IOP Conference Series: Earth and Environmental Science

PAPER • OPEN ACCESS

Environmental safety monitoring of heavy metals accumulation in some species of Sambucus L.

To cite this article: V N Sorokopudov *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **937** 022050

View the article online for updates and enhancements.

You may also like

- The Fortification Effects of Sea Grapes (*Caulerpa racemosa*) Powder on Color and Sensory of Hakau Dim Sum Wrappers
  E Windrayani and N Ekantari
- Antibacterial activity of the symbiotic bacteria of green algae *Caulerpa racemosa* from Pulau Lima Indonesia
  Sujuliyani, E A Thaib, N Indriati et al.
- The administration of *Caulerpa racemosa* extract on total bacteria and survival rates of white shrimp (*Litopenaeus vannamei*) after infected by *Vibrio parahaemolyticus*
  A F Pratiwi, W H Satyantini, G Mahasri et al.

ECS Membership = Connection

ECS membership connects you to the electrochemical community:

- Facilitate your research and discovery through ECS meetings which convene scientists from around the world;
- Access professional support through your lifetime career:
- Open up mentorship opportunities across the stages of your career;
- Build relationships that nurture partnership, teamwork—and success!

Benefit from connecting with your community

Join ECS! **Visit electrochem.org/join**

ECS

This content was downloaded from IP address 188.170.217.49 on 07/06/2022 at 08:27

AFE 2021 IOP Publishing
IOP Conf. Series: Earth and Environmental Science **937** (2021) 022050 doi:10.1088/1755-1315/937/2/022050

Environmental safety monitoring of heavy metals accumulation in some species of Sambucus L.

V N Sorokopudov[1,*], O A Sorokopudova[1], N A Trusov[2], N G Pachukova[3] and I M Bamatov[4,5]

[1]Russian State Agrarian University- Moscow Agricultural Academy named after K.A. Timiryazev, 127550, Moscow, Russia
[2]Tsytsin Main Botanical Garden of Russian Academy of Science, 127276, Moscow, Russia
[3]Belgorod State University, 308015, Belgorod, Russia
[4]V.V. Dokuchaev Soil Science Institute, 119017, Moscow, Russia
[5]Chechen State University, 366007, Grozny, Russia

E-mail: sorokopud2301@mail.ru

Abstract. The aim in this work was to monitor heavy metals in plants of elderberry species. The objective of the research was to identify the actual concentrations of heavy metals in the fruits and leaves of the studied elderberry species. The need to determine deviations in the content of heavy metals in various parts of plants arose because the current ecological situation in Belgorod's area requires special attention. The presence and concentration of heavy metals in different elderberry species and different parts of plants vary greatly and have the following features. Increased magnesium content was observed in almost all elderberry species, especially in red-fruited (*Sambucus racemosa* 'Aurea', *S. sibirica* Nakai, *S. racemosa* L., *S. racemosa* 'Plumosa', *S. coreana* Nakai), And its concentration much higher in fruits than in leaves. The highest deviation of the magnesium content from the norm was noted in the fruits and leaves of *S. sibirica* (2 and 1.5 times, respectively). Black elderberry species (*S. nigra* L., *S. canadensis* L., *S. canadensis* 'Plumosa') have a lower magnesium concentration in fruits and leaves. On the other hand, the concentration of copper in fruits and leaves in elderberry species is many times higher than the norm.

1. Introduction

The study of the ecological situation is one of the priority directions in the study of the environment. At the same time, more and more attention is paid to the state of such essential components as green spaces and soil cover. By absorbing and accumulating toxic compounds in their tissues, plants play an irreplaceable role in improving the environment. At the same time, in urban conditions, plant organisms themselves experience the negative impact of several factors, of which the most significant are emissions from vehicles and industrial enterprises, severe recreational load on the soil cover, and etc. [1]. As a result of anthropogenic changes in the environment in many cities, there is a deterioration in green spaces, a reduction in their areas, and structural transformation [2]. Given the high sensitivity of plants to many industrial gases, it is possible to reasonably associate the unsatisfactory state of green spaces in cities with increased pollutants in the air and use them as bioindicators of environmental pollution.

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

The transformation of heavy metal compounds from atmospheric emissions to the soil surface occurs under biotic and abiotic factors. The mechanism of fixation of heavy metals is mainly associated with the formation of organomineral complexes with different solubility and availability for plants. In the process of the vital activity of soil microorganisms, which are the main destructors of plant litter, the mobilization and immobilization of heavy metals occur in the upper soil horizons. The toxicity of metals for plants depends on many reasons: the chemical nature of pollutants, soil acidity, cation exchange capacity, redox potential of the soil, composition of organic matter, etc. The toxicity of heavy metals in soil depends not so much on their concentration as on mobility.

