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The Investigation of the Change in Concentrations of Some Heavy Metals in Seeds, Leaves, and Branches because of Traffic Density: a Case Study of *Acer platanoides* L.

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ABSTRACT

Heavy metals are pollutants that are released into the atmosphere usually through industrial or traffic sources. Monitoring the heavy metal pollution is of great importance because, in addition to being carcinogenic in terms of their effects on human health, some are toxic even in low concentrations. They also tend to bioaccumulate. Using the plants as biomonitors, it is vital to determine the appropriate and effective plant species and the organelles of the plants to monitor each heavy metal type for the most accurate calculations. In this study, changes of the concentrations of Ba, Al, B, Ca, Fe, K, Mg and Mn elements in *Acer platanoides* were determined depending on the organelle and traffic density. As a result of the study found out that the elements subject to the study differed significantly at least at a 95% confidence level on the organelle basis of the elements other than Ba and Mn. When the changes of the elements depending on the traffic density were separately evaluated, it was determined that Ba and Fe elements increased depending on the traffic density in all organs.

Anahtar Kelimeler:
Acer platanoides,
Biomonitor,
Ağır metal,
Organ,
Trafik.

ÖZ

Ağır metaller, genellikle endüstriyel veya trafik kaynakları yoluyla atmosfere salınan kirleticilerdir. Ağır metal kirliliğinin izlenmesi büyük önem taşımaktadır, çünkü insan sağlığı üzerindeki etkileri açısından kanserojen olmasının yanı sıra, bazıları düşük konsantrasyonlarda bile toksiktir. Ayrıca biyolojik olarak birikme eğilimindedirler. Bitkileri biyo-monitörler olarak kullanmak, her bir ağır metal tipini en doğru hesaplamalar için izlemek üzere uygun ve etkili bitki türlerini ve bitkilerin organellerini belirlemek çok önemlidir. Bu çalışmada *Acer platanoides* lerinde Ba, Al, B, Ca, Fe, K, Mg ve Mn elementlerinin konsantrasyonlarındaki değişiklikler organel ve trafik yoğunluğuna bağlı olarak belirlenmiştir. Çalışma sonucunda, araştırmaya konu olan elementlerin Ba ve Mn dışındaki elementlerin organel bazında en az % 95 güven düzeyinde önemli ölçüde farklılık gösterdiği tespit edilmiştir. Trafik yoğunluğuna bağlı elementlerin değişimleri ayrı ayrı değerlendirildiğinde, tüm organlardaki trafik yoğunluğuna bağlı olarak Ba ve Fe elementlerinin arttığı belirlenmiştir.

1. Introduction

Today, the most important problems of the world in general are the problems related to population growth. While the world population was only 717 million in 1750, it exceeded 6 billion in 2000 and is estimated to exceed 8 billion in 2025 [1]. In addition to the increase in the world population, the increasing number of the populations living in urban centers has created many challenges. This process ruins nature, pollutes the air, water and soil, and the destroys the ecological balance [2-12]. Air pollution is one of the most important problems of today [10-12]. In fact, it is stated that approximately 6.5 million people die every year from to air pollution related causes. Weather many considered quite clean by country Turkey on air pollution, even in 2016 it is stated that due to the 29 thousand people lost their lives [13].

Metals such as Hg, Cd, As and Pb have serious toxic effects on organisms even at low levels [14-16]. Although micronutrients such as Mn, Zn, Cr, Cu, Fe and Ni are required for living organisms, including plants, they can also produce harmful effects at high concentrations. Studies show that almost all metals are toxic when taken over a certain amount [17-19]. Since heavy metals are so important to human health, the determination and monitoring of the concentration of heavy metals in the air is extremely important to determine risk zones and risk levels [20-26].

The change of heavy metal pollution in the atmosphere can be determined by direct and indirect methods. However, bioindicators are one of the most effective methods for detecting air pollution. In addition to being cheap and easy, this method can provide information on the effect of heavy metal concentration on the ecosystem [27,28].

Landscaping plants most exposed to air pollution are the best indicators of this pollution. The accumulation of heavy metal pollution caused by fossil fuels in various organs, especially in the regions where traffic is heavy, shows the progress of heavy metal concentration in air over time [5, 15, 21, 24]. Therefore, instead of direct detection of heavy metal pollution, bioindicators or biomonitorers are often used as indicators of pollution [21, 29-31]. In this study, it was aimed to determine the change of some heavy metal concentrations in *Acer platanoides* leaf seeds and branches grown in Kastamonu city center as in many regions of our country depending on plant organ, washing status and traffic density.

