

## Assessment of radionuclide contamination of medicinal plant raw materials in the central black earth on the example of yarrow grass

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#### SUMMARY

The Voronezh region is traditionally the most important region of plant growing and agriculture. The aim of the study was to study the contamination of medicinal plant materials by natural and artificial radionuclides in the Voronezh region using the example of common yarrow collected throughout the region in urban and agroecosystems experiencing various anthropogenic influences. As part of the study, the activity of artificial and natural radionuclides (strontium-90, cesium-137, potassium-40, thorium-232, radium-226) was determined in 36 samples of yarrow grass and the upper layers of soils on which the plants grew. All samples meet the existing requirements of the regulatory documentation for the activity of radionuclides. To assess the accumulation of radionuclides by yarrow from soils, the accumulation coefficients were used. The average value of the accumulation coefficient of strontium-90 was 0.59; in different samples of the region, it varied from 0.48 to 0.74. The accumulation coefficients of cesium-137 ranged from 0.86 to 1.15 with an average of 1.02. For thorium-232, the average accumulation coefficient in the herb of yarrow is 0.13 and took values in the studied samples from 0.07 to 0.31. For potassium-40, the average accumulation coefficient in the raw material was 1.04 and varied from 0.86 to 1.12, and for radium-226 - 0.59, varying from 0.51 to 0.81. Thus, cesium-137 and potassium-40 accumulate to the greatest extent in the herb of yarrow. in different samples of the region, it varied from 0.48 to 0.74. The accumulation coefficients of cesium-137 ranged from 0.86 to 1.15 with an average of 1.02. For thorium-232, the average accumulation coefficient in the herb of yarrow is 0.13 and took values in the studied samples from 0.07 to 0.31. For potassium-40, the average accumulation coefficient in the raw material was 1.04 and varied from 0.86 to 1.12, and for radium-226 - 0.59, varying from 0.51 to 0.81. Thus, cesium-137 and potassium-40 accumulate to the greatest extent in the herb of yarrow. in different samples of the region, it varied from 0.48 to 0.74. The accumulation coefficients of cesium-137 ranged from 0.86 to 1.15 with an average of 1.02. For thorium-232, the average accumulation coefficient in the herb of yarrow is 0.13 and took values in the studied samples from 0.07 to 0.31. For potassium-40, the average accumulation coefficient in the raw material was 1.04 and varied from 0.86 to 1.12, and for radium-226 - 0.59, varying from 0.51 to 0.81. Thus, cesium-137 and potassium-40 accumulate to the greatest extent in the herb of yarrow. For potassium-40, the average accumulation coefficient in the raw material was 1.04 and varied from 0.86 to 1.12, and for radium-226 - 0.59, varying from 0.51 to 0.81. Thus, cesium-137 and potassium-40 accumulate to the greatest extent in the herb of yarrow.

**Key words:** Central Black Earth Region, common yarrow, radionuclides, accumulation factor.

#### RESUME

The Voronezh region traditionally is the most important region of crop production and agriculture. A research objective was pollution studying by natural and artificial radionuclides of medicinal vegetable raw materials in the Voronezh region on the example of a yarrow ordinary, collected across all territory of the area in urbo- and the agroecosystems which are influenced by various anthropogenic influence. Within carrying out a research in 36 exemplars of a grass of a yarrow ordinary and high layers of soils on which plants grew, the activity of artificial and natural radionuclides (strontium-90, cesium-137, potassium-40, thorium-232, radium -226) was defined. All exemplars meet the available requirements of standard documentation on activity of radionuclides. We used storage coefficients to estimate accumulation of radionuclides from soils in yarrow ordinary. Mean value of a storage coefficient of strontium-90 was 0.59, in different exemplars of area it varied from 0.48 to 0.74. Storage coefficients of cesium-137 fluctuated from 0.86 to 1.15 at an average 1.02. For thorium-232 the average storage coefficient bird's is equal in a grass of the mountaineer 0.13 and accepted values in the studied exemplars from 0.07 to 0.31.

For a potassium-40 the average storage coefficient in raw materials was 1.04 and varied from 0.86 to 1.12, and for radium-226 - 0.59 at variation from 0.51 to 0.81. Thus, cesium-137 and potassium-40 are more accumulated in grass of a yarrow ordinary.

Keywords: Central Black Earth, yarrow ordinary, radionuclides, storage coefficient.

