SIXTH FRAMEWORK PROGRAMME

Neptune FP6 Project

LCA and nutrient removal

Joris Roels, Tom Wambecq, Kris De Gussem, Alessio Fenu, Aquafin, Belgium

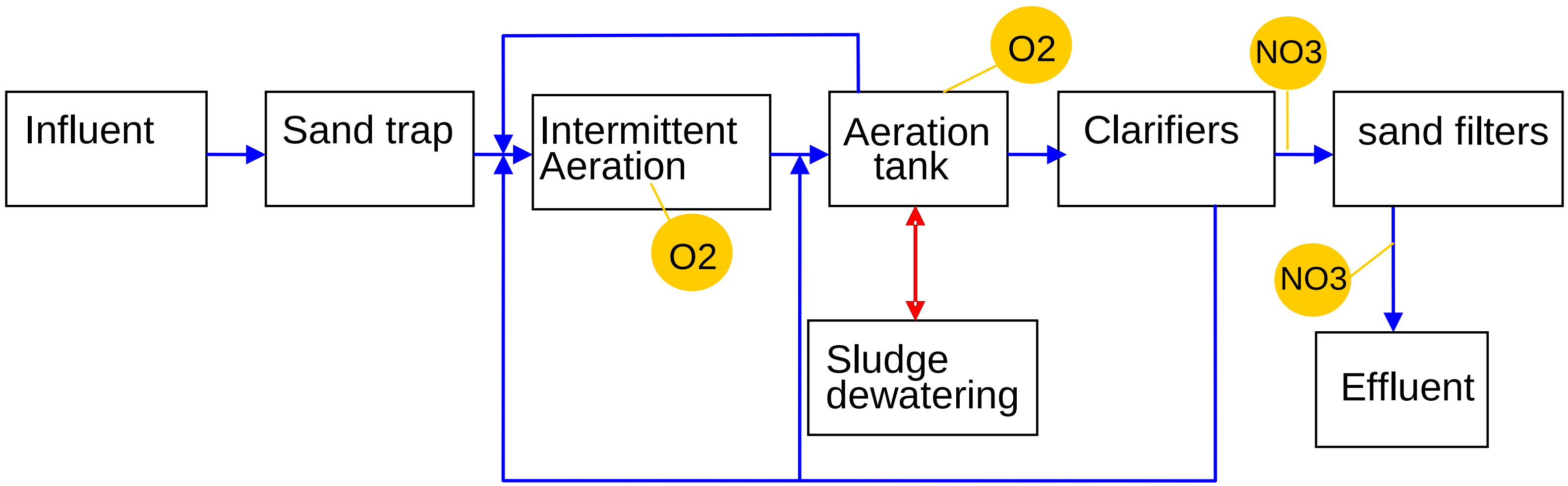
Xavier Flores-Alsina, Peter Vanrolleghem
ModelEAU, Canada

Introduction

- Online control for nutrient removal is standard practice at Aquafin (AQF) (Flanders)
- Goal of online control at Aquafin = meeting the effluent consent at the lowest cost
- Currently AQF has no stimulus to produce a cleaner effluent than strictly necessary since AQF doesn’t pay a levy for the residual pollution
- A new methodology was assessed which sets as goal a reduction of the the footprint of wastewater treatment following a life cycle approach
- For this purpose, calibrated, asm2d models were made of 3 full scale WWTP’s on which the two methodologies (costs respecting effluent consent versus lowest footprint) were compared

