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Study of soil processes in the southwestern spurs of the Zarafshan ridge by the method of γ-spectrometry

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ABSTRACT: Using the method of gamma spectrometry, an express assessment of erosion processes in the soils of the experimental site, located on the southwestern spurs of the Zarafshan ridge, was carried out. The assessment was based on the content of the technogenic radionuclide ^{137}Cs in the soils ($T_{1/2}$ = 30 years, E_γ = 661 keV). Quantitative results were obtained for the degree of soil erosion depending on the terrain.

KEYWORDS: Radionuclide, spectrum, spectrometer, Marinelli, reference standards, activity, experimental spectra, gamma background, minimum detectable activity, low-level radionuclide.

I. INTRODUCTION

The technogenic radionuclide (TRN) ^{137}Cs ($T_{1/2}$ = 30 years, E_γ = 661 keV) and the cosmogenic radionuclide ^{7}Be ($T_{1/2}$ = 54 days, E_γ = 478 keV) [1]. Vertical distributions of long-lived primary radionuclides of the uranium-thorium families and ^{40}K give an idea of the long-term (hundreds of years) processes of soil erosion and sedimentation.

This paper presents and discusses the results of the γ-spectrometric study of reserves and vertical distributions of precipitated ^{137}Cs radionuclides in the soils of individual areas of the intermontane area.

II. CHARACTERISTICS OF THE STUDIED AREA

The investigated territory is located in the saddle of the Karatepa and Chakylkalyan mountains, which are the southwestern spurs of the Zarafshan ridge, 2.5 km east of the Takhta-Karacha pass (height above sea level H = 1685 m). The absolute height of the territory varies from 1786 m above sea level on the crest of the Cg hill to 1642 m - in zone V.

The average monthly values of temperature and relative humidity are +11.7 ^{0}C and 54%, and the amplitudes of their fluctuations in winter and summer are from -35 to +35 ^{0}C and from 90 to 20%, respectively. The amount of annual precipitation is 800 mm, with ~ 50% falling in the first quarter of the year. The average wind speed per year is 6-8 m/s.

The soil cover of the territory belongs to mountain brown typical soils, with a well-defined humus layer. The exceptions are the soils of the L-hollow, in which erosion processes are intense, and the V-zone, on which a significant amount of sediments accumulates. Soil moisture increases in the lower parts of the plots. The areas of the study area differ markedly in the species composition and the density of the vegetation cover. Woody vegetation on the territory is highly thinned out.

III. TEST SITES, SAMPLING, SAMPLE PREPARATION

Sampling was carried out in the last days of April, May, July and October from sample plots typical of the studied areas.

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Fig. 1 Terrain relief (satellite image)

Sampling was carried out as follows:

• soil layers with a thickness of ΔZ = 5 mm were taken from 17 plots with dimensions of 0.5 m^2 from depths Z = 0-20 mm (surface samples);

• from 44 plots measuring 0.2 m^2 from depths Z = 0-40 cm (for V_1 and V_2 Z = 0-70 cm), soil layers with a thickness of ΔZ = 1-10 cm were cut (deep samples);

• all samples were weighed, the soils were thoroughly mixed, and 1.5 kg of the substance was taken from each;

• the selected samples were transported to the laboratory, where samples were made from them.

To make measuring samples, the samples were brought to an air-dry state, crushed, packed in one-liter Marinelli vessels, weighed and labeled.

The masses of soil samples were - m_s = 1.2-1.3 kg / l (specific density of the samples $\rho_s \approx 1.35$ kg/l).

IV. METHODS FOR MEASURING AND PROCESSING Γ-SPECTRA

The spectra of the samples were measured using a γ-spectrometer with a scintillation detector (NaI (Tl), ∅63x63mm, energy resolution ~ 10% at the 1332 keV line) placed in a lead shield 10 cm thick. Registration and processing of spectra were carried out on an IBM-PC operating in mode 1024 channel pulse analyzer. Measurements and processing of-spectra were carried out according to the method [2] using reference sources ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs from the set of special purpose volumetric activity measures (SPVAM) in one-liter Marinelli vessels with filler densities 340-960 g/l and an inert background sample.

Errors in the measurement results, depending on the content of RN in the samples, vary within the limits of $\delta A_{Cs,Be}$ ~ 10-40% and $\delta A_{Ra,Th,K}$ ~ 9-20%. When comparing the experimental results, it is necessary to take into account that the accuracy of attestation of the activity of reference sources - $\delta A^{et} \approx 7\%$ makes a significant contribution to the errors.

