

## A Research on the Soil Characteristics and Woody Plant Species of Urban Boulevards in Bursa, Turkey

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### ABSTRACT

Proper planning and design of transportation networks in the cities is an important subject, and the avenues, boulevards and refuges in the cities give the cities an aesthetic and functional feature as open green spaces. In addition to their aesthetic qualities, planting in urban areas also plays an important role in preventing pollution and improving air quality in the cities. In this context, the existing woody plant taxa were identified on the boulevards located in Nilufer district of Bursa in Turkey. The soil characteristics and soil heavy metal accumulations of these woody plant taxa were also determined. In the studied boulevards, there were 34 genera, 31 species, 10 subspecies and varieties belonging to 23 families. Among the total woody species gathered, 72.73% of the woody species were tree species and the rest were shrubs. The soils found on the boulevards were usually sandy and clay loam, and inadequate in terms of organic matter contents. On the other hand, the heavy metal deposits in the territories of the boulevards situated in the industrial zones were higher than those in other housing areas but below the permissible values.

**Keywords:** Bursa-Nilüfer district, Heavy metals, Road plants, Species composition.

### INTRODUCTION

Urban roads, refuges, and pedestrian paths are important places in urban green spaces, which provide ecological, economic, and social benefits to urban people. These areas are open green spaces widely used to serve the city people and have important position as a city showcase. Roads are important means that determine the skeleton and developmental direction of the cities, improving the quality of life, and providing aesthetic and functional contributions that link various urban areas to each other (Aslanboga, 1986; Ender, 2015; Kucuk and Gul, 2005; Saglik *et al.*, 2012; Sakici *et al.*, 2014; Sogut, 2005;

Yilmaz and Aksoy, 2009). Planting studies carried out on roads that connect the city with natural areas as well by wrapping up the settlement areas like a network (Sogut, 2005) increase the prestige and aesthetic quality of boulevards, roads, and refuges (Gerstenberg and Hofmann, 2016) and affects the city health positively (Aslanboga, 1986; Dirik, 2014; Onder and Polat, 2007). In particular, with the appropriate planting made in the city roads, the opportunity of passing through a beautiful perspective is offered to those traveling along the road. The applications carried out do enrich the urban landscape with the connecting green gates as a continuation and complement of the urban green areas (Onder and Polat, 2007;

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Sengul, 2011). It is obvious that non-forest woody vegetation has many functions and provides a wide range of ecosystem services (Tóth *et al.*, 2016). On the other hand, it also contributes to safe transportation through plantings with appropriate compositions (Ozturk, 2002). Road planting provides aesthetic contributions such as naturalizing the urban environment, breaking monotony, constructing a background for buildings, creating a series of places along the road, providing contrast and harmony, furnishing the path a visual value and depth, masking ugly images, connecting and separating places and spaces. At the same time, road planting presents functional contributions including increasing safety by separating pedestrian and vehicle traffic, shading pedestrian and vehicle bands, noise reduction, dust holding, scaling, providing signaling and redirecting the drivers. Also, road planting contributes to urban ecology by balancing the temperature, (Aslanboga, 1986; Dirik, 2014) increasing relative humidity, reducing the force of strong air movements (De Abreu-Harbach, 2015; Dirik, 2014; Streiling and Matzarakis, 2003), influencing quality of the air by keeping heavy metal accumulations in the forms of leaves, shells, fruits, etc. (Bozdogan, 2016). However, urban areas have adverse conditions such as climatic characteristics in the city are different from those of the surrounding rural areas, deterioration of soil structure, limitation of growing area, and environmental pollution and damage caused by human activities. Urban area has higher temperature, precipitation, fog formation and cloudiness, while proportional humidity, radiation, and sunshine times are reduced. While fast winds lose 10-20% speed in the city, winds within the city can accelerate by 5-20% when the wind is not fast (Sukopp, 2004). The boundaries of these differences vary depending on the size of the city and the vegetation there (Sogut, 2005).