#### INTRODUCTION

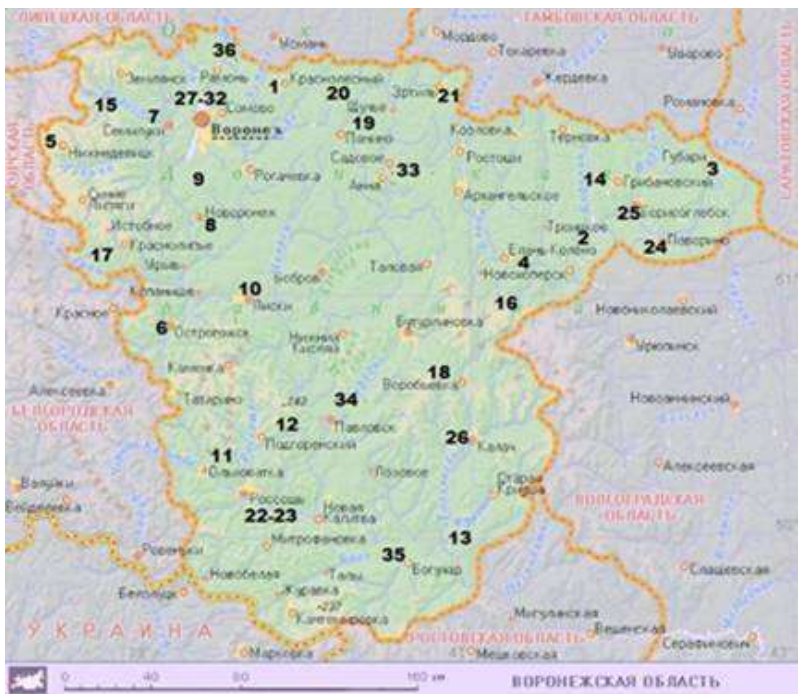
Urbanization is the most important socio-ecological problem of the modern world. In the process of growth and formation of cities, the natural ecosystems of the territories occupied by them and those adjacent to them are gradually changing, while new anthropogenic ecosystems are formed with their own peculiarities of anthropogenic impact, characterized by a change in the composition of atmospheric air, soils and water bodies [1, 2].

The Voronezh region is traditionally the most important region of plant growing and agriculture. However, the development of mineral resources, active chemicalization in agriculture, the consequences of the Chernobyl accident have actualized the issue of supplying the food industry with safe and effective plant raw materials [3, 4]. Poor quality plant raw materials and products obtained from it are important sources for the intake of various ecotoxins, in particular radionuclides, into the human body [5, 6].

The purpose of the research is to study pollution by natural and artificial radionuclides of medicinal plant raw materials of the common yarrow of the Voronezh region, collected throughout the region in urban and agroecosystems experiencing various anthropogenic influences.

#### MATERIALS AND METHODS

The choice of territories for collecting samples on the territory of the Voronezh region - the average region of the Central Black Earth Region - is due to the peculiarities of human impact (Fig. 1): industrial chemical enterprises (Fig. : 23, 24, 28); combined heat and power plant (CHP) (Fig. : 27); Nuclear power plant (NPP) (Fig. : 8); airport (fig: 30); Voronezh street (Leningradskaya street) (Fig. : 31); high-voltage power lines (VLE) (Fig. : 9); city reservoir (Fig. : 29); small towns with developed infrastructure (Borisoglebsk (Fig: 25), Kalach (Fig: 26); zone of large deposits of sulfide copper-nickel ores (Fig: 4); areas located in the zone of contamination as a result of the accident at the Chernobyl nuclear power plant ( fig. : 5-7), areas of active agricultural activity (fig. : 10-22). As a comparison (background), protected areas were selected (Voronezh Natural Biosphere Reserve (Fig. : 1) and Khopersky State Natural Reserve (Fig. : 2, 3)). Also, the sampling was carried out along roads of varying degrees of congestion and in different natural zones: forest zone (Ramonsky district) (Fig: 32) - highway M4 "Don", forest-steppe zone (Anninsky district (Fig. : 33)) - highway A144 " Kursk-Saratov ", steppe zone (Pavlovsky district) (Fig. 34) - M4 Don highway, low-traffic country road (Bogucharsky district) (Fig. 35) and railway tracks (Ramonsky district) (Fig. : 36).