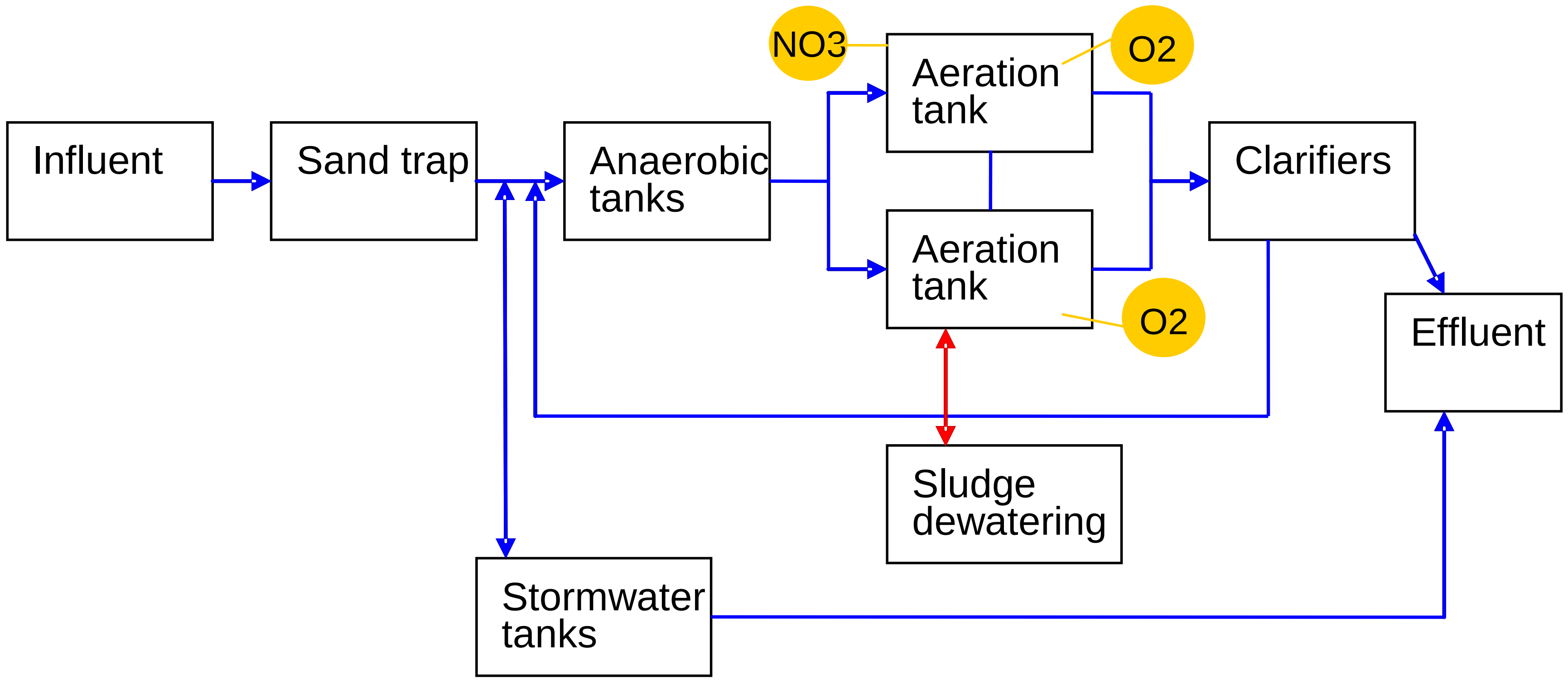
Outline of the 3 plants

- Plant 1: 27.000 PE, limited online control already in place



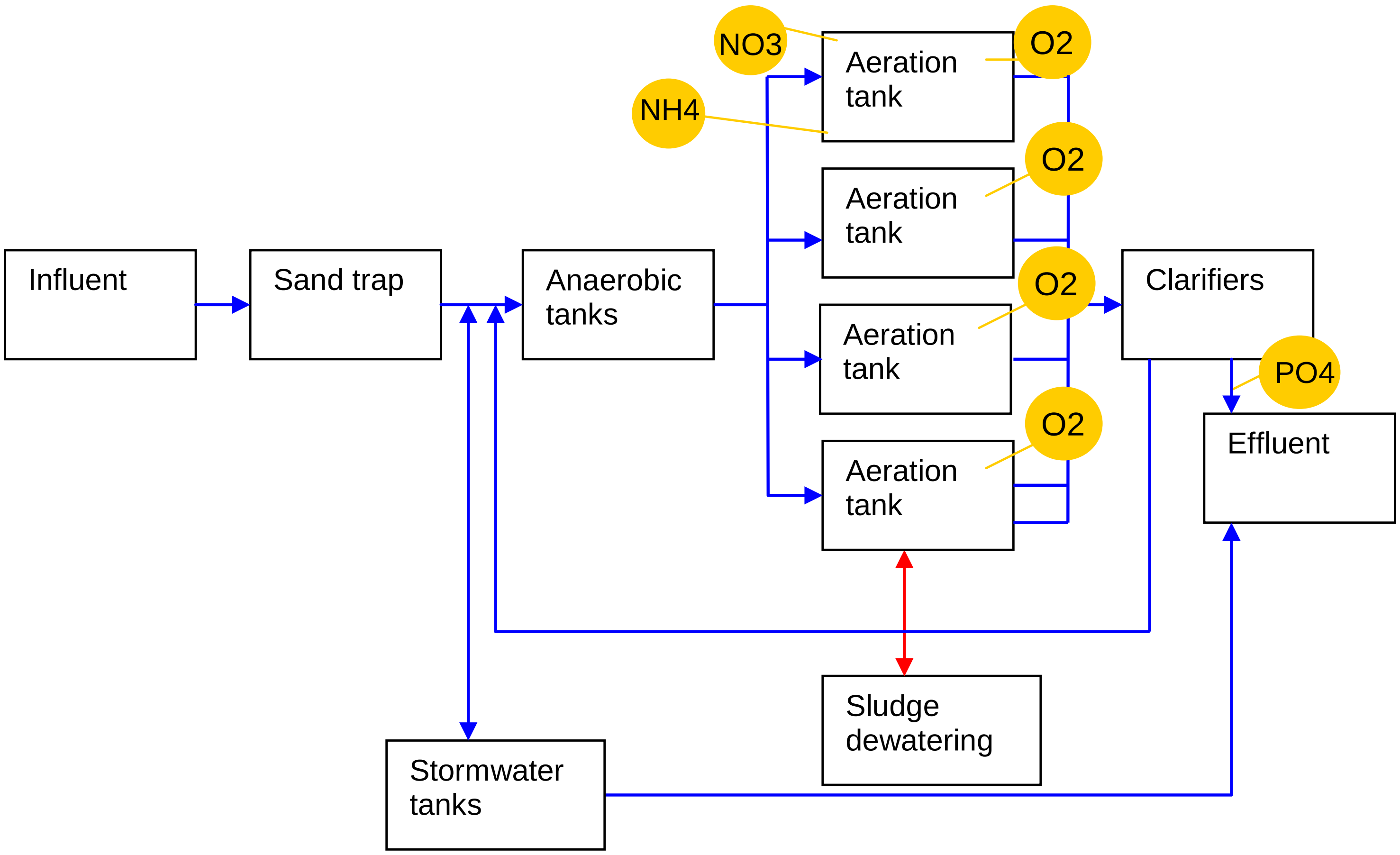
Outline of the 3 plants

- Plant 2: 100.000 PE, online control of length of the aerated phase in place

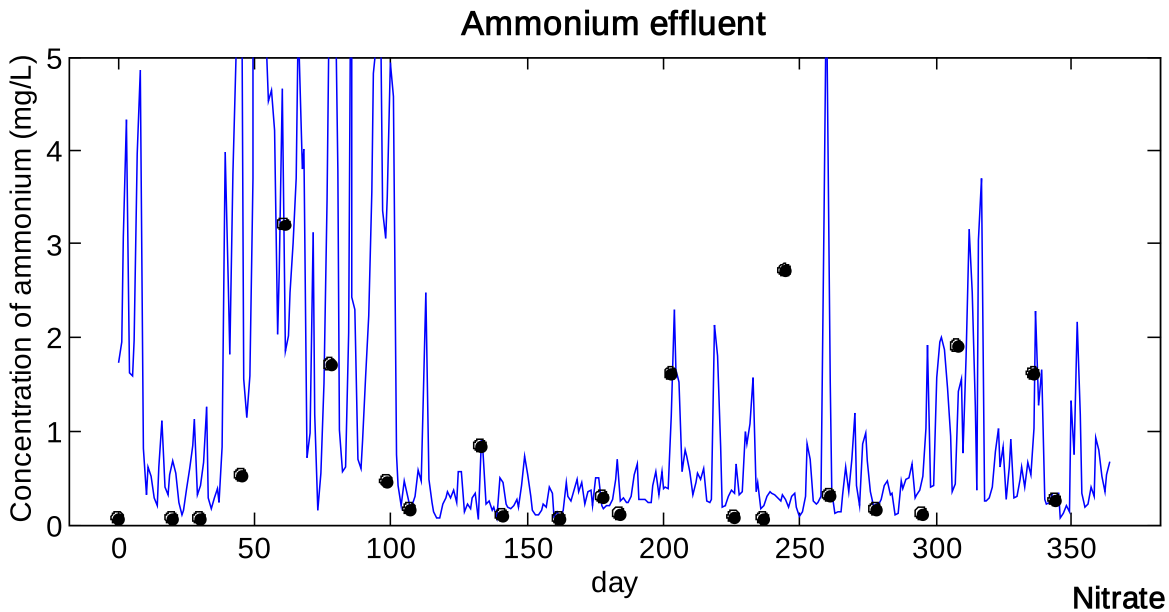


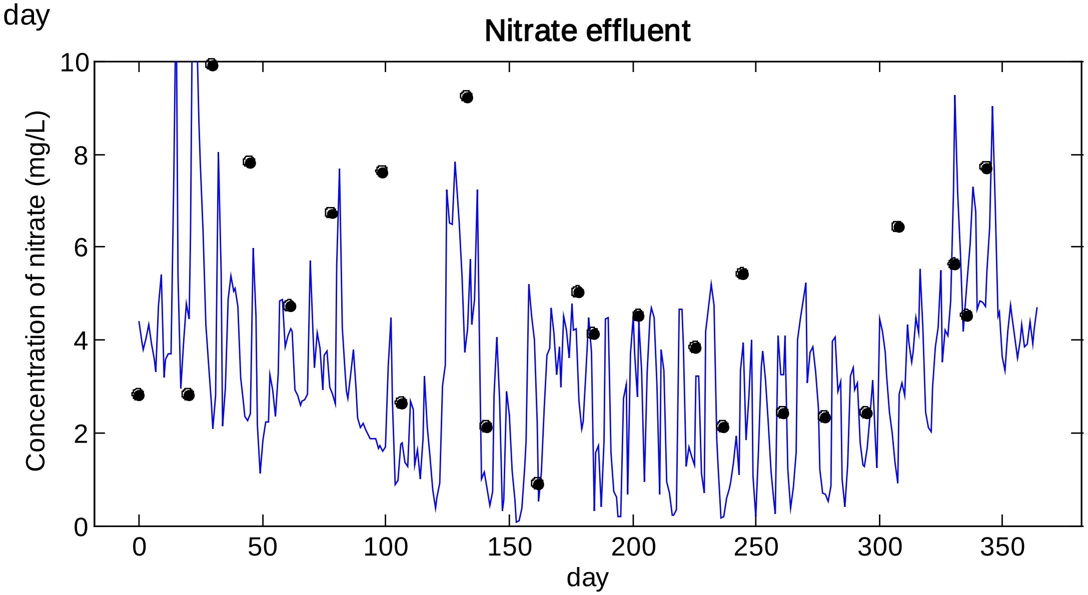
Outline of the 3 plants

