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MEDICINAL PLANTS

FEATURES OF ACCUMULATION AND QUALITATIVE COMPOSITION OF ESSENTIAL OIL OF COMMON YARROW HERB FROM VORONEZH REGION

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The goal of the study is to reveal the features of accumulation and qualitative composition of essential oil in common yarrow herb (*Achillea millefolium* L.) harvested in agro- and urbocenoses of Voronezh Region. All analyzed samples of herbal raw material gathered in 13 selected points of Voronezh Region are considered to have good-quality essential oil. A sample of common yarrow growing on the territory of Khopersky Reserve exhibited the maximum content of essential oil (0.76%). The minimum percentage of essential oil was revealed in the samples collected along M4 highway in Pavlovsky District (0.18%). The content of essential oil in samples of control areas and agrobiocenoses is higher than that in herb samples of urbobiocenoses. Chromatography-mass spectrometric analysis of essential oils contained in the studied samples revealed greater than 130 different compounds in them. The qualitative composition of the essential oil was significantly different and depended on the place of harvesting. The place of growth of the species and anthropogenic factors can thus significantly affect the features of the synthesis of secondary metabolites in plants.

Keywords: common yarrow, *Achillea millefolium* L., essential oils, agrocenoses, urbocenoses.

Interest in drugs based on herbal raw material is increasing yearly because of the high therapeutic efficacy of such medicines and, most importantly, the safety and lack of side effects. A significant fraction of medicinal plants is harvested in central Russia, which is typified by a high population density, economic activity, extensive transportation networks, many industrial facilities, and widespread agricultural technologies. The threat arises under these circumstances that herbal raw material could be harvested in ecologically unfavorable regions so that anthropogenic pollution of the plant chemical composition begins to become serious [1 – 3].

Common yarrow (*Achillea millefolium* L.) is a species of raw material that is often harvested in natural habitats. It is a perennial and ubiquitous herbaceous plant that has been used since antiquity in medicine. It possesses pronounced antiseptic, antiparasitic, anti-inflammatory, and hemostatic activity [3 – 10]. The broad pharmaceutical and medical use is due to the rich chemical composition of yarrow herb that is based on flavonoids and essential oil in addition to alkaloids, iridoids, bases, carotene, vitamin C, and macro- and trace elements [11 – 15]. Common yarrow herb is currently standardized for content of flavonoids and essential oil. The content of total flavonoids is recalculated for luteolin in raw material intended for preparing aqueous, alcoholic, and aqueous alcoholic infusions and extracts. The essential oil content is determined in raw material intended for production of essential oil.

The synthesis of antioxidants such as low-molecular-mass peptides, organic acids, and flavonoids is known to be activated under conditions stressful for the plant. For example, previous research on the influence of various consequences of economic activity, particularly the accumulation of flavonoids in common yarrow herb harvested in urbocenoses and agrocenoses of the central Chernozem region, gave highly variable results. Synthesis of flavonols was induced with moderate anthropogenic impacts. The flavonoid content recalculated as luteolin decreased relative

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to other raw-material samples with elevated impacts, which could be explained by suppression of the plant antioxidant system [16]. A literature search for data on the influence of stressful anthropogenic factors on the biosynthesis of essential oil in plants found no information.

The goal of the present work was to study features of the accumulation and constituent composition of essential oil in common yarrow herb harvested in agro- and urbocenoses of Voronezh Region.

EXPERIMENTAL PART

Territories for harvesting common yarrow herb were selected according to anthropogenic impacts (Table 1). A reserve zone (control), i.e., Voronezh State Nature Biosphere Reserve (1), was used as a reference zone for evaluating the essential oil composition of common yarrow. The test zones were Khopersky Reserve (Borisoglebsky District) (2); a zone contaminated by radionuclides after the Chernobyl NPP accident (Ostrogozhsk city) (3); zones with active agricultural activity (Liskinsky) (4), Petropavlovsky (5), and Verkhnekhavsky Districts (6); Minudobreniya JSC chemical plant (7); Borisoglebsk city with light industry (8); a Voronezh street (9); the territory along highways M4 "Don" (10, 12) and A144 (11); and a railroad (13).

