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Analysis of trace elements accumulation in some landscape plants as an indicator of pollution in an urban environment: Case of Ankara

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Abstract: As a result of the increase in structure and population densities in urban areas, many problems arise in cities that need to be solved. With the effect of keeping the planned approaches to air pollution in the city's background, urban air pollution has started to feel serious with the adverse effects it has created on living things. Heavy metals, which are one of the components of air pollution, seriously threaten living things because they cannot be eliminated from metabolism. For this reason, heavy metal pollution should be monitored in order to make the necessary interventions. The research aims to interpret the trace element level by using *Cupressus sempervirens* L. *Thuja occidentalis* L. *Platanus orientalis* L. *Prunus cerasifera* Ehrh. and *Photinia serrulata* Lindl. plants in the city center of Ankara as biomonitors. In this context, variance analysis was performed on lead and cadmium concentration levels with the SPSS package program. The mean values were subjected to the Duncan test for multiple comparison purposes. The difference in the accumulation levels of plant species and organs was revealed due to the research.

Keywords: Urban Air Quality, Trace Elements, Accumulation, Biomonitoring, Ankara

Öz: Kentsel alanlarda yapı ve nüfus yoğunlukların zamanla artmasının bir sonucu olarak kentlerde pek çok çözülmesi gereken sorun ortaya çıkmaktadır. Kentlerde hava kirliliğine yönelik plan yaklaşımlarının geri planda tutulmasının etkisiyle kentsel hava kirliliği, kendini canlıların üzerinde yarattığı olumsuzluklar ile ciddi bir şekilde hissettirmeye başlamıştır. Hava kirliliği bileşenlerinden biri olan ağır metaller metabolizmadan tamamen atılamadığından canlı yaşamını ciddi bir şekilde tehdit eder. Bu nedenle gerekli müdahalelerin yapılabilmesi için ağır metal kirliliğinin izlenmesi gerekmektedir. Araştırmada Ankara kent merkezinde yer alan *Cupressus sempervirens* L. *Thuja occidentalis* L. *Platanus orientalis* L. *Prunus cerasifera* Ehrh. *Photinia serrulata* Lindl. Bitkilerinin biyomonitör olarak kullanılmasıyla trace element düzeyinin yorumlanması amaçlanmaktadır. Bu bağlamda kurşun ve kadmiyum konsantasyon düzeylerine SPSS paket programıyla varyans analizi yapılmıştır. Ortalama değerler çoklu karşılaştırma yapılması amacıyla Duncan teste tabi tutulmuştur. Araştırma sonucunda, bitki türü ve organların birikim düzeylerinin farklılığı ortaya konmuştur.

Anahtar Kelimeler: Kentsel Hava Kalitesi, Eser elementler, Birikim, Biyoizleme, Ankara

1. Introduction

Urban researches are studies that need to be handled multidimensionally, such as transportation [1-3], urban design [4-8], urban economy and development [9-11], landscape planning [12, 13], urban policy [14, 15] environment and infrastructure [16-18]. Increasing the quality of life in cities, which constitutes the main stage of daily activities in today's conditions, depends on determining the sources of the problems and interventions [19]. The main reasons for reducing the quality of urban life can be counted as population density, various industrial activities, use of poor quality fuel, the density of traffic, and the use of chemical products harmful to nature in many areas [20-23]. Problems such as climate change, global warming, and air pollution that arise from these problems affect all ecological systems [24, 25]. Air pollution, which is one of the problems that occur, is highly affected by the release from sources, the behavior of pollutants in the atmosphere, their transport by wind, and the silhouette and morphology of the city that cause their accumulation [26, 27]. In this context, air pollution research is of vital importance in terms of urban planning.

