

UDC 615.322:574.2

<https://www.doi.org/10.34907/JPQAI.2021.45.57.002>

STUDY OF TOTAL MINERAL COMPLEX OF MEDICINAL PLANT RAW MATERIALS OF SYNANTHROPIC FLORA IN THE VORONEZH REGION

N.A. Dyakova, *Candidate of Biological Science, Associate Professor of the Department of Pharmaceutical Chemistry and Pharmaceutical Engineering, Voronezh State University, Voronezh, Russia, Ninochka_V89@mail.ru*

On the basis of ten plants, the content of the total mineral complex of medicinal plant raw materials of agro- and urban cenoses of the Voronezh region was studied. The study was provided on the example of medicinal plant raw materials harvested within the time limits according to the regulatory documentation. The most frequent excess of the standard values for the "total ash" numerical indicator was noted for samples of quinquelobate motherwort (*Leonurus quinquelobatus*) herb and common tansy (*Tanacetum vulgare*) flowers (in 16 of 51 samples), which can be explained by pubescence of these types of raw materials absorbing well the pollutants suspended in the air, as well as by sufficiently high requirements of the relevant pharmacopoeial monographs for these types of raw materials. In 15 samples of common plantain leaves out of 51 studied samples, the total content of mineral substances was also exceeded, which is caused by the large area of the leaf blade located mainly in the horizontal plane, as well as its squat growth, which creates good conditions for the deposition of dust particles on the raw material surface. The analysis of the average values of the total ash content makes it possible to build a series of reductions in the content of the total mineral complex from the analyzed types in medicinal plant raw materials, which looks as follows: leaves of common plantain (*Plantago major* L.) > leaves of stinging nettle (*Urtica dioica* L.) > knotgrass (*Polygonum aviculare* L.) herb > common

yarrow (*Achillea millefolium* L.) herb > absinthium (*Artemisia absinthium* L.) herb > quinquelobate motherwort (*Leonurus quinquelobatus* Gilib.) herb > flowers of common tansy (*Tanacetum vulgare* L.) > flowers of tillet (*Tilia cordata* Mill.), > roots of common burdock (*Arctium lappa* L.) > roots of dandelion (*Taraxacum officinale* F.H. Wigg).

Keywords: ash total, Voronezh region, *Polygonum aviculare* L., *Artemisia absinthium* L., *Achillea millefolium* L., *Leonurus quinquelobatus* Gilib., *Plantago major* L., *Urtica dioica* L., *Tilia cordata* Mill., *Tanacetum vulgare* L., *Taraxacum officinale* F.H. Wigg, *Arctium lappa* L.

Herbal medicinal products in the domestic pharmaceutical market have always been very popular, which is explained by their good therapeutic effect and relative harmlessness. Thus, according to the data of the Register of Medicines of Russia for July 2021, there are more than 2.1 thousand herbal medicinal products, and the number of biologically active supplements based on medicinal plant raw materials (MPRM) exceeds 7.9 thousand [1]. At the same time, a large share of medicinal plant raw materials collected falls on the European part of the Russian Federation, which is characterized by significant population density, high economic activity, and dynamic development of transport highways [2,3]. In this regard, the threat of harvesting the medicinal

plant raw materials in ecologically unfavorable areas increases and the relevance of identifying the influence of anthropogenic pollution on the chemical composition of plants increases [2].

Currently, there are about 200 kg of suspended dust particles for every inhabitant of Russia. According to the data of the Federal Service for Hydrometeorology and Environmental Monitoring as of 01.01.2019, Voronezh belongs to the four cities of Russia in which the average annual concentrations of suspended solids in the air exceed the MPC by more than twice, and the city is the first in this negative rating (the excess of the MPC of suspended substances by 3.1 times). At the same time, according to the Hydrometeorological Center, in especially dry summers and autumns, the dust MPC in Voronezh is exceeded by 3.3 times [4].