2. Materials and Methods

2.1 Materials

The study was conducted on samples collected from the city center of Kastamonu. Kastamonu city center was established in a valley as a general view, and the has densest traffic during the day. Samples were collected from regions where traffic density is high, lower and almost no traffic with no vehicles in a radius of at least 50 m.

Kastamonu city center is a region where 2 lanes in each direction pass through a 4 lane highway. The areas where the traffic is less dense are the areas outside the city center where the traffic is flowing along the main road. Taşköprü and İnebolu routes were determined as the areas with less traffic. There is a two-lane road in this region, the traffic is very smooth and the traffic density is quite low compared to the town center. In the absence of traffic, Kastamonu University campus area was selected and the points where no motorway was located at least 50 m near the campus area were selected and samples were collected from these areas. Leaf, seed and branch samples were collected from the same branch towards the end of the 2018 vegetation season, in late August bagged, labeled and takento the laboratory**.**

2.2 Methods

Leaves, branches and seeds in the laboratory were separated and grouped. Then, the branches were broken and crushed to dry more easily, and the seeds were crushed. The seeds were crushed with marble pieces and no metal tools were used. The prepared samples were placed in glass petri dishes and re-labeled. The samples prepared in this way were left to dry for 15 days and the laboratory was ventilated daily. The air-dry samples were put into the oven at 45oC for one week to allow them to dry completely.

In the next step, the plant samples were milled and pulverized and 0.5 g weighed into tubes designed for microwave. 10 mL of 65% HNO_3 was added to the samples. During these processes, fume was worked in. The prepared samples were then burned for 20 minutes at 280 PSI and 180 ºC in the microwave. The tubes were removed from the microwave after the completion of the treatments and allowed to cool. Deionized water was added to the cooled samples to 50 ml. The prepared samples were read on the ICP-OES device at appropriate wavelengths after filtration through filter paper.

The data obtained were analysed with the help of SPSS, Variance analysis and Duncon test was done in order determine to the means with statistical differences of at least a 95% confidence level and then to obtain homogeneous groups.

3. Ressults

3.1. Variation of heavy metal concentrations on organ basis

The variation of heavy metal concentrations on the basis of organs presented in Table 1.

Table 1. Variation of heavy metal concentrations on organ basis

	Leaf	Seed	Branch	F	Error
Ba	18,367	11,533	15,122	1,800	0,187
Al	158,22 c	113,00 b	31,22 a	58,114	0,000
B	110,11 b	42,44 a	48,44 a	8,391	0,002
Ca	2694,78 b	1899,89 a	3831,89 c	13,104	0,000
Fe	411,00 b	326,00 b	133,44 a	11,812	0,000
K	9418,67 b	15303,00 c	5566,56 a	44,058	0,000
Mg	7420,78 b	4453,56 a	8816,78 c	27,001	0,000
Mn	68,00	43,78	71,56	1,461	0,252

According to Table 1 was observed that only the change of Ba and Mn concentrations on organ basis was not statistically significant at least a 95% confidence level, the change of B concentration on organ basis was statistically significant at 99% and other elements at 99.9% confidence level. The highest concentrations were found in leaves in Al, B and Fe, in branches in Ca and Mg and in seeds in K.

3.2. Variation of heavy metal concentrations in leaves due to traffic density

Variance anlysis and Duncon test results for the variation of heavy metal concentrations due to traffic density was given in Table 2.

Table 2. Variation of heavy metal concentrations in leaves due to traffic density

	No traffic	Low Traffic	Dense Traffic	F Value	Error
Ba	6,400 a	22,267 b	26,433 b	10,011	0,012
Al	137,00 b	124,67 a	213,00 c	3252,053	0,000
B	192,67 c	75,67 b	62,00 a	69636,5	0,000
Ca	3461,67 b	846,00 a	3776,67 c	12485,948	0,000
Fe	329,33 a	324,00 a	579,67 b	8116,521	0,000
K	4791,00 a	12675,00 c	10790,00 b	37389,221	0,000
Mg	8910,67 c	4454,00 a	8897,67 b	3,57E+07	0,000
Mn	103,67 c	53,00 b	47,33 a	12988,5	0,000

As seen in Table 2, the change in traffic density of all elements in leaf samples is statistically significant at least a 95% confidence level. According to the average values and Duncan test results, Ba and Fe concentrations increase with traffic density and the change of concentrations of other elements was not related to traffic density.

