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Urban Public Spaces, Public Health, and Heavy Metal Pollution Threatening in Ankara City Center: Strategies for Urban Planning

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Abstract: In the last century, population growth and concentration in urban areas have caused many problems, especially in the central regions of metropolitan cities worldwide. One of these problems is air pollution. It reduces the quality of life of the citizens and threatens public health. Among the components of air pollution, heavy metals are the most dangerous because they accumulate in metabolism. Some are toxic and poisonous even at low concentrations and deadly for human health at high concentrations. Studies on the determination of air pollution are limited to revealing the current situation and do not offer solutions for urban planning. In this context, the accumulation of copper elements, which is extremely dangerous for public health, in the city center was investigated using landscape plants as a tool in the research. Within the scope of the study, the change of copper concentration in five plant species grown in areas with no vehicle density, less dense, and dense regions were investigated. As a result of the research, the increase in the concentration of copper in the air due to traffic has been revealed statistically. The study emphasizes the relationship between heavy metal pollution, which poses a severe threat to public health, and urban planning, and shows the basic strategies in terms of urban planning.

Keywords: City centers, Urban quality of life, Public health, Air pollution, Ankara

Öz: Son yüzyılda dünya genelinde nüfus artışı ve nüfusun kentsel alanlarda yoğunlaşması, özellikle metropol kentlerin merkezi alanlarında pek çok soruna neden olmaktadır. Bu sorunların başında kentlinin yaşam kalitesini düşüren ve halk sağlığını tehdit eden hava kirliliği gelmektedir. Hava kirliliği bileşenleri içerisinde ise ağır metaller, metabolizmada birikmeleri, bazılarının düşük konsantrasyonlarda bile, toksik ve zehirli olmaları, yüksek konsantrasyonlarda insan sağlığı için ölümcül olmaları nedeniyle en tehlikeli olanlarıdır. Hava kirliliğinin tespitine yönelik çalışmalar mevcut durumu ortaya koymakla sınırlı kalmakta ve şehir planlama açısından çözüme yönelik stratejiler sunmamaktadır. Bu kapsamda araştırmada peyzaj bitkileri bir araç olarak kullanılarak halk sağlığı açısından son derece tehlikeli olan bakır elementinin kent merkezinde yer alan bitkilerdeki birikimi araştırılmıştır. Çalışma kapsamında taşıt yoğunluğunun olmadığı, az yoğun olduğu ve yoğun olduğu alanlarda yetiştirilen beş bitki türündeki bakır konsantrasyonunun değişimi incelenmiştir. Çalışma sonucunda havadaki bakır konsantrasyonunun trafik kaynaklı olarak artışı istatistiki olarak ortaya konulmuştur. Araştırma halk sağlığına ciddi tehdit oluşturan ağır metal kirliliği ile kent planlama ilişkisine vurgu yaparak, kentsel planlama açısından temel stratejileri ortaya koymaktadır.

Anahtar Kelimeler: Kent merkezleri, Kentsel yaşam kalitesi, Halk sağlığı, Hava kirliliği, Ankara

1. Introduction

The World Health Organization (WHO) draws attention to the fact that air pollution is defined as one of the biggest environmental threats to human health [1]. The production mechanism that emerged in urban areas in response to the intense consumption demand of today's world [2] has transformed urban areas into areas with high human, building, and vehicle density and continues to change them, especially in developing countries [3,4]. The metropolitan structure and density of urban areas make it difficult to deal with cities in terms of urban economy, design, planning, environment, and aesthetics [5,6]. Difficulties in urban management bring along some problems, such as accessibility, a decrease in quality of life due to density, and the emergence of pollution [7-10]. One of the most significant of these problems is environmental pollution because it threatens the citizens' health [11-12]. Today, it is reported that 92% of the world's population lives in regions with low air quality [13], deaths directly caused by air pollution are increasing [14-16], and the role of water pollution, especially in epidemics [17]. Reports of international organizations reflect environmental concerns [18]. However, even the basic needs of the increasing population, such as heating and shelter, require energy [19]. The world's energy need is provided by fossil fuels with intense carbon content and the gases that emerge after energy production increase carbon emissions [20]. The resulting greenhouse gases are considered to be one of the main culprits of urban heat island formation [21].