In pharmacopoeia analysis, the "total ash" indicator allows to judge about the total mineral complex of the medicinal plant raw materials. The "total ash" is the residue of inorganic substances, which is obtained as a result of burning medicinal substances or medicinal plant raw materials and subsequent calcination up to constant weight. The definition is based on the fact that some analyzed objects do not contain elements which are capable of producing ash residue. Other objects burn up leaving a mineral residue that has a more or less definite value. The total ash content makes it possible to judge about the mineral residue associated with the presence of inorganic substances in the plant, as well as with the content of impurities in it that got into the raw material from the outside. Deviations in the amount of the ash residue in comparison with the natural ash content indicate contamination of the analyzed object with mineralizing impurities, in particular dust particles [5,6].

The purpose of the research is to study the content of the total mineral complex of medicinal plant raw materials of agro- and urban cenoses of the Voronezh region.

MATERIALS AND METHODS

As study objects quinquelobate motherwort (*Leonurus quinquelobatus* Gilib.) herb, knotgrass (*Polygonum aviculare* L.) herb, absinthium (*Artemisia absinthium* L.) herb, common yarrow (*Achillea millefolium* L.) herb, leaves of stinging nettle (*Urtica dioica* L.), leaves of common plantain (*Plantago major* L.), flowers of tillet (*Tilia cordata* Mill.), flowers of common tansy (*Tanacetum vulgare* L.), roots of dandelion (*Taraxacum officinale* F.H. Wigg), roots of common burdock (*Arctium lappa* L.) were used. When choosing the study objects, researchers were guided by several conditions: different types of medicinal plant raw materials were presented, including different organs or groups of plant organs (leaves, flowers, herb) from different forms of source plants – herbaceous and woody forms of vegetation. In addition, the selected objects are representatives of both natural plant communities and synanthropic vegetation. They are harvested mainly from wild raw materials in central Russia, including in the Voronezh region.

The choice of the studied areas is determined by the nature of the specific anthropogenic impact on them (Fig. 1, Table 1): combined heat power plant (CHP) (Fig. 1: 27); nuclear power plant (NPP) (Fig. 1: 8); chemical industrial enterprises (Fig. 1: 23, 24, 28); international airport (Fig. 1: 30); Voronezh street (Fig. 1: 31); high-voltage power transmission lines (Fig. 1: 9); Voronezh reservoir (Fig. 1: 29); small towns – Borisoglebsk (Fig. 1: 25), Kalach (Fig. 1: 26); nickel ore deposit zone (Fig. 1: 4); zones of radioactive contamination after the Chernobyl NPP accident (Fig. 1: 5–7); areas of active crop production using chemicals (Fig. 1: 10–22); control (for comparison) – protected areas (Fig. 1: 1–3). Sampling was also carried out along roads of varying degrees of load: forest zone (Fig. 1: 32–35) – highway M-4, forest-steppe zone (Fig. 1: 36–39) – highway A-144, steppe zone (Fig. 1: 40–43) – highway M-4, country road (Fig. 1: 44–47) and railway (Fig. 1:

48–51). The order of sampling from highways was determined in increments of one hundred meters (0, 100, 200, 300 m).

The total ash content in the tested samples of medicinal plant raw materials, characterizing the content of mineral substances which are peculiar to raw materials, and foreign mineral impurities, was determined in accordance with the OFS.1.2.2.2.0013.15 "General ash" [6]. The comparison was carried out with numerical indicators specified in individual pharmacopoeia monographs for these types of raw materials [7]. Each determination was carried out three times. The data obtained during the study was statistically processed in Microsoft Excel.

RESULTS AND DISCUSSION

The obtained average values of the results of determining the total ash content in the studied samples of medicinal plant raw materials are shown in Table 1.

All samples of medicinal plant raw materials harvested in control territories and in conditions of agrobiocenoses meet the requirements of pharmacopoeia monographs for the studied types of medicinal plant raw materials according to the "total ash" indicator [7].

