Metabolic Activity of Activated Sludge and its Relation to Xenobiotic Degradation Potential of a Variety of WWTPs in Luxembourg

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Introduction
Polar xenobiotics were reported to elude classical elimination pathways in Wastewater Treatment Plants (WWTP) like the binding to sewage sludge and often pass sewage treatment processes without being completely degraded. Their main degradation path is biodegradation via co-metabolism suggesting a correlation with WWTP performance for carbon and nitrogen elimination. The latter can be successfully modeled following the calibration of the metabolic activity of activated sludge. This calibration is readily performed via respirometric experiments with individual activated sludges. Depending on the design and the hydraulic load of the treatment plant, removal efficiencies of carbon and nutrients can vary strongly. Xenobiotic degradation efficiencies have recently been shown to correlate with sludge age [Clara et al. 2005]. While this is a valuable first proxy, respirometric measurement of sludges take into account the actual metabolic activity including impediment by other raw water constituents. In this study the relationship between xenobiotic removal and the classical performance of WWTPs in Luxembourg is investigated using respirometry. The method can be used for dynamic simulations of WWTP emissions of xenobiotics taking into account the performance of the treatment plants. The modeling will allow for more realistic exposure scenarios in surface water systems.

Materials and methods
Biokinetics have been estimated using Activated Sludge Models (ASM) in order to characterize activated sludge. A cost-effective and powerful tool for deriving biokinetic parameters in ASMs is respirometry that has recently been used for the specification of activated sludge. Respirometric measurements were conducted using a filled batch-reactor providing stable conditions in terms of temperature, pH and oxygen. It enables the calculation of the metabolic rate from changes in the concentration of oxygen. The oxygen uptake rate (OUR) represents the microbial activity and was modeled using the ASM-based wastewater simulation software GPS-X. In a first approach, the 3 chelating agents NTA, DTPA and EDTA (in order of degradability) were tested under aerated conditions on 4 activated sludges stemming from different WWTPs. The substances were added together with and without defined amounts of co-substrates containing a CNP-ratio of 100:5:1. The analytes were transformed into their Fe(III)-complexes and measured using HPLC-UV. The speciation of the chelating agents has to be taken into account due to its influence on their fate including biodegradation. This has been realized by means of measured metal ion concentrations in the influents and the Visual Minteq Modeling Software.

Results and Discussion
Using this experimental set-up, first order degradation rate constants of NTA could be determined under representative conditions together with biokinetic parameters describing the biomass activity such as the maximum OUR and the fraction of active biomass. No significant removal was monitored for EDTA. A great variation was observed between the degradation rates of NTA. The half-life at the WWTP Petange was only 0.7 h compared to around 8.3 h at the WWTP Martelange. Co-substrates containing C, N and P enhanced the NTA degradation which was 1.5 times slower adding carbon only
and 2 times slower without any co-substrate, respectively. The degradation rate constants depend on the co-substrates and on the microbial activity to a significant extent. Biokinetic parameters could be derived from ASM simulations and correspond to other studies conducted in Luxemburg [Plattes et al. 2007]. Interestingly, the fraction of heterotrophic active biomass as well as the heterotrophic maximum OUR strongly correlate with the NTA half-lives. They both show promise to be suitable predictor variables expressing microbial activity and are in good correlation with the heterotrophic yield \( Y_H \), which is an additional indicator for an increased microbial metabolism.

**Figure 1:** Relationships between the half-lives of NTA, the maximum OUR and the fraction active biomass tested in 4 different Luxemburgish WWTPs;

**Conclusions**

In this first approach strong evidence was found for the relationship between biological WWTP performance and xenobiotic removal potential. The fraction of active heterotrophic biomass, the maximum OUR and the SRT have been identified as possible predictor variables that can be used for modelling the co-metabolic fate of chelating agents. For confirmation and mathematical description further experiments will be carried out with sludge from Luxemburgish WWTPs of different size and design in fall 2008. Degradation rate constants under anoxic conditions will also be investigated. In view of a broader spectrum of polar micropollutants, further testing on other substances, like polar pharmaceuticals is planned for calibration and comparison.

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**References**