The gases produced adversely affect the outdoor air quality [22]. However, air quality can be managed with sustainable planning decisions in terms of air quality by making use of energy-efficient planning approaches based on environmental and social sustainability. Spatially open urban air quality knowledge is essential for developing effective strategies and measures. Monitoring systems are challenging to measure urban air quality with global technics [23]. Since air pollution components are not closed and traceable mechanisms, determining their sources is a multidimensional structure, and the determination of these factors is quite complex [24]. In studies, measurements are generally applied with sparsely placed fixed monitor networks. However, the difficulties in using these devices in outdoor conditions, their economic unsustainability, and their analysis processes limit air quality research, so some researchers try to sample large scales with closed setups [25]. Air quality components are monitored by different methods [26-27]. Since heavy metals from these pollutants are not eliminated from metabolism, they accumulate in the body. Based on this, the biomonitoring technique, which is applied using structures belonging to living things, is widely preferred because it has less cost [28] and has a wide application area compared to other methods [29]. The research, using five species (*Acer negundo, Aesculus hippocastanum, Tilia platyphyllos, Prunus ceracifera, Ailanthus altissima*) that are commonly preferred in urban open green areas, determine the heavy metal accumulation levels due to vehicle density in Ankara city center and producing planning strategies for metropolitan areas. Accordingly, the study seeks to answer two basic research questions:

- Do different plant species and different organs of plants differ significantly in terms of heavy metal accumulation levels?
- Does traffic density affect the deposition level of copper metal?

2. Material and Method

The study was carried out in the city center of Ankara, one of the most crowded cities in Türkiye. The city where the first zoning plan of the country was made after it was declared the capital city. Urban arrangements reflecting the republican ideology were produced by planners, urban designers, and architects. The modernization process of the city began to take place with this development. The city's development continued with the implementation of the modernity project, separating squares, parks, and boulevards as components of contemporary community life [30]. In this process, Atatürk Boulevard has assumed the role of a publicity image located at the city's core beyond its transportation function. It has formed the main backbone of public open spaces such as Youth Park, Guvenpark, Kurtulus Park, and Zafer Square, where the society comes together and communicates. As the Jansen Plan of Ankara aimed, it lived for a while as a field of communication and action where individuals saw, heard, and interacted with each other. However, with the arrangements made around the area, it lost its publicity role. The boulevard, which turned into a speedway that moved away from the human scale on the city's axis, with the road widening works at the beginning, turned into a speedway with the open green spaces that define social life away from publicity over time.

The processes experienced have triggered the transformation of the social space that holds the society together in the city center into a physical space that has the characteristics of a transition point. The loss of the central function of the Ankara city center points to a planning problem such as the search for a center. However, one of the negative effects of the implemented decisions is the emission emissions that threaten public health due to the exposure of the public spaces network in the city center to vehicle density. These gases, which affect the air quality, reduce the quality of life in society and not only, but also pose a severe threat to public health. Therefore, in urban planning, the pollution levels in the city center of Ankara were measured and analyzed statistically to reveal the city center's heavy metal pollution and emphasize its significance in terms of public health. Based on these findings, it is aimed to question the decisions produced for the city center. In this context, it was conducted on *Acer negundo, Aesculus hippocastanum, Tilia platyphyllos, Prunus ceracifera*, and *Ailanthus altissima* species, which are the most frequently used plants in landscape studies in urban centers. The samples that are the subject of the study were collected from the species that grow in the city center of Ankara, one of the most crowded cities of Türkiye, in areas with heavy traffic, low density, and almost no traffic (at least 100 m near there is no highway). The specimens were cut from the last year's shoot with pruning shears, packaged, labeled, and brought to the laboratory. The samples obtained in the laboratory were first subjected to the dissection process, then they were cut into pieces, marked, and placed in glass Petri dishes so they could dry quickly. For the samples to become room dry for 15 days and then to dry completely, they were dried in an oven at 45 °C for seven days.

