



## **Chlorine-36 and chlorine concentrations within several compartments of a deciduous forest ecosystem in Meuse/Haute-Marne (France)**

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Chlorine-36 is a cosmogenic nuclide mainly produced in the atmosphere by interactions between energetic particles originating from the cosmic radiations and  $^{40}\text{Ar}$ . Because of its long half-life ( $T_{1/2} = 3.01 \cdot 10^5$  yr) and its high mobility, chlorine-36 is a critical radionuclide concerning radioactive waste repository sites. Moreover, it has been shown that inorganic chlorine could be enriched along the trophic chain due to its high solubility and bioavailability (Ashworth and Shaw, 2006). Additionally, many studies during the last decades have established that due to chlorination process, organic chlorine may account for a large proportion of the total soil chlorine pool (more than 80 % in surface soils of temperate ecosystems. Redon et al., 2012).

The aim of this study is thus to measure chlorine-36 in all the compartments of the biogeochemical cycle, to better understand its recycling in the biosphere.

The study site is the experimental beech forest site of the Andra long-term monitoring and testing system (OPE\*). It is located at Montiers-sur-Saulx, North-East of France and is associated to the future radioactive waste repository site of Bure. Since March 2012, rainwater above (rainfall collected from a 45 m high tower built on purpose) and below (throughfall and stemflow) the canopy, has been collected monthly, as well as soil solutions (gravitational and bound waters) at four depths (0, 10, 30, 60 cm deep).

Chlorine-36 and chlorine have been measured in the rainfall samples between March and July 2012 and in water solutions collected from all compartments of the biosphere using isotope dilution mass spectrometry at the french AMS national facility ASTER located at CEREGE.

The results yielded from the rainfall samples allow to study the temporal fluctuations of chlorine-36 in the atmosphere, which represents the main inflow of chlorine-36 in its biogeochemical cycle. The first results indicate a flow increase during the late spring-early summer. Santos et al., 2004 have also observed a similar pattern in southern Spain. This increase might be due to a tropopause break, a natural process which occurs in spring and in fall. This break implies an increase of the air masses exchange between the tropopause and the stratosphere and therefore could cause high chlorine-36 inflow.

All together, those results allow to draw a profile of the evolution of chlorine-36 concentrations in the various pools of the biogeochemical cycle (from the upper rainfall through stemflow and throughfall to the lower soil). Both  $^{36}\text{Cl}$  and Cl concentrations in stemflow samples are 25-50% higher than in the rainfall and throughfall samples. In water solutions collected from the soil, chlorine-36 concentrations vary between 3 to  $8 \cdot 10^3$  at/ml, with an increase in the concentration at 30 cm depth.

To understand the chlorine-36 recycling in soil, the next step will be to isolate and measure the  $^{36}\text{Cl}$  concentrations in the inorganic and organic fractions of chlorine in a soil profile.

\* : OPE : Observatoire Pérenne de l'Environnement (SOERE), French national long-term monitoring and experimental system for research in environment, [www.andra-ope.fr](http://www.andra-ope.fr)

Ashworth, D. J. and Shaw, G. (2006). A comparison of the soil migration and plant uptake of radioactive chlorine and iodine from contaminated groundwater. *Journal of environmental radioactivity*, 89(1) :61–80.

Redon, P.-O., Jolivet, C., Saby, N. P. a., Abdelouas, A., and Thiry, Y. (2012). Occurrence of natural organic chlorine in soils for different land uses. *Biogeochemistry* (In press), doi : 10.1007/s10533-012-9771-7.

Santos, F., Lopez-Gutierrez, J., Garcia-Leon, M., Schnabel, C., Synal, H., and Suter, M. (2004). Analysis of  $^{36}\text{Cl}$  in atmospheric samples from Seville (Spain) by AMS. *Nuclear Instruments and Methods in Physics Research Section B : Beam Interactions with Materials and Atoms*, 223-224 :501–506.