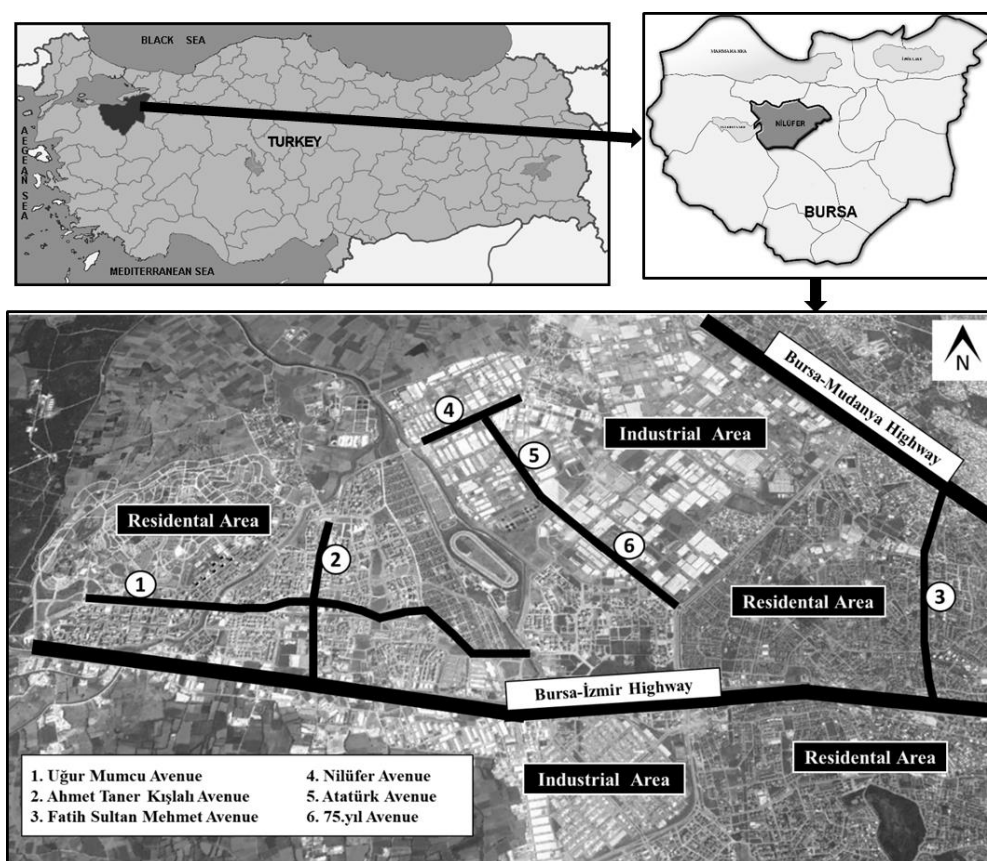
In this context, the selection of the species to be used in the roads, the size of the road, the characteristics of the planting and the position of the plants with respect to the road, and the appropriate soil conditions with a large volume at a sufficient level are of great importance (Bassuk, 1999; Kucuk and Gul, 2005; Onder and Polat, 2007). Especially in the city, as a result of various activities, the soil is compressed and its structure changes (Sogut, 2005). Assessment and improvement of urban soil quality are imperative for the establishment, growth, and longevity of urban trees (Scharenbroch and Catania, 2012). Although the importance of soils for influencing tree performance is widely acknowledged, very little is known about those soil properties which are most influential in the urban landscape (Ghos *et al.*, 2016).

The plant species to be selected should possess adequate ecological tolerance for harsh climate and soil conditions and should be resistant to adverse climatic effects (Aslanboga, 1986; Onder and Polat, 2007; Rahman *et al.*, 2015). Appropriate plant characteristics are also imperative to create greenery but not easily broken and more flexible. (Koc and Sahin, 1999).

In this study, we aimed to evaluate woody plants taxa in Nilüfer district, one of the central districts of Bursa province and the fourth largest city of Turkey in terms of population. The present plant taxa, soil characteristics, and heavy metal accumulations were to be evaluated to develop suggestions.

## MATERIALS AND METHODS

Study site includes boulevards and refuges linked to them and sidewalks, which are located within the boundaries of Nilüfer district and used intensely by the people of the district and the city. The district is currently under rapid development in the province of Bursa where housing, industry, and agricultural areas are included (Figure 1). Nilüfer, where the research boulevards



**Figure 1.** Satellite image of the position of the research area.

are located, is one of the three central districts of the province of Bursa and was established in 1987. According to census in 2015, a population of 397,303 persons lives in the district, which neighbors Osmangazi to the east, Orhaneli to the south, Mustafakemalpaşa and Karacabey districts and Uluabat Lake to the west, and Mudanya to the north. The elevation of the district from the sea level varies between 100-150 meters (Anonymous, 2016). Under the context of the research, 6 boulevards were studied out of which 3 boulevards (Uğur Mumcu Boulevard, Ahmet Taner Kışlalı Boulevard, Fatih Sultan Mehmet Boulevard) were in the residential areas and 3 in the industrial areas (Nilüfer Boulevard, Atatürk Boulevard, 75. Yıl Boulevard), with a total length of 896 km (Figure 2). The information regarding the boulevards subject to the study are given below.