The activity of RN in the samples – *T(RN)* was recalculated for specific activities *A(RN)=N(RN)/m*, and for the precipitated *RN* of ^{137}Cs and ^{7}Be, specific activities were recalculated for reserves in separate layers q_Z = A(*RN*) ρ and on plots $Q = \sum_{Z=0}^{Z_f} q_t$ where Z_f is the depth of vertical migration of *RN* in the soil. In addition, to describe the vertical distribution (hereinafter referred to as the profile), the maximum depth - Z_M and the depth of the soil layer containing 1-1/e part of the ^{137}Cs - Z_e reserve were used.

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The duration of measurements of surface samples was t = 6 hours, deep - t = 2 hours.

V. EXPERIMENTAL RESULTS AND THEIR DISCUSSION

Stocks and profiles in the soils of the sites of ^{137}Cs precipitated with wet precipitation are due to:
- the amount of rain and melt water absorbed into their soil (hereinafter moistening);
- the processes of water and wind erosion, and sediment deposits, depending on the state of their soil cover and the intensity of the impact on them of water and wind flows;

The stocks and parameters of the ^{137}Cs profiles in the soils of the studied sites vary within a fairly wide range (Fig. 2) - Q = 0.5-11.7 kBq / m^2, Z_f = 5-70 cm, Z_e = 2.5-20 cm and Z_M = 0-20 cm, at the same time, for sites within one site, these differences are relatively small (Fig. 2, Table 1).

Taking into account that the losses of ^{137}Cs stocks in the studied sites do not exceed the background stocks in the Z_e layer and the possibility of considering the ^{137}Cs profile in this layer as uniform, we estimated the rates of soil degradation processes by the equation - $Y = (Q_{ex} - Q_f)\rho Z_0 / Q_f \Delta T$, where Z_0 = 1 cm,, T is the year of study, Y < 0 - erosion, Y> 0 - sedimentation.

The values of Y (Fig. 3) correspond to the characteristics of the sites.

