Simulation of Diclofenac concentrations in small German rivers with GREAT-ER

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Introduction

Water is a basic element of life on earth and of fundamental importance for all forms of life. For this reason, knowledge about emissions, transport and fate of pollutants in surface waters is of special interest. Simulation models can be used to estimate predicted environmental concentrations (PEC) based on chemical and physical properties and consumption data. The Geography-referenced Regional Exposure Assessment Tool for European Rivers (GREAT-ER) constitutes a model tool for exposure and risk assessment of chemicals in surface waters that calculates spatially resolved substance concentrations in a whole catchment under the assumption of steady state (Figure 1).

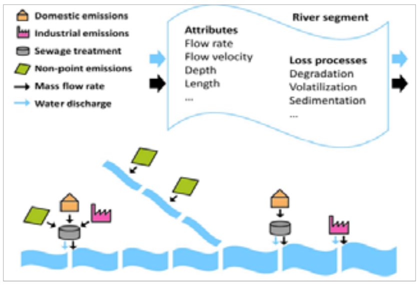

Figure 1: Method of the GREAT-ER model

GREAT-ER has already been successfully applied in a number of studies [e.g. 1,2]. Since Monitoring efforts are often focusing on the large waterways neglecting smaller creeks and tributaries due to their small flow values, GREAT-ER can help to identify possible hot-spots.

Aim

The main objective of this study is to show that the model can be used to support risk management of surface waters not only in large rivers with high flow values, but also in small creeks receiving wastewater from treatment plants with unsatisfactory dilution ratios.

Substance

- Diclofenac (CAS number: 15307-86-5), a non-opioid analgesic drug
- Most prescribed drugs in Germany for many years (3)
- Not completely removed during conventional sewage treatment and detected almost ubiquitously in European surface waters (4)
- Environmental quality standard (EQS) of 100 µg/L (4)
- Was added as priority substance under the EU Water Framework Directive
- Member states need to take action to survey the actual contamination and to prevent exceedance of the EQS

Study area

The study area contains the German part of the catchment of the river Vecht, which becomes a tributary to the Dutch river Ijssel later on. The catchment is located in the west of Lower Saxony and small parts of North Rhine-Westphalia (Figure 2). The studied river basin covers an area of only 1800 km², but covers the relatively large amount of 22 wastewater treatment plants (WWTPs), six hospitals and around 400,000 inhabitants. The Vecht river itself is a medium sized cross-border river with many small tributaries of mean discharge values below 2 m³/s, e.g. the Steinfurter Aa. In addition to the emissions of sewage treatment plants, emissions from hospitals in the catchment area will be taken into account.

Figure 2: Location of the Catchment

Results

To represent the status quo of Diclofenac contamination in the German Vecht watershed including small creeks so called "Monte Carlo" simulations with 10,000 runs were performed. Figure 3 shows the calculated risk quotient as the ratio of the average PEC and EQS for Diclofenac in the Vecht catchment as a color-coded map of the catchment. It can be seen that exceedance of the EQS is predicted to occur in a number of small creeks as well as in parts of the Vecht river itself.

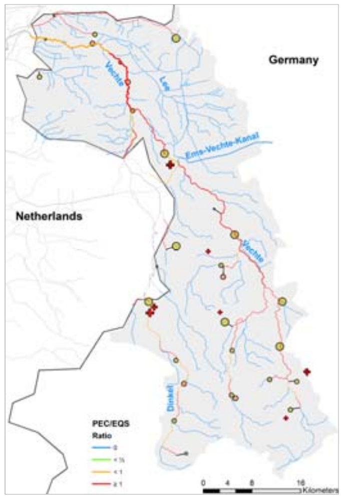

Figure 3: Simulation results shown as PEC/EQS ratio

Management scenarios

At this point the GREAT-ER Model can now be used to gain deeper insight into the origin of elevated concentration levels. Concentrations in the Steinfurter Aa downstream WWTP Steinfurt-Burgsteinfurt are predicted to be above the EQS despite a dilution factor of 50:1. However, upstream emissions from three small WWTPs also contribute significantly to the Diclofenac load. Figure 4 shows a theoretical management scenario rerouting the emissions from these small WWTPs to the WWTP Steinfurt-Burgsteinfurt. If this WWTP is now equipped with better removal techniques (e.g. activated carbon treatment), concentrations downstream are calculated below the EQS, while additionally in this case the small creeks would not be polluted (left sided streams in the network).

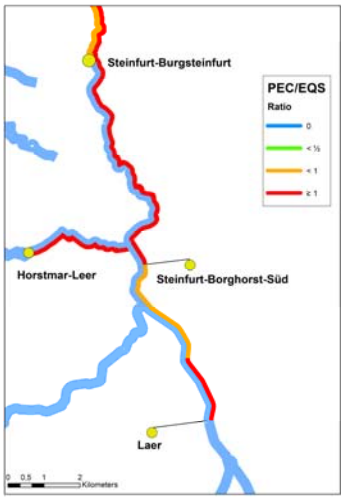

Figure 4: Comparison of the simulation results with a possible management scenario

Conclusions

- Predicted PEC/EQS exceedances are in a range also measured by monitoring campaigns in Europe (4) and the Meduwa project
- The model allows an a priori evaluation of reduction strategies
- Monitoring efforts are often focusing on the large waterways neglecting smaller creeks and tributaries → GREAT-ER can be a powerful tool for calculating the impact of possible management scenarios

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