Assessing the recycling of chlorine and its long-lived ^{36}Cl isotope in terrestrials ecosystems through dynamic modeling

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A need to improve our understanding of the biogeochemical cycle of chlorine and its long-lived isotope ^{36}Cl in terrestrial ecosystems has been recognized in different scientific fields. That encompass environmental radiation impact assessments assuming potential ^{36}Cl discharge from nuclear facilities, a better use of bomb-tests ^{36}Cl as a hydrologic tracer for groundwater dating as well as the influence of long-term road salt use on surface waters quality.

Recent studies have evidenced that an organic cycle for Cl (and by analogy ^{36}Cl) coexists with its inorganic cycle, involving simultaneous formation, degradation, percolation and volatilization of organic chlorine. Inputs of both chlorine and ^{36}Cl are allowed to well mix and persist in various terrestrial compartments, but little is known about their residence time in response to recycling and time-variable inputs. The reactions of Cl with vegetation and soil leading to transformation, possible retention and later release are numerous and difficult to integrate from field studies. Based on our numerical modeling approach and a further sensitivity analysis, an accurate representation of plant-soil interactions combining both the inorganic and organic Cl cycle that operate over different time scales was shown to be important for a comprehensive simulation of Cl dynamics. The different processes representation was mainly guided by the level of detail which can be supported by the availability of most recent litterature data; it is quite simple but was able to reproduce chlorine partitioning and its retention rather well for different observation datasets corresponding to scenarios: (i) of the global ^{36}Cl fallout including those of bomb tests and (ii) of the natural Cl atmospheric deposits. The timeframe required for the soil organochlorine pool to reach equilibrium in a steady-state system was found to be of several thousands of years although it may exceed the inorganic pool in at most decadal timescale. An extra finding concerned the divergence between rain and drainage water $^{36}Cl/Cl$ ratios after the bomb-tests fallout. A complete recovery of the natural rain fallout ratio will need a time close to the residence time of bomb-tests ^{36}Cl in soil i.e. 500 years.