In a number of samples of raw materials harvested in urban cenoses of the Voronezh region, an excess of the numerical parameters of the total



FIG. 1. Map of sampling (numbers are deciphered in the text)

Table 1

TOTAL ASH CONTENT, %

№	Area of harvesting	Type of medicinal plant raw materials									
		Knotgrass (<i>Polygonum aviculare</i> L.) herb	Absinthium (<i>Artemisia absinthium</i> L.) herb	Common yarrow (<i>Achillea millefolium</i> L.) herb	Quinquelobate motherwort (<i>Leonurus quinquelobatus</i> Gilib) herb	Leaves of common plantain (<i>Plantago major</i> L.)	Leaves of stinging nettle (<i>Urtica dioica</i> L.)	Flowers of tillet (<i>Tilia cordata</i> Mill.)	Flowers of common tansy (<i>Tanacetum vulgare</i> L.)	Roots of dandelion (<i>Taraxacum officinale</i> F.H. Wigg)	Roots of common burdock (<i>Arctium lappa</i> L.)
1.	Voronezh Biosphere Reserve	7.72	8.42	9.34	8.01	11.23	12.73	5.92	6.27	4.74	6.86
2.	Khopersky Nature Reserve (Novokhopersky district)	6.19	6.90	8.67	7.34	13.85	14.09	6.05	5.07	4.90	7.22
3.	Khopersky Nature Reserve (Borisoglebsky district)	9.42	7.99	7.44	6.06	12.09	11.85	4.82	7.30	3.88	5.30
4.	Village settlement of Elan-Koleno	8.60	9.05	10.40	8.90	10.11	16.73	3.22	5.33	5.10	6.17
5.	Village settlement of Nizhnedevitsk	9.25	8.03	8.55	6.55	9.85	17.05	5.08	6.86	6.12	7.88
6.	Town of Ostrogozhsk	7.32	8.44	9.42	10.08	14.88	19.00	6.93	7.45	4.90	7.15
7.	Town of Semiluki	9.90	10.28	10.97	9.65	13.05	18.41	7.30	8.22	5.31	4.99
8.	Town of Novovoronezh	10.74	11.09	8.08	8.07	16.72	15.38	6.59	8.00	4.89	6.12
9.	High-voltage power transmission line	12.61	13.50	8.12	14.55	17.21	20.67	9.03	10.44	5.09	5.52
10.	Liskinsky district	7.94	6.59	6.55	7.54	9.55	12.09	8.35	6.19	5.12	6.78
11.	Olkhovatsky district	10.73	7.02	7.09	6.49	14.52	14.44	7.43	7.02	4.90	5.55
12.	Podgorensky district	11.68	7.88	6.02	8.05	17.43	17.02	6.08	8.21	5.33	6.19
13.	Petropavlovsk district	9.21	8.90	6.90	8.39	14.08	16.71	5.21	6.23	6.17	6.97
14.	Gribanovsky district	10.00	9.39	8.16	7.62	10.12	12.34	8.53	3.78	3.90	5.76
15.	Khokholsky district	7.55	7.21	5.41	7.37	15.62	10.06	4.94	4.90	4.76	7.09
16.	Novokhopersky district	11.07	10.05	7.08	9.05	16.02	8.32	3.86	7.29	5.95	8.09
17.	Repyevsky district	6.82	7.03	5.32	8.88	9.00	9.07	7.34	6.55	6.41	7.22
18.	Vorobyevsky district	8.74	7.53	7.22	5.66	12.85	12.89	6.66	5.90	5.08	6.77
19.	Paninsky district	9.05	8.90	6.07	7.79	10.64	13.06	5.39	6.29	5.37	7.39
20.	Verkhnekhavsky district	6.86	8.05	9.07	8.40	13.99	15.28	4.28	5.89	5.62	6.84
21.	The town of Ertil	10.43	9.32	10.21	10.42	17.32	13.75	4.23	7.77	6.82	7.03
22.	Rossoshansky district	7.60	7.96	8.09	7.56	12.48	9.45	5.28	7.95	4.08	8.67
23.	Near Minudobreniya JSC	12.33	11.67	14.19	11.05	19.81	17.82	8.94	8.32	6.02	7.09
24.	near Bormash LLC	11.02	12.05	13.05	14.09	23.62	18.90	11.53	9.90	5.76	7.22