- Plant 3: 270.000 PE, state of the art of online control at AQF

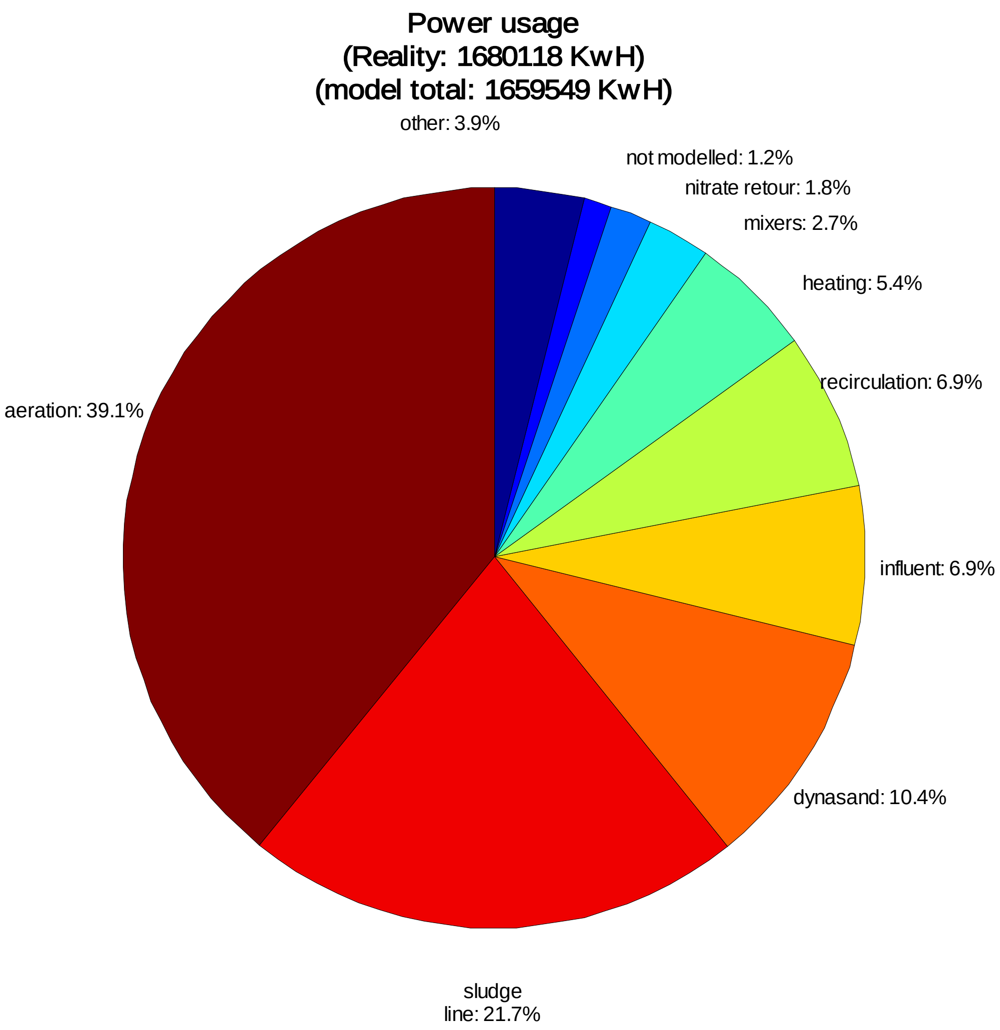


Calibration





Calibration



Comparison of optimisation strategies

Meeting effluent consent at lowest cost = straigthforward

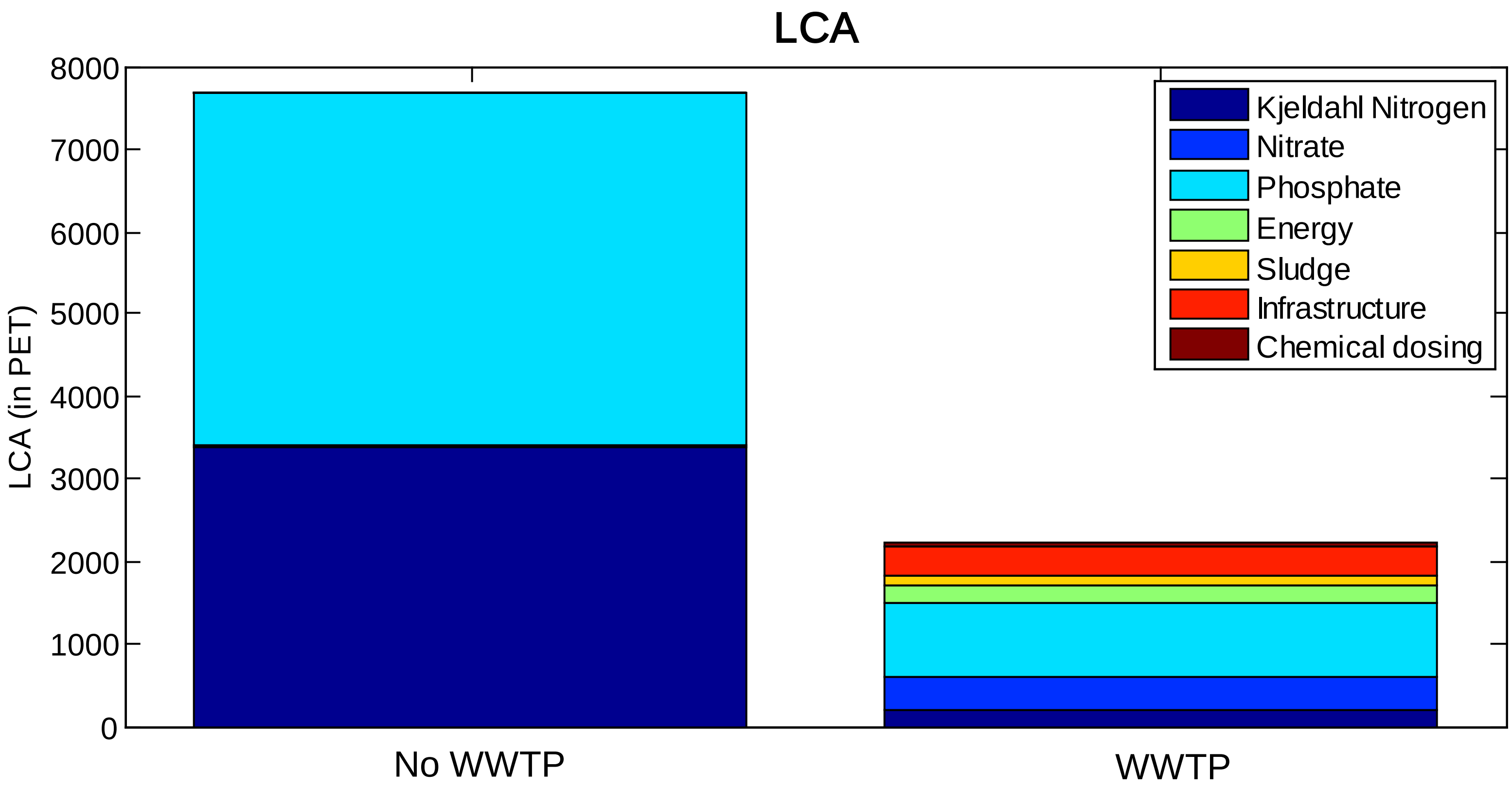
Reducing footprint of WWTP's

- Impact is expressed as mPET: milli people equivalents targeted. 1 PE represents the environmental impact of 1 hypothetical person in a defined country and year.
- Impact is composed of a number of impact categories such as global warming, eutrophication, acidification, ozone depletion, ecotoxicity, human toxicity, …. E.g. the EDIP97 methodology normalises the global warming impact of 1 PE to 8700 kg CO2-equivalents per year.
- Data from Henrik Fred Larsen:

Parameter	Impact
Nitrogen	37,23 mPET / kg N
Phosphorus	269,2 mPET / kg P
Electricity consumption	0,12324 mPET / kWh
Sludge production	0,1 mPET / kg 37% DM sludge
Infrastructure	0,127 mPET / m³ influent treated
$FeCl_3$ 40% dosing	2,611 mPET / kg
Sodium acetate dosing	0,7781 mPET / kg NaOAc

Impact reduction of wastewater treatment

- Waste water treatment plants are lowering the ecological footprint (as expected..)



Optimisation scenario's

- Migration from manual to online control by installing extra online sensors
- Changing setpoints of existing controllers (NH4, SRT, O2, …)
- Alternative (rule based) control algorithms
- Changing position of existing sensors
- Increasing internal recycle pumping capacity

- For each plant roughly 2000 simulations were run

Results / Conclusions

		Cost optimisation	Footprint optimisation
Plant 1	Costs*	-15 %	-10 %
	Footprint	- 3 %	- 7 %
Plant 2	Costs*	- 2 %	0 %
	Footprint	- 13 %	- 22 %
Plant 3	Costs*	- 7 %	- 2 %
	Footprint	- 7 %	- 11 %

* Sum of operational cost for electricity consumption, sludge disposal and chemical dosing

- Cost optimisation leads to a cost reduction of 2 – 15 % and an impact reduction of 3 – 13 %
- Footprint optimisation leads to a cost reduction of 0 – 10 % and an impact reduction of 7 – 22 %
- Footprint optimisation leads to a cleaner effluent than the legally imposed quality, favours bio-P over chemical P removal and results into less NH4 in the effluent

Conclusions

- A reduction of footprint with 1 % leads to an increase of operational costs with 1 %
- Standardisation of footprint calculation is necessary (!)
- Optimisation towards footprint is very compatible with the way operators tend to manually control the plants
- Online control reduces operational costs and increases treatment efficiency
- A plant that is already (partly) controlled online can perform even better if the correct controller settings are applied. These correct settings vary from plant to plant even when layouts are similar since every plant has its own characteristic influent composition.
- Custom made controllers are necessary to achieve the best performance

Acknowledgment

- This study was part of the EU Neptune project (Contract No 036845, SUSTDEV-2005-3.II.3.2), which was financially supported by grants obtained from the EU Commission within the Energy, Global Change and Ecosystems Program of the Sixth Framework (FP6-2005-Global-4)

