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Variability of the element composition of *Pentaphylloides fruticosa* vegetable samples during long-term storage

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Abstract

The content and composition of the elements of the *Pentaphylloides fruticosa* vegetable samples have been first studied by the method of X-ray fluorescence analysis, using synchrotron radiation from the VEPP-3 storage ring (SRXRF method), in connection with storage periods. It has been established that the element composition of the *P. fruticosa* samples, analyzed just after sampling, and that of the samples, stored for 10 years, were almost the same. Most stable are the concentrations of K, Ca, Mn, Fe, Co, Cu, Zn, and Sr. The content of Br in the long-stored samples decreased 2-4 times as compared with that of the freshly collected samples.

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Keywords: X-ray analysis with synchrotron radiation, *Pentaphylloides fruticosa,*element composition, radionucleotide contamination, long-term storage

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1. Introduction

The reliability of the results from the analysis of samples depends much on the preliminary preparation of vegetation material, storage conditions, and periods, the methods of investigation.

The advantages of the X-ray analysis, using synchrotron radiation include nondisruptiveness, panoramic, the possibility to use small samples, relatively easy sample preparation, the possibility of simultaneous determination of many elements with high sensitivity, fair accuracy and reproducibility (Baryshev et al., 1991; Mazalov, 2003; Daryin, Rakshun, 2013). In this case, a comparatively rare application of the SR XRF method for analyzing vegetation material is related to the insufficient number of categorized samples that serve references for the analysis by "external standard" method. Therefore, the problems of the reliability of the long-stored vegetation samples are important for both using and researching the optimal standards and the analysis of herbarium samples.

In 2005, the surface organs of *P. fruticosa*, planted in the gradient of ^{90}Sr and ^{137}Cs radionuclide contamination, were sampled and the content of chemical elements was studied in some of these just after sampling (Chankina et al., 2007). Some samples were left for storage. In 2015, the samples, stored for 10 years, were analyzed.

The goal of the work was to perform a comparative analysis of chemical elements in the freshly collected and in the long-stored samples of *Pentaphylloides fruticosa* to elucidate the variability of the content and composition of elements in the samples by the SR XRF method.

2. Experimental

Experiment on the study of the effect of the long-term storage of the *P. fruticosa* samples on the variability of the element analysis results was carried out using the samples collected over the territory of the East-Ural radioactive trace (EURT) formed in 1957 due to the accident in the "Mayak" Production Association.

In the gradient of ^{90}Sr and ^{137}Cs radionuclide contamination there are three plots, located in the front part of the trace (impact), and for comparison, one conditionally "background" plot in the observation area where the three-year young plants were planted in 2004. The mean density of the radioactive contamination of soil by ^{90}Sr decreases from 133.5 MBk/m^2 for the most contaminated plot 1 to 0.07 MBk/m^2 for plot 3, by ^{137}Cs – from 8.4 to 0.2 MBk/m^2, which is four-two orders of magnitude higher than the background level (Khramova et al., 2013). The density of the radioactive contamination of soil by ^{90}Sr and ^{137}Cs over the peripheral regions of the observation area of Federal State Unitary Enterprise «Mayak» Production Association corresponds to the regional "background" (global) values and amounts to 2.0 kBk/m^2 for ^{90}Sr and 4.0 kBk/m ^{2} for ^{137}Cs (Report on ecological safety, 2013).

We have analyzed eight samples collected from four plots in 2005 and eight samples after a 10-year storage in 2015. A total of 5–10 one-year shoots were collected (September, 2005) with each plant in each of the four test plots evenly spread throughout the crown and separated into leaves and stems; the average sample was formed for the determination of elements. The samples were not washed, and dried.

The air-dry samples of vegetation and soil (1g) were first crushed in an agate mortar and then pressed into tablets about 1 cm in diameter and with a weight of 30 mg (with a surface density of 0.04 g/cm^2). The elements were determined by the SRXRF method at the station of element analysis (VEPP-3 storage ring, Levichev 2016) of the Siberian Center of Synchrotron and Teraherz Radiation, INP SB RAS. The working mode during the measurements of 2005 was as follows: for elements with the atomic number Z = 16-39 the energy of exciting monochromatized radiation E_{mon} = 21 keV. In 2005, the samples were measured at the exciting radiation energy of 23 keV, and the time of each measurement varied from 300 to 500s for vegetation samples. The monochromatization of synchrotron radiation was carried out using a monochromator based on a silicon crystal of the "butterfly" type with working planes (111). The fluorescence radiation was recorded by means of a PentaFET (Oxforf Instruments) detector with a power resolution of ~135 eV (in Kα line Fe - 5.9 keV). The basic characteristics of the experimental station and the methodic aspects of the work are described by Daryin and Rakshun (2013) and on-line