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Original paper

Some atmospheric trace metals deposition in selected trees as a possible biomonitor

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Abstract Several trees are effectively used to biomonitor of trace metals in urban environmental pollution. It gives information about the speciation of trace metals and their transition between organs in the plant. In the wood of the trees, it can be determined which part is formed in which year with the help of organs formed by the effect of seasonal differences. Air pollutants damage to humans and other living things in nature is generally referred to as a sign of pollution. They are released from anthropogenic sources accumulate in the bodies of nearby species over time. They give information about the history of air pollutants due to the accumulation in their wood, inner bark, and outer bark. In this study, organs of *Robinia pseudoacacia* L., *Cupressus arizonica* G., and *Platanus orientalis* L. were analyzed as biomonitors with Inductively Coupled Plasma Mass Spectrometry (ICP-MS). All samples were taken from Kocaeli province industrial zone which has quite a wide industrial area. The concentration of selected trace elements as Iron (Fe), Magnesium (Mg), and Zinc (Zn) their emission caused by industrial activities and transport vehicle density. The results of the study show that *Robinia pseudoacacia* L. was the most suitable species for Fe, Mg, and Zn concentration levels as a biomonitor.

Keywords Atmospheric deposition; biomonitor; trace elements; trees

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Introduction

Clean air is a vital requirement for sustainable life including plants, which is necessary for metabolism processes such as respiration, digestion, photosynthesis, which are necessary for living things to survive (Isinkaralar et al. 2021). Despite all air pollution is a global problem that increasingly threatens the ecosystem with the development of technology and irregular urbanization (Greg et al. 2003; Sevik et al. 2018; Shen et al. 2021; Yılmaz and Işınkaralar 2021a, b). It has many sources that trace metals release does not deteriorate and disappear easily in nature also bioaccumulate in their cells (Jayakumar et al. 2021). They can be toxic, poisonous, or carcinogenic on organs which cause various damages depending on their amount (Dai et al. 2021; Rahaman et al. 2021). They can occur with fossil fuel combustion, mining activities, fertilizer application, agricultural activities, and dispersing to certain distances by movements of the wind. It is aimed to identify the sources of each pollutant such as heavy metal, polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs), trace metal, a toxic metal, and macronutrients and micronutrients (can be dangerous in high concentration) (Isinkaralar 2020; Ghoma et al. 2022; Isinkaralar et al. 2022). Therefore, it is important to detect the accumulation levels in plants and trees in the urban environment (Tong et al. 2021). Trace elements that can be needed in very small quantities by humans, animals, and plants despite they play a very important role with high concentrations (Soetan et al. 2010). Especially in plants, high concentrations of these chemicals reduce the growth rate and demonstrate negative effects on cells (Soetan et al. 2010; Adamec et al. 2021).

