Pedosphere **25**(1): 82–92, 2015
ISSN 1002-0160/CN 32-1315/P

Published by Elsevier B.V. and Science Press

PEDOSPHERE

www.elsevier.com/locate/pedosphere

Soil Acidification and Heavy Metals in Urban Parks as Affected by Reconstruction Intensity in a Humid Subtropical Environment

HOU En-Qing[1,2], XIANG Hui-Min[1,2,3], LI Jian-Li[4], LI Jiong[1,2] and WEN Da-Zhi[1,2,*]

[1] *Institute of Ecology and Environmental Sciences, South China Botanical Garden, Chinese Academy of Sciences, Guangzhou 510650 (China)*
[2] *Key Laboratory of Vegetation Restoration and Management of Degraded Ecosystems, South China Botanical Garden, Chinese Academy of Sciences, Guangzhou 510650 (China)*
[3] *University of Chinese Academy of Sciences, Beijing 100049 (China)*
[4] *Agricultural and Forestry Extension Centre of Nanhai District, Foshan 528222 (China)*

(Received May 11, 2014; revised November 14, 2014)

ABSTRACT

Soil quality is a major concern in the management of urban parks. In this study, the soils at 0–3, 3–13, and 13–23 cm depths were sampled from six urban parks, differing in reconstruction intensity (mainly changes made during conversion of natural forests into parklands), in the Pearl River Delta, China to determine how reconstruction intensity influenced the extent of acidification and heavy metal levels in the soils of urban parks in a humid subtropical environment. High reconstruction intensity (HRI) was practiced in three parks and low reconstruction intensity (LRI) in three other parks. The LRI soils were strongly to extremely acidic (with low exchangeable Ca, Mg, and K concentrations) while the HRI soils were much less acidic. Both total and extractable concentrations of soil heavy metals were related to the specific management practices and age of the park, but did not differ significantly between LRI and HRI parks or among soil depths. Soil pH was significantly related to soil exchangeable cation concentrations and base saturation but was weakly related or unrelated to soil heavy metal levels. Our results suggest that high intensity but not low intensity reconstruction significantly reduces the extent of soil acidification in the urban parks in a humid subtropical environment.

Key Words: exchangeable cations, forest, park age, park management, soil depth, soil pH, soil quality

Citation: Hou, E. Q., Xiang, H. M., Li, J. L., Li, J. and Wen, D. Z. 2015. Soil acidification and heavy metals in urban parks as affected by reconstruction intensity in a humid subtropical environment. *Pedosphere*. **25**(1): 82–92.

INTRODUCTION

As essential components of urban ecosystems, urban parks should provide important services to city dwellers, such as recreation, removal of air pollutants, regulation of the microclimate, and the offsetting of carbon emission (Jim and Chen, 2008, 2009). These ecosystem services enhance the quality of live for city residents (Jim and Chen, 2009). However, the forest vegetation in urban parks differs from natural forests in that the urban vegetation suffers from environmental stresses caused by anthropogenic activities, such as heavy metal contamination and the decline in soil nutrient levels (Jim, 1993; Puskás and Farsang, 2009). Soil quality deterioration is increasingly recognized as an important cause of poor tree performance in urban parks and other urban areas (Jim, 1993, 1998a, c; Zhang *et al.*, 2003). Heavy metals in the contaminated soils in urban parks may also threaten the health of residents, particularly children, directly as a consequence of inhalation, ingestion, or dermal absorption (Ryan *et al.*, 2004; Mielke *et al.*, 2007), or indirectly through interactions with the atmosphere, biosphere, and hydrosphere (Abrahams, 2002). Given the vital importance of urban parks and the common problems of park soils (*e.g.*, heavy metal contamination), multidisciplinary studies have increasingly focused on improving the management of these areas (Abrahams, 2002; Jim and Chen, 2009; Luo *et al.*, 2012).

Selective tree harvesting, site preparation, tree planting, and fertilization are typically applied during the construction and reconstruction of urban parks to improve the recreational services provided (Loeb, 1989; Quigley, 2002). Tree harvesting, site preparation, and thereafter tree planting may influence the levels of soil nutrients (*e.g.*, Ca; Schmidt *et al.*, 1996). Fertilization with sewage, pond sludge or inorganic fertilizer may increase the levels of soil nutrients but may also simultaneously add heavy metals to the soils (Torleif, 2001; Lazdina *et al.*, 2007). The interactions between

*Corresponding author. E-mail: dzwen@scbg.ac.cn.

park management practices and atmospheric deposition of acid precursors (*e.g.*, SO_x and NO_x), heavy metals (*e.g.*, Pb and Zn), and other elements (*e.g.*, Ca and K) may largely explain the marked variations in soil chemical properties within and among urban parks (Jim, 1998b; Lee *et al.*, 2006; Luo *et al.*, 2012). However, while a number of previous studies have reported on the relationship between soil quality deterioration and urban park location and age (Madrid *et al.*, 2002; Chen *et al.*, 2005; Lee *et al.*, 2006), few studies have explored the relationship between soil quality deterioration and park management practices (Jim, 1998b).

