Analysing fluvial transport and deposition of kaolinite-clay during steady and unsteady flow

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Introduction

Cohesive sediments (<63µm) control several biophysicochemical processes in fluvial systems. They act for instance as carrier for nutrients and contaminants, could induce a reduction of light penetration or provoke severe siltation of reservoirs and benthic habitats. Fluvial transport and deposition of such fine-grained particles are strongly linked to the passage of natural flood events. However, owing to the lack of convenient tracers and detection methods, experimental studies with cohesive sediments in natural river systems and particularly during unsteady flow regimes are rather scarce (Harvey *et al.,* 2012; Krishnappan 2007; Packman *et al.,* 2003; Spencer *et al.,* 2010).

Research approach, material & methods

Two strategies were adopted to study fluvial cohesive sediment phenomena in a natural system and during unsteady boundary conditions: First, artificial floods were released from a reservoir in the Olewiger Bach basin (24km²), a mid-mountain gravel bed river. The outstanding advantage of this artificial flood approach is that some of the governing processes can be excluded or steered by the experimental design. This comprises for instance hydraulic boundary conditions such as maximum discharge and runoff volume, wave form as well as flood duration (Kurtenbach *et al.,* 2006). Second, cohesive sediment dynamics were additionally analysed for comparative purposes during stationary, but variable base flow conditions. Suspended particle dynamics during these field experiments were analysed by introducing the clay mineral kaolinite (d_{50}=2µm, ρ=2.6g/cm³) as a cohesive sediment tracer. During the steady-state field experiments, in-channel transport of kaolinite can be analysed via unspecific analytical methods such as turbidimetry/gravimetry, laser diffraction and photometry. However, during the floods the kaolinite tracer is always conveyed in mixtures with natural suspended matter. Consequently, a specific analytical method is indispensable to accurately quantify tracer fluxes during such unsteady flow regimes. For this purpose, we apply Fourier transform infrared spectroscopy (FTIR) in diffuse reflectance mode (DRIFT) (Gallé *et al.,* 2004).

Results

Our laboratory tests confirm that FTIR-DRIFT spectrometry is capable of detecting the kaolinite tracer even in low percentage solid concentrations. Tracer mass balance calculations during the field experiments reveal significant loss rates of kaolinite both during steady and unsteady flow regimes. Consequently, fluvial retention of fines could be orders of magnitude higher than the expected deposition derived for instance from gravitational settling velocities estimated via the Stokes equation. Potential mechanisms and determining factors of cohesive particle retention such as kinematic wave effects, hyporheic exchange, deposition in riverine dead and channel periphery zones, adhesion on biofilms as well as flocculation will be discussed.

References

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