Although 53 of the 90 elements found in nature are considered heavy metals, only 17 of them can be found in living life and ecosystems according to their solubility level. Iron (Fe) is the 4th most abundant element in the lithosphere and is one of the most vital elements in the life of living things (Abdu et al. 2017). It is a limiting element for the plant mainly due to the low solubility of ferric in an aerobic environment (Emerson et al. 1999). Fe, which is an important micronutrient for the functioning of metabolic activities, biochemical and physiological processes, plays an active role in the formation of many enzymes, DNA and chlorophyll synthesis, respiration, and photosynthesis, increasing yield and plant health (Oleszkiewicz and Sharma 1990). Although abundant in well-aerated soil, its biological activity is low. This is mainly because it forms insoluble iron compounds at neutral pH levels (Kasotia et al. 2021). Due to its presence in insoluble oxidized forms, 30% of globally cultivated soils have low iron concentrations (Rout and Sahoo 2015). However, in soils filled with water, the iron concentration can be found in high amounts in the form of Fe^{+3} (insoluble ferric) due to its low redox potential (Rehman et al. 2021). In this case, high amounts of iron taken into their bodies can turn into toxic effects through lipid peroxidation. Another important heavy metal is Zinc (Zn), a micronutrient necessary for plants. It is one of the major global pollutants in the atmosphere because it releases into the soil and atmosphere from minerals containing Zn, volcanic activities, forest fires, and biotic processes (Pacyna and Pacyna 2001; Shah 2021). Zinc isotopes were found in remote arctic areas due to atmospheric deposition (Simonetti et al. 2000). Although plants take in the form of Zn^{+2} or their compounds with their roots, leaves, cuticles, and stomata thanks to protein carriers from the soil, it is still not known how they are taken into their structures (Rawashdeh and Florin 2015). High concentrations of Zn cause some negative effects on plant bodies (Suresh and Ravishankar 2004). Foremost among them, it has been seen in the studies that it causes weakening of the roots, retardation of growth and development, oxidative stress, disruption of DNA and proteins, photosynthesis, and thus loss of biomass (Fryzova et al. 2017). Magnesium (Mg) is an essential element used in the formation of protein structure and phosphorylation enzymes in plants (Santos et al. 2017). In its deficiency, it causes retardation in plant growth and a decrease in yield, as well as losses in the photosynthesis stage due to it being an essential macronutrient for plants (Guo et al. 2015). Depending on the structure and genotypes of the plants, if they are taken in high amounts, they show different toxic effects. It has a higher level of toxic effect, especially in soils with high acidity but insufficient drainage (Peres et al. 2016). Especially Mg^{+2} has an important mission for climate regulation and carbon sequestration (Goddard et al. 2007; Groshans et al. 2019). Although the presence of the elements that are the subject of the study in the soil is low, their level is increasing thanks to atmospheric transports (from ocean, sea, desert dust, etc.) (Mahowald et al. 2009). The transport, accumulation, and transformation of all these elements into other forms primarily occur with atmospheric deposition including wet, dry, and total (Keesstra et al. 2016).

Biomonitoring with plants is being increasingly used as an alternative method compared to the active methods of working locally and anthropogenic substances range from the atmosphere to the soil. This is due to the high-cost implications of the active and traditional instrumental method. Biomonitors accumulate some environmental pollutants that occur in anthropogenic activities that can tell more information about quantitative (Gómez-Arroyo et al. 2021). Several studies show that the ability of the species to be used as biomonitors to accumulate heavy metals in their bodies and the fact that we can measure their levels have enabled them to become biological receptors (Blevins 1994). The tree species used as biomonitors should not be disinformation immediately due to the accumulation of air pollutants, and they should have stayed in that area for many years. In addition to these, it is desired that they be more in number and have a sufficient amount of organs and tissues in that region so that the correlation can be easily seen (Maresca et al. 2020). Many studies have been conducted on the usability of plants as biomonitors, bioindicators, and bio accumulators since plants are the creatures that provide easy identification and sampling (Guéguen et al. 2012; Turkyilmaz et al. 2018). A variety of environmental conditions as well as anthropogenic differences have emerged about the use of plants as biomonitors (Pellegrini et al. 2014; Dadea et al. 2017). It is not known how long plants such as moss and lichens are exposed to heavy metal pollution in the air (He et al. 2005). As the best alternative to these plants, the use of leaves of annual plants that are not evergreen solved this problem, and their leaves can easily give data on heavy metal pollution that occurs in a vegetation season (Stojanowska et al. 2020; Isinkaralar and Erdem 2021a, b). It is stated that the healthiest information is obtained with the use of biomonitors by pine, spruce, and fir. The needles of this species have remained on the tree and whose needle ages can be determined clearly for many years. The using barks of trees as biomonitors, the availability of biological material throughout the year healthier, and longer years of information have been obtained from the past to the present. Especially in regions with four seasons, in areas with traffic and industry, the barks of tree species taken from areas very close to the pollutant source clearly showed the level of pollutants. While the ages of the trees are determined by their rings, the change in trees that live for many years reveals the situation more clearly.

