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Comparative study on soil properties in a picnic and undisturbed area of Belgrad forest, Istanbul

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Abstract: *The aim of this paper was to investigate the recreational impacts on some soil properties (sand, silt, clay, pH, electrical conductivity, organic carbon, bulk density, fine soil weight, compaction and saturation capacity), and litter (unit weight-mass, organic matter content (%) and organic matter mass) properties in a picnic area by comparing an undisturbed area in Istanbul Belgrad Forest-Turkey. According to the results obtained in this study, the litter mass on the picnic area has been found considerably lower. There were some crucial changes in the characteristics of the soil which has been investigated in 0-5 cm depth. No important difference had been detected between the picnic area and the undisturbed area in terms of sand, silt and clay proportions. However, other investigated soil properties in 0-5 cm depth showed significant differences between undisturbed area and picnic area. Soil was significantly compacted by recreational activities in picnic area. Moreover, organic carbon content (1.328%) on the picnic area has found quite lower. Depending on the compaction of the soil and lessen quantity of soil organic matter, the value of saturation capacity (24.13%) in the picnic area was considerably lower, bulk density and fine soil weights significantly higher. Thus, the soil properties in the picnic area were negatively affected by recreational pressure.*

Key words: *Recreation, Visitors' pressure, Soil, Litter, Picnic areas*
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Introduction

Over the past decades, adverse effects associated with human recreation activities have increased progressively (Roovers et al., 2006). Typically studied under the rubric of 'recreation ecology', the studies of the disturbance as a result of visitor activities, have grown significantly. Studies conducted during the last 20 years have demonstrated that without adequate protection from visitor-related stresses, ecological conditions can rapidly deteriorate to unacceptable levels, affecting the recreational experience of the visitors and threatening the long-term viability of natural areas that are set aside for protection (Marion and Farrell, 2002; Arocena *et al.*, 2006). People are concerned with appearance in virtually every aspect of life, so it is more than reasonable to state that appearance strongly influences visitors' perception of their recreation environment (Roovers *et al.*, 2006).

In all kinds of recreational areas, soil and vegetation properties are the most ecosystem properties affected by visitors' pressure (Hegetschweiler *et al.*, 2007; Sarah and Zhevelev, 2007). Trampling is acknowledged to be the most widespread and also the most tolerated form of impact (Roovers *et al.*, 2006), and soil is the environmental factor that is stressed most immediately by the level of recreational activity (Kutiel *et al.*, 1999).

Erosion, compaction, and declining productivity of soils are considered some of the most damaging effects of visitor activities (Arocena *et al.*, 2006; Hegetschweiler *et al.*, 2007; Kutiel *et al.*, 1999; Zhevelev and Sarah, 2008). Visitor traffic and other recreational activities cause soil compression, the reduction in soil volume resulting from a loss of natural porosity, as well as a drop in the infiltration/ percolation ratio which causes increased overland flow and erosion. A decrease in the soil porosity volume also causes a reduction in the soil moisture (Kutiel *et al.*, 1999).

Recreational stress also reduces the amount of litter and organic matter in the upper layer of the soil. This layer is of the greatest importance since it forms a buffer that protects the mineral soil. The organic matter also contributes nutrients to the soil, and is responsible to a considerable measure to maintain for soil stability (Kutiel *et al.*, 1999).

The goal of this study is to detect the changes in some litter and soil properties as a result of visitors' pressure in a picnic area by comparing with the adjacent undisturbed area under oak dominated forest in Istanbul-Belgrad Forest.

Materials and Methods

The study was conducted in Istanbul, which is the largest and the most important cultural and industrial city in Turkey. About 10 million inhabitants live in Istanbul. The research area (Belgrad Forest - Nesetsuyu Picnic Area in Istanbul) was located in Belgrad Forest (41°N, 28°E). According to the Thornthwaite classification system,

the climate of the picnic areas and surrounding areas is described as ''humid, mesothermal oceanic with a moderate soil-water deficit in summer'', average annual precipitation is 1074.4 mm, annual mean temperature is 12.8°C, mean high temperature is 17.8°C and the average low temperature is 9°C. Vegetation growth period maintains for 7.5 months (230 days) in average. Parent materials in the region mainly consist of neocene loamy, gravelly deposits. The soils are usually shallow to deep, gravelly, sandy-clay loam in texture. Soils have no carbonate reaction. Topography is generally mild, and mean elevation is around 130 m.

