Pedosphere **25**(3): 392–404, 2015
ISSN 1002-0160/CN 32-1315/P

Published by Elsevier B.V. and Science Press

PEDOSPHERE

www.elsevier.com/locate/pedosphere

Urban Park Soil and Vegetation: Effects of Natural and Anthropogenic Factors

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(Received August 22, 2014; revised March 16, 2015)

ABSTRACT

Various soil surface components, such as trees, shrubs and biological crusts, and human recreational activities, *e.g.*, barbecues and trampling by visitors, may divide the area of the urban park into smaller fragments/microenvironments, differentiated by their microenvironmental conditions, which may differ in soil and vegetation characteristics. The spatial changes in the soil and vegetation characteristics and their causes were investigated in an urban park located south of Tel Aviv-Jaffa, Israel. The area of the park is 0.5 km^2, including groves, a lake, lawns, and rest areas. Soil was sampled in nine microenvironments, of which seven were within the park: under *Ceratonia siliqua* trees (CsU), under *Ficus sycomorus* trees (FiU), rest area between tables under *F. sycomorus* (FiB), rest area under tables under *F. sycomorus* (FiT), open area with bare soil (OaS), open area with biological crust cover (OaC), and open area covered by herbaceous vegetation (OaV). Two more microenvironments, planar and sloping open areas (CoP and CoS, respectively) in the vicinity of the park, were used as the controls. Electrical conductivity, concentrations of soluble ions (Mg^{2+}, Ca^{2+}, Na^{+}, K^{+} and HCO_3^{-}), pH, contents of organic carbon, calcium carbonate and moisture, and grain size distribution were determined. In addition, herbaceous vegetation cover, number and diversity of herbaceous vegetation species were measured. It was found that soil properties and herbaceous vegetation characteristics varied within the park. Soil organic carbon, electrical conductivity, soluble salts, penetration depth, and vegetation characteristics were affected by human activities, mainly in the rest area between the tables. In contrast, the above characteristics were affected by natural factors mainly in the rest of the microenvironments, which were subjected to low levels of anthropogenic intervention. The heterogeneous structure of the park, as represented by the various microenvironments, offered new habitats and promoted the preservation of natural vegetation.

Key Words: anthropogenic activity, herbaceous vegetation, microenvironment, soil properties, species diversity

Citation: Sarah, P., Zhevelev, M. H. and Oz, A. 2015. Urban park soil and vegetation: Effects of natural and anthropogenic factors. *Pedosphere*. **25**(3): 392–404.

An urban park system involves mutual interactions among human activities, soil, air, and plants (Thompson, 2002; Tyrväinen *et al.*, 2005; Li *et al.*, 2006). Various soil surface components, such as trees, shrubs and biological crusts, and human recreational activities, *e.g.*, barbecues and trampling by visitors, divide the area of the park into smaller fragments, differentiated by their microenvironments, which differ in soil and vegetation characteristics (Sarah and Zhevelev, 2007). Various studies addressed the social functions of urban parks with respect to their contributions to leisure, public health, social interactions, and entertainment (Godbey *et al.*, 2005; Cohen *et al.*, 2007; Suckall *et al.*, 2009). However, parks also function as green havens within the urban area, and they provide a variety of ecological niches that support the maintenance and preservation of biological diversity (Li *et al.*, 2006; Shwartz *et al.*, 2008). The present study focused on the roles of soil surface components and recreational activities, which function as "urban ecosystem activators" in the development of soil and landscape variability and in promoting species diversity. Urban ecosystem activators are defined in this study as factors that encourage changes in the environmental conditions in an urban soil, therefore new habitats for plants and animals are generated.

In parks, not just in natural areas, vegetation protects soil from direct radiation, and thereby moderates increases in soil temperatures and evaporation, so that soil moisture content is maintained higher than that of bare soil (Sarah, 2002; Kotzen, 2003). These conditions are favorable to soil fauna, which increase soil infiltration through their digging and bioturbation activities. Soil fauna and litter increase the supplies of soil organic matter and soil nutrients (Lodhi, 1977; Morris, 1999), and enhance soil structural stability and infiltration (Bochet *et al.*, 1999; Sarah, 2002; Sarah and Rodeh, 2004). The canopy of trees and shrubs also prevents

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direct impact of raindrops on the soil. These prevent the formation of soil crusts, which would increase infiltration capacity and soil moisture content (Janeau *et al.*, 1999; Sarah, 2002).