Common yarrow herb was harvested according to pharmacopoeial requirements during flowering, carefully cutting the upper stem to a length of 15 – 20 cm with scissors. The raw material was naturally dried in the shade in a layer 30 – 40 cm thick with periodic turning over. The essential oil content in the samples was estimated according to PM.2.5.0101.18 "Common yarrow herb" and GPM.1.5.3.0010.15 "Determination of essential oil content in medicinal plant raw materials and medicinal herbal preparations." Raw material (20.0 g) for analysis was distilled for 2 h [17, 18] and was weighed on an A&D GH-202 analytical balance (A&D, Japan). Each determination was made in triplicate. The results were statistically processed to confidence probability 0.95.

The research results were obtained using equipment at the Common Use Center of Voronezh State University. The constituent compositions of the obtained essential oils were determined on an Agilent Technologies 7890B GC gas chromatography system with an Agilent Technologies 5977A MSD mass-selective detector. The sample injector temperature was 310°C, analytical interface, 290°C. The separation was made over an HP-5ms UI capillary column using (5% phenyl)-methylpolysiloxane stationary phase (30 m × 0.250 mm × 0.25 μm). The carrier gas flow rate was constant at 1 mL/min. The injected sample volume was 1 μL; flow division 20:1; temperature regime 40°C, isothermal for 5 min, heating at 5°C/min to 65°C, isothermal for 5 min, heating to 180°C at 5°C/min, isothermal for 1 min, heating at 10°C/min to 270°C, isothermal for 1 min, heating at 10°C/min to 320°C, isothermal for 3 min. Electron-impact ionization at 70 eV was used. The total ion current (TIC) in mass range 20 – 550 *m/z* was recorded. Data were analyzed and processed using the NIST11 database (May 19, 2011) and MassHunter v. B.06.00 and NIST MS Search 2.0 software.

RESULTS AND DISCUSSION

Essential oil was quantitatively determined using a mass-volume method based on steam distillation in the first

TABLE 1. Essential Oil Contents in Common Yarrow Herb

Sample No.	Collection site	Essential oil content, %	Color of obtained essential oil
1	Voronezh State Reserve	0.65 ± 0.03	Blue
2	Khopersky Reserve (Borisoglebsky District)	0.76 ± 0.06	Deep blue
3	Ostrogozhsk city	0.29 ± 0.04	Light blue
4	Agricultural fields of Liskinsky District	0.46 ± 0.04	Dark blue
5	Agricultural fields of Petropavlovsky District	0.48 ± 0.03	Deep blue
6	Agricultural fields of Verkhnekhavsky District	0.36 ± 0.04	Deep blue
7	500 m from Minudobreniya JSC	0.39 ± 0.02	Colorless
8	Borisoglebsk city	0.30 ± 0.03	Light blue
9	Voronezh city street	0.28 ± 0.02	Light blue, close to transparent
10	Highway M4 in Ramonsky District (0 m)	0.21 ± 0.02	Light brown, almost colorless
11	Highway A144 (0 m)	0.24 ± 0.02	Colorless
12	Highway M4 in Pavlovsky District (0 m)	0.18 ± 0.02	Colorless
13	Railroad (0 m)	0.32 ± 0.02	Light blue, close to transparent
Numerical parameter from PM [17]		≥0.1	

stage of the study. Table 1 presents the determined parameters of the essential oil content in common yarrow herb.

All analyzed herbal raw material met the requirements of the pharmacopoeial monograph for the determined parameter [18]. The essential oil contents in the studied common yarrow herb samples varied from 0.18 to 0.76%. Samples harvested in reserve zones without anthropogenic impacts contained 0.65 – 0.76% essential oil. Samples growing in agrobiocenoses accumulated this group of biologically active compounds in the range 0.36 – 0.48%. Most samples harvested under urbanized conditions contained significantly less essential oil than herb harvested on controlled territories and in agrocenoses, i.e., from 0.18 to 0.39%. The essential oil content was especially low (≤0.3%) in raw material growing on streets of Borisoglebsk, Ostrogozhsk, and Voronezh and along highways M4 and A144.

Essential oils synthesized in common yarrow herb in essential-oil glands fulfill several functions, the main ones of which are protection of the plant from insects, bacteria, fungi, and other pests and from sudden drops in temperature. Common yarrow in urbobiocenoses with a limited variety of plant species and a low population of plants that are also subject to constant trampling, compaction, and other anthropogenic impacts is probably more susceptible to the effects of solar radiation so that essential oils contained in it are much more rapidly evaporated to protect it from overheating. This could explain the sharp drop of essential oil content (by two times and more) in raw-material samples harvested in urbanized areas that suffered significant anthropogenic impacts [12 – 14].

