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Analysis of Distribution of Radionuclides in Various Organs of *Taraxacum officinale* Web., Which Grows in Rock Waste Disposal Areas of Coal Pits in Kuznetsk Basin

[1]*Irina Nikolaevna Egorova* and [1,2]*Olga Alexandrovna Neverova*
[1]Institute of Human Ecology SB RAS, Russia
[2]Kemerovo Institute of Food Science and Technology, Kemerovo, Russia

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Abstract: The regularities of natural (K-40, Th-232, Ra-226) and artificial (Sr-90 and Cs-137) radionuclides accumulation by embryonic soils and various organs of Taraxacum officinale Web. in rock waste disposal areas of the Kedrovsky coal pit in the Kuznetsk Basin were studied. The K-40 natural radionuclide causes major radioactivity of embryonic soils at rock waste disposal areas – its share in the total radioactivity is 91% and the share of artificial radionuclides in embryonic soils is about 1%. The absence of contamination of embryonic soils at rock waste disposal areas with the Sr-90 and Cs-137 artificial radionuclides was revealed. It was determined that the largest values of K-40 weight-average specific activity are typical of the explored organs of Taraxacum officinale Web. It was revealed that the content of the Sr-90 and Cs-137 artificial radionuclides in organs of Taraxacum officinale Web. is ranked as follows: leaves > roots > inflorescences. Cs-137 is more accumulated by Taraxacum officinale Web. and is 1.6...1.8 times larger than the specific activity of Sr-90. The ratios of Sr-90 and Cs-137 accumulation by various organs of Taraxacum officinale Web. are less than unity, which indicates that the plant does not accumulate these radionuclides. Hygienic assessment of the content of artificial radionuclides (Sr-90 and Cs-137) in various organs of Taraxacum officinale Web., which grows at the rock waste disposal area of the Kedrovsky coal pit, did not reveal excessive radiation in conformance with the Sanitary Rules and Regulations (SanPin) 2.3.2.1078-01 developed for plant-based nutritional supplements and is not dangerous for consumers' health.

Key words: Rock waste disposal areas of coal pits · Radionuclides · Herbs · Hygienic assessment

INTRODUCTION

Over the last years, spontaneous collection of medicinal herbs in recreational areas of industrial centers has become a frequent practice [1]. It is especially topical for the Kuznetsk Basin where there are over 50 mines and coal pits. The total square of soils disturbed by coal mining is more than 100 thousand hectares. Over the last years, nearly 20 thousand hectares have been reclamated and the remaining man-caused areas are naturally recovering as a consequence of delivering seeds from nearby territories [2, 3].

The performed analysis of literary sources and our own study have revealed that a large number of herbs, which are applied in practical medicine, grow at the rock waste disposal areas of coal pits in the Kuznetsk Basin [3, 4]. However, the coal mining wastes (disposal areas, terricones) can be the sources of excessive radiation background [5].

Radionuclides (RN) are the most dangerous source of natural environment contamination. Herbs used as raw material for production of medicines are one of the sources of RN penetration into the human organism [6, 7].

It is a known fact that the amount of RN accumulated by plants depends on the properties of radionuclides, their forms, in which they are represented in soil, physical and chemical parameters of soil, climate conditions and biological peculiarities of plants [8-16].

In this view, research of resource potential of herbs, which grow at the rock waste disposal areas of coal pits in the Kuznetsk Basin and assessment of their safety are a topical issue. Such researches will allow to assess the possibility in principle of introduction and industrial collection of herbal raw materials (HRM) at the disposal areas of coal pits in the Kuznetsk Basin for their use in medical practice; expand the range of harvested HRM in the region, on the one hand; and commercialize soils disturbed by coal mining, on the other hand.

Corresponding Author: Neverova, Kemerovo Institute of Food Science and Technology,
47 Stroiteley Boulevard, 650056 Kemerovo, Russia.

The purpose of this research is to study the regularities of accumulation of natural (K-40, Th-232, Ra-226) and artificial (Sr-90 and Cs-137) radionuclides by embryonic soils and various organs of Taraxacum officinale Web. growing in the rock waste disposal area of the Kedrovsky coal pit in the Kuznetsk Basin.

MATERIALS AND METHODS

The research was carried out at the Yuzhny rock waste disposal area of the Kedrovsky coal pit. The total square of the Yuzhny disposal area is 599.3 ha and the height is 58 m. The terrain is flat to sloping. The rocks of the disposal area are represented by sandstone (60%), aleurolit (20%), argillite (15%), sandy clay and clay (5%). Coarse aggregates (3 to 10 mm and bigger) are the dominant fraction, smaller particles are less. Embryonic soils are characterized by alkaline reaction (pH of the water extract is 7.1-7.7), average provision with humus (3.5%), low provision of mobile forms of phosphorus and nitrogen (1.7- 7.0 mg/kg). The exchange potassium content is slightly below the normal rate (125 mg/kg).

