The spatial distribution of radionuclides in the soils of the Urals contaminated from different sources

Ludmila N. Mikhailovskaya, Vera N. Pozolotina

Institute of Plant and Animal Ecology, Ural Branch, RAS
Ekaterinburg, Russia

Research purpose

The purpose of the research is comparative study of the spatial distribution of ^{90}Sr and ^{137}Cs in the soils of the Ural region contaminated from different sources.

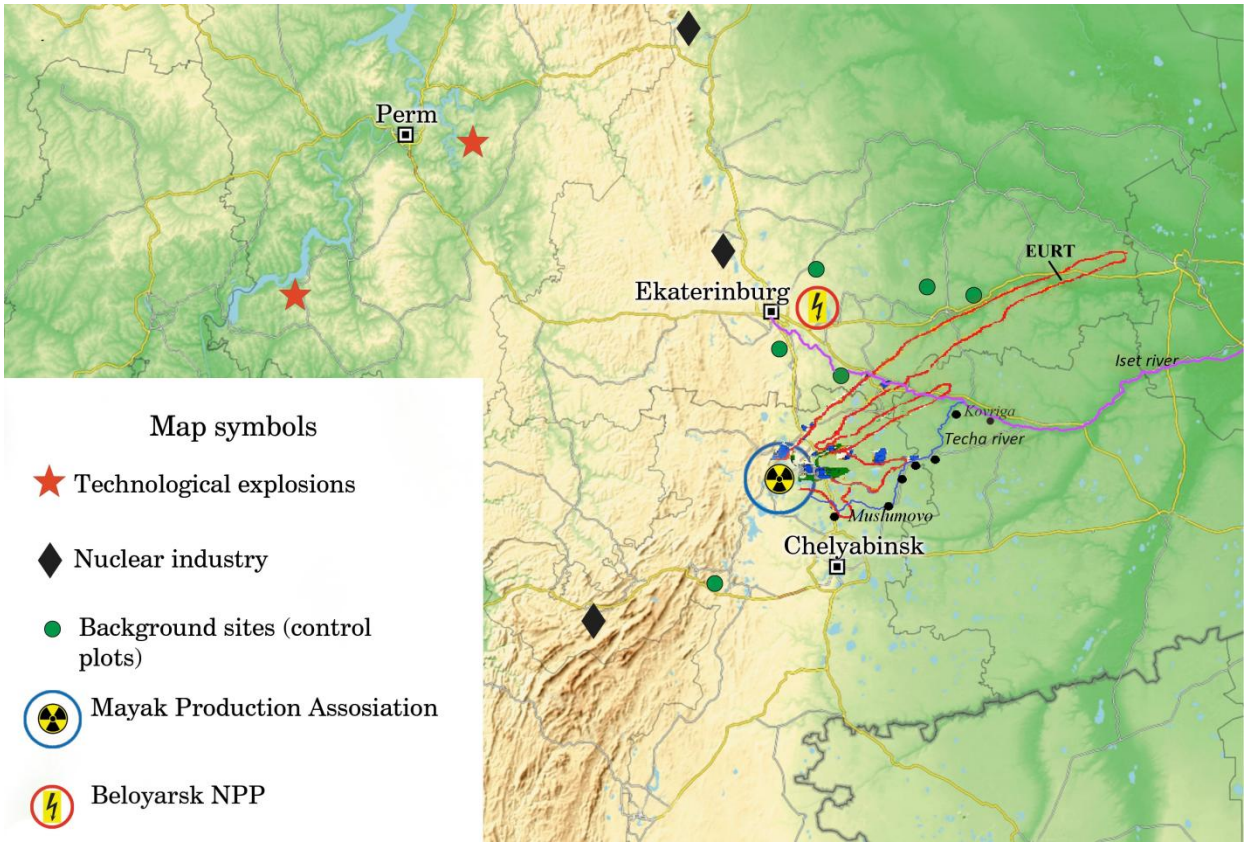
Material and methods

We studied geochemical conjugations in the coastal zones of the Ural lakes and rivers, which included plakors (watershed territories), slopes and foots of slopes. Three soil sections were laid within each site of 100 m^2 at the corners of the triangle with a side of 10 m. Samples of the soil were collected by layers with a thickness of 5-10 cm to a depth of 50 cm, taking into account the sample areas.

