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Change of Mg concentration in several plants depending on plant species, washing status, and traffic density

Halil Baris Ozel [1], Hande Nur Varol [2] and Hakan Sevik [3,*]

[1] Bartin University; Faculty of Forestry; Forest Engineering Department, Bartin, Turkey
[2] Bartin University; Graduate School; Forest Engineering Department, Bartin, Turkey
[3] Kastamonu University; Faculty of Engineering and Architecture; Environmental Engineering Department, Kastamonu, Turkey

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Abstract

Air pollution is one of the most important problems threatening the organic life and ecosystem throughout the world. Among the components of air pollution, the most important ones are the heavy metals that can be toxic and carcinogenic even at low concentrations and even the nutrient elements can be harmful when at high concentrations. Thus, monitoring the heavy metal pollution in the air is very important and plants are widely used as biomonitor for this purpose. However, which plants and organs are more suitable for monitoring which heavy metal pollution can be determined with detailed studies. In the present study, it was aimed to determine which plant species and which organ of that species would be more suitable for monitoring the concentration of magnesium (Mg) in air. For this purpose, five organs of five species grown in regions having different traffic densities were examined. In conclusion, it was found that Mg concentration in washed bark of *Robinia pseudoacacia*, wood of *Platanus orientalis*, washed leaves of *Ulmus minor*, and non-washed leaves of *Acer negundo* and *Nerium olender* increased with increasing traffic density.

Keywords: Air pollution; Heavy metal; Biomonitor; Magnesium; Mg

1. Introduction

Throughout the world, the most important problems of the current era are considered to be population growth [1, 2] and increasing population in urban areas [3-5], which refers to the urbanization [6-8], and consequently the other problems arising from these problems. Growing population and advancements in technology increase individuals' fundamental needs and need for comfort [9]. The production made in order to meet the sheltering [10, 11] and nutrition [12] needs, which are the most important ones among increasing fundamental needs, causes excessive use of underground sources such as mineral deposits, besides the agricultural lands, forests, and waters throughout the world [13, 14].

Excessive use of these sources deteriorates the balance of ecosystem and the wastes arising from the production process cause excessive pollution in air [15, 16], water [17], and soil. Occurring as a result of this interconnected process, global climate change and urbanization are considered as the most important irreversible problems of today [18-21], while environmental pollution is accepted as the most important problem threatening the organic life and ecosystem [22, 23].

Environmental pollution is seen in urban areas at a higher level and the pollution arising from anthropological activities both deteriorates the balance of ecosystem and causes the death of millions of individuals annually. In particular, the

* Corresponding author: Hakan Sevik
Kastamonu University; Faculty of Engineering and Architecture; Environmental Engineering Department, Kastamonu, Turkey.

air pollution has become a very severe problem such that the World Health Organization (WHO) reported that 90% of global population breathes polluted air [24]. Among the components of air pollution, heavy metals have a specific importance since they can be toxic and lethal even at low concentrations, they accumulate within the bodies of organisms, and even the elements that are necessary for organisms can be harmful when at high concentrations [25].

Thus, monitoring the heavy metal pollution in the air is very important. Since directly monitoring the change of heavy metal concentration in the atmosphere is very difficult and expensive, the method used for this purpose at most is the biomonitors [26, 27]. In the present study, it was aimed to determine the most suitable biomonitor plant and its most suitable organ to be used for monitoring the heavy metal pollution in air and, for this purpose, the change of magnesium concentration by the traffic density was examined in leaves, branches, and woods of five different plant species.

2. Material and methods

The plants used in the present study were collected from the areas with different levels of traffic density, which is considered as one of the most important sources of heavy metal pollution [28, 29]. For this purpose, the samples were collected from high-traffic (TRHigh), low-traffic (TRLow), and no-traffic (TRNo) regions. Within the scope of this study, leaf and branch samples were collected from *Robinia pseudoacacia* (RPse), *Platanus orientalis* (POri), *Acer negundo* (ANeg), *Ulmus minor* (UMin), and *Nerium oleander* (NOle) species and some of the samples were washed. Wood samples were then added into the analyses and Mg concentrations were determined in washed leaf (WaLF), non-washed leaf (UnWaLF), washed bark (WaB), non-washed bark (UNWaB), and wood (Wood) samples using ICP-OES device. The data obtained were subjected to variance analysis and Duncan test using SPSS 22.0 package software.

