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Bazı Peyzaj Bitkilerinin Biyoizleme Tekniğinde Kullanılabilirliği: Ağır Metallere Yönelik Bir Analiz

Usability of Some Landscape Plants in Biomonitoring Technique: an Anaysis With Special Regard to Heavy Metals

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ÖZ

Günümüz kentlerinde endüstriyel faaliyetlerin yaygınlaşması ile kentsel nüfus ve yapı yoğunluğundaki artış sonucunda kent coğrafyasında kirlilik değerleri artmaktadır. Çevresel kirleticilerin birikimi, kentlerin yapılaşmasında dikkate alınması gereken en önemli sorunlardan biridir. Kentsel alanlarda çeşitli faaliyetlerden kaynaklanan ağır metal kirliliği, en riskli çevresel problemlerden biridir. Ağır metaller, insan faaliyetleri nedeniyle yoğunlaşmakta olup, izlenmesi ve birikim düzeylerinin belirlenmesi gerekmektedir. Belirli bir dozun üzerinde birikim yaşanması hayati sorunlara neden olabileceğinden nüfus yoğunluğunun olduğu bölge ve alanların ağır metal seviyelerinin tespiti ve azaltım çalışmaları kritik öneme sahiptir. Ağır metallerin birikimine ilişkin araştırmalar oldukça farklı boyutlarda parametrelerden etkilenmekte olup düzeyin belirlenmesi ve kaynak tespiti oldukça karmaşıktır. Ancak bazı peyzaj alanlarında kirleticilerin türünün etkisiyle yüksek birikim sağlayabilmesi nedeniyle, bu bölgelerdeki kirleticilerin seyrini ortaya koymaktadır. Bu çalışma, ağır metallerin biyoizlenmesi yöntemiyle çeşitli peyzaj türlerinde yaprak, ağaç kabuğu ve odundaki Bakır (Cu) ve Demir (Fe) konsantrasyon değerlerini belirlemeyi amaçlamıştır. Cu ve Fe konsantrasyonu karşılaştırılarak kullanılan türlerin ağır metal tutma kapasiteleri, bitki türleri ve aynı bitkinin farklı organlarında önemli ölçüde değişmiştir. Çalışma sonucunda Schinus molle L. türünün kentsel alanlarda tercih edilebileceği, Cu ve Fe birikiminde biyomonitör olarak kullanılabileceği tespit edilmiştir.

Anahtar Kelimeler: Ağır metal, Biyoizleme, Hava kirliliği, Kentsel yeşil alan

ABSTRACT

As a result of the widespread industrial activities in today's cities and the increase in the urban population and building density, the pollution values in the urban geography are increasing. The accumulation of environmental pollutants is one of the most important problems to be considered in the construction of cities. Heavy metal pollution from various activities in urban areas is one of the riskiest environmental problems. Heavy metals are concentrated due to human activities and it is necessary to monitor and determine their accumulation levels. Detection and reduction studies of heavy metal levels in regions and areas with population density are of critical importance, as accumulation above a certain dose can cause vital problems. Studies on the accumulation of heavy metals are affected by parameters of quite different sizes, and determination of the level and identification of the source is quite complex. However, due to the high accumulation of pollutants in some landscape areas due to the effect of their type, it reveals the course of pollutants in these regions. This study aimed to determine the concentrations of Copper (Cu) and Iron (Fe) in leaves, bark and wood in various landscape species by biomonitoring heavy metals. By comparing the Cu and Fe concentrations, the heavy metal holding capacities of the species used varied significantly in plant species and in

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different organs of the same plant. As a result of the study, it has been determined that Schinus molle L. can be preferred in urban areas and can be used as a biomonitor in Cu and Fe accumulation.

Keywords: Air pollution, Biomonitoring, Heavy metals, Urban green

INTRODUCTION:

The phenomenon of urbanization brought by industrialization expresses the increase in the population within the urban borders and the dissolution of the rural population, and the migrations (Tammaru, 2001; Novotný, 2016; Węcławowicz, 2016). Social and economic services offered in urban areas, unlike rural areas, have caused people to migrate to areas where service supply is concentrated (Knickmeyer, 2020; Öztürk et al., 2021). As a result of the inability to meet the spatial requirements due to the increase in the population in the cities, many land-use forms have chosen a place by self-organizing (Sang et al., 2011; Arribas-Bel and Schmidt, 2013; Rodríguez-Pose and Storper, 2020; Işınkaralar and Varol, 2021). Global capitalist activities, especially in the last century, have shown themselves as a rapid competition environment and structuring on the urban plane (Graham, 1999; Watson, 2009; Urry, 2010; Isinkaralar et al., 2021). Decision-making processes have progressed uncontrollably, and the need for a scientific and positivist approach to the urbanization process has arisen (Alexander, 2006). Cities, which were the scene of the planning operation, encountered some environmental problems in the long term, while their periodic needs were met in practice (Bibri, 2022; Isinkaralar, 2022d). As time progresses, the artificial environment created in urban areas has started to show itself as many problems such as air, water, soil pollution, and climate change (Douglas et al.,2008; Çetin et al.,2018; Yilmaz and Isinkaralar, 2021a).

In today's World, environmental pollutants whose sources depend on domestic, industrial, and fossil fuel use pose a threat to urban residents in terms of health (Sevik et al.,2018; Adimalla et al.,2020; Isinkaralar, 2021). Especially in large-scale cities where population density and activities are concentrated and accumulated, diseases have become widespread due to many adverse developments caused by environmental pollution. These diseases are caused by polluted water sources, unclean air, and the ingestion of products grown in poisoned soils by people (Isinkaralar and Erdem, 2022; Sellami et al., 2022).

Some metals found in nature are necessary for up to specific concentrations for the body (Shah et al., 2020). However, these heavy metals, which can quickly accumulate when exceeding a particular dose, are released into the atmosphere with various emissions and small particles (Cetin et al.,2021; Isinkaralar et al.,2022). Toxic heavy metals are common pollutants in cities (Nakagawa et al.,2022). Iron (Fe) and copper (Cu), which form the scope of the study, are elements that are widely emitted in towns and have a higher accumulation in those regions than other heavy metals. Although there are various forms of iron, +2 (ferrous) and +3 states (ferric) are commonly seen in nature (Singh et al., 2018). Cu is the raw material of materials widely used in various industrial activities. Due to its conductivity capability is frequently used in underground and aboveground electrical transmission cables, especially in cities. Both elements corrode over time and mix first with the atmosphere and then with the soil and water (Mishra et al., 2019).

As a result of not investigating the corridors that will allow airflow in cities from a functional point of view and keeping them in the background in spatial decisions, heavy metals are also carried to distant regions by meteorological transports, especially in the area where they are released. Both are incredibly harmful to human health due to their toxic effects at high concentrations (Turkyilmaz et al., 2018). These poisonous metals, which can accumulate in the human body even at low concentrations, cause acute and chronic diseases (Valavanidis et al., 2008; Ghoma et al., 2022). Therefore, determining the sources of these elements in the urban area and monitoring their quantities is vital in terms of quality of life and public health. Passive sampling types are widely preferred in this context (Isinkaralar and Erdem, 2021a, b). Furthermore, the preference of species that can easily absorb heavy metals in open-green areas in urban land use in planting design has been indicated with examples in the literature as a successful method in monitoring urban-scale air quality (Yilmaz and Isinkaralar, 2021b). This study aims to determine the levels of heavy metal accumulations in different organs of different types of plants that can be used to monitor environmental pollution. The regional variation of Fe and Cu accumulation levels was analyzed by comparing species. In addition, leaves, bark, and woody structures were used to investigate the usability of plants as biomonitors.

MATERIALS AND METHODS

Study area and species sampling

The study analyzed different samples collected from a large park area in Mersin, Turkey. The fact that plant species have the same climatic conditions and age ranges is a significant parameter in the accumulation of Fe and Cu pollutants. It is possible to use motor vehicles in large quantities, be predominantly residential and commercial, and have small-scale industrial activities in the area where the species are found. It has been determined by the accumulation in the organs of landscape plants as a result of exposure to these sources. The collected leaf, bark, and wood samples were brought to the laboratory in closed polyethylene containers. Species in Table 1 were collected for the analysis their accumulation.