We aimed to investigate the recreational impacts on the litter and the surface soil layer (0-5 cm depth) in the picnic area that has been used for a long time and has been examined in comparison with the undisturbed area. The both areas were chosen close to each other to keep the same site factors. The picnic area is frequented for everyday recreation but intensively on weekends; it functions under high visitors' pressure, and it is equipped with various installations for picnic and barbeques (Caglayan, 1999). Main tree species in picnic and undisturbed areas are oak (*Quercus frainetto*), hornbeam (*Carpinus betulus*), beech (*Fagus orientalis*) and chestnut (*Castanea sativa*). The picnic area was sampled at 20 different points at 10 m intervals, for this purpose 20 samples were taken from each of litter and 0-5 cm soil. For control purpose, soil and litter samples from 20 different points were taken again at 10-meter intervals (20 samples from each of the litter and 0-5 cm soil) in the undisturbed area where there is no any disturbance impact and at least 125 m away from the picnic area to reduce side effects. The samples of the litter were taken from 20x20 cm area by collecting litter layer of the forest floor. Soil compaction was measured at 50 different soil points by using a pocket penetrometer in both picnic and undisturbed area. Soil samples were taken from 0-5 cm with the help of 100 cm^3 steel soil cores. A total of 300 cm^3 soil sample was taken from each of the sampling points. All samples were collected in January 2008. Samples were put in polyethylene bags and labeled. Collected samples were brought to the laboratory. Weight values of oven dried samples were calculated from the difference between the values of wet and oven dried samples after drying litter and soil samples under 105°C for 24 hr in an oven. Organic matter amounts of the litter samples were estimated by the loss on ignition method after grinding and burning at 550°C. Soil bulk density was determined by the core method. Soil samples were sieved to pass through 2 mm screen with plant materials and other debris removed and thus, fine soil weights were found. Sand, silt and clay proportions of soil samples in the laboratory were determined by Bouyoucos hydrometer method. Organic carbon content was determined by Walkey and Black dichromate oxidation procedure. All samples were free of carbonate so that the total C concentration equals to the organic carbon concentration. Also saturation capacity, pH and electrical conductivity values were measured in the laboratory as described in Karaoz (1989a,b, 1992).

All the values estimated for the undisturbed area and for the picnic area were compared statistically at 0.05 significance level by using independent sample t-test statistical analysis.

Results and Discussion

Litter properties: In the undisturbed area litter mass (1095.35 kg ha^{-1}) was significantly higher than in the picnic area (513.20 kg ha^{-1}) (Table 1). Lower amount of litter in the picnic area indicated that recreation activities tended to decreas the litter. In addition, we have found no shrub layer and herbaceous cover in the picnic area. It is also estimated that, due to no shrub layer and herbaceous cover in the picnic area, amount of litter fall was also low. Many studies have pointed out that, vegetation was affected by recreational activities, and they noticed a negative correlation between recreational intensity and plant cover, plant height, species richness and species diversity (Cole, 1987; Kutiel *et al.*, 1999; Sarah and Zhevelev, 2007). Organic matter content (64.54%) of litter in the picnic area was significantly lower than those in the undisturbed area (79.07%) (Table 1). Due to visitors trampling and long term recreational impacts, sticking and mixing of litter with mineral soil layers led to decrease in organic matter contents in the litter of the picnic area. In addition, changed soil properties because of long term recreational impacts may be effective in the decrease of biological activities, decomposition and mineralization of litter in the picnic area. Depending on the considerable difference in the litter mass, organic matter (kg ha^{-1}) in unit area also showed significant differences, and organic matter in undisturbed area (865.75 kg ha^{-1}) was very much higher than in the picnic area (335.58 kg ha^{-1}) (Table 1). Similar to our results, other studies also found that litter biomass and cover decreased due to visitors' pressure (Kutiel and Zhevelev, 2001; Marion and Cole, 1996). Reduction in litter biomass as a result of visitors' pressure was also found for eucalyptus (~ 4.5 times), Tabor oak (<"3.5 times) (Kutiel *et al.*, 2000) and Aleppo pine (~ 15 times) stands (Kutiel and Zhevelev, 2001). Decreases in litter cover, ranging from ~100 to ~1%, as a result of visitors' pressure were reported by Marion and Cole (1996) and Andres-Abellan *et al.* (2005) (as described in Sarah and Zhevelev, 2007). Also, Zhevelev and Sarah (2008) found that average litter biomass significantly decreased with increasing visitors' pressure in an urban park in Tel Aviv. The decrease in litter biomass under trees is attributed to the 'dispersive' effect of visitors (Zhevelev and Sarah, 2008).