Work package 4

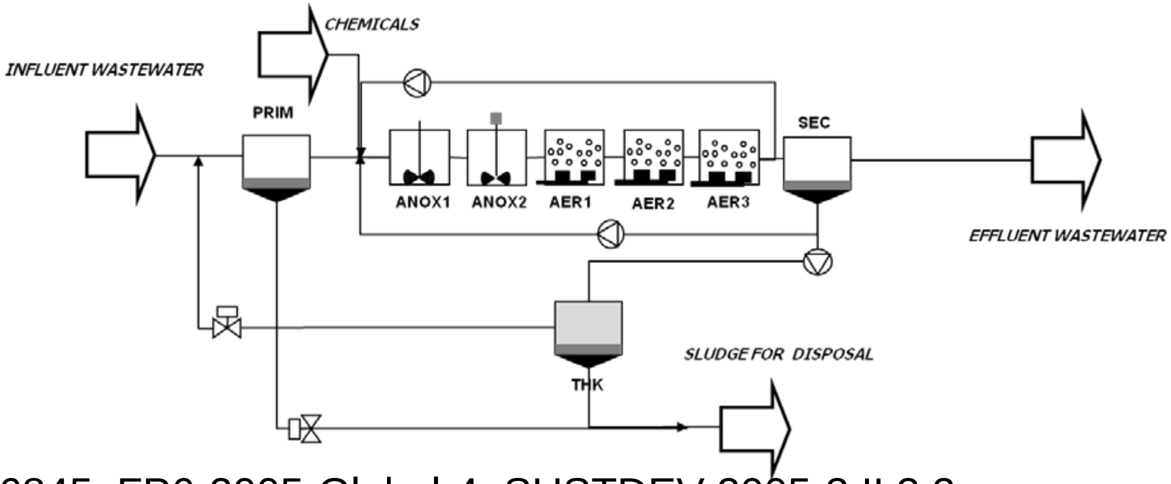
LCA and ICA

Lluís Corominas, Xavier Flores-Alsina, Peter Vanrolleghem

Case study

Neptune Simulation Benchmark

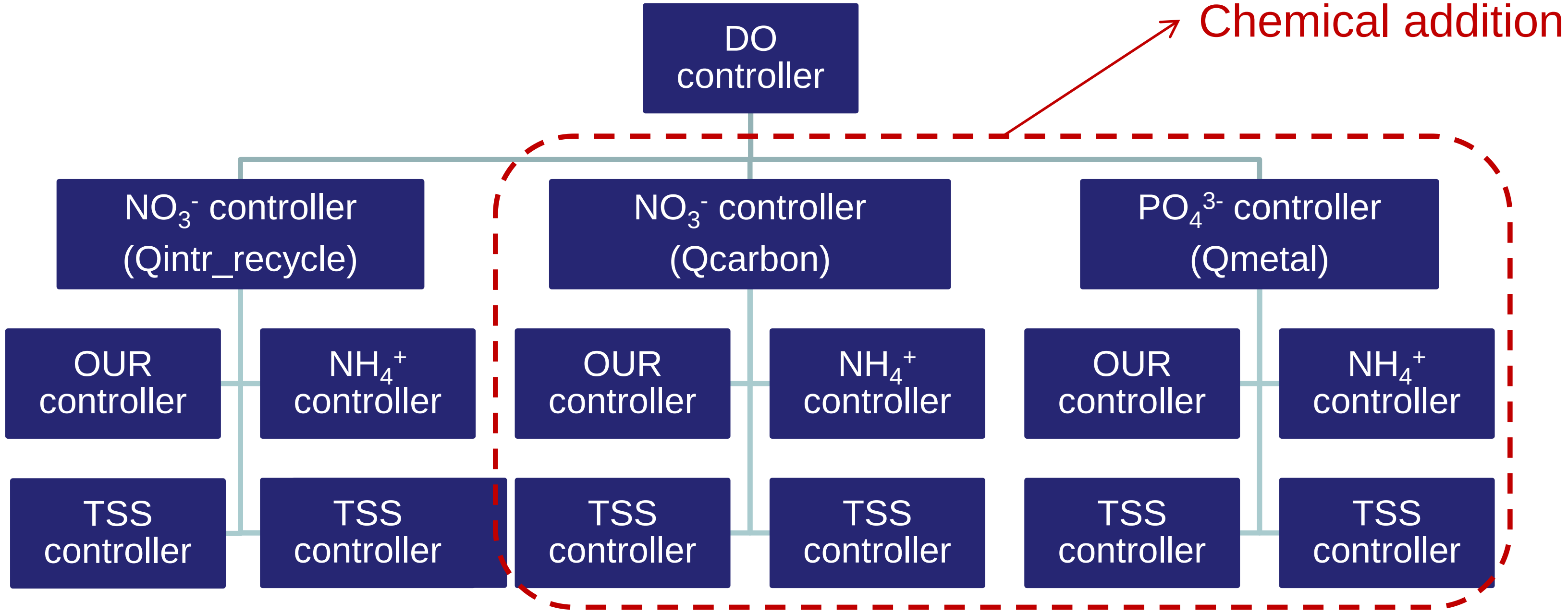
- A2O plant sized using the Metcalf & Eddy design guidelines
- The influent profile have been generated using phenomenological models including daily, weekly and seasonal variation (low C/N ratio)
- The EAWAG ASM3 bio P and the double exponential velocity function of Takács are the main process models



Case study

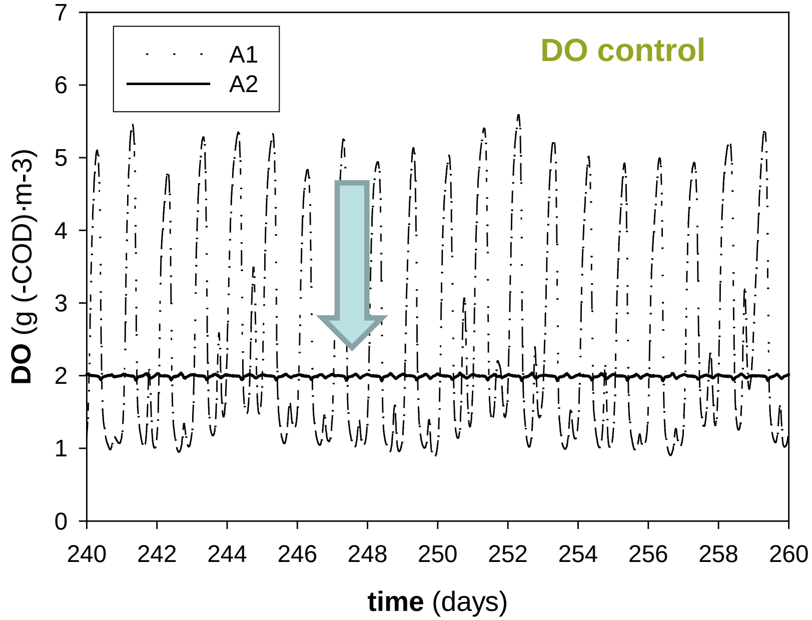
Evaluation of control strategies

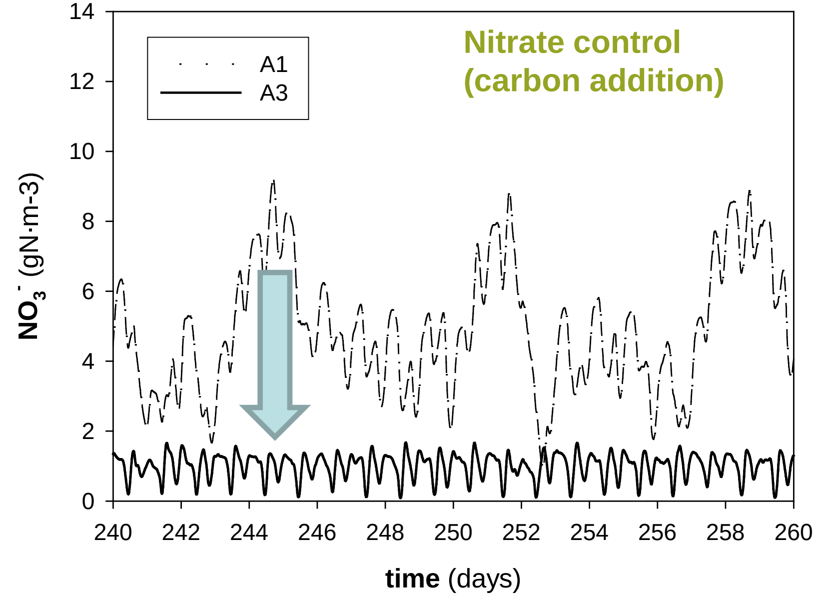
- Different combinations of controllers tested using the Neptune Benchmark
- Comparison of strategies with and without chemical addition
- Is the implementation of control reducing environmental impact?
- Are the controllers based on the addition of chemicals the right solution to reduce environmental impact? (evaluation using LCA)

