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Potential metal(loid)s mobilization from acid mine drainage-affected sediments under sea level rise projections

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Metals and metalloids are among the most dispersed hazardous substances released to estuarine systems, which often accumulate within the sediments, contributing to a global problem of pollution in estuaries. In this context, the projected future sea level rise predict the inundation of metal-polluted sediments in littoral areas, which may have serious implications in the mobility of sediment-bound contaminants.

The Tinto River estuary (SW Spain), which is projected to be partially flooded by seawater in 2050 due to the rising sea level, have historically received significant amounts of potentially toxic elements originating from former metal mines, transported to the estuary by the Tinto River.

To estimate the potential release of metal(loid)s associated with seawater flooding, surface sediments were sampled to determine metal concentrations, total carbon content, pH, and particle size distribution. In addition, the contamination factor, geoaccumulation index, and pollution load index were calculated to evaluate metal(loid) pollution. To estimate metal(loid) mobilization upon sea level rise a delimited area of the Tinto River estuary was defined (according to sea level rise projections), and elements mobilization was calculated using values obtained from inundation experiments (Kerl et al., 2023) and sequential extraction methods.

Sediments from the study site turn out to be highly polluted with calculated pollution load indices over 1 and surpassing Spanish guidelines and international sediment quality guidelines , especially for As (300 – 1300 mg/kg), Cu (300 – 3500 mg/kg) and to a lesser extent Zn (100 – 1400 mg/kg) and Cd (0.2 – 5.8 mg/kg). Results show that significant amounts of Fe, Cu, Zn and As (36800, 11200, 1390, 3.22 kg, respectively) can be mobilized under short-term inundations (65 days) related to climate change scenarios predicted for 2050. Under 2100 projections, the mobilization of those metal(loid)s is expected to be further enhanced by the additonal release of large amounts of Fe, as a result of the reductive dissolution of Fe- or Mn-oxyhydroxides, which is mainly attributed to the promotion of reduced conditions in currently oxic sediment layers. These results provide a first

estimation of the potential mobilization of potentially toxic elements upon climate change, which is of paramount importance for risk assessment in metal(loid) polluted estuaries worldwide.