The forecast accumulation in vegetative and generative organs of black currants and plum with $^{90}$Sr its location on the surface of the soil

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Abstract. As a result of field studies, experimental material on the accumulation of $^{90}$Sr in vegetative and generative organs of black currant and cherry plum in the link of the trophic chain «soil-plant» was obtained. Coefficients of transition (CT) from soil to bark, wood, leaves and fruits of black currant and coefficients of transition from soil to bark, wood, leaves and fruits of cherry plum which will allow to make the forecast of accumulation of radionuclide at any known density of pollution of the soil in the conditions of Krasnodar region on the studied soils are defined.

Introduction
Natural biogeochemical cycles on planet Earth have evolved throughout its evolution. Moreover, natural radionuclides were an integral part of them. However, as a result of human activity, technogenic radionuclides began to enter the environment, which were also included in natural biogeochemical cycles. Nuclear weapons testing, production, processing, use and disposal of radioactive substances, global redistribution of natural radionuclides (construction, production and use of natural resources) all lead to global redistribution and contamination of the environment with radioactive substances. As a result, radioactive contamination occurs not only in urban and natural areas, but also in agricultural land. The growing number of people on Earth against the background of a decrease in the area of fertile land for various reasons, including radioactive contamination, requires a solution to the issue of returning fertile territories for use in the economy, as well as territories for their possible use in construction.

Many scientific works have been devoted to the study of the migration of radionuclides along trophic chains in recent decades [1-6], however, the issue of reclamation of contaminated areas during construction work in the Krasnodar Territory remains open. This raises many questions, including the forecast of the possible use of radioactively contaminated areas for construction work. Therefore, the timeliness and relevance of such work in the conditions of the Krasnodar Territory is beyond doubt.

The Krasnodar Territory has always been distinguished by the variety of plants grown in agriculture. Cereals, vegetables, grapes are grown there and, of course, a certain area is set aside for growing orchards and obtaining fruit products from this.
In the urban conditions of the Krasnodar Territory, crops such as currants, gooseberries, raspberries, cherries, cherry plums, apple trees, pears, etc. are grown everywhere. Much attention is paid to the cultivation of crops such as cherry plum and black currant. These plants are distinguished by high productivity, quick entry into the season of fruiting, high nutritional value of fruits. Cherry plum fruits contain malic and citric acid, sugar, pulp contains pectin, tannins and minerals. Delicious syrups, compotes, preserves, and jam are prepared from the fruit; thanks to the presence of pectins in it, a fragrant golden jelly is obtained [7,8]. The fruits of black currant are rich in various useful substances: sugars, organic acids - citric, malic, salicylic, succinic. They contain many vitamins: B1, P, E, K, B12, PP, carotene.

The purpose of this work is based on experimental data on the accumulation of $^{90}$Sr in cherry plum and black currant, with its surface location on the soil. Calculate the coefficients of transition to the vegetative and generative parts of them and make a forecast of the possible use of the territory for the needs of farming and construction work.

**Research methodology**

The experiments were carried out on leached chernozem, low-humus, super-powerful [9,10].

All work on the preparation of the site was carried out very carefully, observing the uniformity of conditions. For such experiments, plots with 6 plants are recommended and most often used in research work [11]. At the ends of the rows there are protective plants - 2 plants each. With that said, field trials are based on the standard method of placing options.

In 2008, an experimental site was laid in the field. On the plots of the first option, there were black currant plants. The food area is standard - $4 \times 4$ m. The experiment was repeated 6 times. Cherry plum plants were located on the plots of the second option. The food area is standard - $6 \times 4$ m. The experiment was repeated 6 times. The soil surface was contaminated in 1989 by the application of $^{90}$SrCl$_2$, the contamination level of the experimental site was 500 MBq / m$^2$.

After sampling, the plants were divided into organs and parts, dried at a temperature of $105 \, ^\circ \text{C}$, weighed and milled in mills MRP-1 or EM-3A.

Tests of products on the basis of radioactive contamination were performed on the USK "Gamma Plus" device according to the method of measuring the activity of beta-emitting radionuclides in counting samples using the "Progress" software. The technique was developed by SE VNIIFTRI and approved by the State Standard of Russia on 05.05.1996. This technique is the main one in determining the values of the activity of beta-emitting radionuclides in a counting sample and allows you to calculate the error of each measurement. To register beta radiation from a counting sample, a beta-spectrometric path with a scintillation detection unit (SDU) is used. For exposure of counting samples, special aluminum cuvettes are used (Complex universal spectrometric "Gamma Plus", 1995).