This study has been carried out in Fe, Mg, and Zn elements (another name as nutrient elements) accumulation due to their transition between atmosphere to plants. The use of wood, inner bark, and outer bark was evaluated in selected trees as biomonitors grew in Kocaeli province industrial zone. The *Robinia pseudoacacia* L., *Cupressus arizonica* G., and *Platanus orientalis* L. were determined deposition of Fe, Mg, and Zn in organs.

Materials and Methods

Sample site

This study was the preferred species as *Robinia pseudoacacia* L. (Locust tree), *Cupressus arizonica* G. (Arizona cypress), and *Platanus orientalis* L. (Eastern sycamore). All samples were taken from the main trunk of trees in the organized industrial zone (OSB) of Kocaeli city. A 10 cm thick log sample was taken from the northern part and approximately 50-60 cm high from the ground. The organs of *Robinia pseudoacacia* L., *Cupressus arizonica* G., and *Platanus orientalis* L. were coded as W (wood), IB (inner bark), and OB (outer bark). They were determined different age portions as to be 30 years old, have come from 1991-1993 to 2018-2020 within three years (taking into account their widths).

Preparation of samples

The samples were not washed due to organs do not have direct contact with the external environment (such as atmosphere and soil) that were physically trapped on the surfaces of the bark. All samples were kept in room conditions until they became air-dry without being exposed to direct sunlight for two weeks after pre-treatment. The samples were brought to the 1-2 cm interval without using metal and weighed as powder as 0.5 g each sample. Samples taken into glass containers were dried in a controlled oven at 50 ºC for 7 days. The samples were taken as 0.5 g weighed and 5 mL nitric acid (65% HNO_3, Merck, Germany) and 2 mL hydrogen peroxide (30% H_2O_2, Merck, Germany) were added to vessels. The combustion process was carried out in the microwave oven at 200 ºC for 15 minutes in the 3052 Method (USEPA 1996). The resulting samples were made up to 25 mL with ultrapure water for dilution and Fe, Mg, and Zn analyzes were made by atomic emission spectrometry (ICP-OES) with a plasma source device (SpectroBlue, Spectro). All solutions were prepared using analytical reagent grade and ultrapure water was used for sample digestion.

Statistical data analyses

Statistical analyses were carried out by using SPSS 22.0 statistical package program. All measurements are repeated in triplicate and the obtained data are analyzed by analysis of variance (ANOVA) and Duncan test. The ANOVA was also used to specify significant differences among varied species for the organs.

Results and discussion

Changing of the Fe Concentration

The biomonitor chosen was the bark and organ of a *Robinia pseudoacacia* L., *Cupressus arizonica* G., and *Platanus orientalis* L. which, due to its widely used as plants in parks, roads, and landscape. Table 1 has been proven that they can provide information on the presence of the Fe element in the district.

As regards the ANOVA that the change in the concentration of Fe element on an organ basis in all three species is statistically significant (p<0.001). Considering the Duncan test results, the lowest values are obtained in the W and the highest values were obtained in the OB. In the W and IB, the values were obtained as the same group of *Platanus orientalis* L., and in other species, each organ formed a separate group. It is noteworthy that the values obtained in the OB are many times higher than the values obtained in the IB and W in all species. The lowest value in the OB is obtained in *Platanus orientalis* L. with 137.7 ppm, the highest value is obtained in *Robinia pseudoacacia* L. with 3008.4 ppm, the highest value in the IB is obtained in *Robinia pseudoacacia* L. with 60 ppm, and the lowest value is obtained in *Platanus orientalis* L. with 6.6 ppm. In the W, the lowest value is obtained in *Robinia pseudoacacia* L. with 14.7 ppm, and the highest value is obtained in *Platanus orientalis* L. with 16.9 ppm. According to these results, it can be said that the lowest values are obtained in *Platanus orientalis* L. and the highest values are obtained in *Robinia pseudoacacia* L. The change in the Fe concentration in W depending on the age range is given in Table 2.

