Geoderma 264 (2016) 244–251

Contents lists available at ScienceDirect

Geoderma

journal homepage: www.elsevier.com/locate/geoderma

Quantification of soil macropores under alpine vegetation using computed tomography in the Qinghai Lake Watershed, NE Qinghai–Tibet Plateau

Xia Hu [a,c,e], Zong-Chao Li [a,c], Xiao-Yan Li [b,d], Lian-you Liu [a,c]

[a] Key Laboratory of Environmental Change and Natural Disaster of Ministry of Education, Beijing Normal University, Beijing 100875, China
[b] Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, Beijing 100875, China
[c] Academy of Disaster Reduction and Emergency Management, Beijing Normal University, Beijing 100875, China
[d] College of Resources Science and Technology, Beijing Normal University, Beijing 100875, China
[e] Corresponding author at: Academy of Disaster Reduction and Emergency Management, Beijing Normal University, No. 19, Xinjiekouwai Street, Haidian District, Beijing 100875, China

ARTICLE INFO

Article history:
Received 19 May 2015
Received in revised form 1 October 2015
Accepted 1 November 2015
Available online 16 November 2015

Keywords:
Kobresia meadow
Achnatherum splendens steppe
Potentilla fruticosa shrub
Alpine vegetation
Soil architecture
Macropore
Root
Mattic epipedon

ABSTRACT

The importance of soil macropores as preferential pathways for water, air, and chemical movement in soils has long been recognized. However, studies concerning macropores of soils under alpine vegetation remain scarce. The objective of this study was to quantify the architecture of soils beneath Alpine *Kobresia* meadow, *Achnatherum splendens* steppe, and *Potentilla fruticosa* shrubs using computed tomography in the Qinghai Lake Watershed of northeastern Qinghai–Tibet Plateau. Nine soil cores (0–50 cm deep) were taken at three sites with three replicates. At each site, the three cores taken were scanned with a GE HISPEED FX/I Medical Scanner. The number of macropores, macroporosity, and macropore equivalent diameter within the 50-cm soil profile were interpreted from X-ray computed tomography, to analyze soil architecture. The results indicated that soils under *A. splendens* steppe and *P. fruticosa* shrubs had greater macroporosity, and developed deeper and longer macropores than those in the other vegetation types. For the Alpine *Kobresia* meadow, macropores were distributed mainly in the 0–100-mm soil layer, while they were distributed in the 0–200-mm soil layer for *A. splendens* steppe and in the 0–200-mm soil layer for *P. fruticosa* shrub. The large number of macropores found in the soil surface layer under Alpine *Kobresia* meadows can be attributed to "mattic epipedon". The large number of macropores found in soil under *A. splendens* steppe and *P. fruticosa* shrubs can be attributed to greater root development. Soil hydraulic conductivity was significantly greater for *A. splendens* steppe and *P. fruticosa* shrub (great macroporosity) than for Alpine *Kobresia* meadow (small macroporosity).
© 2015 Elsevier B.V. All rights reserved.

1. Introduction

Soil macropore is one of the important factors of soil structure (Brewer, 1976), which largely control fluid and solute transport, making visualization and quantification of macropore characteristics essential for better understanding and predicting soil hydrological functions. Macropores are large soil voids, often distinct in some manner from the soil matrix, which permit the preferential flow of water and contaminants through the soil profile (Edwin & David, 2009). The importance of macropores as preferential pathways of water, air, and chemicals in the soil has been widely recognized (Beven and Germann, 1982; Lin et al., 2005; Jarvis, 2007). The conductivity of macropores to water flow strongly depends on their 3-D geometry and topology. Macroporosity, the number of macropores, pore length, pore size distribution, continuity, tortuosity, and connectivity are considered significant characteristics that influence water flow and solute transport through macropores (Perret et al., 2007; Pierret et al., 2002; Bastardie et al., 2003; Peth et al., 2008; Luo et al., 2008). Different types of macropores have distinct geometrics and therefore function differently (Lin et al., 1996; Luo et al., 2008). Previous studies showed that soil type and land use were among the main factors influencing pore characteristics (e.g., Gantzer and Anderson, 2002; Zhou et al., 2008; Udawatta et al., 2008; Mooney and Morris, 2008). Luo et al. (2010) reported that soil type, land use, and their interaction, significantly influenced macroporosity, network density, surface area, length density, node density, and mean angle. Moreover, within the same soil type, soils under pasture had greater macroporosity, length density, and node density than those under row crops, especially in the subsoil. Therefore, there would be complex interactions between vegetation and soil structure, and it is necessary to investigate the relationships between soil pore characteristics and soil functions under a wide range of vegetation, soil, and climate conditions.

