EGU21-3232, updated on 22 Jan 2022
https://doi.org/10.5194/egusphere-egu21-3232
EGU General Assembly 2021

Integrated Simulation of Particle-Bound Contaminants in Urbanised Catchments Using High-Resolution Data

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During heavy rainfall events, the large amounts of generated runoff in urban areas mobilise particulate matter from different surfaces. These particles have attached other contaminants such as heavy metals, polycyclic aromatic hydrocarbons and, faecal microorganisms. In urbanised areas, particle-bound contaminants (PBCs) may reach rivers through surface runoff, combined sewer overflows or storm water discharges. This may affect the water quality of receiving water bodies and creates health risks to humans and ecosystems. Due to the spatial variability of PBCs, associated to different land uses and pollution sources, the quantification and characterisation of contaminant pathways remain a challenge. Despite high investments, the implemented management alternatives to improve river water quality are still inefficient due to late identification of pressures and lack of a real paradigm shift towards holistic approaches. Therefore, it is necessary to better understand and describe the main factors controlling PBCs pathways in urban areas. This is expected to facilitate the selection of appropriate technologies and strategies to reduce the impact of urban discharges on receiving water bodies.

In this context, the aim of this study is to evaluate the influence of spatial and temporal variability of sediments and PBCs sources on river water quality in an urbanised catchment, considering land-use distribution within the sewersheds. This is expected to provide a better understanding of the relationship between drivers of relevant PBCs and the response of the urban water system under dynamic conditions (i.e. variable sediment load, urban runoff, storm water discharge and river flow).

Data for this study is obtained from an integrated monitoring network in a small watershed (Lockwitzbach) located in Dresden, Germany. This urban observatory consists of four water quality monitoring stations within the stream and in the sewer network. High-resolution (1min) discharge and turbidity data are collected. This allows to understand the dynamic transport mechanisms of sediments in the catchment, providing insights in complex runoff and discharge processes.

Integrated simulation of sediments and PBCs (i.e. heavy metals) is done by using EPA SWMM to evaluate surface build-up and wash-off. Additionally, the impact of sedimentation, accumulation and re-suspension of sediments and heavy metals within the sewer network and river are

analysed using a simplified block developed in Simba#. Calibration and validation of the integrated model was done using online monitoring data and water samples taken during the period 2018-2020. Turbidity was used as a proxy for total suspended solids and PBCs. We identified and prioritised urban areas that are hotspots for high sediment and PBCs loads. Those represent potential locations for an optimal control and reduction of water pollution strategies. Results suggest that integrated simulation is an effective approach to analyse transport mechanisms and pathways of sediments and PBCs within urbanised catchments. Furthermore, high-resolution discharge and turbidity data are especially useful to represent the wash-off of contaminants associated to the first flush process during rainfall events.