In contrast, the bare soil is exposed to direct radiation and wind, which promotes higher evaporation, and higher diurnal temperature fluctuations. Also, it is subjected to the direct impact of raindrops and therefore experiences higher soil compaction (Rostango and del Valle, 1988). All these bare soil features lead to drier conditions and poor organic matter and nutrient contents in such soil. Herbaceous microenvironments enhance soil organic matter content, soil stability, and infiltration (Bathke and Blake, 1984). The crusts result from an intimate association between soil particles and cyanobacteria, algae, microfungi, lichens, and bryophytes which live within, or immediately on top of, the uppermost millimeters of soil (Belnap *et al.*, 2001). Biological crusting positively affects soil organic matter, soil nutrients and soil stability (Zaady, 1999), but its effects on infiltration and runoff are not clear: some studies (Alexander and Calvo, 1990) found increased infiltration through soil biological crust, whereas others (Eldridge and Green, 1994) found an opposite trend.

A factor, which affects the areas under human management by similar biological and physical processes to those existing in nature, is defined as natural one. For example, plant cover (such as canopy of trees, biological crust on soil surface) affects its surrounding by the similar processes (shading, evapotranspiration, organic matter input, *etc.*) both in natural areas and in urban parks. Therefore plant cover in an urban park can be considered as natural factor. A factor, which involves human activity (such as hiking and picnicking) that dominates the aforementioned processes in any environment, is defined as anthropogenic one.

Soil and vegetation on the rest areas in parks are strongly affected by anthropogenic factors. Pressure imposed by passing, trampling visitors causes soil compaction, which reduces soil porosity, and moisture and organic matter contents (Kuss, 1986; Jim, 1993; Grieve, 2001; Kutiel and Zhevelev, 2001; Andrés-Abellán *et al.*, 2005), and reduces vegetation cover, height, and species diversity (Jim, 1987; Kutiel *et al.*, 2000). Remnants of food and ashes left by visitors might affect soil physicochemical properties and herbaceous vegetation characteristics (Sarah and Zhevelev, 2007; Zhevelev and Sarah, 2008). Organic amendments, particularly compost, improve trees and shrubs growth and strengthen restoration of disturbed urban soils. Such amendments increase both soil moisture and infiltration rates, thereby increasing the volume of plant-available water in soil (De Lucia *et al.*, 2013). Diagnostic soil properties such as artefacts, humus content and humus quality were used as markers of human activities (Puskás and Farsang, 2008, 2009).

Investigation on soil and vegetation characteristics in their specific microenvironmental conditions is of great importance for designing and construction of the park scenery and its sustainability. The present research aimed: i) to study the changes in soil and herbaceous vegetation characteristics in the various microenvironments in an urban park; ii) to identify soil and vegetation characteristics mainly affected by surface cover components (natural effects) and those affected by human activities (anthropologic factors); and iii) to assess whether open areas in the park can support species diversity of natural herbaceous vegetation.

MATERIALS AND METHODS

Study site

The study was carried out in a municipal park, Menachem Begin Park, located south of Tel Aviv-Jaffa (32°04′16″ N, 34°80′87″ E), Israel. This park was established in 1970 on an area of about 0.5 km^2. It provides various installations for children's games and other outdoor recreation, such as barbecues and biking.

The park includes groves, a lake, lawns, and rest areas. Tel Aviv, with a population of approximately 404 750 people occupying a 51.79 km^2 area of municipal jurisdiction, is located on the Mediterranean coastal area. These soils belong to sandy soils with a predominance of Luvisols (locally known as "Hamra") and were formed on sandy parent material. The soil in the 0–15 cm depth is characterized by low organic matter content (< 10 g kg^{-1}), neutral pH values of 6.5–7.5, and low cation exchange capacity (7.5 cmol kg^{-1}), with predominance of sand (60%–80%) and low contents of clay (5%–20%) and silt (5%–20%) (Dan *et al.*, 1972; Ben-Dor *et al.*, 2003). The color of the dry and wet soil is yellowish red (5YR 4/6) and dark reddish brown (5YR 3/4), respectively. The soil structure is massive and disintegrates into single grains. The park was established on the original soil of the study area; *i.e.*, no other soil types were transferred into the park.

The climate is Mediterranean, with mean annual rainfall of 550 mm and mean annual temperature of 20 °C. The warmest dry month is August, with mean maximum temperature of 30 °C; the coldest wet month is January, with mean minimum temperature of 10 °C. Mean monthly temperatures and precipitations are se-