3. Results

Within the scope of this study, the change of Mg concentration by species and traffic density is presented in Table 1.

Table 1 Change of Mg (ppm) concentration by species and traffic density

TUR	TR No	TR Low	TR High	F Value
RPse	806,08	1104,56 b	560,10 a	2,218 ns
POri	690,44	365,64 a	750,68 ab	1,736 ns
ANeg	1199,10 AB	1827,27 cB	1031,90 abcA	3,245*
UMin	1021,86	571,32 ab	1177,86 bc	2,537 ns
NOle	1386,74	1736,02 c	1508,22 c	0,513 ns
F Value	1,851 ns	9,519***	3,557*	

Table 2 Change of Mg (ppm) concentration by organ and traffic density

Organ	TR No	TR Low	TR High	F Value
WaLF	641,36 aA	2113,32 cB	492,68 aA	25,422***
UnWaLF	1076,07 ab	943,29 ab	1717,37 c	2,574 ns
WaB	1423,37 b	852,14 ab	1398,81 bc	2,774 ns
UnWaB	1381,09 b	1275,91 b	954,44 ab	1,050 ns
Wood	582,33 a	353,64 a	465,52 a	1,063 ns
F Value	4,055**	9,104***	10,578***	

As seen in Table 1, the change of Mg (ppm) concentration by traffic density was statistically significant at the confidence level of 95% ($p<0.05$) only in ANeg and the lowest value was found in TRHigh and the highest value in TRlow.

Considering from the aspect of species, the change of Mg concentration was statistically significant in TRLow and TRHigh. Moreover, the highest values in both densities were found in ANeg and NOle. The change of Mg concentration by organ and traffic density is presented in Table 2.

Examining the change of Mg concentration by traffic density, it can be seen that the change by traffic density was statistically only in WaLF at the confidence level of 99.9% ($p<0.001$). Moreover, the change of Mg concentration by organ was found to be statistically significant in all three traffic densities. The Duncan test results of wood in all three traffic densities were all in the first group. The change of Mg concentration by species and organ and the change by traffic density were analyzed together and presented in Table 3.

Table 3 Change of Mg (ppm) concentration by species, organ, and traffic density

Species	Organ	TR No	TR Low	TR High	F Value
RPse	WaLF	1342,90 jB	3200,66 tC	230,26 dA	100193,392***
	UnWaLF	1249,00 iC	910,80 iB	601,53 iA	10146,457***
	WaB	541,33 dA	646,43 fB	1045,50 iC	1815,760***
	UnWaB	652,53 eB	444,86 dA	668,80 kC	2595,024***
	Wood	244,63 cA	320,06 cC	254,66 eB	451,076***
POri	WaLF	636,56 eB	1550,13 lC	103,20 bA	21088,397***
	UnWaLF	1958,23 nC	53,16 aA	906,53 mB	94963,845***
	WaB	264,93 cB	100,13 bA	547,20 hC	3917,458***
	UnWaB	518,70 dB	37,80 aA	595,66 iC	46231,126***
	Wood	73,80 bA	87,00 bB	1600,83 pC	73858,343***
Aneg	WaLF	90,66 bA	3119,46 sC	1048,20 nB	316490,943***
	UnWaLF	98,40 bA	1485,00 kB	1733,06 sC	29071,387***
	WaB	1674,63 lB	1783,00 mC	913,83 mA	249,019***
	UnWaB	3137,73 rC	2281,56 oB	1165,93 oA	5224,224***
	Wood	994,06 fC	467,33 dB	298,46 fA	24447,688***
UMin	WaLF	8,00 aA	667,30 fB	700,13 lC	3344,040***
	UnWaLF	238,06 cB	54,80 aA	2124,80 uC	65068,868***
	WaB	2203,8 oB	996,3 jA	2411,40 vC	7750,207***
	UnWaB	1580,23 kC	815,83 hB	627,33 jA	19509,552***
	Wood	1079,20 fC	322,4 cB	25,63 aA	133389,477***
NOle	WaLF	1128,66 hB	2029,06 nC	381,60 gA	10888,579***
	UnWaLF	1836,66 mA	2754,4 rB	3220,93 yC	9579,115***
	WaB	2432,16 pC	734,86 gA	2076,13 tB	3100,088***
	UnWaB	1016,26 fA	2590,40 pC	1714,46 rB	8926,529***
	Wood	519,96 dB	571,40 eC	148,0 cA	1905,449***
F Value		6250,101***	11266,967***	28159,296***	

As seen in Table 3, the results obtained from variance analysis showed that the change in Mg concentration by species and organ and in all traffic densities were statistically significant at the confidence level of 99.9%. Given the results presented in Table, it can be seen that Mg concentration increased with increasing traffic density in WaB organ of RPse species, Wood organ of POri species, UnWaLF organ of ANeg species, WaLF organ of UMin species, and UnWaLF organs of NOle species.

