Towards BSM2-GPS-X

A plant-wide benchmark simulation model not only for carbon and nitrogen, but also…

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Introduction

BSM2 – …

- ***G*** *- greenhouse gases*
- ***P*** *- phosphorus*
- ***S*** *- sulphur*
- -
- ***X*** *- micropollutants*

Introduction

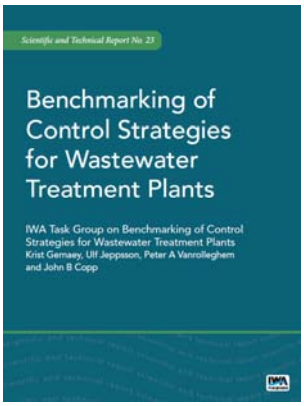
Benchmark Simulation Model No 2

Benchmarking of control strategies of whole facilities

Also vehicle for:

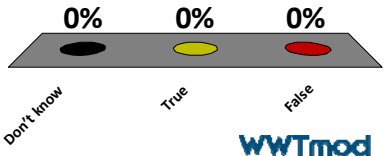
- *model development*
- *model consensus building*
- *model implementation*
- *model verification*

Believer or non-believer ?



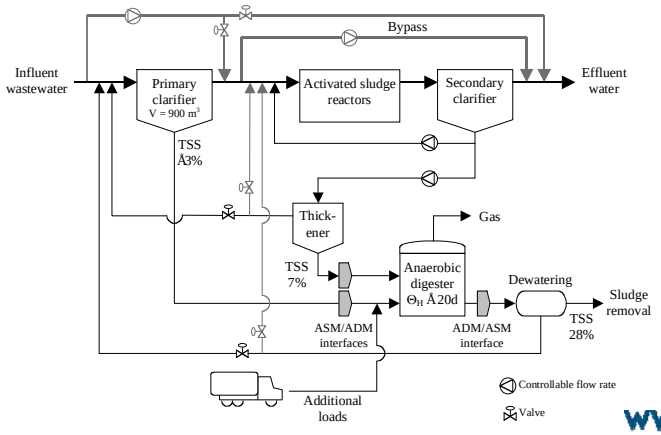
I believe in Benchmarking

A. Don't know
B. True
C. False



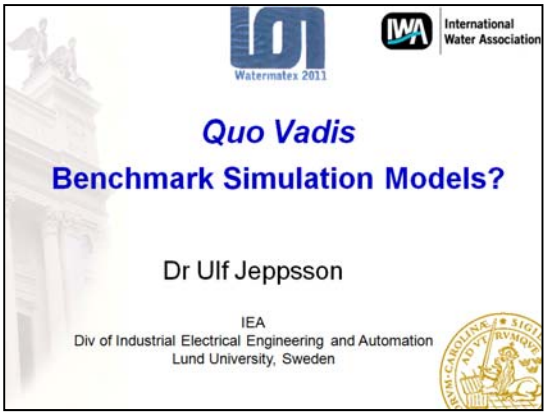
Introduction

Benchmark Simulation Model No 2 (2004)



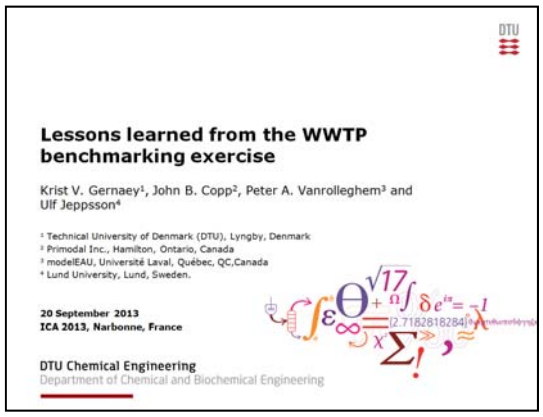
Introduction

Post-project audit – Watermatex2011



Introduction

Post-project audit – ICA2013



Problem statement

BSM3? – What do we want more?

