Faculty of Civil, Geo and Environmental Engineering
Institute of Water and Environment
Chair of Urban Water Systems Engineering

Evaluation of Current and Alternative Strategies for Managing CECs in Water - International Project of the Water Research Foundation

Name **Stefan Bieber**
E-Mail **s.bieber@tum.de**
Supervisors **Prof. Dr.-Ing Jörg E. Drewes**
Prof. Dr. rer. nat. Thomas Letzel
Chair of Urban Water Systems Engineering
Started **01/2014**
Status ☒ **ongoing** ☐ **finalized**

Project WRF 4494

The international project #4494 of the Water Research Foundation (USA) is carried in collaboration with Carollo Engineers (USA), Southern Nevada Water Authority (USA), University of Arizona (USA), and Technische Universität München. The overall aim is to evaluate current strategies to manage compounds of emerging concern (CECs) and to develop a holistic alternative management approach, which is internationally applicable and can result in a significant reduction of trace compound concentrations in water bodies. CECs are organic compounds, which can be detected in water bodies in the ng/L to µg/L range and pose a potential risk for human health and/or the environment. These compounds originate from human activities and belong to substance classes like pharmaceuticals, industrial chemicals, pesticides, and others. In the first phase of this project, current management strategies for CECs in Europe, Germany, Switzerland, the United States and Australia were collected and reviewed. The motivation and drivers, which led to the implementation of certain management strategies, were investigated. The strategies itself were categorized and evaluated, based on the individual initial situations in every country.

Motivations and Drivers

The occurrence situation of CECs is similar in most investigated countries, but the motivations to implement measures differ strongly. Two major motivations were observed, the protection of

human health or the ecosystem. While Australia and the United States mainly focus on the protection of human health, Switzerland and the European Union primarily aim to protect the aquatic ecosystem. The drivers for implementing measures for the reduction of CEC concentrations depend on initial situation in a state and the political and social tradition. In Europe, policy is in general more based on the prevention of possible adverse effects than on controlling already present effects like in the US. This leads to two different, but combinable concepts; the precautionary principle and risk-based approaches. A notable example for a precautionary principle is the Swiss strategy. In early 2014, the Swiss government decided to upgrade 100 of 700 wastewater treatment plants with advanced wastewater treatment. This measure is expected to reduce the load of organic compounds, originating from human activities, in Swiss water bodies by 50%. Adverse effects of CECs in water bodies have not been proven in Switzerland, but the concern about effects was sufficient to trigger this decision. The European Union has adopted a combined approach of the precautionary principle and a risk-based strategy. Within the European Union (EU-Water Framework Directive), in all water bodies, a good water quality should be achieved, in order to reduce the risk for the environment (precautionary principle). Environmental quality standards for allowed compound concentrations of compounds in water bodies are defined to control the most critical substances, which may occur in water bodies (risk-based). In the United States, the precautionary principle is hardly present. The implemented strategies are mostly based on human health relevant concentration values. These values are determined by toxicity tests and divided by a safety factor, to provide a certain degree of safety for human health. Australia has adopted the hazard analysis and critical control point concept (HACCP) in order to determine and control the risks. If a potential risk is identified, a concept of multiple barriers is implemented to prevent hazardous events.

Measures to reduce CEC concentrations

CECs can enter the environment by two different pathways. Wastewater treatment plants are regarded as point sources, because the entrance point of compounds into the environment is well defined. The entrance pathways of non-point sources in contrast, are not so clearly defined. Both, urban and agricultural run-off, but also combined sewer overflow belong to this pathway and compounds can enter the environment everywhere. The difference between these two pathways already displays the challenges in controlling compound emissions. Those originating from point sources could be managed in the wastewater treatment plant. Technologies to reduce CEC concentrations in wastewater treatment plants are available, but are often cost intensive and the success for the removal of different compound classes is uncertain. Often, the removal efficiency of a technology is only investigated on the basis of a rather small set of indicator substances. Since CECs are a heterogeneous class of compounds, the success of a technology for other, than the indicator substances remains uncertain. Further effects of such advanced treatment technologies, like improved eco-health or the toxicological relevance of transformation products are hardly investigated. Technologies are mainly assessed by the determination of CEC removal rates and/or cost-benefit analyses. Besides the implementation of advanced wastewater treatment additional measures could be taken into consideration. These could be organizational approaches like the grouping of urban catchments to larger and more effective treatment plants or separate wastewater

treatment at local emission hotspots like industrial facilities or hospitals. Source directed measures, like emission reduction on the basis of legal restrictions, compound substitution or a chance in user behavior can be used to reduce the concentrations of CECs, originating from non-point sources.

The results of this project phase were subject of two international workshops (Munich, Germany and Dallas, Texas). In the upcoming phases of this project, a representative set of indicator substances will be defined. The applicability of CEC management strategies will then be tested with these indicator substances. The success of different strategies will be qualified by using a triple-bottom line assessment, which does not only include to removal of compounds from water bodies, but also considers cost-benefit ratios and effects for the environment (carbon foot print, etc.) and the society (costs for consumers, etc.).