**Uğur Mumcu Boulevard:** The Uğur Mumcu Boulevard intersecting with Ahmet Taner Kışlalı Boulevard is the longest boulevard and is 4.60 km long. Bursa Rail line passes along the boulevard and covers 23 Nisan, Ertuğrul, Özlüce and 100.Yıl quarters.

**Ahmet Taner Kışlalı Boulevard:** It is located within the borders of Ertuğrul and Özlüce quarters and is 0.95 km long. This boulevard is linked to Izmir highway and includes residential areas, eating and drinking places, and so on.

**Fatih Sultan Mehmet Boulevard:** It is located within the borders of İhsaniye quarter and is 1.75 km long. On the boulevard linking Beşevler intersection and Mudanya intersection has an intense vehicle and pedestrian traffic. This location, with residential areas, hospitals, eating-drinking places, etc. is one of the busiest boulevards of Bursa.



**Figure 2.** Bursa Nilüfer District Boulevards overview: (1) Uğur Mumcu Boulevard, (2) Ahmet Taner Kışlalı Boulevard, (3) Fatih Sultan Mehmet Boulevard, (4) Nilüfer Boulevard, (5) Atatürk Boulevard, and (6) 75. Yıl Boulevard.

**Nilüfer Boulevard:** The Nilüfer Boulevard located in the Nilüfer Industrial Zone intersects with Atatürk Boulevard. It is 1.10 km long.

**Atatürk Boulevard:** The Atatürk Boulevard, located in the Nilüfer Industrial Zone, is adjacent to 75.Yıl Boulevard and intersect with Nilüfer Boulevard. It is about 1.25 km long.

**75. Yıl Boulevard:** The 75<sup>th</sup> Year Boulevard, located in the Nilüfer Industrial Zone, is adjacent to Atatürk Boulevard and linked to Ata Street. It is 1.50 km long.

The study was carried out in two phases. In the first phase, observations and inspections were carried out on the selected boulevards and related refuges and side roads, and samples were taken to determine the existing woody plant species. Identification of the collected and examined woody species were done according to Davis (1965-1985), Dirr (1998), Guner *et al.* (2000), Hillier (1998), Kayacik (1980, 1981, 1982), Krussman (1984, 1985a, 1985b, 1986), Yaltirik (1991), and Zencirkiran (2013). Families, genera, species, subspecies, and varieties distributions of the

identified plants (plant characteristics) were determined and evaluated.

In the second phase of the study, samples were taken from soil pertaining to the determined study areas and soil analysis was carried out. In the analysis, the general characteristics of the soil and conditions of heavy metals were investigated. Soils were collected from 6 avenues with a core samples from 0-30 and 30-60 cm depths. Soil samples were passed through a 2 mm sieve and stored at 4°C until analyses of physical and chemicals characteristics were undertaken. Soil pH was measured in 1:2.5 soil: water suspension using a pH meter (Hanna Inst., Model 211, Italy; Gulcur, 1974; Jackson, 1962). Electrical Conductivity (EC) of the samples was measured using a conductivity bridge (Hanna Inst., Model 215, Italy) (Jackson 1962). Lime was determined by Scheibler calcimeter (Gulcur, 1974). Soil organic carbon was determined by Walkley-Black wet oxidation method (Walkley and Black 1934). Exchangeable Phosphorus (P) was determined colorimetrically following the ascorbic acid reluctant method as outlined by Watanabe and Olsen (1965).

Exchangeable potassium (K), Calcium (Ca), Magnesium (Mg) and sodium (Na) content of the soils were determined by 1 M  $\text{NH}_4\text{OAc}$  extraction method (Sparks *et al.* 1996). The heavy metal (Co, Cd, Cr, and Ni) concentrations were determined using ICP with Diethylenetriamine Pentaacetic Acid (DTPA) extraction procedure. Although N is potentially important for plant growth, it was not determined due to its temporal instability in soil (Ghosh *et al.*, 2016).

