A study of the mobility of uranium and thorium in soils after freezing

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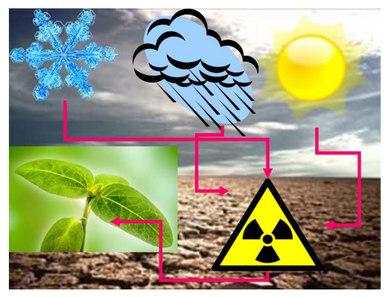
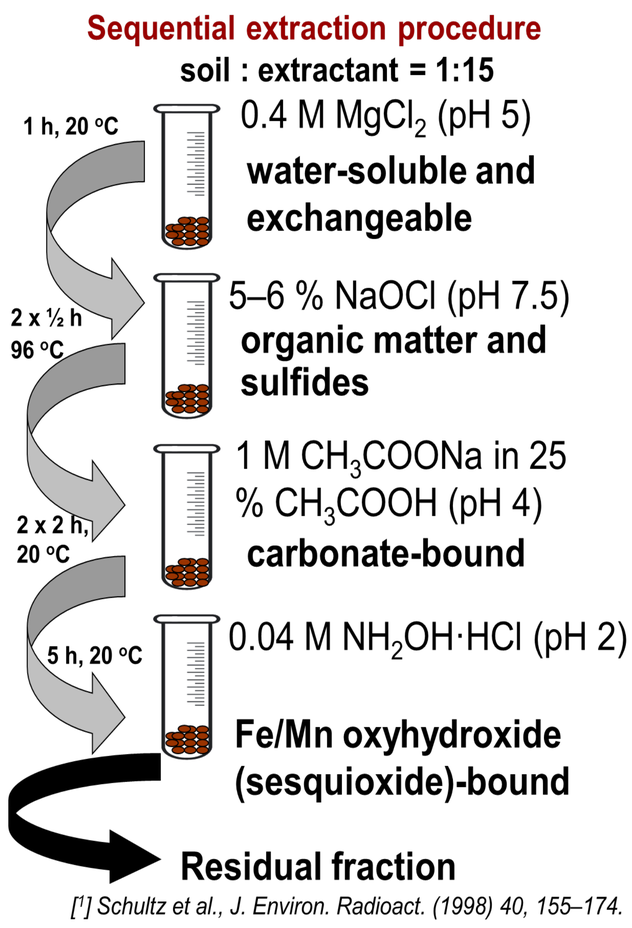


Summary

The mobility of uranium and thorium in soils and their transfer through food chain has been the subject of long-term studies aimed at assessing the dose load and the radiological risk to the population in case of contamination. Sufficient data are lacking, however, regarding the influence of abrupt changes in climatic parameters on the mobility and geochemical forms of natural radionuclides. The study of the sharp decrease in ambient temperature on the mobile fractions of uranium and thorium in different types of soil, especially in the first weeks after contamination, would contribute to a more adequate modeling of the geochemical fate of these radionuclides and a risk assessment of radiation exposure in case of an accident. The present work is an investigation of the effect of soil freezing for a period of 3 weeks, shortly after contamination, on the water-soluble and exchangeable forms and the carbonate-bound forms of uranium and thorium.

Materials and Methods

A model experiment was conducted with 6 soil types: Haplic chernozem, Chromic cambisol, Haplic luvisol, Calcaric chernozem, Gleyic fluvisol, Vertisol. The soils were characterized in terms of pH, CEC, humus content, morphological and mineralogical composition, and contaminated with a solution containing ^{238}U, ^{235}U and ^{234}Th. The contaminated soils were stored at 18°C for one week. Each of the soil samples was then divided into 2 aliquots, which were stored at 18 °C and -18 °C for a period of 3 weeks. The geochemical binding forms of uranium and thorium were investigated using a sequential extraction procedure. Measurements of the radionuclides extracted in each fraction were carried out using gamma-spectrometer with HPGe detector, using the gamma lines of ^{234}Th at 63.29 keV and ^{235}U at 185.72 keV.