The color of the isolated oil was noted to vary from a light brown to light blue and almost colorless to deep blue and dark blue during the quantitative assessment of the essential oil contents. This indicated that the study of the constituent composition of the essential oil from these samples was critical. The next stage of the research was GC-MS analysis of the yarrow essential oil samples with the most contrasting colors (Table 2) [19, 20].

Table 2 shows that both qualitative and quantitative differences were observed in the constituent composition of the studied essential-oil samples from common yarrow. The greatest number of compounds (92) was found in the reference sample harvested in Voronezh State Reserve. The other samples contained from 49 to 85 compounds. A total of >30 different constituents were identified in the essential oils. The constituent compositions of essential oils from raw material harvested at the various sites differed significantly. This suggested that the habitat and anthropogenic factors affected the specific secondary metabolism of terpenes in the plant itself.

The qualitative composition of common yarrow essential oils was represented mainly by monoterpenes (C10) and sesquiterpenes (C15). The monoterpene fraction in essential oil harvested as a reference was 63.8%; sesquiterpenes, 34.7%. The fraction of other organic compound classes was ~2%. About the same ratio (2:1) was observed in the other essential-oil samples. It is noteworthy that the common constituents for all samples were eucalyptol (11.4 – 23.8%), spathulenol (1.2 – 2.4%), camphor (3.3 – 8.9%), caryophyllene (3.7 – 5.5%), caryophyllene oxide (2.0 – 8.4%), pinocarvone (0.1 – 0.6%), ledene oxide (0.1 – 0.7%), *cis*-2-menthol (0.1 – 0.3%), epicubedol (0.2 – 0.8%), β-cubebene (0.2 – 4.9%), α-copaene (0.2 – 0.6%), β-copaene (0.1 – 0.4%), α-phellandrene (0.6 – 1.8%), β-bourbonene (0.4 – 0.7%), γ-terpinene (0.6 – 2.7%), and camphene (0.5 – 1.1%). Differences in the dominant constituents were determined by comparing the percent contents of the constituents in essential-oil samples according to harvesting site. For example, essential oil from yarrow harvested at Voronezh State Reserve was dominated by monoterpenes such as eucalyptol, camphor, and β-phellandrene, the mass fractions of which were 11.4, 8.9, and 8.8%, respectively. Samples harvested near agricultural fields were also dominated by monoterpenes such as β-pinene and eucalyptol (23.7 and 13.6%) in Liskinsky District; β-pinene, eucalyptol, and camphor (14.9, 10.5, and 8.9%), in Verkhnekhavsky District of Voronezh Region. Essential oil from raw material harvested near Minudobreniya JSC contained eucalyptol and camphor, the contents of which were maximal in these samples (23.8 and 12.0%, respectively). The monoterpene homocamphene was detected in large amounts (18.6%) in the sample harvested along the railroad tracks. The natural insecticide 5-methyl-2-(1-methylethyl)phenol, which is used, for example, to combat *Varroa* mites in bee hives, was observed in essential oil of common yarrow herb harvested along the railroad. The bicyclic monoterpene ascaridol was observed in essential oil of raw material harvested near Minudobreniya JSC and possessed anthelmintic activity against parasitic worms from plants, pets, and people [10].

The color differences of the isolated essential oils that were, as a rule, due to chamazulene-type compounds, could be explained using the GC-MS analytical results [9, 11]. The greatest contents of chamazulene were found in essential oils of common yarrow herb harvested in agrocenoses, which also had the brightest blue color. Chamazulene was not detected in colorless oil isolated from the sample harvested near Minudobreniya JSC. Significantly higher contents of components such as α- and β-pinene (characteristic of the sesquiterpene fraction of essential oil from the camphor tree and conifers and possessing disinfecting and insecticidal properties), epiglobulol (azulene derivative characteristic of essential oil from eucalyptus leaves), and σ-cadinene (found in essential oil of the camphor, Atlas cedar, west-Indian sandalwood, and juniper trees) were noted in essential oil samples from common yarrow herb harvested in agrocenoses of Voronezh Region [21, 22].