Rice. 1. Card of procurement of medicinal plant materials (figures are deciphered above)

The object of the study was the herb of yarrow (*Achillea millefolium* L.). Yarrow is a perennial synanthropic plant that grows everywhere in the Voronezh region. To study the mechanism of contamination of plant materials, samples of the upper soil layers (from a depth of 0–10 cm from the surface) were taken for analysis.

Determination of the content of artificial and natural radionuclides in the grass of yarrow and in the upper soil layers was carried out using the spectrometer-radiometer MKGB-01 "RADEK". The activity of natural (potassium-40, thorium-232, radium-226) and basic artificial (strontium-90, cesium-137) radionuclides was studied [7].

To assess the possibility of accumulation of various radionuclides from the soil by the yarrow grass, the accumulation coefficient (KN) was used, calculated by the formula:

$$KH = \frac{\text{Raw material}}{\text{Soil}} \quad (1),$$

where  $C_{\text{raw material}}$  - activity of a radionuclide in a sample of herb yarrow, Bq / kg;  
WITHthe soil - activity of a radionuclide in the upper soil layers, Bq / kg [7].

RESULTS AND ITS DISCUSSION

The determined indicators of the activity of radionuclides in the herb of yarrow are given in table. 1.

Table 1

Activity of radionuclides in samples  
herb yarrow (*Achillea millefolium* L.)

P / p No.	Collection area	Radionuclide activity, Bq / kg				
		Strontium-90	Cesium-137	Thorium-232	Potassium-40	Radium-226
1.	Voronezh Biosphere Reserve	3.6	52.3	3.2	316	3.7
2.	Khopersky reserve	3.2	22.1	3.4	408	3.2
3.	Borisoglebsky district	3.0	20.4	3.6	390	2.7
4.	with. Elan-Koleno	2.8	26.7	2.6	483	3.7
5.	with. Nizhnedevitsk	5.1	47.2	5.3	415	4.4
6.	Ostrogozhsk	4.0	50.4	4.8	518	4.7
7.	Semiluki	4.1	57.7	2.6	607	5.6
eight.	Novovoronezh	3.0	59.1	3.0	491	6.2
nine.	VLE (Novovoronezh)	3.2	59.6	3.5	534	5.8
ten.	Liskinsky district	2.8	44.1	7,7	408	4.1
eleven.	Olkhovatsky district	3.4	40.5	3.2	513	5.3
12.	Podgorensky district	3.6	36.8	3.8	597	4.3
13.	Petropavlovsk district	3.2	27.8	3.4	590	6.1
fourteen.	Gribanovsky district	3.0	24.1	3.6	511	5.7
15.	Khokholsky district	4.9	53.7	2.8	621	5.2
16.	Novokhopersky district	3.4	23.8	3.7	512	5.6
17.	Repyevsky district	4.7	53.5	5.6	529	6.3
eighteen.	Vorobievsky district	3.2	18.4	6,7	438	6,7
19.	Paninsky district	4.0	46.3	6.2	497	5.8
twenty.	Verkhnekhavsky district	4.9	57.4	3.5	524	7.0
21.	Ertil	4.9	32.3	5.8	505	6.2
22.	Rossoshansky district	3.6	40.7	4.2	567	4.4
23.	Near OJSC "Minudobreniya"	3.7	42.1	4.3	583	4.9
24.	Near LLC "Bormash" (Povorino)	3.5	25.3	4.6	415	4.5
25.	Borisoglebsk	3.2	22.1	4.5	455	5.7
26.	Kalach	3.7	27.5	3.1	555	5.2
27.	Near TPP VOGRES (Voronezh)	3.6	78.6	3.2	941	6.8
28.	Near OOO Sibur (Voronezh)	4.0	75.3	8.2	948	7.2
29.	Along the reservoir (Voronezh)	4.0	76.1	8.8	882	7,7
thirty.	Near the airport	3.0	52.7	4.2	418	4.2
31.	Street in Voronezh (Leningradskaya st.)	4.9	75.1	7.6	715	7.0
32.	Along the M4 highway (Ramonsky district)	4.3	55.6	6.5	406	4.1
33.	Along the A144 highway (Anninsky district)	3.1	56.6	7,7	442	3.0
34.	Along the M4 highway (Pavlovsky district)	2.8	44.8	6.4	376	4.1
35.	Along the non-speed road	3.4	23.4	7.6	407	5.2
36.	Along the railroad	5.3	35.9	6.8	380	4.9
Mean		3.7	44.1	4.9	525	5.2
PDS		200	400	-	-	-

The results of the study of plant raw materials showed the compliance of the samples of raw yarrow with the requirements of regulatory documents on the content of artificial radionuclides [7]. The content of natural radionuclides in plant raw materials is currently not standardized.

