

Heavy Metal Concentration in the Herbal Medicinal Products of *Hippophae Rhamnoides L.* Which Grows on Refuse Dumps of the Kuznetsk Coal Basin Surface Mines

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Abstract: The features of the HM accumulation have been studied and the hygiene evaluation of the herbal medicinal products of *Hippophae rhamnoides L.* which grows in the context of the refuse dump of the "Kedrovsky" surface coal mine has been conducted. Low concentration of the biologically active micro-elements - Cu and Zn - below the sufficient soil supply sensu N.K. Krupsky - G.N. Alexandrova has been exposed in the embryonic soils of the refuse dump. It has been established, that the HM concentration in the embryonic soils of the refuse dump does not exceed MAC (TAC). It has been found, that the sea buckthorn leaves compared with its berries substantially better accumulate Mn and Fe. Calculations of the biological motility coefficients have shown that the leaves and berries of the sea buckthorn to a greater extent take up Cu and Zn from the embryonic soils. The hygiene evaluation of the *Hippophae rhamnoides L.* leaves and berries has shown the MAC non-exceedance of the heavy metals, provided for the plant-based BAA, MAC based on the integrated world data and the regional background of the Kuznetsk Basin unpolluted areas.

Key words: Refuse dumps of surface coal mines • Heavy metals • Medicinal plants • Hygiene evaluation

INTRODUCTION

The Kuznetsk Basin - is the region of the developed coal-mining industry. As a result of the coal mining the area of disturbed lands in the region is 100.000 he, which is unavoidably followed by the ecological disturbance. Over the last years about 20.000 he have been reclaimed. One of the most promising crops for the reclamation is the sea buckthorn (*Hippophae rhamnoides L.*), a dioecious plant of the oleaster family (Elaeagnaceae). On the Kuznetsk Basin refuse dumps about 3.000 he of this crop have been planted. It has been previously found that the bioecological sea buckthorn features fully conform to the refuse dump site [1].

The sea buckthorn has been historically used in both folk and traditional medicine. In the medical practice the greatest use has been found for the sea buckthorn berries, which contain: glucose, organic acids (malic acid, tartaric acid, oxalic acid), fatty acids (oleic, linolenic), vitamins (C, B₁, B₂, B₁₂, E, P, PP, K), carotenoids, flavonoids, micro-elements (Ferrum, Boron, Manganese,

etc.), tannins, nitrogen compounds, etc. The sea buckthorn oil, extracted from the sea buckthorn and the medical products which contain it, are used as an anti-inflammatory and regenerative agents [2-6].

Over the last years the *Hippophae rhamnoides L.* leaves have begun to use as the medicinal products [7-9]. The sea buckthorn thickets on the Kemerovo Region refuse dumps are favourite berrying places for the local population.

However, the coal mining wastes (refuse dumps and mine wastes) could be the sources for the heavy metals (HM) high concentration [10]. HM take a special place among the soil and plant technogenic pollutants due to its wide spread occurrence and high toxicity. They are able to join the biological cycle and be accumulated in the human body.

Hence, the studies on the resource potential of the medicinal plants, which grow on the refuse dumps of the Kuznetsk Coal Basin surface mines and the evaluation of its environmental and hygiene safety level are relevant.

The objective of this work - is to evaluate the HM pollution of the *Hippophae rhamnoides* L. medicinal plants, which grows on the refuse dump of the "Kedrovsky" surface coal mine and the associated embryonic soils.

MATERIALS AND METHODS

The studies have been conducted on the "Yuzhny" refuse dump of the "Kedrovsky" surface coal mine. The total area of the "Yuzhny" refuse dump is 599.3 ha and of 58 m in height, with a plain and sloping terrain. The refuse dump rocks are presented by sandstone (60%), siltstone (20%), mudstone (15%), loam and clay (5%). The predominant fraction is the large aggregates (from 3 to 10 mm and more), the concentration of fine particles is reduced. The embryonic soils are characterized by the alkaline reaction (pH 7.1-7.7 aqueous extract), the medium humus supply (3.5 %), the low supply of the phosphorus and nitrogen motile forms (1.7-7.0 mg / kg), the concentration of the exchangeable potassium is slightly below the mark (125 mg / kg).