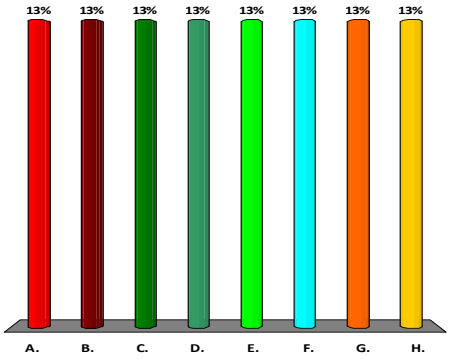
→ BSM2 – What do we have now?

- *COD & N-removal*
- *Anaerobic digestion*

Problem statement

BSM3? – What do we want more?

A. Sewer – river
B. 20-50 years
C. GHG
D. P-removal
E. Sulphur
F. Micropollutants
G. Aeration/Energy
H. Settling



Whatever the outcome, this is it:

BSM2 – …

- ***G*** *- greenhouse gases*
- ***P*** *- phosphorus*
- ***S*** *- sulphur*
- ***X*** *- micropollutants*

Overview of the presentation

BSM2 – GPS-X

- *New evaluation criteria (variables)*
- *New transformations (affecting the variables)*
- *New components (affecting the transformations)*
- *New influent characteristics (driving the system)*
- *New layout – unit processes (subsystems)*
- *Model integration (putting it all together)*
- *New sensors & control (what we do it for)*

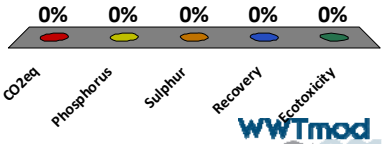
GPS-X - New evaluation criteria

To assess controller performance

- *CO_{2eq} performance criteria?*
- *P-related criteria – weighting?*
- *Relevant sulphur components?*
- *Nutrient recovery as objective – how?*
- *Ecotoxicity of effluents?*

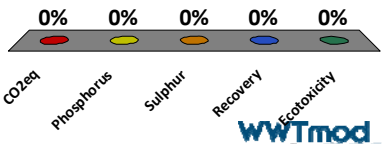
What is important on the short term?

A. CO2eq
B. Phosphorus
C. Sulphur
D. Recovery
E. Ecotoxicity



What is important on the long term?

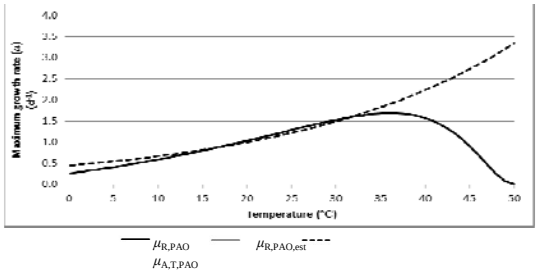
A. CO2eq
B. Phosphorus
C. Sulphur
D. Recovery
E. Ecotoxicity



GPS-X - New transformations

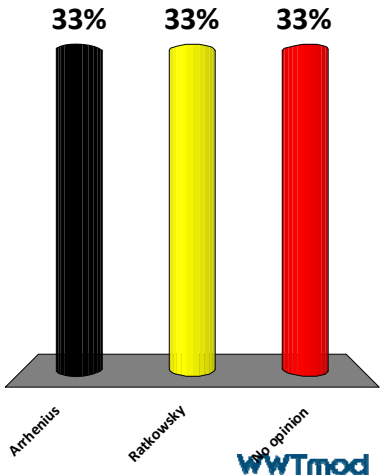
Chemical / biochemical → G

- *GHG modelling (Unified model !)*
- *Ratkowsky or Arrhenius T-dependency*



Temperature dependency should be:

