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The Change of Mn Concentration by Organ and Species in Several Edible Plants

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Abstract – Nowadays, air pollution is one of the most important environmental problems affecting millions of people annually. Among the air pollution factors, heavy metals have specific importance since they are toxic for human health even at low concentrations. Thus, monitoring the heavy metals is of significant importance. This is important especially for the plants that are consumed as food.

The present study aims to determine the change of Manganese concentration by species and organ in several plants that are consumed as food. Within the scope of this study, leaf, branch, and fruit samples were collected from six plant species, organs of which are consumed as food, and Manganese analyses were performed using an Inductively Coupled Plasma-Optical Emission Spectrometry device. As a result of the study, it was determined that the difference of Manganese concentrations between the species was statistically significant for all the species and the highest concentrations were found in leaves and the lowest ones in fruits.

Keywords – Heavy metal, Manganese, Organ, Plant.

I. Introduction

Nowadays, together with the rapid urbanization and increase in energy consumption, environmental pollution reached a level that threatens human health, especially in developing countries [1], [2]. The gradually increasing population, especially in the city centers, also resulted in many problems such as deterioration of nature, pollution in the air, soil, and water, and degradation of ecological balance [3], [4], [5].

Among the air pollution factors, heavy metals have a specific importance because they tend to bio accumulate and can be toxic for human health even at low concentrations. Thus, many studies have been carried out on heavy metals [6], [7]. The toxicity symptoms of Mn (Manganese), which reaches humans through the food chain, are mainly observed in the respiratory system and brain. The symptoms of manganese poisoning include hallucinations, fatigue, sleeplessness, weakness, forgetfulness, and neural damages. Moreover, Mn causes Parkinson's disease, lung embolism, and bronchitis, while long-term exposure to Mn toxicity may cause impotency among men [8]. Hence, monitoring the Mn concentrations in plants, especially in those consumed as food, is very important for human health. In the present study, it was aimed to determine the change of Mn concentrations by species and organ in several plants grown in high-traffic areas.

II. Material and Method

2.1. Sample Collection

Within the scope of this study, the plants that are widely used in landscaping projects at city centers, where the traffic density is high, and have organs that are consumed as food were determined. The samples were collected from scarlet firethorn, linden, apple, rose, walnut, silverberry, cherry, and sour cherry trees. The main objective of this study was to compare the heavy metal concentrations in the organs, which are consumed as food, to the concentrations in other organs. Within the scope of this objective, the leaf, fruit, and branch samples were collected from these species.

Since it was aimed to compare the heavy metal concentrations in organs, attention was paid to sample the organs from the same branch. Hence, the branches containing all the organs examined here were collected as a whole in order to eliminate the errors, which may arise from the difference between the locations of organs on the plant, and to achieve more accurate results.

2.2. Analyses

The samples collected were labeled and then taken to the laboratory. Then, they were separated into organs in the laboratory. After labeling them, the samples were placed on paper plates and left for drying. Branch and fruit samples were crushed in order to let them dry better and then they were left in glass petri plates to dry. The samples, which were air-dried in the laboratory by mixing minimum once a week for approx. 2 months, were taken into paper cups and dried at 50 °C in a drying oven for a month. The dried samples were packaged to protect them from humidity and then sent to the laboratory for analysis.

1. At the next step, the plant samples were ground into powder and 0.5g of samples were put into tubes designed for microwave. The samples were then added with 10 mL 65% HNO_3. These procedures were conducted in a fume cupboard. The samples were then combusted in microwave under 280 PSI pressure and at 180 ºC temperature for 20 minutes. After the process, the tubes were taken out of the microwave and left for cooling. The cool samples were completed to 50 mL by adding deionized water. The preparations were filtered through filter paper and then read at appropriate wavelengths using ICP-OES device.

2.3. Data Analysis

2. The data obtained were analyzed using SPSS package software. Variance analysis was conducted. The values found to have a difference at the statistical significance of 5% were subjected to the Duncan test and homogeneous groups were obtained. The data obtained were interpreted by simplifying and translating them into tables.

III. Results

The mean Mn concentrations of organs (leaf, branch, and fruit) by species, F values obtained from variance analysis, and homogeneous groups obtained from the Duncan test by significance level are presented in Table 1.

Table 1. Change of Mn Concentration by Species

Species	Organ			F Values
	Leaf	Branch	Fruit	
Scarlet Firethorn	197,60^{cg}	14,90^{af}	23,26^{be}	1149145,021***
Linden	28,83^{bd}	1,83^{aa}	-	46864,286***
Apple	26,26^{cc}	7,16^{bd}	5,15^{ad}	16416,450***
Rose	146,26^{cf}	5,36^{ac}	33,13^{bf}	70611,864***
Walnut	44,83^{ce}	9,00^{be}	1,73^{aa}	41071,400***
Silverberry	25,20^{cb}	3,60^{bb}	2,80^{ab}	20763,429***
Cherry	24,36^{ca}	32,96^{bg}	3,72^{ac}	1331,280***
Sour cherry	25,20^{cb}	56,16^{bh}	5,89^{ad}	17613,082***
F Values	93885,306***	67557,218***	24059,407***	