### Statistical Analyses

Statistical analyses were carried out using IBM SPSS 22 software. Soil characteristics were compared and analyzed using one-way ANOVA. Mean separations were conducted using Duncan's multiple range test at  $P \leq 0.05$ .

## RESULTS

### Plant Characteristics

As a result of evaluations, 31 species and 10 subspecies and varieties belonging to 34 genera in 23 families were identified. Distributions of plant species under different boulevards and distribution of genus, species, subspecies and variety are given in Tables 1 and 2, respectively.

Ugur Mumcu and Atatürk Boulevards were found to be richer in terms of plant diversity (numbers of woody species were 22 and 21 for Ugur Mumcu and Atatürk Boulevards, respectively) than other boulevards and species and cultivars such as *Robinia pseudoacacia* "Umbraculifera", *Magnolia grandiflora* "Gallisoniensis", *Prunus cerasifera* "Atropurpurea", *Rosa sp.*, *Platanus orientalis* and *Juniperus sabina* were observed on all boulevards. The least number of plant variety was found in Ahmet Taner Kışlalı Boulevard (numbers of woody species were 6) (Table 1).

When genus and species distributions were examined, it was found that the most common genera belonged to Rosaceae (14.71%) and

Cupressaceae (11.76%) families, and the families containing the most common species were Cupressaceae, Rosaceae and Pinaceae. In the Berberidaceae, Caprifoliaceae, Pittosporaceae, Celastraceae and Moraceae, only subspecies or varieties were identified (Table 2). In the evaluations made in terms of intensity of life form, 72.73% of the detected taxa were found in trees and 27.27% in the group of shrubs. On the boulevards, the broad-leaved tree taxa was found to be used in more places than coniferous tree taxa, and the highest percentage of coniferous tree taxa was found in Atatürk Boulevard (28.57%). The highest rate of shrubs was observed in Fatih Sultan Mehmet Boulevard (Figure 3).

### Soil Characteristics

As a result of analyses of soil samples taken from boulevards, the data obtained in terms of soil characteristics and heavy metal accumulation are given in Tables 3 and 4, respectively. When the 100. Yıl Boulevard was examined, it was found that the soil was sandy textured, non-saline, moderately alkaline, less chalky, with insufficient organic matter content. The samples studied on all boulevards were found to have very low available phosphorus, poor for available zinc, but good for available iron, manganese, and copper. On the other hand, exchangeable calcium and magnesium contents were also found to be of good levels in the samples (Table 3). Although in the analyses of soils heavy metals such as Cobalt (Co), Cadmium (Cd), Chromium (Cr), and Nickel (Ni) were found, the amounts of Cr, Cd, and Co were considerably low compared to the amount of Ni. Quantities of all these heavy metals were well below the acceptable limit (Table 4).

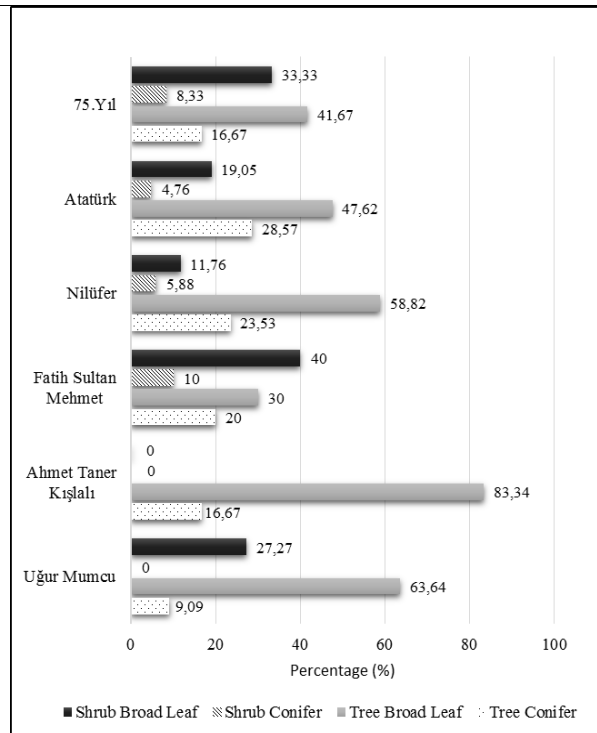
The soil of A. Taner Kışlalı Boulevard was also sandy texture, non-saline, moderately alkaline character, less chalky and insufficient in organic matter. The samples were found to have very low available phosphorus, good quantity of

