J. Mater. Environ. Sci. 6 (2) (2015) 333-342 *Anđić et al.*
ISSN : 2028-2508
CODEN: JMESCN

Comparative analysis of trace elements in the mosses - *Bryum argenteum* Hedw. and *Hypnum cupressiforme* Hedw. in Podgorica (Montenegro)

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Abstract
This paper presents the first results of the comparative analysis of reading 11 trace elements (Pb, Cd, As, Hg, Cr, Ni, Cu, Zn, Mn, Fe, Co) in the mosses - *Bryum argenteum* Hedw. and *Hypnum cupressiforme* Hedw. that are collected in Podgorica (Montenegro). These researches showes 7 trace elements (Pb, Cd, Cr, Cu, Zn, Fe, Co, Mn) which have the highest concentration in the sample collected at the site located near the center of Podgorica, where a great frequency of traffic is present every day. By conducting of comparative analysis, it is concluded that there is a strong correlation between the concentration of trace elements in *Bryum argenteum* Hedw. and *Hypnum cupressiforme* Hedw. at study area. Also, this analysis showed that moss can accumulate substantial amounts of trace elements, which once again confirms the fact that these plants are good indicators of the environment pollution (biological indicators).

Keywords: moss, trace elements, Podgorica, Montenegro

Introduction
Heavy metals are the elements whose concentration in the environment is constantly increasing. According to a study [1], the most important sources of different metals in Europe are: industrial metals (Al, As, Cr, Cu, Fe, Zn), other manufacturing industries, construction (As, Cd, Cr, Hg, Ni, Pb), the production of electricity and heating (As, Cd, Hg, Ni), ground transportation (Cu, Sb, Pb, V, Zn), oil (Ni, V), phosphate fertilizers in agricultural regions (Cd). According to the report of Environmental Protection Agency of Montenegro from 2009, the main sources of air pollution in Montenegro are: industry, transport, utility problems (inadequate treatments of solid waste and illegal dumps), increased consumption of solid and liquid fuel during the heating season. Households in the cities of Pljevlja, Nikšić, Podgorica are the most heavily loaded with pollutants from industry and traffic, while the air in other parts of the country has good or very good quality [2].
Thanks to the ability to accumulate heavy metals in their tissues, plants are widely used in biomonitoring. Their populations can become resistant to heavy metals either by adaptation (ecotypes), or by gradually acclimatization to the increased volume of heavy metals [3, 4, 5, 6]. Mosses have the ability to rapidly undergo evolutionary response when they are exposed to increased concentrations of heavy metals in the soil [7]. Number of functional groups located in the cell wall of moss allows them to bind metals [8, 9,10]. These plants have slow growth and lack of both a protective cuticle and epidermis, what allows them to easily leak water, minerals, and metal ions [11]. Inherence of their high cationic exchange allows the accumulation of heavy metals between apoplast and symplast without damaging vital functions [12]. Also, they have the ability to transfer and dispose heavy metals in their vacuoles [13].
Compared to vascular plants Chakrabortty and Paratkar (2006) [14], mosses have the following advantages in the monitoring of pollution: i) perennial form without deciduous ii) absorb atmospheric contents within their

entire surface, iii) get most of the nutrients from the air, iv) a large area of to-weight ratio makes them easy to absorb pollutants, v) slow growth rate allows the accumulation for a long period of time, vi) undeveloped vascular bundles provide better absorption than vascular plants, vii) minimal morphological changes in the life cycle, viii) have wide distribution, ix) easy to sample.

