Radioecological Characteristics of the Techa-Iset-Tobol Rivers; Including Floodplain Ecosystems (The Urals)

A. Trapeznikov, A. Aarkrog, I. Molchanova, S. P. Nielsen, V. Pozolotina, V. Trapeznikova, P. Yushkov, M. Chebotina, E. Karavaeva,
Ekaterinburg, Roskilde

In the 1950's the Techa river was contaminated with radioactive waste from MAYAK production Association, the first enterprise in the Soviet Union established for production of nuclear weapons material. The total discharge of radionuclides into the river is estimated as 100 PBq, among which ^{90}Sr and ^{137}Cs amounted to 11.6 and 12.2% rrespectively. As a result thebottom sediments, water, biota and also riverside exosystems of the Techa river were significantly contaminated. Some of the discharged radionuclides, especially ^{90}Sr were carried by water from Techa via the Iset-Tobol-Irtysh-Ob river system into the Arctic seas.

Between 1951 and 1964 a system of dambs and artificial reservoirs along the upper part of Techa was constructed in order to eliminate the discharge. Presently this system contains 7.1 PBq ^{90}Sr and ^{137}Cs [1].

Our investigation was conducted in 1990-1995. Sediment, water and water plants samples (duplicate) were collected from the Techa, Iset and Tobol rivers (Fig. 1). The flood plain soil was collected at distance of 3-4 m from the canal of the Techa and Iset rivers down to a 30 cm depth. Some soil sections were made in the central flood plain of the Techa within 30-40 m from the canal. The aliquots of samples were analysed at the Institute of Plant and Animal Ecology Russia, (for ^{90}Sr and ^{137}Cs) and at the Riso National Laboratory, Denmark (for ^{137}Cs, $^{239,240}Pu$ and ^{241}Am).

Techa river

Our study has shown, that sediments of the Techa river are enriched to a greater degree with ^{137}Cs than with other radionuclides. Compared with the global fallout levels in sediments, the Techa samples showed ^{90}Sr and ^{137}Cs concentrations one to four orders of magnitude higher. The power function was best suited to describe the behaviour of radionuclides in sediments of river system [3]. The study of the distribution of radionuclides in the sediment profile in the Techa upper stream has shown, that the maximum ^{90}Sr concentration occurred in the 18-20 cm layer, the maximum ^{137}Cs and $^{239,240}Pu$ took place at the depth of about 15 cm [4].

Concentrations of ^{90}Sr, ^{137}Cs and $^{239,240}Pu$ in the Techa river water decrease with distance from point of discharge according to the exponential model [3]. It is clear from this equation, that the ^{90}Sr carried by the water more than 2000 km downstream from the Techa. Comparison with the concentrations of radionuclides in rivers of northern moderate latitudes shows that the contents of ^{90}Sr and ^{137}Cs in the water of the Techa river is two or three orders of magnitude higher.

A considerable part of the radionuclides is contained within the Techa flood plain. At the same time, flood plain landscapes are one of the main secondary sources of contamination of the river system [2]. The distribution of radionuclides in the soil profiles vary. At some locations ^{90}Sr and ^{137}Cs are distributed evenly. In other places, a

maximum may be displaced towards the deeper layers, and in others, the most of the radionuclides may be absorbed on the upper layers of the soil.

The contamination of the central flood plain of the Techa river depends from the type of landscape. If the landscape is hilly there is a geochemical barrier to the migration of the radionuclides. In this case the total deposition in central flood plain is higher than the deposition near the Techa river (Table).

According to calculation, the total amount of ^{90}Sr and ^{137}Cs discharged into the open river ecosystem is presently estimated as 8.9 PBq, taking into account radioactive decay. The total amount of radionuclides in the water, sediments and floodplain soils of the Techa river is about 0.3 PBq for ^{137}Cs and 0.2 PBq for ^{90}Sr. Consequently, about 1 PBq radioactive discharges has migrated beyond the Techa river [3].

Iset river

Radioecological investigation showed that the Techa river had influence on the level of contamination of the Iset river. It is possible to illustrate by data of the ^{137}Cs concentrations in the silt sediments from the Techa and Iset rivers (Fig. 2). These results may be compared with the concentrations of this radionuclides in the water plants, for example in Cladophora. The concentration of ^{137}Cs in Cladophora from V. Jarh (Iset river upper Techa outlet, see Fig. 1) was 1.6±1.0 Bq/kg, from Krasnoisetskoe (Iset after confluence with Techa) 91.0±7.0 Bq/kg.

The samples collected at the place of confluence the Iset river with Tobol showed that the Tobol sediments have higher levels of radioactivity after the confluence with Iset river than before, because Iset river is more contaminated than the Tobol (Fig. 2).

Conclusion

Radioecological investigation of the Techa-Iset-Tobol river system polluted with radioactive waste from MAYAK Production Association around 1955 has shown, that presently the level of long-lived radionuclides (^{90}Sr, ^{137}Cs, $^{239,240}Pu$, ^{241}Am) in the principal components of the Techa river is several orders of magnitude higher than that expected from global fallout.

The Techa flood plain contains a considerable part of the radionuclides and is one of the main secondary sources of contamination of the river system.

The contamination of the Techa river influences the radionuclides concentrations of sediments and water plant in the Iset and Tobol rivers.