Soil properties: Sand, silt and clay proportions of the soil samples taken from 0-5 cm depth did not show significant differences between the undisturbed area and the picnic area (Table 2). However, other investigated soil properties in 0-5 cm depth such as fine soil (<2 mm) weight, organic carbon, pH, electrical conductivity, saturation capacity, compaction and bulk density showed significant differences between the undisturbed area and the picnic area.

Average compaction value has been measured as 3.14 kg cm^{-2} on the picnic area and 0.39 kg cm^{-2} in the undisturbed area (Table 2). We measured very low soil penetration resistance values in the undisturbed area when compared with the former studies in similar research sites (Demir *et al.*, 2007a,b) possibly due to wet soil when sampling time. These compaction values showed that 0-5 cm soil depth of the picnic area was substantially compacted in comparison with those in undisturbed area and soil was significantly compacted

Table - 1: Litter properties under picnic and undisturbed areas

Characteristics	Picnic area	Undisturbed area	p and significance	
Litter mass (kg ha^{-1})	513.20	1095.35	0.000	***
Organic matter (%)	64.54	79.07	0.000	***
Organic matter mass (kg ha^{-1})	335.58	865.75	0.000	***

Significance level *** = p<0.001

Table - 2: Soil characteristics under Picnic and undisturbed areas

Characteristics	Picnic area	Undisturbed area	p and significance	
Compaction (kg cm^{-2})	3.14	0.39	0.000	***
Bulk density (g cm^{-3})	1.583	0.850	0.000	***
Fine soil (<2mm) weight (g cm^{-3})	1.513	0.790	0.000	***
Sand (%)	66.5	66.5	1.000	NS
Silt (%)	15.2	14.9	0.736	NS
Clay (%)	18.3	18.6	0.624	NS
Organic carbon (%)	1.328	7.691	0.000	***
pH	6.31	6.66	0.000	***
Electrical conductivity (μS cm^{-1})	166.59	353.11	0.000	***
Saturation capacity (%)	24.13	71.47	0.000	***

* Values are mean, NS = Non significant and *** = p<0.001

by recreational activities. Compaction, and declining productivity of soils are considered some of the most damaging effects of visitor activities (Arocena *et al.*, 2006). Visitor traffic and other recreational activities cause soil compression, the reduction in soil volume resulting from a loss of natural porosity (Kutiel *et al.*, 1999). Sarah and Zhevelev (2007) and Zhevelev and Sarah (2008) concluded that in micro-environments with high visitors' pressure, penetration depth decreased significantly. Visitors' pressure causes increased soil compaction, decreased soil porosity and increased bulk density (Sarah and Zhevelev, 2007). This is consistent with the findings of Kutiel *et al.* (2000) and Kutiel and Zhevelev (2001) in which low penetration depth was associated with low litter biomass (Sarah and Zhevelev, 2007).