The idea of moss usage in monitoring of air pollution dates back to the late 1960s [15,16] , while "The heavy metal in Mosses Survey" was established in 1980. Since then monitoring has been repeated in 5-year intervals, and the number of countries and participants is constantly growing [1, 17].Thus, in the 2000/2001 Survey included 28 countries, 7000 locations and 100 participants who were monitoring a concentration of 10 heavy metals (As, Cd, Cr, Cu, Fe, Pb, Hg, Ni, V, Zn) in the wild mosses [17]. With the exception of Slovenia, the region was not included in the monitoring. In 2005, Croatia, Serbia and Macedonia became the part of the Survey, and thus the interest for this topic in the region intensifies [18, 19, 20, 21, 22]. Territory of Bosnia and Herzegovina, and Montenegro remained excluded from the monitoring. Generally in Montenegro, the use of wildlife in the monitoring of environmental pollution does not have long tradition and it is not continuous. In particular, there is only one publication about mosses as bioaccumulators [23]. It treated the presence of radioactive substances in mosses sampled in the Durmitor mountain region, after the Chernobyl disaster.

The aim of this paper is pioneering determination of concentrations of trace elements in mosses, identifying sites with the highest concentrations, their comparison with the relevant papers published up to now, as well as comparative analysis of the concentration of trace elements in two moss species *Bryum argenteum* Hedw. and Hypnum cupessiforme Hedw., what would establish guidelines for future research in this area. The final goal would be making of legal regulations for maximum allowable concentrations of trace elements in plants.

2. Materials and methods

2.1. Study area

Podgorica is the capital and largest city of Montenegro. It is located in the northern part of the Zeta plain, at the meeting point of Skadar basin, Bjelopavlići plain and Morača valley. It lies 48-56m above the sea level, within the confluence of Ribnica in Morača [24]. The census of 2011th showed that about 188.000 inhabitants live there [25]. The area is characterized by the modified Mediterranean climate, with mild and short winters, mainly without snow and long, hot summers. The average annual air temperature is 15.4˚C, the temperature of the coldest month (January) is around 5.2˚C and in the warmest (July) 26.2˚C. The annual rainfall is 1673mm, with minimum excreted in the warm season (July) and the maximum in the cold season (November). According to Köppen's classification climate is defined as Csax″ [26]. Thanks to favorable natural conditions, especially for fruit breeding and agriculture, significant part of the periurban area is arable (Agro combine "July 13", private properties). The city is also an important industrial center (Aluminium Plant, diverse manufacturing industries), as well as the main crossroads in Montenegro [24].

The material is sampled within ten sites in the urban area of Podgorica. The selected sites are those with diverse environmental conditions because they obtain more comprehensive information about the concentration of trace elements. For each site, coordinates are specified with the device Garmin e-Trex Vista C. Table 1 provides the names and coordinates of the sites.

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Table 1. Sampling sites with coordinates

Ordinate nubmers of sampling sites, and names	Coordinates:
Site 1- Cetinjski put	42º26'07.9"N 19º13'44.2"E
Site 2- City kvart	42º26'16,2" N 19º14'050"E
Site 3- KAP 1	42º23'17,2" N 19º14'10,7"E
Site 4- KAP 2	42º23'44,3"N 19º14'10,7"E
Site 5- Cijevna 1	42º23'000"N 19º16'51,6"E
Site 6- Cijevna 2	42º22'07,9"N 19º13'20,4"E
Site 7- Tološka polje 1	42º27'24.00"N 19º12'06,0" E
Site 8- Tološko polje 2	42 º26'54,7''N 19º13'54,6" E
Site 9- Park šuma Gorica 1	42º27'009"N 19º16'39,7"E
Site 10- Park šuma Gorica	42º26'00,8"N 19º14'27,4"E

2.1. Processing of plant material

The content of trace elements is determined in two moss species: *Bryum argenteum* Hedw. and *Hypnum cupressiforme* Hedw.. *Bryum argenteum* Hedw. is acrocarpous moss that can absorb trace elements deposited several years in the surface layers and serves as an indicator of long-term atmospheric pollution [19]. *Hypnum cupressiforme* Hedw. is pleurocarpous moss which is not firmly attached to the substrate and the accumulation is done mainly from precipitation [27, 28, 29]. It is used to get the data about short-term atmospheric pollution.

