Use of *Euonymus japonicus* Plant in Landscape Design According to Human and Traffic Density on Campus

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Abstract

In this study, samples were collected from a total of 5 locations on the campus, three of which have very heavy traffic and the others have relatively low human density. *Euonymus japonicus* used as an ornamental plant in the landscaping study metal content was determined by ICP-MS. 13 metals, including Al, Ti, Cr, Mn, Ni, Cu, Zn, Se, Sr, Mo, Cd, Hg and Pb, were analyzed in soil and plant samples. Before the samples to be used in the study were analyzed by ICP-MS, concentrated nitric acid and hydrogen peroxide were used for wet digestion with microwave. Statistical analysis of the obtained data was performed and the relationship between the metals was examined by Pearson correlation analysis. Heavy metals are absorbed and collected from the soil to different parts of the plant through the roots. In this study, bioaccumulator factor (BAF) values were calculated to examine the relationship between metal accumulation in plant samples. Mn, Mo, Sn, Ni and Cd, Pb, Ni showed strong negative correlations among each other. When BAF values were examined, *Euonymus japonicus* plant species was thought to exhibit bioaccumulator behavior for Hg, Pb, Mo and Se metals for all locations. It is thought that examining these characteristics of ornamental plant species used in landscape studies will contribute to studies on metal pollution and removal in soil.

Key word : *Euonymus japonicus*, metal, ICP-MS, landscape

1. Introduction

Heavy metals emerge from various sources such as heavy traffic, pesticides, mining, industrial and domestic wastes, and combustion of fossil fuels with the development of industry [1]. Ions of heavy metals, which are major environmental pollutants, are found in air, water, and soil, and some metals can have serious harmful effects on humans and ecosystems due to their toxicity [2, 3]. In addition, the toxicity of heavy metal ions also emerges as an important environmental problem due to their volatility and portability [3, 4].

Any metal that is not biodegradable is considered a “heavy metal”. Fifty-three elements with an atomic density greater than 6 g cm-3 are also included in the heavy metal category. However, common toxic metals are chromium (Cr), manganese (Mn), copper (Cu), mercury (Hg), lead (Pb), cadmium (Cd), zinc (Zn), molybdenum (Mo), nickel (Ni) and aluminum (Al) [5]. Many of these elements (Fe, Zn, Mn, Cu, Ni, Mo) are essential elements required for the growth and metabolism of plants, but high concentrations of all are toxic to plants [6, 7].In addition to negatively affecting the growth physiology of plants, these metals can also cause chronic and epidemic diseases when they enter the food chain [8]. Biochemical, physiological and morphological changes occur in plants as a result of heavy metal stress [9,10].

Euonymus japonicus is a shrub that can stay green in all seasons and grow up to 2-3m tall. Its shoots are four-sided and the buds arranged oppositely on the shoots are long and green. The narrow egg-shaped leaves are 3-7 cm long, thick as leather; the upper surface is shiny, the lower surface is pale green and the edges are finely toothed. It blooms in June and July. Taflans can grow in cold regions as well as in hot regions. They are widely used in city gardens and coastal areas with their tolerance to wet soils, heat, shade and sun. They can be grown in sunny and semi-shady, dry and humid places and in various soils. However, they prefer fertile humus clay soils. They also rarely need pruning. They need pruning when used as a hedge. It has been reported that attention should be paid to the pruning time as it is sensitive [11]. They bloom small white flowers in spring and small red fruit is formed in autumn. Its leaves can be green, variegated, yellow and silvery. It is preferred in landscaping works due to its flower, fruit and leaf visuality [12]. It has a wide range of uses due to its features such as being evergreen, easy to prune and shape [13].

Landscape architecture is a professional discipline that creates aesthetic and functional areas with inanimate objects and living materials. Plants are indispensable elements of landscape studies. In these studies, ornamental plants are used for their aesthetic effects such as the scent of their flowers, flower and leaf color, autumn coloration, fruit characteristics, and many other functional functions such as reducing the effect of wind and noise, retaining soil, and preventing erosion. Some of the ornamental plants used in landscaping are also used in the industry due to their different features such as texture, color, smell, and active ingredient content [14].