Table continuation 1

№	Area of harvesting	Type of medicinal plant raw materials									
		Knotgrass (<i>Polygonum aviculare</i> L.) herb	Absinthium (<i>Artemisia absinthium</i> L.) herb	Common yarrow (<i>Achillea millefolium</i> L.) herb	Quinquelobate motherwort (<i>Leonurus quinquelobatus</i> Gilib) herb	Leaves of common plantain (<i>Plantago major</i> L.)	Leaves of stinging nettle (<i>Urtica dioica</i> L.)	Flowers of tillet (<i>Tilia cordata</i> Mill.)	Flowers of common tansy (<i>Tanacetum vulgare</i> L.)	Roots of dandelion (<i>Taraxacum officinale</i> F.H. Wigg)	Roots of common burdock (<i>Arctium lappa</i> L.)
25.	The town of Borisoglebsk	15.74	14.17	14.11	10.98	28.26	23.94	12.40	7.40	3.87	8.95
26.	The town of Kalach	17.40	15.90	13.79	12.66	22.91	20.65	9.42	8.29	4.10	6.43
27.	near the TPP "VOGRES"	15.97	14.86	14.21	13.09	25.05	19.53	13.72	9.55	7.27	7.55
28.	near Sibur LLC	12.56	11.09	15.76	13.36	28.04	25.97	12.07	10.55	5.08	7.78
29.	along the Voronezh reservoir	9.96	7.45	9.02	7.73	17.93	15.51	6.12	7.33	6.25	7.37
30.	airport named after Peter I	11.88	9.04	10.44	11.26	19.42	18.57	8.03	8.20	6.11	7.99
31.	Street of Voronezh (Dimitrova Street)	19.74	18.09	18.77	19.04	31.74	29.15	15.94	16.03	8.53	9.88
32.	along the M-4 highway (Ramonsky district)	21.94	19.55	19.99	18.90	29.52	30.41	15.09	18.12	9.01	10.04
33.	100 m from the M-4 highway (Ramonsky district)	17.42	16.32	17.08	15.53	25.71	23.91	12.07	10.67	5.55	8.27
34.	200 m from the M-4 highway (Ramonsky district)	11.80	10.07	13.11	11.08	18.64	15.06	7.90	8.43	4.89	6.12
35.	300 m from the M-4 highway (Ramonsky district)	10.78	10.29	11.98	9.06	17.93	16.38	6.08	6.22	3.98	6.08
36.	along the A-144 highway	16.06	17.46	18.90	17.51	30.06	26.41	12.85	15.35	8.31	9.51
37.	100 m from the A-144 highway	15.33	15.40	16.52	15.30	27.42	23.06	12.09	12.22	5.78	7.22
38.	200 m from the A-144 highway	13.84	14.80	15.08	11.22	20.65	17.41	9.69	11.08	6.17	7.08
39.	300 m from the A-144 highway	12.55	11.06	10.12	9.60	17.32	13.09	7.53	7.45	4.21	6.41
40.	along the M-4 highway (Pavlovsky district)	18.94	17.46	18.89	19.05	28.51	32.62	14.98	14.87	7.77	7.90
41.	100 m from the M-4 highway (Pavlovsky district)	16.45	15.21	16.33	17.43	26.12	28.06	11.08	13.88	6.33	7.33
42.	200 m from the M-4 highway (Pavlovsky district)	16.73	13.75	13.16	13.75	23.33	23.95	9.34	13.07	6.04	7.97
43.	300 m from the M-4 highway (Pavlovsky district)	12.60	11.87	12.87	12.66	19.38	18.04	6.38	12.08	5.28	7.90
44.	along a non-high-speed road	13.65	12.33	14.21	13.88	19.08	19.05	9.04	10.55	4.39	8.89