Table 2. The Fe concentration (ppm) age interval and species change of in wood**.**

Table 1. Change of Fe concentrations (ppm) based on species

Organ	Species			*F* value
	Robinia pseudoacacia L.	*Cupressus arizonica* G.	*Platanus orientalis* L.	
W	14.7 a	15.4 a	16.9 a	0.214 ns
IB	60 Cb	33.4 Bb	6.6 Aa	4918***
OB	3008.4 Cc	2937.3 Bc	137.7 Ab	150839.7***
F value	118349.1***	185795.1***	64.9***	

Uppercase letters: horizontal direction, Lowercase letters: vertical direction, ***significant level at 0.001, ns: not significant

Table 2. The Fe concentration (ppm) age interval and species change of in wood

Range of age	Species			*F* value
	Robinia pseudoacacia L.	*Cupressus arizonica* G.	*Platanus orientalis* L.	
2018-2020	16.7 Cg	11.4 Be	7.3 Ae	179***
2015-2017	11.1 Ad	23.2 Ch	11.7 Bg	16280.9***
2012-2014	8 Bb	9.3 Cc	5.9 Ac	1248.5***
2009-2011	14.4 Bf	10.6 Ad	55.2 Cj	121256.5***
2006-2008	33.6 Ch	17.6 Ag	19.9 Bh	167844.7***
2003-2005	9.2 Bc	25.6 Ci	3.3 Ab	41708***
2000-2002	13.5 Be	7.3 Ab	50.6 Ci	223201.3***
1997-1999	34.5 Ci	6.4 Aa	7.6 Bf	396930.2***
1994-1996	3.1 Ba	30 Cj	1 Aa	57430.1***
1991-1993	3 Aa	12.5 Cf	6.7 Bd	23315***
F Value	3178.6***	17870.1***	290581.9***	

Uppercase letters: horizontal direction, Lowercase letters: vertical direction, ***significant level at 0.001

When the values showing the change of Fe element according to the age range were examined, it is seen that the highest value in *Robinia pseudoacacia* is obtained with 34.5 ppm in 1997-1999, the lowest value with 3 ppm in 1991-1993. In *Cupressus arizonica* G., the lowest value was obtained 6.4 ppm in 1997-1999, the highest value is obtained as 30 ppm in 1994-1996. In *Platanus orientalis* L., the highest value with 55.2 ppm in the years 2009-2011, and the lowest value with 1 ppm in the years 1994-1996. According to the ANOVA, it is determined that the variation of Fe concentration depending on the species is statistically significant at least 99% confidence level ($p<0.001$) in all age ranges. When the values were examined, it is very difficult to say that the Fe concentration changes regularly based on species or year. This situation can be interpreted as the change of Fe concentration in plants does not change primarily depending on the species or year, and other factors are more dominant.

Changing of the Mg Concentration

The biomonitor chosen was the bark and organ of a species in the variation of the Mg concentration assessed depending on the species in Table 3.

Table 3. Change of Mg concentrations (ppm) based on species

Organ	Species			*F* value
	Robinia pseudoacacia L.	*Cupressus arizonica* G.	*Platanus orientalis* L.	
W	78.6 Aa	119.6 Ba	376 Ca	351.086***
IB	206.4 Ab	857.6 Bb	3486.8 Cc	459489.9***
OB	1639 Ac	1744.2 Bc	3224.6 Cb	1921.4***
F value	876.2***	7484.5***	12764.9***	

Uppercase letters: horizontal direction, Lowercase letters: vertical direction, ***significant level at 0.001

According to the ANOVA, it is determined that the change of Mg element in all organs is statistically significant (at least $p<0.001$) in both species and organ basis in all species. When the average values and Duncan test results are examined, the lowest value is obtained in the OB is *Robinia pseudoacacia* L. with 1639 ppm, the highest value in *Platanus orientalis* L. with 3224.6 ppm, and the highest value in the IB with 3486.8 ppm in *Platanus orientalis* L., the lowest value with 228.4 ppm in *Platanus orientalis* L. and the lowest value in the W part with 78.6 ppm in *Robinia pseudoacacia* L. and the highest value is obtained in *Platanus orientalis* L. with 376 ppm. However, it can be said that the Mg concentration is generally listed as W<IB<OB (There is no statistically significant difference between W and IB in *Platanus orientalis* L.). In addition, it is seen that the values obtained in the OB are much higher than the values obtained in the IB and W. The change in the Mg concentration in W is given depending on the age in Table 4.