When controlling the content of strontium-90 in soils and plants, methodological guidelines were applied (Guidelines for determining the content of strontium-90 and cesium-137 in soils and plants, TsINAO, 1985), GOST R 50801-95, as well as OST R 10070-95 Soils. Methods for the determination of strontium-90 in farmland soils (OST R 10070-95). The results obtained were processed by the methods of mathematical statistics according to B.A. Dospekhov [11].

$$\text{CT} = \frac{\text{specific activity of plants (Bq / kg)}}{\text{density of soil contamination (Bq / m}^2)$$

When calculating the CT, the content of radionuclides in a plant is reduced to a unit of pollution density, which neutralizes the influence of the latter and makes it possible to reveal the dependence of the accumulation of radionuclides on soil-ecological conditions, species characteristics of plants and other factors.

**Results and discussion**

As a result of a field experiment when growing black currants on soil contaminated with $^{90}$Sr when it is on the soil surface, the coefficients of the nuclide transfer to bark and wood in the soil-plant trophic chain were calculated (Figure 1).

In the studied variant of the experiment, the contact of the root system of black currant with a radionuclide located on the soil surface was close and prolonged.
When the radionuclide is located on the soil surface, the leaf of the studied plant has the highest accumulation coefficient. The difference in CT between black currant leaves and bark is 1.2 times. The leaves of black currant have the greatest pollution due not only to the intake of a nuclide from the soil, but also due to their external pollution due to falling dust torn from the surface of the field. Through the stomata from the surface of the leaf blade, the nuclide can penetrate into the leaf and increase its radioactive contamination.

In general, the CT for bark and leaves of black currant is 1.7 and 1.4 times higher than for wood, respectively. Radioactive contamination of black currant wood occurs only by the root route, while the KP is $11.4 \times 10^{-7} \text{ (Bq/kg)} / \text{ (Bq/m}^2\text{)}$.

The obtained coefficients of transfer of $^{90}$Sr from soil to plants for vegetative organs will not only make it possible to make the right decisions about the advisability of growing this crop in a specific contaminated site, but also to develop options for the disposal of contaminated plant parts.

The lowest CT of $^{90}$Sr from soil to plants at the studied location of the nuclide on the soil was determined for black currant fruits. The difference in CT in the fruits of black currant and bark, wood, foliage of this plant, respectively, was 5.4; 3.9; 6.6 times. Due to the fact that the fruits of black currant are used for food, the established fact is important for making a forecast and recommendations on the further use of the contaminated area for the needs of the national economy. In general, after the performed experiment and the calculated CT of $^{90}$Sr from soil to plants, it can be argued that this berry shrub can be used when growing in an urban zone.

When making a forecast about the option of using a radioactively contaminated area, one should take into account the CT of the nuclide from soil to plants. But it can only be applied to the environmental and soil conditions in which it was obtained. For other regions, more research should be done.

When growing cherry plum on soil contaminated with $^{90}$Sr when it was on the soil surface, experimental material was obtained and the coefficients of the transition of the nuclide into bark and wood in the “soil-plant” trophic chain were calculated (Figure 2).
Figure 2. Coefficients of transfer from soil to plant (cherry plum) $^{90}\text{Sr}$ at its location on the soil surface

In the studied version of the experiment, the contact of the cherry plum root system with the radionuclide located on the soil surface was at first close, but later the close contact decreases, since the root system penetrates deep into the depths, and the nuclide remains on the soil surface.

With the surface location of the radionuclide on the soil in cherry plum, the highest transfer coefficient was recorded for leaves. The difference in CT between cherry plum leaves and bark is 1.4 times. Cherry plum leaves are located in the crown of a tree, nevertheless, their contamination can occur due to the ingress of radioactive dust torn from the surface of the contaminated soil. This additional variant of leaf contamination should be taken into account and, using various options for agricultural technology, reduce its likelihood.

In general, the CT of $^{90}\text{Sr}$ from soil to plants for the bark and leaves of cherry plum is 1.5 and 2.0 times higher than for wood, respectively. Radioactive contamination of cherry plum wood occurs only by the root route, while the KP is $19.2 \times 10^{-7} \text{ (Bq/kg)/(Bq/m2)}$.

