The role of contaminated sediment monitoring for dredging management in the Elbe estuary

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Introduction: The Elbe estuary is an important federal waterway including the Port of Hamburg as the third largest port in Europe. Natural sediment dynamics require continuous maintenance dredging to ensure navigation in the Elbe estuary and to allow access to the Port of Hamburg. Since the year 2000, the focus of dredging activities moved upstream and the amount of dredged sediments in the Port of Hamburg increased continuously. The huge amount of dredged sediments needs sophisticated management. Especially fine-grained dredged material has to be taken into consideration for management concepts as contaminant concentrations in fine-grained sediments in the Elbe estuary are still elevated. To assess the impact of different strategies of depositing dredged sediments on the sediment balance and sediment quality, besides hydrological and morphological aspects, monitoring of contaminants in suspended particulate matter, in sediments at dredging sites and in sediments at deposit sites and their surroundings is crucial. As contaminants can act as tracers for transport pathways of sediments, monitoring of contaminants provides important data for temporal and local trends as well as for handling dredged sediments. This data was also used as basis for recommendations on how to handle dredged sediments in two studies compiled by the Federal Institute of Hydrology in 2008 and 2014 [1,2].

Methods: In the Elbe estuary long-term monitoring of contaminants in recently deposited sediments and suspended particulate matter (SPM) is carried out on a monthly basis. Four stations in the estuary and one station at the entrance of the estuary are operated by the Federal Waterways and Shipping Administration. Besides them sediments at deposit sites and adjacent Wadden Sea areas or branches are monitored every two years. Since the contaminants of interest predominantly accumulate in fine fractions, contaminant concentrations were measured in or normalised to this fraction. The loads of contaminants spreading from deposit sites and the direction of their dispersal are estimated taking into account the amount and contamination of dredged material as well as the discharge-dependent transport paths of sediments that were derived from dispersion calculations of the Federal Waterways Engineering and Research Institute (BAW).

Results: The long-term monitoring of contaminants in particulate matter revealed e.g. that (1) concentrations of most contaminants decreased since the beginning of monitoring, (2) most contaminants are mainly introduced from the freshwater part of the Elbe River, (3) the contamination of sediments or SPM in the estuary depends on freshwater discharge, (4) as a result of mixing of more strongly contaminated fluvial sediments with less strongly contaminated marine sediments, the concentrations of many contaminants in sediments and SPM decrease downstream the estuary [3]. Large amounts of marine sediments reached the inner estuary and led to a distinct increase of the quantities of the sediments to be dredged. The investigation of sediment cores in areas adjacent to deposit sites revealed more highly contaminated sediments in deeper layers and concentrations comparable to the current contaminant concentrations measured in SPM at monitoring stations in upper layers. The patterns of contaminants in sediment cores indicate that in some areas sedimentation still prevails. Based on estimated contaminant loads at variable discharge conditions it was concluded that in the last three years with continuously low freshwater discharge rates, the upward transport of fine-grained particulate matter dominated. Thus, contaminated sediments accumulate within the inner estuary. The same sediments had to be dredged repeatedly and only a small percentage was transported further downstream to the German Bight. Due to the accumulation of sediments in the first two years the typical decrease of contamination within the estuary was missing. Only after longer periods of low freshwater discharge contaminant concentrations decrease as the input of less strongly contaminated marine sediments prevails over the input of more strongly contaminated fluvial sediments.

Conclusion: Management concepts in complex systems require large datasets and regular monitoring. In addition to that, after the implementation of a management concept detailed monitoring is needed to verify the expected impacts and if required to adapt the recommendations.

References: [1] BfG (2008) BfG-1584, pp. 336, [2], BfG (2014), BfG-1763, pp. 238, [3], Ackermann et al. (2007) in: *U. Förstner und B. Westrich (ed.): Sediment Dynamics and Pollutant Mobility in Rivers, 296-304. Springer-Verlag*.