

# *Water Resource Recovery Facilities : Modelling and Control Challenges*

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## Outline

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



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## Resources in Water & Sludge

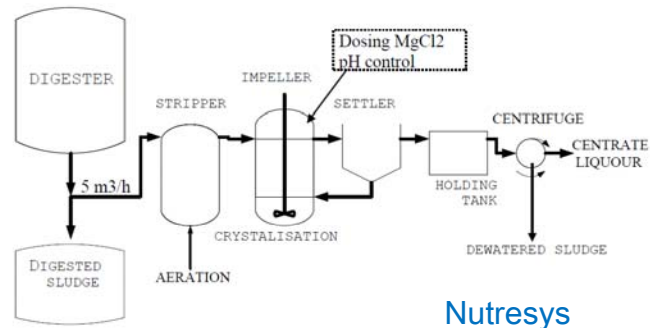
- Water
- Energy
- Biofuels (butanol, ethanol, methanol, H<sub>2</sub>)
- Nutrients (Mg,N,P – struvite, (NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub>)
- Sulphur (S, H<sub>2</sub>SO<sub>4</sub>)
- Fibers (toilet paper)
- Bioplastics (PHA)
- Basis for bio-refineries  
(succinic acids, carotenoids, fatty acids, ...)

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# “Wurfs”

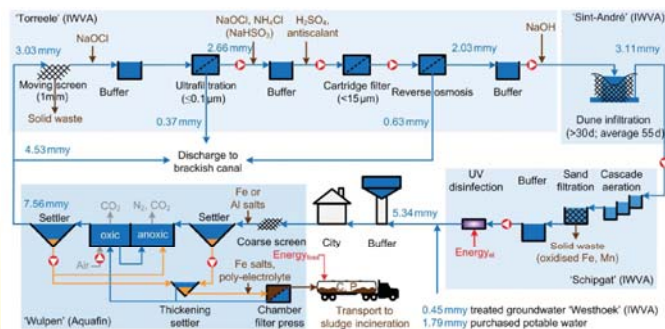
- Water resource recovery facility (WRRF)



Nutresys

# “Wurfs”

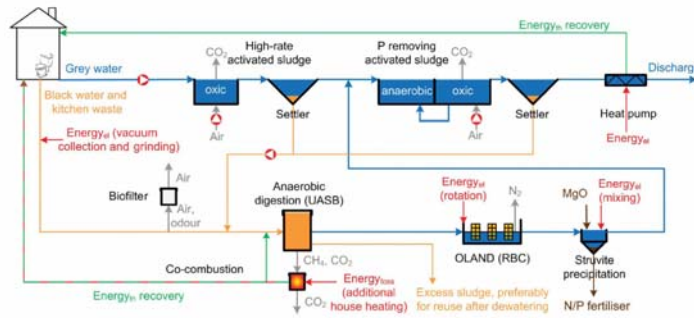
- Water resource recovery facility (WRRF)



Scheme of wastewater reuse as practised in Koksijde (Belgium), with IWA (Intercommunale Waterleidingsmaatschappij -Ambacht) responsible for drinking water production and distribution and Aquaflin for sewage and wastewater treatment

# “Wurfs”

## Water resource recovery facility (WRRF)



Scheme of source-separated sanitation implementing energy and nutrient recovery as practised for 32 houses in Sneek



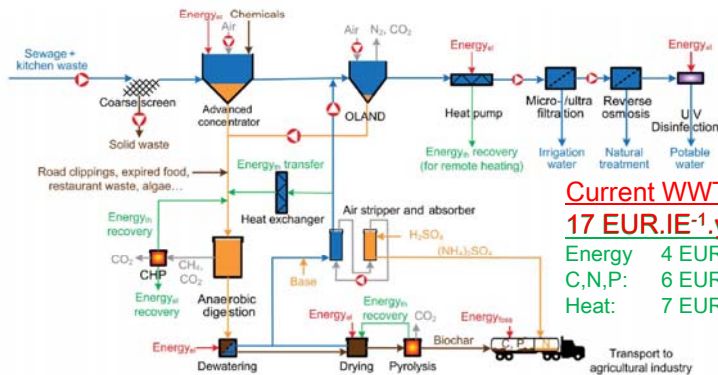
Verstraete & Vlaeminck (2011)  
Int. J. Sust. Dev. World Ecol., 18, 253-264.

