



## Elimination of pharmaceuticals in single- and three-stage pre-denitrifying MBBR

Polesel, Fabio; Torresi, Elena; Loreggian, L.; Escola Casas, Monica; Bester, Kai; Plósz, Benedek G.

*Publication date:*  
2015

*Document Version*  
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

*Citation (APA):*

Polesel, F., Torresi, E., Loreggian, L., Escola Casas, M., Bester, K., & Plósz, B. G. (2015). *Elimination of pharmaceuticals in single- and three-stage pre-denitrifying MBBR*. Abstract from 9th IWA Specialist Conference on Assessment and Control of Micropollutants and Hazardous Substances in Water, Singapore, Singapore.

---

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

# ELIMINATION OF PHARMACEUTICALS IN SINGLE- AND THREE-STAGE PRE-DENITRIFYING MBBR

F. Polesel<sup>1</sup>, E. Torresi<sup>1</sup>, L. Loreggian<sup>1</sup>, M. Escolà Casas<sup>2</sup>, K. Bester<sup>2</sup>, B.G. Plósz<sup>1</sup>

<sup>1</sup>Technical University of Denmark (DTU), Department of Environmental Engineering, Miljøvej 113, 2800 Kgs. Lyngby, Denmark

<sup>2</sup>Aarhus University (AAU), Department of Environmental Science, Roskilde, Denmark

**Summary:** This study investigated the elimination of pharmaceuticals in pre-denitrifying moving bed biofilm reactors (MBBRs) in single- and three-stage configurations. Under batch conditions, biotransformation and retransformation of two pharmaceuticals (trimethoprim, sulfamethoxazole) occurred at comparable or higher rates than in denitrifying activated sludge. Based on estimated rate coefficients, concentrations in continuously operated MBBRs were predicted.

**Keywords:** pharmaceutical removal; moving bed biofilm reactor (MBBR); pre-denitrification

**Introduction.** Moving bed biofilm reactors (MBBRs) have been recently proposed as a means to enhance the elimination of pharmaceuticals during biological wastewater treatment. Falås et al. (2012) showed the enhancement of biological transformation kinetics by MBBR biofilm under aerobic conditions. To date, scarce results are available on the fate of pharmaceutical in denitrifying MBBR. In denitrifying activated sludge, biotransformation rates for pharmaceuticals were found either as significantly lower or comparable to rates obtained under aerobic conditions (Suarez et al., 2010; Plósz et al., 2010). Staging of activated sludge (Plósz, 2007) and biofilm reactors (Plósz and Vogelsang, 2012) induced specialization of heterotrophic biomass due to reaction kinetic principles and to the gradient in carbon source availability, thereby enhancing pre-denitrification. The objectives of this study were (i) to assess and compare pharmaceutical removal kinetics in single- and three-stage denitrifying MBBR configurations; and (ii) to evaluate the kinetic model developed by comparing predicted and measured concentrations in continuous-flow MBBR systems.

**Materials and Methods.** Two MBBR configurations, with single-stage (U) and three-stage (S1, S2, S3) bioreactors (total operating volume=6 L each, HRT=8.9 h), were operated in parallel, receiving pre-clarified wastewater with only indigenous pharmaceutical concentrations and external nitrate dosing (influent=103 mgN L<sup>-1</sup>). After 100 d of continuous operation, 24-h batch experiments were performed using pre-clarified wastewater (initial adjusted nitrate=100 mgN L<sup>-1</sup>) for each MBBR. Samples were analyzed with HPLC-MS/MS (Escolà Casas et al., *submitted*). Analytical solutions, derived from the Activated Sludge Model for Xenobiotics (ASM-X, Plósz et al., 2013), were used to estimate biotransformation ( $k_{\text{Bio}}$ ) and retransformation rate coefficients ( $k_{\text{Dec}}$ , referring to the retransformation from, e.g., conjugated metabolites to parent chemicals). Values of  $k_{\text{Bio}}$  were corrected using literature  $K_d$  (Plósz et al., 2010; Göbel et al., 2005) to account for sorption. Parameters were estimated by minimizing mean average error (MAE) between measured and simulated batch concentrations. Estimated  $k_{\text{Bio}}$  and  $k_{\text{Dec}}$  were then used to predict concentrations in MBBRs during continuous operation, which were compared to measured concentrations. Results for trimethoprim (TMP) and sulfamethoxazole (SMX) have been selected and are presented here.

