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Contribution of stormwater to contaminants in bed sediment

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Stormwater effluent from urban areas may deteriorate the quality of the receiving water sediments by emitting particulate matter and associated contaminants. Various studies have shown that Zn, Cu and Pb, which are typically associated with human activities and urban areas, exhibit elevated concentrations in river bed sediments downstream of stormwater outlets. However, the relevance of stormwater effluent for the contamination of bed sediments was not yet quantified.
Therefore, we investigated how much stormwater emissions may contribute to the accumulation of fines and associated contaminants based on a chemical mass balance approach.

A measurement campaign was conducted at the Bode River in the Town of Staßfurt, Germany. We installed sediment traps at three sites to capture the intrusion of fines. As possible sources of these fines we sampled stormwater effluent within Staßfurt and river bed fines upstream of Staßfurt. The particle-bound concentrations of P, N, C and metals were determined according to standardized analytical methods. Based on a mixing model approach, we estimated how much stormwater particulate matter and river borne fines contribute to the captured fines and associated contaminants. Chemical mass balances assume that linear mixing of sources determines the receptor concentration profile.

Based on the mixing model approach, about 20% of the fines captured by the sediment traps originate from stormwater effluent in our case study. Compared to river bed fines serving as reference, the captured fines are enriched in P, N, C and the metals Zn, Cu, Cd, As and Pb. On the contrary, they are less loaded with Ti, Ni and V. The enrichment and depletion of most constituents can be explained by mixing of river bed fines and particulate matter from urban areas. We calculated that particulate matter from stormwater effluent contributes 5 – 7% of Cu and Zn and up to 15 – 60% of P, N and C in the bed sediment, while it contributes 20% of the fines. This deviance highlights the relevance of physico-chemical processes such as sorption, precipitation and transformation. Moreover, the enrichment of Pb and As cannot be explained by mixing of river bed fines and particulate matter from stormwater effluent. This also suggests that physico-chemical processes are critical regarding the bed sediment contamination. Further, it is possible that we missed an important source of As and Pb. According to national quality standards, especially Cu and Zn concentrations reach critical levels in the river bed sediment.

The mixing of river bed fines and stormwater particulate matter explained a significant portion of the variabilities of enrichment and depletion of most constituents in the river bed sediments of the studied reach of the Bode River. Therefore, it can be concluded that mixing models may be a useful tool to quantify the contribution of known sources to river bed sediment contamination. For further improvement of the understanding of river-bed contamination physico-chemical processes must be considered.