β-Phellandrene (characteristic of essential oil from Siberian fir and used in the perfume industry); γ-terpinene (contained in dill, cardamon, marjoram, coriander, and caraway

TABLE 2. Constituent Composition of Essential Oil from Common Yarrow Herb from Various Collection Sites from Chromatography–Mass-spectrometric Analysis

Sample No.	Retention time, min	Constituent	Collection site				
			Voronezh State Reserve	Agricultural fields of Liskinsky District	Agricultural fields of Verkhnekhavsky District	Minudobreniya JSC	Railroad
			Mass fraction in sample (of total sum), %				
1	8.380	α-Pinene	1.9	8.0	6.2	1.9	3.1
2	8.400	5-Methyllinalool	0.1	–	0.3	–	0.8
3	8.455	4,5-Dimethyloctane	–	–	0.3	–	–
4	8.521	Homocamphene	0.1	–	–	0.5	18.6
5	8.833	3,6-Dimethyloctane	–	0.3	0.2	–	–
6	8.941	α-Gurjunene	0.6	0.2	0.2	–	–
7	9.249	Camphene	1.1	0.9	0.8	0.9	0.5
8	9.791	Cumene	0.3	1.0	0.2	–	0.3
9	10.276	β-Phellandrene	8.8	–	–	–	–
10	10.387	β-Myrcene	–	0.3	0.3	–	–
11	10.853	2,3-Dehydro-1,8-cineol	0.1	–	–	0.5	0.1
12	11.023	β-Pinene	3.0	23.7	14.9	6.0	2.8
13	11.430	α-Phellandrene	0.6	1.8	1.4	0.6	0.9
14	11.975	*p*-Menth-1-ene	–	0.9	–	0.4	0.4
15	12.002	4-Carene	2.1	–	0.7	–	–
16	12.394	*p*-Cymene	–	1.3	1.5	0.7	1.6
17	12.414	Benzene-2-ethyl-1,3-dimethyl	1.5	–	–	–	–
18	12.500	Methyl-β-ionol	–	–	–	–	0.1
19	12.752	Eucalyptol (1,8-cineol)	11.4	13.6	10.5	23.8	14.8
20	13.909	β-Ocimene	0.1	–	–	0.1	–
21	14.386	γ-Terpinene	2.7	1.6	1.3	0.6	0.6
22	14.846	*cis*-2-Menthenol	0.3	0.1	0.2	0.3	0.2
23	16.220	γ-Pyronene	–	–	–	0.2	0.2
24	17.036	Borneol	–	1.4	2.7	5.2	2.8
25	17.326	1,2,6-Hexanetriol	0.1	–	–	–	–
26	17.659	Thujone	–	–	0.1	3.6	0.1
27	17.858	1,6-Dimethyldecalin	–	0.9	–	–	–
28	18.128	α-Campholenal	0.1	–	0.2	–	–
29	18.635	Pinocarvyl acetate	–	–	–	0.7	0.1
30	18.930	Camphor	8.9	7.1	8.9	12.0	3.4
31	19.046	Verbenol	–	–	0.2	0.6	0.1
32	19.414	*trans*-4,5-Epoxycarane	–	–	–	–	0.1
33	19.707	Pinocarvone	0.7	0.2	0.4	0.4	0.1
34	20.018	8-Hydroxyneomenthol	1.5	–	–	0.5	–
35	20.287	Lavandulol	0.8	–	–	4.7	–
36	20.425	Terpinene 4-acetate	–	2.4	2.9	–	2.4
37	20.521	Terpinen-4-ol	5.2	–	2.0	4.6	–
38	20.716	Myrtenal	0.1	–	0.3	0.6	–
39	20.867	*p*-Cymen-8-ol	–	–	0.1	–	–