Completely dried samples were ground into powder, 0.5 g was weighed, placed in tubes designed for microwave use, and 10 mL of 65% HNO_3 was added. The samples were then burned in a microwave device at 280 PSI and 180 ºC for 20 minutes. After the combustion process was completed, the tubes were removed from the microwave and allowed to cool. Deionized water was added to the cooled samples, made up to 50 ml, and filtered through filter paper. Samples prepared in this way were read at appropriate wavelengths in the ICP-OES device. This method is one of the most used methods in heavy metal analysis in plants, and many studies have been carried out using this method in recent years [31, 32].

The data obtained as a result of the study were evaluated with the help of the SPSS 23.0 statistical package program, analysis of variance was applied to the data, and homogeneous groups were obtained by using the Duncan test to the data with significant differences of at least 95% confidence level ($p<0.05$). The data obtained were organized according to the scope of the research, and the importance of the findings was interpreted within the framework of decisions and strategies.

3. Result and Discussion

There is the change in copper concentration in the samples subject to the study in areas where there is no traffic, where there is little or no traffic, and based on species and organs in Table 1. As a result of the analysis of variance, it was determined that the change of copper concentration based on organs in all traffic densities differed statistically at the 99.9% confidence level (p<0.001).

Table 1. Variation of copper concentration (ppm) by species and organs

Species	Organs	Traffic Density		
		None	Slightly intense	Intensive
Acer negundo	Leef	5.13 bc	0.70 a	1.86 a
	Seed	5.80 cd	6.16 d	52.33 c
	Branch	1.20 a	10.60 h	15.53 a
Aesculus hippocastanum	Leef	7.13 d	1.83 b	23.83 ab
	Seed	0.40 a	0.93 a	3.33 a
	Branch	3.70 b	8.96 f	10.10 a
Tilia platyphyllos	Leef	0.63 a	0.76 a	13.03 a
	Seed	15.46 f	19.16 j	330.66 d
	Branch	7.16 d	7.26 e	2.86 a
Prunus ceracifera	Leef	8.73 e	12.16 i	42.63 bc
	Seed	9.30 e	10.00 g	10.66 a
	Branch	6.43 cd	0.53 a	19.16 a
Ailanthus altissima	Leef	3.83 b	4.13 c	8.26 a
	Seed	16.60 f	20.00 k	23.16 ab
	Branch	5.60 cd	9.13 f	13.40 a
F Value		89.16***	1892.71***	132.42***

The relationship between traffic density and copper accumulation is questioned in the study. In this context, the lowest values from the Duncan test were obtained in *Aesculus hippocastanum* seeds in areas with no traffic, *Prunus ceracifera* branches in areas with low traffic density, and *Acer negundo* leaves in areas with heavy traffic. The highest values were obtained from *Ailanthus altissima* seeds in areas with less traffic and less intense areas and *Tilia platyphyllos* seeds in areas with heavy traffic. The variation of copper concentration depending on traffic density is given in Table 2.

Table 2. Variation of copper concentration (ppm) depending on traffic density

Species	Organs	Traffic Density			F Value
		None	Slightly intense	Intensive	
Acer negundo	Leef	5.13 c	0.70 a	1.86 b	2851.80***
	Seed	5.80 a	6.16 a	52.33 b	31.71**
	Branch	1.20 a	10.60 b	15.53 c	5113.00***
Aesculus hippocastanum	Leef	7.13 b	1.83 a	23.83 c	11864.70***
	Seed	0.40 a	0.93 a	3.33 b	71.65***
	Branch	3.70 a	8.96 b	10.10 c	149.25***
Tilia platyphyllos	Leef	0.63 a	0.76 a	13.03 b	9127.46***
	Seed	15.46 a	19.16 a	330.66 b	140.18***
	Branch	7.16 b	7.26 b	2.86 a	246.91***
Prunus ceracifera	Leef	8.73 a	12.16 b	42.63 c	156691.2***
	Seed	9.30 a	10.00 b	10.66 c	21.74**
	Branch	6.43 b	0.53 a	19.16 c	2814.56***
Ailanthus altissima	Leef	3.83 a	4.13 a	8.26 b	789.19***
	Seed	16.60 a	20.00 b	23.16 c	529.43***
	Branch	5.60 a	9.13 b	13.40 c	840.57***

