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A DETAILED DESCRIPTION OF THE FEATURES OF THE PROCESS OF ACCUMULATION OF RADIONUCLIDES IN THE ECOSYSTEMS OF THE SEMIPALATINSK TEST SITE IN THE PREVAILING RADIOECOLOGICAL CONDITIONS

The main pollutants of the soil cover of the Semipalatinsk test site are Sr90, Cs137, Am241, Eu152,154[1].
1. A high level of contamination Am241 –112 451 Bq/kg (layer 0-25 cm) was detected in the light chestnut surface-damaged (in the process of decontamination) soils occupying a significant area at the landfill. But in the ash of plant roots, it reaches only 59-600 Bq/kg, and in the ash of the aboveground part –16-43 Bq/kg. The content of Eu152,154 is 3 164-3 530 Bq/kg (in a layer of 0-12 cm), 384-1 900 Bq/kg - in the ash of plant roots and 99-182 Bq/kg in the ash of the aboveground part. The results of gamma–spectrometric analysis of soil and plant samples revealed a similar pattern in the migration of other pollutants –Cs137, α–and β–emitters in zonal ecosystems. Vertical and horizontal migration of technogenic radionuclides in zonal ecosystems is difficult due to the following factors: 1) arid climate (high temperature, low precipitation, insufficient soil moisture); 2) non-washing type of water regime; 3) insignificant humus content in the surface horizon of soils, slightly alkaline reaction of soil solution, predominance of loamy differences, sufficient availability of Mg++ and Ca++. These factors and features of zonal soils limit the possibility of sorption of radionuclides by plant roots. Soils are polluted in the surface layer 0-2, 0-5, 0-10 cm. The main mass of plant roots is located in the soil layer 0-28(30) cm. The absorption of radionuclides by the root system of the dominant species Stipa sareptana and Artemisia sublessingiana is significantly less than their content in the soil. The exception is the hyperaccumulator of the β–emitter Artemisia sublessingiana, accumulating 9 100-9 300 Bq/kg in the aboveground part of the plant, and 6 580-7 800 Bq/kg in the roots (3 780 Bq/kg in the soil).
2. The content of α–emitters according to standards [2] exceeds the maximum permissible concentration (MPC) in soils (in a layer of 0-12 cm) by 8 times, in the ash of the dominant roots - 1.6-11.5 times, in the aboveground part of the plants - 2.5 times. The value of Cs137 is 1.5-3 times higher than the MPC according to [3]in soils, and 2.4 times higher in plant roots.
3. In the soils of military-technical structures, the main pollutant is the alpha emitter. In the 0-15 cm layer according to [2], its content exceeds the MPC by 7 times, in the ash of the roots of the predominant plant - from 0.7 to 1.8 times, in the aboveground part –from 0.7 to 1.8 times.
II. The main pollutants of meadow ecosystems are Cs137 and β-emitters. In meadow solonchakous soils (in a layer of 0-10 cm) Cs137 –3 166 Bq/kg accumulates, β-emitters –41 600 Bq/kg; in meadow drying soils, respectively, 4 130 Bq/kg and 28 800 Bq/kg [2]; in meadow settling soils –1 053-1 394 Bq/kg and 46 200 Bq/kg, in meadow settled soils 896 Bq/kg and 16 970 Bq/kg. The content of Cs137 in meadow soils exceeds the MPC according to [3] from 2 (meadow settled) to 11 times (meadow drying).
According to the level of accumulation of radionuclides in plants, β-particles predominate. The hyperaccumulator of this pollutant is Inula britannica (in the ash of the roots 79 100 - 115 000 Bq/kg, above–ground part – 84 000-229 400 Bq/kg); Galatella biflora –respectively in the roots - 189 600-450 000 Bq/kg and above-ground part 242 000 –390 000 Bq/kg, Phragmites australis - 42 900 Bq/kg and 85 800 Bq/kg; Achnatherum splendeus –87 000 Bq/kg and 207 000 Bq/kg.
A high content of β-particles was detected in the roots of Elytrigia repens, Leymus angustus, Calamagrostis epigeios, Sanguisorba officinalis, Glycyrrhiza uralensis. Significant accumulation of α-particles was noted in the roots of Leymus angustus –1 740 –2 100 Bq/kg (in the aboveground part <800-1 380 Bq/kg), Achnatherum splendens –1 830 and 900 Bq/kg, respectively, Elytrigia repens - 3300-11 600 and <800-390 Bq/kg, Calamagrostis epigeios –6 780-18 600 Bq/kg and <1000-400 Bq/kg, Galatella biflora –3 880-5 600 Bq/kg and <360 Bq/kg –<1 100 Bq/kg. According to [3], the content of α–pollutants exceeds the MPC from 1.5 to 18 times.
Cs137 hyperaccumulators are Potentilla acaulis: in the ash of the aboveground part 320 Bq/kg, in the ash of the roots - 100 Bq/kg, Glycyrrhiza uralensis, respectively - 173-1794 Bq/kg and 340-438 Bq/kg, Achnatherum splendens 151-382 Bq/kg and 24-198 Bq/kg. High content was noted in the roots of Inula britannica - 682-3 100 Bq/kg, Elytrigia repens 5 400-7 906 Bq/kg, Calamagrostis epigeios 3 672-4 130 Bq/kg, Leymus angustus 1 690-5 382 Bq/kg. According to [4], the content of Cs137 in the ash of the roots of these plants exceeds the MPC by up to 20 times.
Significant pollution of meadow ecosystems by β–α–emitters and Cs137 is caused by the following factors: high humus content in the surface layer of soils, PH change - from neutral to slightly alkaline. Mechanical