№	Area of harvesting	Type of medicinal plant raw materials									
		Knotgrass (<i>Polygonum aviculare</i> L.) herb	Absinthium (<i>Artemisia absinthium</i> L.) herb	Common yarrow (<i>Achillea millefolium</i> L.) herb	Quinquelobate motherwort (<i>Leonurus quinquelobatus</i> Gilib) herb	Leaves of common plantain (<i>Plantago major</i> L.)	Leaves of stinging nettle (<i>Urtica dioica</i> L.)	Flowers of tillet (<i>Tilia cordata</i> Mill.)	Flowers of common tansy (<i>Tanacetum vulgare</i> L.)	Roots of dandelion (<i>Taraxacum officinale</i> F.H. Wigg)	Roots of common burdock (<i>Arctium lappa</i> L.)
45.	100 m from a non-high-speed road	10.53	10.89	12.04	10.62	19.57	15.98	8.34	8.90	5.99	6.80
46.	200 m from a non-high-speed road	9.05	9.06	12.14	8.09	17.31	16.62	7.09	6.00	4.65	7.31
47.	300 m from a non-high-speed road	7.41	8.21	11.08	8.50	14.02	10.09	7.66	6.27	3.90	6.91
48.	along the railway	15.62	14.22	16.78	14.74	24.63	20.43	12.87	11.98	6.59	7.90
49.	100 m from the railway	12.04	11.75	12.09	10.89	15.98	13.84	7.90	8.35	4.29	7.23
50.	200 m from the railway	11.49	9.56	11.20	8.44	13.80	11.08	6.94	5.08	5.22	6.47
51.	300 m from the railway	10.07	8.11	8.23	8.68	14.66	9.05	4.12	5.66	4.90	6.17
Average		11.77	11.00	11.36	10.80	18.29	17.35	8.23	8.64	5.50	7.20
Numerical indicator under the pharmacopoeial monograph, no more than		13	13	15	12	20	20	10	9	8	11

ash specified in the pharmacopoeia monograph was noted. Thus, the total content of mineral substances was exceeded in the absinthium (*Artemisia absinthium* L.) herb, quinquelobate motherwort (*Leonurus quinquelobatus* Gilib.) herb, leaves of stinging nettle (*Urtica dioica* L.), flowers of common tansy (*Tanacetum vulgare* L.) harvested under high-voltage power lines, characterized by the occurrence of corona discharges, accompanied by air ionization in an electric field with high intensity and the movement of gas particles and impurities contained therein from the corona electrode to the neutral power lead, that is, from high-voltage power lines to the ground, which contributes to the deposition of dust particles and other airborne pollutants on plants. The excess of the numerical indicator

for total ash was noted in quinquelobate motherwort herb, common plantain leaves, flowers of tillet and flowers of common tansy harvested near Bormash LLC, as well as in the quinquelobate motherwort herb, common yarrow herb, stinging nettle leaves, common plantain leaves, tillet flowers and common tansy flowers harvested near Voronezhskintezkauchuk JSC.

The total content of mineral substances does not meet the requirements of the regulation documents in the knotgrass herb, absinthium herb, common plantain leaves, stinging nettle leaves, tillet flowers growing in Borisoglebsk, as well as in the knotgrass herb, absinthium herb, quinquelobate motherwort herb, stinging nettle leaves, common plantain leaves harvested in the town of Kalach. In the samples harvested near the TPP-1

“VOGRES”, an excess of total ash was found in the grass of the knotgrass herb, absinthium herb, quinquelobate motherwort herb, common plantain leaves, tillet flowers and common tansy flowers.

In all samples of medicinal plant raw materials, except for the roots of common burdock, harvested on the street of Voronezh, along the highways M-4 “Don” in Ramonsky district and A-144 in Anninsky district, the excess of permissible levels for the “total ash” indicator was found. All the studied samples of herbs, leaves and flowers that grew along the railway tracks, along and at a distance of 100 m from the M-4 “Don” highway in the Pavlovsky district, at a distance of 100 m from the M-4 “Don” highway in the Ramonsky district and A-144 highway in the Anninsky district, also turned out to be of poor quality according to this numerical indicator. At a distance of 200 m from the highway A-144, the knotgrass herb, absinthium herb, common yarrow herb, common plantain leaves, common tansy flowers; at a distance of 200 m from the highway M-4 “Don” in the Pavlovsky district – the knotgrass herb, absinthium herb, quinquelobate motherwort herb, common plantain leaves, stinging nettle leaves, common tansy flowers; at a distance of 300 m from the highway M-4 in the Pavlovsky district – quinquelobate motherwort herb and flowers of common tansy were harvested that did not meet the requirements of the pharmacopoeial monograph.