Table 4. Age interval and directional change of Mg (ppm) element in wood

Range of age	Species			F value
	Robinia pseudoacacia L.	*Cupressus arizonica* G.	*Platanus orientalis* L.	
2018-2020	254.9 Bj	65.2 Aa	478.4 Ci	18109.6***
2015-2017	51.6 Ad	104.4 Bb	393.1 Cg	14902***
2012-2014	24.6 Aa	122 Be	327.7 Ca	27538.2***
2009-2011	31 Ab	134.3 Bg	366.9 Ce	74288.3***
2006-2008	45.2 Ac	166 Bh	349.6 Cb	14127.7***
2003-2005	82.7 Ah	129.8 Bf	416.2 Ch	120178.8***
2000-2002	56.7 Ae	128.3 Bf	357.6 Cc	33548.6***
1997-1999	60.4 Af	123 Be	327.5 Ca	33506.6***
1994-1996	69.9 Ag	108.5 Bc	380.1 Cf	33147***
1991-1993	109.5 Ai	114.3 Bd	362.6 Cd	28626.4***
F Value	3798.5***	587.5***	2182.6***	

Uppercase letters: horizontal direction, Lowercase letters: vertical direction, ***significant level at 0.001

Table 5. Change of Zn concentrations (ppm) based on organ and direction

Organ	Species			*F* value
	Robinia pseudoacacia L.	*Cupressus arizonica* G.	*Platanus orientalis* L.	
W	2.8 Aa	3.8 Bb	2.5 Aa	11.347***
IB	4.9 Ab	11.8 Cc	5.6 Bb	4961.4***
OB	178.4 Cc	0.2 Aa	10.3 Bc	157246.2***
F value	28931.6***	57.2***	294.5***	

Uppercase letters: horizontal direction, Lowercase letters: vertical direction, ***significant level at 0.001

Table 6. Age interval and directional change of Zn (ppm) element in wood

Range of age	Species			*F* value
	Robinia pseudoacacia L.	*Cupressus arizonica* G.	*Platanus orientalis* L.	
2018-2020	3.3 Cf	3.1 Bc	2.6 Ag	142.8***
2015-2017	2.5 Bd	4.5 Ch	2.2 Ad	10310.2***
2012-2014	1.4 Ab	4.0 Cg	2.6 Bf	21501.6***
2009-2011	2.1 Bc	3.6 Cd	1.8 Ab	9516.8***
2006-2008	1.4 Ab	7.6 Ci	3.5 Bj	48562***
2003-2005	3.1 Be	4.0 Cg	2.0 Ac	14522.8***
2000-2002	4.4 Ch	3.7 Be	2.8 Ah	3577.6***
1997-1999	4.6 Ci	1.8 Aa	2.5 Be	22632.8***
1994-1996	1 Aa	2.4 Cb	1.5 Ba	23277.2***
1991-1993	4.1 Cg	3.8 Bf	3.1 Ai	605.3***
F value	4616.4***	16115.8***	3069.7***	

Uppercase letters: horizontal direction, Lowercase letters: vertical direction, ***significant level at 0.001

The Mg concentration was examined based on species in all periods it is statistically significant (at least $p<0.001$) except for 1991-1993. The highest value in *Robinia pseudoacacia* L. is 254,9 ppm in 2018-2020, the lowest value with 24.6 ppm in 2012-2014, the lowest value in *Cupressus arizonica* G. with 65.2 ppm in 2018-2020, the highest value with 166 ppm in 2006-2008, the highest value in *Platanus orientalis* L. with 478.4 ppm in 2018-2020, the lowest value is obtained between 1997-1999 with 327.5 ppm. When the average values are examined, it is seen that the Mg concentration generally tends to increase until the period of 2006-2011, but it shows a general decrease after these dates, and *Platanus orientalis* L. more clearly reflects variance.

