How much suspended particulate matter enters long-term in-channel storage?

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Introduction: The routing of suspended particulate matter (SPM) downstream rivers strongly depends on discharge conditions and involves transport times and periods with resting times in deposits e.g. areas with low-flow conditions close to the channel bed. It is, however, difficult to estimate the contribution of SPM on the sediments of the river bed.
Knowledge about transport velocities and the residence time of (contaminated) SPM is an import factor for the sediment management.

Methods: In this study, particle bound polychlorinated biphenyls (PCB), which were released by an incident in the Elbe river (Central Europe) in spring 2015 [1], could be used as unique tracer for transport pathways of SPM along the entire river stretch (over 700 km length), including low mountain ranges, lowlands, and the estuary. In 2015 the Elbe River was characterized by low-discharge conditions. Thus, the export of SPM on flood plains was strongly limited.
The incident was monitored by concentration measurements of seven indicator PCB congeners along the inland part of the Elbe River as well as in the Elbe estuary. Data from ten monitoring stations (settling tanks) are considered. The total PCB load is calculated for all stations on the basis of monthly contaminant concentrations and daily suspended sediment concentrations [2]. Monte-Carlo simulations assess the uncertainties of the calculated load. It is shown that the ratio of high versus low chlorinated PCB congeners is a suitable tracer to distinguish the PCB load of the incident from the long-term background signal (hereafter PCB6 ratio). We demonstrate that both the load of PCB as well as its chemical fingerprint allows the estimation of transport durations for the transport processes involved.

Results and Discussion: Only a little part of the suspension has been transported via wash load. The PCB6 ratio is used to estimate mean transport velocities of the wash load fraction. A direct transport of wash load via the mean flow velocity of the water was not observed. Shortly after the incident, the PCB6 ratio was monitored 257 km downstream of the incident site in April 2015, in May first occurrence was monitored 514 km downstream of the incident site and in July 2015 it reaches the tidal weir at Geesthacht, 626 km downstream and enters the estuary. Here the transport velocity strongly decreases and the PCB6 ratio was not detected 25 km downstream the tidal weir before December 2015.
The major part of the PCB-marked suspension is transported via suspended load. Interestingly, the reduction of total PCB tagged SPM load within the first 514 km downstream of the incident site indicates that roughly 75% of the annual SPM load (of the most upstream station located 43 km downstream of the incident site) is stored in the sediments of the Elbe River, suggesting that suspended sediment in transport enters storage after a relatively short distance (Fig. 1). Once SPM settle, significant storage can occur over decadal time scales [3,4]. This might strongly complicate sediment management issues in the future.

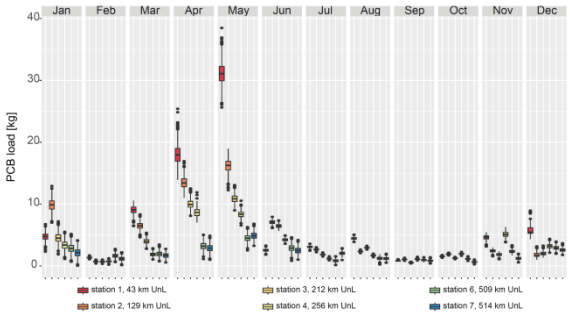

Fig. 1: Monthly distribution of PCB loads in 2015. Uncertainties are estimated via Monte Carlos-Simulation. The amount of the PCB-load drops suddenly, suggesting that suspended sediment in transport enters storage after a relatively short distance.

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