A. Arrhenius
B. Ratkowsky
C. No opinion



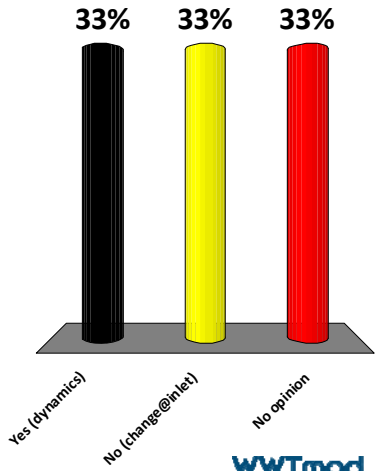
GPS-X - New transformations

Chemical / biochemical → P

- *ASM2d (with modifications) still relevant?*
  - *O_2/NO_3-decay , specific substrates for DN*
  - *Mg^{2+}, K^{+}, Ca^{2+}*
- *Do we need to model PAO behaviour in AD?*
- *Is ADM1 the proper model to start from?*
- *Include anoxic/aerobic digestion for Bio-P?*

PAO-model for digestors

A. Yes (dynamics)
B. No (change@inlet)
C. No opinion



GPS-X - New transformations

Chemical / biochemical → S

- *Which S-related processes are required?*
  - *Chemical S-oxidation/-reduction*
  - *Biological S-oxidation/-reduction*
  - *Competition with methanogens for H_2*

GPS-X - New transformations

Chemical / biochemical → X

- *Biodegradation*
- *Hydrolysis*
- *Volatilization*
- *Sorption - desorption*
- *Photolysis*

- *Sufficient chemical property information?*

GPS-X - New transformations

Physico-chemical models

- *Acid-base reactions, pH*
- *Ion strength/ion activity/ion pairing*
- *Precipitation*
  - *Which components (all or selected)?*
  - *Kinetics*
  - *Nucleation – seeding*
- *Solver to be selected*

GPS-X - New components

Extension of the component vector

- *Inert inorganic suspended solids*
- *GHG-related components* (NH_2OH,N_2O,NO,NO_2)
- *Bio-P related components* (X_{PAO}, X_{PP}, X_{PHA}, …)
- *P-precipitation related components*
  (Mg, K, Ca, Fe, struvite, K-struvite, iron phosphate)
- *S-related components*
  (sulphide, sulphite, sulphate, poly-S, sulphur)
- *Micropollutants* (S_X, X_X)

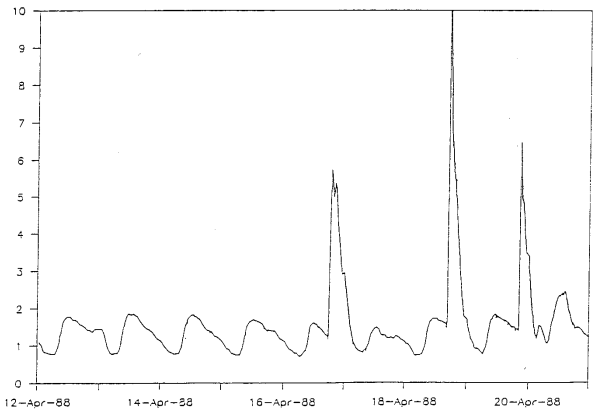
GPS-X - New influent characteristics

G, P, S and X-related influent loads

- *Influent generator with*
  - *CH_4 production in sewer?*
  - *H_2S production in sewer?*
  - *Influent pH-dynamics*
  - *Influent with acid-base / ion composition dynamics*

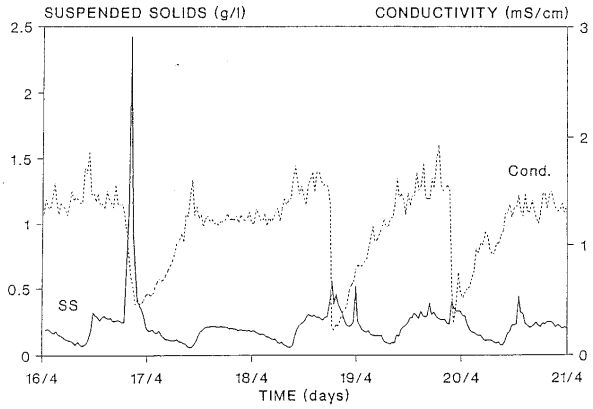
GPS-X - New influent characteristics

Ion composition dynamics (example)