TABLE 2. Continued

Sample No.	Retention time, min	Constituent	Collection site				
			Voronezh State Reserve	Agricultural fields of Liskinsky District	Agricultural fields of Verkhnekhavsky District	Minudobreniya JSC	Railroad
			Mass fraction in sample (of total sum), %				
40	21.071	α-Terpineol	3.0	1.5	–	3.1	3.8
41	21.218	Myrtenol	0.6	0.1	0.4	0.9	–
42	21.482	Bornyl acetate	2.2	0.4	0.4	1.7	–
43	21.504	Lavandulyl acetate	0.7	–	0.4	–	–
44	21.630	Thujopsanone	–	–	0.2	–	–
45	21.730	Piperitol	–	–	–	–	0.1
46	21.852	*trans*-3(10)-Caren-2-ol	2.5	–	–	0.1	–
47	22.007	Grandisol	–	–	0.2	–	–
48	22.563	Carveol	0.4	–	–	–	0.1
49	22.749	Isogeraniol	0.8	–	–	–	–
50	22.957	*D*-Carvone	0.2	–	0.1	–	–
51	23.286	Sabina ketone	0.2	–	0.4	0.5	–
52	23.347	*cis*-Piperitol	–	0.1	–	0.3	–
53	23.516	*trans*-Pinane	0.3	–	0.1	0.3	–
54	23.629	*cis*-Verbenyl acetate	–	–	0.2	–	–
55	23.762	β-Cubebene	–	1.9	–	–	–
56	23.850	Ascaridol	–	–	–	0.1	–
57	24.115	4-Thujene-2α-acetate	0.2	–	–	0.4	–
58	24.529	Menthol	–	–	0.1	–	–
59	24.708	α-Copaene	0.4	0.4	0.6	0.2	0.6
60	24.813	Thymol	0.1	–	–	–	0.6
61	25.032	Mentha-1,8-dien-9-ol	0.3	–	–	–	0.1
62	25.166	*trans*-4-Thujanol	0.2	–	–	–	–
63	25.957	*o*-Menth-8-ene	0.2	–	0.1	–	–
64	26.044	*trans*-Carvyl acetate	0.2	–	0.2	–	–
65	26.269	Longipinene	–	–	–	0.1	–
66	26.347	α-Ylangene	0.1	–	–	–	–
67	26.583	Cedreanol	0.3	–	0.7	–	–
68	26.768	Cycloisosativene	0.3	–	0.8	–	–
69	26.833	2-Carene	0.8	0.4	0.4	–	–
70	27.300	β-Bourbonene	0.6	0.5	0.4	0.7	0.6
71	27.617	*allo*-Aromadendrene	–	0.5	0.2	0.4	0.7
72	27.786	*cis*-Jasmone	–	–	0.1	–	–
73	27.800	Sesquicineole	–	–	–	0.4	–
74	27.990	α-Acorenol	0.2	0.6	–	0.1	0.2
75	28.219	γ-Murolene	–	–	0.3	–	0.3
76	28.259	Caryophyllene	3.7	5.3	4.1	3.1	5.5
77	28.506	6-Epi-β-cubebene	4.9	0.2	2.1	0.9	2.3
78	28.823	β-Copaene	0.4	0.3	0.3	0.1	0.1