Various organs of common dandelion (Taraxacum officinale Web.) (roots, leaves, inflorescences and conjugated embryonic soils, collected during 2010-2012) were the objects of the research.

Common dandelion (Taraxacum officinale Web.) is a herbaceous perennial plant of the Asteraceae family, which is one of the first plants to inhabit rock waste disposal areas. Practical medicine uses dandelion's roots, which contain polysaccharides (inuline), triterpene compounds, sterols (taraxerol, taraxol, stigmasterol), flavonoids, fatty oil, etc. Over the last years, aboveground organs of dandelion attracted the attention of scientists, which organs are widely used by folk medicine both in our country and abroad [17, 18].

Raw material was collected on sunny days, according to common practice. Only those raw materials were collected, which did not have any visible damages. Plant samples were selected within 0.25 – 1 sq. m. grounds, located on top of planned disposal areas. Average sample was prepared by quartering in compliance with the State Standard GOST 24.027.0-80. Allowance in the weight of the average sample was ± 10 % at maximum. Embryonic soils conjugated with plants were collected from the root zone (A 0-10 cm) by common methods.

Study of the radionuclide content of embryonic soils and herbal raw materials was carried out at Kemerovsky, the accredited test center of agrochemical service. Radioactivity of the studied samples was determined with the Progress spectrometric center designed for measuring the activity of alpha-, beta- and gamma-emitting nuclides, which was certified by the All-Russian Scientific Research Institute of Physical-Technical and Radiotechnical Measurements on 22.12.03 [19].

In order to assess the movement of Sr-90 and Cs-137 in the soil – plant system, the accumulation ratio (C_a) was calculated, which is the ratio between concentration of an element in various organs of a plant and the presence of the element in soil.

Analyses were made on a threefold-repetition basis; the experimental data were processed according to standard statistic methods.

RESULTS AND DISCUSSION

The analysis of the received results indicates that the content of natural and artificial RN in embryonic soils is more than in underground and aboveground organs of dandelion. At that, main radioactivity of embryonic soils is caused by natural RN, especially by K-40 with its 91% contribution to the overall radioactivity. The share of artificial RN in embryonic soils is about 1% (Table 1).

Table 1: RN content in Taraxacum officinale Web. and conjugated embryonic soils within a rock waste disposal area

	Specific activity, Bq/kg				
Sample	Sr-90	Cs-137	K-40	Th-232	Ra-226
Embryonic soils (root zone)	1.06±0.11	2.64±0.24	487.83±8.38	23.47±0.71	21.83±0.70
roots	0.587±0.04	1.054±0.05	17.70±0.72	1.577±0.07	1.344±0.06
leaves	0.628±0.09	1.089±0.03	31.50±0.73	1.663±0.06	1.49±0.05
inflorescences	0.560±0.09	0.905±0.07	16.45±0.20	1.613±0.16	1.373±0.16
Maximum allowable concentration:					
- herb-based nutritional supplements	200	100	-	-	-
- Herbal raw materials (grass, bark, underground stem, fruits) [20]	400	200	-	-	-
Average regional level [21]	20-25	20.1	-	-	-
Background rates of natural radionuclides [2]			40-1000	40	40

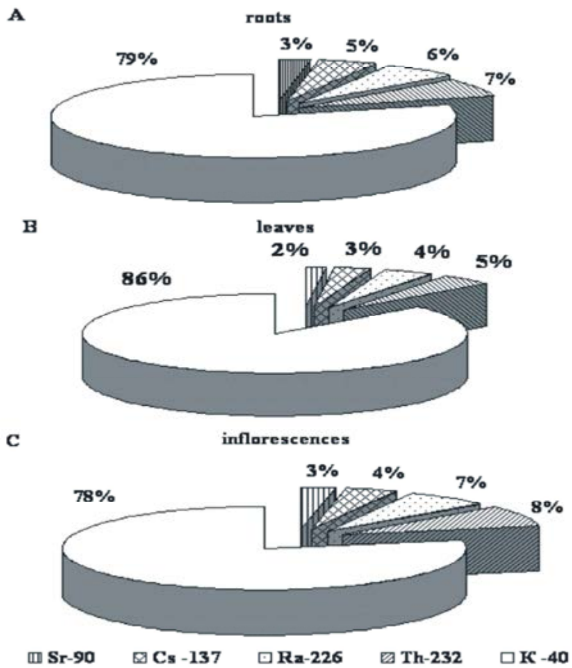

Fig. 1: Comparative assessment of the content of natural and artificial radionuclides in vegetative organs of Taraxacum officinale Web.

The received results indicate absence of embryonic soil contamination with artificial RN at the disposal area – the Sr-90 and Cs-137 content is much lower than the regional average accumulation degree for the soils of the Tomsk region's south, which are adjacent to the Kemerovo region [21]; and the degree of natural RN is within the background rates of radioactive elements content in the Earth crust [2].

