

## Combining PAC-adsorption and nitrification in an MBBR

M. Cimbritz\*, E. Edefell\*, E. Thörnqvist\*\*, M. Ekblad\*, H. El-taliawy\*\*\*, M. Ekenberg\*\*\*\*, K. Bester\*\*\*, M. Hagman\*\*, P. Falås\*

\*Department of Chemical Engineering, Lund University, P O Box 124, SE-221 00 LUND, Sweden, Mail: [michael.cimbritz@chemeng.lth.se](mailto:michael.cimbritz@chemeng.lth.se); [ellen.edefell@chemeng.lth.se](mailto:ellen.edefell@chemeng.lth.se)

\*\*Sweden Water Research AB

\*\*\*Department of environmental science, Aarhus University

\*\*\*\*Veolia Water Technologies AB - AnoxKaldnes

**Abstract:** Dosing of PAC, for removal of organic micropollutants, can be performed in different process configurations, including post-treatment options and direct dosing into an activated sludge process. Another option is dosing into a biofilm process possibly opening up for new compact solutions for removal of nutrients and organic micropollutants.

A nitrifying MBBR with simultaneous PAC-dosing was tested in a long-term pilot study based on a test with parallel reactors – one with nitrification only and one with PAC-dosing. Nitrification was not impaired by the PAC and removal of pharmaceuticals could be controlled by the PAC-dose indicating that the system could be further developed for implementation in large scale.

**Keywords:** PAC; MBBR; organic micropollutants

**Introduction:** With municipal wastewater being a major discharge route for many organic micropollutants (OMP) upgrading of wastewater treatment plants provides a possibility for reduction of emissions to the aquatic environment. Adsorption through dosing of powdered activated carbon (PAC) is one option for implementation in large scale (Eggen et al., 2014).

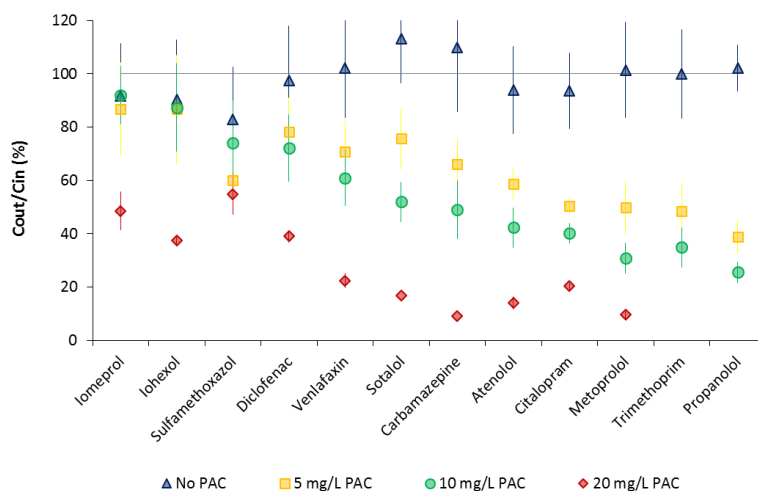
Dosing of PAC can be performed in different process configurations (Boehler et al., 2012; Abegglen & Siegrist, 2012). The dosing point is one key factor studied with several examples of post-treatment configurations being demonstrated (Margot et al., 2013; Altmann et al., 2015). In these systems, recirculation of PAC to the biological reactor is considered crucial to improve sorption efficiency and reduce the required PAC-dose (Meinel et al., 2016). Another option is dosing directly into the activated sludge process. This practice saves space for contact reactors but requires higher doses for equivalent removal of organic micropollutants compared to downstream dosing (Boehler et al., 2012). This is probably attributed to higher DOC concentrations in the biological reactor resulting in competition of sorption sites.

Another option to be tested is direct dosing to a biofilm process with suspended carriers, a moving bed biological reactor (MBBR). The possibility to dose PAC in an MBBR would open up for new compact solutions for removal of nutrients and a wide range of OMPs.

In MBBR-systems the retention times are relatively short, i.e. in the range of a few hours. Considering design recommendations for post-treatment with PAC, suggesting retention times in the order of less than an hour, the available time in an MBBR should be sufficient for far-reaching adsorption of OMPs. With basic conditions for adsorption fulfilled, in terms of available retention time and sufficient reactor turbulence, it is of interest to explore whether adsorption will be impaired by the presence of the carriers and the biomass. At the same time the original purpose with the MBBR must be maintained while dosing PAC. Several potential restrictions could impair biomass activity. With adsorption being non-selective, sorption of trace elements could occur or PAC could physically block the biofilm. Therefore a nitrifying MBBR with simultaneous dosing of PAC was investigated in a long-term study with the purpose to investigate whether nitrification can be maintained while dosing PAC and if adsorption of OMP's can be controlled.

**Method:** Two pilot reactors were operated in parallel, one with addition of PAC and one reference reactor without dosing. The pilot reactors were operated following a high-loaded activated sludge process at Sjölanda WWTP in Sweden. PAC-dosing was varied throughout the test period that lasted six months. Biomass activity was investigated in batch experiments and concentrations of pharmaceuticals were measured before and after the MBBR's by means of HPLC-MS/MS.

**Results and discussion:** The results show that it is perfectly possible to operate a nitrifying MBBR with simultaneous dosing of PAC. Nitrification was not impaired by PAC-dosing, neither in the short nor in the long term perspective. Nitrification rates were relatively high (10-30 mg NH<sub>4</sub>-N/L\*h) and comparable in both reactors. Removal of pharmaceuticals can be controlled by the dosing of PAC. Figure 1 shows an example of the results.



**Figure 1.** Removal of various pharmaceuticals at different PAC-doses.

Removal of contrast media was moderate while several other substances were removed to more than 80 or 90%, when dosing 20 mg/L of PAC ( $\approx 1$  mg PAC/mg DOC). In the full paper removal will be discussed based on a wider dosing range together with implications for further development of the system into full-scale applications, including recycling of PAC.

## REFERENCES

- Abegglen, C. & Siegrist, H. 2012. *Mikroverunreinigungen aus kommunalem Abwasser – Verfahren zur weitergehenden Elimination auf Kläranlagen*. Schweizerische Eidgenossenschaft, Bundesamt für Umwelt BAFU, Bern.
- Altmann, J, Sperlich, A, & Jekel, M 2015. Integrating organic micropollutant removal into tertiary filtration: Combining PAC adsorption with advanced phosphorus removal. *Water Research*, 84, 58-65.
- Boehler, M, Zwicklenpflug, B, Hollender, J, Ternes, T, Joss, A, & Siegrist, H. 2012 Removal of micropollutants in municipal wastewater treatment plants by powder-activated carbon. *Water Science & Technology*, 66, 10, 2115
- Eggen, R, Hollender, J, Joss, A, Stamm, C, & Schärer, M. 2014 Reducing the discharge of micropollutants in the aquatic environment: The benefits of upgrading wastewater treatment plants. *Environmental Science and Technology*, 48, 14, 7683-7689.
- Margot, J, Kienle, C, Magnet, A, Weil, M, Rossi, L, de Alencastro, L, Abegglen, C, Thonney, D, Chèvre, N, Schärer, M, & Barry, D. 2013 Treatment of micropollutants in municipal wastewater: Ozone or powdered activated carbon? *Science of The Total Environment*, 461-462, 480-498.
- Meinel, F, Zietzschmann, F, Ruhl, A, Sperlich, A, & Jekel, M 2016. The benefits of powdered activated carbon recirculation for micropollutant removal in advanced wastewater treatment. *Water Research*, 91, 97-103.