Sampling is done in accordance with the protocol from 2000\2001[30], and the detailed procedure was given by Rühling (1998) [31]. The plant material was collected in October 2011.

After sampling, herbal material was cleaned of impurities. Only green parts of plants were used to read data. The material was dried at a room temperature and pulverized in a mortar. Samples were digested by using microwave digestion (microwave oven - MWS-4, manufacturer Berghof, Germany) and 0.5 g sample was treated with 5 ml HNO3 and 2 ml f H2O2 at the appropriate temperature program decomposition. The content of elements was determined using ICP/OES spectrometer, model iCAP 6300, Thermo Fisher manufacturer. Determination of apron was carried out in the Centre for Eco-toxicological Researches, Podgorica, Montenegro. Determination of total mercury was carried out with a mercury analyzer - Advanced Mercury Analyzer AMA 254, Leco manufacturer. The results were presented in the tabular form.

Statistical program-STATISTICA 10 was used for calculation of correlation of elements concentration.

3. Results and discussion

For better visibility, results are given in the form of two tables (Tables 2, 3).

3.1. Lead (Pb)

Lead is an element which is much used in modern industry. It is used as an additive to gasoline and petroleum products. By their combustion it is released and enters the atmosphere. Batteries are the second largest source of pollution by heavy metals [32]. The minimum concentration of lead is determined in the material collected at the site 9, and the maximum, which is 10 times higher, at the site 10 (Table 2). Near this site the oldest gasoline station in town was located, so a certain amount of this element probably comes from that source. The station was relocated about three months before the sampling of plant material. The site 10 is the closest to the city center, and therefore the traffic frequency is greatest. Such correlation between lead concentration and proximity to the city core was obtained in similar studies in municipality Obrenovac-Serbia [19]. The limit value for concentration of this metal and its compounds in the air is 0.5 mg/m3 [33], and in the soil 50 mg / kg [34]. The limit value of lead content in surface and ground water is 0.001 mg / l for water Class A, 0.01 mg / l for water class A1, 0.05 mg / l for water A2 and A3 classes [35], while in the drinking water it is 25 mg / l [36]. At higher concentrations, it shows toxic effects on plants: reduced root growth, loss of apical dominance, forming the island behind the root tip [37].

3.2. Cadmium (Cd)

Cadmium is an element that has a negative effect on plants, animals and humans. It is a relatively rare element in nature and it can be found in ground in low concentrations. It is mainly produced as a byproduct of zinc refining, which can contain about 0.1-0.3%, and sometimes up to 1% of cadmium [38]. The accumulation of this element in the human environment can happen in two ways: intentionally-production of crude cadmium in the industry, which is further processed; unintentionally - using products that contain cadmium, fossil fuels and phosphate fertilizers [39]. The highest concentration of cadmium is registered at the site 10. Most likely it is a product of combustion of fossil fuels which is heated in inner-city core. The minimum concentration is determined at the site 5 (Table 2). The target value of the total cadmium content in the PM10 fraction of particulate air has a threshold value of 5 ng/m3 as an annual mean [33]. The maximum level of cadmium in the soil is 2 mg / kg [34]. Limit value of cadmium in the surface and ground water is 0.001 mg / l for water class A and A1, and 0.005 mg / l for water A2 and A3 classes [35], while in drinking water it is 5 mg / l [36].

Table 2. Concentrations of lead (Pb), cadmium (Cd), arsenic (As), mercury (Hg) and chromium (Cr) in the material sampled from 10 sites mg/kg d.m. Name of species in which the estimated concentration of metals was measured is given below the name of the site.