Changing of the Zn Concentration

Another element Zn evaluated on the organ is given in Table 5.

According to the ANOVA that the change of Zn element in all organs is statistically significant ($p<0.001$), both based on species and in all species. The highest value in the IB is found to be in *Cupressus arizonica* G. with 11.8 ppm, the lowest value with 4.9 ppm in *Robinia pseudoacacia* L., the highest value in the OB part with 178.4 ppm in *Robinia pseudoacacia* L., the lowest value is found to be in *Cupressus arizonica* G. with 0.2 ppm, the highest value in the W part with 3.8 ppm in *Cupressus arizonica* G., the lowest value is found to be in *Platanus* *orientalis* L. with 2.5 ppm. It is seen that in *Robinia pseudoacacia* L. and *Cupressus arizonica* G., the Zn concentration is listed as W<IB<OB and the values obtained in the OB are much higher than the values obtained in the IB and W, as in other elements. The change in the Zn concentration in W is given depending on the age range in Table 6.

The ANOVA results related to the change of Zn element concentrations according to age range were examined, it is seen that the variation based on species in all organs and statistically significant (p<0.001). When the average values are examined, the highest values are obtained between 1997-1999 with 4.6 ppm in *Robinia pseudoacacia* L. and 7.6 ppm between 2006-2008 in *Cupressus arizonica* G., in *Platanus orientalis* L. between 2006-2008 with 3.5 ppm. When the table values are examined, the first striking result is that the lowest values in all age ranges have been obtained in *Platanus orientalis* L. species. Apart from this, generally, the highest values are obtained in *Cupressus arizonica* G. species. In addition, it can be said that the Zn concentration in *Cupressus arizonica* G. and *Platanus orientalis* L. woods generally tends to increase.

The Fe, Mg, and Zn changes are statistically significant at least at the 99% confidence level on the organ. They are an important factor in atmospheric deposition controlling which can cause global carbon cycling and climate change (Jickells et al. 2005; Lin et al. 2014). The data was obtained that the Fe, Mg, and Zn can firstly accumulate in the outer bark (OB) than inner bark (IB), and finally woods (W) of the trees. While the lowest in W, it is noteworthy that their concentrations were quite high in the industrial zone. In the studies, it is stated that the pollutant concentrations differ greatly depending on the organ. The values can change with the traffic density or some pollutant releases. Studies on Fe have shown that it may have soil pH and redox potential, but may also be due to reactions of macronutrients and auxiliary heavy metals (Bienfait 1988; Briat et al. 2010). Madejón et al. (2004) showed that the heavy metals in *Populus alba* they found in the air were in positive correlation with the amounts in the soil. Currently, researchers have executed many studies on the change of heavy and trace metals that the lowest were obtained in W and the highest in the OB (Akarsu, 2019). Moreira et al. (2016) were revealed a hierarchy of element concentrations according to the street classification by traffic density Another study was obtained the highest concentrations of Pb, Co, and Fe in the outer shell, and the lowest was obtained in W (Sevik et al. 2020). In both studies, while the concentrations of the elements are not significant in the OB facing the direction of traffic and industry, the highest concentrations were obtained in the OB in the part facing the direction of traffic and industry. Drava et al. (2020) was established a relationship between Fe concentration in the bioindicator reflect the mortality in the various areas of the city. Turkyilmaz et al. (2019) have stated that some heavy metal concentrations in the OB are found higher than in other organs. Zhang et al. (2019) was shown that the Pb found in the species analyzed as a biomonitor is air-borne rather than soil. In parallel with this, it has been stated that Hg-based pollution is more caused by air pollution than soil. Ateya (2020) supported that Pb, Cd, Cr, and Ni concentrations are attained a high level in barks than in wood. Alaqouri et al. (2020) stated that although the Cu concentration did not change, Zn and Pb concentrations in the annual rings shifted to a certain extent. As a matter of fact, in many studies, it has been stated that traffic and industrial facilities are the most important source of many heavy metals (Al-Thani et al. 2018; Aricak et al. 2020). Olowoyo et al. (2010) were investigated the *Jacaranda mimosifolia* tree as a biomonitor of atmospheric trace metals in Tshwane City, South Africa. The Zn concentration is necessary although they found high Zn concentration in traffic areas due to emissions of fuel. In addition, Zn is an element used in the production of motor oil and tires and accumulates in tree species as these are eroded and released into the environment over time. Previous work showed that these elements uptake by microorganisms and higher plants due to adsorption on organic and inorganic surfaces (Weiss et al. 2007).

