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Temporal and spatial challenges in the *in situ* monitoring of suspended sediment and element concentrations in rivers

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Suspended sediment and the associated sediment-bound elements play a crucial role in the geomorphic, chemical and ecological status of a river. Representative *in situ* sampling of these suspended solids has shown to be complex, because the concentrations vary strongly over time and across the river cross-section. This leads to large uncertainties in suspended sediment and element load calculations in rivers.

This contribution summarizes the findings of the URSACHEN project which ran between 2020 and 2024 at the German Federal Institute of Hydrology (BfG). The project analyzed the spatiotemporal variability of suspended sediment and element concentrations in rivers and derived the consequences for representative *in situ* river monitoring. The project included case studies along the German part of the Rhine at three focus sites (Koblenz, Brohl-Lützing, Emmerich) under different flow conditions (low, middle and high discharge), as well as studies based on existing monitoring data from the river monitoring network of the Federal Waterways and Shipping Administration (WSV) and data from the Global Water Quality Database GEMStat.

In this PICO, we will present a method that allows to determine the required sampling interval for a river segment, in order to determine the annual suspended sediment load with an uncertainty of <20%. Results from a global study highlight the type of river catchments in which higher sampling intervals are required and others where infrequent sampling is sufficient. Furthermore, we will highlight the importance if amalgamated *in situ* sampling, to reduce the uncertainty introduced by short-term, turbulence-driven temporal variability.

To analyze the spatial variability of suspended solids in the Rhine river cross-section, a new *in situ* sampling method was developed, which enables the simultaneous *in situ* sampling of five samples in a depth-gradient. The collected samples were analyzed on suspended sediment concentrations and the concentrations of 67 different chemical elements. The data from the conducted sampling campaigns, as well as the existing data from the WSV monitoring network, show strong lateral and depth gradients in suspended sediment and element concentrations across the river cross-section. Collecting water samples from the water surface and near the

riverbank can lead to an underestimation of the annual sediment and element loads of up to 30%.

Overall, the URSACHEN project has significantly improved the understanding of the temporal and spatial variability of suspended sediment and element concentrations in rivers. The project provided important insights and recommendations for in-situ water monitoring and river management worldwide.