The accumulation of air pollutants on various living things can represent air quality on an urban scale. To determine the effect of air quality on living things, it has become very important to determine how far they have been moved and their accumulation levels, starting from their source [28]. However, the detection of pollutants in metropolitan cities is a complex research topic [29]. Among the main reasons, many externalities, such as the fact that it cannot be followed instantly, cannot be detected at the source, and the effect of weather events (such as meteorological movements) on the accumulation affects the atmospheric accumulation. Therefore, various studies are being carried out to use some species as biomonitors since it is difficult to monitor and the cost is high. Furthermore, heavy metals from these pollutants are

hazardous in high concentrations as they can have a toxic effect [30]. However, the direct measurement of heavy metals in the air does not provide enough information in terms of environmental impact and monitoring [31, 32].

Some materials such as mosses, indoor plant species, and the rings and organs of perennial trees used in landscape afforestation were used in some studies. High concentrations of metals that can accumulate in these species have been found. However, they have found that various heavy metals can get in multiple areas at a higher rate than others. For example, the differences between the element types found at the industrial sites and the metals found in the areas with high traffic indicate that passive sampling is appropriate in the search for a method. These papers have shown the absorption capacity of accumulation varies between species [33, 34]. Therefore, it is essential to investigate the suitability of the species that can be preferred as biomonitors for the selection of target pollutants. This study was aimed to determine the accumulation levels of Lead (Pb) and Cadmium (Cd) in the organs of 5 different landscape plants in areas with heavy traffic in the city center of Ankara.

2. Material and Method

This paper is conducted on the species grown in the urban center of Ankara, where the traffic is dense. In selecting the study area, the traffic's multi-port and low flow rate were taken into account. Samples were collected from *Cupressus sempervirens* L. (SCs), *Thuja occidentalis* L. (STo), *Platanus orientalis* L. (SPo), *Prunus cerasifera* Ehrh. (SPc) and *Photinia serrulata* Lindl. (SPs) plant, which is frequently used in landscape studies. Samples are from the last year's exile. They were collected in late October towards the end of the vegetation season of 2021, bagged and labeled, and brought to the laboratory. It was then dissected into organs without the use of metal tools. Some of the bark and leaves have been washed. After rinsing with distilled water, all samples were labeled.

In the next stages of the study, The US EPA 3052 was used to apply the method. Organs, leaf, bark and wood samples were also shown with their codes. Labeled samples were kept at room conditions for two weeks after pretreatment without being exposed to direct sunlight. It was then dried in an oven at 45°C for two weeks.

The dried plant samples were ground into powder and weighed 0.5 g, and placed in tubes designed for microwaving. 10 mL of 65% HNO_3 was added to the samples. The prepared samples were then burned in a microwave device at 280 PSI and 180 ºC for 20 minutes. After the processes were completed, the tubes were removed from the microwave and left to cool. Deionized water was added to the cooled samples to make up to 50 ml. After the prepared samples were filtered through filter paper, they were read at appropriate wavelengths in the ICP-OES device. The obtained values were multiplied by the dilution factor, and the element concentrations of the study were calculated.

SPSS program was used to compare the mean values of the analyses performed with three repetitions. Analysis of variance was applied to the data. Homogeneous groups were obtained by applying the Duncan test to statistically different groups, at least at the 95% confidence level. The analysis results are expressed with F values in terms of the storage capacity of the plants.

3. Results

When the high concentration Pb values obtained within the scope of the study were examined among the species, high values were obtained in SPc in Table 1. Although the lowest accumulation among the organs was in the wood, the accumulation level in SPc was relatively high with 6726 ppb. While the lowest value in wood was obtained with 877.66 ppb in SPo, it was found at 6995.2 ppb in outer bark and 6255.53 ppb in leaf. When ranking from high to low in terms of the values of Pb among the organs, they are listed as outer bark, leaf, and wood.

