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EXPERIENCE IN MINIMIZING CONSEQUENCES OF THE 1957 ACCIDENT

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Presented in the Book are the materials of the International Conference dedicated to the 55th anniversary of the 1957 accident at the Mayak PA. The materials published reflect the results of the studies performed by the Russian researchers and their foreign colleagues with a main focus on the impacts on the health of the population resident in the East-Urals Radioactive Trace area, and on the environment, as well as on the assessment of the effectiveness of countermeasures implemented, and the prospects for the further development of the region.

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THE EXPERIENCE OF THE URALS ACADEMIC OF SCIENCE IN THE STUDY OF TERRESTRIAL ECOSYSTEMS of THE EASTERN-URAL RADIOACTIVE TRACE

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The outstanding biologist of the XX century, one of the founders of the radioecology N.V. Timofeeff-Ressovsky worked in the Urals, at the Institute of Biology (presently Institute of Plant and Animal Ecology, Ural Branch of RAS) during 1955−1962. It was then that he created of the conceptual basis of new scientific branch − radioecology. The necessity of the new scientific knowledge was confirmed by two large-scale nuclear accidents in 1957 and 1967. Unfortunately, N.V. Timofeeff-Ressovsky could not carry out research of the accident consequences, as all works had been done under strict secrecy. Only when the information about this accident appeared in the open access (1993), the researchers of our Institute were able to take part in the investigation of the Eastern-Ural Radioactive Trace (EURT) territory.

The aim of this work: to summarize the outcomes of long-term radioecological investigations in EURT terrestrial ecosystems and to carry out coupled analysis of migration characteristics of long-lived radionuclides, dose loads on the biota and biological effects in natural populations of plants.

The results showed that within the central axis of the trace changes in inventories of radionuclides with increasing distance from the epicenter of the accident, are satisfactorily approximated by a power function (Figure). In this case, the radionuclides located according to the level of contamination in a row ^{90}Sr >^{137}Cs >^{239,240}Pu. Maximum stock of ^{90}Sr within the head part of the trace is $95 \cdot 10^3$ kBq/m^2. On the eastern periphery of the trace the distribution of ^{90}Sr, ^{137}Cs and ^{239,240}Pu is subject to the same dependence. Here the values of ^{90}Sr and ^{137}Cs stocks are almost identical, and with increasing distance they are reduced from 100 to 10 kBq/m^2. On the western periphery of the trace the content of ^{137}Cs in soil, regardless of the distance, is kept at a level (5–10) kBq/m^2,and ^{90}Sr remains a major contaminant of the soils.

We made quantitative evaluation of contributions of two events into contamination of soil cover of the EURT. Calculations were made with the use of values of radionuclide ratios that characterize precipitations of various accidents, and stocks of radionuclides at reference sites.As one would expect the main contribution (97%) in the contamination of the central axis was made by accident of 1957, on the western one it constituted 67% and on the eastern one − 31%, based on the total content of radionuclides in soils. Wind transfer of sediments of Karachay Lake added to this contamination 3%, 26% and 63% respectively. Systemic examination of the territory EURT allowed us to assess the total stock of radionuclides in soils. It was 571.2 TBq for ^{90}Sr, 66.1 TBq for ^{137}Cs and 1.7 TBq for ^{239,240}Pu.

