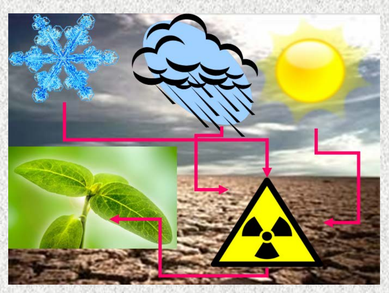
Impact of rapid warming on the mobile forms of uranium and thorium in soils - a model experiment



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Summary

The study of the mobile forms of natural radionuclides in the soil has been an object of interest for a long time, due to the danger of their distribution through food chains and their entry into the human body. The contribution of natural radionuclides, such as uranium and thorium, to the dose burden of the population is determined both by their radioactivity and the radioactivity of their daughter products, and by their fixation in the surface soil layer, which largely depends on their mobility and geochemical forms. The chemical forms of binding of radionuclides in the soil depend to a significant extent on its characteristics, such as pH, cation exchange capacity (CEC), morphological and mineralogical composition, humus content, etc. At the same time, sudden changes in ambient temperature, soon after pollution, can have an impact on the mobility of pollutants in the soil, due to a change in the adsorption-desorption processes, complexation reactions, pH of the soil solution, etc.This work presents the results of a model experiment conducted with soils taken from the surface 0 – 10 cm soil layer from 9 different regions in Bulgaria.

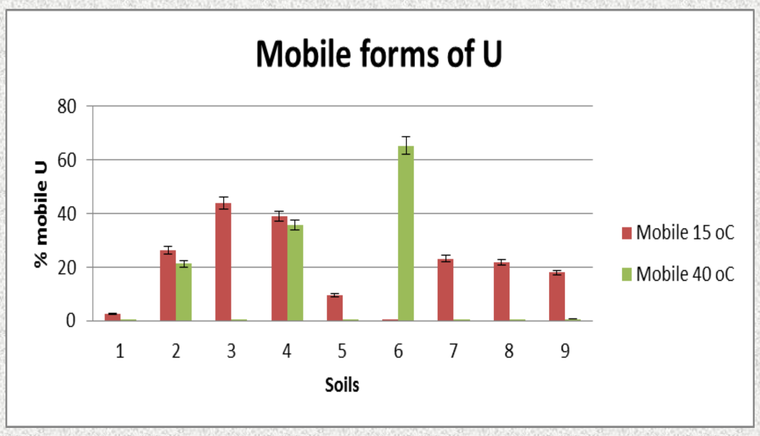
Materials and Methods

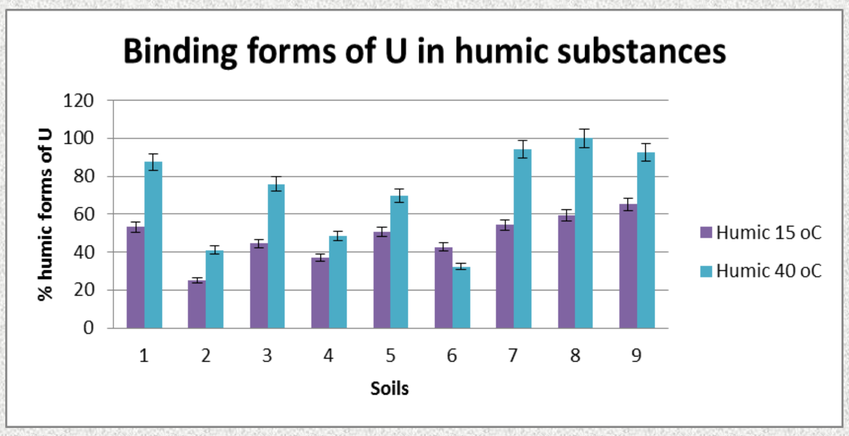
The soils were characterized in terms of pH, CEC, humus content, morphological and mineralogical composition. Aliquots of each soil were contaminated in the laboratory with an aqueous solution of $UO_2(NO_3)_2$ containing ^{238}U, ^{235}U and ^{234}Th and conditioned for a period of 1 to 4 weeks at two temperature regimes: 15 ^oC and 40 ^oC. Afterwards, a sequential extraction procedure was used and the following geochemical forms of uranium and thorium were determined: (1) water-soluble and exchangeable (mobile fraction); (2) bound to humic and fulvic acids and (3) carbonate-bound forms. 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. The % fractions of the extracted mobile forms of the radionuclides stored at the two temperature regimes were compared, taking into account soil characteristics and chemical properties of uranium and thorium.