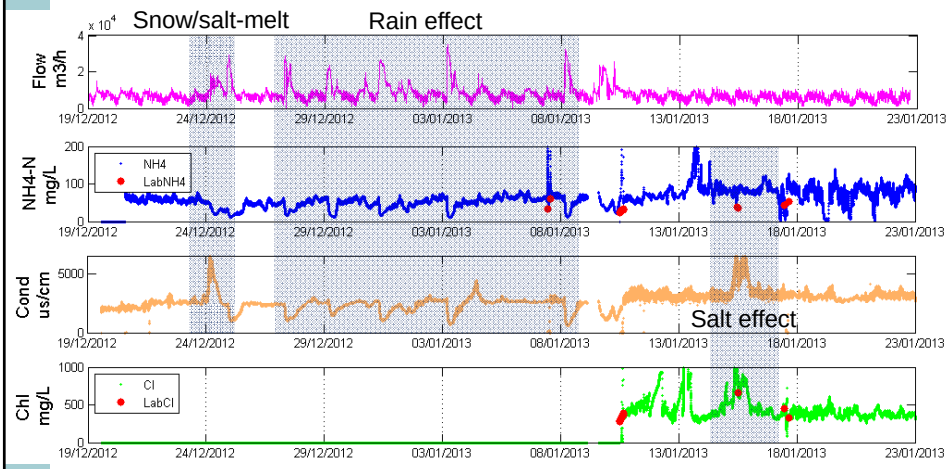


GPS-X - New influent characteristics

Ion composition dynamics (example)



GPS-X - New influent characteristics



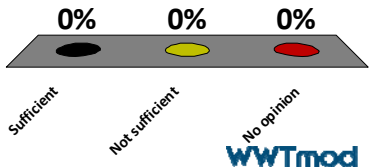
GPS-X - New influent characteristics

G, P, S and X-related influent loads

- *Influent generator with*
  - *CH_4 production in sewer?*
  - *H_2S production in sewer?*
  - *Influent pH-dynamics*
  - *Influent with acid-base / ion composition dynamics*
- *Can we just use correlations with traditional wastewater components?*

Correlation with other variables is …

A. Sufficient
B. Not sufficient
C. No opinion



Overview of the presentation

BSM2 – GPS-X

- *New evaluation criteria* *(variables)*
- *New transformations* *(affecting the variables)*
- *New components* *(affecting the transformations)*
- *New influent characteristics* *(driving the system)*
- *New layout – unit processes* *(subsystems)*
- *Model integration* *(putting it all together)*
- *New sensors & control* *(what we do it for)*

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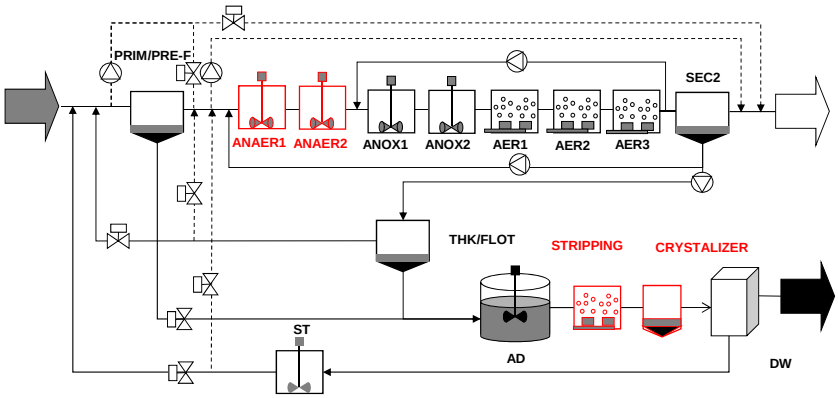
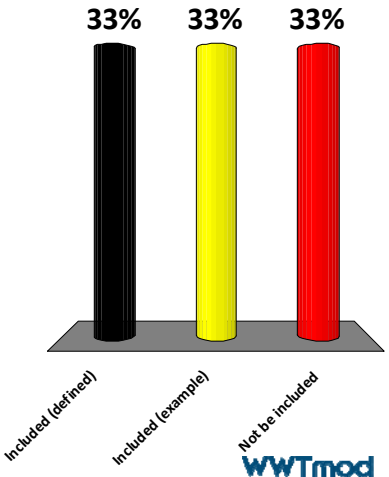
GPS-X - New physical layout