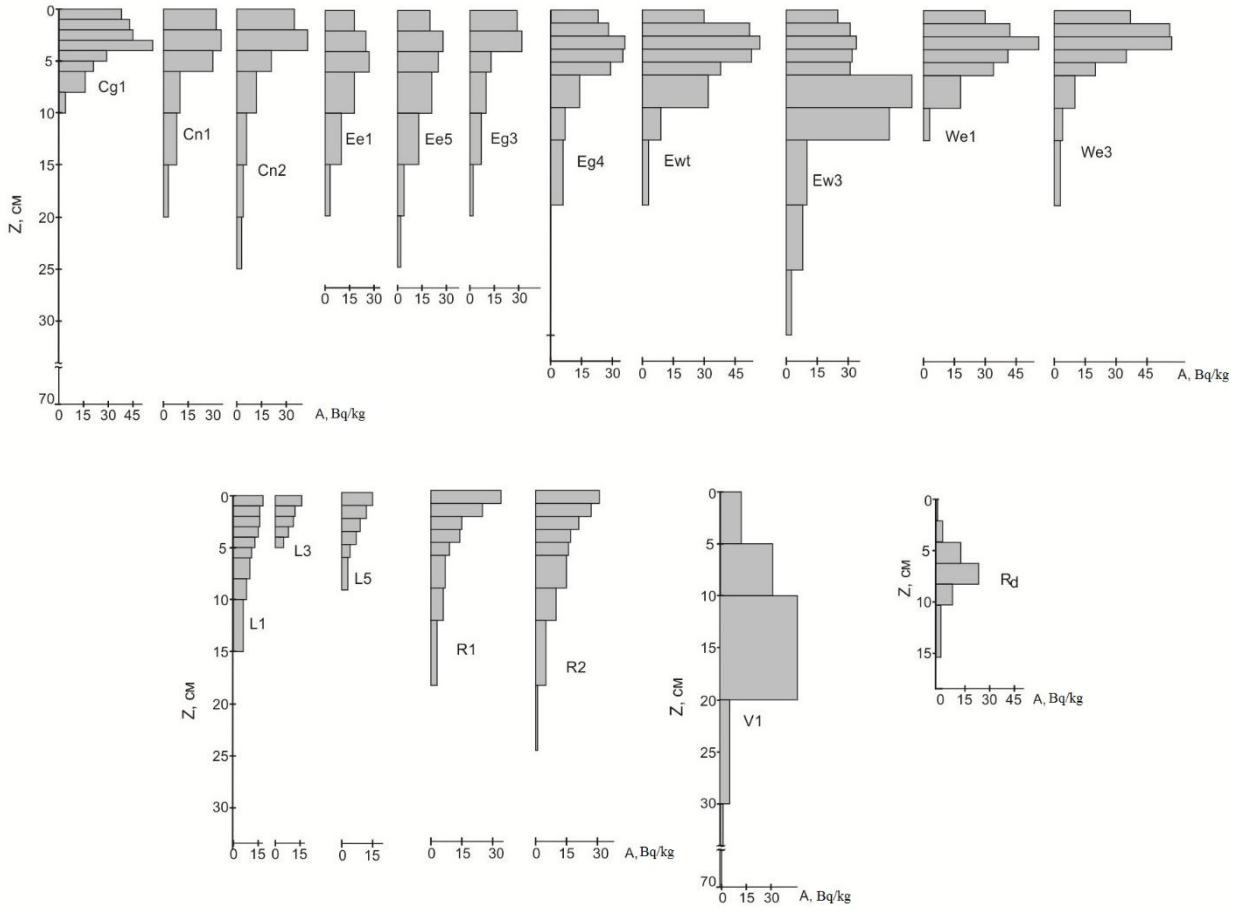

Fig. 2 ^{137}Cs profiles in soils of some plots.

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Table 1

Plot	Area	Q, kBq / m^2	Z_f, см	Z_M, см	Z_e, см
crest	C_g1,2,3	3.5-3.6	10-15	4-5	3.7-4
	E_g1,2,3,4	2.1-3.3	15-20	1.5-2.5	3.1-5
Slopes	C_e1,2	3.7-4.2	20	2.9-3.1	3.9-4.3
	C_w1,2,3	3.8-4.6	20	3.0-3.5	4.0-4.6
	C_n1,2	3.7-4.2	20	3.0-3.5	5.2-6.0
	E_e1,2	2.1-3.8	15-20	1.5-5.0	6.0-8.0
	E_w1,2,3,4,5	4.2-6.3	25	5.5-6.5	4.5-9.0
	W_e1,2,3,4,5	2.1-6.3	10-15	0-2.5	3.5-5.6
Plain	R1,2,3,4,5	1.9-2.8	15-20	0	4.5-6
Lozhbina	L1,2	1.3-2.1	15	0	2.5-7.0
	L3,4,5,6	0.5-0.8	5-7	0	2.2-2.7
Zone	V1,2	10.2;11.1	≥70	15	16-20
Trails	E_wt1,2	2.7;3.8	10-15	0;2.5	3.0-5.0
Road	E_gd	2.4	12	0	4.6
	R_d	1.2	6	7.0	7.4
Plowing	E_gP	2.2	30	-	18

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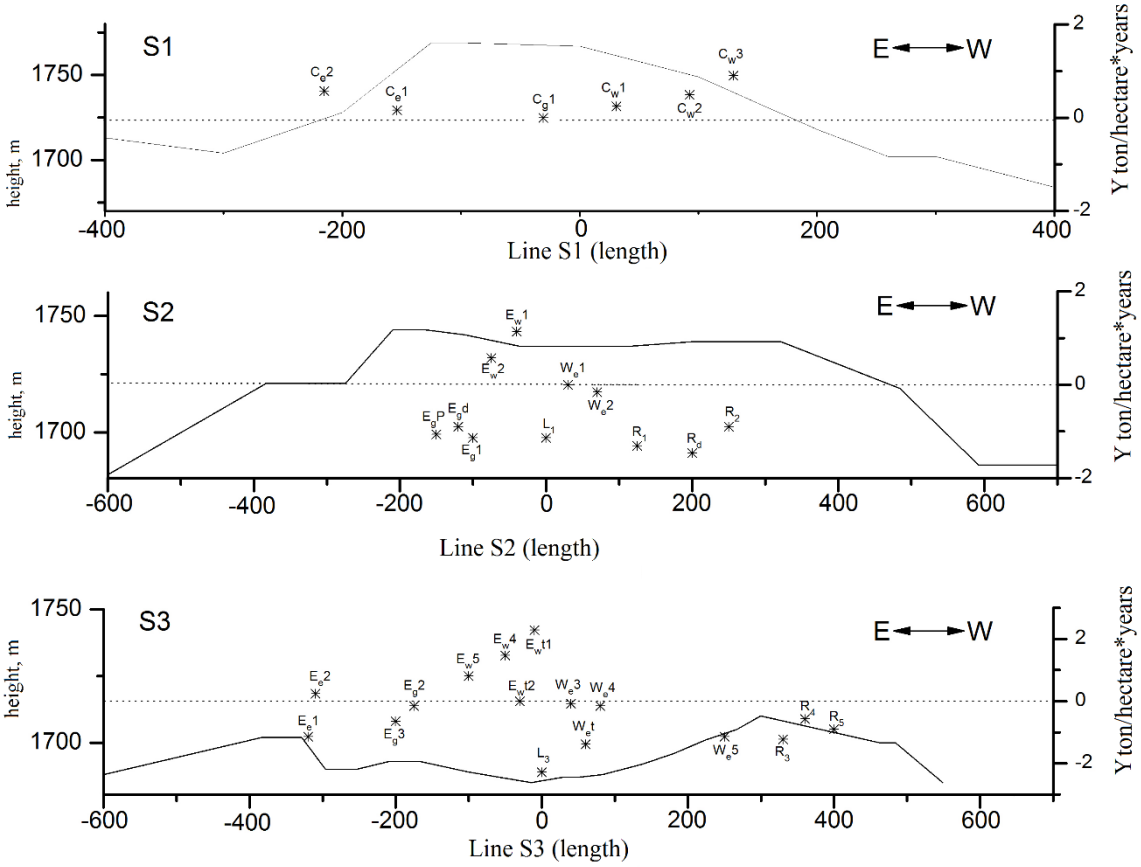

