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Tracing of Plutonium Contamination over Inundated Areas of Camargue (France)

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Alpha emitting 238, 239 and 240 plutonium isotopes were dispersed in the atmosphere all over the world since the first nuclear atmospheric tests in 1945. A large amount of ^{238}Pu was added to the global amount of plutonium in the Northern Hemisphere in 1964, when a satellite equipped with a Pu-powered unit burnt-up in the atmosphere. Until 1980, the atmospheric contamination led to an homogeneous deposit over French territory plains soils that now contain ultra-trace quantities of these long-lived plutonium isotopes, characterised by a ^{238}Pu/$^{239+240}$Pu activity ratio of 0.03 (UNSCEAR, 1982) During October 1993 and January 1994, two exceptional rises in the Rhone River water level induced large inundation of the North East of the Camargue. This area is situated 60km downstream from the Marcoule reprocessing plant that has generated liquid release into this river since the beginning of the 60's. This release contained different artificial radio-nuclides, and especially 238, 239 and 240 plutonium isotopes with a ^{238}Pu/$^{239+240}$Pu activity ratio of 0.3. Below Marcoule installation, scavenging and sediment transport processes are governing plutonium fluxes in the Rhone River, and these particles are characterised by an activity ratio ^{238}Pu/$^{239+240}$Pu equivalent to Marcoule release's (Coughtrey et al., 1984; Lambrechts and al., 1991; Noël, 1996).

In this study, ^{238}Pu/$^{239+240}$Pu activity ratio of some flooded soils are measured as it reflects the mixing between the two possible sources, Marcoule industrial plant release and the global fallout. During inundation, an input of 391,000 tons of Rhone sediments on Camargue soils occurred as 9 levees have broken (Pont, 1994). As the mass activity of ^{238}Pu and $^{239+240}$Pu has been measured in lower Rhone sediments before the inundation, one can calculate the total brought activity to be 104MBq and 375MBq for ^{238}Pu and $^{239+240}$Pu respectively. However, the dispatch of sediments over all the 130 squared kilometres flooded area was very inhomogeneous. One can postulate that the main sediment deposit occurred near the main levee breaches, but the finest sediment fraction could have migrated further.

To check this hypothesis, we sampled fourteen cultivated soils 20cm deep, from which seven were sampled all over the inundated area in order to investigate the contamination dispersion at the global scale. The other seven samples are devoted to the particular study of the Rhone sediment deposition near one of the main levee breaches.

From obtained activity results, we use the mixing equation between the two different activity ratio to calculate the portion of ^{238}Pu and $^{239+240}$Pu originating from the Rhone inputs. Some samples give Pu surface activities significantly higher than global fallout mean deposit. More than half of their ^{238}Pu total activity is attributable to Rhone inputs. The part that Rhone sediments represent in sampled soils is also estimated. This portion is very different depending of the sample location, and can vary from 0 to 10%, which corresponds to a Rhone sediment deposit thickness from 0 to 2cm assuming a 20cm uniform ploughing of soils .

This study leads to a modelling of Pu distribution over the inundated area, showing that the Pu addition was very heterogeneous and was mainly concentrated straight from and near the levee main breaches.

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