It is thought that the reason why the heavy metal concentrations in the OB are at higher levels than in other organs. This pollution is seen more clearly in industrial regions due to the rough structure of the bark and the heavy metals adhering to this structure and the particulate matter contaminated (Kumar and Khan 2021). Studies have shown that other pollutants adhere to particulate matter and infect particulate matter with heavy metals. Then heavy metal concentrations in these organs increase as these particulate substances settle on plant organs (Çobanoğlu 2019; Cetin et al. 2021). The rough surface structure of the OB facilitates the adhesion of particulate materials. The high concentration of heavy metals is explained in the barks from traffic and industry areas. So contamination of particulate materials with heavy metals originating from intense emission (Sevik et al. 2020). Because traffic and industry release many pollutants (Turkyilmaz et al. 2020; Savas et al. 2021). The ability of each plant or tree species to absorb pollutants depends on its physiological character, as well as the accumulation and behavior of each heavy metal (Sert et al. 2019; Świsłowski et al. 2020). Thus, the accumulation of these pollutants is shaped under many factors such as the presence, over years, the tolerance capacities in different bodies, climate, prevailing wind direction (Sevik et al. 2019; Karacocuk et al. 2022). Because many factors affect the entry and accumulation of heavy metals in the plant body (Vymazal 2016). In addition to plant structure and environmental factors such as plant type, rainfall and moisture amount, plant habitus, organ structure, the type of heavy metal and its interaction with the plant are also important factors affecting the accumulation of heavy metals in plant organs (Belimov et al. 2003). The concentrations of the elements in different periods are at different levels reveals this situation again because many factors are affecting the entry and accumulation of heavy metals into the plant body (Wang et al. 2018). It shows that the transfer of heavy metals within the plant, especially in the wood part, is limited. For this reason, the fact that the heavy metal concentration in the atmosphere during the formation of woods is variable causes the heavy metal concentrations in the woods formed in different years to be at different levels.

Conclusion

One of the main purposes of the study is to obtain information about the movement of trace metals into the plant from industrial and transportation over the years. It is determined that there may be great differences between the OB, IB, and W adjacent to each other in the same direction, as well as the element concentrations of the trees formed in the OSB, Kocaeli. This shows that the transfer of Fe, Mg ve Zn between organs can be interpreted as very limited. The level of knowledge about the speciation and displacement of heavy metals from their entry into the plant is quite limited. The Fe, Mg ve Zn concentrations can accumulate in *Robinia pseudoacacia* L., *Cupressus arizonica* G., and *Platanus orientalis* L. over the years depending on the organ factor in the industrial area. Trees organs have an accumulation of atmospheric trace metals from the recent past to the present. Although the most suitable species to be used for Fe concentration levels is *Robinia pseudoacacia* L., Mg concentration levels are *Platanus orientalis* L. and *Cupressus arizonica* G. is the most suitable species for Zn accumulation.

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