Contamination of sediments in the Elbe estuary and its sensitivity to climate change

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Introduction: This study was part of the KLIWAS programme and focuses on the assessment of the potential influence of climate change and of other man-made changes on particle-bound contaminant concentrations in the estuary of the river Elbe and the resulting challenges for sediment management that is important for navigation. As a result of projected climate-induced changes of temperature and precipitation [1], alterations of the frequency and intensity of extreme events such as floods, storm surges or extended periods with low river discharge and a rise of the sea level are expected. An increase in intensity and occurrence of floods would result in an additional input of contaminated sediments from the inland reaches of the rivers to the estuary and consequently, a deterioration of the quality of estuarine particulate matter (PM) may occur. In case of more frequent low river discharge situations and of sea level rise, the upstream transport of slightly contaminated sediments of marine origin may be intensified, and cause decreasing concentrations of contaminants in PM.

Methods: In order to identify potential alterations of estuarine contaminant concentrations resulting from a) climate-induced changes of PM input to the estuary or b) a reduction of fluvial contaminant concentrations, sensitivity studies based on a binary mixing model were carried out. The results from a long term monitoring programme on contamination of PM at five sites in the estuary, including the monitoring site upstream of the tidal weir, were used for calculations. The estimation of climate-induced changes of contaminant concentrations in estuarine PM was based on results of projections on the fluvial PM input into the Elbe estuary in the near (2021-2050) and far future (2071-2100) and further, on assumed extreme changes of such inputs [2].

Results: In the Elbe estuary, projected changes of contaminant concentrations in the near future vary from -12 % to +12 %, and thus remain within the natural variability (reference period 2003 to 2012). However, regarding the far future, two of the five PM projections indicate distinct impacts on sediment quality. The projected rates of change of -25 % and +34 %, respectively, slightly exceed the natural variability of the reference contamination. For the inner Elbe estuary, where already the reference concentrations of HCB, p,p'-DDD and p,p'-DDE are above the upper action levels of the national regulations for the management of dredged material in the coastal area, the results of the worst-case projection for the potential climate-induced change of contamination (+34 %) indicate a considerably higher exceedance of the action-triggering levels in the far future. However, a significant increase of concentrations compared to the reference period is to be expected only for the assumed changes of PM inputs by -50 %, and +100 %, respectively [2].

Discussion: Although results of the sensitivity study are associated with large uncertainties, the approach allows estimating the range of changes in particle-bound contamination levels in the Elbe estuary as a consequence of changing boundary conditions.
With regard to the worst-case projection of a potential increase of particle-bound contaminant concentrations in the Elbe estuary by 56 % in the far future, the study recommends to consider adaptations in sediment management strategies to changed concentration levels in the medium or the long terms. However, before the planning of adaption measures begins, the respectively prevailing contamination status should be verified, as climate-induced changes of contaminant concentrations might be superimposed by direct anthropogenic activities, e.g. remediation measures to reduce contamination or construction works in waterways [2].

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References: [1] IPCC (2007) Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp. [2] Kleisinger et al. (2015 In Sediment Matters, Heininger, P., Cullmann, J. (eds.), Springer Verlag, pp. 247