As a result of the analysis of variance, it was determined that the change of copper concentration in all organs, depending on the traffic density, differed significantly, at least at the 99% confidence level (p<0.001). As a result of the Duncan test, the lowest values were obtained in 11 of the 15 organs subject to the study in areas without traffic, while the highest values were obtained in areas with heavy traffic in 13 of them. Copper concentration in 11 organs increases with traffic density. This value shows that the copper concentration is directly related to traffic density. It was determined that the copper concentration increased in all organs of *Ailanthus altissima* depending on the traffic density.

Firstly, the changes in copper concentration depending on the organ and traffic density were determined as a result of the study. Copper is an essential trace element for human and animal metabolism and is an indispensable part of red blood cells and many oxidation and reduction processes in animals and humans. However, when taken in excess, it is harmful to a life-threatening level. Therefore, monitoring and reducing copper pollution is a necessity. The study results show that the copper concentration increased depending on the traffic density. This finding indicates that traffic is an essential source of copper pollutants. Numerous studies show that heavy metals are emitted mainly into the atmosphere from anthropogenic sources such as mining activities, industry, and traffic [32-34]. It is emphasized that the most significant heavy metal source, especially in urban areas, is traffic. However, there are still not enough studies on the relationship between pollution levels, traffic, and urban planning, with different land uses and transportation types. Increasing the number of studies on heavy metals, which are extremely dangerous for human health, even at low concentrations, is of great importance in monitoring the change in heavy metal pollution, reducing pollution, and protecting and improving public health.

City centers can be defined as the most complex area of the city by nature and it is very difficult to explain their dynamic relationships [8, 35-38]. The public spaces in the city centers can be accepted as the primary communication object of society. At the same time, these areas are the building blocks of urban life quality and urban identity. The relationship that the city centers establish with the city is an essential criterion for the identity of a contemporary capital. However, Atatürk Boulevard and its surroundings, which were chosen as the research area, moved away from being a part of the social life due to the decisions taken and became a passageway that divides the public uses in the center that pedestrians find it difficult to overcome. The research focuses on the level of air quality in the context of its quality of life. The findings reveal the accumulation of plants as a striking result of traffic concentration in the city center. Accordingly, the recommendations can be listed as follows: it is of great significance in terms of protection and development.

4. Conclusions

The limitation of urban air corridors with high-rise buildings and the construction of the open green space pattern is effective based on air pollution in the city center. The density of vehicles in the city center is mainly due to the density of cars on the existing axes connecting to the center. Using the city center for transit purposes encourages the transfer of journeys produced in urban development and expansion areas by using the city center. But the trips to residential districts can be reduced through spatial decisions and demand management. It is known that this vehicle density is primarily due to individual use. The number of vehicles using the city center can be reduced by encouraging alternative and public transportation modes.

However, with access control strategies (taxation in different zones, parking costs, etc.) in developed countries, measures can be taken to discourage private vehicle use. Working areas other than the uses bearing the identity of the city center can be planned in development areas. In addition to these, pedestrian spaces can be revitalized, and approaches to strengthen pedestrian mobility (traffic clarification, level crossings, etc.) can be developed. Among the species subject to this research, which was developed based on air quality, the highest copper concentrations were obtained in *Tilia platyphyllos* and *Acer negundo*. Therefore, these species can be used in different areas to reduce copper concentration in the air and to monitor copper pollution. It is essential to increase the research related to monitoring air quality in cities in a way that is related to planning and developing alternative methods.

Competing Interest

The authors declare that they no conflict of interest. The none of the authors have any competing interests in the manuscript.

Author Contribution

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