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# “Wurfs”

## Water resource recovery facility (WRRF)



**Current WWT cost**  
**17 EUR.IE<sup>-1</sup>.yr<sup>-1</sup>**  
 Energy 4 EUR.IE<sup>-1</sup>.yr<sup>-1</sup>  
 C,N,P: 6 EUR.IE<sup>-1</sup>.yr<sup>-1</sup>  
 Heat: 7 EUR.IE<sup>-1</sup>.yr<sup>-1</sup>



Verstraete & Vlaeminck (2011)  
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## Resource recovery processes

- Stripping ( $\text{NH}_3$ , fatty acids)
- Precipitation (struvite)
- Filtering (paper fibers)
- Extraction (PHA)
- Ion exchange ( $\text{NH}_4^+$ )
- Reverse osmosis ( $\text{H}_2\text{O}$ )
- Phase separation (butanol)
- Pyrolysis, gasification, incineration (energy)
- Chemically enhanced primary treatment (COD)

All  
physico-  
chemical  
unit  
processes

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## Modelling physico-chemical processes

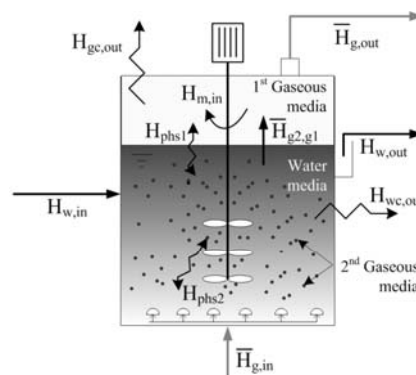
- We've done it simply:
  - Aeration:  $Kla (C_{sat}-C)$
  - pH:  $f(pKa, TAN, Alk, \dots)$
  - Precipitation: MeOH/MeP
  - Membrane:  $J = TMP/\mu \cdot (R_m + R_f + R_c)$



## Modelling physico-chemical processes

- We have to do it differently:

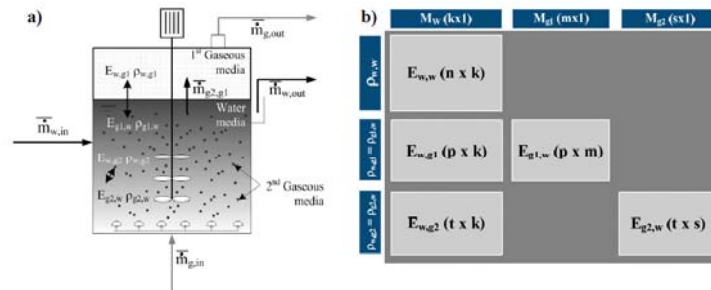
Temperature:



## Modelling physico-chemical processes

- We have to do it differently:

### Gas exchange:



## Modelling physico-chemical processes

- We have to do it differently:

### Precipitation:

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#### Towards a generalized physicochemical framework

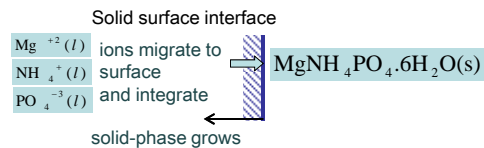
Damien J. Batstone, Youri Amerlinck, George Ekama, Rajeev Goel, Paloma Grau, Bruce Johnson, Ishin Kaya, Jean-Philippe Steyer, Stephan Tait, Imre Takács, Peter A. Vanrolleghem, Christopher J. Brouckaert and Eveline Volcke

ABSTRACT

## Modelling physico-chemical processes

- We have to do it differently:

### Precipitation:

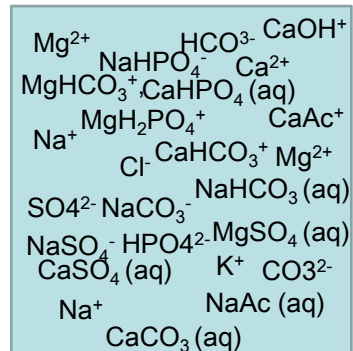


## Modelling physico-chemical processes

- We have to do it differently:

### Precipitation:

*It gets a little crowded in wastewater*



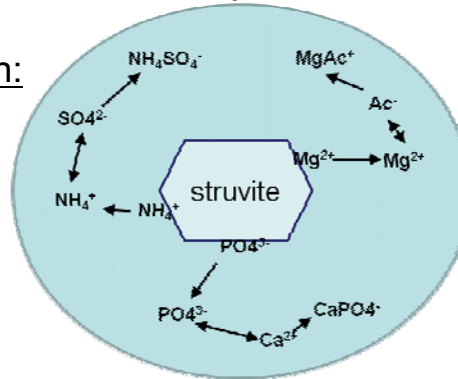


## Modelling physico-chemical processes

- We have to do it differently:

Precipitation:

*Ion pairs increase solubility*

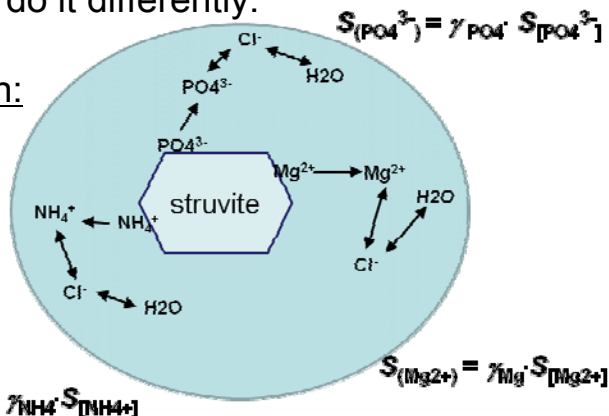


## Modelling physico-chemical processes

- We have to do it differently:

Precipitation:

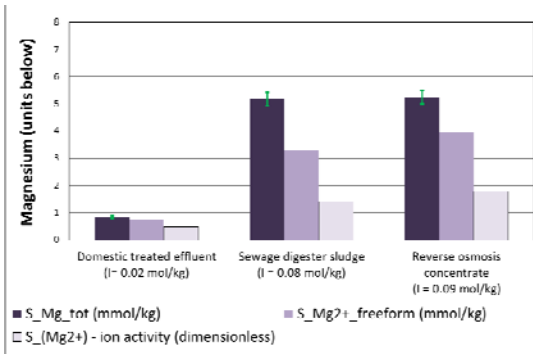
*Ionic strength increases solubility*



## Modelling physico-chemical processes

- We have to do it differently:

### Precipitation:



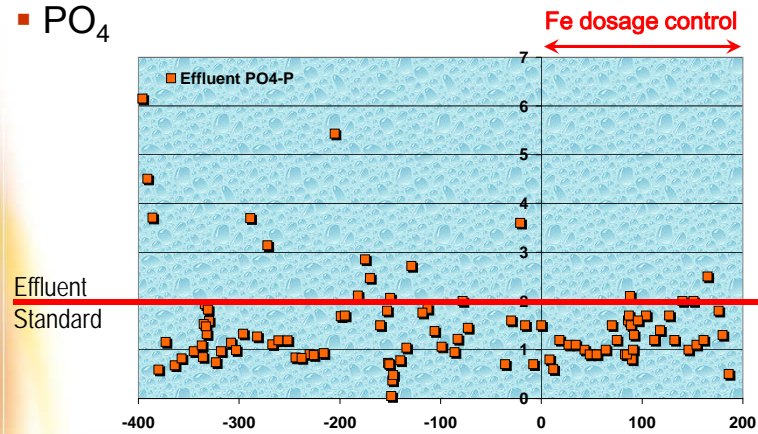
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## Successful control in WWTP



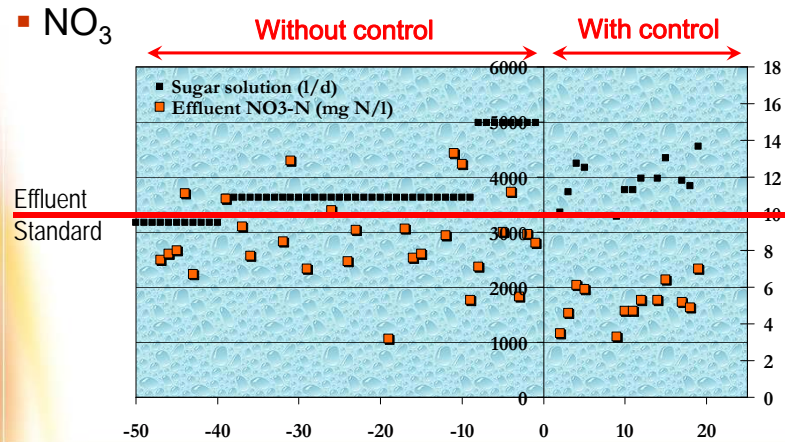
PO<sub>4</sub>



## Successful control in WWTP

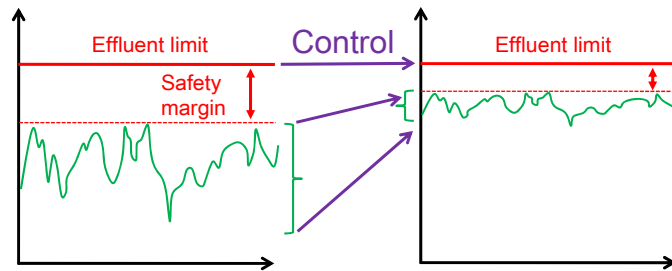


NO<sub>3</sub>



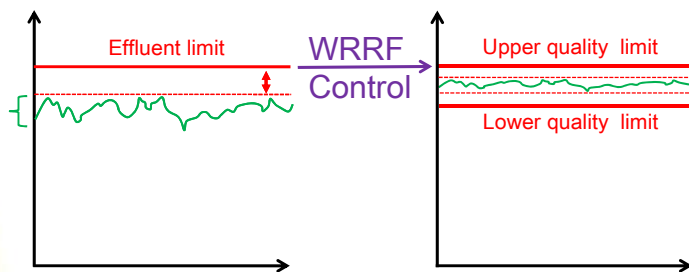
## Control challenges

- 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



## 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 (no more forgiveness!)