Anaerobic tanks / nutrient recovery unit?



Nutrient recovery system should be

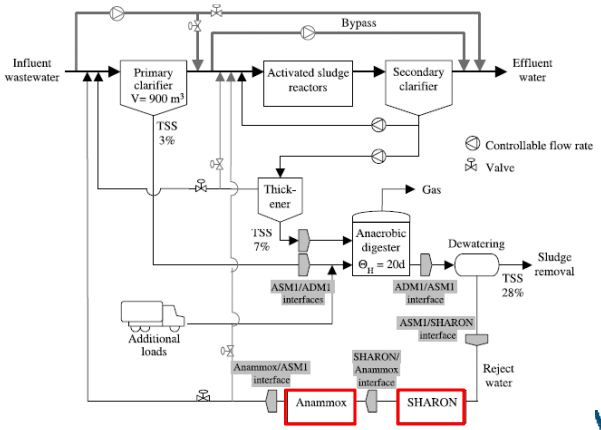
A. Included (defined)
B. Included (example)
C. Not be included



GPS-X - New physical layout

Sludge reject

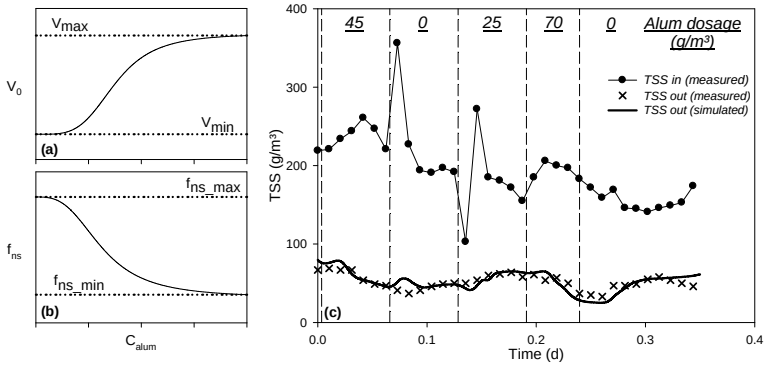
Volcke E.I.P., Gernaey K.V., Vrecko D., Jeppsson U., van Loosdrecht M.C.M. and Vanrolleghem P.A. (2006) Plant-wide (BSM2) evaluation of reject water treatment with a SHARON-Anammox process. Wat. Sci. Tech., 54(8), 93-100



GPS-X - New physical layout

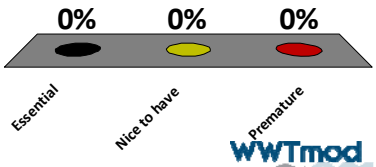
New primary

Tik S., Langlois S. and Vanrolleghem P.A. (2013) Establishement of control strategies for chemically enhanced primary treatment based on online turbidity data. In: *Proceedings ICA2013*. Narbonne (F), 18-20 SEP 2013.



Primary clarifier model for CEPT is

A. Essential
B. Nice to have
C. Premature



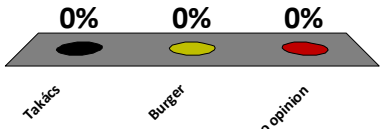
GPS-X - New unit process models

Secondary clarifier

- *Compression?*
- *Flow-dependent dispersion?*
- *Denitrification (full reactive / separate tank)*

Secondary clarifier model should be:

A. Takács
B. Burger
C. No opinion



GPS-X - New unit process models

Secondary clarifier – Thickener/Storage

- *Compression?*
- *Flow-dependent dispersion?*
- *Denitrification (full reactive / separate tank)*

Add effluent polishing?