TABLE 2. Continued

Sample No.	Retention time, min	Constituent	Collection site				
			Voronezh State Reserve	Agricultural fields of Liskinsky District	Agricultural fields of Verkhnekhavsky District	Minudobreniya JSC	Railroad
			Mass fraction in sample (of total sum), %				
79	28.983	α-Methylionone	–	0.3	–	–	–
80	29.132	Humulene	1.6	0.8	0.7	0.5	0.9
81	29.230	β-Curcumene	–	0.1	–	–	–
82	29.331	*allo*-Aromadendrene	0.3	–	–	–	0.4
83	29.456	β-Calarene	0.3	–	–	–	–
84	29.621	σ-Cadinene	0.9	1.5	1.9	–	1.2
85	29.989	*cis*-Thujopsene	–	–	–	0.2	–
86	30.223	Cubedol	–	–	0.4	–	–
87	30.284	Diepi-α-cedrene	0.8	–	–	–	–
88	30.384	α-Murolene	0.1	0.5	0.2	–	0.3
89	30.456	β-Elemene	1.1	–	–	–	0.2
90	30.622	β-Bisabolene	0.1	–	–	–	–
91	30.704	4-Epicubedol	0.2	0.2	0.8	0.4	0.7
92	31.173	γ-Himachalene	0.1	–	–	–	–
93	31.264	β-Guaiene	0.1	–	–	–	0.4
94	31.398	α-Calacorene	0.1	0.1	0.1	–	–
95	31.580	β-Elemol	0.2	–	–	–	–
96	31.679	γ-Costol	–	–	–	–	0.2
97	31.961	Peruviol	–	–	0.4	–	–
98	32.225	Copaborneol	0.5	–	0.5	–	0.7
99	32.464	Ledene oxide	0.1	0.5	0.3	0.6	0.3
100	32.582	Ledol	2.9	–	0.5	0.5	5.3
101	32.733	3-Isopropyl-6,7-dimethyltricyclo[4.4.0(2,8)]decane-9,10-diol	–	–	0.6	–	–
102	32.854	Epiglobulol	1.1	1.9	4.4	–	0.5
103	32.959	Caryophyllene oxide	2.0	2.9	4.9	5.4	8.4
104	33.043	Tricyclo[5.2.2.0(1,6)]undecan-3-ol	0.2	–	–	–	–
105	33.403	Diepicendrene-1-oxide	0.4	0.4	–	0.6	–
106	33.493	Corymbolone	–	–	–	0.4	–
107	33.598	4,4-Dimethyltetracyclo[6.3.2.0(2,5).0(1,8)]tridecan-9-ol	0.5	–	–	1.0	1.1
108	33.620	β-Eudesmol	–	–	–	–	0.9
109	33.712	α-Cadinol	–	–	–	–	1.0
110	33.765	τ-Muurolol	0.2	0.2	–	–	–
111	33.812	Longiverbenone	–	–	0.7	1.0	–
112	33.899	α-Copaen-11-ol	1.3	0.2	0.5	–	–
113	33.982	Selina-6-en-4-ol	0.9	–	1.2	2.1	1.1
114	34.003	Selina-4(15),7(11)-diene	–	–	0.1	–	–
115	34.060	Isoaromadendrene epoxide	–	0.2	–	–	0.4

TABLE 2. Continued

Sample No.	Retention time, min	Constituent	Collection site				
			Voronezh State Reserve	Agricultural fields of Liskinsky District	Agricultural fields of Verkhnekhavsky District	Minudobreniya JSC	Railroad
			Mass fraction in sample (of total sum), %				
116	34.190	*allo*-Aromadendrene oxide	0.3	–	0.5	–	–
117	34.346	Spathulenol	2.2	1.2	2.1	2.4	2.4
118	34.719	Longipinocarveol	2.0	–	0.1	1.0	2.2
119	34.840	*cis*-α-Bisabolene epoxide	0.3	–	0.3	–	0.3
120	35.525	*trans*-Geranyl geraniol	0.1	–	0.2	–	0.3
121	35.625	Chamazulene	1.7	8.4	4.8	–	0.3
122	36.352	Cedren-13-ol	0.5	–	0.2	0.3	0.4
123	36.535	Nonenol	–	–	0.1	–	–
124	37.116	Aromadendrene oxide	0.1	–	0.3	–	–
125	37.844	4-(3,3-Dimethylbut-1-ynyl)-4-hydroxy-2,6,6-trimethylcyclohex-2-enone	–	–	–	0.2	0.2
126	38.079	Hexahydrofarnesyl acetone	0.2	–	0.2	–	–
127	38.660	Doconexent	0.1	–	–	–	–
128	38.868	Eudesma-4,11-dien-2-ol	–	–	1.0	–	–
129	39.605	7,9-Di-*tert*-butyl-1-oxaspiro[4.5]deca-6,9-dien-2,8-dione	–	–	–	0.3	0.3
130	39.861	Dihydroxanthin	0.1	–	–	–	–
131	40.307	Geranyl-α-terpinene	0.5	–	–	–	–
132	41.278	Geranyl-*p*-cymene	0.2	0.1	0.4	–	0.1
133	41.920	Estafiatin	0.1	–	–	–	–
134	42.702	Phytol	0.1	–	0.1	–	0.1
135	43.372	*trans*-Farnesol	0.1	–	0.1	–	–
136	43.480	2-*cis*-Geranyl geraniol	–	–	–	–	0.2
137	43.988	1-Heptatriacotanol	0.1	–	–	–	0.1
138	54.952	β-Betasone acetate	–	0.3	–	–	–
Total identified			99.2	97.5	97.4	99.5	99.4

