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Concentrations and migration forms of strontium in groundwater used for drinking within the Moscow artesian basin (Russia, Bryansk region)

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Introduction and area of research

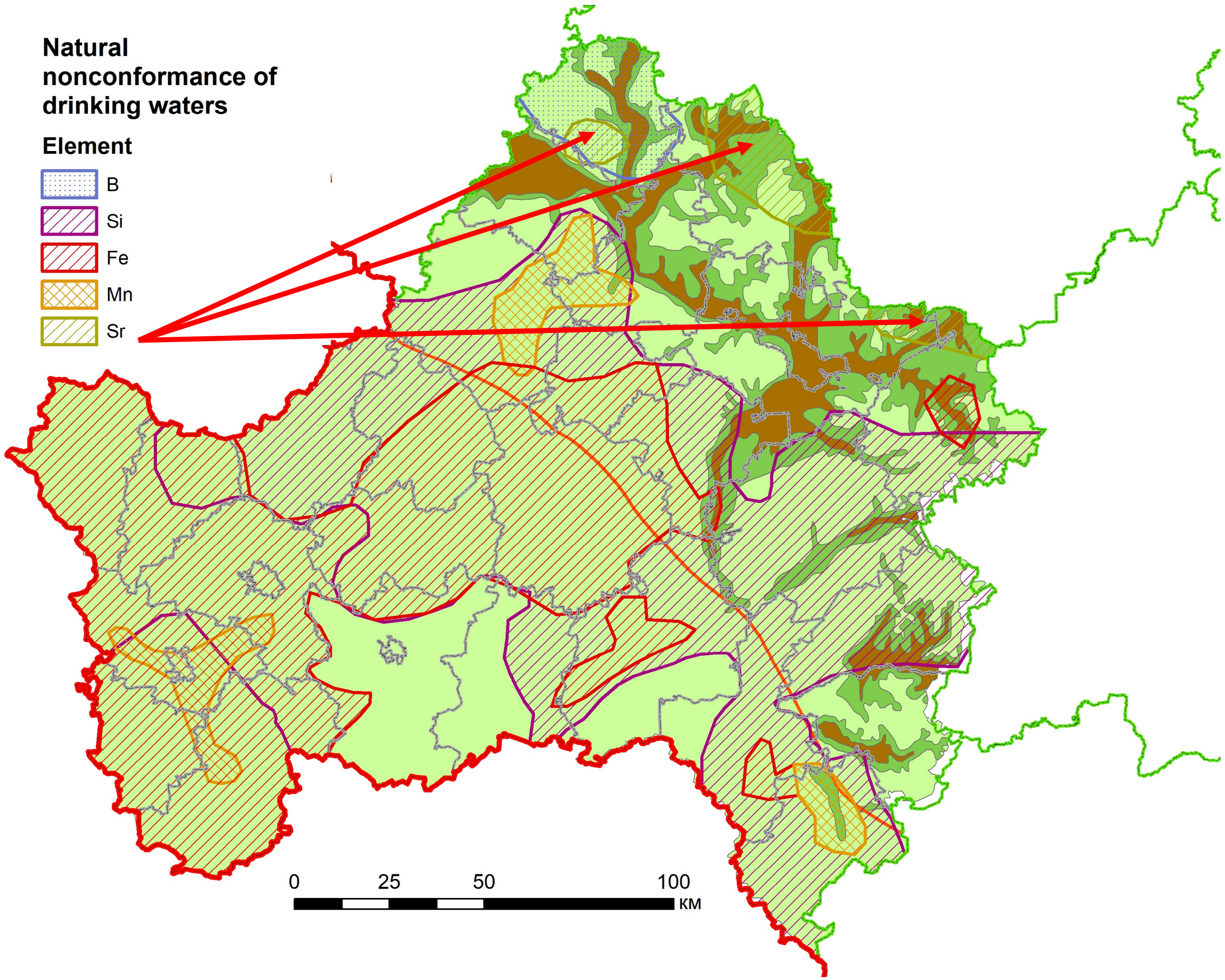

Fig. 1 Distribution of groundwater with a natural inconsistency in the content of some elements