^{90}Sr from the soil samples were isolated by radiochemical method. Measurement of β-activity of the preparations was carried out by the radiometer "UMF-2000" (Russia) with a lower detection limit of 0.2 Bq. The ^{137}Cs content was determined by means gamma spectrometer Ortec (USA), with a detection limit of 0.1 Bq. All data were calculated for air-dry weight.

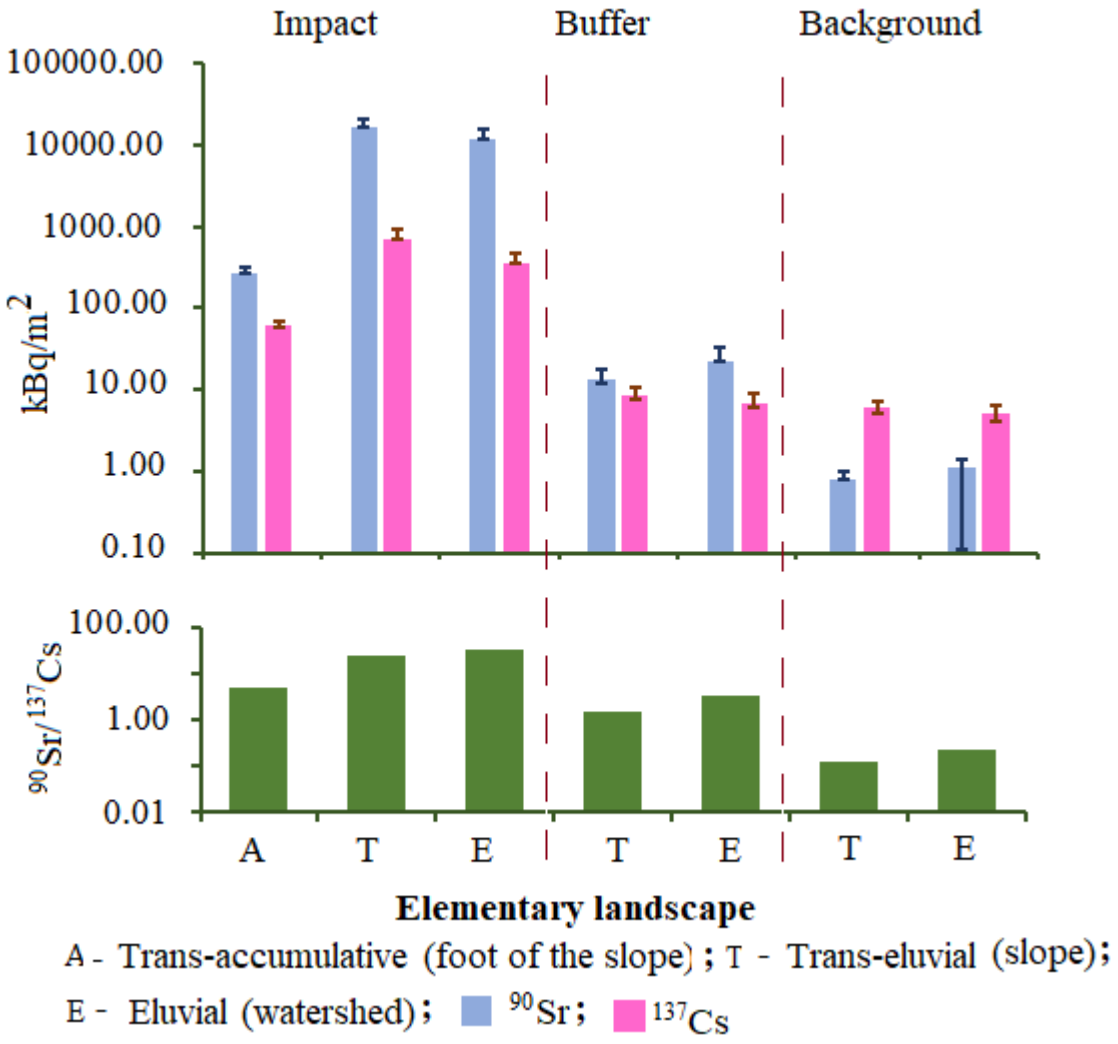
The study area

The research was conducted in 2003-2017 in the Middle and Southern Urals (Sverdlovsk and Chelyabinsk regions).
The studies were carried out in zones of influence of the largest nuclear enterprises: PA "Mayak" (including the East-Ural Radioactive Trace – EURT, the Techa river floodplain) and Beloyarsk NPP (BNPP), as well in background areas (Fig. 1).



