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Prediction of heavy metal contamination in a floodplain using a coupled hydro- and morpho-dynamic model: A case study in Luxembourg.

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Sediment transports play a central role in the contamination of river systems by heavy metals. This strongly impacts water quality and cause contamination in downstream areas such as wetlands and floodplains. Hydrodynamic models, set up using in situ measurements, arguably represent the only available tool for predicting the impacts of natural and man-induced environmental changes on sediment dynamics.

The objective of this study is to predict floodplain contamination in heavy metals due to river sediment deposition and to heavy metal partitioning between particulate and dissolved phases. In this framework, we focus on a multidisciplinary approach combining environmental geochemistry (multitracing), 2D hydrynamic modelling (using Telemac-2D) and morpho-dynamic modelling (using Sisyphe).

Telemac-2D can simulate free surface flow in the two horizontal dimensions, averaging variables and processes over the vertical dimension. It simulates open water flow dynamics based on the Saint-Venant equations in order to predict among other hydraulic variables water depth and flow velocity for every node of the mesh representing the model domain. The model can also simulate current entrainment as well as the diffusion of tracers (e.g. heavy metal concentration in the dissolved phase). Coupled with Sisyphe, a sediment transport and morpho-dynamic model, it can simulate erosion, deposition and bed load and suspended sediment transport in the water column. Therefore, a coupled Telemac-2D+Sisyphe model was set up for a 5 km long reach of the Alzette river between the gauging stations of Livange and Roeser (Luxembourg). The January 2011 flood event was selected for setting up and evaluating the model. During the entire flood event, the river water was sampled every hour in order to collect the particulate and the dissolved fractions and analyze tracer concentrations.

To investigate the sensitivity of the model with respect to the different parameters a three-step approach was adopted. First, model parameter sets were randomly generated from a priori determined ranges of plausible values. Second, model simulations were carried out using the generated parameter sets. The investigated parameters are the river bed and floodplain roughness, as well as the way the turbulence is computed by the model (k-epsilon or uniform viscosity). Finally, the results of the model simulations were compared with the in situ-collected data. The latter consist of time series of discharge, water surface elevation, dissolved tracer concentration and suspended matter. This three-step approach was adopted in order to clearly understand the influence of the different parameters on the hydrodynamics and the sediment and chemical element dynamics, respectively. As expected, the channel roughness coefficient proved to be the most critical parameter, especially with respect to the hydrodynamics and the dissolved phase. The more surprising conclusion is that the other parameters have also a rather limited but significant influence on the model results in terms of hydrodynamics. When comparing model results with field measurements of suspended matter, the three investigated parameters show comparable influence.