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RESEARCH ARTICLE

VARIATION OF SOME HEAVY METAL CONCENTRATIONS IN *MORUS ALBA L.* LEAVES AND BRANCHES DUE TO TRAFFIC DENSITY

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ABSTRACT

Today, the increase in population and in the number of vehicles in the cities has increased the air pollution to such an extent that it has become one of the most important problems of the modern age. Many pollutants emerge from city roads due to exhaust gases, car wheels and vehicle wear, and these pollution sources adversely affect the development and health of living beings inhabiting the surrounding areas. The heavy metals tend to bioaccumulate and some of them have toxic effects even at very low concentrations. Therefore, it is utmost important to monitor the change in heavy metal concentration. Usually, plants are used as biomonitors in determining heavy metal pollution. This study tries to determine the possibilities of using Morus alba as a biomonitor; Morus alba is frequently used in landscaping. For this purpose, concentrations of Ni, Cd, Zn, Fe, K, Mg, and Mn elements have been determined by analyzing the leaves and branches of Morus alba collected from areas with no, little, and heavy traffic.

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INTRODUCTION

The world population has increased more than ever in its history over the last 150 years, and this increase combined with the migration from rural to urban areas has caused extreme population density and consequently high air pollution in the city centers (Isinkaralar *et al.,* 2017; Cetin *et al.,* 2017a,b). Air pollution one of the most important problems we are facing today (Kalaycı Önaç *et al.,* 2017, Birişçi *et al.,* 2017). In fact, it is reported that about 6.5 million people lose their lives every year the world over because of the causes attributable to air pollution. It was reported Even in Turkey, the country that is considered as having clean air in comparison to many other countries, that 29,000 people lost their live due to air pollution related causes (Şevik *et al.,* 2017a). Among the air pollutants, heavy metals are particularly important as they tend to bioaccumulate and some of them have toxic effects even at very low concentrations. Although micronutrients such as Mn, Zn, Cr, Cu, Fe, and Ni are necessary for living organisms, including plants, they can cause harmful effects at high levels. Metals such as Hg, Cd, As, and Pb have serious toxic effects in organisms even at low levels (Shahid *et al.,* 2017). Due to the importance of the subject matter, a great number of studies have been carried out on heavy metals (Ozel *et al.,* 2015a; Turkyilmaz *et al.,* 2018a, b). Usually, plants are used as biomonitors in monitoring heavy metal concentrations. However, different heavy metals accumulate at different levels in plant species and organelles. Therefore, it is necessary to determine the extent to which a particular heavy metal accumulates in various plants and their organelles, and then use those plants and organelles as biomonitors. This study tries to determine the variation in Ni, Cd, Zn, Fe, K, Mg and Mn concentrations in Morus alba L. leaves and branches due to traffic density

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MATERIALS AND METHODS

The study was carried out on *Morus alba* leaves and branches. Within the scope of the study, leaf and branch samples from Morus alba trees were taken from three areas: Kastamonu city center a heavy traffic area; out of Kastamonu city center a low traffic area and from a no-traffic area that is, no vehicle approached the area closer than 50 meters. The samples were classified and labeled and were made ready for analysis in the laboratory. In the laboratory, the samples were left to stand for 15 days until they became air-dried, and then were further dried at 45 °C in an oven for one week. Dried samples were triturated, and each of the dried samples (amount weighing 0.5 g) was placed in a microwave-compatible tube. 10ml of 65% HNO_3 was added to the samples. During these operations, the work was carried out by using a quarry. The samples were then fired at 280 PSI and at 180ºC for 20 minutes in a microwave.

Table1. Changes in heavy metal concentrations in *Morus alba* organelles due to traffic density

Element	Leaf			Branch			F Value
	No traffic	Low traffic	Heavy traffic	No traffic	Low traffic	Heavy traffic	
Ni (ppb)	793 b	1,012 c	1,225 d	229 a	1,405 e	1,759 f	403.241***
Cd (ppb)	20.63 bc	26.77 d	54.00 d	8.33 a	15.60 b	24.67 c	59.598***
Zn (ppm)	11.6 ab	16.6 c	18.2 d	11.4 a	11.8 b	19.5 e	70,745.860***
Fe (ppm)	96 d	145 b	204 c	24 a	32 b	75 c	36,845.143***
K (ppm)	30,620 f	6,074 a	2,8478 e	8,261 c	6,957 b	12,941 d	34,779.712***
Mg (ppm)	9,974 e	4,988 a	4,988 a	5,029 b	8,864 c	9,952 d	306,062.200***
Mn (ppm)	12 c	21 e	38 f	3 a	6 b	15 d	8,557.600***

*** Statistically significant at 99.9% confidence level

Following the completion of the procedure, the tubes were removed from the oven and cooled down. Deionized water was added to the cooled samples to fill up to 50 ml. The samples were drained through filter paper and then analyzed using an ICP-OES instrument at appropriate wavelengths. The data obtained were evaluated with the help of SPSS software package, variance analysis was performed on the data and homogeneous groups were obtained by applying the Duncan test to the values having statistically at least 95% confidence level differences. The data obtained were simplified, tabulated and interpreted.

