Behaviour of inorganic tin along the Gironde fluvial-estuarine continuum: implications for dispersion and fate scenarios of accidental radionuclide release

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Abstract

The nuclear power plant accident of Fukushima Dai-ichi has raised questions on radionuclide behaviour and fate in coastal systems. Inorganic tin (Sn) is both a potentially toxic contaminant and a product of nuclear fission (production rate ~2%) forming non-stable (e.g., 123Sn, T1/2 = 129.2 d) and stable forms (e.g., 119Sn, 120Sn, 122Sn). Due to similar biogeochemical behaviour, the study of natural stable isotopes aims at understanding the fate of radioactive analogues. Herein, we present long-term (2003-2015) particulate (Snp) and dissolved (Snd) Sn concentrations and fluxes in the freshwater reaches of the Gironde Estuary (La Réole site; LR) and Sn partitioning along the estuarine salinity and turbidity gradients for contrasting hydrological conditions. Results show Snp concentrations (22±24 mg/kg) and fluxes (12±9 t/yr) entering the Gironde Estuary are highly variable due to hydrology and roughly 2-fold higher than in the Gironde Estuary maximum Turbidity Zone (MTZ; relatively stable 6-7.5 mg/kg). Mass balances suggest that ~50% of incoming Snp may be dissolved within the estuary. The Snd distribution along the salinity gradient displays increasing values from ~10 ng/L (S=0) to ~110 ng/L (20≤S≤30). Distribution coefficients at LR (average log10Kd=6.4) suggest that in both the freshwater reaches and the low-salinity estuarine turbidity maximum (average log10Kd=5.2) ~90% of total Sn (SnT) is present as Snp (Snp/SnT ≥0.9). Contrastingly, in the less turbid estuary mouth, average log10Kd=4.8 reflect clearly higher solubility, resulting in Snp/SnT ~0.5. Accidental release of Snd radionuclides into the estuary during high discharge (MTZ in the central/downstream estuary) would be rapidly adsorbed and transported by MTZ particles. Under low discharge conditions (MTZ migrates upstream), Snd radionuclides will be diluted and rapidly (within weeks) exported to the ocean, with non-negligible risk of uptake by wild oysters (Bioaccumulation Factors ~3.2±1.9x102).

Keywords: Inorganic tin, Gironde Estuary, Distribution coefficient, wild oysters

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