Site (moss species)	Pb mg/kg d.m.	Cd mg/kg d.m.	As mg/kg d.m.	Hg mg/kg d.m.	Cr mg/kg d.m. (Total)
Site 1- Cetinjski put *(Hypnum cupressiforme)*	18,11	0,308	0,200	0,068	8,43
Site 2- Cyti kvart *(Bryum argenteum)*	52,45	0,633	0,662	0,045	16,01
Site 3- KAP 1 *(Hypnum cupressiforme)*	38,84	0,429	0,594	0,068	7,96
Site 4- KAP 2 *(Bryum argenteum)*	116,56	0,780	2,259	0,067	18,24
Site 5- Cijevna 1 *(Hypnum cupressiforme)*	18,76	0,305	0,907	0,082	10,07
Site 6- Cijevna 2 *(Bryum argenteum)*	121,62	1,749	2,621	0,060	42,35
Site 7- Tološka polje 1 *(Hypnum cupressiforme)*	35,50	0,511	0,761	0,142	13,38
Site 8- Tološka polje 2 *(Bryum argenteum)*	84,38	1,137	0,185	0,068	44,39
Site 9- Park šuma Gorica 1 *(Hypnum cupressiforme)*	16,17	0,320	<0,05	0,079	4,31
Site 10- Park šuma Gorica 2 *(Bryum argenteum)*	166,12	2,161	0,315	0,087	76,33

3.3. Arsenic (As)

The minimum concentration of arsenic is measured at the site 9, and the highest at the site 6. Probably, this concentration at the site comes from both the exhaust gases and the aluminum, and they are passed by the wind. It is usually encountered in air in the form of arsenic trioxide, which is a by-product in the industry of copper, lead, zinc, nickel, glass. Pursuant to the Regulations on emission of air pollutants [33] arsenic trioxide is among the first class of carcinogenic harmful substances along with arenit, arsenic acid and their salts in the respiratory form. The target value of the total arsenic content in the PM10 fraction of particulate air has a threshold of 6 ng/m3 as an annual mean [33]. In the literature, the average concentration of arsenic in the air in the areas of Europe are given values: 0.2 to 1.5 ng/m3 in rural areas, 0.5 to 3 ng/m3 in urban areas and up to 50 ng/m3 in industrial zones [40]. The maximum level of arsenic in soil is 20 mg / kg [34]. The limit value of arsenic in surface and ground water is 0.001 mg / l for water class A, 0.01 mg / l for water class A1 and 0.05 mg / l for water A2 and A3 classes [35], while in the drinking water it is 10 mg / l [36]. Plants show following symptoms of toxic effects of this element: reduced plant growth and its yield [41], plasmolysis and root discoloration, necrosis and leaf curl [42], reduced photosynthetic capacity [43].

3.4. Mercury (Hg)

At the site 2, the lowest concentration of mercury is recorded, while the highest concentration is recorded at the site 7. It is assumed that on some area mercury derives from fossil fuels. Its emissions into the atmosphere are the result of the following human activities: burning fossil fuels, metal processing, gold extraction [44, 45]. This metal has a great possibility of spreading through the atmosphere and occurs in a very remote locations of the sources of contamination [46]. Prolonged exposure to high concentrations of this metal in plants has resulted in reduced growth rate, reduced photosynthetic activity, changes in the structure of chloroplast-disruption of the enzyme for the assimilation of CO2 [47]. Since 1990 the overall decline has been observed in the atmospheric concentrations of mercury [48]. The average sample of air taken at least 30min and 8h maximum concentration limit value of the metal is 0.05 mg/m3 [49].

3.5. Chromium (Cr)

Chromium is used in industry to make stainless steel alloys which improves many properties, and it is used as a catalyst as well as tanning and impregnation of wood. His origin in air comes from industry, especially from the ferro-chromium compounds, mineral processing, cement production, combustion of fossil fuels. The minimum concentration of this metal is determined at the site 9, while the maximum concentration is recorded at the site 10, probably originating from traffic. Its toxicity in plants depends on its valence state. Cr (VI) is very active and toxic, while Cr (III) is less toxic. The negative effects of chromium in plants are: changes in the process of germination, root growth and leaf, disrupts of physiological processes such as photosynthesis, as well as water and mineral absorption [50]. Chromium stress is one of the important factors that affect photosynthesis, CO2 fixation, electron transport, and enzymatic activity of photophosphorylation [51]. The maximum level of total chromium in soil is 50 mg/kg [34]. The limit value of total chromium in surface and ground water is 0.001 mg/l for water class A and A1 and 0.05 mg / l for water classes A2 and A3 [35], while in drinking water it is 50 mg/l [36].