Table 1. Deposition of Pb concentrations (ppb) based on organs

Species	**Organ**			***F* value**
	Leaf	**Bark**	**Wood**	
SCs	8738.46 Cde	8881.60 De	2448.66 Ag	32.9***
STo	8702.00 Bcd	8808.40 Dd	1097.86 Ac	51.5***
SPo	6255.53 Cb	6995.20 Ea	877.66 Aa	1156.5***
SPc	9176.46 Ei	8806.33 Dd	6726.00 Ak	
SPs	8843.66 Eg	8688.33 Bc	2092.13 Af	
F value	9169.43***	2338.07***	16905.84***	

*** expresses p<0.001, lower case letters represent vertical directions, whereas capital letters represent horizontal directions.

When the concentration values in the leaf were compared, the highest value was obtained with SPs 28221.93 ppb, while the lowest value was obtained with STo 7953.20 ppb. Regarding values in the crust, the highest accumulation level was observed in SPo at 15712.86 ppb, while the minor accumulation was observed in SPc at 2940.06 ppb. When the accumulation levels in wood were compared, the accumulation in STo was analyzed, with 1842 ppb being the lowest.

Table 2. Deposition of Cd concentrations (ppb) based on organs

Species	Organ			*F* value
	Leaf	Bark	Wood	
SCs	9447.86 Ee	6525.33 Bd	2612.73 Ae	18034.62***
STo	7953.20 Dd	8805.86 Ei	1842.00 Ab	23105.08***
SPo	17015.13 El	15712.86 Dl	8109.20 An	8552.04***
SPc	19624.06 Dm	2940.06 Ba	2196.66 Ad	35244.1***
SPs	28221.93 Dn	7308.60 Bf	3185.46 Af	33703.61***
F value	44078.52***	13783.27***	30418.68***	

*** expresses p<0.001, lower case letters represent vertical directions, whereas capital letters represent horizontal directions.

4. Discussion and Conclusion

Heavy metal accumulation can cause serious health problems, a multidimensionality researched issue. For example, Conti et al. [35] determined the element levels in bees and edible hive products and interpreted the health risk status with reference doses. Another study analyzed the variation in Zn and Cd levels by exposing algae to cigarette smoke in the living area and investigated its effect on indoor air quality [36]. Therefore, the accumulation of toxic substances in living things can be handled in many contexts.

Heavy metal accumulation was investigated in 5 different plant species selected in the study. Isinkaralar [37] investigated the Cd concentration in the range of 120-250 ppb in *Ailanthus altissima* in his research conducted in another location in Ankara. In addition, the outer bark values of Cd are about twice that of wood. Similarly, a higher concentration was obtained in the bark than in the wood in all species in this study. However, *Thuja occidentalis* L. bark accumulation was approximately four times higher than in wood. Another study [38] compared the heavy metal uptake capacity of 14 species, which also followed the accumulation of Cd. *Chamaecyparis lawsoniana* was found to be quite suitable for monitoring. According to Turkyilmaz et al. [34], the change in Cd amounts according to traffic density was statistically significant at the 99.9% confidence only in the usage of *S. babylonica* according to their analysis of 4 different species. The highest Pb values were obtained in *A. hippocastanum*. Various studies reveal that traffic density and industrial emissions affect Pb and Cd concentrations [39]. Zinikovscaia et al. [40] used the algae biomonitoring technique in air pollution monitoring. Possible sources of air pollution in the case area, including Pb and Cd and other nine metals, have been identified as resuspension of soil particles, agricultural applications, vehicles, industry, and thermal power plants.

5. Suggestions

The most obvious result of the decrease in air quality in cities every day is seen in living things. Growth disorders, stress conditions, and early deaths, especially seen in landscape plants in urban areas, are the leading causes of toxic metals at very high levels. Although the ability of trees used in urban areas to absorb heavy metals in their bodies differs between species, it has been observed that all of them have the ability to absorb. The presence of Pb and Cd-containing metals, which are among the species' traffic-induced releases, is increasing due to the formation of both fuel-oriented and motor vehicles caused by wear and corrosion. More comprehensive information about the sources can be obtained by diversifying the locations in future studies.

Competing Interest / Conflict of Interest

The authors declare that they have no competing interests.

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Author Contribution

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