The study objects were the samples of the *Hippophae rhamnoides* L. berries and leaves and the associated embryonic soils collected over the period of 2011-2013.

The plant procurement was carried out in early September, in the dry sunny weather, on the top of the planned refuse dump according to the conventional rules. The plants were gathered without any visible signs of damage. The average sample was prepared by quartering in accordance with the GOST 24.027.0-80. The permissible tolerances in the average sample weight did not exceed $\pm 10\%$. The embryonic soils associated with the plants were selected from the root layer (A 0-15 sm) using the common method.

The elemental analysis of the samples of the embryonic soils and plants was carried out by atomic absorption using the spectrophotometer AAS-30 (Germany) in the air-acetylene flame on the basis of an accredited test centre of the "Kemerovo" agrochemical service. The concentration of Pb, Cd, Cu, Zn, Mn, Ni, Co, Fe, Cr was analysed. For the HM extraction from soils the ammonium acetate buffer with pH-4,8 at the ratio of soil / solution - 1/10, the extraction time of 24 hours was applied. The sample preparation of the plants was carried by dry ashing followed by extraction of the diluted nitric acid (1:1), the extraction time of 24 hours. The analyses were performed in triplicate, the results were statistically processed using the Statistica 6.0 software.

The biological mobility coefficients (B_x) have been calculated to characterize the availability of the chemical elements for plants - the ratio of the element concentration in the air-dry weight of the plant parts (mg/kg) to the concentration of motile forms of the element compounds in the soil (mg/kg).

RESULTS AND DISCUSSION

The analysis of the obtained results showed that the investigated embryonic soil samples contain more Fe and Mn, less - Cd (Table 1). The comparison of the HM concentration in embryonic soils of the refuse dump with the Hygiene Regulations has not detected its MAC (TAC) exceedance (Table 1). Low concentration of such biologically active micro-elements, as Cu and Zn - below the sufficient soil supply sensu N.K. Krupsky - G.N. Alexandrova has been exposed.

It has been experimentally established that in the quantitative terms the leaves and berries of the *Hippophae rhamnoides* L. contain more metals-Biophilia, which could be placed in the following order: $Fe > Mn > Zn > Cu$. The increased need of the plants in metals-Biophilia is obviously connected with its participation in the vital biochemical processes that determine the normal growth and development.

The obtained results comply with the literature data [17]. The comparative profile of the storage capacity showed that sea buckthorn leaves significantly more accumulate Mn and Fe in comparison with berries - in 2,3 and 1,6 times respectively (Table 1).

This is probably due to the synthesis in the leaves of the biologically active compounds.

We have not found a direct relation between the HM concentration in plants and the associated embryonic soils, what confirms the fact of selective absorption of the chemical elements by plants. It has been experimentally established that the low concentration of motile forms of Cu and Zn in the embryonic soils (0,28 mg/kg and 0,90 mg/kg respectively), its accumulation in the leaves and berries of sea buckthorn is stated (Cu - 3,08 and 2,64 mg/kg, Zn - 12,92 and 11,59 mg/kg respectively).

The calculations of the biological motility coefficients have shown that the leaves and berries of the sea buckthorn to a greater extent take up Cu and Zn from the embryonic soils. (B_x for Cu -11,00 and 9,43, for Zn - 14,35 and 12,88 respectively) (Fig. 1). For the sea-buckthorn the suppression of the biological absorption for a wider range of HM compared with the leaves has been revealed ($B_x < 1$ for Pb, Cd, Mn, Ni, Co,

Table 1: The HM concentration in embryonic soils and Hippophae rhamnoides L. collected on the refuse dump of the "Kedrovsky" surface coal mine (average data for 2011-2013)