To assess the accumulation of artificial and natural radionuclides from soils

Coefficients of accumulation were calculated by common yarrow (Table 2).

The average value of the accumulation coefficient of strontium-90 was 0.59, in different samples of the region it varied from 0.48 to 0.74. The values of the accumulation coefficient of cesium-137 ranged from 0.86 to 1.15 with an average of 1.02. For thorium-232, the average accumulation coefficient in the herb of yarrow is 0.13 and took values in the studied samples from 0.07 to 0.31. For potassium-40, the average accumulation coefficient in the raw material was 1.04 and varied from 0.86 to 1.12, and for radium-226 - 0.59, varying from 0.51 to 0.81.

Thus, cesium-137 and potassium-40 accumulate to the greatest extent in the herb of yarrow. The absorption of cesium-137 and potassium-40 from the soil by the plant is associated with the behavior of exchangeable potassium. It is known that plants that accumulate high concentrations of potassium usually also contain significant amounts of cesium-137 [8]. Potassium-40 accumulates in plant organisms similarly to its non-radioactive isotopes and in concentrations directly proportional to those in nature. Potassium and cesium are elements of the same group of the periodic system, they have the same mechanisms of entry from the soil into the plant and transport in its tissues. Thus, the accumulation of cesium-137 in plant organs is closely related to potassium, including potassium-40.

#### CONCLUSIONS

1. We analyzed 36 samples of yarrow grass collected in districts of the Voronezh region, different in terms of the level of anthropogenic impact, for the activity of natural and artificial radionuclides contained in them.
2. All tested samples met the requirements of regulatory documents, which allows us to consider the medicinal plant raw materials in the region as radiation safe.
3. It was revealed that, to a greater extent, the herb yarrow accumulates from soils cesium-137 and potassium-40 (the average accumulation factors were 1.02 and 1.04 for cesium-137 and potassium-40, respectively).
4. Strontium-90, radium-226 are accumulated by common yarrow in moderate degree (average accumulation factors for both radionuclides were 0.59), and thorium-232 - to an insignificant degree (average accumulation coefficient - 0.13).
5. The obtained data should be taken into account when preparing the medicinal vegetable raw materials in areas with unexplored radiation conditions.

#### LITERATURE

1. Dyakova, N.A. Efficiency and radiation safety of the medicinal plantain plantain, collected in the Central Chernozem region / N.A. Dyakova // Development and registration of medicines. - 2018. - No. 3 (24). - pp. 140-143.
2. Dyakova, N.A. Study of radionuclide contamination of medicinal raw materials Voronezh region on the example of plantain leaves and stinging nettle leaves / N.A. Dyakova, A.I. Slivkin, S.P. Gaponov // Bulletin of Voronezh State University. Series: Chemistry, Biology, Pharmacy. - 2017. - No. 2 - P.148-154.
3. Dyakova, N.A. Assessment of radionuclide contamination of medicinal plant raw materials of the Voronezh region on the example of burdock roots / Dyakova N.A., Slivkin A.I., Gaponov S.P., Samylin I.A. // Bulletin of the Voronezh State University. Series: Chemistry. Biology. Pharmacy. - 2016. - No. 3. - pp. 110-115.
4. Velikanova, N.A. Environmental assessment of the state of medicinal plant raw materials (for example Polygonum aviculare L. and Plantago major L.) in the urban conditions of the city of Voronezh and its environs: author. dis. ... Cand. biol. nauk / N.A. Velikanova. -

Voronezh: Voronezh State University Publishing House, 2013. -- 21 p.

5. Tereshkina, O.I. Assessment of the risk of radionuclide contamination of medicinal vegetable raw materials / O.I. Tereshkina, I.P. Rudakova, I.A. Samylina // Pharmacy. - 2011. - No. 7. - P.3-6.