X-ray computed tomography (CT) has been used in recent years as a new method to quantify soil pores, especially macropore development,

E-mail address: huxia@bnu.edu.cn (X. Hu).

http://dx.doi.org/10.1016/j.geoderma.2015.11.001
0016-7061/© 2015 Elsevier B.V. All rights reserved.

at a much higher resolution than the previous methods, such as dye tracing, spectral image analysis and soil thin section (Grevers et al., 1989; Capowiez et al., 2003; Taina et al., 2008; Munkholm et al., 2012). X-ray CT technique has been proven to be a very powerful and non-destructive technique to visualize and quantify soil structure at different scales (Garbout et al., 2013 and Taina et al., 2008). For example, Garbout et al. (2013) quantified the effects of tillage on topsoil structural quality using X-ray CT, and Katuwal et al. (2015) linked air and water transport in intact soils to macropore characteristics by X-ray CT. Moreover, a few recent studies have used helical medical CT to quantify macropore characteristics and linked them with soil hydraulic functions (Munkholm et al., 2012; 2013). Moreover, Sammartino et al. (2012) proposed a novel method to visualize and characterize preferential flow in undisturbed soil cores using multi-slice helical medical CT. Hu et al. (2015) also quantified the architecture of soils beneath the shrub canopy and in the adjacent interspace grass area during evolution of shrub encroachment using helical medical X-ray computed tomography. These studies suggest that helical medical CT could be viewed as a method suitable for quantifying soil macropores.

Alpine vegetation grows in the high-latitude area and has a unique soil and harsh climate condition, which is characterized by low temperatures, dryness, ultraviolet radiation, freeze and thaw cycle as well as a short growing season. The soil structures under alpine vegetation could be different from that in low-latitude areas; however, studies concerning interactions between soil macropores and alpine vegetation are rare, particularly for the Qinghai–Tibet Plateau. Therefore, the objective of this study was to quantify soil pore features using helical medical CT for soils beneath alpine vegetation in the Qinghai Lake Watershed of the NE Qinghai–Tibet Plateau, and this study would provide a better understanding of the interaction between vegetation types and pore characteristics in the alpine environment.

2. Materials and methods

2.1. Study sites and core samples

This study was conducted in the watershed of the Shaliu River, the second largest river in the Qinghai Lake Watershed, situated in the northeastern of the Qinghai–Tibet Plateau, which lies in the semiarid, cold and high-altitude climate zone. Mean annual temperature and precipitation between 1957 and 2015 were 0.1 °C and 400 mm in the watershed, respectively. Approximately 70%–80% of the annual precipitation occurs in summer and autumn. Winters are clear, dry, and cold, and the summer is warm and wet. The soil types are classified as Typic Cryoboroll and Typic Haploboroll according to USDA taxonomy, or Haplic Kastanozem and Cryi-Haplic Kastanozem according to the World Reference Base for Soil Resources (WRB). The dominant vegetation types are *Kobresia* meadow, *Achnatherum splendens* steppe, and *Potentilla fruticosa* shrub. Alpine meadow is the main ecosystem in the Qinghai Lake Watershed, and it accounts for 55.9% of the total land area (Zhang et al., 2015). Alpine steppe is the second largest ecosystem type, and it occupies 15.6% of the total land area. Alpine shrub meadow is the only ecosystem with a chamaephyte functional group. We selected three sites as sampling areas in each vegetation type (*Kobresia* meadow, *A. splendens* steppe, and *P. fruticosa*) in the Shaliu River watershed (Fig. 1). Landscapes of the three vegetation types are shown in Fig. 2. At Site 1, the main species were *Kobresia pygmaea*, *Saussurea pulchra*, and *Polygonum viviparum*, and the average vegetation cover was 97.00 ± 2.00%. At Site 2, the main species were *A. splendens*, *Artemisia frigid*, *Dracocephalum heterophyllum*, *Heteropappus altaicus*, and *Potentilla saumdersiana*, and the *A. splendens* cover was 8.00 ± 3.00%. At Site 3, the main species were *P. fruticosa*, *Carex moorcroftii*, and *P. saumdersiana*, and the *P. fruticosa* shrub cover was 21.00 ± 3.00%. A total of 9 undisturbed soil cores were taken under plant canopy at the three sampling sites with three replicates. Plexiglas cylinders with