In this study, the metal content of *Euonymus japonicus* used as an ornamental plant in landscape study was determined by ICP-MS. 13 metals, including Al, Ti, Cr, Mn, Ni, Cu, Zn, Se, Sr, Mo, Cd, Hg and Pb, were analyzed in soil and plant samples. Before the samples to be used in the study were analyzed by ICP-MS, concentrated nitric acid and hydrogen peroxide were used for wet digestion with microwave. Statistical analysis of the obtained data was performed and the relationship between the metals was examined by Pearson correlation analysis. Heavy metals are absorbed and collected from the soil to different parts of the plant through the roots . In this study, bioaccumulator factor (BAF) values were calculated to examine the relationship between metal accumulation in plant samples.

2. Material and Methods

2.1 Sample Collection and Preparation

Zonguldak province has a rugged terrain due to its location. In addition, the widespread presence of thermal power plants in the region restricts agricultural activities and has negative effects on the environment. In this study, *Euonymus japonicus* was established in 5 different locations of the campus as given in Figure 1. plant and soil samples were collected. These locations were named A, B, C, D and E. Locations B and D are the quietest areas of the campus, while the other locations are locations with heavy vehicle traffic and human movement. Plant samples were collected in dry weather, especially between 8 and 10 am.



Figure 1.
Sample area.

Euonymus japonicus taken from designated locations plant samples were kept at room temperature in the laboratory before starting the study. Then they were dried in the oven. The samples taken from the oven were ground into powder, labeled and stored in sealed plastic bags in a desiccator for chemical analysis. For soil samples, the plant residues on the surface were cleaned and a V-shaped pit was opened and a 3-4 cm thick soil slice of approximately 30 cm was taken from the smooth side of the pit without throwing away the topsoil. Soil samples taken from this mixture, weighing about 1 kg, were placed in polyethylene bags.

2.2. Heavy metal analysis of plant and soil samples

Plant and soil samples collected from the determined locations of the campus were carried out at the Science and Technology Application and Research Center of Zonguldak Bülent Ecevit University. 0.1 gr of the ground plant samples were taken and burned in a microwave oven for one hour with a mixture of hydrogen peroxide and 60% nitric acid (2:4 ml v:v) according to the wet burning method. Then, it was filtered through a blue-banded filter paper and completed to 10 ml with pure water. Metal analyses in the soil were determined after wet burning. For wet burning, 0.1 mg of soil sample was burned in a microwave oven with a mixture of HNO3 and HCI (5:3 ml v:v) and placed in the DAP 60 container system. After the

samples cooled down, 3 mL of boric acid was added to them and burned again in the microwave. At the end of this process, the completely burned samples were transferred to 15 mL taken to the falcon and 1mL of the samples were taken and completed to 5mL with ultrapure water . Finally, Perkin Elmer It was read on the NexION 300D brand ICP-MS device.

2.3. Statistical Analysis

Minitab 18 and origin for analysis results, statistical analysis and graphics pro 2018 package programs were used. Pearson Correlation analysis was performed to determine the relationship between metal concentrations . 3D graphs were drawn to see the change in metal concentrations according to locations.

3. Results and Discussion

3.1. Euonymus japonicus Heavy Metal Analysis in Samples

In our study, a total of 13 metal analyses including Al, Ti, Cr, Mn, Ni, Cu, Zn, Se, Sr, Mo, Cd, Hg and Pb were carried out simultaneously in plant and soil samples from 5 different locations on the campus. Statistical data on metal concentrations in plant samples are given in Table 1. In the literature, toxic metal concentrations in plant samples were reported as 30 mg/kg for Ni, 20 mg/kg for Cu, 20 mg/kg for Pb, 2 mg/kg for Cr, 5 mg/kg for Hg, 400 mg/kg for Mn and 10-50 mg/kg for Mo [15,16]. When Table 1 is examined, it is seen that the average concentration values for all metals are below toxic values. Pb is one of the important metals that can cause considerable damage to the ecological system through human activities. In this study it varied between 0.76-4.01 mg/kg.

Table 1.
Metal concentrations of *Euonymus japonicus* samples (mg/kg).

