PRACTICAL APPLICATION OF DYNAMIC PROCESS MODELS FOR WASTEWATER TREATMENT PLANT OPTIMIZATION: WORK IN PROGRESS

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Introduction

In the European Union, the Water Framework Directive (WFD) enforces a good ecological and chemical status of all surface waters, which is to be accomplished before 2015 (2000/60/EC). Exceptions are only allowed after proper justification, e.g. when it is technically infeasible or disproportionately costly to restore the water body to good status by 2015. Many surface waters throughout Europe still do not meet the WFD requirements due to discharges of combined sewer overflows (CSO) and effluents of wastewater treatment plants (WWTP). The extent of non-compliance and the need for measures are to be decided in 2012, based on the results of the monitoring programs, established since 2009 (Commission reports, COM(2009) 156 final and COM(2012) 670 final). Mathematical models provide a valuable tool for guiding these decisions.

Waterboard De Dommel (Boxtel, The Netherlands) has been using models of the WWTP since the early 1990s. Since 2007 a cooperation was set up with Ghent University (Department of Mathematical modeling, Statistics and Bioinformatics) to model the WWTP of Eindhoven (The Netherlands). During the course of time these models have continuously been improved to be able to address more difficult model objectives. Although the model predictions have improved significantly over the course of time, there is still the need to take decisions under uncertainty as models are simplifications of reality and by definition contain a certain degree of uncertainty (Belia et al. 2009).

Materials and methods

With a treatment capacity of 750,000 population equivalents (PE), the WWTP Eindhoven (The Netherlands) is the largest treatment plant of Waterboard De Dommel and the third largest in The Netherlands. The incoming wastewater is treated in three parallel lines with a maximum hydraulic load of 26,250 m3/h, each containing a primary settler, a biological tank and four secondary clarifiers. An extra 8.750 m3/h can be treated mechanically and passes a pre-settling tank before it is discharged in the river Dommel or treated in the biology when the hydraulic load is again less the 26,250 m3/h. The biological tanks comprise a modified UCT configuration (Tchobanoglous et al. 2004). A process model of the plant has been set up and calibrated for dry weather on an extensive set of online sensor data using WEST (http://www.mikebydhi.com, Denmark; Vanhooren et al. 2003). Several scenarios have been simulated to answer questions for possible upgrade options taking into account measures for both dry and rain weather.

In order to reduce the uncertainty related to the use of models, stakeholders were involved (Belia et al. 2009). I.e. the chosen approach to communicate the modelling results was based on a detailed discussion with the technologists of Waterboard De Dommel. As such, this entailed increasing the level of understanding both for the wastewater technologists and the modellers. This resulted in a greater confidence in the modelling results.

Results and discussion

The goal of the study was to evaluate whether some measures could be taken to reduce the yearly total nitrogen discharged. Table 1 lists up the different optimization scenarios for dry weather conditions and Table 2 gives the different options chosen for scenario 1.3.1., i.e. for the carbon dosing and for the relocation of the nitrate recycle (Figure 1). The objective of this scenario is the optimization of nitrogen removal (nitrification and denitrification) by the increase of the COD load to the anoxic tank. Simulation results for this scenario are shown

(Figure 3-4). The scenarios with chemical dosing and the original location of recycle B (scenario 1.3.1.A and 1.3.1.F) give the largest improvement in the removal of nitrate (about 57%). However, this is caused by the higher consumption of chemicals (Figure 4). The other scenarios also give a large improvement of nitrate removal (between 52 and 54%) but with much lower carbon dosing (about 25 to 30% less). This leads to the conclusion that the same optimal recirculation as found in scenario 1.2.1 leads to the best results in terms of denitrification performance and carbon dosage. During the discussions with the technologists, the simulations proved valuable to confirm their comprehension of the wastewater treatment plant. Results of the other scenarios will be shown in the full paper.

References

Commission report (COM(2012) 670 final) “Report from the commission to the European parliament and the council on the Implementation of the Water Framework Directive (2000/60/EC) River Basin Management Plans”.

Commission Report (COM(2009) 156 final) "Report from the Commission to the European Parliament and the Council in accordance with Article 18.3 of the Water Framework Directive 2000/60/EC on programmes for monitoring of water status" + Accompanying Commission Staff Working Document (SEC(2009) 415).

Belia, E., Y. Amerlinck, L. Benedetti, B. Johnson, G. Sin, P. Vanrolleghem, K. Gernaey, S. Gillot, M. Neumann, L. Rieger, A. Shaw & K. Villez (2009) Wastewater treatment modelling: dealing with uncertainties. *Water Science and Technology*, 60**,** 1929-1941.

Tchobanoglous, G., F. L. Burton, Metcalf, Eddy & H. D. Stensel. 2004. *Wastewater Engineering: Treatment and Reuse*. McGraw-Hill.

Vanhooren, H., J. Meirlaen, Y. Amerlink, F. Claeys, H. Vangheluwe & P. Vanrolleghem (2003) WEST: modelling biological wastewater treatment. *Journal of Hydroinformatics,* **5,** 23.

Figures & Tables

Table 1. Overview of the different scenarios for dry weather treatment.

#	GOAL	MEASURE	TECHNICAL
1.1.1.	Denitrification	Increased MLSS concentrations	Increasing overflow height SST (incl. Qr) and lowering sludge wastage
1.2.1.	Denitrification	Location recycle B	Adjusting configurations
1.3.1.	Denitrification	Increasing COD to anoxic tank	Chemical dosing (carbon)
1.3.2.	Denitrification		Bypass PST

Table 2. Overview of the different options executed and evaluated for the carbon dosing location and the relocation of the nitrate recycle (dry weather scenario 1.3.1).