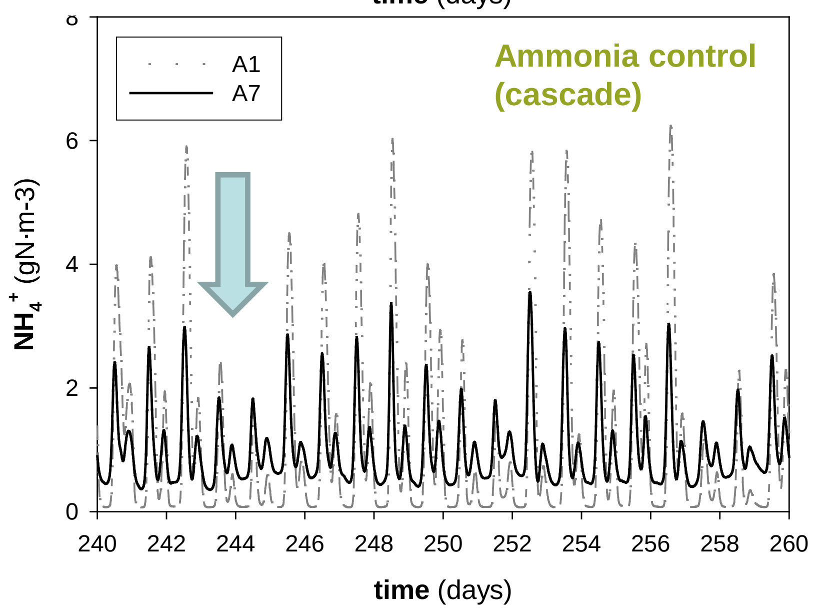


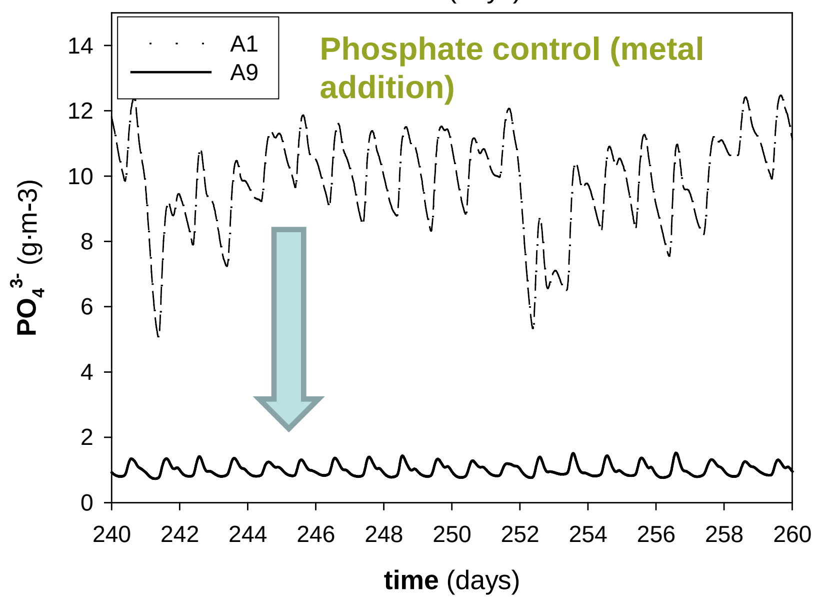
Neptune project, contract no 036845, FP6-2005-Global-4, SUSTDEV-2005-3.II.3.2

