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Effect of Soil Bulk Density to Urban Plant in Semi-Arid Landscape

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Abstract

Semi-arid landscapes are widespread in Central Anatolia, Turkey. Plant management has a considerable influence on the soil physical properties such as soil bulk density in urban area. Plant roots affecting the soil, therefore, soil bulk density may be changed. The aim of this study was to evaluate the variation in soil bulk density (Db) as affected by urban plant variety in semi-arid landscape in Cankırı, Turkey. Soil samples were taken from each sample spot and analyzed for bulk density (total 11 spots). Undisturbed soil samples were taken with 100 cm3 steel rings to measure bulk density. Exploratory data analyzes was conducted by calculating the mean, standart deviation, coefficient of variation, skewness and kurtosis. The results of descriptive statistics showed that soil bulk density was more at *Berberis* sp. spot. Results further showed that the differences in soil bulk density from the different ornamental plants (*Berberis* sp. and *Juniperus* sp.).

Keywords: semi-arid landscape, soil bulk density, ornamental plant, descriptive statistics

INTRODUCTION

Urban open and green areas, meeting the need for people's increasing recreation and integration with nature in cities, offers an important contribution with their aesthetic and ecological functions to the city. In order to provide these contributions, the quality of the open and green areas as well as the quantity is very important. For this reason especially in plant selection, urban ecosystem conditions as well as natural factors should be considered in the planning and design of these areas. Urban ecosystems differ from natural ecosystems due to intensive construction, industrial facilities, intensive population and convenient use for urban life [1] . Soils are part of ecosystems, and thus, urban soils can be considered in the context of urban ecosystem research [2]. Moreover, it is quite likely that within the context of urban ecological restoration, city-specific soil ecological knowledge will be necessary [3].

Regarding the planting of the landscape, it is necessary to take into consideration the soil properties in the urban areas [4]. Soils are part of ecosystems, and thus, urban soils can be considered in the context of urban ecosystem research [5]. Well-grown landscape plants are recognized as one of a city's greatest assets. Unfortunately, growing plants successfully in the modern urban environment is extremely problematic [6]. Plants can encounter some difficulties such as rooting restrictions [7]. They respond to variation in bulk density by growing fastest at an intermediate density [8]. In very hard soil, the uptake of water and nutrients may become limiting because roots have difficulty penetrating the soil [9]. Urban soils commonly include artifacts, especially building debris, mortar pieces, concrete, cobbles and other waste materials [10]. These large and inert materials physically impede root growth, and the limitation aggravates with increase in stone size [11]. A layer with excessive stone contents may form a rather impenetrable barrier to roots, confining them to the soil above it and reducing effective soil depth. Compacted surface and subsurface soils in urban area are restrictive to root spread and comprise the free movement of air and water compaction in urban soils is a rather pervasive and often important phenomenon [4].

This study evaluated the soil bulk density of urban soils in Çankırı, with an emphasis an urban planting, through field assessment and laboratory analysis. In this study, 33 soil samples were taken from the root circumference of various shrub species from 11 locations determined in Çankırı city center and soil bulk density was measured by statistical program. The results of descriptive statistics showed that soil bulk density was more at *Berberis sp*. spot. Results further showed that the differences in soil bulk density from the different ornamental plants (*Berberis* sp. and *Juniperus* sp.).

MATERIALS and METHOD

The study area is located nearby Çankırı city, in North Central Anatolia (between 400 30′ and 410 30′ North latitudes and 320 and 330 East longitudes) (Fig. 1). The climate is semi-arid continental, with annual mean total precipitation of 538 mm, of which 60-80% falls from April to June[12].

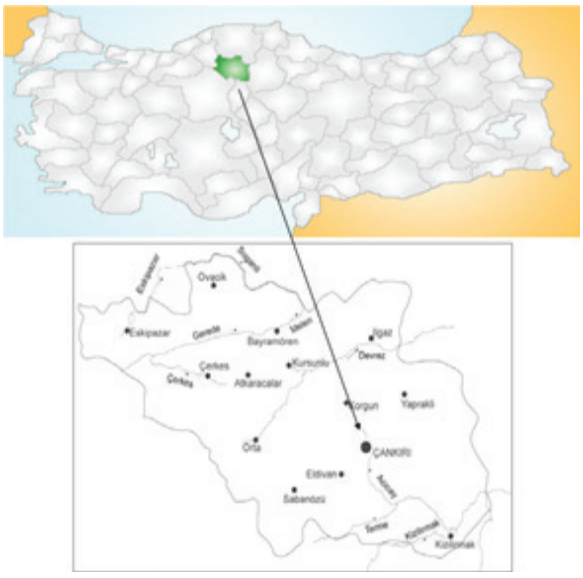

Figure 1. Location of the study area

Sampling design

In total 11 sites chosen among parks and roadsides were sampled at a depth of 0–15 cm and plant species were determined at each sampling site (Fig. 2). Urban sampling locations were recorded by means of a GPS. The soil samples were taken from the root periphery of *Juniperus sp., Buxus sp., Mahonia sp. Berberis sp., Thuja sp., Cupressus sp., Euonymus sp.* They were transported to laboratory. Undisturbed soil samples were taken with 100 cm^3 steel rings to measure bulk density [13].