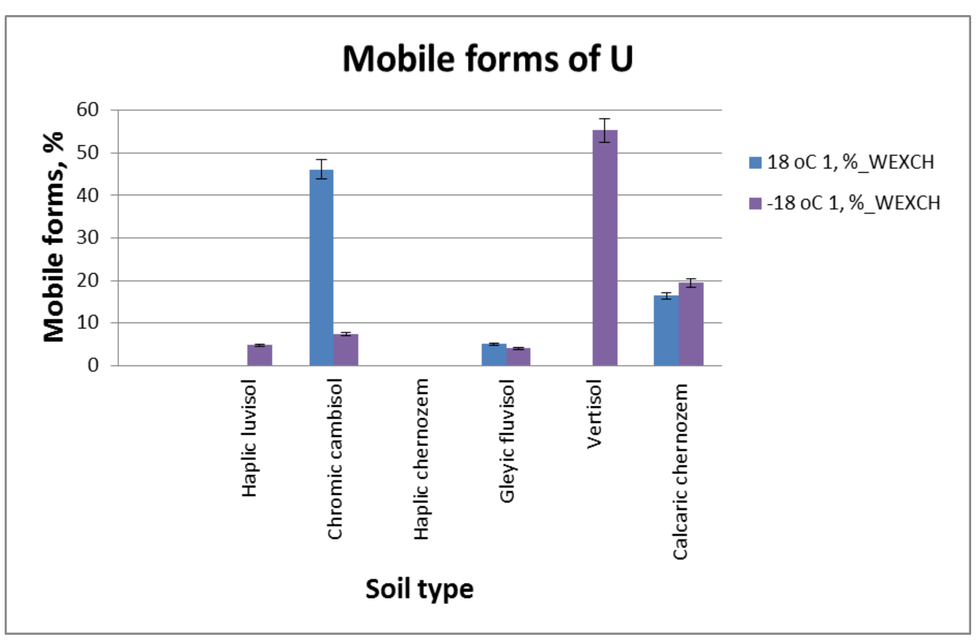
[1] Schultz et al., J. Environ. Radioact. (1998) 40, 155–174.

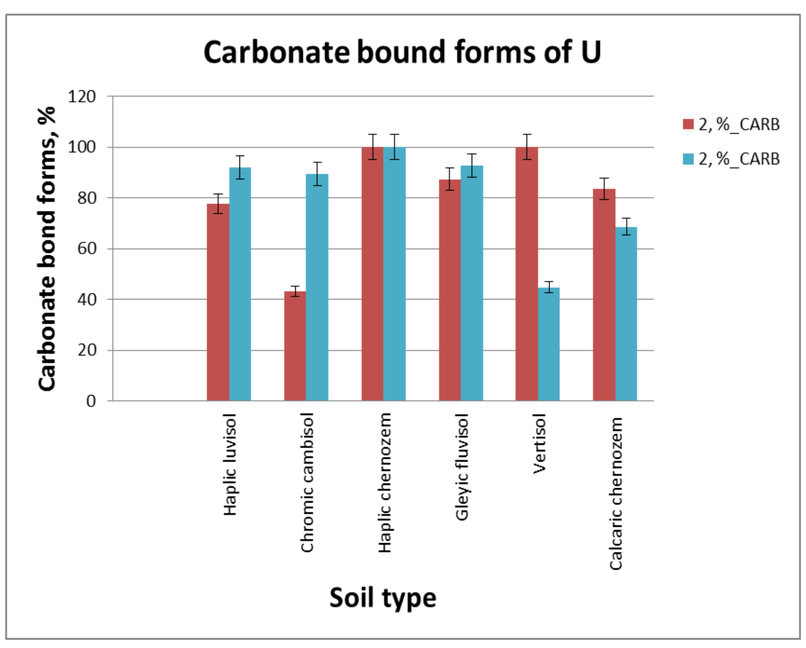
Results and discussion

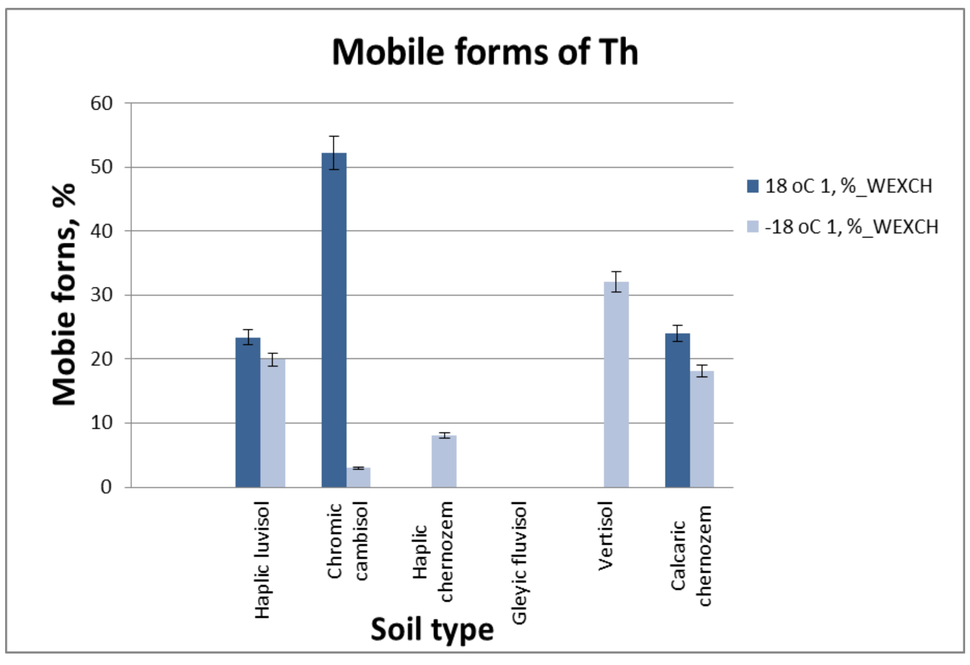
Characteristics of the investigated soils

