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# Radioactive contamination of the soils of Georgia

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ABSTRACT

After 29–30 years from Chernobyl atomic plant accident the main soil types of Georgia have been examined on contamination presence of $^{137}$Cs and $^{90}$Sr.

Level of radioactive contamination of soils ($^{137}$Cs deposition) we can separate three levels: I - 0–10 kBq/m$^2$ - Black, Cinnamonic, Raw carbonate, Mountain meadow, Chernozems, Black forest brown, Primitive and Yellow soils; II - 10–37 kBq/m$^2$ - Red, Bog and Yellow forest brown soils; III - > 37 kBq/m$^2$ - Yellow podzolic soils.

In a big majority of soils $^{137}$Cs deposition of layer 0–20 cm does not exceed 37 kBq/m$^2$ (1 Ci/km$^2$), that allows us to attribute this examined sample points to non-contaminated territories.

In five points of sampling with maximum $^{137}$Cs deposition in a layer of 0–20 cm have been measured specific activities of $^{137}$Cs in a layer of 20–40 cm and have been evaluated $^{137}$Cs deposition in a layer of 0–40 cm. Results for most of the soils also does not exceed 37 kBq/m$^2$ (1 Ci/km$^2$).

Exclusion is Yellow podzolic soil near to v.Jvari (West Georgia), where $^{137}$Cs deposition was 38.0 and 70.4 kBq/m$^2$ accordingly in layers of 0–20 cm and 0–40 cm. We can attribute this zone to radiological contamination, particularly to living zone of privileged socio-economic status. In Yellow podzolic soils we can observe high mobility of $^{137}$Cs primary in kaolinite composition of clay fraction and in connection to this lowering of intensity of non-exchangeable absorption by soil of this radionuclide.

In all soils $^{90}$Sr deposition in a layer of 0–20 cm does not exceed 11.1 kBq/m$^2$ (0.3 Ci/km$^2$) that allows us to attribute examined territories to “relatively satisfying situation”.



## Introduction

From the main types of radioactivity of soils the biggest treat comes from artificial radioactivity. Sources of radioactive contamination of soils are different. This includes global deposition of radionuclides resulting from testing of nuclear weapon, radiation breakdowns/accidents and “peace” nuclear explosions. Radioactive elements are easily accumulating in agricultural products. Radioactive contamination of soils is an independent type of contamination, lowering quality of agricultural production [1].

Exceptionally dangerous in biological relations are anthropogenic radionuclides and in first place $^{90}$Sr ($T_{1/2}$ = 28.79 years) and $^{137}$Cs ($T_{1/2}$ = 30.17 years) [2]. Both radionuclides are actively involved in biological circuit of substances as Cs is a chemical analogy of K and Sr of Ca. We must mention that direct proportional dependency between their content in soil and in plants that grow on it is observed often.

In Georgia after examination of contamination of plants by global deposition of strontium-90 scientist found out, that maximum level of contamination by this radionuclide is in western part of country, on the Black Sea costal area. In high mountain regions contamination level was not so high.

Like Georgia, also Austria was contaminated after Chernobyl accident [3]. Whereby radionuclides showed very small speed of migration in a few millimetres per year and accumulate in upper parts of soils, transforming them into important source of radioactive elements for plants.

It is also interesting to use $^{137}$Cs for evaluation of modern agrogenic transformation of soil layers in Chernobyl contamination region [4]. In addition to the above, ability of using spatial distribution stocks of radioactive isotope $^{137}$Cs for assessment of agrogenic transformation of soil layer on territories with high level of Chernobyl contamination. The main basic requirements for the methodology have been examined for particular region. The best

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results of measuring radionuclide supplies in soils for establishing statistic values of primordiality of $^{137}$Cs were in combination of filed and laboratory methodologies.

Also interesting is modelling fixation of $^{137}$Cs in soils [5]. Exiting models of fixation of $^{137}$Cs have been examined. The most accurate and adequate experimental measurement description gives diffusive model. The main advantage of this model is small amount requisite parameters and ability to evaluate and compare parameters of long term fixation to short term lab experiment. Experiments like these were taking place on example of south-west regions of Briansk region where dynamics of transfer factor of $^{137}$Cs into plants were evaluated and effect of ways of protection of accumulation of this radionuclide in agricultural production [6].

Interest to radioactive contamination of soils started to form in 60–70s of the last century and significantly increased after Chernobyl accident in 1986. Now, radioactive contamination of soils is a separate, independent type of degradation that is leading to lowering of productivity of soils [1,7,8]. In scientific literature it is described natural radioactivity of soils, indicated the main sources of radionuclides on soil surface. Treat of radioactive contamination of soil-plant cover of the planet is being evaluated from two positions: using of anthropogenic (sanitary-hygienic) principle, when we are considering level of radioactive contamination of agricultural production and correspondence content of radionuclides in it by radiological standards (maximum permissible concentration) from one side and using eco-centric (biosphere, ecological) way, when we take in consideration results of exposure of soil biota and on ground living creatures from soil containing radionuclides (in accordance to allowed standards of radiation, allowed dosage of radiation) on other hand.

