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Phytomeliorative properties of plants of Lavandula angustifolia L. in conditions of cultivation in the Forest-steppe zone of Ukraine

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The purpose. To determine the content of inorganic elements in soil and plants of lavender, and also in a product of its processing — oil. **Methods.** Samples of soil and plants were incinerated in nitric acid in system of microwave preparation of samples Milestone Start D and then they detected the content of inorganic elements on ICP-MS Agilent 7700x. Data processed with the use of techniques conventional for farming agriculture, plant growing and statistics. **Results.** The content of metals in soil of experimental soils and plants of lavender is fixed. Plants of lavender accumulated a significant amount of aluminium, barium, calcium, iron, magnesium, potassium, strontium, and zinc. The content of potassium, magnesium, barium, chrome and rubidium in a product of processed plants of lavender — oil — decreased in comparison with the content of metals in plants. The content in oil of aluminium, beryllium, cadmium, calcium, cesium, chrome, copper, iron, lead, manganese, molybdenum, sodium, silver, strontium, thallium, vanadium, and zinc was below the level of detection on ICP-MS Agilent 7700x. **Conclusions.** At environmental pollution by products of anthropogenous activity it is necessary to develop rational ways of neutralization of their negative agency. Intensity of processes of pollution depends on distance to the source of contamination, and specificities of objects of pollution. Plants of lavender can be used as ornamental crop owing to it phytomeliorative property to accumulate significant amount of metals from soil. Thus, the product of lavender processing — oil — contains residual amount of metals. The content in oil of aluminium, beryllium, cadmium, calcium, cesium, chrome, copper, iron, lead, manganese, molybdenum, sodium, silver, strontium, thallium, vanadium, and zinc was below the level of detection on ICP-MS Agilent 7700x.

Key words: *Lavandula angustifolia L., heavy metals, phytomelioration, ICP-MS.*

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The widespread use of xenobiotics, which is the product of technological human activity, often leads to unwanted for environment side-effects. At the same time, heavy metal pollution of soils and ground water dominates among toxic factors in agrophytocenoses. Heavy metals (HM) interact with both the parent rock and the living complex of the soil and can be stored in ecosystems for a long period of time, creating a long-term hazard for cultivated crops. This may limit the possibility of medicinal plants growing.

Therefore, the accumulation of inorganic elements in lavender plants and their interrelation with the content of metals in the soil were studied, as well as the levels of inorganic elements content in the product of plant and oil processing were determined.

Materials and methods of research. Field studies were conducted under stationary experiments of the laboratory of flower-decorative and medicinal plants of the Institute of Horticulture of the National Academy of Sciences of Ukraine in 2015-2017, the sites of which are located at a distance of 1.5 km from the highway Kiev-Odessa. The relief of the site is plain. The soil is dark grey podzol, medium loamy on carbonate forest, typical for the northern part of the forest-steppe Ukraine. The soil analysis was carried out at the laboratory of agrochemistry of the Institute. The content of humus in the arable layer (0-40 cm) was 2.3%, easily hydrogenated nitrogen from 78.4 to 98.0 mg/kg, mobile forms of phosphorus - 93.2-180,9 mg/kg, exchangeable potassium - 106.1-202.8 mg/kg; pH of the soil solution varied from 5.3 to 5.8 to 5.5-6.1.

The size of the sites from which samples of lavender plants of the narrow-leafed 4-year-old age were taken was 50 × 70 cm.

Caring for crops consisted of sequential manual control of weeds according to their appearance. Chemical protection was not used.

Determination of the content of heavy metals in the arable soil layer of the experimental plots, vegetable raw materials of lavender and oil was carried out at the Institute of Plant Physiology and Genetics of the National Academy of Sciences of Ukraine. Determination of the elemental composition in the experimental samples was tested by the ICP-MS Agilent 7700x. The specimens were dried to dry weight and digested in nitric acid using Milestone Start D microwave sampling system. The extract was adjusted to 50 ml with water of the 1st class (18 Mom) prepared on a Scholar-UV NexUp 1000 (Human Corporation, Korea).

The results of the experiments were statistically analyzed using the Exel program and with the mathematical processing of the data using Statistica 8.0 [1, 2].

