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Coupling targeted monitoring, pathway-oriented data intensive modelling and fate process-based modelling to estimate emission loads and concentrations of trace pollutants in the Danube River Basin

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The number of trace pollutants released by anthropogenic activities is increasing exponentially, their distribution in the environment is often ubiquitous and tracking their fate in river systems via monitoring would require a prohibitive financial effort due to high analytical costs. In this context, models are an irreplaceable tool to identify and quantify emissions loads and to estimate concentration levels in unmonitored catchments. Within the Interreg project Danube Hazard m3c, a novel combined approach has been applied in the Danube River Basin. Firstly, the pathway-oriented MoRE model (Modeling of Regionalized Emissions) was applied at the mesoscale in seven largely diverse river catchments (sub catchments of 40-650 km2) located in four different countries. This semi-empirical and relatively data intensive model could be robustly applied thanks to a rarely available data basis, which was achieved via a targeted and harmonized measurement campaign carried out in multiple environmental and engineered compartments for selected trace pollutants representative of larger groups of substances with comparable patterns of diffuse and point emissions, namely agricultural biocides, industrial chemicals, pharmaceuticals and contaminants of both natural and anthropogenic origin. The high parametrization efforts of the MoRE model yield a quite accurate analysis of emission pathways (e.g. wastewater treatment plant discharges, groundwater and interflow, soil erosion) and estimation of contaminants concentration in the rivers. In a second step, the system understanding gained through MoRE was utilized to improve the performance of the DHSM (Danube Hazardous Substance Model, based on the EU SOLUTIONS model), also applied in the same seven catchments for comparison. This second tool is a source-oriented fate process-based model, with only limited regional data requirements (primarily hydrological data) and which thus requires a much easier parametrization. The parallel application of the two models in the test catchments revealed major differences in the identification of emission pathways, e.g. diffuse emissions of industrial chemicals (PFOS and PFOA) and pharmaceuticals, and in the estimation of emission loads of metals from hotspots, e.g. from mining sites. As last step, the improved version of DHSM was applied to the whole Danube River Basin to quantify the relevance of different sources and

pathways of emissions for the selected indicator contaminants and to estimate the risk of exceedance of the environmental quality standards in unmonitored surface water bodies. An early application of the DHSM for 17 target contaminants revealed Danube River Basin-wide emissions ranging between 0.1 and about 4,000 tonnes per year, with the share of point sources ranging between < 1% to >95%. This contribution focuses on the enhanced system understanding and improved modelling performance gained through the novel combined application of both approaches and will include final updated and validated basin-wide emission estimates.