The pH of the soil has a significant effect on the mobility of metals. In the acidic pH range, the mobility of many heavy metals is increased, and decreases as the medium's acidity neutralize. Liming is used to lower the acidity of the soil solution, but this technique is not universal [3]. Natural zeolites, which increase the cationic capacity of the soil, are also used to reduce the toxicity of heavy metals. The fact states that entry of heavy metals into plants occurs not only from the soil but also from the atmosphere. Heavy metals are predominantly scattered chemical elements [4]. According to the classification of J. Wood (1974), the following heavy metals classifies as very toxic: beryllium, cobalt, nickel, copper, zinc, tin, arsenic, selenium, titanium, rubidium, silver, cadmium, mercury, antimony, platinum. Mercury, lead, cadmium, zinc, arsenic are considered the priority pollutants since their accumulation in the environment is the highest.

The ability of plants to absorb from the environment in greater or lesser amounts of practically all known chemical elements has been established. The most dangerous of the listed series of heavy metals are copper and nickel. Copper has a special place in plant life. It plays a significant role in physiological processes - photosynthesis, respiration, redistribution of carbohydrates, restoration and fixation of nitrogen, metabolism of proteins and cell walls. However, in excessive doses, copper is an intense toxicant. The progressive pollution of the biosphere with this metal has noticeably increased interest in the mechanisms of its toxic action in recent years. Under the influence of excess copper, the morphology of the plant organism changes. Changes at the cellular level are manifest in the violation of the constructive structure of membrane formations (mitochondria, chloroplasts, etc.). It is extremely difficult to predict how the concentration of copper in soil toxic effects in plants will occur. Long before the poisoning symptoms become evident, food products obtained from crops with high levels of copper will pose a significant risk to human health [5]. For normal development, plants need an optimal level of copper and a specific ratio of other chemical elements.

In many cases, complex relationships between copper and other elements in plant tissues have been established. Iron is essential for the development of plants. It is known that antagonism is possible between copper and iron. The high level of copper in the plant reduces the iron content in the chloroplasts. The optimal ratio of copper to iron is different for different plant species. The toxic effect of copper can be reduced by the addition of iron.

Nickel is a hazardous environmental pollutant that is released into the atmosphere mainly from emissions from metal processing plants and the combustion of coal and oil. The use of sewage sludge and phosphate fertilizers can also be an essential source of its input into agroecosystems [6, 7]. Due to soil pollution with nickel, the growth slows down, and the productivity of crops decreases. Furthermore, with prolonged use of nickel products in concentrations exceeding the (maximum allowable concentrate, MAC), changes are noted in the human cardiovascular and respiratory systems [8].

Plants are more resistant to higher than to lower concentrations of heavy metals in the soil [9], but their increase to specific values almost always negatively affects the state of plants since heavy metals are the most toxic among chemical elements. For plants, the toxic concentration of elements plays an important role. The entry routes of heavy metals into plants are diverse, the main ones being root and foliar. Data on the distribution of heavy metals in plant organs are very contradictory. Some authors point to an enormous accumulation of them in the aboveground organs, others - in the roots [10]. Differences in the concentrations of heavy metals in different aboveground organs (leaves, stems, fruits) are often noted, which may be associated with the species specificity of plant metabolism and the properties of the elements themselves [11].

2. Methodology

The field experiment was carried out for three years on the territory of the botanical garden of Belgorod State University. In terms of soil, the site territory is located within the Ukrainian province of the chernozem zone, in the subzone of leached typical chernozems [12]. It is characterized by leached chernozemic, slightly eroded soils of heavy loamy texture. The wind rose in this study area indicates that the most frequent winds are North-Western and western directions, and the primary transfer of air masses comes from the city's industrial zone. The research objects were fruits and leaves of the following elderberry species: *Sambucus nigra* L., *S. canadensis* L., *S. racemosa* 'Aurea', *S. racemosa* L., *S. racemosa* 'Plumosa', *S. sibirica* Nakai, *S. canadensis* 'Plumosa', *S. coreana* Nakai. The sampling was carried out during the full ripening of the fruits, and the maximum formed leaf plates. The detection of heavy metals was carried out based on an aqueous extract of fruits and an aqueous extract of leaves using an atomic absorption spectrophotometer (AAS-1N) and a KFK-2 colorimeter. The data obtained were compared with the MAC.