- *Post-denitrification*
- *Disk filter*

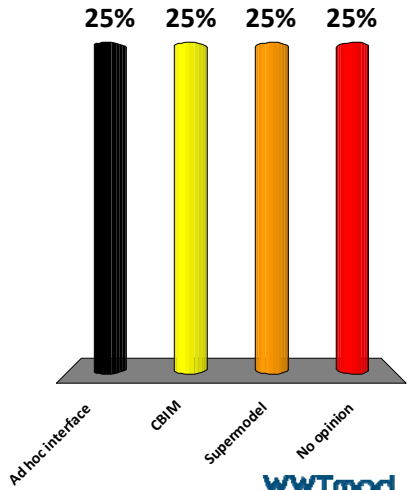
GPS-X – Model integration

Connecting the different unit processes

- *Interface approach*
  (Maintain different sets of components in the different unit processes)
  - *Ad hoc approach*
  - *Continuity-based Interfacing Method*
- *Supermodel approach*
  (Use a common set of components in all individual unit processes)

Integration should be done by:

A. Ad hoc interface
B. CBIM
C. Supermodel
D. No opinion



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GPS-X – New controllers

Sensors & Actuators

- *P-analyzer (or P-polymer) sensors*
- *NO_2, NO, N_2O sensors*
- *Off-gas analysers (O_2, CO_2, CH_4, H_2S, N_2O)*

Controllers

- *CEPT dosing*
- *Nutrient recovery*

Conclusion

BSM2 – …

- ***G*** *- greenhouse gases*
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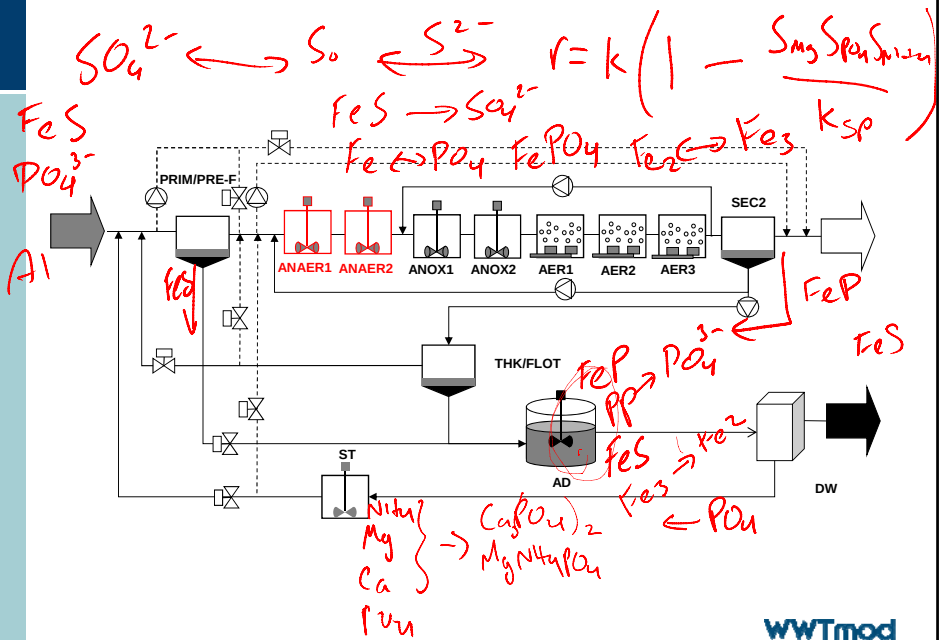
  -
- ***X*** *- micropollutants*



Conclusion

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Thank you for your continued input!