**Table 1.** Plant taxa found in boulevards in Nilüfer District.

Plant Species	Boulevards					
	Uğur Mumcu	Ahmet Taner Kışlalı	Fatih Sultan Mehmet	Nilüfer	Atatürk	75. Yıl
<b>Trees</b>						
<i>Acer negundo</i> L.	*	*		*	*	
<i>Aesculus hippocastaneum</i> L.	*			*		
<i>Ailanthus altissima</i> (Mill) Swingle						*
<i>Cedrus atlantica</i> (Endl.) Manetti ex Carriere.	*			*	*	
<i>Cercis siliquastrum</i> L.	*	*		*		
<i>Celtis australis</i> L.	*					
<i>Cupressus arizonica</i> Greene		*		*	*	
<i>Cupressus sempervirens</i> L.				*		
<i>xCupressoscyparis leylandii</i> A.B. Jacks & D.	*		*			
<i>Eleagnus angustifolia</i> L.	*			*		
<i>Eriobotrya japonica</i> (Thunb.) Lindl.	*					
<i>Fraxinus angustifolia</i> Vahl				*		
<i>Gleditschia triacanthos</i> L.	*				*	*
<i>Lagerstroemia indica</i> (L.) Pers.	*				*	
<i>Magnolia grandiflora</i> L.						*
<i>Magnolia grandiflora</i> “Gallisoniensis”	*		*		*	
<i>Morus nigra</i> “pendula”					*	
<i>Pinus nigra</i> J.F. Arnold				*	*	
<i>Pinus pinea</i> L.					*	*
<i>Pinus mugo</i> Turro.			*			
<i>Platanus orientalis</i> L.	*	*	*	*	*	
<i>Prunus cerasifera</i> ‘Atropurpurea’	*	*		*	*	
<i>Quercus robur</i> L.	*				*	*
<i>Robinia pseudoacacia</i> “Umbraculifera”	*		*	*	*	
<i>Salix babylonica</i> L.						*
<i>Tilia tomentosa</i> Monech.	*	*		*	*	
<i>Thuja orientalis</i> L. (Franco)					*	*
<b>Shrubs</b>						
<i>Abelia x grandiflora</i> “Kaleidescope”	*					
<i>Berberis thunbergii</i> D.C. “Atropurpurea”	*		*			*
<i>Buxus sempervirens</i> L.				*		
<i>Buxus sempervirens</i> ‘Gold Tip’			*			
<i>Euonymus japonica</i> “Aurea Variegata”						*
<i>Juniperus sabina</i> L.			*	*	*	*
<i>Ligustrum japonicum</i> Thunb.				*	*	
<i>Ligustrum ovalifolium</i> Hassk.	*			*	*	
<i>Ligustrum ovalifolium</i> “Aureum”	*					
<i>Nerium oleander</i> L.			*			
<i>Photinia serrulata</i> “Red robin”	*					
<i>Pittosporum tobira</i> “Nana”					*	*
<i>Pyracantha coccinea</i> M.Roem					*	
<i>Rosa</i> sp.	*		*		*	*

**Table 2.** Genus, species, subspecies and variety distributions of plant taxa.

Families	N	Genus distribution (%)	N	Species distribution (%)	N	Subspecies and variety distribution (%)
Aceraceae	1	2.94	1	3.23		
Apocynaceae	1	2.94	1	3.23		
Berberidaceae	1	2.94			1	10.00
Buxaceae	1	2.94	1	3.23	1	10.00
Cannabaceae	1	2.94	1	3.23		
Caprifoliaceae	1	2.94			1	10.00
Celastraceae	1	2.94			1	10.00
Cupressaceae	4	11.76	5	16.13		
Eleagnaceae	1	2.94	1	3.23		
Fabaceae	3	8.82	2	6.45	1	10.00
Fagaceae	1	2.94	1	3.23		
Lythraceae	1	2.94	1	3.23		
Magnoliaceae	1	2.94	1	3.23	1	10.00
Malvaceae	1	2.94	1	3.23		
Moraceae	1	2.94			1	10.00
Oleaceae	2	5.88	3	9.68	1	10.00
Pinaceae	2	5.88	4	12.90		
Pittosporaceae	1	2.94			1	10.00
Platanaceae	1	2.94	1	3.23		
Rosaceae	5	14.71	4	12.90	1	10.00
Saliaceae	1	2.94	1	3.23		
Sapindaceae	1	2.94	1	3.23		
Simaroubaceae	1	2.94	1	3.23		
<b>Total</b>	<b>34</b>	<b>100</b>	<b>31</b>	<b>100</b>	<b>10</b>	<b>100</b>