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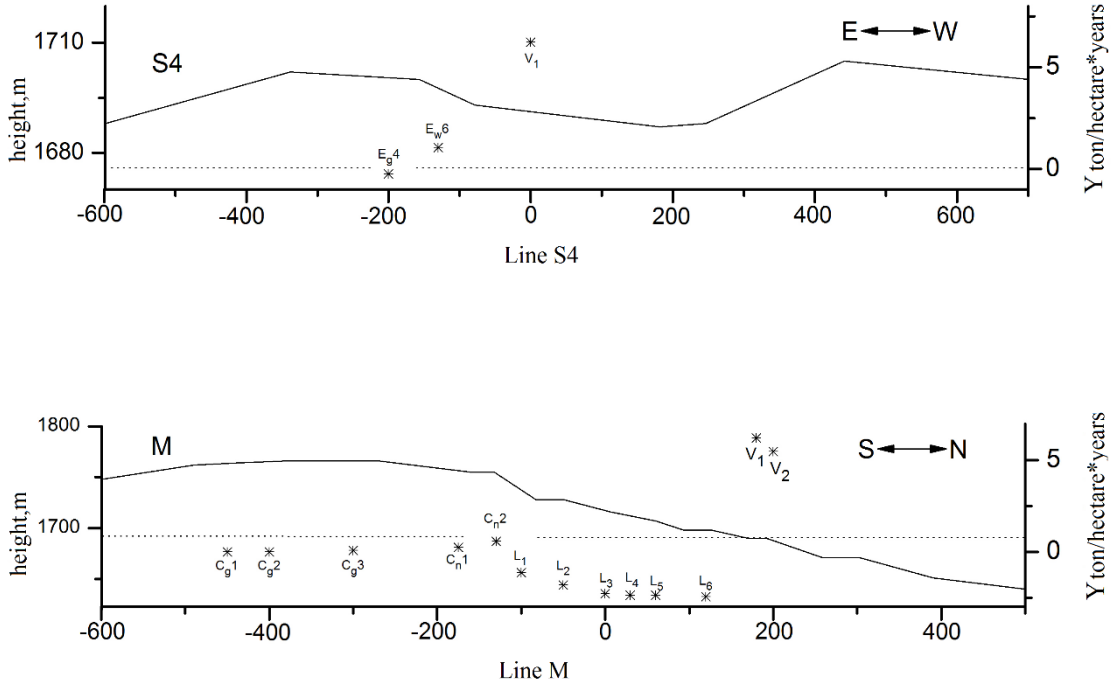

Fig.3 Terrain relief along the lines S_1, S_2, S_3, S_4 and M and the intensity of soil processes on the test plots.

VI. CONCLUSION

The performed γ-spectrometric studies of environmental objects in the intermountain hilly terrain in the southwestern spurs of the Zarafshan ridge, used for grazing and agriculture, made it possible to:

- to show that in eroded soils the maximum of the ^{137}Cs profile is located in the surface layer, and in sedimentary soils it is displaced into the deep layers,
- note that the parameters of the ^{137}Cs profile - Z_f, Z_M, and Z_e at the sites with a predominance of erosion processes, are noticeably lower than in the sedimented ones.
- based on the reserves of TRN ^{137}Cs in soils in the studied sites, to reveal the dependence of the rate of erosion and sedimentation processes on the relief of the sites and the intensity of anthropogenic activity on them over the past half century.

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