Table 1. The Types Used in the Study and Their Identification Codes

Sampling species	**Sample codes**
Cupressus sempervirens L.	*Cs*
Thuja occidentalis L.	*To*
Citrus reticulata Blanco	*Cr*
Platanus orientalis L.	*Po*
Prunus cerasifera Ehrh.	*Pc*
Photinia serrulata Lindl.	*Ps*
Eucalyptus camaldulensis Dehnh.	*Ec*
Chamaecyparis lawsoniana (A. Murr.) Parl.	*Cl*
Laurus nobilis L.	*Ln*
Cercis siliquastrum L..	*Crs*
Schinus molle L.	*Sm*
Pyracantha coccinea M.J.Roemer	*Pyc*
Acer hyrcanum F. et Mey	*Ah*
Pinus brutia Ten.	*Pb*

Figure 1. Location of Sampling Site

Analysis of samples

Samples collected from the study area were put into sample collection containers by giving codes to avoid confusion. Care was taken not to expose the samples brought to the laboratory to any contamination. It was kept in an oven at 45 degrees for 15 days to reduce the humidity. Each sample was then weighed 0.5 g on a precision balance. According to US EPA method 3052, 10 mL of 65% HNO_3 was heedfully mixed to the all samples, and they were well mixed. Then prepared samples were burned in a microwave at 280 PSI 180 ^oC for 20 minutes. After microwave treatment, 50 ml of distilled water was added to the tubes. Then, it was filtered through certain pores with the help of filter paper for filtration. The heavy metal content in the filtered samples was determined with the help of the ICP device. Analysis of variance and Duncan test were applied to the obtained data with SPSS 22 program. The level was determined in the 95% confidence interval and the results were given in the form of a table.

RESULTS

The variation of Fe and Cu concentrations among the species to which analysis of variance was applied was found to be statistically significant at 99.9% confidence level according to each location.

Fe accumulation of species

Table 2, which shows the Fe deposition in the species, also gives the mean values and the statistical analysis result.

Table 2. The deposition of the Fe concentration (ppm)

Species	Leaves	Barks	Woods	F value
Cs	502.09 Dh	681.43 Em	34.46 Afg	52715.17***
To	310.16 Ee	128.53 Cf	35.74 Ag	22965.67***
Cr	224.85 Ec	129.82 Cf	27.47 Ae	116279.17***
Po	538.89 Ei	66.89 Bc	17.49 Ac	32691.36***
Pc	567.51 Ej	439.60 Ck	34.96 Afg	27357.68***
Ps	577.80 Ck	173.47 Bj	55.11 Aj	21950.25***
Ec	90.23 Da	44.86 Ba	15.38 Ab	64788.87***
Cl	1288.55 Dn	597.64 Cl	15.85 Ab	54673.23***
Ln	301.49 Ed	146.10 Dh	23.41 Ad	18037.59***
Crs	359.17 Ef	53.60 Cb	37.41 Bh	234513.95***
Sm	947.11 Em	134.44 Cg	33.61 Af	1491178.71***
Pyc	426.37 Eg	86.27 Cd	13.31 Aa	486855.07***
Ah	642.97 El	94.14 Be	215.75 Ck	157377.01***
Pb	170.78 Cb	171.09 Ci	39.35 Ai	15027.88***
F value	42654.73***	106346.56***	10012.12***	

*** *p*<0.001, and the Duncan's test results that letters present their group.

The Duncan test results are examined that all species are looking for wood in the first group except Crs. It is seen that the species with the highest accumulation among the leaves, Cl and Sm were 1288.55 ppm and 947.11 ppm, respectively. The highest collection in the barks, Cs and Cl, was 681.43 ppm and 597.64 ppm. A significant value was obtained in the woods of Ah as 215.75 ppm.

Cu accumulation of species

The result of the variance analysis, the change in Cu concentration and the significant level of the species within the organs were found at the 99.9% confidence level (*p*<0.001) in Table 3.

Table 3. The deposition of Cu (ppb) concentration

Species	Leaves	Barks	Woods	F value
Cs	3566.13 Cb	6388.60 Eg	122.93 Aa	1254.13***
To	4575.73 Cd	6719.20 Eh	2834.60 Af	672.20***
Cr	8663.60 Dh	5609.66 Cf	845.86 Ac	4624.20***
Po	9563.00 Ej	8585.00 Cj	5497.26 Ag	591.71***
Pc	13478.33 Dk	12307.46 Cl	916.33 Acd	10235.67***
Ps	9510.13 Cj	8147.53 Bi	937.46 Acd	3499.65***
Ec	4235.13 Cc	1595.00 Bb	857.86 Ac	954.19***
Cl	15912.46 El	11495.20 Dk	607.60 Ab	9661.41***
Ln	5130.26 De	1912.66 Cc	1298.13 Ae	644.64***
Crs	5895.60 Df	553.86 Ba	147.20 Aa	2602.74***
Sm	16782.06 Dm	4309.73 Bd	2823.20 Af	10324.15***
Pyc	8077.80 Eg	5149.40 Be	1033.53 Ad	1580.16***
Ah	8907.33 Ei	1961.13 Cc	573.33 Ab	2368.83***
Pb	1231.00 Da	548.00 Ca	112.00 Aa	97.51***
F value	6334.52***	3757.17***	771.08***	