Results: dynamic profiles





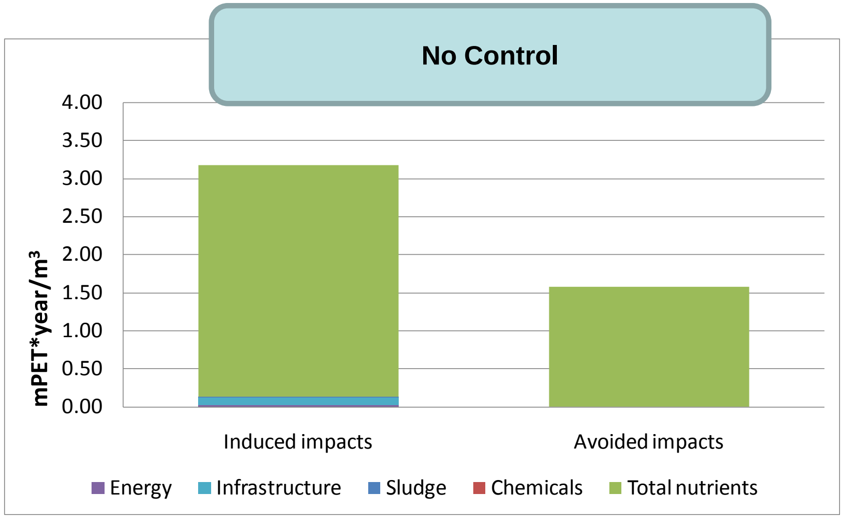




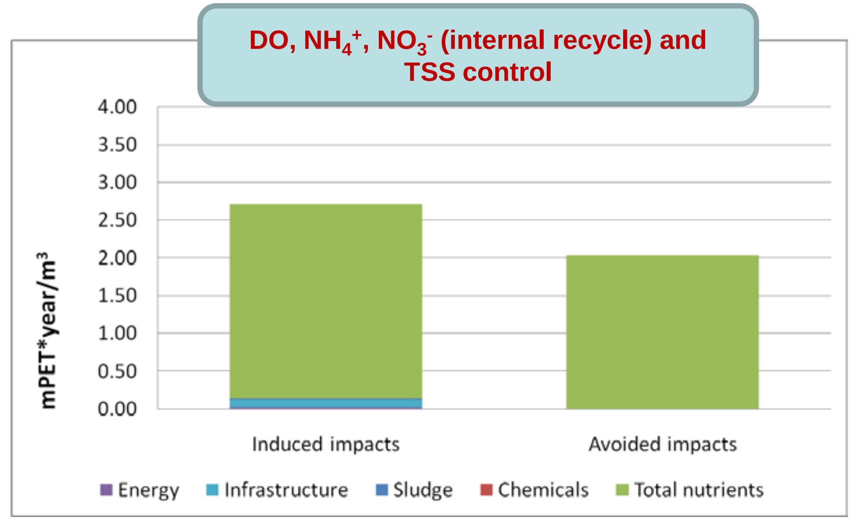
A1: NO CONTROL

Results: LCA evaluation

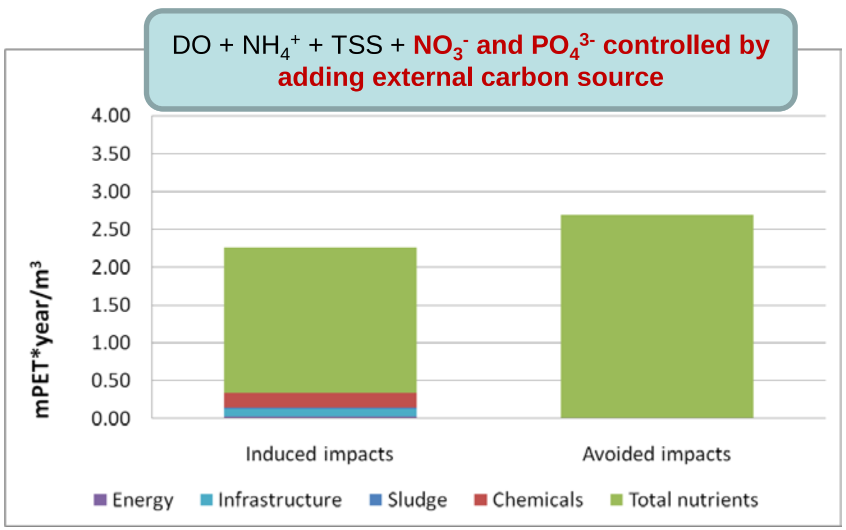
No Control



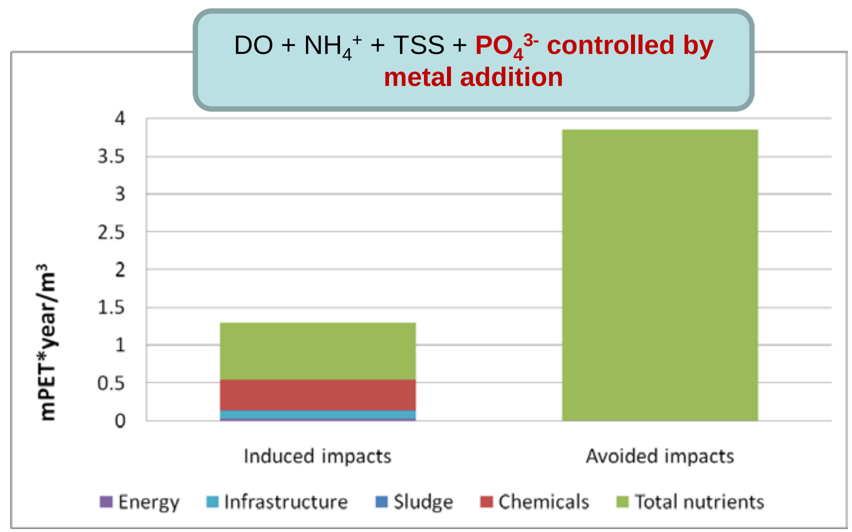
DO, NH_4^+, NO_3^- (internal recycle) and TSS control



DO + NH_4^+ + TSS + **NO_3^- and PO_4^{3-} controlled by adding external carbon source**



DO + NH_4^+ + TSS + **PO_4^{3-} controlled by metal addition**



Avoided impact: Influent – effluent nutrient impact

Induced impact: Effluent nutrient + Electricity + Sludge + Infr + chemicals

Conclusions

- The implementation of control leads to an increase of the avoided impact and a decrease in the induced impact
- The most environmentally friendly strategies are the ones that include metal and carbon addition as they induce a significant reduction of nitrate and phosphorus in the effluent
- LCA gives better results for strategies that improve nutrient removal vs those that reduce energy consumption

Acknowledgements

This research is supported by the Canada Research Chair in Water Quality Modeling and a NSERC Special Research Opportunities grant as part of the Canadian contribution to the European Union 6th framework project NEPTUNE. This study was part of the EU Neptune project (Contract No 036845, SUSTDEV-2005-3.II.3.2), which is financially supported by grants obtained from the EU Commission within the Energy, Global Change and Ecosystems Program (FP6-2005-Global-4).

Canada Research Chair in Water Quality Modeling