essential oils); bornyl acetate (with a conifer-camphor aroma, contained in coriander and valerian essential oils and in conifer oils, used as a food flavor component); *trans*-3(10)-caren-2-ol (found in several turpentines and aromatic grass oils); isogeraniol (an ant tracking pheromone, attracts insects); 2-carene (monoterpene, an important constituent of *Andropogon iwarancusa* L. essential oil, used to produce fragrances); 6-epi-β-cubebene (rare sesquiterpene constituent of essential oil primarily of juniper with a warm woody and slight camphor aroma); humulene (cyclic sesquiterpene that together with caryophyllene is a major constituent of hop essential oil, gives taste to Vietnam coriander and hemp); and α-copaen-11-ol [comparatively rarely encountered sesquiterpene hydrocarbon characteristic together with its β-isomer of essential oil from African *Oxystigma*, *Sindora wallichii*, *Sindora inermis* (up to 70%), east-Indian and Australian trees *Toona ciliata* (up to 35%), rosewood *Dysoxylum fraserianum* Juss., New Zealand celery pine *Phyllocladus trichomanoides* D. Don; used to aromatize soap and cosmetics] [21 – 23] accumulated primarily in essential oil of common yarrow growing in reserve zones devoid of anthropogenic impacts.

Homocamphene (used as a CNS stimulant); eucalyptol (monoterpenoid with a fresh mint aroma and spicy cooling taste, making up to 90% of eucalyptus oil); thujone (contained in essential oils of *Thuja*, cypress, juniper, tansy, and sage; acts as a GAMA-ergic CNS receptor type A antagonist; causes convulsive seizures at high doses; the thujone content is standardized in several food products of the EU, EAEU, etc.; food and drinks in the USA, including those containing various types of yarrow, should not contain thujone according to the FDA); camphor (terpene-type ketone with a characteristic aroma, included in many essential oils, camphor of laurel, basil, *Artemisia*, rosemary; local use causes a cooling, irritating, and often antiseptic action; is used in aromatherapy; internal use improves alveolar ventilation, lung blood flow, and myocardium functioning; is used in several medicines); lavandulol (sesquiterpene alcohol, important constituent of lavender essential oil; has a herbaceous-rosy aroma; used as a component of perfumes; insect pheromone); myrtenal (unsaturated bicyclic aldehyde, an important component in essential oil of myrtle, hyssop, eucalyptus); caryophyllene oxide (sesquiterpenoid oxide, characteristic component of essential oil of medicinal melissa, lemon melissa, and eucalyptus; acts as a broad spectrum antifungal agent); β-eudesmol (possesses hepatoprotective, anticonvulsant, anti-inflammatory, and antioxidant properties for poisoning by organophosphorus compounds); and α-cadinol [sesquiterpene alcohol, important constituent of essential oils from *Plinia peruviana* (up to 19%), lychee (up to 8%), *Salvia aratocensis* (up to 20%), *Protium giganteum* (up to 7%), *Uvaria ovata* (up to 24%), *Schizandra chinensis* (up to 5%), new lychee (up to 10%), *Tetradenia riparia* (up to 8%); acts as antifungal, antituberculosis, and hepatoprotective agent] [23 – 26] could be found in relatively high accumulations in essential oil of common yarrow essential oil from urbanized harvest sites.

Thus, the maximum amount of essential oil (0.76%) was found in common yarrow herb growing in Khopersky State Reserve; the minimum, in the sample harvested along highway M4 in Pavlovsky District (0.18%). In general, higher contents of essential oil could be found in samples from controlled territories and agrobiocenoses than in samples from urbobiocenoses. GC-MS analysis of essential oils from the common yarrow herbs identified 130 different constituents in them. The qualitative composition of the essential oil raw material from the various harvesting sites differed significantly. This could indicate that the habitat and anthropogenic factors had a significant influence on the specific secondary metabolism of terpenes in the plant itself.

In summary of the results of the comparative analysis of the constituent composition of essential oils from *A. millefolium* growing in various ecological zones of Voronezh Region, it is important to note that the qualitative set of major constituents was relatively constant for all samples. A considerable difference in the concentrations of individual compounds in the oils was found and was due to the substantial influence of the habitat on the accumulation of biologically active compounds. This was important to consider for manufacturing of drugs based on it, particularly infusions containing essential oil of common yarrow, and production of essential oil.

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