The smallest CT of $^{90}\text{Sr}$ from soil to plants at the studied location of the nuclide on the soil was determined for cherry plum fruits. The difference in CT in cherry plum fruits and bark, wood, foliage of this plant, respectively, was 3.9; 2.7; 5.4 times. Cherry plum fruits are grown in order to be used for food or to prepare offal. Therefore, the established fact on the CT is important for making a forecast and recommendations on the further use of the contaminated area for growing this woody plant.

The obtained transfer coefficients for vegetative organs will not only make it possible to make the right decisions about the advisability of growing this crop on a specific contaminated site and develop options for the disposal of contaminated parts of the plant, but also to give recommendations on the possible use of the territory for industrial and civil construction.

As a result of the experimental studies performed and the calculated CT, it became possible to determine the difference in the coefficient of $^{90}\text{Sr}$ transfer from the soil to the vegetative and generative organs of the studied plants (Fig. 3).

Coefficients of transfer of $^{90}\text{Sr}$ from soil to vegetative and generative organs of cherry plum are higher than for black currant. The difference in CT for bark between cherry plum and black currant was 1.8 times, for wood - 1.7 times, for foliage - 2.4 times and for fruits - 2.5 times.
As a result of the experiment performed, it was found that over the entire research period (8 years) in the first years of research in the vegetative and generative organs of the cherry plum an intense accumulation of a nuclide occurs, then in the dynamics of observations it decreases.

The content of the nuclide in the vegetative and generative organs of black currant also gradually increases during the first part of the study period, but later on, part of the roots goes deep into the soil, therefore, the intensity of accumulation of the nuclide decreases.

Cherry plum and black currant are grown for the purpose of obtaining fruits. As a result of the experiment, it was found that when the nuclide is located on the soil surface, the intensity of its accumulation in cherry plum fruits is higher than in black currant. The calculated CT of $^{90}$Sr from the soil to the fruits of cherry plum and black currant, when the radionuclide is located on the soil surface, are shown in Figure 3.

**Summary**
1. The calculated transfer coefficients (CT) for the studied plants allow us to predict the pollution of their vegetative and generative organs at a known density of radioactive contamination of the territory.
2. For the leaves of black currant and cherry plum, the highest $^{90}$Sr CT from soil to plants was determined in comparison with other vegetative organs.
3. The smallest CT of $^{90}$Sr from soil to plants was determined for fruits of black currant and cherry plum.
4. In general, for the vegetative and generative organs of cherry plum, CT of $^{90}$Sr from soil to plants is higher than for black currant.
5. With a superficial location of the nuclide on the soil, cherry plum plants are more suitable for land reclamation than black currants.

**References**
[1] Ipatiev V A 1999 Forest Person (Chernobyl, Gomel) 454.
[2] Melchenko A I, Pogorelova V A 2016 Dependence of the migration of radionuclides in the fruit cenosis in the soil horizon of leached chernozem on the depth of their occurrence Bulletin of the Altai State Agrarian University 8 (142) 54-60.
[3] Melchenko A I, Melchenko V A, Melchenko E A 2012 Efficiency of cleaning agricultural plants from radioactive contamination depending on the method of irrigation with water containing radionuclides Proceedings of the Kuban State Agrarian University 1 (34) 166-173.
[4] Melchenko A I, Melchenko V A, Melchenko E A 2011 Accumulation of radionuclides in agricultural crops depending on the time of their contact with plants Proceedings of the Kuban State Agrarian University 4 (31) 157-162.
[5] Melchenko A I, Melchenko V A, Melchenko E A 2012 Accumulation of radionuclides in agricultural plants depending on the physicochemical properties of radionuclides Proceedings of the Kuban State Agrarian University 1 (34) 91-99.

[6] Shcheglov A I 2000 Biogeochemistry of technogenic radionuclides in forest ecosystems (Moscow) 268.

[7] Yakushev V I 1982 Fruit growing (Moscow, Kolos) 415.

[8] Kolesnikov V A 1979 Fruit growing (Moscow, Kolos) 415.

[9] Simakin A I 1988 Fertilizer, soil fertility and harvest (Krasnodar) 270.

[10] Tarasenko B I 1981 Improving the fertility of soils in the Kuban (Krasnodar) 146.

[11] Dospekhov B A 1968 Field experiment technique (Moscow, Kolos) 336.