Results of research and discussion. The genus Lavandula (Labiatae or Lamiaceae), which consists of about 47 species, is widespread in the archipelagos of the Atlantic Ocean and the Mediterranean Sea. Essential oils and plant extracts from plants of the genus Lavandula have been used for therapeutic purposes for many centuries. There are numerous reports of biological activity of essential oils of lavender [3].

Lavender is one of the most important herbaceous crops in Ukraine. Her medicinal properties are widely used in medicine. In addition, lavender is important honey and a fairly popular ornamental plant [4].

The cultural area of lavender is limited, mainly, to areas where producers of plant raw materials are not able to grow it today. Introducing this culture to the regions, uncharacteristic for its traditional cultivation - the Forest-steppe of Ukraine, it is necessary to have a comprehensive assessment not only of the elements of cultivation technology but, of course, the quality of the raw material received. That is why it is important to know the conformity of the obtained crop with the requirements for its processing, that is, which organic compounds and chemical elements and in what amount of plants accumulates for cultivation in the conditions of the region. It should be noted that in the process of vegetation, lavender plants are extracted from the soil with an average yield of 50 t / ha of a dry weight of the following elements: nitrogen - 69 kg/ha; phosphorus - 41 kg/ha; potassium - 77 kg/ha. It should be noted that the study of the peculiarities of their migration in the "soil-plant" system is an important issue [5].

Established (see table) high content of aluminum in the soil of experimental sites. The content of Al in lavender plants was rather stable, on average 35 times smaller and not exceeding 0.4 g/kg. Taking into account that according to the determination of the manual of ST-N MOHU 42-4.5: 2012 [6] the maximum allowable level (MAL) of aluminum in plant products should be within the limits of 20 mg/kg, then the content of aluminum in lavender plants that grown at a distance of 1.5 km from the highway, significantly exceeds the permissible one. However, it should be noted that lavender plants are used mainly for processing to produce oil, or as a decorative culture. After thermal processing into oil, the content of this element decreased to a value that is less than 0.01 ppt, below the level of ICP-MS sensitivity.

The content of iron in the arable layer of soil is significantly less than in the previous element, but changes in the levels of Fe accumulation in lavender and oil plants are similar to those determined for aluminum. In lavender biodiverse, the Fe content was observed to be more than 26 times less than its soil content, but content of iron in oil was less than the threshold of ICP-MS sensitivity.

Excessive accumulation of iron in living organisms causes toxic effects. Overdose with iron stimulates the formation of free radicals, suppresses the antioxidant system of the organism [7, 8]. This applies to crops, including and medicinal plants. Since the lavender is commonly used as an essential oil or ornamental plant, the accumulation of a significant amount of elements such as aluminum and iron from the soil on which they are vegetated can improve these qualitative parameters. Consequently, lavender plants can be used as a phytomelioration culture, which can clean the soil from the excessive presence of a number of metals.

Table. The content of metals in the soil, lavender plants and oil, the average for 2015-2017; M ± m, n = 30.

Elements	Metals content, mg/kg					
	soil		plants		oil	
	M	±m	M	±m	M	±m
Al	13190,7	12,1	377,4	0,5	<0,00	-
Ba	55,1	0,5	60,9	0,4	0,02	0,01
Be	0,32	0,06	0,0016	0,0002	<0,00	-
Cd	0,12	0,4	0,0025	0,0003	<0,00	-
Ca	261,5	1,1	239,3	1,1	<0,00	-
Cs	0,98	0,05	0,05	0,005	<0,00	-
Cr	15,9	0,2	2,3	0,2	0,010	0,002
Co	3,7	0,1	0,1478	0,007	<0,00	-
Cu	7,4	0,1	3,3	0,1	<0,00	-
Fe	9183,8	14,3	349,5	0,9	<0,00	-
Pb	7,4	0,5	0,06	0,01	<0,00	-
Mg	2187,2	10,0	926,9	4,5	1,08	0,04
Mn	263,2	1,5	26,3	0,2	<0,00	-
Mo	2,8	0,5	0,12	0,01	<0,00	-
Ni	9,8	0,1	1,2451	0,0030	<0,00	<0,00
K	2872,5	14,9	592,0	5,4	3,73	0,02
Na	341,9	7,1	32,3	0,8	<0,00	-
Rb	19,5	0,2	1,5	0,1	0,01	0,01
Ag	0,03	0,01	0,02	0,01	<0,00	-
Sr	17,9	0,1	60,0	0,3	<0,00	-
Tl	0,08	0,01	0,003	0,001	<0,00	-
Va	19,8	0,1	0,005	0,001	<0,00	-
Zn	25,2	0,4	77,2	0,5	<0,00	-