**Figure 3.** Life form composition in the studied boulevards.

**Table 3.** Soil characteristic in different boulevards in Nilüfer-Bursa.<sup>a</sup>

Soil characteristics	Soil depth (cm)	Boulevard names					
		Uğur Mumcu	A.Taner Kışlalı	Fatih Sultan Mehmet	Nilüfer	Atatürk	75.Yıl
Water saturation	0-30	29 a	34 b	57 d	59 e	52 c	68 f
	30-60	29 a	30 a	53 c	60 e	51 b	56 d
Texture class	0-30	Sand	Loam	Clay loam	Clay loam	Clay loam	Clay loam
	30-60	Sand	Sand	Clay loam	Clay loam	Clay loam	Clay loam
EC (dS m <sup>-1</sup> )	0-30	0,305 c	0,229 a	0,443 e	0,472 f	0,386 d	0,297 b
	30-60	0,227 b	0,198 a	0,436 f	0,392 d	0,360 e	0,249 c
pH	0-30	8,47 f	8,37 e	7,85 a	7,87 b	7,96 c	7,99 d
	30-60	8,36 d	8,39 e	8,04 b	7,82 a	8,07 c	8,05 b
Lime (%)	0-30	1,94 a	3,49 b	14,15 e	6,01 c	6,20 d	6,20 d
	30-60	2,13 a	2,91 b	14,73 e	6,40 c	6,40 c	8,72 d
Organic Matter (%)	0-30	0,43 a	0,70 b	4,24 f	2,29 e	1,55 c	1,82 d
	30-60	0,39 a	0,71 b	3,97 f	2,08 e	1,61 d	1,34 c
Available phosphorus (mg kg <sup>-1</sup> )	0-30	2 ab	3 bc	5 d	14 e	4 cd	1 a
	30-60	1 a	1 a	3 bc	5 d	4 cd	2 ab
Exchangeable potassium (cmol kg <sup>-1</sup> )	0-30	0,23 b	0,13 a	0,58 c	2,26 f	0,60 d	0,94 e
	30-60	0,14 a	0,14 a	0,46 b	1,29 d	0,47 b	0,89 c
Exchangeable calcium (cmol kg <sup>-1</sup> )	0-30	27,23 a	30,47 b	43,30 c	51,88 f	46,15 d	46,88 e
	30-60	25,24 a	26,76 b	43,47 c	51,61 f	45,04 d	46,75 e
Exchangeable magnesium (cmol kg <sup>-1</sup> )	0-30	1,55 a	2,02 b	3,32 c	6,55 e	9,08 f	5,09 d
	30-60	1,62 a	2,22 b	3,10 c	5,31 e	7,80 f	4,90 d
Exchangeable sodium (cmol kg <sup>-1</sup> )	0-30	0,50 b	0,51 b	1,39 e	0,92 c	1,16 d	0,44 a
	30-60	0,55 b	1,64 e	1,01 d	0,84 c	0,83 c	0,48 a
Available iron (mg kg <sup>-1</sup> )	0-30	12,9281 e	12,4646 d	14,1989 f	4,78091 a	8,94471 c	6,25299 b
	30-60	14,1452 f	12,8018 e	12,2681 d	6,64887 b	9,30008 c	6,19917 a
Available manganese (mg kg <sup>-1</sup> )	0-30	5,89021 a	8,94199 b	18,8385 e	19,7937 f	16,276 d	12,8092 c
	30-60	4,93421 a	6,93638 a	18,2558 e	18,3834 f	14,6621 d	13,7933 c
Available zinc (mg kg <sup>-1</sup> )	0-30	0,241586 a	0,466071 b	7,10109 e	2,69996 d	7,68676 f	2,20923 c
	30-60	0,208952 a	0,290997 b	4,64147 e	2,88291 d	10,3782 f	2,80153 c
Available copper (mg kg <sup>-1</sup> )	0-30	1,16006 a	1,35508 b	7,22067 f	1,80597 d	2,53899 e	1,72002 c
	30-60	1,12365 b	0,960046 a	5,10701 f	1,88863 d	2,49598 e	1,77802 c

<sup>a</sup> Mean separation in columns by Duncan's Multiple Range Test,  $P \leq 0.05$ .

available iron, manganese and copper, but poor in available zinc. On the other hand, exchangeable calcium and magnesium contents were also found to be in good levels (Table 3). Among the heavy metals, the amounts of Cr, Cd and Co were considerably low compared to the amount of Ni. However, the quantities of these heavy metals were well below the acceptable limit (Table 4).