The Pearl River Delta (PRD) area of China has been a major economic area since the late 1970s. In 2012, 47.7 million (83.8%) of the 56.9 million residents in this region were living in urban areas (Guangdong Statistical Bureau, 2013). The high percentage of the population living in the urban areas increases the importance of the social and ecological services provided by urban green lands. For decades, however, parks and other urban ecosystems in the PRD area have been suffering from serious atmospheric deposition of acid precursors and heavy metals (Wong *et al.*, 2003; Huang *et al.*, 2012). Recent studies in the PRD and surrounding areas suggest that most soils in the natural and plantation forests are extremely acidic (the pH in water is usually < 4.5) (Hou *et al.*, 2012b), while soils in the urban parks might be contaminated with Pb and other heavy metals (Guan and Peart, 2006; Lee *et al.*, 2006). To our knowledge, however, no study has comprehensively investigated soil acidity, exchangeable cations, and heavy metals in urban parks in the PRD area, and little attention has been paid as to how these soil chemical properties are related to park management practices in humid tropical and subtropical environments (Jim, 1998b). In these environments, natural soils are always acidic, and plants are mostly adapted to acidic soils (Ulrich, 1983; Von Uexküll and Mutert, 1995; Jim, 1998c), while management practices (*e.g.*, fertilization with pond sludge and trail construction) may introduce neutral or alkaline materials into the soils (Jim, 1998c, 2003). Therefore, the impacts of park management practices on soil properties, especially the extent of soil acidification, in humid subtropical and tropical environments may differ from those in temperate environments (Jim, 1998b, 2003).

The purposes of this study were to characterize the levels of acidity, exchangeable cations, and heavy metals in soils of six urban parks that differed in management practices in the subtropical Pearl River Delta, China, and to investigate the relationships between park reconstruction intensity and the soil chemical properties and soil depths.

MATERIALS AND METHODS

Site description

The Pearl River Delta area is located in Guangdong Province, China. This area is characterized by a typical subtropical monsoon climate, with an annual precipitation of about 1 700 mm and a mean annual temperature of about 22 °C. The typical zonal vegetation is subtropical monsoon evergreen broad-leaved forest. The natural soils are mainly Ferralsols (FAO-UNESCO, 1974) developed from granite and sand shales.

The six parks investigated in this study (Table I) are major recreational or scenic areas located in the urban core of Chancheng District, Foshan City (Chen, 1995), which is a highly urbanized city centrally located in the PRD and had a population of 7.3 million in an area of 3 814 km^2 in 2013. The six parks are frequently visited by many people. During the establishment of three of the parks (Xiqiao, Wufeng, and Leigang parks), the original trees and shrubs were selectively harvested, and seedlings of landscape or native species (*e.g.*, *Symplocos racemosa* and *Ficus microcarpa*) were planted (Deng, 2005). Because the soils in these three parks have seldom been managed, the three parks were classified as "low reconstruction intensity" (LRI) parks in the present study. In contrast, the soils in the three other parks (Baixi, Shiwan, and Zhongshan parks) have been intensively and extensively managed, and these parks were classified as "high reconstruction intensity" (HRI) parks. In Baixi Park, the original hilly land (with a slope of about 12°) was flattened, and thereafter planted with seedlings of landscape or native species (*e.g.*, *Cinnamomum camphora* and *Delnis regia*) in 2004 (Tian *et al.*, 2010). In Shiwan and Zhongshan parks, management practices, such as site preparation, planting, and fertilization with pond sludge and inorganic fertilizers, have been frequent (every few years) since establishment (Chen, 1995; Lin, 1995). At the time of this study, the vegetation in these two parks was mainly composed of landscape or native species but some large, original trees remained, and pond sludge had been applied to the soil surface in many areas. Information concerning management practices at these six parks was obtained from interviews with local park managers, the published literature, policy documents, online information sources, and field observations.

Sampling and analysis

At the outset of this study, we were aware that soil