Analysis of natural RN content in plants showed that the studied organs of common dandelion typically have the largest values of weight-average specific activity of K-40. The K-40 share in the overall radioactivity is: 79% for roots, 86% for leaves and 78% for inflorescences (refer to Figure 1). This proves the requirement of K-40 for normal growth of plants. Similar results were received by D.R. Orudzheva et al. [22].

Absolute values of specific activity of other natural RN (Th-232, Ra-226) are less than of K-40. According to the Table 1 and Figure 1 data, the specific activity of Th-232 and Ra-226 is 8-5% and 4-7% accordingly of the overall radioactivity, with maximum content in inflorescences.

Comparative assessment of accumulation of artificial RN by Taraxacum officinale Web. proved that accumulation of Cs-137 is more extensive and is 1.6…1.8 times more than the specific activity of Sr-90 in inflorescences, leaves and roots. However, a similar tendency has been revealed with respect to distribution of artificial RN among organs of plants – the content of Sr-90 and Cs-137 in the dandelion's organs is ranked as follows: leaves > roots > inflorescences.

The Figure 2 data show that the ratio of accumulation (Ñà) of Sr-90 and Cs-137 by various organs of common dandelion is less than unity – 0.56 and 0.40 for roots, 0.60 and 0.41 for leaves, 0.54 and 0.34 for inflorescences, accordingly. This indicates that the plant does not accumulate these RN.

Hygienic assessment of Taraxacum officinale Web. materials proved that the specific activity of the Sr-90 and Cs-137artificial RN in various organs of plants (roots, leaves, inflorescences) does not exceed the maximum allowable concentration as per the Sanitary Rules and Regulations (SanPin) 2.3.2.1078-01, developed for nutritional supplements based on herbal and plant raw materials (grass, bark, underground stem, fruits) (refer to Table 1) and is not harmful for consumers.

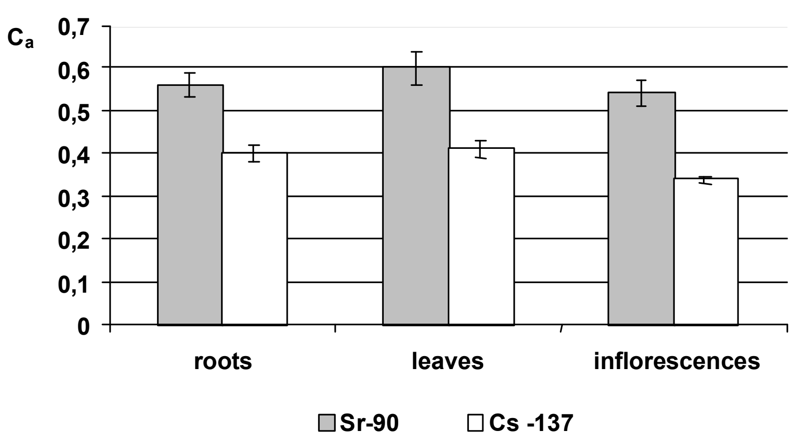

Fig. 2: Ratios of artificial radionuclides accumulation by various organs of *Taraxacum officinale* Web.

CONCLUSION

Experimentally, it was proved that the K-40 natural radionuclide causes major radioactivity of embryonic soils at the rock waste disposal areas of the Kedrovsky coal pit – its share in the total radioactivity is 91% and the share of artificial RN in embryonic soils is about 1%.

The received results indicate absence of embryonic soil contamination with artificial RN at disposal areas – the Sr-90 and Cs-137 content is much lower than the regional average accumulation degree for soils; and the degree of natural RN is within the background rate of radioactive elements' content in the Earth crust.

It was revealed that the largest values of weight-average specific activity of K-40 are typical of the explored organs of Taraxacum officinale Web. Its share of the overall radioactivity is: 79% for roots, 86% for leaves, 78% for inflorescences, which proves that K-40 is required for normal growth of plants.

A similar tendency has been revealed with respect to distribution of artificial RN among organs of plants – the content of Sr-90 and Cs-137 in the organs of Taraxacum officinale Web. is ranked as follows: leaves > roots > inflorescences. Cs-137 is more accumulated by Taraxacum officinale Web. and is 1.6...1.8 times larger than the specific activity of Sr-90.

The ratios of accumulation of Sr-90 and Cs-137 are less than unity for various organs of Taraxacum officinale Web., which indicates that the plant does not accumulate these RN.

Hygienic assessment of the content of artificial RN (Sr-90 and Cs-137) in various organs of Taraxacum officinale Web., which grows at the Yuzhny disposal area of the Kedrovsky coal pit, did not reveal excess radiation in conformance with the Sanitary Rules and Regulations (SanPin) 2.3.2.1078-01 developed for plant-based nutritional supplements and is not dangerous for consumers' health.

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