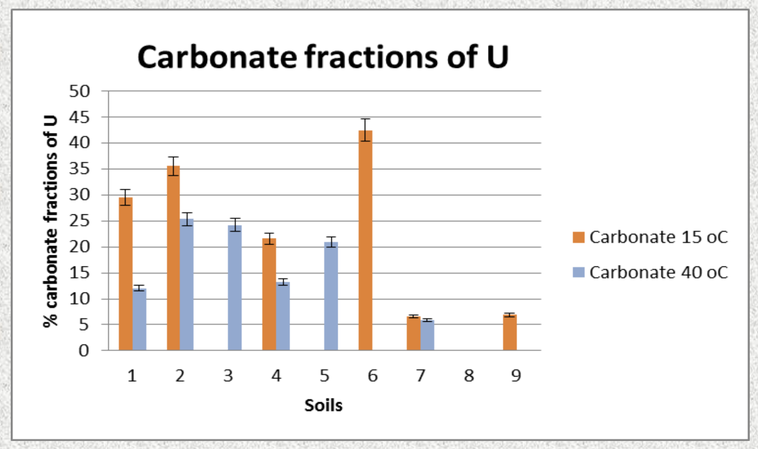
Results and discussion

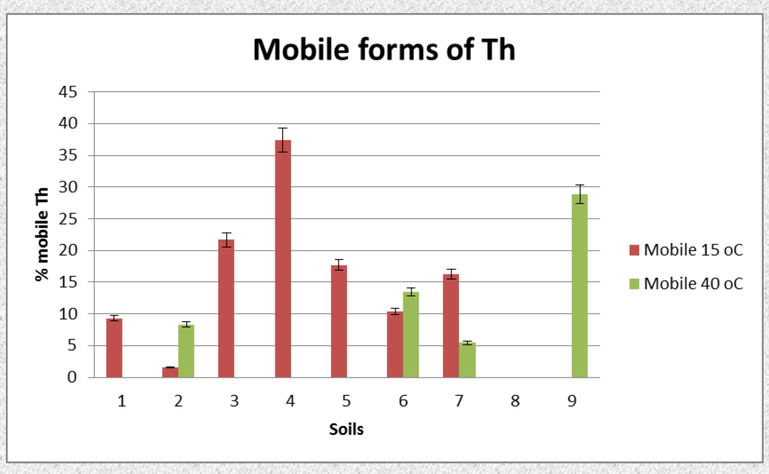
General characteristics of the investigated soils

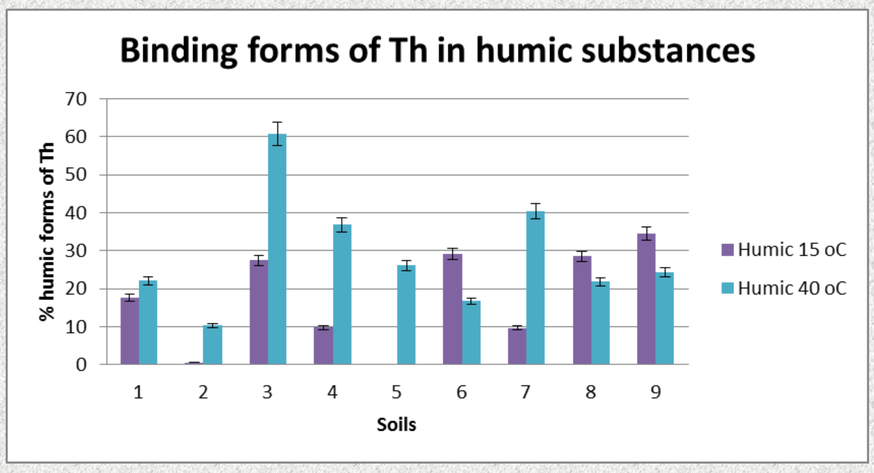
Soil №	Soil pH		CEC	% Sand	% Silt	% Clay	% Humus
	H2O	KCl	(cmol+/kg)				
1	7.8	7.4	13	24.71	70.18	5.11	3.18
2	7.3	7	13	64.95	31.21	3.84	4.95
3	7.9	7.7	9.8	77.73	19.13	3.14	3.09
4	7.6	7.4	31	61.6	33.2	5.2	2.03
5	7.5	6.8	30	32.1	38.2	29.7	3.06
6	7	6.4	23	35.6	43.9	20.5	4.16
7	6.6	6.3	32	43	31.7	25.3	2.35
8	7.8	7.1	38	32.9	36.8	30.3	2.59
9	7.7	7.2	33	74.3	21.5	4.2	4.5

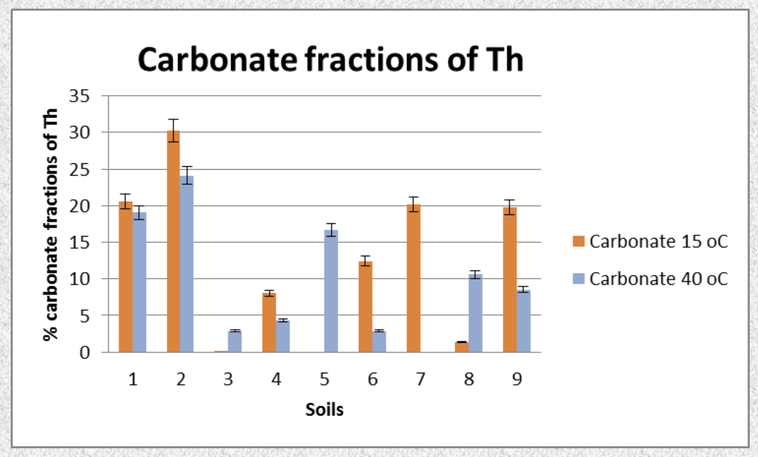












Conclusions

The results showed that a sudden increase in ambient temperature from 15 ^oC to 40 ^oC over a period of 2 weeks, soon after contamination of the soil with uranium and thorium, caused a decrease of the water-soluble and exchangeable fraction and of the carbonate-bound forms of the radionuclides and an increase in the fraction of nuclides associated with humic and fulvic acids in most of the studied soils.