RESULTS

The variation in heavy metal concentrations due to traffic density in *Morus alba* leaf and branch samples - the subject matter of this study - was determined, and variance analysis and Duncan test were performed on the data obtained. The mean values, the F value and significance level obtained from the variance analysis and the homogeneous groups resulting from the Duncan test are given in Table 1. As shown in Table 1, the changes in the concentrations of the elements considered in this study are statistically different depending on the traffic density and the organelles, at 99.9% confidence level. As a result of the study, while Ni, Cd, Zn, Fe and Mn concentrations have been found to increase due to the traffic density, there was no clear relationship between the K and Mg concentrations and the traffic density. The Ni concentration in leaves was 793 ppb in no-traffic area but was found to have increased to 1012 ppb in low-traffic area and to 1225 ppb in heavy-traffic area; in branches the Ni concentration was found to have increased to 1405 ppb (low-traffic area) and to 1759 ppb (heavy-traffic area) from 229 ppb (no-traffic area). The Cd concentration in leaves was 20.63 ppb in no-traffic area but was found to have increased to 26.77 ppb in low-traffic area and to 54.00 ppb in heavy-traffic area; in branches the Cd concentration was found to have increased from 8.33 ppb (no-traffic area) to 15.60 ppb (low-traffic area) and to 24.67 ppb (heavy-traffic area). The Fe concentration in leaves was 96 ppm in no-traffic area but was found to have increased to 145 ppm in low-traffic area and to 204 ppm in heavy-traffic area; in branches the Fe concentration was found to have increased from 24 ppm (no-traffic area) to 32 ppm (low-traffic area) and to 74 ppm (heavy-traffic area). Similarly, the Mn concentration in leaves was 12 ppm in no-traffic area but was found to have increased to 21 ppm in low-traffic area and to 38 ppm in heavy-traffic area; in branches the Mn concentration was found to have increased from 3 ppm (no-traffic area) to 6 ppm (low-traffic area) and 15 ppm (heavy-traffic area). The proportion of increase in the concentrations of these four elements, due to traffic density with respect to their respective concentrations in no-traffic area, was more in branches than that in leaves. The increase in Zn concentration in leaves due to traffic density was almost the same as that in branches.

While the Zn concentration in leaves was 11.6 ppm in no-traffic area and was found to have increased to 16.6 ppm in low-traffic area and to 18.2 ppm in heavy-traffic area, the Zn concentration in branches was 11.4 ppm in no-traffic area and had increased to 11.8 ppm in low-traffic area and to 19.5 ppm in heavy-traffic area. It was found that the variation in the concentration of K and Mg in leaves and branches did not dependent on the traffic density.

DISCUSSION AND CONCLUSION

Air quality is presently one of the most important study topics because it directly affects human health, comfort and performance. Therefore, a large number of studies have recently been carried out on air quality (Cetin and Sevik, 2016). The heavy metals are particularly of serious concern as air pollutants because they do not naturally break down or decompose and tend to bioaccumulate (Turkyilmaz *et al.,* 2018a,b). Hence determining the extent of heavy metal pollution is very important. In this study, it has been found that Ni, Cd, Fe, Mn and Zn concentrations in *Morus alba* leaves and branches increased due to traffic density. Further, the proportion of increase in the Zn concentration in leaves was comparable to that in branches, but that in the concentrations of the other four elements was more in branches than in leaves. This is probably due to the concentration of heavy metals in the particulate matter (PM) adhering to the bark of the branches rather than the presence of heavy metals inside the branches. According to some studies, precipitation and adhering of heavy metals on plant organelles vary greatly depending on heavy metal levels in PM in the atmosphere (Shahid, 2017). Research has revealed that PM in the air acts like a pharynx for heavy metals and that by settling on the surface of the plant the PM can enter into the plant through various ways and stay there; therefore, the concentrations of heavy metals in plants are closely related to the amount of PM that is contaminated with heavy metals (Uzu *et al.,* 2009; 2011; Shahid *et al.,* 2017). Additionally, it has been stated that the heavy metal concentration in plants can vary considerably depending on the traffic density (Assirey *et al.,* 2015; Lei *et al.,* 2015) and on plant's organelle (Emamverdian *et al.,* 2015), and the developmental stage (Shahid *et al.,* 2017) of the plant. As a result, the heavy metal concentration in plants is formed due to the interaction of many factors such as plant species, heavy metal concentration in the air, plant organelle, and environmental conditions (Beckett *et al.,* 2000a,b; Shahid *et al.,* 2017; Ozel *et al.,* 2015b). The effectiveness of afore-mentioned factors has been proven by the earlier studies. Apart from these, there are also other factors that have the possibility of influencing the heavy metal concentration. For example, besides the plant species, subspecies, form, variety and origin (Sevik *et al.,* 2017b; Yigit *et al.,* 2017; Ozel and Bilir, 2016), plant stress level (Sevik and Cetin, 2015; Topacoglu *et al.,* 2016; Sevik and Karaca 2016; Yigit *et al.,* 2016b), even genetic structure (Hrivnák *et al.,* 2017; Sevik *et al.,* 2012) are factors likely to affect heavy metal absorption and hence heavy metal concentrations in plants. Moreover, all these factors interact with each other. For example, the amount of light may affect the amount of chlorophyll and growth rate of a plant, and the rate of growth of a plant may affect heavy metal intake. As a matter of fact, Sevik et al. (2013) stated that there can be two or three times difference in the amount of the chlorophyll between the leaves of the same plant growing under shadow and the leaves receiving intense light. On the other hand, it has been also stated that there is a relationship between plant growth and metal concentration (Speak *et al.,* 2012; Shahid *et al.,* 2017). Therefore, the variation of heavy metal concentration in plants is the result of a complex mechanism dependent on the interaction of many factors.

Suggestions

In this study, *Morus alba L.* leaves and branches have been determined to be quite suitable for determining particularly Ni, Cd, Fe, Mn and Zn concentrations. As a result of the study, it has been determined that the rate of increase of Ni, Cd, Fe and Mn concentrations in branches was higher than in the leaves. However, this increase is thought to originate from PM that adhere easily to the bark of the branches and are contaminated by heavy metals. In order to confirm this, subsequent work can be carried out by applying a washing procedure and to determine the variations in heavy metal concentration in the washed and non-washed samples. The same applies to leaves as well.

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