Transit times of artificial radionuclides in a large nuclearized river system

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Many nuclear power plants are located along rivers in which they release artificial radionuclides (RN) through authorization or incident. Their behavior is controlled by biogeochemical characteristics, potential sinks along the river and transit times. If these times can be extrapolated from hydrological model for water and dissolved RN, it is more difficult to evaluate those of particles and particulate RN.
Five nuclear power plants and two plants (Uranium conversion and spent fuel treatment) have released RNs along 400 km of the Rhône River (France) since the 50's. The transfer in this river mainly depends on floods which transport up to 90% of the annual suspended matter flux in less than 10% of time. This induces a disconnection between inputs and output fluxes because releases are not allowed during flood. Since 2005, IRSN collect and measure dissolved and particulate RN with an automatized station located 30Km upstream of the mouth. The measured RN output fluxes can thus be directly compared to the releases declared, providing an opportunity to evaluate transit times along the system. Important results are:
- Fluxes of RN linked to releases and atmospheric fallouts (Pu, Am, Cs, Sr) are slightly higher than those declared by the industries. This is due to leaching from the watershed soils but also to resuspension of past sediment within the river, as evidenced by Pu isotopic ratios.
- Fluxes of RN only issued from the releases (Co, Ag, Sb, Mn, Cm) are in equilibrium with those declared (or slightly lower), traducing an efficient and rapid export from the system on a yearly basis, even for particulate RN.
Transit and resilience times of these RN in the river system will be presented and discussed based on their mass budgets.