	Mean	SD	Min	Max
Take it	11.91	2.04	9.31	14.65
Ti	1.11	0.48	0.59	1.87
Cr	3.24	2.25	0.85	5.57
Mn	16.52	4.52	10.70	21.19
What	1.67	0.81	0.58	2.54
Cu	2.19	1.33	0.55	3.66
Zn	14.37	3.55	10.20	19.20
If	1.00	0.21	0.84	1.36
Sr	1.23	0.57	0.56	2.01
B.C	2.50	1.41	0.98	4.11
CD	1.19	1.21	0.26	2.56
Hg	0.80	0.58	0.33	1.78
Pb	2.34	1.34	0.76	4.01

The graph showing the change in metal concentrations according to locations is given in Figure 2. In Figure 2, it was seen that Pb, Mo , Cu and Cr metals were especially present in locations A, C and D, where campus traffic is intense. Cr, Hg and Cd are found in the environment as a result of the burning of fossil fuels, wood and paper products. Although found at normal levels in this study, it increased in areas where human activities were high.

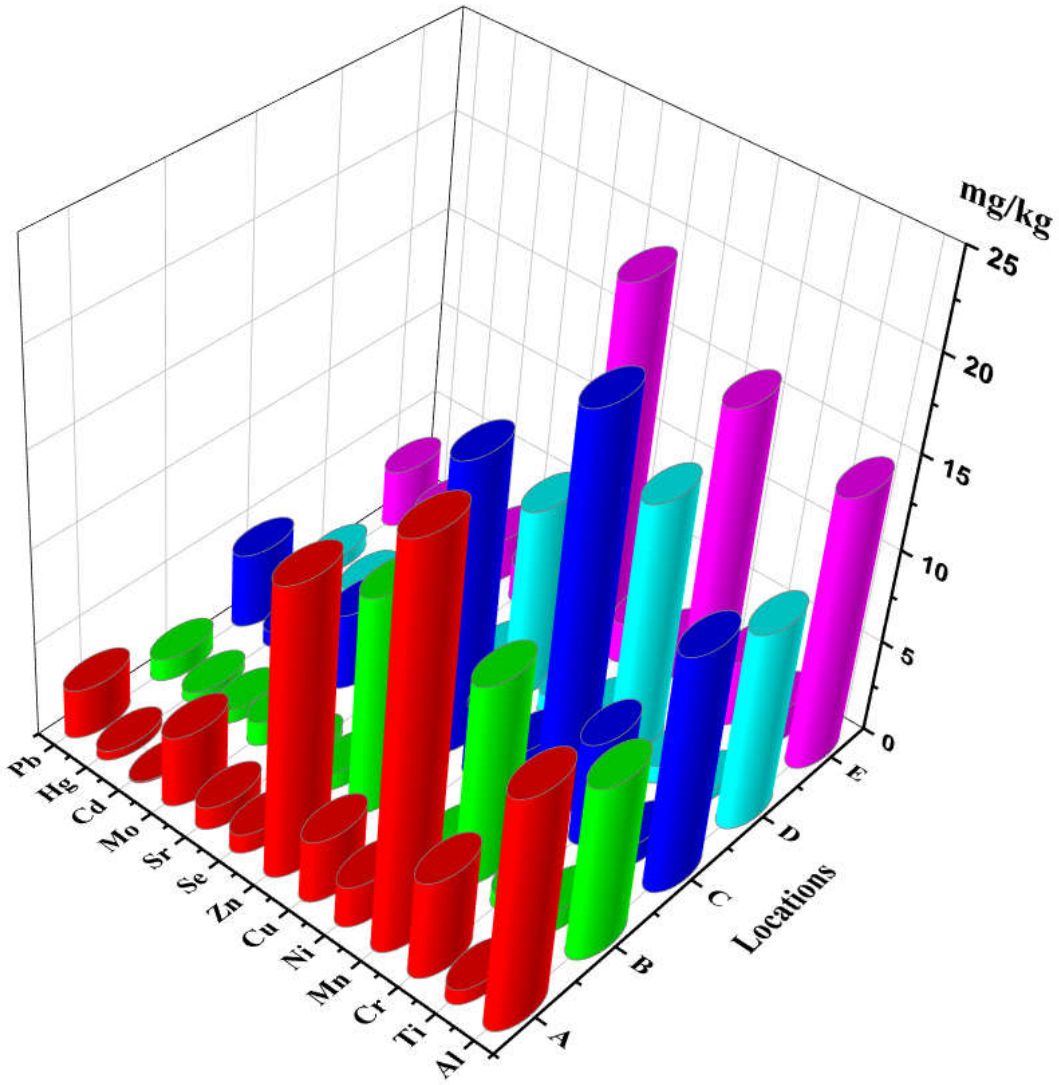

Figure 2.
Metal concentrations in *Euonymus japonicus* samples.

