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# Influencing factors on particle-bound contaminant transport in the Elbe estuary

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Particulate matter, i.e. suspended particulate matter and sediments in rivers and estuaries, often are contaminated with trace metals and selected organic contaminants and are mainly associated with fine-grained fractions. Transport processes and fate of particles in estuaries are influenced by several factors, e.g. freshwater discharge, tide, flow velocity and dredging activities (Kappenberg et al., 2007). Understanding the transport processes in estuaries may help to achieve the objectives of the Water Framework Directive and the Marine Strategy Framework Directive. The German Federal Institute of Hydrology (BfG) operates for more than 20 years five monitoring sites in the Elbe estuary in order to monitor the development of particle-bound contaminant concentrations over time and to understand their transport mechanisms. Results of the monitoring revealed freshwater discharge as an important influencing factor on the transport of contaminated particulate matter (Ackermann et al., 2007). The bidirectional transport of marine and fluvial water and particulate matter in estuaries results in a turbidity zone where large amounts of particulate matter are temporarily retained and thus in a delayed transport of particulate matter towards the sea. The extent and the location of the turbidity zone as well as the ratio of highly contaminated fluvial and less contaminated marine sediments at a given location are mainly influenced by the freshwater discharge (Kowalewska et al., 2011). Furthermore, at high freshwater discharge conditions the highly contaminated particulate matter from fluvial origin are transported downstream the estuary, whereas at low freshwater discharges, upstream transport of less contaminated marine sediments prevails. Hence, residence times of particulate matter in the estuary are difficult to estimate. Furthermore, sedimentation areas with flow reduced conditions, e.g. wadden areas or branches of the Elbe estuary, may act as sinks for particle bound contaminants and remove them temporarily or in long term from further transport. In the past, highly contaminated sediments were deposited in these retention areas. The estimated total contamination load in these areas exceeds the annual contamination load entering the estuary by a factor up to 11 (BfG, 2014). Monitoring in sedimentation areas by the means of sediment cores gave no indications for current distinct sedimentation or erosion. It is assumed that the highly contaminated sediments in greater depths are most likely to be resuspended only due to extreme events or human intervention (BfG, 2014). Additionally, dredging and depositing of dredged sediments in the Elbe estuary influence the transport of contaminated sediments. Deposition of dredged material further downstream the dredging site accelerates the transport of particulate matter towards the sea. As the residence time of particulate matter within the estuary varies by many influencing factors, mass balances are associated with large uncertainties and accordingly, annual particle-bound contaminant loads released into the North Sea cannot be calculated reliable.

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