3.6. Nickel (Ni)

Nickel in the air originates mainly from industry, combustion of fossil fuels and waste incineration [52]. Concentration greater than 50 mg / kg in plant tissue is toxic [53]. Toxic concentration of nickel is registered on the sites 3 (KAP1), 4 (KAP2), 8 (Tološko polje 2) and 10 (Forest Park Gorica 2). It is likely that at sites 3 and 4 nickel has industrial origin, and at sites 8 and 10 it comes from exhaust gases (Table 2). The target value of the total nickel content in the PM10 fraction of particulate air has a limiting value of 20 mg/m3 as an annual mean [33]. The maximum level of nickel in soil is 50 mg / kg [34]. The limit value of nickel in surface and ground waters is 0.002 mg / l for water class A and A1, 0.05 mg / l for water class A2 and 0.1 mg / l for water class A3[35], while in the drinking water it is 20 mg / l [36].

3.7. Copper (Cu) and zinc (Zn)

Copper and zinc are metals whose concentrations are correlated in urban areas [54]. Minimal inhibitory concentrations of these two metals are observed at the site 9, and the highest at the site 10. There are two hypotheses about the origin of the metals in the above mentioned sites. The first one is about the construction activities: processing, grinding and welding of metals. By Pascale et al. (2010) [54] these activities can be the source of copper and zinc in urban and agricultural areas. Another possibility is that they are sourced from the metal industry, and they are brought in air by currents. The results are correlated with data of [19]. Increased concentrations of copper and zinc in plants have resulted in the following: reduced amount of chlorophyll, reducing photosynthesis, respiration inhibition [55]. Study of Shaw et al. (1987) [56] indicated on zinc inhibitory effect on the growth of moss protonemata. Limit value for zinc in the air is 5mg/m^3 [57]. The maximum concentration of copper in the air is 0.5 mg/m3 [49].

3.8. Manganese (Mn)

The main anthropogenic sources of manganese in the air are: industrial emissions (iron and steel production, power plants, foundries), combustion of fossil fuels, drawing supplies from the land of manganese [58]. It might come in air as a result of metal welding and the use of fungicides [44]. The site 9 is the least burdened by this heavy metal, while the greatest concentration is determined on the site 10. It is assumed that the surrounding traffic and welding of metal structures in the construction are the main sources. By SABOVLJEVIĆ et al. (2009) [19] the concentration of manganese dust and manganese vapor should not exceed the value of 5mg/m3. This element is essential for plants because it participates in the transfer of electrons during the photo oxidation of water in photo system II [59]. At higher concentrations it is toxic, displaying the following symptoms: brown necrotic center, chlorosis, necrosis.

Table 3. Concentrations of nickel, copper, zinc, manganese, iron and cobalt in plant tissue within the appropriate site.

Site (moss species)	Ni mg/kg d.m.	Cu mg/kg d.m.	Zn mg/kg d.m.	Mn mg/kg d.m.	Fe mg/kg d.m.	Co mg/kg d.m.
Site 1- Cetinjski put *(Hypnum cupressiforme)*	10,83	13,78	49,69	74,17	2824,78	1,12
Site 2- Cyti kvart *(Bryum argenteum)*	25,64	53,46	94,98	206,12	5930,19	2,17
Site 3- KAP 1 *(Hypnum cupressiforme)*	51,51	36,75	66,79	71,27	3804,30	1,72
Site 4- KAP 2 *(Bryum argenteum)*	143,17	108,80	160,33	219,27	9809,76	3,31
Site 5- Cijevna 1 *(Hypnum cupressiforme)*	32,32	18,93	46,24	159,98	4726,37	2,12
Site 6- Cijevna 2 *(Bryum argenteum)*	41,53	372,54	401,13	408,38	22677,06	4,46
Site 7- Tološka polje 1 *(Hypnum cupressiforme)*	15,29	28,70	68,97	95,24	3767,71	1,35
Site 8- Tološka polje 2 *(Bryum argenteum)*	55,15	71,84	149,50	647,60	14319,83	5,30
Site 9- Park šuma Gorica 1 *(Hypnum cupressiforme)*	9,55	10,64	35,60	38,99	4506,79	0,70
Site 10- Park šuma Gorica 2 *(Bryum argenteum)*	53,15	208,11	576,66	878,61	31189,85	7,61

