OCCURRENCE AND FATE OF ORGANIC MICRO-POLLUTANTS IN WASTEWATER TREATMENT PLANTS

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1 Introduction

The consulting company Deutsche Projekt Union GmbH (DPU GmbH) and the Institute for Environmental Technology of the University of Dortmund were instructed by the Ministry for Environment of North-Rhine-Westphalia (MUNLV NRW) to conduct a joint research project called “Occurrence and Elimination of Hazardous Substances in Municipal Wastewater Treatment Plants” from 2002 to 2005. In this project more than 70 different organic micro-pollutants, including pharmaceuticals, x-ray contrast media, endocrine disrupting compounds and personal care products, were analysed at different measuring points in three large wastewater treatment plants (WWTPs).

The guiding principles of the EU-Water Framework Directive (EU-WFD) from 2000 are the main reason for implementing the research project. It’s goal is the realisation of a “Good Chemical and Ecological State” for surface waters. Several annexes with lists of important pollutants like Annex X: “Priority Substances” are defined in the EU-WFD. In addition to these regulations many other water-relevant substances are in discussion. For these substances with partly higher quantities of input the risks for the aquatic environment are not exactly known. The considered groups of substances within the research project are listed in Tab. 1.

Tab. 1: Considered organic micro-pollutants

Pesticides (Annex X EU-WFD)		Synthetic und natural estrogenes
Polycyclic aromatic hydrocarbons		Pharmaceuticals and X-Ray contrast media
Biocides like organotin compounds and Pentachlorphenol		Personal care products like synthetic musk fragrances and desinfectants
Organophosphates (flame retardants)		Industry chemicals like alkylphenole, plasticizer, bisphenol A,

The measuring program included the main treatment steps of the WWTPs like mechanical pre-treatment, biological treatment and the final sandfiltration. Both water samples and sludge samples were taken into account. Additional investigations at a pilot plant of 20 m^3 were accomplished.

2 Results

A “Prescreening” in the years 2002 - 2003 has included measurements of the influent and the effluent of the WWTPs for 70 different pollutants. A different elimination for all the detected substances was shown. The following measurements in 2004 -2005 should specify the different ways of elimination. For this purpose a mass balancing for almost 50 selected substances was performed. The elimination of the substances was differentiated by sorption processes, biological degradation and elimination in sandfiltration.

The mass balancing revealed that all pharmaceuticals, x-ray-contrast-media and estrogens are eliminated by biological degradation. Sorption processes onto sludge do not play a significant role for the elimination. Other substances with irrelevant sorption onto sludge are bisphenol A and some organophosphates like TBEP and TBP. The substances with the highest sorption-rates are triclosan, polycyclic muskfragrances and nonylphenol.

The achieved elimination of the WWTPs shows that many detected substances have an elimination of more than 85%, but there are also some substances from the group of pharmaceuticals, contrast media and organophosphates with an elimination of less than 50%. For an assessment of the effectiveness of the WWTPs the specific ecotoxicological relevance of the several detected substances was taken into account. Despite the low concentrations the occurrence of many different organic compounds in the effluent of municipal WWTPs can not absolutely be characterized as uncritical due to the lack of the knowledge of their effects in the aquatic environment.

To specify the results of the full scale plants a series of investigations were made on a pilot plant with approx. 20 m³. On this pilot plant the influence of different biological treatment parameters for the elimination of micro-pollutants was specified.

The results showed a better elimination at higher sludge age for almost all detected compounds. The simultaneously analysed sludge samples indicate that the increasing elimination results from a better biological degradation and not from added sorption processes. Within another test series a comparison was made between a conventional activated sludge plant and a Membrane Bioreactor (MBR). Some of the pharmaceuticals, especially the beta-blockers, show a higher elimination. This causes in higher biological degradation which is confirmed by the analysed sludge samples. For many other substances like musk-fragrances and some flame-retardants the elimination decreased. One reason for this behaviour could be the shorter retention time inside the MBR. In review there is the possibility to optimize the elimination of organic trace pollutants in biological WWTPs e.g. by increasing the sludge age, although, the conventional WWTPs are not able to eliminate the organic micro pollutants underneath the limit of detection (LOD).

3 Conclusion and future prospects

Municipal WWTPs are able to reduce the concentration of many organic trace compounds by more than 85%, but some substances were eliminated only marginally. Biological degradation and sorption play a more or less significant role for each substance. There are some possibilities to increase the efficiency of the treatment with higher sludge ages or higher concentration of suspended solids but the remaining concentrations are still causing concerns.

If there is a political and ecological goal to eliminate the compounds above the LOD new advanced treatment technologies are necessary. Newest results of the researcher project show possible technologies could be an adsorption with activated carbon or an oxidation stage with ozone.