Thus, the roots of common burdock can be recognized as the most prosperous in terms of “total ash” because all the harvested samples of this type of medicinal plant raw materials meet the requirements of the pharmacopoeia monograph, as well as the roots of dandelion, in which only three samples were found to be substandard, can be considered as the most successful. The results obtained can be explained by the absence of aerosol contamination of plant roots by airborne particles from motor transport and emissions from industrial enterprises.

The most frequent exceedance of statutory limits for the “total ash” numerical indicator was noted for samples of quinquelobate motherwort herb and common tansy flowers (in 16 of 51 samples), which can be explained by the pubescence of these types of raw materials that well absorb airborne pollutants, as well as sufficiently high requirements of the relevant pharmacopoeia monographs for these types of medicinal plant raw materials. In 15 samples of common plantain leaves out of 51 studied ones, the total content of mineral substances was also exceeded, which is caused by the large leaf blade of the plant located mainly in the horizontal plane, as well as its squat growth, which creates good conditions for the deposition of dust particles on the surface of the medicinal plant raw materials.

CONCLUSION

The content of total ash was determined as an indicator of the content of the total mineral complex and an indicator of contamination of medicinal plant raw materials by dust particles in ten objects collected within the periods of harvesting regulated by regulatory documentation in various agro- and urban cenoses of the Voronezh region. The analysis of the average values of the total ash content makes it possible to build a series of reductions in the content of the total mineral complex in the analyzed types of medicinal plant raw materials, which looks as follows: leaves of common plantain (*Plantago major* L.) > leaves of stinging nettle (*Urtica dioica* L.) > knotgrass (*Polygonum aviculare* L.) herb > common yarrow (*Achillea millefolium* L.) herb > absinthium (*Artemisia absinthium* L.) herb > quinquelobate motherwort (*Leonurus quinquelobatus* Gilib.) herb > flowers of common tansy (*Tanacetum vulgare* L.) > flowers of tillet (*Tilia cordata* Mill.) > roots of common burdock (*Arctium lappa* L.) > roots of dandelion (*Taraxacum officinale* F.H. Wigg).

REFERENCES

1. Dyakova N.A. Ecological and hygienic assessment of the state of soils of anthropogenic ecosystems of the Voronezh region / N.A. Dyakova, A.I. Slivkin, S.P. Gaponov // *Bulletin of Kaliningrad State Technical University*. – 2020. – No. 59. – pp. 61–72.
2. Dyakova N.A. Accumulation of heavy metals and arsenic by absinthium herb / Dyakova N.A. // *Bulletin of Saratov University. A new series. The series "Chemistry. Biology. Ecology"*. – 2020. – Vol. 20, No. 4. – pp. 445–453. DOI: <https://doi.org/10.18500/1816-9775-2020-20-4-445-453>
3. Dyakova N.A. Features of accumulation of biologically active substances in the roots of common burdock of the synanthropic flora in the Voronezh region / Dyakova N.A. // *Conventional medicine*. – 2021. – No. 2(65). – pp. 47–52.
4. Dyakova N.A. Identification of permissible zones of harvesting of medicinal plant raw materials near major transport routes / N.A. Dyakova, A.I. Slivkin, E.E. Chupandina, S.P. Gaponov // *Chemistry of plant raw materials*. – 2020. – No. 4. – pp. 5–13. DOI: [10.14258/jcprm.2020047609](https://doi.org/10.14258/jcprm.2020047609)
5. *The State Pharmacopoeia of the Russian Federation. Edition XIV. Vol. 2.* – Moscow: Federal Electronic Medical Library (FEML), 2018. – 2303–2323 pp.
6. Kurkin V.A. *Pharmacognosy* / V.A. Kurkin. – Samara: Etching, 2004. – 46–50 pp.
7. *The State Pharmacopoeia of the Russian Federation. Edition XIV. Vol. 4.* – Moscow: Federal Electronic Medical Library (FEML), 2018. – 6251–6389 pp.