Soil in Fatih Sultan Mehmet Boulevard had a clay loam texture, was slightly saline,

moderately alkaline character, and moderate chalky, with insufficient organic matter content. The samples had very low available phosphorus, good for available iron, sufficient for available manganese and zinc, and sufficient with regard to copper. On the other hand, exchangeable calcium and magnesium contents were also found to be in good levels in the samples (Table 3). The amounts of Cr, Cd and Co were considerably low compared to the amount of



**Table 4.** Heavy metals in soils of different boulevards in Nilüfer-Bursa.<sup>a</sup>

Heavy metal in soil	Soil depth (cm)	Boulevard Names						Limits (mg kg <sup>-1</sup> )
		Ugur Mumcu	A.Taner Kislali	Fatih Sultan Mehmet	Nilufer	Ataturk	75.Yil	
Cobalt (mg.kg <sup>-1</sup> )	0-30	0,049409 a	0,082253 b	0,103669 c	0,178798 f	0,120809 d	0,128471 e	< 20
	30-60	0,045175 a	0,058742 b	0,099357 d	0,126725 e	0,094111 c	0,142459 f	
Cadmium (mg kg <sup>-1</sup> )	0-30	0,019002 f	0,020962 b	0,039849 c	0,044176 d	0,062405 e	0,020371 a	< 3
	30-60	0,018336 b	0,017351 a	0,03643 d	0,052219 e	0,066056 f	0,022008 c	
Chromium (mg kg <sup>-1</sup> )	0-30	0,016863 c	0,017295 e	0,019624 f	0,015679 a	0,016413 b	0,017188 d	< 100
	30-60	0,017017 c	0,017806 d	0,018082 e	0,015887 a	0,016178 b	0,019317 f	
Nickel (mg kg <sup>-1</sup> )	0-30	0,361656 a	0,437084 b	0,789226 c	1,88361 f	1,03998 e	0,909826 d	< 75
	30-60	0,34852 b	0,33824 a	0,645387 c	1,77331 f	0,987253 e	0,946806 d	

<sup>a</sup> Mean separation in columns by Duncan's Multiple Range Test,  $P \leq 0.05$ .\*)Turkish Republic, Soil pollution control regulation -

Ni, and all these heavy metals were well below the acceptable limit (Table 4).

Soil in the Nilüfer Boulevard was characterized by clay loam texture, slightly saline, moderately alkaline character, moderate chalky with moderate content of organic matter. The samples had low-moderate available phosphorus, adequate available iron, manganese, zinc, and were sufficient with regard to availability of copper. On the other hand, exchangeable calcium and magnesium contents were also found to be of good levels (Table 3). The amounts of Cr and Cd were considerably low compared to the amount of Ni and Co, and the quantities of these heavy metals were well below the acceptable limit (Table 4).

Soils in Atatürk Boulevard were clay loam in texture, non-saline, moderately alkaline character, moderately chalky, and had insufficient organic matter. The samples showed very low available phosphorus but adequate available iron, sufficient available manganese, zinc and copper. On the other hand, exchangeable calcium and magnesium contents were also of good levels in the samples (Table 3). However, among the heavy metals, the amounts of Cr and Cd were considerably low compared to the amount of Ni and Co, and quantities of these heavy metals were well below the acceptable limit (Table 4).

The 75.Yil Boulevard was examined, and soil was clay loam, non-saline, moderately alkaline character, moderately chalky and insufficient in organic matter. The samples showed very low available phosphorus, adequate available iron, sufficient in available manganese, zinc, and sufficient with regard to copper. On the other hand, exchangeable calcium and magnesium contents were adequate in the samples (Table 3). Nevertheless, the amounts of Co and chromium were considerably high compared to the amount of cadmium and nickel and quantities of these heavy metals were well below the acceptable limit (Table 4).