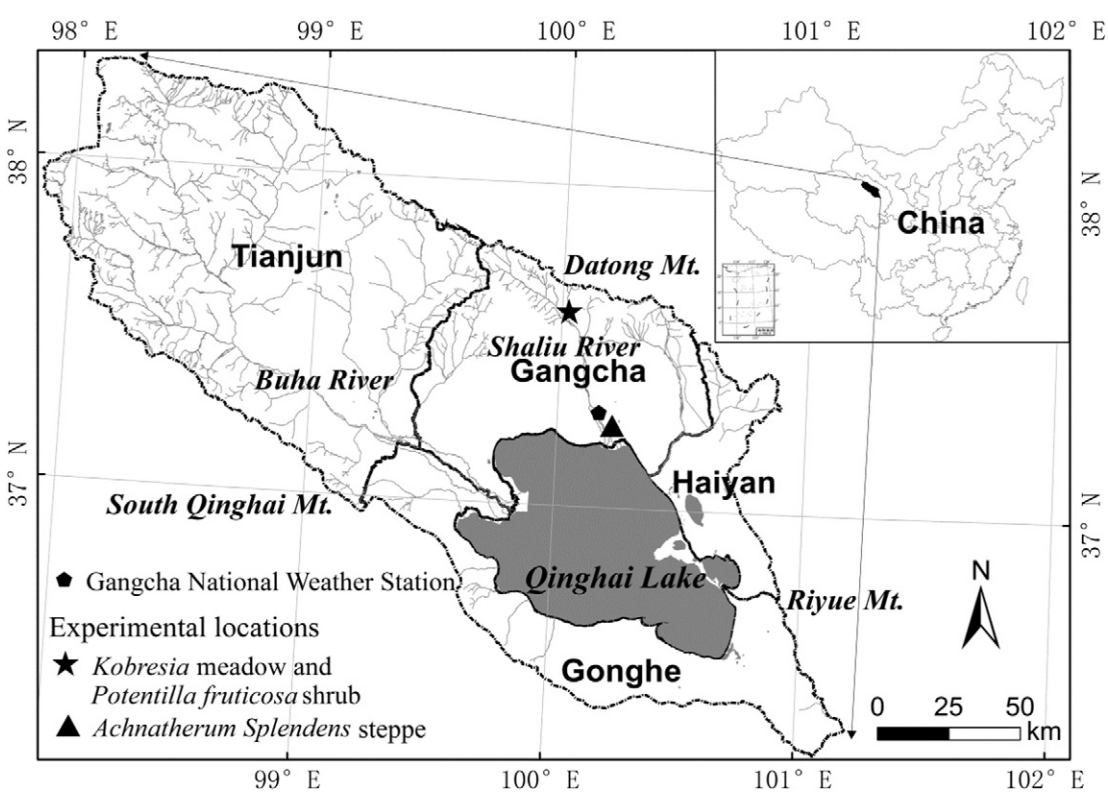

Fig. 1. Study sites and sampling positions.

Download English Version:

https://daneshyari.com/en/article/4573102

Download Persian Version:

https://daneshyari.com/article/4573102

Daneshyari.com