3. Results and discussions

As a result of this work, we obtained the following results (Table 1).

Table 1. The content of heavy metals in fruits

	Micronutrient content							
	Mn		Cu		Al		Pb	
Species name	mg./l.	% from MAC	mg./l.	% from MAC	mg./l.	% from MAC	mg./l.	% from MAC
Sambucus nigra	0.09 ± 0.08	90 ± 79	7.4 ± 6.14	737 ± 614	5.1 ± 3.32	1020 ± 663	0.05 ± 0.035	166 ± 116
S. canadensis	0.07 ± 0.07	72 ± 70	7.6 ± 6.51	760 ± 651	5.7 ± 3.23	1133 ± 646	0.05 ± 0.043	169 ± 144
S. racemosa 'Aurea'	0.11 ± 0.10	110 ± 96	7.2 ± 5.41	720 ± 541	4.8 ± 3.81	961 ± 762	0.03 ± 0.025	97 ± 84
S. racemosa	0.10 ± 0.09	100 ± 87	7.9 ± 7.08	795 ± 708	5.2 ± 4.14	1043 ± 827	0.05 ± 0.047	180 ± 156
S. racemosa 'Plumosa'	0.11 ± 0.10	107 ± 93	7.7 ± 7.00	774 ± 704	5.2 ± 4	1045 ± 800	0.03 ± 0.024	93 ± 81
S. sibirica	0.20 ± 0.18	197 ± 18	8.6 ± 5.47	855 ± 547	4.2 ± 3.37	844 ± 675	0.03 ± 0.030	112 ± 100
S. canadensis 'Plumosa'	0.07 ± 0.07	72 ± 70	9.7 ± 8.15	970 ± 815	6.1 ± 3.65	1220 ± 730	0.05 ± 0.041	172 ± 136
S. coreana	0.11 ± 0.10	110 ± 96	8.9 ± 7.71	891 ± 771	4.0 ± 3.11	807 ± 623	0.05 ± 0.048	181 ± 159
MAC in water	0.1	100	1	100	0.5	100	0.03	100
	Micronutrient content							
	Zn		Co		Ni		Sr	
Species name	mg./l.	% from MAC	mg./l.	% from MAC	mg./l.	% from MAC	mg./l.	% from MAC
Sambucus nigra	0.22 ± 0.19	22 ± 19	0.016 ± 0.004	16 ± 4	0.017 ± 0.012	17 ± 12	0.073 ± 0.038	1.0 ± 1.0
S. canadensis	0.23 ± 0.15	23 ± 15	0.016 ± 0.008	16 ± 8	0.021 ± 0.011	21 ± 11	0.093 ± 0.029	1.4 ± 0.4
S. racemosa 'Aurea'	0.28 ± 0.06	28 ± 6	0.013 ± 0.015	13 ± 15	0.011 ± 0.009	11 ± 9	0.143 ± 0.12	2.0 ± 2.0
S. racemosa	0.28 ± 0.20	28 ± 20	0.013 ± 0.013	13 ± 13	0.009 ± 0.009	9 ± 9	0.114 ± 0.081	1.6 ± 1.1
S. racemosa 'Plumosa'	0.37 ± 0.15	37 ± 15	0.013 ± 0.013	13 ± 13	0.012 ± 0.011	12 ± 11	0.124 ± 0.089	1.8 ± 1.3
S. sibirica	2.00 ± 3.08	200 ± 308	0.013 ± 0.013	13 ± 13	0.046 ± 0.065	46 ± 65	0.103 ± 0.031	1.5 ± 0.5
S. canadensis 'Plumosa'	0.29 ± 0.24	29 ± 24	0.016 ± 0.008	16 ± 8	0.020 ± 0.011	20 ± 11	0.083 ± 0.038	1.2 ± 0.5
S. coreana	0.17 ± 0.10	17 ± 10	0.013 ± 0.013	13 ± 13	0.013 ± 0.011	13 ± 11	0.115 ± 0.079	1.6 ± 1.1
MAC in water	1	100	0.1	100	0.1	100	7	100

The presence and concentration of heavy metals in different elderberry species and different parts of plants vary greatly and have the following features. Increased magnesium content was observed in almost all species of elderberry, especially in red-fruited species (*S. racemosa* 'Aurea', *S. sibirica*, *S. racemosa*, *S. racemosa* 'Plumosa', *S. coreana*). Moreover, the magnesium concentration in fruits is much higher than in leaves; the greatest deviation of magnesium content from the norm was noted in the fruits and leaves of *S. sibirica* (2 and 1.5 times, respectively). Black elderberry species (*S. nigra*, *S. canadensis*, *S. canadensis* 'Plumosa') have a slightly lower magnesium concentration in fruits and leaves; its values are still close to critical.