Soil bulk density (1.583 g cm^{-3}) and fine soil weight (1.513 g cm^{-3}) in the picnic area were higher than those in the undisturbed area (Table 2). In agreement, visitors' pressure led to increased soil compaction and increased bulk density (Sarah and Zhevelev, 2007). Cole (1987), for instance, found that the soil bulk density was 20% higher and the infiltration percentage was 80% lower in a camping area of the Grand Canyon in Arizona than in inaccessible parts of the same area (Kutiel *et al.*, 1999).

Organic carbon content (1.328%) in the picnic area was quite lower than those in the undisturbed area (7.691%) (Table 2). Depending on the compaction of the soil and lower quantity of soil organic carbon, considerable differences in saturation capacity were found between the undisturbed area and the picnic area. The value of saturation capacity (24.13%) in the picnic area was considerably lower than the saturation capacity (71.47%) in the undisturbed area. Although soil organic matter accounts for a proportionally low amount in the soil, numerous other physical and chemical properties depend on the quantity of organic matter present in the soil. Firstly, organic matter plays an important role in the structure and stability of the soil most favorable for plant growth and secondly the nutrient supply present in the soil and its availability to plants has a direct correlation to the condition of the soil organic matter (Xie and Wittig, 2004). Recreational stress also reduces the amount of litter and organic matter in the upper layer of the soil (Cole, 1987; Kutiel *et al.*, 1999). Several studies (Andres-Abellan *et al.*, 2005; Kutiel *et al.*, 2000) also found that soil organic matter content fell sharply with increasing visitors' pressure. In contrast, Sun and Liddle (1993) and Kutiel and Zhevelev (2001) reported no clear relationship between soil organic matter content and visitors' pressure. In addition, Sarah and Zhevelev (2007) gave the special results for oak dominated recreation area that visitors' pressure reduced soil moisture and organic matter contents only in the oak micro-environment. In the remaining micro-environments visitors' pressure had no effect on these properties. This means that the oak microenvironment was the most sensitive to visitors' pressure, which can be attributed to the combined effects of presence of the highest values of litter biomass and soil moisture content, which enabled the highest organic matter production. In contrast, the remaining micro-environments contained low levels of litter biomass and/or soil moisture, with consequently low organic matter contents, so that any effect of visitors' pressure on organic matter content could not be seen (Sarah and Zhevelev, 2007).

The soil pH and electrical conductivity were significantly higher in the undisturbed area than in the picnic area. Possibly due to the changes in the other soil properties, decreasing litter and absence of herbaceous cover in the picnic area and changes in the properties of the decomposing organic matter there is negative effects on the soil acidity and electrical conductivity. Similar to our findings, some researchers found that alkalinity and soil pH increased with increased visitors' pressure (Andres-Abellan *et al.*, 2005; Kutiel *et al.*, 2000, Sarah and Zhevelev, 2007; Zhevelev and Sarah, 2008). Arocena *et al.* (2006) also described that besides compaction, soils were known to react to the slightest introduction of chemicals into the environment. Soils act as natural filters and a storage medium for many anthropogenic materials introduced into ecosystems. Thus soil chemical properties can change because of recreation activities, and these properties can alter the soil pH and electrical conductivity.

The result of this study showed that recreation activities decreased litter in the picnic area to a great extent. Furthermore, recreation activities have negatively influenced soil (0-5 cm) properties. Compaction of soil and decreased organic matter content increased fine soil weight and bulk density values and decreased saturation capacity in the soil of picnic area. It is obvious that changes because of soil compaction will cause negative impacts on the water and air economies of the soils. Results of this study also provide some ecological basis for framing the rules and regulations within the picnic areas.

Recreation managers try to limit the impact of recreation activities on natural resources and amenity qualities through visit regulations and the visit flows (Roovers *et al.*, 2006). Planning should consider visitors' pressure as a dominant factor, which may affect vegetation and soil characteristics towards spatial homogeneity (Sarah and Zhevelev, 2007). This form of management was largely based on the concept of carrying capacity. This concept aims to define a maximum level of recreational use that can be sustained without unacceptable or irreversible damage to the site (Hegetschweiler *et al.*, 2007)

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