3.9. Iron (Fe)

Iron can occur in the air as a result of the following human activities: industry, coal combustion, traffic and soil dust [60]. The minimum concentration of iron is registered at the site 1, while the highest concentration is registered at the site 10. The symptoms caused by toxic effects of metals on plants depend on the type of plant nutrition and plant age [61]. Symptoms of poisoning are usually slow root growth and root tip, and the appearance of dark green spots on the leaves [62]. The limit value of manganese in surface and ground water is 0.001 mg/l for water class A, 0.005 mg/l for water class A1, 0.01 mg / l for water class A2 and 0.05 mg / l for water class A3 [35], while in the drinking water it is 50 mg / l [36].

3.10. Cobalt (Co)

Cobalt occurs as a by-product in mining and industry, and in the exhaust gases. It is found in tobacco smoke also. The minimum concentration is determined at site 9, and the highest concentration is determined at site 10, which is assumed to be caused by traffic. The maximum level of cobalt in soil is 50 mg/kg [34]. The limit value of cobalt content in surface and ground water is 0.001 mg/l for water A and Class A1, 0.01 mg/l for water class A2 and 0.05 mg/l for water class A3[35], while in drinking water by USEPA it is 100 mg/l [63]. Cobalt salts incite many plant processes - stable growth, leaf expansion drive, developing buds [64]. Toxic concentrations of metals can block the active transport through the plant [65].

3.11. Correlation analysis

Mosses can some substances are probably absorbed directly from the substrate by diffusion through the cells of the gametophyte [66].

In the study area there is a strong correlation between the concentration of trace elements, which are accumulated in two species of moss, amounting to 0.94 ($p < 0,05$).

The highest correlation in the concentration of trace elements is among the locations Cijevna and KAP, even 0.9909 ($p < 0.50$), table 4. We assume that the cause of high correlation is the vicinity of these two sites. The smallest correlation in the concentration of trace elements is between sites Cijevna and Gorica, which is caused by the distance, different habitat type and anthropogenic pressure (table 4).

Table 4. Correlations between concentrations of trace elements between sites in the study area.

	Cijevna	Tološko polje	Park šuma Gorica	Cetinjski put	KAP
Cijevna	1.00				
Tološko polje	0.96	1.00			
Park šuma Gorica	0.93	0.97	1.00		
Cetinjski put	0.95	0.99	0.99	1.00	
KAP	0.99	0.97	0.94	0.96	1.00

In the species *Hypnum cupressiforme* Hedw., the highest degree of correlation of trace elements is between copper and nickel- even 1.00 and the lowest negative correlation is between the zinc and iron, -0.600 (table 5). In the tissue of this species, nickel shows the correlation with most of the trace elements: copper, cobalt and lead, $p < 0.50$.