#	Carbon dosing in	recycle B from outer ring	recycle B to middle ring
A	DT01	BT05	DT01
B	DT01	BT01	DT01
C	DT01	BT01	DT02
D	DT01	BT03	DT01
E	DT01	BT03	DT02
F	DT02	BT05	DT01
G	DT02	BT01	DT01
H	DT02	BT01	DT02
I	DT02	BT03	DT01
J	DT02	BT03	DT02

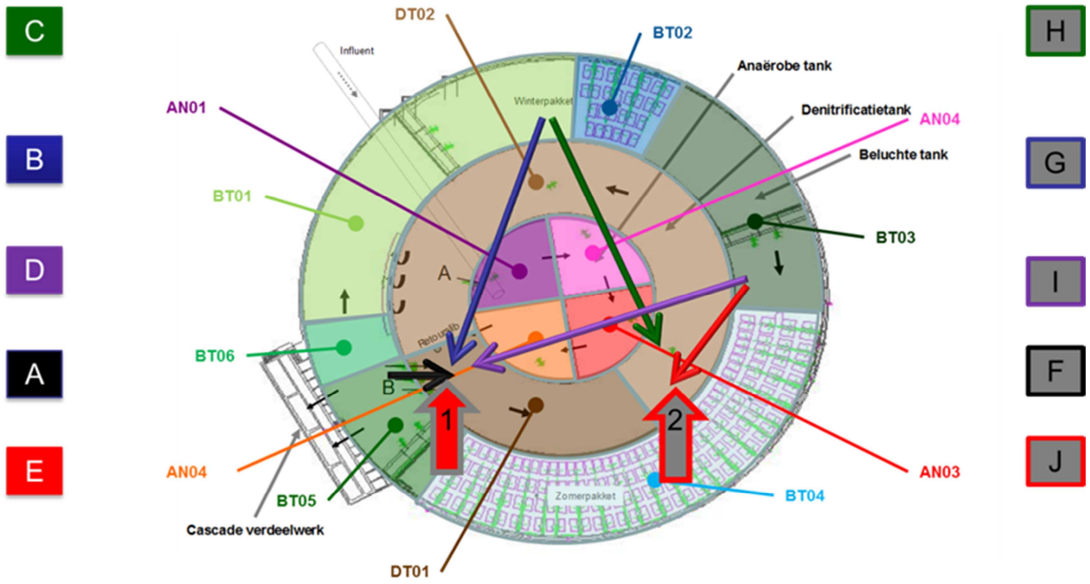

Figure 1. scheme of the activated sludge tanks with two possible chemical dosing location (large red/grey arrows) and possible relocation of recycle B (dry weather scenario 1.3.1).

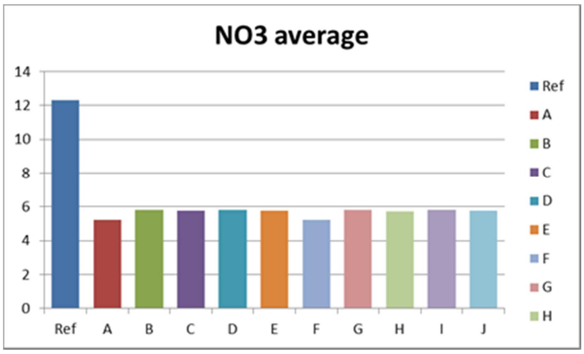

Figure 2. Results of the scenario analysis for the carbon dosing location and the relocation of the nitrate recycle (dry weather scenario 1.3.1) in average nitrate concentration.

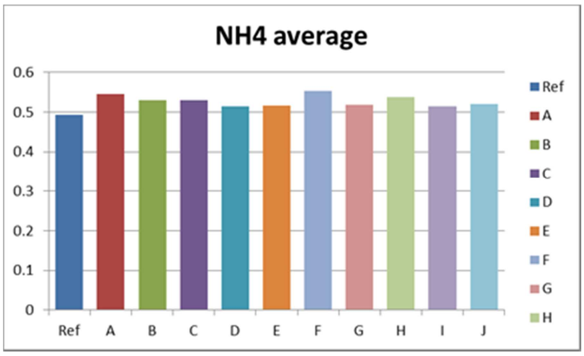

Figure 3. Results of the scenario analysis for the carbon dosing location and the relocation of the nitrate recycle (dry weather scenario 1.3.1) in average ammonium concentration.

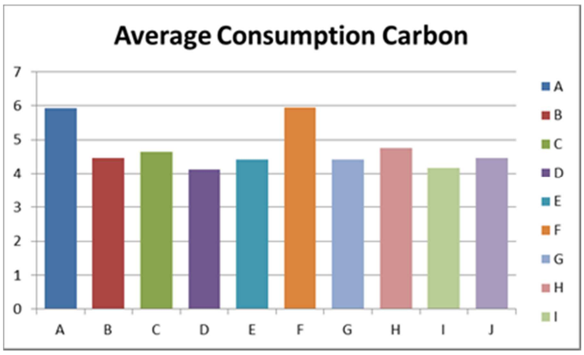

Figure 4. Results of the scenario analysis for the carbon dosing location and the relocation of the nitrate recycle (dry weather scenario 1.3.1) in average carbon consumption.