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Tellurium radionuclide dispersion scenarios in aquatic systems: coupling of adsorption kinetics, radionuclide decay and estuarine hydrodynamics

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Tellurium (Te) is a Technology Critical Element (TCE), an emerging contaminant and a relevant radionuclide produced in nuclear power plants (NPPs), potentially released into the environment after major NPP accidents [1]. Little is known about the environmental behaviour and fate of both, stable and radioactive Te, particularly in complex aquatic environments such as continent-ocean transition systems [2], such as the Gironde Estuary, France. Information on solid/liquid partitioning is necessary for developing dispersion scenarios to simulate dissolved Te radionuclide discharges into dynamic coastal environments featuring strong salinity and turbidity gradients and seasonal variations in hydrodynamics.

This study presents experimental adsorption kinetics of dissolved Te exposed to a wide range of suspended particulate matter (SPM) concentrations in both, freshwater and seawater. Tellurium solid/liquid distribution kinetics in simulated estuarine salinity and turbidity gradients are compared to Te radionuclide decay timescales (i.e., several min to months) and to estuarine dynamics controlling water and SPM residence times as well as the seasonal position of the Maximum Turbidity Zone (MTZ) in the Gironde Estuary. Solid/liquid partitioning (equilibrium: log Kd~5.3) was achieved within ~5 h in highly turbid conditions (1000 mg L^{-1}) and after more than 2 days for average SPM concentrations (100 mg L^{-1}; log Kd~4.9), independent from salinity.

Radionuclide releases into low-turbidity conditions would imply that, within the first days, part of Te radionuclides decay into other elements (I, Cs, Xe) and/or are transported to the ocean in the dissolved phase. Further dilution in the coastal ocean would be expected, although radionuclide transfer to marine organisms (e.g. oysters) cannot be excluded. Contrastingly, Te radionuclide release into turbid conditions, i.e. when the MTZ is located near to /downstream from the NPP, would result in rapid, nearly total adsorption onto SPM within the first tide. Given the long estuarine residence times of SPM (1-2 years [3]) and the seasonal upstream migration of the MTZ, this scenario potentially implies the risk of upstream transport of radionuclides with relevant half-lives (^{127m}Te, ^{129m}Te) into the fluvial estuary (Bordeaux agglomeration) during the following dry season.

References

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