Table 5: Correlations between concentrations of trace elements in *Hypnum cupressiforme.*

	Cu	Zn	Mn	Fe	Ni	Co	Pb	Cd	As	Hg	Cr
Cu	1.00										
Zn	0.80	1.00									
Mn	0.30	0.30	1.00								
Fe	-0.10	-0.60	0.10	1.00							
Ni	0.90	0.50	0.40	0.20	1.00						
Co	0.70	0.30	0.70	0.40	0.90	1.00					
Pb	1.00	0.80	0.30	-0.10	0.90	0.70	1.00				
Cd	0.50	0.70	-0.30	-0.40	0.10	-0.20	0.50	1.00			
As	0.60	0.40	0.90	0.30	0.70	0.90	0.60	-0.10	1.00		
Hg	0.05	0.15	0.56	0.31	-0.05	0.20	0.05	0.26	0.56	1.00	
Cr	0.40	0.60	0.90	-0.20	0.30	0.50	0.40	0.10	0.80	0.66	1.00

In the moss specie *Bryum argenteum* Hedw. degree of correlation is 0.900 and it occurs between the following elements: copper and zinc, zinc and iron, manganese and iron, cobalt and iron, lead and copper, lead and iron, cadmium and manganese, cadmium and zinc, cadmium and cobalt, cadmium and lead, mercury and manganese, mercury and cobalt, chromium and iron, chromium and cadmium, chromium and mercury (Table 6). Cadmium has the correlation with five elements: zinc, manganese, cobalt, lead, chromium. Arsenic has a negative correlation with 7 elements: manganese, iron, nickel, cadmium, arsenic, chromium, $p < 0.50$.

Conclusion

- Mosses are good accumulators of trace elements and can be used for monitoring.
- On the site 10 the highest concentration of 8 trace elements was recorded: Pb, Cd, Cr, Cu, Zn, Fe, Co, Mn. It is assumed that their main sources are: traffic and burning of fossil fuels. The highest concentration of arsenic is recorded at the site 6, which originates from the industry.
- The highest concentration of mercury is recorded at the site 2, which originates from the fossil fuels.
- Nickel has the highest concentration at the site 4, and it also originates from the industry.
- The most trace elements have the least concentration in the mosses sampled at the site 9.
- Reduction of the concentration of trace elements could be achieved by reducing of fossil fuels usage.
- The biomonitoring of the site 10 has particular importance, taking into account that the pollutant-gas station was removed from the location.

- By the comparative analysis of trace elements, it is concluded that there is a strong correlation between concentrations of the studied elements in two moss *species - Bryum argenteum* Hedw. and *Hypnum cupressiforme* Hedw..
- In the species *Hypnum cupressiforme* Hedw. the highest correlation of concentration of trace elements is between copper and nickel, 1.00 (p <0,50).
- In the species *Bryum argenteum* Hedw. the highest correlation is 0.900 and it occurs between the following elements: copper and zinc, zinc and iron, manganese and iron, cobalt and iron, lead and copper, lead and iron, cadmium and manganese, cadmium and zinc, cadmium and cobalt, cadmium and lead, mercury and manganese, mercury and cobalt, chromium and iron, chromium and cadmium, chromium and mercury.
- Further research should go towards increasing the number of monitoring sites and the accession of Montenegro in "The heavy Metaline Mosses Survey" and the determination of trace elements in soil and air, in the direction of adopting legal regulations by which the maximum permissible concentrations of trace elements in plants would be prescribed.

Table 6. Correlations between concentrations of trace elements in *Bryum argenteum* Hedw..

	Cu	Zn	Mn	Fe	Ni	Co	Pb	Cd	As	Hg	Cr
Cu	1.00										
Zn	0.90	1.00									
Mn	0.50	0.70	1.00								
Fe	0.80	0.90	0.90	1.00							
Ni	0.10	0.20	0.30	0.10	1.00						
Co	0.50	0.70	1.00	0.90	0.30	1.00					
Pb	0.90	1.00	0.70	0.90	0.20	0.70	1.00				
Cd	0.80	0.90	0.90	1.00	0.10	0.90	0.90	1.00			
As	0.50	0.20	-0.50	-0.10	-0.20	-0.50	0.20	-0.10	1.00		
Hg	0.30	0.60	0.90	0.70	0.60	0.90	0.60	0.70	-0.60	1.00	
Cr	0.50	0.70	1.00	0.90	0.30	1.00	0.70	0.90	-0.50	0.90	1.00

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