About 5-10% of the total discharge of radionuclides contains in the water, sediments and flood plain of the Techa river. The most part (80%) ^{90}Sr and ^{137}Cs discharged from MAYAK are found in the cascade of reservoirs in the upper reaches of the Techa, within the territory of Majak. Over 1 PBq radionuclides have to be found outside the Techa, probably in the Ob river system and in the Arctic Ocean. This estimation needs further verification.

References

1 Genesis and conception of the national programme of the Russia on the radiation reabilitation of the Urals. Ekaterinburg, 1993, 66.

2 Molchanova I.V., Karavaeva E.N., Pozolotina V.N., Yushkov P.I., Mikhailovskaya L.N. Behaviour patterns of radionuclides in floodplain landscapes of the Techa river in the Urals. Russian Journal of Ecology, Vol. 25, No. 3, 1994, pp. 181-186

3 Trapeznikov A.V., Pozolotina V.N., Chebotina M.Ya., Chukanov V.N., Trapeznikova V.N., Kulikov N.V., Nielsen S.P., Aarkrog A. Radioactive contamination of the Techa river, the Urals. Health Physics 65, 1993, 481-488

4 Trapeznikov A., Aarkrog A., Pozolotina V., Nielsen S.P., Polikarpov G., Molchanova I., Ka-

ravaeva E., Yushkov P., Trapeznikova V., Kulikov N. Radioactive Pollution of the Ob River System from Urals Nuclear Enterprise „MAYAK". J. Environ. Radioactivity, Vol. 25, 1994, pp. 85-98

Table: Radionuclides in the soil of the Techa and the Iset flood plain, kBq/m²

Location, River	River bank	Distance from the river, m	^{90}Sr	^{137}Cs
v. Anchogova, Techa river	right left	3-4 3-4	230 96	235 145
v. Bugaevo, Techa river	right left	3-4 30-40 3-4	87 610 230	88 470 167
v. Pershino, Techa river	right left	3-4 30-40 3-4 30-40	122 34 290 380	94 55 155 123
v. Zatechenskoe, Techa river	right	3-4 30-40	230 25	83 58
v. V. Jarh, Iset river	left	3-4	3.4	5.9
v. Krasnoisetsko, Iset river	right	3-4	32	18
v. Kondino, Iset river	right	3-4	64	3.5
v. Mekhonskoe, Iset river	right	3-4	19	8.4

Figure 1: **Map-scheme of investigated area**

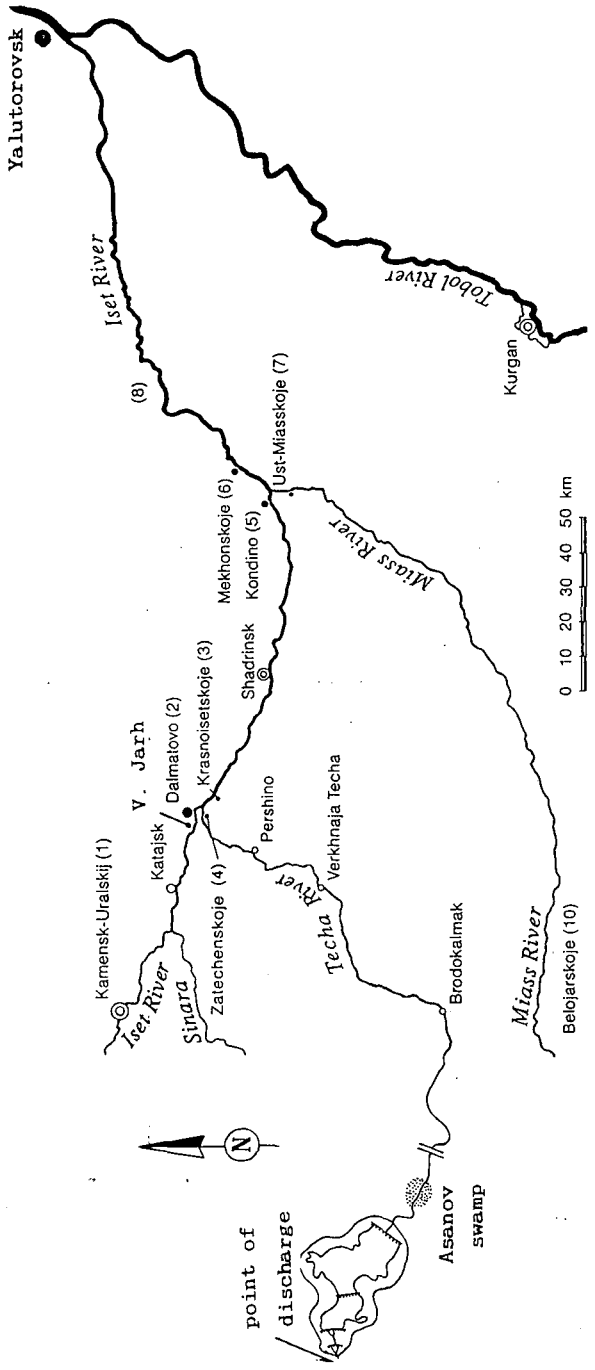

Figure 2: **^{137}Cs concentrations in silt sediments of the Techa, Iset, Tobol rivers**