3.3. Variation of heavy metal concentrations in seeds due to traffic density

Variance anlysis and Duncon test results for the variation of heavy metal concentrations due to traffic density was given in Table 3.

Table 3. Changes in heavy metal concentrations depending on traffic density in seeds

	No traffic	Low Traffic	Dense Traffic	F Value	Error
Ba	8,900 a	11,967 b	13,733 c	3229,800	0,000
Al	108,00 a	111,67 b	119,33 c	82,091	0,000
B	61,67 c	30,67 a	35,00 b	3804,500	0,000
Ca	1887,33 a	1913,00 c	1899,33 b	2226,500	0,000
Fe	218,00 a	222,00 b	538,00 c	33712,000	0,000
K	13700,67 a	15282,33 b	16926,00 c	1539,500	0,000
Mg	4454,67 b	4453,33 a	4452,67 a	9,333	0,014
Mn	110,00 c	4,00 a	17,33 b	90004,000	0,000

As considered Table 3 the change of all elements depending on traffic density was statistically significant at least a 95% confidence level in seed samples as in leaf samples. According to the average values and Duncan test results, the concentrations of Ba, Al, K and Fe increase with the traffic density and the change of the concentration of other elements was not related to the traffic density.

3.4. Variation of heavy metal concentrations in branches due to traffic density

Variance anlysis and Duncon test results for the variation of heavy metal concentrations due to traffic density was given in Table 4.

Table 4. Variation of heavy metal concentrations in branches due to traffic density

	No traffic	Low Traffic	Dense Traffic	F	Error
Ba	8,200 a	11,767 b	25,400 c	22249,300	0,000
Al	28,33 b	48,00 c	17,33 a	3258,500	0,000
B	41,00 b	75,33 c	29,00 a	15613,000	0,000
Ca	3818,67 b	3804,00 a	3873,00 c	3567,700	0,000
Fe	56,00 a	126,67 b	217,67 c	35469,800	0,000
K	5682,00 b	5788,67 c	5229,00 a	467,391	0,000
Mg	8664,00 a	8926,33 c	8860,00 b	1560,115	0,000
Mn	109,00 c	69,67 b	36,00 a	9010,750	0,000

When Table 4 was examined, the change of all elements depending on traffic density was statistically significant at least a 95% confidence level in branch samples as in leaf and seed samples.

According to the average values and Duncan test results, Ba and Fe concentrations increased with traffic density and the change of concentrations of other elements was not related to traffic density.

4. Discussion

As a result of the study, it was determined that the concentrations of elements other than Ba and Mn elements on organ basis were statistically significant at least a 95% confidence level. This has been demonstrated in numerous studies to date. Mossi [32] stated that the concentrations of Cu, Ni, Pb, Cd and Ca in the plants subject to the study were higher than those in the leaves, whereas Mn concentration was higher in the leaves than the branches. Sevik et al. [29] stated that the concentrations of heavy metals in organs were different based on species, for example, the highest Ni concentration was obtained in ornamental plum in seed, horse chestnut, linden and ash, and there was no statistically significant difference between organs in maple.

In studies related to heavy metals, the variation of heavy metal concentrations depending on the organ is often the subject of studies. Mossi [32] leaf and branch, Turkyilmaz et al., [23] bark and wood, Sevik et al., [30] leaf, seed and branch, Elfantazi et al., [33,34] leaf and branch, Ozel [35] leaf, branch and fruit, Pınar [36] leaf, branch and seed, Akarsu [37] determined the differences between the inner shell, outer shell and wood organelles. In these studies, it has been shown that heavy metal concentrations variedy significantly on an organelle basis.

The exchange of heavy metals in relation to the organ is a complex and not yet fully understood mechanism that is shaped by the structure of the plant and organelle as well as the structure of the heavy metal, the environmental conditions and the mutual interaction between them, and the information on this issue is limited [14, 19, 38]. Heavy metals can enter the plant via root or leaf uptake, but it is very difficult to distinguish whether heavy metals in the plant's internal tissues are taken from the soil or atmosphere because both uptake pathways can work simultaneously [21, 39-41]. Therefore, it is difficult to determine the source of metal deposition particularly in the branches.