*** *p*<0.001, and the Duncan's test results that letters present their group.

The statistically insignificant ($p>0.05$) values of organs was found in Ah and Cl. The highest accumulation among the leaves in Sm and Cl were 16782.06 ppb and 15912.46 ppb, respectively. Cl and Po's highest collection in the barks was 11495.20 ppb and 8585 ppb. A significant value was obtained in the woods of Ah as 5497.26 ppb.

DISCUSSION

The organs of various plants were used to investigate the change in Fe and Cu concentration and the level of accumulation, which is considered in terms of the amount of accumulation and diversity in their sources in the cities. Among the organs examined in the study, the accumulation level was leaves, bark, and wood. Although the accumulation of pollutants was mainly seen in the leaves, accumulation was also observed in other organs by intercellular transport due to their genetic structures (Şevik, 2021).

Studies on biomonitors have revealed that various species are used and the accumulation levels (Turkyilmaz et al., 2020; Isinkaralar, 2022a, b; Karacocuk et al., 2022). Since some species have a higher capacity to absorb heavy metals than others, their widespread use in cities seems reasonable. Urban air quality biomonitoring using landscape plants and their organs has been used to evaluate the effects of atmospheric heavy metals deposition (Turkyilmaz et al., 2019). Petrova et al., (2014) studied biomonitoring of air pollution in Plovdiv, Bulgaria. They selected *Acer platanoides* L., *Aesculus hippocastanum* L. and *Betula pendula* Roth. as deciduous trees that were found heavy metals accumulation on their leaves. Savas et al., (2021) used *Cedrus atlantica* Manetti for Cr and Mn pollution in Kastamonu, Türkiye. They were found a positive correlation between traffic emission and heavy metal pollution. Isinkaralar et al., (2022) aimed to investigate some toxic metals due to atmospheric deposition in Mersin, Türkiye. They found several species for Cd, Cr and Zn as biomonitoring plants. Fusaro et al., (2021) investigated particulate matter (PM) with *Quercus ilex* L. leaves. The PM can be easily deposited on its leaves which is crucial to induce urban vegetation in Rome, Italy. They found an ecophysiological method that was a practical approach to determining atmospheric PM deposition in low air quality—many studies on atmospheric heavy metal accumulation caused by urban air quality and traffic emissions in the literature. In addition, current studies on heavy metal accumulation in landscape plants grown in industrial and residential areas have been viral (Isinkaralar, 2022c). The common point of all these studies is that passive sampling can be easily and inexpensively monitored for toxic elements without active sampling.

CONCLUSION:

Urban air pollution is a rapidly emerging phenomenon affecting the whole World. It is impossible to measure or monitor all air pollutants precisely because of their complex dynamics. The detection of different levels of heavy metals in plant species indicates the presence of resources in the urban fabric. Therefore, it is vital to consider air quality indicators in the plan studies to be carried out for cities. Outdoor air quality measurements provide limited data because they take a long time and are costly. In urban planning studies, biomonitors can be preferred not to carry the pollutant sources to the whole city with the prevailing and secondary winds but construct the green system and urban corridors correctly. Thus, long-term impurities that may occur will be monitored. Experimental study results give more theoretical and narrow-scoped results than urban-scale studies. Especially in the studies on heavy metal accumulation and their sources, the most effective system has been the analysis of plants. In this context, it is very important to determine the accumulation of plants taken from reference points and the absorbing capacity of species taken from points where potential pollutants are located. In this study, *Schinus molle* L. is a suitable type that can be used to monitor and reduce the Cu and Fe concentration in the air. The extent to which the specified species absorbs other elements and the diversification of pollutant types will lead to further studies.

Compliance with Ethical Standard

Conflict of Interests: There is no conflict of interest between the authors.

Ethics Committee Approval: Ethics committee approval is not required for this study.

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