Element Concentration, mg/kg							
Elements	Embryonic Soils		Plants				
	Motile Form	MAC, TAC* [11, 12]	Berries	Leaves	MAC for BAA [13]	MAC, integrated, world [14]	RB* [15,16]
Pb	1.96±0.43	6.0	0.57±0.03	0.58±0.03	6.0	5-10	1.18
Cd	0.06±0.02						
TAC		1.0	0.04±0.002	0.04±0.003	1.0	0.05-0.2	0.21
Cu	0.28±0.02	3.0	2.64±0.13	3.08±0.15	-	5-30	6.94
Zn	0.90±0.05	23.0	11.59±0.65	12.92±0.65	-	27-150	9.96
Mn	34.13±2.18	140-500	7.76±0.46	17.73±0.85	-	20-300	21.58
Ni	1.77±0.09	4.0	0.60±0.02	0.71±0.04	-	-	1.98
Co	0.68±0.04	5.0	0.42±0.02	0.40±0.02	-	-	2.15
Fe	38.48±3.66	-	26.57±1.41	43.05±2.69	-	-	104.51
Cr	1.06±0.10	6.0	0.41±0.03	0.49±0.02	-	-	4.08

Note: TAC* - is the tentative allowable concentration; RB* - is the regional background (a conditionally pollution-free area)

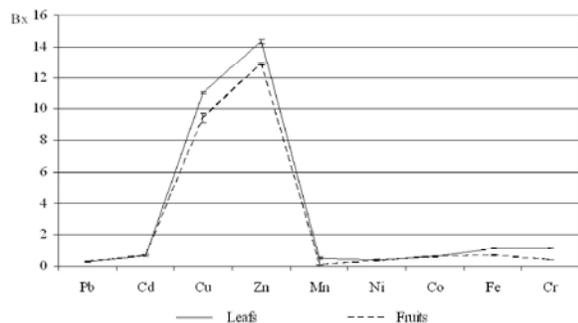


Fig. 1: The biological motility coefficient (Bx) for leaves and berries Hippophae rhamnoides L.

Fe, Cr). For both the sea-buckthorn leaves and berries the minimum index of Bx is characterized for Pb (0,29). About the most storage capacity of the sea buckthorn leaves against HM indicates M. Lavinia *et al.* [18].

W. Letchamo *et al.* [19] it has beenfound that different cultivars of the sea buckthorn are characterized by itsability to accumulate in the berries HM, it must be taken into consideration when using this plant in the disturbed land reclamation

The modern regulatory documentation does not standardize the HM concentration in the herbal medicinal products, thus for its analysis MAC are often used, provided for the plant-based (BAA); the HM concentration in plants of the control, unpolluted areas and MAC based on the integrated world data [19].

The hygiene evaluation of the Hippophae rhamnoides L. leaves and berries has shown the MAC non-exceedance of the heavy metals, provided for the plant-based BAA, MAC based on the integrated world data and the regional background of the Kuznetsk Basin

unpolluted areas (Table 1). Therefore, this Herbal Medicinal Products in the matter of HM concentration poses no danger to the human health.

CONCLUSION

As a result of the work done the features of the HM accumulation have been exposed and the hygiene evaluation of the herbal medicinal products of Hippophae rhamnoides L. which grows in the context of the refuse dump of the "Kedrovsky" surface coal mine has been conducted. Low concentration of such biologically active micro-elements, as Cu and Zn - below the sufficient soil supply sensu N.K. Krupsky - G.N. Alexandrova has been exposed in the embryonic soils. The comparison of the HM concentration in embryonic soils of the refuse dump with the Hygiene Regulations has not detected its MAC (TAC) exceedance.

It has been experimentally established that in the quantitative terms the leaves and berries of the Hippophae rhamnoides L. contain more metals-Biophilia, which could be placed in the following order: Fe>Mn>Zn>Cu. It has been found, that the sea buckthorn leaves compared with its berries substantially better accumulate Mn and Fe.

Calculations of the biological motility coefficients have shown that the leaves and berries of the sea buckthorn to a greater extent take up Cu and Zn from the embryonic soils. For the sea-buckthorn the suppression of the biological absorption for a wider range of HM compared with the leaves ihas been revealed (Bx<1 for Pb, Cd, Mn, Ni, Co, Fe, Cr). The hygiene evaluation of the Hippophae rhamnoides L. leaves and berries has shown

the MAC non-exceedance of the heavy metals, provided for the plant-based BAA, MAC based on the integrated world data and the regional background of the Kuznetsk Basin unpolluted areas. Therefore, this Herbal Medicinal Products in the matter of HM concentration poses no danger to the human health.

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