## DISCUSSION

The boulevards evaluated in this study were located in the residential and industrial areas of Nilüfer district of Bursa province dominated by rapid urbanization in parallel with the population increase. However, the study revealed that the existing plant species were suitable for use on urban roads and boulevards. Taxon variety was most concentrated in Uğur Mumcu, Atatürk, and Nilüfer boulevards, followed by 75. Yıl and Fatih Sultan Mehmet boulevards, and the least was in the Ahmet Taner Kışlalı Boulevard. In boulevards of residential areas



(Uğur Mumcu, Ahmet Taner Kışlalı, and Fatih Sultan Mehmet) broad-leaved trees (e.g. *Tilia tomentosa*, *Prunus cerasifera*, “*Atropurpurea*”, *Platanus orientalis*, *Acer negundo*) and coniferous tree species and cultivars (e.g. *Cupressocyparis leylandii*, *Cupressus arizonica*)

were present. On the other hand, in boulevards located in industrial zones (Atatürk, Nilüfer and 75. Yıl), generally, coniferous species such as *Pinus pinea*, *Pinus nigra* and *Cedrus atlantica* were grown extensively. The most common shrub species were *Juniperus sabina*, *Ligustrum ovalifolium* and *Rosa* sp. The Atatürk and Nilüfer boulevards were the sites where trees and shrubs species were most abundant. The data obtained were in agreement with those of other investigators (Aslanboga, 1986; Dokumaci and Korkut, 1999; Thomsen *et al.*, 2016; Torun, 2014). On the other hand, researchers including Lu *et al.* (2014), Doygun and Ok (2006), and Kucuk and Gul (2005) have emphasized that allergen pollens of the species like *Cupressosypris leylandii* and *Platanus orientalis* may adversely affect the urban life. Because of allergenic properties, care should be taken when the woody species determined in the study area are selected to be used in urban boulevards.

Another important factor limiting the development of plants was the soil. Due to human influences, the quality of soils in urban landscapes was often impaired (Ghosh *et al.*, 2016). The development of plants was adversely affected in areas with shallow soil depth, insufficient nutrients, and presence of heavy metal pollution. In particular, chemicals and heavy metals from industrial areas and heavy vehicle traffic caused a great risk to the environment and the plants. Therefore, it is necessary to take this into account when choosing a plant, considering that pollution may arise. As such, it is important to use more pollution-resistant species (Aslanboga, 1986; Bozdogan, 2016; Lorenzini *et al.*, 2006; Mori *et al.*, 2015).

## CONCLUSIONS

It should be noted that species such as *Pinus pinea*, *Cupressus sempervirens*, *Fraxinus angustifolia*, *Lagerstroemia indica*, *Prunus ceracifera*, *Robinia pseudoacacia* “*Umbraculifera*”, *Pyracantha coccinea* perform better on boulevards in urban and industrial areas with limited soil conditions. It is recommended that designs with aesthetic and functional characteristics be developed in consultation with the local administrators and experts from professional disciplines to overcome the shortcomings of the Bursa Nilüfer district boulevards in view of the current situation and the dynamics of urban development.

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## پژوهشی روی ویژگی های خاک و گونه های گیاهان چوبی در بلوارهای شهری در منطقه بورسا در ترکیه

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### چکیده

برنامه ریزی و طراحی درست شبکه های حمل و نقل در شهرها موضوع مهمی است و خیابان ها، بلوارها و پناهگاهها به شهرها جنبه های زیبایی و خدماتی و فضا های سبز را می دهند. افزون بر کیفیت های زیبایی شناسی، کاشت گیاهان در مناطق شهری نقش مهمی در جلوگیری از آلودگی هوای شهرها دارد. در این زمینه، آرایه (رده) گیاهان چوبی موجود در بلوارهای منطقه نیلوفر در بورسا ی ترکیه شناسایی شد. ویژگی های خاک و انباشت فلزات سنگین در خاک این گیاهان چوبی نیز تعیین شد. در بلوارهای مطالعه شده، ۳۴ جنس، ۳۱ گونه، و ۱۰ زیرگونه و رقم متعلق به ۲۳ فامیل وجود داشت. در میان همه گونه های چوبی جمع آوری شده، ۷۲/۷۳٪ از گونه های درختی و بقیه درختچه بود. خاک ها در این بلوارها بیشتر شنی و رسی لومی و دارای مقدار ناکافی مواد آلی بود. ازسوی دیگر، نهشته های فلزات سنگین در بلوارهای واقع در مناطق صنعتی بیشتر از مناطق مسکونی ولی کمتر از حد مجاز بود.