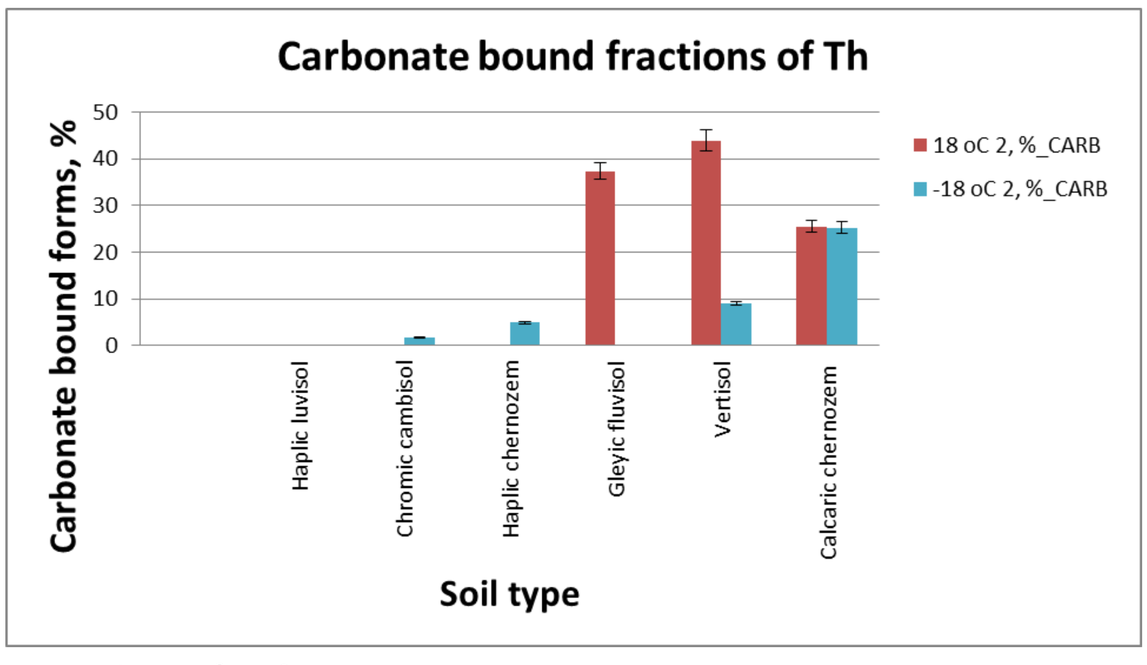
№	Soil type/Texture class	Soil pH		CEC*	% Sand	% Silt	% Clay	% Humus
		H_2O	KCl	(cmol+/kg)				
1	Calcaric chernozem/Silt loam	7.8	7.4	13.2	24.71	70.18	5.11	3.18
2	Vertisol/Sandy loam	7.3	7	12.8	64.95	31.21	3.84	4.95
3	Gleyic fluvisol/Loamy sand	7.9	7.7	9.8	77.73	19.13	3.14	3.09
4	Haplic chernozem/Clay loam	7.5	6.8	30.3	32.1	38.2	29.7	3.06
5	Haplic luvisol/Loam	7	6.4	23.2	35.6	43.9	20.5	4.16
6	Chromic cambisol/Loam	6.6	6.3	32	43	31.7	25.3	2.35

**CEC- cation exchange capacity*









Conclusions

The obtained results showed that the effect of freezing affects the mobile forms of radionuclides in a different way and depends on the acidity of the soils, the clay content and the cation-exchange capacity. Radionuclides from soil characterized by neutral pH, very low CEC and low clay content increase their mobility the most after freezing. At the same time, in soil with alkaline pH, very low CEC and low clay content, uranium and thorium do not change their mobility after freezing. The sharp decrease in temperature led to a decrease in the mobility of radonuclide in the soil, which is characterized by high CEC, high clay content and slightly acidic pH.