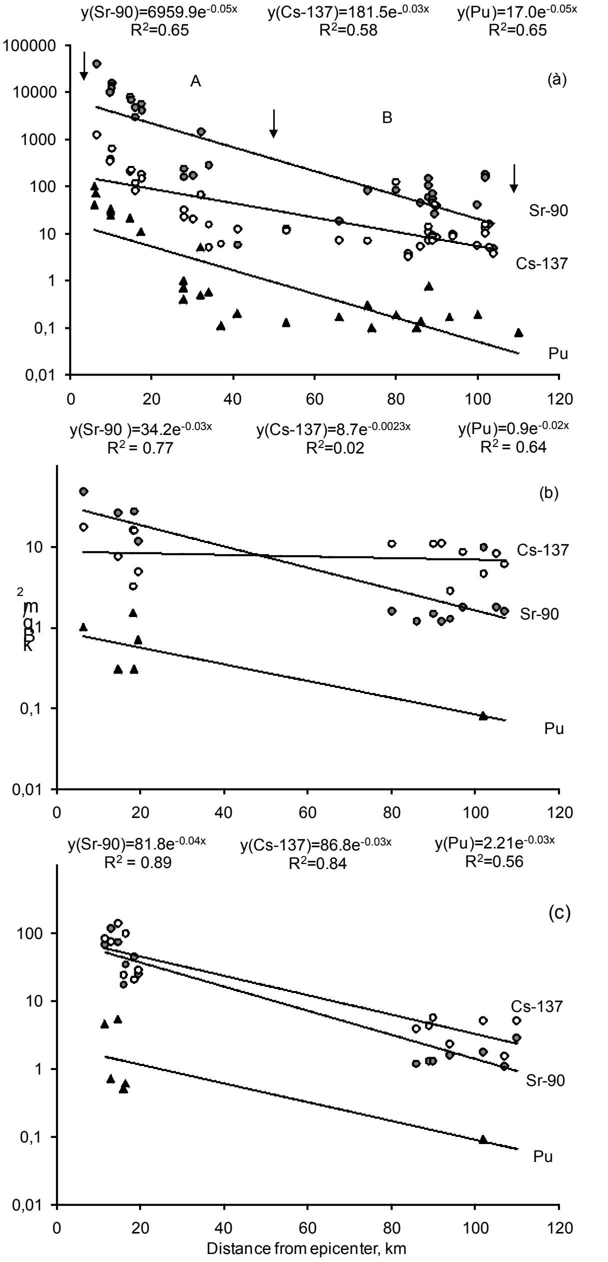

Figure. Radionuclides distribution in the soils of the nearest (A) and the farther (B) from epicenter accident parts of the EURT.
a – the central axis, b – western periphery, c – eastern

periphery.

For a quantitative estimation accumulative capacity of plants growing in a gradient of pollution we used the most informative indicator – transition coefficient (TC, $m^2/kg \cdot 10^{-3}$). In the surveyed areas all examined species were characterized with a high variability of these coefficients, depending on the specific features and conditions for plant growth. As a rule, these coefficients have been decreased with increase the radionuclide stocks in the soil. There were found the species – indicators of the radionuclide contamination.

On the basis of concentrations of radionuclides in soil and vegetative mass of plants we calculated absorbed doses to the plants. The doses calculated for plants within the farther areas of the EURT are usually greater by one order of magnitude than the background areas. In head part of this territory differences with background plots were 3−4 orders of magnitude. If one takes into account that lifetime of many herbaceous plants can reach 20 years, plants can accumulate doses of about 15–17 Gy during the entire period of ontogeny. Obviously these doses refer to small doses for vegetable objects.

The vegetation of the EURT head part is a complex of synanthropic and semi-natural plant communities at different stages of degradation and restoration succession. Species diversity of the forest and meadow cenoses is high, and involvement of ruderal species is reduced, that is associated with low anthropogenic load. It is significant to note that the current state of phytocoenoses on the places of the demolished local villages is still largely determined by the degree of man's impact in the pre-accident period and reclaiming activities. In general, despite on the high levels of radioactive contamination, the vegetation of the EURT head part is regarded as the core of ecological frame of the forest-steppe zone, which plays an important role in preserving biodiversity and maintaining ecological stability in the region. However, the quality of the gene pool of the flora in this area is reduced under the influence of chronic exposure.

Our researches of the EURT plants have shown that, 40-55 years after the accident, the viability (survival, growth rate of roots and leaves) seed progeny of many plant species in the early stages of ontogeny: 1) does not differ from background samples, and 2) below or 3) higher background values. This variety of effects was associated not only with radiation exposure, but also with the changeable weather conditions.

Evaluation of mutability on the frequency of occurrence of seedlings with various abnormalities led to the conclusion that for the majority of cenopopulations from the EURT area mutation process pass more intense than that on the background areas. Part of the damage exists in the seeds in a latent form and is manifested phenotypically only after provocative irradiation. It is impossible to set up the definite relationship between mutability and intensity of the radiation exposure on the parent plants, as the nonlinear effect is manifested. The stable effect of the radioadaptation has not been revealed upon the viability of the seed progeny. The observed effects are evidence of increased genomic instability in plants, they can be considered as the effects of prolonged exposure to low doses of radiation on natural populations of plants.

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