Impact of vegetation and ecosystems on chlorine(-36) cycling and its modeling

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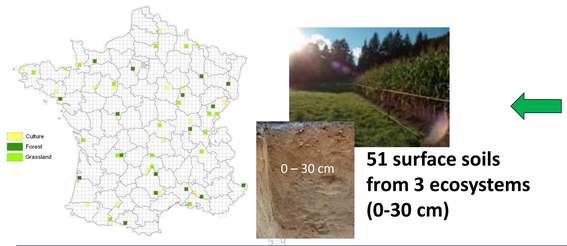
Problem statement:

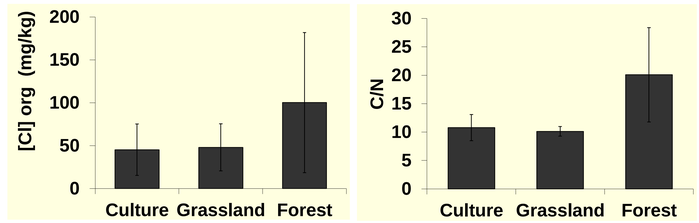
Because of its high mobility, chlorine is usually perceived as a conservative tracer in hydrological studies and by analogy as little reactive in biosphere. By assuming ^{36}Cl redistribution similar to that of stable Cl at steady-state, specific activity models are simplified interesting tools for regulatory purposes and long term environmental safety assessment.
Recent studies have strengthened the view that an organic cycle for chlorine(-36) should now be recognized, in addition to its inorganic cycle. New information and appropriate modeling tools are thus opportune for improving (radio-)ecological realism.

Recent accomplishments:

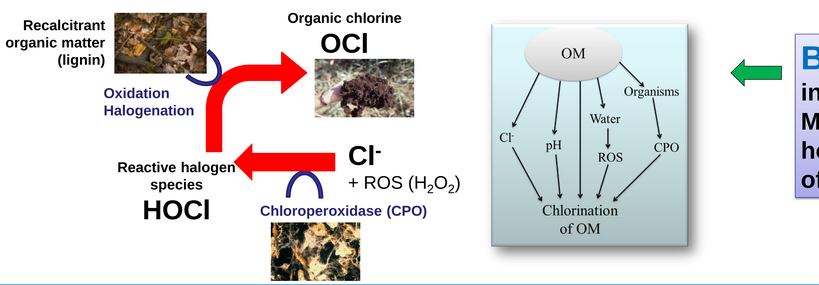


51 surface soils from 3 ecosystems (0-30 cm)

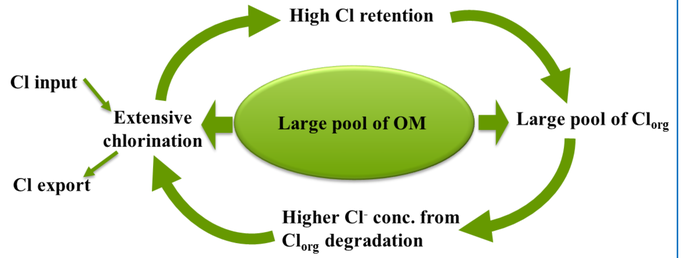
Average value	$[Cl]_{total}$ (ppm)	$[Cl]_{org}$ (ppm)	$\%Cl_{org}$
Culture	49.7	33.5	87
Grassland	54.0	49.6	83
Forest	89.8	68.1	89



A. Organochlorine (Cl_{org}) formation occurs in all type of soils and ecosystems (culture, grassland, forest), leading to an average fraction of the total Cl pool in soil of about 80 % (Redon *et al.*, 2012). The content of organic chlorine was related to the quantity and quality of organic matter (C/N), in addition to soil pH and Cl input.

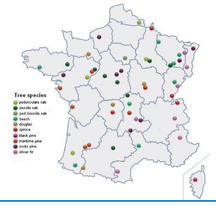


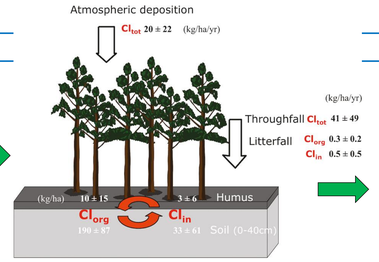
B. The multiple soil factors influencing chlorination explains the difficulty in identifying a simple regulation of natural formation of organic chlorine. Measured higher chlorination rate in more organic soils over time leads however to a larger Cl_{org} pool and in turn to a possible high internal supply of inorganic chlorine (Cl_{in}) upon dechlorination (Gustafsson *et al.*, 2012)



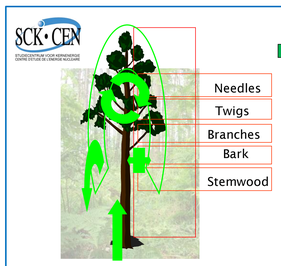
C. Average Cl residence time in forest soils calculated for Cl_{in} and Cl_{org} together was 5-fold higher than the residence time estimated for Cl_{in} alone (Redon *et al.*, 2011).

51 forest sites involving contrasted OM turnover (Cl in rain, throughfall, litterfall, humus and soil (0-30 cm))

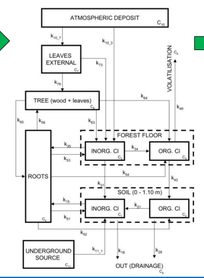




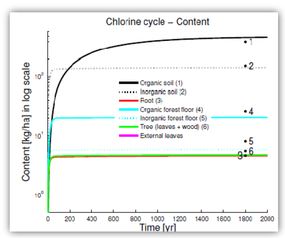
$$\text{Residence time in soil}: \frac{\text{Total Cl in humus} + \text{soil}}{\text{Annual atmospheric deposits}} = 3 - 67 \text{years}$$



Field study



Model calibration



Model calculation and sensitivity analysis

D. After calibration, a dynamic empirical model was shown to simulate realistic values for the chlorine content within the different forest compartments – A true equilibrium for organic Cl in soil was estimated to occur after 2000 years. Cl root uptake and transformation rates in soils are among the most influencing processes (Van den Hoof & Thiry, 2012)

Conclusions:

The influence of vegetation and the range over which the rate of Cl transformation in soil varies with ecosystem types are of high interest. Those processes are influenced by various environmental factors that are not clearly understood due to the lack of studies at the ecosystem scale. Our observations challenges hydrological or risk assessment models considering Cl^- as inert in biosphere.

Gustavsson M., Karlsson S., Öberg G., Sandé, P., Svensso, T., Valinia S., Thiry Y. and Bastviken D. (2012). Organic matter chlorination rates in different boreal soils: the role of soil organic matter content. *Environmental Science & Technology,* 46 (3): 1504-1510
Redon P-O., Abdelouas A., Bastviken D., Cecchini S., Nicolas M. and Thiry Y. (2011). Chloride and organic chlorine in forest soils: storage, residence times, and influence of ecological conditions. *Environmental Science & Technology,* 45: 7202-7208.
Redon P-O., Jolivet C., Saby N., 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.
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