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Quantifying the in-channel retention of cohesive sediments during artificial flood events using FTIR-DRIFT spectrometry

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Cohesive sediments control river ecosystem quality both as a transport medium for contaminants and as clogging material of stream bottom habitats. However, experimental field studies with fine-grained sediments in fluvial systems are rather scarce owing to the lack of adequate tracers and detection methods. As a result, current modelling approaches only insufficiently describe hydrodynamic transport and depositional behaviour of fine-grained sediments in rivers. We adopted two strategies to specifically study cohesive sediment dynamics in natural systems under defined boundary conditions. First, artificial floods were generated in the Olewiger Bach basin (24 km^2), a mid-mountain gravel bed river, in order to characterise the in-channel fine sediment dynamics on their own. The advantage of these artificial flood waves lies in the selective control on some governing processes by experimental design. Second, fine sediment transport and deposition during these controlled reservoir releases were analysed by introducing the clay mineral kaolinite as a fine particle tracer, whose concentration was measured by Fourier transform infrared spectroscopy (FTIR) in diffuse reflectance mode (DRIFT). The DRIFT technique offers some important advantages such as the ability to assess both mineral and organic structures in aquatic particles, good sensitivity and high throughput (Gallé et al. 2004).

Our laboratory tests confirm that FTIR-DRIFT spectrometry is capable of detecting the kaolinite tracer even in low percentage solid concentrations. The mass balance of the injected kaolinite for near bank-full artificial floods showed that, in spite of the very fine material and the non-stationary boundary conditions, over 50 percent of the tracer could be retained over a flow length of only 500 m. By combining fine particulate and natural dissolved tracers (e.g. dissolved organic carbon, DOC) we were able to identify the hyporheic zone as a potential short-term retention and storage zone for the introduced kaolinite. Thus, hyporheic exchange and/or deposition losses in riverine dead and channel periphery zones are significant determinants for the mass balance of cohesive particles during floods.

Within a multidisciplinary research group, accentuating the relevance and interaction of hydraulic, groundwater, biogeochemical and ecological processes, we will model the kaolinite retention dynamics. This will be performed with the STRIVE-package (STReam-RIVer Ecosystem) developed in the modelling platform "FEMME" (http://www.nioo.knaw.nl/projects/femme). FEMME (a Flexible Environment for Mathematically Modelling the Environment) takes care of the basic necessities for dynamic ecological modelling along with other facilities (calibration, validation, sensitivity analysis, output formulation etc.). It supports a modular structure, facilitating an easy implementation or exchange of submodels to build ecosystem models of different complexity. STRIVE is such a package devoted to model stream or river ecosystems by linking different submodels (e.g. hydraulic and solute/particle transport modules, hyporheic zone module, groundwater module etc.) to integrate and study process interactions and the role of lateral exchanges with adjacent subsystems. A brief overview concerning this modelling environment and its adaptation on the Olewiger Bach system will be outlined.

References

Gallé, T., Van Lagen, B., Kurtenbach, A., Bierl, R. (2004): An FTIR-DRIFT Study on River Sediment Particle Structure: Implications for Biofilm Dynamics and Pollutant Binding. - Environmental Science and Technology, 38, 4496-4502.