With that, presence of radionuclides in soils is not their property, caused only by from human activities. In soils, there always are natural radionuclides. So results from examination of radioecological situation in high mountains of Great Caucasus in interval from 2200 m till 3800 m from sea level on territories of Azerbaijan, Georgia and in some parts of Russia (Dagestan, Chechnya, Ossetia, Kabardo-Balkania, Karachevo-Cherkesia, Stavropol and Krasnodar Krays) have shown certain regularitie of migration of special properties (starting level of contents in parent rock, intensity of soil formation, processes of vertical and horizontal migration, geographical, climate, landscape-geochemical factors) characterizing this region [9]. Analysis of radioecology of agricultural landscapes that are directly abutting to Gardabani thermal electric power plant have shown a large diapason of presence of radionuclides in biological chain “soil-production, plants and animal husbandry” [10]. Natural levels of radiation in population of South Caucasus in general is higher than in other countries from former USSR. This is resulted from increasing cosmic expose of radiation because of high altitude of the territories mainly for high mountain regions. Getting regularities is only natural radionuclides and in major part differs from unnatural (anthropogenic) radionuclides [11].

All of this determines actuality of examination radioactive contamination of soils in Georgia and especially its western part. As well as resulting Chernobyl nuclear accident in 1986 Georgia among other former USSR countries was contaminated after Ukraine, Belarus and Russia [12].

## Objectives and methods

Objectives of examination are the main soil types of Georgia [12,13]. Including: Red soils - Ferralic Nitisols, Haplic Nitisols, Yellow soils - Ferric Luvisols, Bog soils - Dystric Gleysols, Eutric Gleysols, Histosols, Yellow Podzolic soils - Stagnic Acrisols, Ferric Acrisols, Yellow Brown Forest soils - Stagnic Luvisols, Mollic Luvisols, Humic Luvisols, Ferric Luvisols, Brown Forest soils - Humic Cambisols, Ferric Cambisols, Eutric Cambisols, Dystric Cambisols, Raw Carbonate soil - Rendzic Leptosols, Grey Cinnamonic soils-Calcic Kastanozems, Vetric Kastanozems, Cinnamonic Soils - Chromic Cambisols, Calcaric Cambisols, Humic Cambisols, Eutric Cambisos, Meadow Cinnamonic Soils - Chromic Cambisols, Calcaric Cambisols, Gleyic Cambisols, Eutric Cambisols, Black Soils-Haplic Vertisols, Chernozems-Voronic Chernozems, Calcic Chernozems, Mountain Meadow soils - Hyperdistric Umbrisols) and primitive (Leptosols).

Measuring specific activities of $^{137}$Cs have been done with gamma-spectrometric on spectrometric complex “Multirad” with gamma detector NaI(Tl) 63 × 63 on program software “Progress” in geometry “Denta” (100 cm$^3$) with exposition 7200 s. Measurements of specific activities of $^{90}$Sr have been done with beta-spectrometric on spectrometric complex “Multirad” with beta detector on program software “Progress”. Preparing of counting samples have been done with oxalate method in accordance with [14].

The biggest part of measurement have been done in upper layer of soil (0–20 cm) where 80–90% of radionuclides is being accumulated [4,15–18].

## Results and discussion

During the whole term after the accident in Chernobyl nuclear power plant there have been observed high irregularity of soil contamination with radionuclides almost in all regions. Research that has been held in Georgia in 2005–2009 found out that statement [12]. Activity of $^{137}$Cs have changed from 0 to 1279 Bq/kg. Besides that, high levels of contamination with $^{137}$Cs have been observed in west Georgia: Red soils – 640, Yellow soils – 965 and Yellow-podzolic soils 1279 Bq/kg.

Results of research of Georgian soils in 2015–2016 are presented in Table 1. In the results, specific activities of $^{137}$Cs are significantly lower. So, in west Georgia in Yellow-podzolic soils it is 144, in Red soils – 66, in Yellow brown forest soils – 63 and in Yellow soils 25 Bq/kg (see Table 2).

Profile distribution activity of $^{137}$Cs in some examined soils are presented on Fig. 1. Activity of $^{137}$Cs in Red and Yellow brown forest soils in west Georgia is being dropped through the floor down the profile particularly to zero. In Brown forest soils of west Georgia lowering activity is exposed more slightly: activity in a layer of 20–40 cm in 2,4 times lower than in a layer of 0–20 cm. In Yellow-podzolic soils in west Georgia distribution of $^{137}$Cs in profile particularly is equal.

For $^{137}$Cs non-exchangeable absorption trilaminar clay minerals (hydrated mica group and montmorillonite) shell be considered as main mechanisms of fixation in soils [17,19–24]. It's downside migration through profile with soil solution is not intense. Relative takeout of radiocesium in forest soils according to A. I. Shelgov [24] is 0,002–0128% per year.

In Yellow podzolic soils of west Georgia in silt fraction dominates kaolinite [12]. That must be the reason of high mobility of $^{137}$Cs in them.

For evaluation of ecology condition during contamination by $^{137}$Cs it is possible to use criteria that is being used in Russia [25,26]:

- Ecology disaster (zone of compulsory evacuation): >1480 kBq/m$^2$ (>40 Ci/km$^2$);
- Environmental emergency (zone of compulsory evacuation): 555–1480 kBq/m$^2$ (15–40 Ci/km$^2$);
- Residence permit zone with right of resettlement: 185–555 kBq/m$^2$ (5–15 Ci/km$^2$);
- Residence permit zone with privileged socio-economic status: 37–185 kBq/m$^2$ (1–5 Ci/km$^2$);
- Relatively passable situation: < 37 kBq/m$^2$ (<1 Ci/km$^2$);

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