It was shown that regional (Urals) background levels of radioactive contamination (^{90}Sr 1.6-3.0 kBq·m^{-2}, ^{137}Cs 4.6-6.8 kBq·m^{-2}) exceed the global background (^{90}Sr - 1.3 kBq·m^{-2}, ^{137}Cs - 2.2 kBq·m^{-2}) which is characteristic for the middle latitudes of the Northern Hemisphere. Density of soil contamination in local sites of the EURT (result of the Kyshtym accident, 1957) and the Techa river floodplain (liquid waste of "Mayak") reach up to n × 10^{4} kBq·m^{-2} (^{90}Sr) and n × 10^{3} kBq·m^{-2} (^{137}Cs).

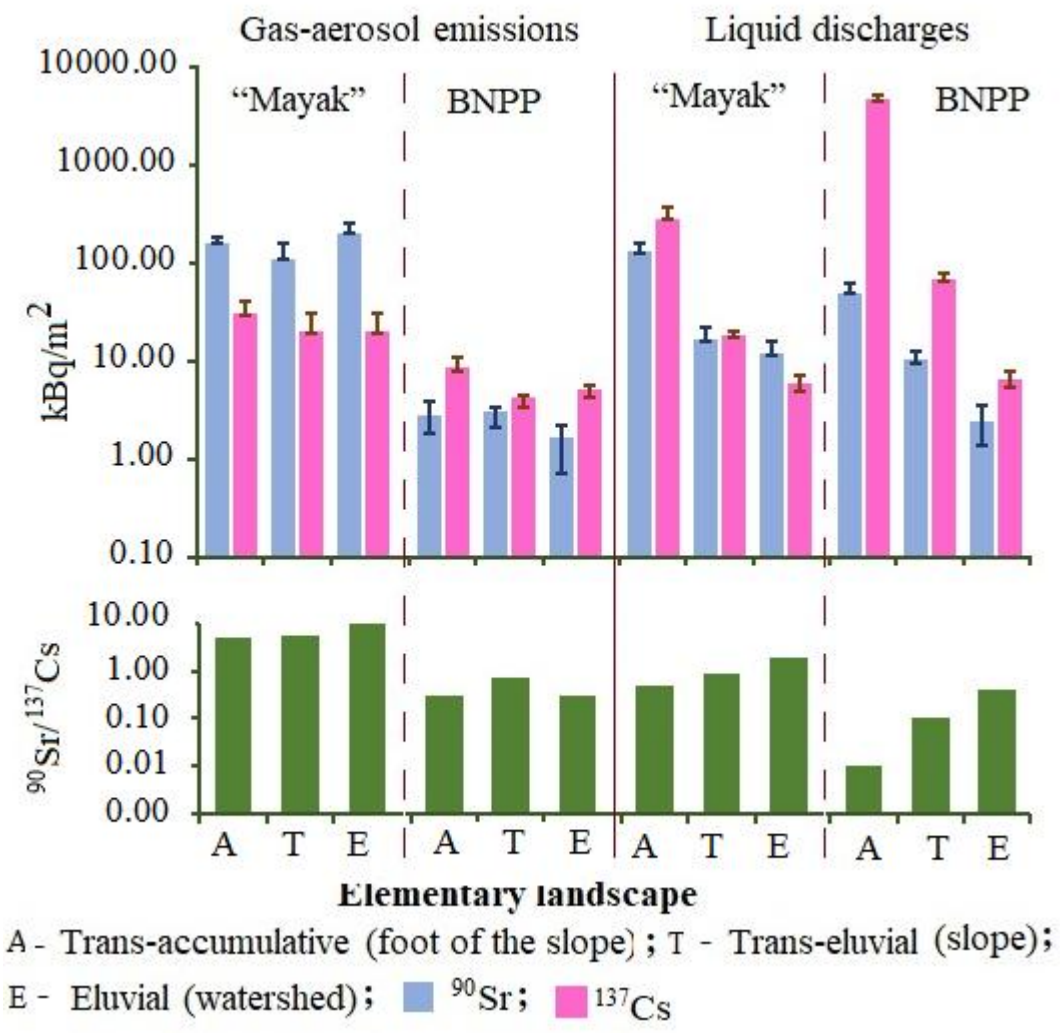
^{90}Sr and ^{137}Cs inventories in the soils of geochemical conjugations (coastal zone of the EURT lakes)