4. Discussion

Environmental pollution is one of the leading problems threatening the lives of organisms, including humans, and the balance of ecosystem throughout the world. The most important ones among the environmental pollutants are the heavy metals, which can remain in nature without any degradation for a long time, accumulate within the bodies of organisms, and be toxic or carcinogenic even at low concentrations [30]. Thus, it is very important to monitor the concentrations of heavy metals. Examined in the present study, Mg is a white mineral, which exists in soil in form of various compounds, is very light, and can burn with a white flame in air. In earth, it exits most widely in seas. Magnesium is one, maybe the most important one of 11 minerals, which have vital importance, together with calcium, phosphorus, ferrous, copper, chromium, iodine, and selenium. Since the body cannot create this mineral on its own, magnesium must be taken via nutrients. Chlorophyll of plants contains this mineral and it captures energy photons coming from the sun [31-33].

The magnesium in soil is used by plants and it can be called ferrous of the plant kingdom. Similar to the ferrous-hemoglobin duo in humans, magnesium enters into the chlorophyll structure in plants. The use of potassium and phosphor in animal manure depletes the magnesium and it alters the plants' magnesium intake capacity [31]. Magnesium is the center atom of chlorophyll and it plays a vital role in photosynthesis. Magnesium surplus prevents the intake of potassium and negatively affects the root development of trees [33].

In conclusion, it was determined in the present study that Mg concentration changed depending on the plant species and organ and the traffic density. Mossi (2018) reported the Mg concentration in plants, which were examined in that study, to vary between 4009 ppm and 6557.5 ppm and to increase depending on the traffic density. Mg is rarely examined as heavy metal in studies [34, 35] but more frequently as a plant nutrient [36]. However, the magnesium in soil and the magnesium in air should not be examined in the same category because there are few studies carried out on the potential harms of Mg intake through air to the human body and the studies reported that Mg concentration in air increased with increasing traffic density and Mg mineral deposits are the areas, which also include some other harmful heavy metals [37].

Heavy metal pollution is very important from many aspects and it concentrates generally in urban areas and industrial zones [38]. Increasing pollution threatens both organic life and ecosystem. For this reason, monitoring and reducing the heavy metal pollution in water, soil, and air is of vital importance. The heavy metal pollution in soil and water can be directly measured [39, 40]. However, heavy metal pollution in air is generally monitored by using the biomonitors [41]. The heavy metal pollution in water can be reduced using various treatment methods [42], while the heavy metal pollution in soil can be reduced by using the polluted materials as raw material again [43] or by making use of plants (Cesur et al., 2021).

Plants play a major role in organic life and fulfill many ecologic, economic, and social functions in nature. The development and phenotypic characteristics of plants depend on genetic structure [44-46], edaphic factors such as soil structure and nutrient content [47-49], and climatic factors such as light, temperature, and precipitation [50-53].

Thus, the heavy metals in soil or air significantly influence the plant development. High concentrations of heavy metal in air or soil constitute a stress factor for the plants [54]. Stress factors such as aridity [55], frost [56], radiation [57, 58], and pollution [28] affect the structure of plants. Hence, high concentrations of heavy metals cause stress in plants and plants can accumulate the heavy metals from air, soil, and water in its body [59]. For this reason, plants can plan important roles in both monitoring and decreasing the heavy metal pollution. However, further comprehensive studies should be carried out in order to determine which plant should be more suitable for these purposes.

Conclusion

Air pollution is one of the most important problems of today's world. Using plants is considered as one of the most effective methods among the solution proposals. For as much, plants can reduce air pollution significantly. However, the impacts of different species on different pollution factors are also at different levels. Although a large number of plant species have been the subject of studies to date, these studies are not at a sufficient level yet. Therefore, it can be recommended to continue and diversify similar studies.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they no conflict of interest. The none of the authors have any competing interests in the manuscript.

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