Danish BAT for hospital wastewater treatment - Full scale treatment of hospital wastewater consisting of MBR, GAC and ozone

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Abstract
A regulatory framework for hospital wastewater is currently being implemented in Denmark. In order to study best available techniques (BAT) for handling hospital wastewater, a full scale wastewater treatment plant (WWTP) has been constructed and commissioned on-site at Herlev University Hospital. The WWTP encompasses all aspects of treating the total wastewater flow from the hospital, including water, sludge and air treatment. The WWTP has been designed to handle all wastewater from the hospital's 825 beds (180,000 m^3/year). The treatment consists of a membrane bioreactor (MBR) followed two different polishing lines. Line 1 consists of granular activated carbon (GAC), followed by ozone and UV. Line 2 consists of ozone, followed by GAC and UV. Operation of the two lines allows for comparison of GAC and ozone treatment. Results shows that Line 2 (Ozone-GAC-UV) was the most efficient setup. All substances were removed to below $PNEC_{Freshwater}$. Also, there were no toxic effects towards daphnia or fish embryos observed. Total operational and maintenance costs including treatment steps plus service were €1.23/m^3. Direct discharge to the local stream, as well as reuse in the hospital's cooling tower, is planned and authority approval is currently being processed.

Keywords
Hospital wastewater, pharmaceuticals, MBR, PNEC, BAT

INTRODUCTION

A regulatory framework for hospital wastewater is currently being implemented in Denmark. Specific limit values for discharge of pharmaceuticals to public sewers are being enforced by the municipalities. In order to study best practice (BAT) for handling hospital wastewater, a full scale wastewater treatment plant (WWTP) has been constructed and commissioned on-site at Herlev University Hospital in Copenhagen, Denmark. The design of the full scale WWTP is based on results from previous laboratory and pilot scale studies (Nielsen *et al*, 2012) (Nielsen *et al*, 2013). The WWTP encompasses all aspects of treating the total wastewater flow from the hospital, including water, sludge and air treatment. The WWTP has been designed to handle all wastewater from the hospital's 825 beds (180,000 m^3/year). The WWTP is the result of a public-private partnership with participation of Grundfos BioBooster (plant responsible), DHI (test, development and documentation), Herlev Hospital (plant owner) and the Capital Region of Denmark, among others. The aim of the project is to develop and adjust the treatment process and demonstrate effective, robust and cost-effective treatment allowing for direct discharge of the treated water to the local stream and reuse for technical purposes.

METHODS

The wastewater treatment at Herlev Hospital consists of a membrane bioreactor (MBR) followed by a combination of polishing technologies. The polishing step is split into two separate lines with different configurations, Line 1 and Line 2, which operate in parallel. Line 1 consists of granular activated carbon (GAC) treatment (9.3 m^3), followed by ozone (2.5 mg O_3/mg DOC) and UV (45 mJ/cm^2). Line 2 consists of ozone (3.4 mg O_3/mg DOC), followed by GAC treatment (9.3 m^3) and UV (45 mJ/cm^2). Operation of the two lines allows for comparison of GAC and ozone treatment.
Analysis of pharmaceuticals was performed after solid phase enrichment followed by tandem mass spectrometry by the Institute of Energy and Environmental Technology (IUTA) in Duisburg,

Germany. Tests for toxicity and genotoxicity were performed by the Research Institute for Ecosystem Analysis and Assessment (gaiac) in Aachen, Germany. Non-enriched wastewater samples taken before and after treatment were tested in the algal growth inhibition test with *Pseudokirchneriella subcapitata*, a *Daphnia magna* short-term reproduction test and the fish embryo test with the zebrafish *Danio rerio* for evaluation of potential effects on the environment.

RESULTS AND CONCLUSIONS

Figure shows removal of total concentrations of pharmaceuticals by MBR, polishing (ozone-GAC-UV) at the WWTP in May to November 2015 after 17 months of WWTP operation. In November 2015 Line 2 had treated 80,772 m^3 of wastewater.

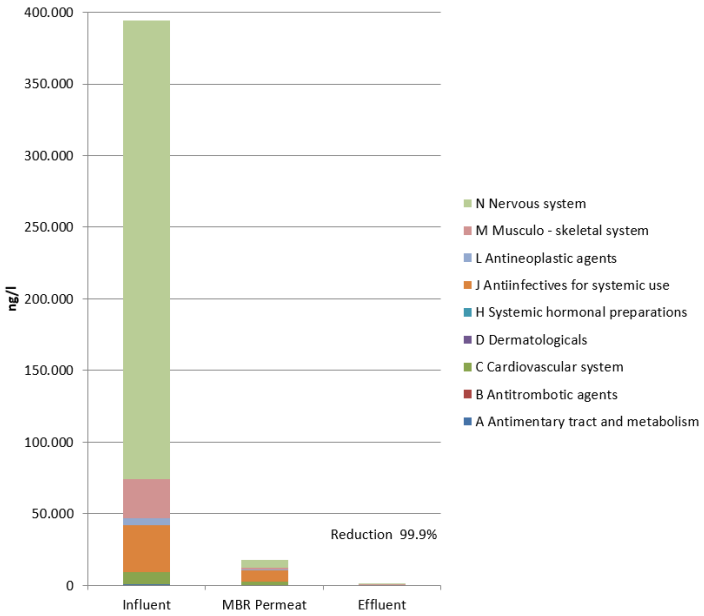

Figure 1. Total concentration of pharmaceuticals – without contrast media - in influent, after MBR (permeate) and effluent (Line 2). Data from May, June and November 2015

Figure 1 shows that 95% of pharmaceuticals are reduced by the MBR and 99,9% are removed after final polishing by ozone and GAC. Contrast media were removed by 99% in the effluent. Although 95% of the pharmaceuticals are removed in the MBR 14 substances are still above the $PNEC_{Freshwater}$. In the effluent after polishing with ozone and GAC no pharmaceuticals can be measured above $PNEC_{Freshwater}$. Also, there were no toxic effects towards daphnia or fish embryos observed in the final effluent from either line. Inhibition of algal growth was seen in the effluent, but the same growth inhibition was seen in clean tab water from the hospital, indicating that the tab water composition itself may have an inhibiting effect.

Operational treatment costs including all steps of water, sludge and air treatment plus service were €1.23/m^3. Direct discharge to the local stream is planned and authority approval is currently being processed. A full scale use of treated water in the hospital's cooling tower is planned for implementation in 2016.

REFERENCES

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