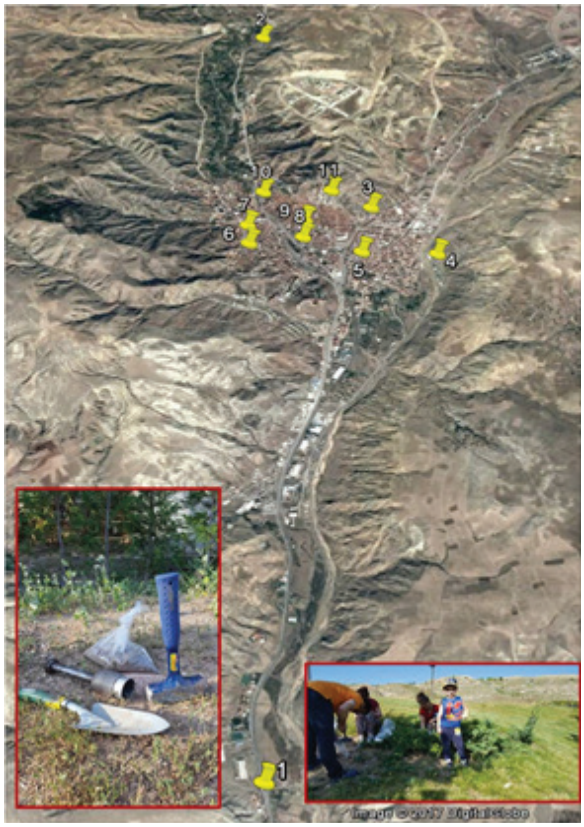

Figure 2. Choosen areas and used tools (Original 2017)

Statistical Analysis

Descriptive statistics of mean, minimum, maximum values, standard deviation, coefficient of variation (CV), skewness, and kurtosis were calculated for soil bulk density, using the Statistical Package for the Social Sciences (SPSS). Values for bulk density in *Berberis* sp. and *Juniperus* sp.(Fig. 3) spots were compared by a paired t-test.

Figure 3. View from *Berberis* sp. and *Juniperus* sp. in the research area (Originial 2017)

RESULTS and DISCUSSIONS

Descriptive statistics for properties of study soils are given in Table 1. The soil bulk density mean is 1.41 g/cm3. The soil bulk density maximum exceeding 1.69 g/cm3 is the upper threshold above which root growth can be hampered [14]. Some two-third of the samples exceed this critical limit. High contents of sand and silt tend to reduce bulk density due to the lack of fine materials to fill the interstitial pores formed by the coarse matrix [15]. Similarly, the researcher has reported mean soil bulk density is 1.65 g/cm3[4]. For comparison, compaction in urban soils is a rather pervasive and often acute phenomenon [16], with bulk density ranging from near normal at 1.4 (g/cm3) to extremely densely packed of 2.2 (g/cm3) [4].

Skewness characterizes the degree of asymmetry of a distribution around its mean. Positive skewness indicates a distribution with an asymmetric tail extending towards more positive values [17]. So a skewness statistic of 0.24 would be an acceptable skewness value for a normally distributed set of test scores. Kurtosis characterizes the relative peakedness or flatness of a distribution compared to the normal distribution [17]. So a kurtosis statistic of 0.05 would be an acceptable kurtosis value for a mesokurtic (that is, normally high) distribution because it is close to zero. *Berberis* sp. and *Juniperus* sp. spots were compared by a one sample t-test are given in Table 2. The results of descriptive statistics showed that soil bulk density was more at *Berberis* sp. spot.

Table 1. Results of descriptive statistics for urban soil bulk density

	Min.	Max.	M	SD	Sk	Kr	CV
Bulk density (g/cm^3)	1.18	1.69	1.41	0.14	0.24	0.05	9.92

M: Mean, Min: Minimum, Max: Maximum, SD: Standard deviation, Sk: Skewness, Kr. Kurtosis, CV: Variation of variance

The results showed that while plant roots influenced the soil bulk density significantly (Table 2). Several factors would be effective on this. Differences in soil bulk density between plant species would also be attributed to differences in roots structure.

Table 2. Results of One-way ANOVA for soil bulk density and plant

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0,120	1	0,120	10,355	0,011
Within Groups	0,104	9	0,012		
Total	0,224	10			

Urban soils may have soil bulk densities that occur within the range of natural soils, but most often they are at or exceed the higher limit of the bulk density range. Urban soil characteristics present plant survival and growth problems.

CONCLUSION

Many urban-soil problems are due to inadequacies in physical composition and properties, such as excessively sandy texture, weakly-developed and easily degraded structure, and compaction. Soils have to be brought in from an external source, a proper soil specification should be drawn up preferably a medium-textured and well-structured soil which is resistant to structural decline, with adequate porosity for aeration, drainage and storage of plant-available moisture. Thorough soil survey with field assessment and laboratory soil tests should be included as an integral part of landscape projects.

We studied influences of soil bulk density to relationship *Berberis* sp. and *Juniperus* sp. in a semi-arid urban area.

Soil bulk density was a significant variable affecting urban planting in the studied semi-arid urban area. We attributed this are restrictive to root development and a re believed to be an important cause of widespread poor performance in urban planting. More studies are needed to generalize the results and better understand the urban planting and soil variables in semi-arid urban area. In addition soil bulk density should be considered as an important factor in managing the urban studied soils.

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