3.2. Heavy Metal Analysis in Soil Samples

Natural concentrations of heavy metals in soils depend mainly on the type and chemistry of parent materials in soils. The limit values of average concentrations of some heavy metals in soils are according to the data of the World Health Organization (WHO)/World Agriculture Organization (FAO) and the Ministry of Environment and Urbanization. For CD 3 mg/kg, 100 for Cr, 100 for Cu mg/kg and 140 mg/kg, 2000 for Mn mg/kg, 50 for Ni mg/kg and 75 mg/ kg, 100 for Pb mg/kg and 300 mg/kg, 1.5 for Hg It is reported as mg/kg [17,18].

Table 2.
Metal concentrations in soil samples (mg/kg).

	Mean	SD	Min	Max
Take it	14.93	2.61	11.02	18.00
Ti	1.72	0.74	0.95	2.66
Cr	40.13	5.68	31.67	45.87
Mn	735.91	103.03	598.70	820.15
What	28.70	7.33	19.43	39.63

Cu	29.27	4.80	21.20	33.52
Zn	75.73	8.78	66.78	88.14
If	0.80	0.19	0.57	1.01
Sr	41.66	11.60	29.79	54.72
B.C	0.83	0.22	0.59	1.17
CD	1.30	0.09	1.21	1.45
Hg	0.62	0.42	0.20	1.16
Pb	2.13	0.87	1.25	3.56

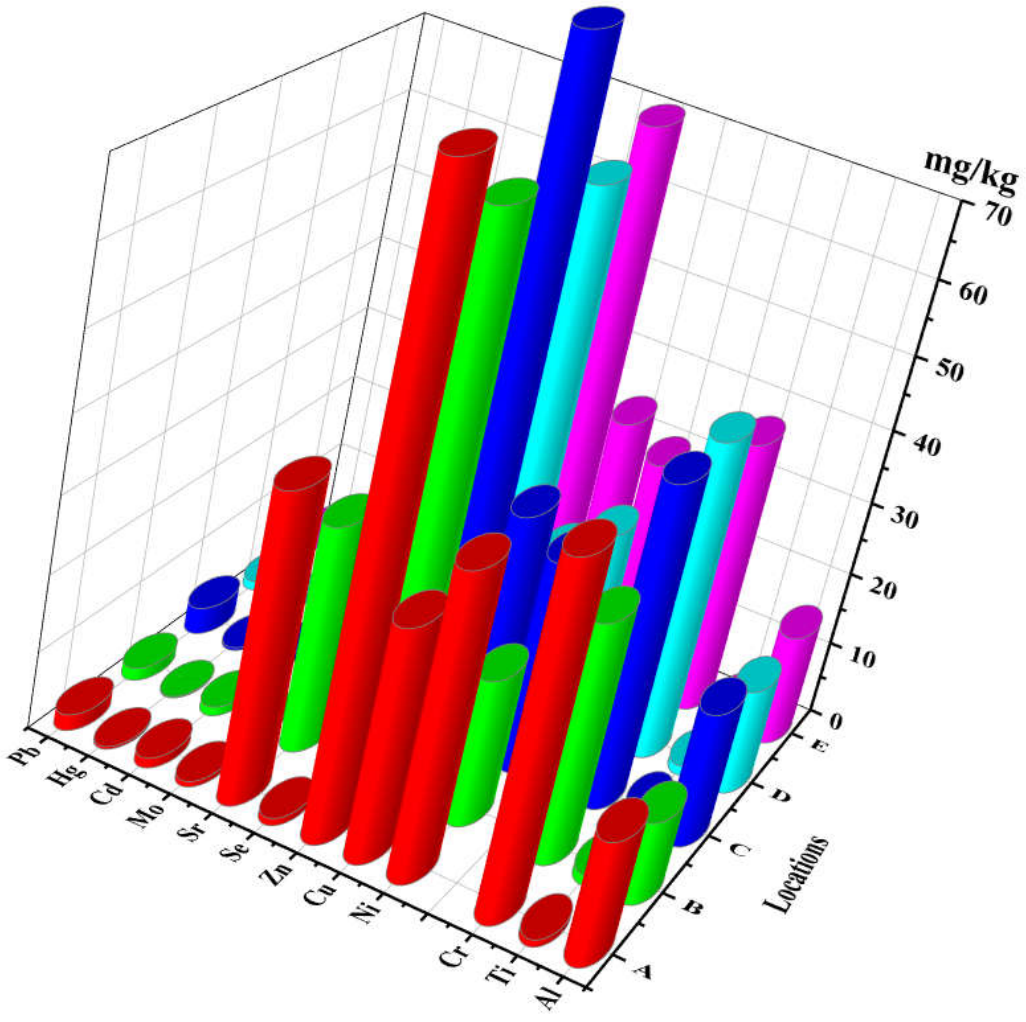

Figure 3.
Metal concentrations in soil.