composition of soils (sandy loam, loamy, heavy loam), sufficient soil moisture (due to additional surface and groundwater). They contribute to the migration of technogenic radionuclides in the "soil–soil solution"and "soil–plant systems".

A significant contribution to the pollution of meadow ecosystems is also made by the currently manifested "secondary effects associated with the accumulation of fission products during underground nuclear explosions, especially in the Degelen mountain range, and their removal to the daytime surface by thawed and stormwater"[2].

III. In halophytic ecosystems, the main soil pollutant is Cs137: in ordinary salt marshes –1 053-1 394 Bq/kg, in meadow–desert–steppe salt marshes –5 397 Bq/kg, in meadow-desert-steppe salt marshes –anthropogenic disturbed (during the construction of engineering and technical communications) –14 470 Bq/kg. According to [4], the level of pollution of these soils exceeds the MPC from 2.8 to 28 times. The main pollutants of plants are β–and α–particles. In the ash of the roots of the dominant species, β–emitters accumulate from 3 370 to 31 000 Bq/kg, in the aboveground part, respectively, from 2 380 to 10 600 Bq/kg. The level of accumulation of α–particles is significantly lower: in the ash of plant roots –from 1 200 to 3 900 Bq/kg, in the aboveground part –from <350 to 1 700 Bq/kg. The content of Cs137 is insignificant: in the ash of the roots of the dominant species reaches 135-753 Bq/kg, the aboveground part –83-556 Bq/kg. The exception is Artiplex cana, which accumulates 2 440 Bq/kg in the ash of the roots and 2 770 Bq/kg of the aboveground part.

The hyperaccumulator of Cs137 is the lichen Parmelia vagans, accumulating 54 000 Bq/kg. This value exceeds the MPC by [4] by 145 times.

In the roots of the dominant species (higher plants), in accordance with [4], the level of Cs137 pollution exceeds the MPC up to 6 times, in the aboveground part up to 1.5–7.4 times.

Soils in halophytic ecosystems are formed under conditions of additional moisture due to rain and meltwater (slope runoff) Additional moisture in the negative elements of the relief contributes to some activation during the migration of radionuclides. Thus, in the ash of the aboveground part of Halimione verrucifera, the level of contamination with β-emitters is 5 100 Bq/kg, and in the roots –4 300 Bq/kg. But there is no significant redistribution of radionuclides in the soil profile. The maximum accumulation of pollutants is noted in the surface layer of 0-5 cm. the main physical and chemical parameters of salt marshes and salt marshes also do not affect the intensity of migration of radionuclides. The humus content in salt marshes reaches 2.0–2.3%, the PH of the solution is 7.6–8.6; in salt marshes, respectively, 1.8–1.9% and 7.4–8.4. Loamy and heavy loamy differences prevail in the mechanical composition of these soils. The complex of these factors limits the possibility of vertical and horizontal migration of radionuclides in halophytic ecosystems.

List of literature

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Section

Radiation ecology and methods of analysis (Section 3)

Primary author: PLISSAK, Rimma (Republican State Enterprise on the Right of Economic Management "Institute of Botany and Phytointroduction"of the Committee of Forestry and Wildlife of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan)

Presenter: PLISSAK, Rimma (Republican State Enterprise on the Right of Economic Management "Institute of Botany and Phytointroduction"of the Committee of Forestry and Wildlife of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan)

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