Forschungsvorhaben im Auftrag des Ministeriums für Energiewende, Landwirtschaft, Umwelt, Natur und Digitalisierung des Landes Schleswig-Holstein

Micropollutants and Multiresistant Bacteria in the drainage system of Schleswig-Holstein, Germany

Determination of parameters for the quantification of origin, diffusion and removal

Abstract

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Beauftragt vom:

Ministerium für Energiewende, Landwirtschaft, Umwelt, Natur und Digitalisierung des Landes Schleswig-Holstein

Kiel/ Lübeck/ Hamburg, November 2019

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Abstract

The aim of the present study was to derive parameters that enable the prediction of micropollutants in the urban water cycle. In addition, micropollutant´s load in raw sewage and the specific elimination performance of individual process stages were determined. Consideration was given to sewage treatment plants that are currently typical for Schleswig-Holstein. According to the state of the art, these sewage treatment plants are equipped with an activated sludge tank and possibly further biological or physical stages (e. g. trickling filter, filtration) for an enhanced nutrient removal (C, N, P). Process steps which serve for the targeted elimination of micropollutants have not been investigated. This study is based on a series of previous international and German studies and supplements those by a specific perspective from Schleswig-Holstein. A total of 50 pollutants were taken into account, suggesting various sources (heavy metals, pharmaceuticals, pesticides, polycyclic aromatic hydrocarbons [PAH] and other chemicals used in industry or households). The substances considered in this study are based on substances previously detected in Schleswig-Holstein in the effluent of wastewater treatment plants and in surface waters.

The study considered the occurrence of pollutants and multi-resistant germs together in an integrated measurement program. The wastewater samples were quantitatively investigated for 3rd generation cephalosporin-resistant E. coli (3GCREC) as a marker organism. Representative isolates of the isolated 3GCREC were further characterized by total genome sequencing.

Two separate measurement campaigns focused on different aspects. In an intensive measuring program, in particular, individual procedural steps and their elimination performance were examined. This measurement program is therefore used for the process-specific assessment of micropollutant´s removal and for setting up a mass balance, which allows the identification of relevant sinks. In a subsequent routine measurement program, the seasonal variance of the infeed load and the elimination performance was examined on the basis of 7-day monthly mixed samples of the raw sewage and the wastewater treatment process.

With regard to the removal of micropollutants, biodegradation and sorption prove to be the most relevant mechanisms during mechanical-biological wastewater treatment. Further abiotic processes (hydrolysis, photolysis) or stripping are only taking place for individual substances in these processes and are usually neglectable. On the basis of well-known substance characteristics (sorption coefficient k_d and biodegradation constant k_{bio}) micropollutants can be classified into groups. These groups of substances group together individual substances with similar properties with regard to the aforementioned mechanisms. With knowledge of the properties of the substance, they also allow predicting the behaviour of substances that were not considered in this study.

The results show that well biodegradable substances (some pharmaceuticals) and sorptive substances (especially heavy metals and PAHs) can be well retained in the mechanical-biological wastewater treatment. In this case, the relevant stage of the process is the activated sludge tank in which, on the one hand, the largest proportion of biodegradation takes place. For sorption-affine substances, the surplus sludge extracted from the secondary clarifier provides the relevant sink. These substances accumulate in the sewage sludge after sludge treatment. In the context of common and practicable operating parameters (sludge age, sludge load, dry matter content), only marginally improved removal of micropollutants in the activated sludge system can occur.

Substances which do not tend to sorption and which are not or only moderately biodegradable are not or not completely retained in conventional biological wastewater treatment. These groups of substances include, for instance, many pharmaceuticals and pesticides. In addition, it can be assumed that other substances used as industrial or household chemicals are not completely removed.

It turns out that in the conventional mechanical-biological wastewater treatment, a significant reduction of multi-resistant bacteria in the water path (log 2.46 to 4.31) takes place. This is primarily due to the retention of suspended substances mainly in the final clarifier, since the

germs usually are bound to solids. Nevertheless, an average of around 10^3 3GCREC pathogens per litre remain in the sewage treatment plant´s effluent. The number can be significantly reduced by UV disinfection. As a relevant sink for germs, however, the sewage sludge is addressed, which could not be examined in the context of this study.

The present study does not include the assessment of an ecotoxicological assessment of the substance loads emitted to surface waters. If a corresponding consideration comes to the conclusion that individual substances of the not completely retained substance groups represent an ecotoxicological risk, the implementation of a further process step is inevitably necessary. The consideration of this so-called fourth purification stage is not the subject of this study.

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