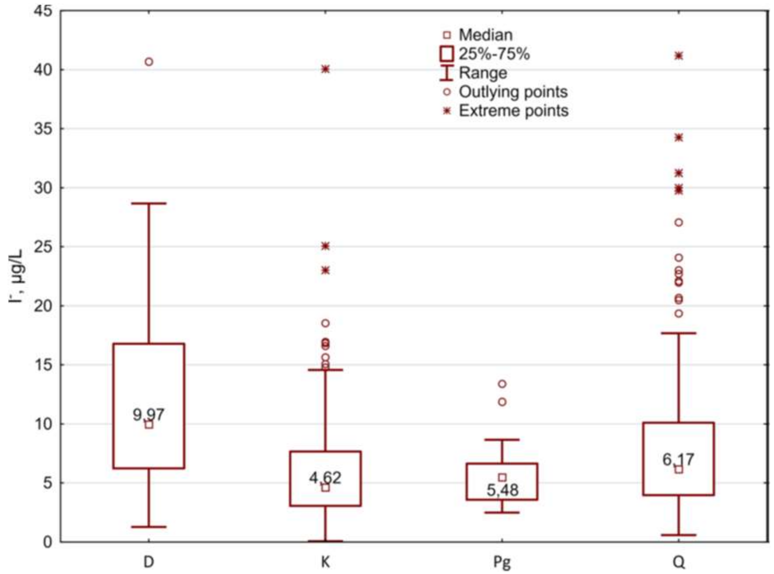

Fig. 2 Descriptive statistics of iodine in drinking water from areas of different hydrogeological complexes (D-Upper Devonian complex, K-Upper Cretaceous complex, Pg-Paleogene complex, Q-Quaternary complex)

The purpose of this research was to consider geochemical features of stable strontium distribution in groundwater of the Upper Devonian hydrogeological complex within the southwestern flank of the Moscow artesian basin used for centralized drinking water supply in the northeastern part of the Bryansk region in order to detail the potential influence of additional geochemical factors on the manifestation of endemic diseases caused by natural iodine deficiency.