The concentration of copper in fruits and leaves (Table 2) of all presented elderberry species is many times higher than the MPC. Its content in fruits is seven times (*S. racemosa* 'Aurea') - 10 times (*S. canadensis* 'Plumosa') exceeds the maximum permissible concentration and in leaves 2.5 times (*S. coreana*) - 6 times (*S. racemosa* 'Plumosa'). It was noted that black-fruited species accumulate copper more intensively in various plants, which is associated with their biological characteristics.

Table 2. Content of heavy metals in leaves

	Micronutrient content							
	Mn		Cu		Al		Pb	
Species name	mg./l.	% from MAC	mg./l.	% from MAC	mg./l.	% from MAC	mg./l.	% from MAC
Sambucus nigra	0.07 ± 0.06	68 ± 62	4.15 ± 3.5	415 ± 350	2.96 ± 2.02	591 ± 403	0.05 ± 0.04	157 ± 132
S. canadensis	0.05 ± 0.05	52 ± 50	4.69 ± 4.03	469 ± 403	3.17 ± 1.74	633 ± 348	0.05 ± 0.04	158 ± 140
S. racemosa 'Aurea'	0.10 ± 0.08	97 ± 84	3.57 ± 3.06	357 ± 306	1.80 ± 1.61	359 ± 323	0.03 ± 0.04	110 ± 126
S. racemosa	0.10 ± 0.09	97 ± 87	3.61 ± 3.11	361 ± 311	1.83 ± 1.24	367 ± 249	0.04 ± 0.04	135 ± 134
S. racemosa 'Plumosa'	0.11 ± 0.10	107 ± 101	5.74 ± 5.85	574 ± 585	3.30 ± 3.38	659 ± 675	0.04 ± 0.04	115 ± 134
S. sibirica	0.14 ± 0.12	137 ± 123	4.77 ± 2.83	477 ± 283	3.22 ± 3.07	645 ± 614	0.04 ± 0.05	130 ± 154
S. canadensis 'Plumosa'	0.05 ± 0.05	52 ± 50	4.89 ± 4.14	489 ± 414	3.84 ± 2.64	769 ± 527	0.05 ± 0.04	169 ± 146
S. coreana	0.11 ± 0.10	113 ± 98	2.47 ± 3.84	247 ± 384	1.65 ± 1.72	331 ± 343	0.04 ± 0.04	140 ± 142
MAC in water	0.1	100	1	100	0.5	100	0.03	100

	Micronutrient content							
	Zn		Co		Ni		Sr	
Species name	mg./l.	% from MAC	mg./l.	% from MAC	mg./l.	% from MAC	mg./l.	% from MAC
S. nigra	0.10 ± 0.08	10 ± 8	0.010 ± 0.003	8 ± 3	0.01 ± 0.009	7 ± 9	0.08 ± 0.07	1.2 ± 1.0
S. canadensis	0.12 ± 0.10	12 ± 10	0.007 ± 0.003	7 ± 3	0.011 ± 0.011	11 ± 11	0.107 ± 0.090	1.5 ± 1.3
S. racemosa 'Aurea'	0.21 ± 0.10	21 ± 10	0.005 ± 0.006	5 ± 6	0.007 ± 0.006	7 ± 6	0.090 ± 0.066	1.3 ± 0.9
S. racemosa	0.20 ± 0.05	20 ± 5	0.006 ± 0.007	6 ± 7	0.008 ± 0.008	8 ± 8	0.088 ± 0.057	1.3 ± 0.8
S. racemosa 'Plumosa'	0.25 ± 0.14	25 ± 14	0.007 ± 0.006	7 ± 6	0.010 ± 0.009	10 ± 9	0.088 ± 0.057	1.3 ± 0.8
S. sibirica	1.25 ± 1.91	125 ± 191	0.005 ± 0.009	5 ± 9	0.004 ± 0.006	4 ± 6	0.062 ± 0.040	0.9 ± 0.6
S. canadensis 'Plumosa'	0.10 ± 0.08	10 ± 8	0.007 ± 0.002	7 ± 2	0.010 ± 0.011	10 ± 11	0.090 ± 0.075	1.3 ± 1.1
S. coreana	0.22 ± 0.14	22 ± 14	0.007 ± 0.008	7 ± 8	0.048 ± 0.075	49 ± 75	0.078 ± 0.039	1.1 ± 0.6
MAC in water	1	100	0.1	100	0.1	100	7	100

Aluminum has the highest deviations from the norm among the identified heavy metals. Its highest concentrations are noted in fruits, slightly lower - in leaves, and, as in the case of copper, black-fruited elderberry species accumulate aluminum more intensively. The highest deviation of the content of this element from the norm was noted in the fruits and leaves of *S. canadensis* 'Plumosa' - 12 and 8 times, respectively, and the smallest in the fruits and leaves of *S. coreana* - 8 and 3 times, respectively.

