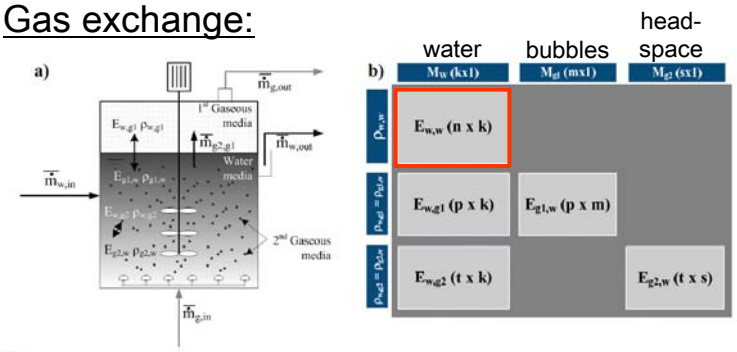
Temperature:



Modelling physicochemical processes

- We have to do it differently:

Gas exchange:



Modelling physicochemical processes

- We have to do it differently:

Precipitation:

1147 © IWA Publishing 2012 Water Science & Technology | 66.6 | 2012

Towards a generalized physicochemical framework

Damien J. Batstone, Youri Amerlinck, George E
Paloma Grau, Bruce Johnson, Ishin Kaya, Jean-
Stephan Tait, Imre Takács, Peter A. Vanrollegh
Christopher J. Brouckaert and Eveline Volcke

ABSTRACT

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Modelling physicochemical processes

- We have to do it differently:

Precipitation:

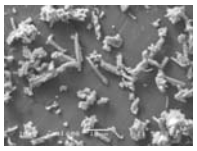
Solid surface interface

$Mg^{+2}(l)$
$NH_4^{+}(l)$
$PO_4^{-3}(l)$

ions migrate to surface and integrate

$MgNH_4PO_4.6H_2O(s)$

solid-phase grows



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modelEAU

Modelling physicochemical processes

- We have to do it differently:

Precipitation:

It gets a little crowded in wastewater

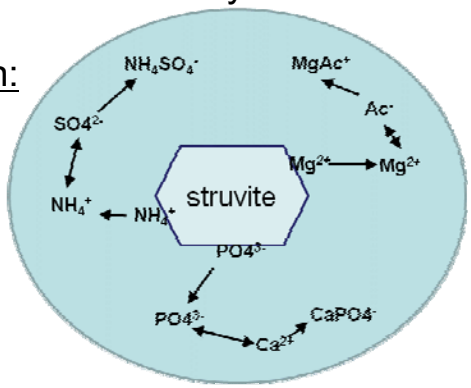
Mg^{2+} HCO^{3-} $CaOH^{+}$ $NaHPO_4^{-}$ Ca^{2+} $MgHCO_3^{+}$ $CaHPO_4$ (aq) Na^{+} $MgH_2PO_4^{+}$ $CaAc^{+}$ Cl^{-} $CaHCO_3^{+}$ Mg^{2+} SO_4^{2-} $NaCO_3^{-}$ $NaHCO_3$ (aq) $NaSO_4^{-}$ HPO_4^{2-} $MgSO_4$ (aq) $CaSO_4$ (aq) K^{+} CO_3^{2-} Na^{+} NaAc (aq) $CaCO_3$ (aq)

Modelling physicochemical processes

- We have to do it differently:

Precipitation:

Ion pairs increase solubility

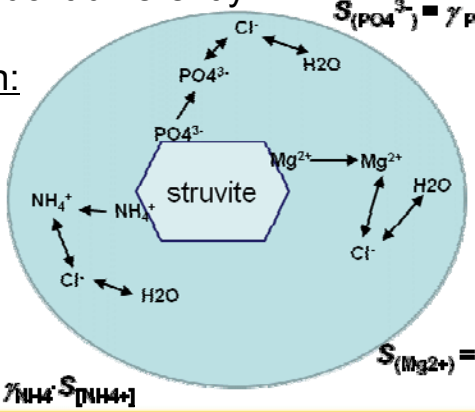


Modelling physicochemical processes

- We have to do it differently:

Precipitation:

Ionic strength increases solubility

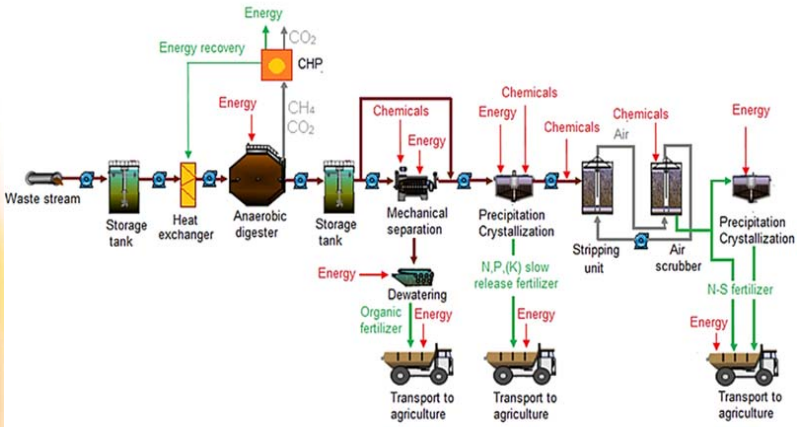


$S_{(PO4^{3-})} = \gamma_{PO4} \cdot S_{[PO4^{3-}]}$

$S_{(Mg2+)} = \gamma_{Mg} \cdot S_{[Mg2+]}$

$S_{(NH4+)} = \gamma_{NH4} \cdot S_{[NH4+]}$

Model-based optimization of resource recovery trains in WRRFs



Céline Vaneeckhaute (2014)
PhD thesis, Université Laval, in preparation

Outline

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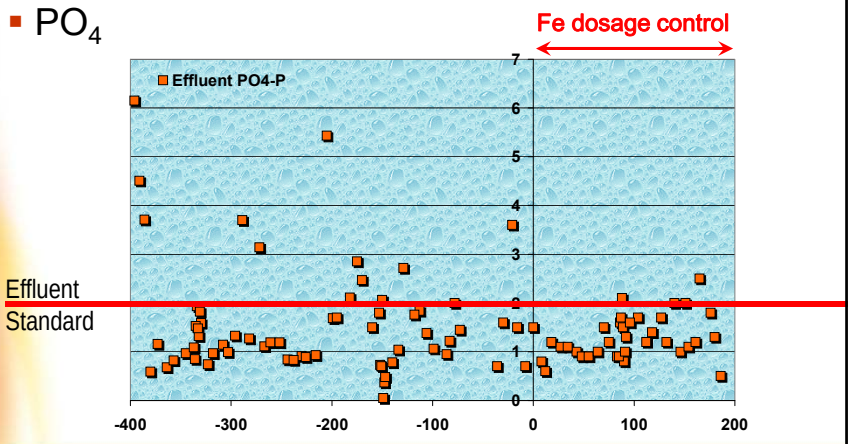
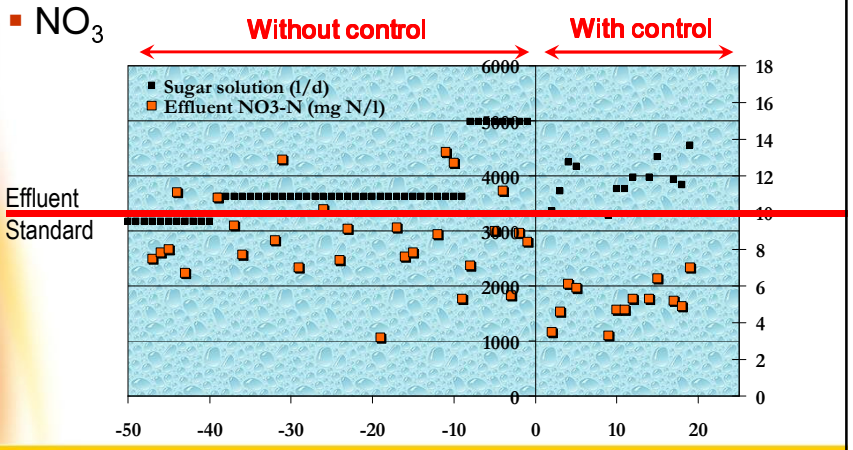
Successful control in WWTP

- PO_4



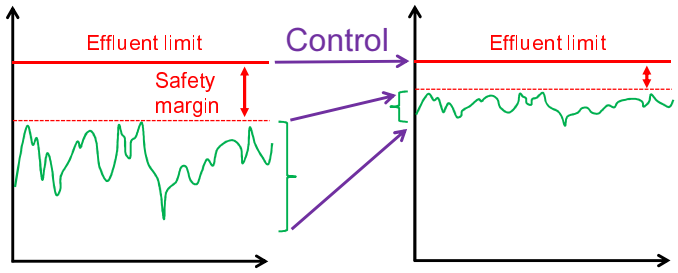
Successful control in WWTP

- NO_3



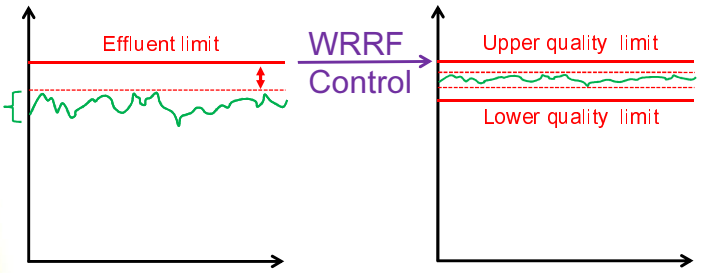
Control challenges

- Paradigm shift:



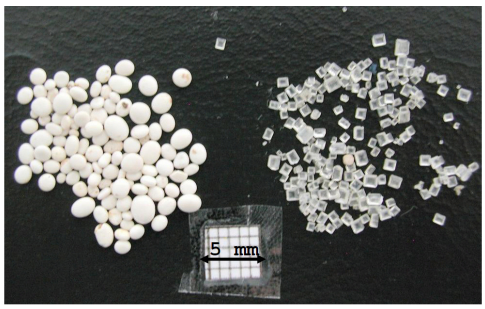
Control challenges

- Paradigm shift:



Control challenges

- Much stricter product specifications!



Control challenges

- No more forgiving client

Control challenges

- No selection of raw materials

Outline

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Take home messages

- WWTPs → WRRFs !
- Physico-chemical processes !
- Modelling challenges are non-trivial
- Resource recovery products must compete with existing products
- Product specifications are strict
- Control is much more strict (upper & lower limit) (no more forgiveness!)

Acknowledgements