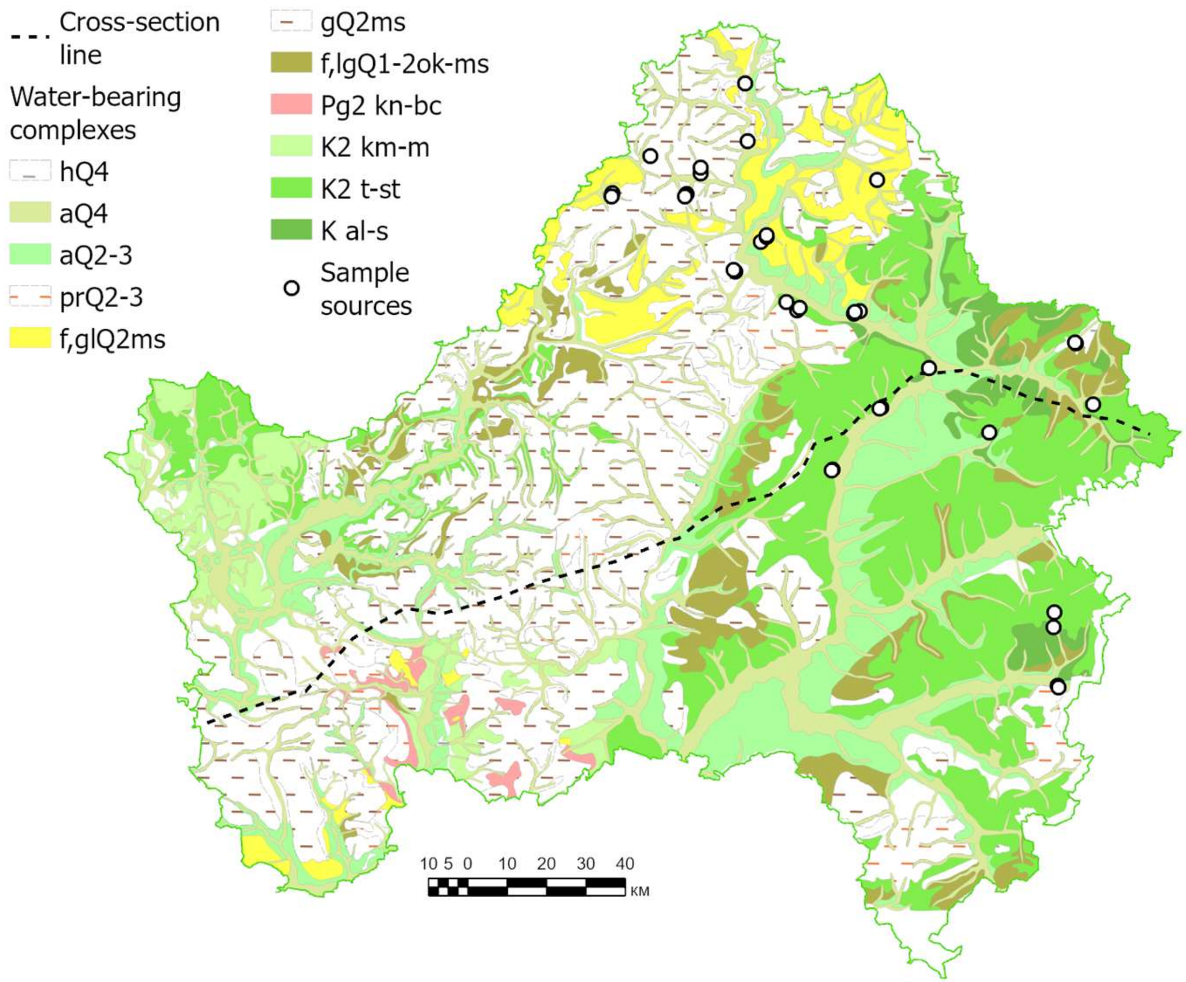

Fig. 3 Spatial distribution of groundwater sampling within the area of distribution of Upper Devonian sediments (against a schematic hydrogeological map (Geocenter-Bryansk, 2011) and administrative borders (OpenStreetMap contributors, 2020)

General characteristics of waters

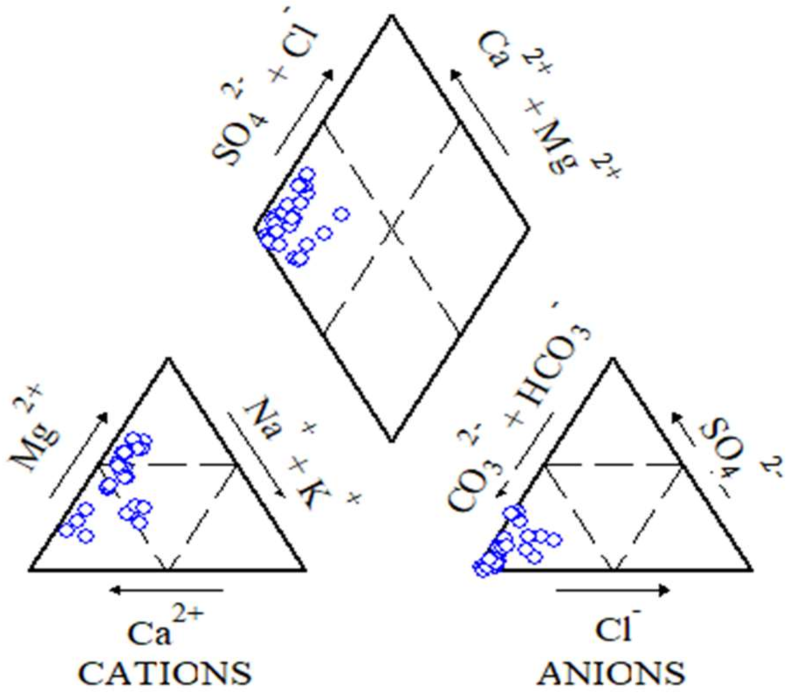

Fig.4 Piper diagram of artesian groundwater samples

Tab. 1 Some elements and ions in selected groundwater (mg/l)

