A preliminary approach to multiple radionuclide NPP accidental release and dispersion in the Gironde Estuary (France)

Teba Gil-Díaz[a], Jörg Schäfer[a], Frédérique Pougnet[a], Angélique Husson[a], Thomas Gardes[a], Lionel Dutruch[a], Cécile Bossy[a], Frédérique Eyrolle-Boyer[b], Alexandra Coynel[a], Gérard Blanc[a]

[a]Université de Bordeaux, UMR CNRS 5805 EPOC, 33615 Pessac, France
[b]Laboratoire de Recherche sur les Transferts dans l'Environnement. Institut de Radioprotection et de Sûreté Nucléaire (IRSN) PRP-ENV/SERIS/LRTE Centre de Cadarache, bat 159, 13115 St Paul lez Durance, France

Abstract

During nuclear power plant (NPP) accidents, radioactive emission monitoring focuses on noble gases, health-relevant or persistent volatile isotopes (^{131m}Xe, ^{131}I, ^{137}Cs). Nevertheless, many other understudied radionuclides are equally/more importantly released with unknown environmental behaviour/dispersion. This information is fundamental for medium-term radiological risk assessment. We propose a preliminary qualitative multi-elemental scenario for accidental releases from the Blayais NPP in the Gironde Estuary for Sn, Sb and Te fission products based on the biogeochemical behaviour of their stable isotopes.

Decay models predict dominance of Sn, Sb and Te radionuclides during the first months and up to >1 year (^{125}Sb) after an accident. Natural solid/liquid partitioning coefficients ($\log_{10} K_{d\,Sn} = 5.2$ l kg^{-1} >$\log_{10} K_{d\,Te}$ ≈4.8 l kg^{-1} >$\log_{10} K_{d\,Sb}$ = 4.0 l kg^{-1}) suggest that ≈90% of total Sn, Te and Sb are within the Suspended Particulate Matter (SPM) for SPM = 100 mg l^{-1} to >1 g l^{-1}, i.e. in the estuarine Maximum Turbidity Zone (MTZ).

This study shows that freshwater discharge as well as the seasonal position and biogeochemical dynamics of the MTZ will play a major role in estuarine transport and residence times of Sn, Sb and Te radionuclides. High-discharge scenarios with a down-estuary MTZ position suggest high MTZ radioactivity, long retention of radionuclides in the estuary (SPM residence time of 2–3 years) and upstream transport to Bordeaux city of ^{125}Sb ($t_{1/2}$ = 2.76 y) during the following summer draught. Low-discharge scenarios with an upstream MTZ position suggest rapid (days to weeks) radionuclide release to the coastal sea, mainly in dissolved (and probably more bioavailable) form, implying risks for aquatic organisms and human beings (seafood consumption). However, higher Sn and Te K_d values suggest that SPM ≈100 mg l^{-1} may retain ^{125}Sn and ^{127m}Te inside the estuary during their disintegration (≈3 months).

Keywords: radionuclides, distribution coefficient, Gironde Estuary, accidental scenarios