**Results and Conclusions.** TMP was effectively biotransformed during batch experiments (Fig. 1a;  $k_{\text{Bio}}=0.39\text{--}1.03\text{ L gTSS}^{-1}\text{ d}^{-1}$ ). Previous investigations on denitrifying activated sludge did not reach conclusive results, and either significantly lower (Suarez et al., 2010) or comparable (Su et al., 2015)  $k_{\text{Bio}}$  values were reported for TMP. Concentration of SMX (Fig. 1b) increased in the first part of the batch experiment, indicating comparably fast retransformation from conjugated metabolites. Estimated  $k_{\text{Dec}}$  values ( $2.24\text{--}5.78\text{ L gTSS}^{-1}\text{ d}^{-1}$ ) were consistently higher than  $k_{\text{Bio}}$  ( $0.64\text{--}1.90\text{ L$

gTSS<sup>-1</sup> d<sup>-1</sup>), in agreement with findings for denitrifying activated sludge (Plósz et al., 2010). The lowest  $k_{\text{Bio}}$  and  $k_{\text{Dec}}$  values were obtained for S3, in which denitrifying biofilm was exposed to limiting electron donor availability during continuous operation. Predicted concentrations, based on batch estimations of  $k_{\text{Bio}}$  and  $k_{\text{Dec}}$ , were in good agreement with the measurements during continuous operation for both TMP (Fig. 1c) and SMX (Fig. 1d).