index	median	interquartile range
Ca	47.5	39.4-59.4
Sr	1.03	0.45-3
Mg	31.4	19.2-37.8
Mn	0.05	0.01-0.05
Fe	0.22	0.05-0.5
HCO3-	305	231-357
NO3-	5.6	4.2-8.15
Cl-	7.46	6.38-11.9

Geochemical features of strontium distribution in groundwater. Water quality assessment

Strontium concentration in water samples varied from 0.21 to 28.8 mg/L (median (Me) = 1.03 mg/L, n=34). The analysis of strontium distribution with considering the genetic features of water-bearing rocks showed no significant differences in the content of this element in the waters of depositions of the Frasnian (Me=0.86 mg/L, n=25) and Famennian stages (Me=1.09 mg/L, n=9) (p<0.01).

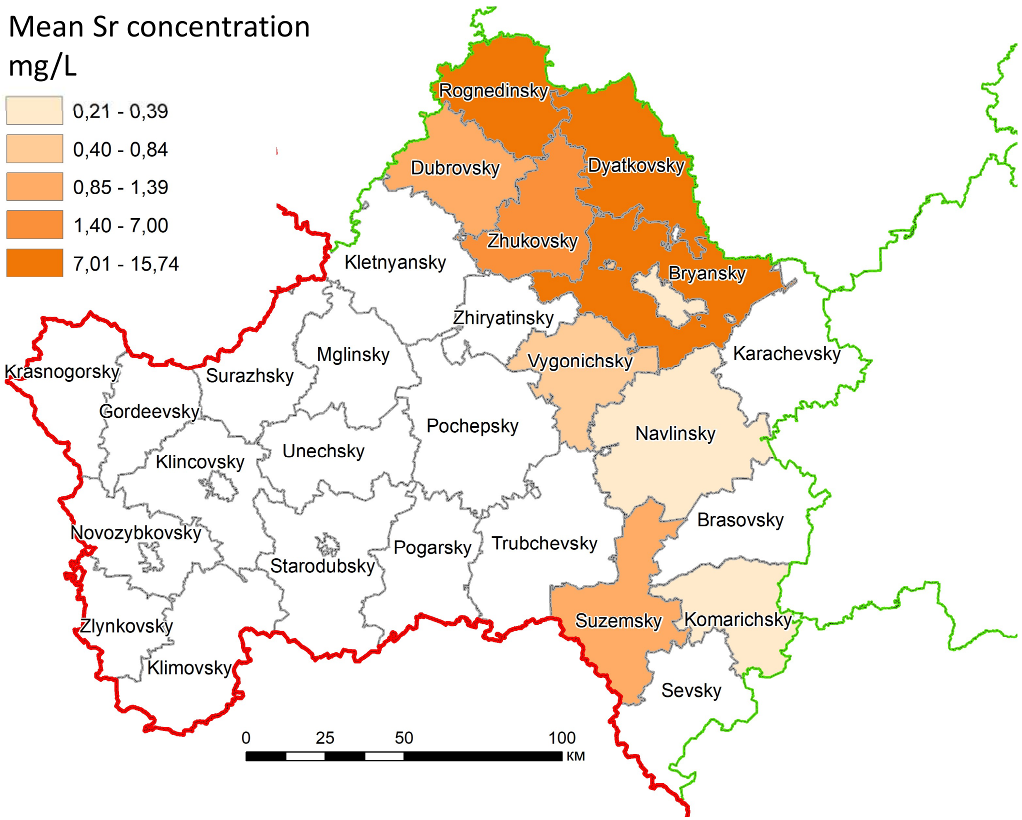

Fig. 5 Strontium concentration in groundwater used for drinking within individual districts