Such chemical elements as potassium, magnesium, calcium, and sodium are part of a group of macroelements and are biologically important in agrophytocenoses. Potassium takes an active part in the metabolic processes of carbohydrates and proteins, as well as accelerates the processes of achieving, strengthening mechanical tissues of plants. Plants for lack of potassium (K) are low-growth and underdeveloped root system, their leaves are covered with characteristic spots, twisted and dry from the edges. Yields in most types of plants are low due to lack of potassium [9].

In addition, potassium and sodium ions, in the process of vegetation, play an important role in forming the corresponding osmotic pressure both in the cytoplasm of cells and in the leading plant systems and in the absorption of water and inorganic elements from the soil [10].

The content in the soil and in plants of calcium and magnesium depends essentially on the soil and the levels of organic and inorganic fertilizers. However, some patterns of accumulation of their compounds in lavender plants should be noted.

Potassium compounds were found to be most commonly found in the soil of the named group of inorganic compounds in the soil, but its content in lavender plants is much lower than that of magnesium. Potassium and magnesium ions in small quantities were found in plant's oil. Among of all the chemical elements identified in the experiments, the content of potassium compounds in the product of processing - oil, was the highest - 3.73 mg/kg.

Sodium and calcium were detected in the arable soil layer much less than the previously described chemical elements, and their content in the tissue of lavender plants was less than the MAL.

However, not all chemical elements and their compounds, which were identified in samples of soil and in biological raw materials, are safe. Chemical elements such as cadmium, cesium and lead are quite dangerous for a person if their amount exceeds the permissible concentrations. The intake of cesium and its compounds to the plant and the accumulation of its compounds in the crop depends on the properties of the soil, in particular, its mechanical and elemental composition, the level of acidity of the soil solution and a number of other indicators. The introduction of lime and organics into the soil greatly reduces the availability of cesium for plants [11, 12].

According to the State Standard [13], the content of cesium in plants is regulated in Ukraine, with a maximum content allowed (MDR) of 20.0 Bq/kg, which differs significantly from the requirements of EU legislation, where MDR cesium is 600 Bq/kg, and Codex Alimentarius Commission - 1000 Bq/kg [14, 15].

On average, over three years of research, in the arable layer of soil, the content of cesium was 0.98 mg/kg, which, according to all the indicated documents, this amount significantly exceeds the permissible standards. However, it was found that plants of lavender accumulated significantly less Cs - 0.05 mg/kg.

Similar ratios for soil-to-plant inputs were recorded for lead and cadmium. In lavender processing product - essential oil, cadmium, cesium and lead have not been found.

The results of determination of the content of heavy metals in the soil of the experimental sites of lavender and their accumulation in plants have shown the presence and different ability to absorb and accumulate such inorganic elements as chrome, manganese, cobalt, nickel, copper, zinc and silver.

Clarification of the peculiarities of their migration in the "soil-plant" system is an important issue. According to the results of three-year experimental studies, their presence in the soil was insignificant, and, accordingly, lavender plants accumulated in small quantities, and after thermal processing and distillation their content was less than the sensitivity levels of the analytical device.

Thus, as a result of the conducted research, the possibility of purification of soils contaminated with metals, improvement of their ecological status by the method of phytomelioration - in particular, with the help of a plant such as lavender is experimentally established.

Conclusions

1. Pollution of the environment by products of anthropogenic activity requires taking into account its side effects and developing rational ways of neutralizing negative effects. The intensity of pollution processes depends on the distance to the source, which produces pollution and specifics of pollution objects.

2. Lavender plants can be used as a decorative crop due to its phytomelioration ability to accumulate significant amounts of metals from the soil.

3. Oil from *Lavandula angustifolia* plants contains trace amounts of metals, and for aluminum, beryllium, cadmium, calcium, cesium, chromium, copper, iron, lead, manganese, molybdenum, sodium, silver, strontium, thallium, vanadium and zinc content in the oil were below the ICP-MS Agilent 7700x detection level.

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