3.3. Correlation

Pearson correlation analysis was performed to determine the relationship between total metal concentrations in the soil. In Table 5, Cr, Cu, Pb, Ni and Fe, Mo , Hg, Sn concentrations showed a strong positive correlation between each other. Mn, Mo , Sn , Ni and Cd , Pb, Ni showed a strong negative correlation between each other. In addition, a statistically significant relationship was found between Pb and Ni at the level of $p<0.01$ and between Mo and Sr at the level of $p<0.05$.

Table 3.
Correlation table.

	Take it	Ti	Cr	Mn	What	Cu	Zn	If	Sr	B.C	CD	Hg
Ti	0.68											
Cr	0.68	0.23										
Mn	0.60	0.00	0.96**									
What	0.79	0.26	0.97**	0.96*								
Cu	0.66	0.11	0.98**	0.99	0.98**							
Zn	0.93*	0.83	0.69	0.53	0.72	0.60						
If	0.20	0.00	0.74	0.72	0.69	0.75	0.25					
Sr	0.99**	0.75	0.66	0.56	0.77	0.63	0.93*	0.27				
B.C	0.55	0.14	0.98**	0.94*	0.92*	0.96*	0.59	0.81	0.53			
CD	0.90	0.98	0.97	0.66	0.83	0.82	0.98*	0.12	0.92	0.95*		
Hg	0.82	0.97**	0.29	0.10	0.37	0.20	0.87	-0.04	0.86	0.16	0.99*	
Pb	0.77	0.54	0.91*	0.80	0.91*	0.87	0.82	0.75	0.81	0.88	0.97*	0.57

3.4. Bioaccumulator Factor (BAF)

Absorbed and collected from the soil to different parts of the plant through the roots. In our study, the BAF factor was used to examine the relationship between metal accumulation in soil and plant systems and was calculated with Equation (1).

BAF=M plant/M soil (1)

In equation (1), M plant corresponds to the element content (mg/kg) in plant samples, and M soil corresponds to the element content (ppm) in the soil where the plant is grown [19]. This equation is used to estimate the capacity of the degree of transfer of each element to the plant in soil and plant systems grown in soil, and to show the ability of biological element transport and migration. Table 4 shows the BAF values calculated for plant parts according to locations. In Figure 4, the BAF values of *Euonymus japonicus* plant samples according to locations are plotted with a bar graph.

Table 4.
BAF values by locations.

	A	B	C	D	TO
Take it	0.75	0.84	0.70	0.75	0.97
Ti	0.86	0.81	0.49	0.46	0.70
Cr	0.11	0.03	0.13	0.02	0.10
Mn	0.03	0.02	0.03	0.02	0.02
What	0.06	0.03	0.09	0.04	0.06
Cu	0.11	0.02	0.11	0.06	0.07
Zn	0.19	0.16	0.18	0.15	0.27

If	1.04	1.60	1.35	1.13	1.26
Sr	0.03	0.02	0.03	0.03	0.04
B.C	5.14	2.22	3.52	1.33	2.48
CD	0.06	0.62	0.29	0.20	2.06
Hg	1.38	2.73	2.14	5.70	1.53
Pb	1.25	0.73	1.13	0.61	1.48

Table 4 shows the BAF value for metals close to 1 and *Euonymus japonicus* plant is a bioaccumulator plant. Metals with high BAF values for all locations were Pb, Mo , Hg and Se, and were found to be higher in location E. Also, Cd was found to be BAF>1 only in location E. According to the findings of this study, *Euonymus japonicus* plant can be used as a bioaccumulator and also a bioindicator plant for Pb, Hg, Mo and Se metals in all locations.