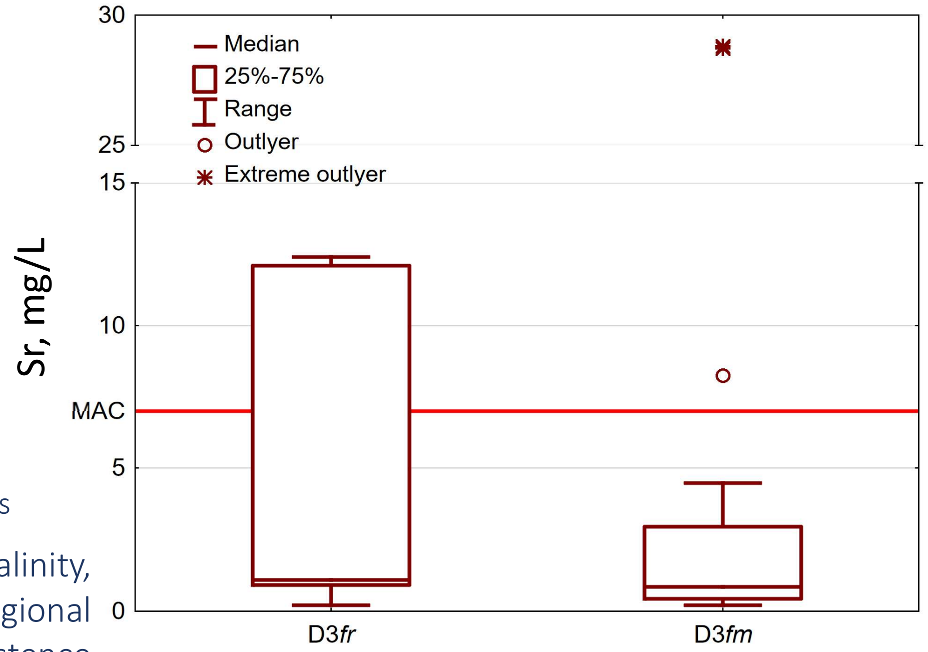

Fig. 6 Strontium levels in groundwater of the Frasnian (D3fr) and Famennian (D3fm) stages

Given the lack of significant correlation between strontium content and water salinity, which is usually observed for strontium-enriched artesian waters of regional hydrogeochemical provinces (Kraynov et al., 2012) it can be explained by the existence of natural local strontium anomaly in this area (Ca/Sr <7).

Experimental and theoretical assessment of strontium migration forms. Membrane filtration and equilibrium modelling

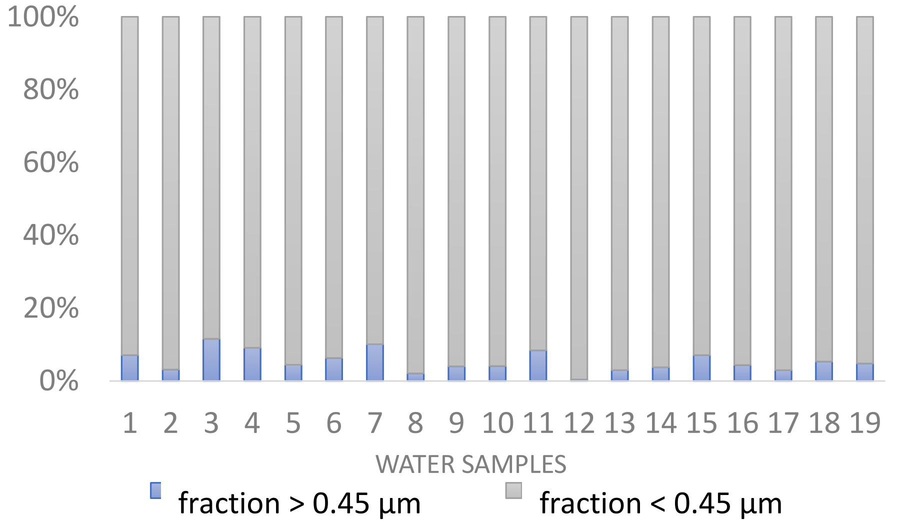

Fig. 7 Strontium in suspended and dissolved groundwater fractions

- Software package HCh (Shvarov, 2008),
- Unitherm thermodynamic database,
- The simulated system O-H-C-N-Ca-Sr-Mg-K-Na-Zn-Fe-Fe-Cl-S-P-S-Al-Mn was open for oxygen and carbon dioxide,
- In 2021 organic complexes of elements with humic (Hu) and fulvic (Fu) acids were included in the model.