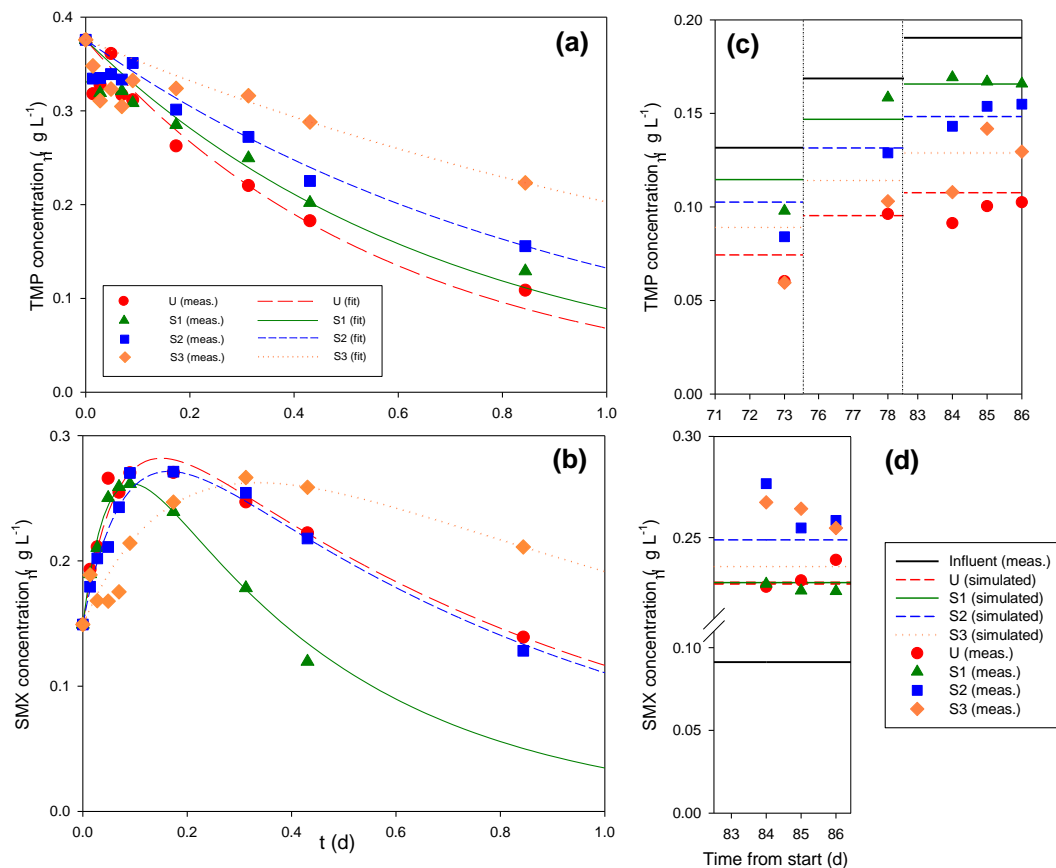


Figure 1. Measured (dots) and predicted concentrations (lines) during batch experiments and during continuous-flow operation of the reactors in the single-stage (U) and three-stage (S1, S2, S3) MBBR configuration for TMP (a, c) and SMX (b, d).

Our experimental and model-based observations suggest that: (i) TMP can be rather effectively removed in denitrifying MBBRs; (ii) retransformation to parent SMX can significantly impact its elimination; and (iii) electron donor availability in single- and three-stage MBBRs can shape microbial community functions in terms of secondary/co-metabolic processes.

## References

- Escolà Casas, M., Chhetri, R.K., Ooi, G., Hansen, K.M.S., Litty, K., Christensson, M., Kragelund, C., Andersen, H.R., Bester, K. Biodegradation of pharmaceuticals in hospital wastewater by a hybrid biofilm and activated sludge system (Hybas). *Sci. Total Environ.*, submitted.
- Falás, P., Baillon-Dhumez, A., Andersen, H.R., Ledin, A., la Cour Jansen, J. (2012). Suspended biofilm carrier and activated sludge removal of acidic pharmaceuticals. *Water Res.* 46(4), 1167–1175.
- Göbel, A., Thomsen, A., McArdell, C.S., Joss, A., Giger, W. (2005). Occurrence and sorption behavior of sulfonamides, macrolides and trimethoprim in activated sludge treatment. *Environ. Sci. Technol.* 39(11), 3981–3989.
- Plósz, B.G. (2007). Optimization of the activated sludge anoxic reactor configuration as a means to control nutrient removal kinetically. *Water Res.* 41(8), 1763–1773.
- Plósz, B.G., Leknes, H., Thomas, K.V. (2010). Impacts of competitive inhibition, parent compound formation and partitioning behavior on the removal of antibiotics in municipal wastewater treatment (2010). *Environ. Sci. Technol.* 44(2), 734–742.
- Plósz, B.G., Vogelsang, C. (2012). Innovative and integrated technologies for the treatment of industrial wastewater—The BIOZO process (Innowatech). Edited by Lopez, A., Di Laconi, C., Mascolo, G., Pollice, A. European Water Research Series, *IWA Publishing*, England, 91-177.
- Plósz, B.G., Reid, M.J., Borup, M., Langford, K.H., Thomas, K.V. (2013). Biotransformation kinetics and sorption of cocaine and its metabolites and the factors influencing their estimation in wastewater. *Water Res.* 47(7), 2129–40.
- Su, L., Aga, D., Chandran, K., Khunjar, W.O. (2015). Factors impacting biotransformation kinetics of trace organic compounds in lab-scale activated sludge systems performing nitrification and denitrification. *J. Hazard. Mater.* 282, 116–124.
- Suarez, S., Lema, J.M., Omil, F. (2010). Removal of Pharmaceutical and Personal Care Products (PPCPs) under nitrifying and denitrifying conditions. *Water Res.* 44(10), 3214–3224.