One of the most important results of the study was that Ba and Fe concentrations increase with traffic density in all organs. These elements can be very dangerous for human health. Ba (barium), if swallowed, brain, liver, kidney and heart damage and swelling can be seen, reduces nerve reflexes, breathing difficulties, high blood pressure, heart rhythm disorders, muscle weakness, stomach irritations and reflux, inflammation, tumors, constipation, swallowing difficulty, and even damage to paralysis and death [42]. Fe (Iron) is a very important element for the human body, although it is a toxic substance, it is harmful to the body if taken too much. Fe height; excessive fatigue, pain in the joints, pain in the abdominal region, diabetes, rhythm disturbance in the heart, heart attack, heart failure disease, cirrhosis and liver cancer known as liver disease, impotence, infertility, skin color change, menstrual irregularity, osteoarthritis and osteoporosis , hair, eyebrow and eyelash loss, bloating of the liver and spleen, hypothyroidism, high blood sugar, depression, adrenal function problems, neurodegenerative disease and high liver enzymes can be seen. As a result of iron overload due to the high level of iron from food or beverages, Fe can accumulate in internal organs and cause fatal damage to the brain and liver [43]. Therefore, increasing Ba and Fe depending on traffic density is extremely dangerous for human health.

Ba and Fe have been the subject of many studies because they are important for human health. Batır [44] found that the highest concentrations were obtained in all organs of apples in his study on eight different species. In general, the lowest Ba concentrations were obtained in fruits [44]. Saleh [45] stated that Fe concentration in 6 species increased with traffic density. Saleh [45] states that Fe concentration in the subject species varies between 7,860 ppm and 40,573 ppm in areas with low traffic and between 13,033 ppm and 54,353 ppm in areas with high traffic. Similarly, Mossi [32] found that Fe concentration increased due to traffic density, Fe concentration was 45.95 ppm in areas where there was no traffic, and 60.17 ppm in areas with less traffic and 97.91 ppm in areas with high traffic. Ba and Fe have been the subject of numerous other studies on heavy metals [46-48].

Heavy metals in air may accumulate in plant leaves by leaf transfer following precipitation of atmospheric particles on leaf surfaces. The potential for absorbing nutrients, water and metals from leaf parts of plants has long been recognized. However, information about the uptake of metal by plant leaves from the atmosphere is very limited [14].

There are many factors affecting the penetration and accumulation of heavy metals in the air. Studies conducted to date have shown that the diffusion of heavy metals in the atmosphere and the introduction of plants into the plant is a very complex mechanism [14, 32]. The heavy metal accumulation potential of the plants grown in the same environment as well as plant species and plant organ, organelle structure, physico-chemical properties of metals, organelle morphology and surface area, organelle surface texture and size, plant habitus, duration of exposure to heavy metal and amount of particulate matter [14-16, 40]. In addition, environmental conditions, especially air humidity and precipitation, also affect the influx of heavy metals into the plant significantly [14, 35].

In addition to these factors, there are also other factors likely to affect the concentration of heavy metals. For example, the growth performance of plants, for example, morphological, anatomical and phenotypic characteristics, emerges as a result of the interaction of genetic structure and environmental conditions [49,50] and it is known that each genetic structure can give different responses to the same environmental conditions [24-26, 31, 51]. For example, different clones of the same species were found to have different resistance to water and frost stress [21, 24-26, 52]. The components of these factors are therefore likely to affect the factors that influence the uptake of heavy metals in the plant. Because the studies show that many phenological, morphological and anatomical characters are significantly affected by these factors [30, 53-56].

Heavy metal uptake and accumulation in plants are closely related to plant metabolism [14, 29,30]. Therefore, the stress level of the plant that significantly affects plant metabolism [22,23,57], plant origin [53] and hormone applications [58-61] can be expected to affect heavy metal uptake and accumulation of plants.

As a result, the change in heavy metal concentration in plants is the result of a complex mechanism due to the interaction of many factors. However, this mechanism is not fully solved. Information on the uptake of heavy metals from above-ground organs is very limited [14,32]. Therefore, the studies on the subject should be diversified and increased.

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