



Kinetic processes of trace metals remobilization during resuspension of contaminated sediments from a dam reservoir

Lucie Monnin (1), Philippe Ciffroy (2), Jean-Marie Garnier (1), Jean-Paul Ambrosi (1), Olivier Radakovitch (1,3)
(1) Aix Marseille Univ, CNRS, IRD, Coll France, CEREGE, BP80, 13545 Aix-en-Provence, France, (2) EDF, Division Recherche et Développement, Laboratoire National d'Hydraulique et Environnement (LNHE), Chatou, France, (3) Institut de Radioprotection et de Sécurité Nucléaire (IRSN). PSE-ENV/SRTE/LRTA., BP3, 13115 Saint-Paul-Lez-Durance, France

Dam reservoirs sometimes need to be fully drawn down for maintenance operations. In contaminated environments, the sediment resuspension induced during this process may promote the remobilization of trace metals from the solid to the more bioavailable dissolved phase. Being able to anticipate the release of these contaminants is essential to improve the management of reservoirs and assess the risk of water quality degradation.

Surface sediments were collected in a contaminated dam reservoir and the total contents of trace elements were analysed. A sequential extraction procedure was used to assess the trace metals fractionation. Aliquots of wet sediments were resuspended for a week in a reactor and three solid/solution ratios (2.7, 5.0 and 9.4 g.L⁻¹) were tested. The pH and Eh were continuously measured. Dissolved samples were collected, and the evolution of dissolved organic carbon, alkalinity, major ions and trace elements concentrations were measured.

The sediment contained high levels of As (43 mg.kg⁻¹), Cd (6 mg.kg⁻¹), Pb (213 mg.kg⁻¹) and Zn (687 mg.kg⁻¹) compared to usual quality guidelines. During resuspension, the temporal evolutions of a given element were similar, regardless of the mass of sediment used. Different trends of dissolved concentrations can be highlighted: 1) Cd, Cr, Cu, Ni, V and Zn were not remobilized; 2) Al, Mo, As, Ba and Sr continuously increased during the experiments; and 3) Mn, Co, Fe and Pb increased at the beginning of the experiments and then were removed from the dissolved phase. This removal was likely due to precipitation and adsorption onto Fe- and Mn-oxyhydroxides. The sequential extractions did not allow to relate these groups to specific distributions in the solid phase. The greater risk of water quality degradation for this reservoir during resuspension would be posed by the remobilization of As, which reached a maximum concentration of 30 µg.L⁻¹.

To extend the scope of the laboratory experiments, the temporal trends of some elements were used to calibrate a new chemical speciation model. This model was based on an existing thermodynamic model Visual Minteq for the dissolved speciation and the solid surface speciation. Our objective was to combine the equilibrium speciation calculation, with a modelling of the kinetic exchange reactions of the free dissolved metal between water and these solid surfaces. The experimental trends of dissolved trace metal can be successfully reproduced by calibrating a set of kinetic rates for the adsorption-desorption reactions on the surfaces of Fe-oxyhydroxides and on particulate organic matter; and the precipitation-dissolution of carbonates with the release or removal of the associated trace elements.