***: p<0,001

Given the values presented in Table 1, it can be seen that the changes of Mn concentration by species were statistically significant for all the organs (at the confidence level of 99.9%). In leaves, the lowest Mn concentrations were found to be 24.36 ppm in cherry and 25.20 ppm in sour cherry, whereas the highest values were found to be 197.60 ppm in firethorn and 146.26 ppm in rose. In branches, the lowest Mn concentrations were found to be 1.83 ppm in linden and 3.60 ppm in silverberry, whereas the highest values were found to be 56.16 ppm in sour cherry and 32.96 ppm in cherry. In fruits, the lowest concentrations were found to be 1.73 ppm in walnut and 2.80 ppm in silverberry, while the highest concentrations were found to be 33.13 ppm in rose and 23.26 ppm in firethorn.

Similarly, it was determined that the change of Mn concentration by organ was found to be statistically significant for all the species (at the confidence level of 99.9%). Given the values, it can be seen that the highest values were found in leaves in all the species. The lowest values, however, were found in branches in rose and firethorn and in fruits in all other species.

IV. Discussion and Conclusion

It was determined that the change of Mn concentration by organ was found to be statistically significant (at the confidence level of 99.9%) for all the species. In studies carried out to date, it was reported that the changes of elements by organ were generally statistically significant but the changes by species were generally at different levels. For instance, as in [9] and [10] reported that the concentrations of Cu, Ni, Pb, Cd, and Ca in plants they examined were higher in branches in comparison to leaves, whereas Mn concentration was higher in leaves than in branches. As in [11], stated that the changes of heavy metal concentrations in organs by species were different; the highest Ni concentration was found in seed in ornamental plum tree and in leaves in horse chestnut, linden, and ash tree but there was no statistically significant difference between organs in alder tree.

Studies carried out on heavy metals frequently examine the changes of heavy metal concentrations by organs. In studies carried out on this subject, the differences between bark and wood [12], [13], [14], between leaf, branch, and seed [15] and between leaf and branch [16], [17], [18] were determined. In these studies, it was revealed that the heavy metal concentrations significantly varied between the organs.

Mn is an element that can be absorbed by plants via both roots and leaves. Mn toxicity differs by the plant species. The toxicity symptoms of Mn reaching the human body through the food chain include hallucinations, sleeplessness, fatigue, weakness, forgetfulness, and neural damages. Moreover, Mn causes Parkinson’s disease, lung embolism, and bronchitis, while long-term exposure to Mn toxicity may cause impotency among men [8], [19].Thus, the change of Mn concentration in different plant species has been examined in the previous studies. As in [9] examined the change of Mn concentration in *Ligustrum vulgare, Eonymus japonica, Biota orientalis, Juniperus sabina, Berberis thunbergii, Mahonia aquifolium,* and *Buxus sempervirens,* whereas in [20], examined it in *Tilia tomentosa, Eleagnus angustifolia, Prunus cerasifera,* and *Ailanthus altissima*, [21] in *Cedrus atlantica*, and [18] in *Robinia pseudoacacia, Platanus orientalis, Acer negundo, Ulmus minor,* and *Nerium oleander*.

In the air, the heavy metals can accumulate in the plant leaves through the leaf transfer after the precipitation of particles in atmosphere on the leaf surfaces. There are many factors influencing the intake and accumulation of heavy metals in air into plant organism and the propagation of heavy metals in atmosphere and their intake into plant body occur as a result of a complex mechanism [22]. The heavy metal accumulation potential of the plants grown in the same region varies depending on various factors such as plant species, organ structure, metal characteristics, duration of exposure to heavy metal, and particle amount [23], [24]. Moreover, environmental conditions, especially the humidity and precipitation significantly affect the heavy metal intake into the plant body [25], [26], [27].

Besides these factors, the intake of heavy metals into plant body may vary depending on many factors because the growth performance of plants (morphological, anatomical, and phenotypic characteristics) may affect the intake of heavy metals into the plant. Phenotypic characteristics of plants arise from the mutual interaction between genetic structure [28], [29] and environmental conditions [30], [31], [32], [33], [34], [35], and it is known that different genetic structures may respond differently to the same environmental condition [36], [37], [38], [39], [40], [41]. Hence, many factors significantly influencing the plant metabolism such as stress level [42], [43], [44], [45], plant’s genetic structure [46], [47], hormone treatments [48], [49], cultivation practices such as pruning and shading [50], [51], [52], etc. affect the accumulation of elements within the plants. Moreover, the environment and soil structure altered by people in urban areas and also the micro-ecological factors created by people [53], [54], [55] affect the concentration of elements in plant organs.

In conclusion, the change of heavy metal concentration in plants is a result of a very complex mechanism that depends on the mutual interactions of many factors. However, this mechanism couldn’t be completely revealed yet. Especially the knowledge on the intake of heavy metals through aboveground organs is very limited [56], [9], [57]. Therefore, future comprehensive studies examining this subject are needed.

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