The presence of lead in the fruits and leaves of the presented elderberry species also exceeds the maximum permissible concentration. However, the excess values are not as large as in the case of the above-mentioned heavy metals. The maximum excess of MAC for lead in fruits was found in *S. coreana* and *S. racemosa* - almost two times, and in the leaves - in representatives of the species *S. canadensis* 'Plumosa' (2/3 of the norm).

As for such a heavy metal as zinc, its presence in elderberry fruits and leaves does not go beyond the permissible concentrations, except for one species – *S. sibirica.*

Revealing the concentrations of such heavy metals as cobalt, nickel, and strontium showed that their presence in various parts of plants does not deviate from the norm and varies in different representatives of the genus from 1 to 46% in fruits and from 1 to 49% in leaves compared to the maximum permissible concentrations.

4. Conclusion

The conducted monitoring showed that such heavy metals as aluminum, magnesium, copper, zinc in their concentrations in fruits and leaves of most of the genus *Sambucus* L. species exceed the limits of permissible concentrations. Lead, cobalt, nickel, strontium are contained in fruits and leaves in permissible concentrations or slightly exceed them. In this regard, fruits and leaves of some elderberry species (*S. racemosa* 'Aurea,' *S. sibirica, S. nigra*) cannot be used for medicinal and food purposes due to the accumulation of certain heavy metals above the normal limit. The rest of the types are recommended to be used with restrictions depending on the purpose of use. Elderberries should be grown in areas not prone to technogenic pollution to obtain environmentally friendly products.

References

[1] Deineka V I, Sorokopudov V N, and Kol'tsov S V 2005 Antocyans from Fruit of Some Plants of the Caprifoliaceae Family *Chemistry of Natural Compounds* **2** pp 162-164

[2] Koltsov S V, Sorokopudov V N , and Martynova N A 2009 Influence of meteorological conditions on the phenorhythm of black elderberry (Sambucus nigra L.) in the Belgorod region *Problems of regional ecology* **1** pp 8-11

[3] Koltsov S V and Sorokopudov V N 2011 Drought resistance of some representatives of the genus Sambucus L. in the conditions of the Belgorod region // *Scientific Bulletin of BelSU. Ser. Natural Sciences* **9(104)** pp 313-316

[4] Prokhorova N V, Matveev N M, Pavlovsky V A 1998 *Accumulation of heavy metals by wild and cultivated plants in the forest-steppe and steppe Volga region* (Samara: Publishing house "Samara University") p 131

[5] Demidchik V V, Sokolik A I, and Yurin V M 2001 Toxicity of excess copper and plant tolerance to it *Successes of modern biology* **5** pp 511-525

[6] Kabata-Pendias A and Pendias X 1989 *Trace elements in soils and plants* (Moscow: Mir) p 439

[7] Zulfugarova M B and Novruzov E N 2017 Composition and content of anthocyanins of fruits of Sambucus ebulus L. *Chemistry of vegetable raw materials* **1** pp 163-167 DOI:10.14258/jcprm.2017011422

[8] Shilnikov I A *et al.* 2014 Factors affecting the entry of heavy metals into plants *Agrochemistry* **10** pp 94-101

[9] Sorokopudov V N and Voloschenko L V 2016 Some aspects of the chemical composition of fruits of Sambucus nigra L. When introduced *Questions of biological, medical and pharmaceutical chemistry* **6** pp 74-77

[10] Agapkina T A 2016 Symbols of trees in the traditional culture of the Slavs: elderberry (genus Sambucus L.) *Slavic world in the third millennium* **11** pp 487-495.

[11] Vtorova V N 1993 Variability of the elemental composition in representatives of the genera Populus, Lycium and Tamarix on saline soils *Botanical journal* **8** pp 17-33

[12] Belykh V I *et al.* 2002 *The state of the environment and the use of natural resources of the Belgorod region in 2001 (Annual report)* (Belgorod) p 96