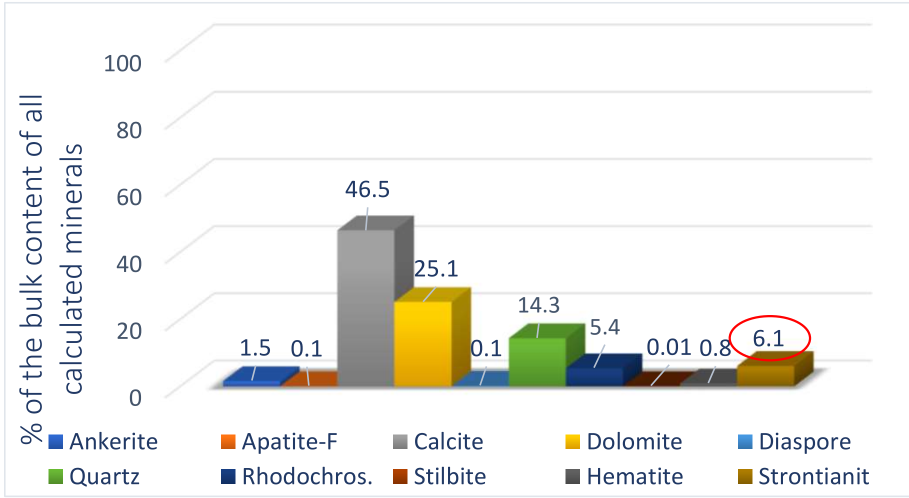

Fig. 8 Calculated composition of equilibrium association of solid phases (%)

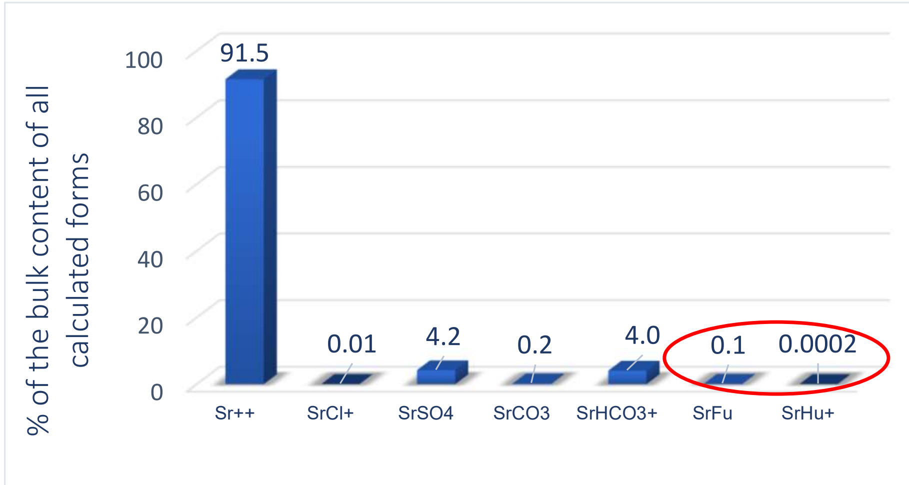

Fig. 9 Calculated forms of strontium (%)

Conclusions

The method of equilibrium modeling showed that the introduction of organic ligands into the modeled system does not change the image of strontium distribution of the forms of location.

The presence of a local anomaly of strontium-containing waters within the Moscow artesian basin, which impair the quality of drinking water in this area, can be a factor of potential risk to the health of the local population living under conditions of iodine deficiency.