In geochemical conjugations of coastal zones of the EURT lakes, the contamination density of ^{90}Sr and ^{137}Cs decreases in the trans-accumulative landscapes. The ratio of $^{90}Sr/^{137}Cs$ decreases by the vector of the runoff (from the watershed to the foot of the slope).

This can be explained by the self-cleaning processes of the submerged soils of the coastal zone, which are appeared for ^{90}Sr and ^{137}Cs in varying degrees.

The ^{90}Sr and ^{137}Cs inventories in floodplains of river contaminated from different sources, kBk/m^2



In the case of gas-aerosol pollution, migration processes are weak. There is only a tendency to an increase in the content of radionuclides in the trans-accumulative elements of the landscapes

In cases of liquid discharges of radioactive waste, a high content of radionuclides in floodplain soils is formed during the floods. The ^{90}Sr inventory in floodplain soils are an order of magnitude and ^{137} Cs is 2–3 orders of magnitude higher than at the watershed and coastal slopes. The $^{90}Sr/^{137}Cs$ ratios decrease in the direction of the runoff vector.

Table. The ^{90}Sr and ^{137}Cs inventory in 0-20 cm layer of automorphic and hydromorphic soils, % of the total content in the soil profile

Site	Source of pollution	Density of contamination, %			
		Automorphic soil		Hydromorphic soil	
		^{90}Sr	^{137}Cs	^{90}Sr	^{137}Cs
Gas-aerosol emissions	PA "Mayak"	86±2	96±1	80±7	98±1
	BNPP	94±6	98±1	41±14	94±2
Liquid discharges	PA "Mayak"	90±2	96±1	42±4	58±1
	BNPP	94±6	97±1	44±5	46±9
Background	-	99±1	95±5	70±6	88±8

The content of ^{90}Sr and ^{137}Cs in the upper 0-20 cm layer of automorphic soils, as a rule, is higher than in hydromorphic soils. At the same time, the differences between the distribution of these isotopes are small.

The content of radionuclides in the upper layer of hydromorphic soils is reduced due to intensive water migration. This process is revealed particularly strong in areas contaminated by liquid radioactive waste.

Conclusion

1. The spatial distribution of radionuclides (^{90}Sr and ^{137}Cs) in the soils of Ural region is determined by the landscape-geochemical features of the territory and depends on the type of industrial discharges (gas-aerosol emissions or liquid waste).

2. After prolonged contamination (Kyshtym accident, 1957 and regular operation of BNPP from 1964) 86-99% of ^{90}Sr, 95-98% of ^{137}Cs are located in the upper layer (0-20 cm) of automorphic soils. Along with that 41-80% of ^{90}Sr, 46-98% of ^{137}Cs are located in the upper layer of hydromorphic soils. The vertical distribution of ^{90}Sr and ^{137}Cs in the soil profile have a similar character and are largely determined by the moistening regime of soils.

Thank you for your attention

Ludmila N. Mikhailovskaya

Vera N. Pozolotina