6. Dyakova, NA Analysis of the relationship between the accumulation of pollutants and principal groups of biologically active substances in medicinal plant raw materials using knotweed (*Polygonum aviculare* L.) and broadleaf plantain (*Plantago major* L.) leaves as examples / NA Dyakova, AI Slivkin, SP Gaponov, AA Myndra, IA Samylina // Pharmaceutical Chemistry Journal. - 2015. - T.49. - No. 6. - 384-387. DOI: 10.1007 / s11094-015-1289-6

7. State Pharmacopoeia of the Russian Federation. Edition XIV. Volume 2. - M.: FEMB, 2018. - 2303-2323 p.

8. Velikanova, N.A. Eco-assessment of medicinal plant raw materials in the urban conditions of the city of Voronezh / N.A. Velikanova, S.P. Gaponov, A.I. Slivkin. - LAMBERT Academic Publishing, 2013. - 101-112 p.

## REFERENCES

1. D'yakova NA EHffektivnost' i radiacionnaya bezopasnost' lekarstvennogo rastitel'nogo syr'ya podorozhnika bol'shogo, sobrannogo v Central'nom Chernozem'e [Effectiveness and radiation safety of medicinal vegetable raw materials of a plantain big, collected in the Central Black Earth]. Razrabotka i registraciya lekarstvennyh sredstv, 2018, no3, pp. 140-143.

2. D'yakova NA, Slivkin AI, Gaponov SP. Izuchenie radionuklidnogo zagryazneniya lekarstvennogo syr'ya Voronezhskoj oblasti na primere list'ev podorozhnika bol'shogo i list'ev krapivy dvudomnoj [Studying of radio nuclide pollution of medicinal raw materials of the Voronezh region on the example of leaves of a plantain big and leaves of a nettle a two-blast furnace]. Vestnik Voronezhskogo gosudarstvennogo universiteta. Seriya: Himiya. Biologiya. Farmaciya, 2017, no 2, pp. 148-154.

3. D'yakova NA, Slivkin AI, Gaponov SP, Samylina IA Ocenka radionuklidnogo zagryazneniya lekarstvennogo rastitel'nogo syr'ya Voronezhskoj oblasti na primere kornej lopuha obyknovennogo [Assessment of radio nuclide pollution of medicinal vegetable raw materials of the Voronezh region on the example of roots of a burdock ordinary]. Vestnik Voronezhskogo gosudarstvennogo universiteta. Seriya: Himiya. Biologiya. Farmaciya, 2016, no 3, pp. 110-115.

4. Velikanova NA EHkologicheskaya ocenka sostoyaniya lekarstvennogo rastitel'nogo syr'ya (na primere *Polygonum aviculare* L. i *Plantago major* L.) v urbousloviyah goroda Voronezha i ego okrestnostej: avtoref. dis. ... kand. biol. nauk. [Ecological assessment of a condition of medicinal vegetable raw materials (on the example of *Polygonum aviculare* L. and *Plantago major* L.) in the urbanized conditions of the city of Voronezh and its vicinities: abstract of the thesis ... Candidate of Biology] ... Voronezh, Izd-vo VGU, 2013, 21 p.

5. Tereshkina OI, Rudakova IP, Samylina IA Ocenka riska radionuklidnogo zagryazneniya lekarstvennogo rastitel'nogo syr'ya [Assessment of risk of radio nuclide pollution of medicinal vegetable raw materials]. Farmaciya, 2011, no7, pp. 3-6.

6. Dyakova NA, Slivkin AI, Gaponov SP, Myndra AA, Samylina IA Analysis of the relationship between the accumulation of pollutants and principal groups of biologically active substances in medicinal plant raw materials using knotweed (*Polygonum aviculare* L.) and broadleaf plantain (*Plantago major* L.) leaves as examples. Pharmaceutical Chemistry Journal. 2015. T. 49. no.6. Pp. 384-387. DOI: 10.1007 / s11094-015-1289-6

7. Gosudarstvennaya farmakopeya Rossijskoj Federacii. Izdanie XIV [State pharmacopeia of the Russian Federation. Edition XIV], 2018, Vol. 2, Moscow, FEMB, 2303-2323 p.

8. Velikanova, NA, Gaponov SP, Slivkin AI Ekoocenka lekarstvennogo rastitel'nogo syr'ya v urbousloviyah g. Voronezha [Ecological assessment of medicinal vegetable raw materials

in the urbousloviyakh of Voronezh]. LAMBERT Academic Publishing, 2013, 101–112 p.

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black earth on the example of yarrow grass. Dyakova, S.P. Gaponov, A.I. Slivkin // Traditional medicine. -  
2019. - No. 4 (59). - S.48-52.

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