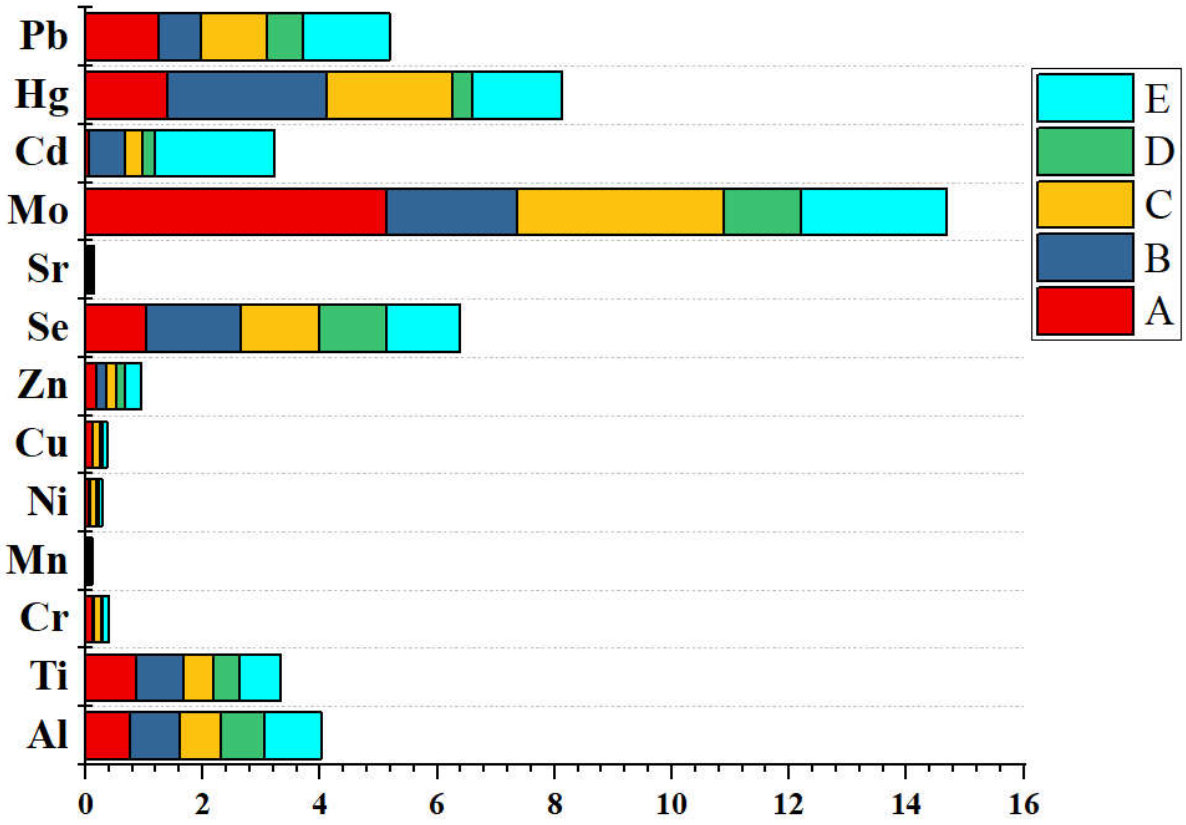

Figure 4.
BAF values of *Euonymus japonicus* according to locations.

4. Conclusion

In the literature, 4 main headings have been addressed in determining the characteristics of plant use in landscape. Accordingly, the aesthetic and visual characteristics of plants (flower, fruit, leaf, trunk-shoot, calligraphy, habitus, texture, smell), spatial functional characteristics (fencing, utilization of fruit, limitation, surface covering, orientation, screening, emphasis, shading, naturalness), ecological characteristics (tolerance to shade, drought, air pollution and salt) and sociocultural characteristics (regionality) have been evaluated [20]. Considering the aforementioned characteristics, some ornamental trees, shrubs and bushes, perennial plants, seasonal flowers are mostly preferred in the design of open green areas. It is also possible to

use fruit species in landscape architecture studies with their aesthetic characteristics such as flower, fruit, leaf form, texture and autumn coloration of leaves and other functional and ecological characteristics [21].

Plants easily take in components from the soil with the help of roots. Thus, plants form an important link in the transfer of useful and harmful substances from the soil to living things. In this study, the metal analysis performed simultaneously in the *Euonymus japonicus* plant species used for landscaping and in the soil provides valuable data on the metal bioaccumulation of the plant. It can also provide important information for the use of *Euonymus japonicus* species in phytoextraction studies.

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