Science of the Total Environment 562 (2016) 353–363

Contents lists available at ScienceDirect

Science of the Total Environment

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

Climate change and human activities altered the diversity and composition of soil microbial community in alpine grasslands of the Qinghai-Tibetan Plateau

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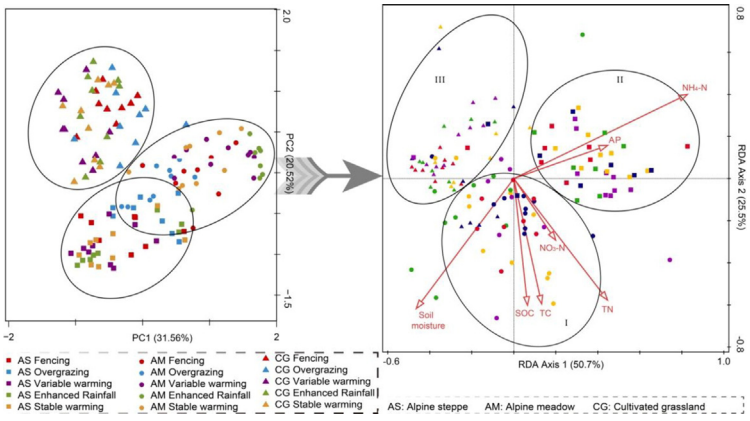
HIGHLIGHTS

- Enhanced rainfall reduced soil microbial diversity in native grassland.
- Variable warming reduced soil microbial diversity in cultivated grassland.
- Soil microbial community in cultivated grassland varied from in native grassland.
- Soil properties strongly explained variations of soil microbial communities.

GRAPHICAL ABSTRACT



Variations among soil microbial communities could be strongly explained by soil nutrients and moisture.

ARTICLE INFO

Article history:
Received 13 January 2016
Received in revised form 25 March 2016
Accepted 28 March 2016
Available online xxxx

Editor: Simon Pollard

Keywords:
Bacteria
Fungi
Climate change

ABSTRACT

Alpine ecosystems are known to be sensitive to climate change and human disturbances. However, the knowledge about the changes of their underground microbial communities is inadequate. We explored the diversity and structure of soil bacterial and fungal communities using Ilumina MiSeq sequencing in native alpine grasslands (i.e. the alpine meadow, alpine steppe) and cultivated grassland of the Qinghai-Tibetan Plateau (QTP) under three-year treatments of overgrazing, warming and enhanced rainfall. Enhanced rainfall rather than warming significantly reduced soil microbial diversity in native alpine grasslands. Variable warming significantly reduced it in the cultivated grassland. Over 20% and 40% variations of microbial diversity could be explained by soil nutrients and moisture in the alpine meadow and cultivated grassland, separately. Soil microbial communities could be clustered into different groups according to different treatments in the alpine meadow and cultivated grassland. For the alpine steppe, with the lowest soil nutrients and moistures, <10% variations of microbial diversity was explained by soil properties; and the soil microbial communities among different treatments were similar.

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http://dx.doi.org/10.1016/j.scitotenv.2016.03.221

Overgrazing
Grass cultivation
Qinghai-Tibetan Plateau

The soil microbial community in the cultivated grassland was varied from it in native grasslands. Over 50% variations of soil microbial communities among different treatments were explained by soil nutrients and moisture in each grassland type. Our results suggest that climate change and human activities strongly affected soil microbial communities by changing soil nutrients and moistures in alpine grassland ecosystems.

1. Introduction

Climate change and anthropogenic disturbance are threatening global biodiversity (Petchey et al., 1999). The loss of biodiversity undermines the ability of an ecosystem to adapt to environmental changes (Chapin et al., 2000; Hua et al., 2015; Lynch and Neufeld, 2015). Soil microbes, mostly bacteria and fungi, are important components of the biodiversity of the Earth and play crucial roles on soil nutrient supply and element cycling in terrestrial ecosystems (Bardgett, 2005). However, they are strongly affected by climate changes (Stevnbak et al., 2012; Bragazza et al., 2013) and anthropogenic disturbances (Wang et al., 2015).

The change of soil temperature and moisture caused by the warming climate and the fluctuations in precipitation, on the one hand, can directly change the habitats of soil microbes, e.g. soil nutrients and soil moisture contents, and then alter the diversity and composition of soil microbial communities (Singh et al., 2010; Sheik et al., 2011). The warming climate and the fluctuation in precipitation, on the other hand, can affect the growth and diversity of plant communities, and change the quality and quantity of the litter inputs to soils and thereby change the soil microbial communities (Bardgett, 2005; Singh et al., 2010). Anthropogenic activities, such as livestock grazing and grass harvesting, not only significantly change the quantity and quality of litter inputs into the soils but also elevate the soil temperature and reduce the moisture of soils by reducing the vegetative cover (Wan et al., 2008). Consequently, soil microbial communities are affected significantly. Moreover, human activities, such as planting and fertilization, also significantly affect belowground microbial communities (Levine et al., 2011).

Alpine regions are more sensitive than other regions in response to environmental changes (Walther et al., 2002; Hinzman et al., 2005). However, knowledge regarding the effects of environmental changes on soil microbial communities is still inadequate (Stark et al., 2015). The Qinghai-Tibetan Plateau (QTP), well-known as the "Roof of the World" and the "Water Tower" of Asia (Dong et al., 2010), is a typical alpine region located in one of the global biodiversity hotspots (Myers et al., 2000) and one of the most important grassland biomes (mainly alpine meadow and alpine steppe) in the world (Foggin, 2008; Harris, 2010). As one of the world's most fragile and sensitive regions, the QTP has been seriously degraded by climate change, such as warming (Xue et al., 2009; Harris, 2010), and human disturbances such as inappropriate livestock grazing (Dong et al., 2010) in recent decades. To restore the degraded grassland ecosystems, the artificial grassland is generally cultivated in this region (Dong et al., 2010).

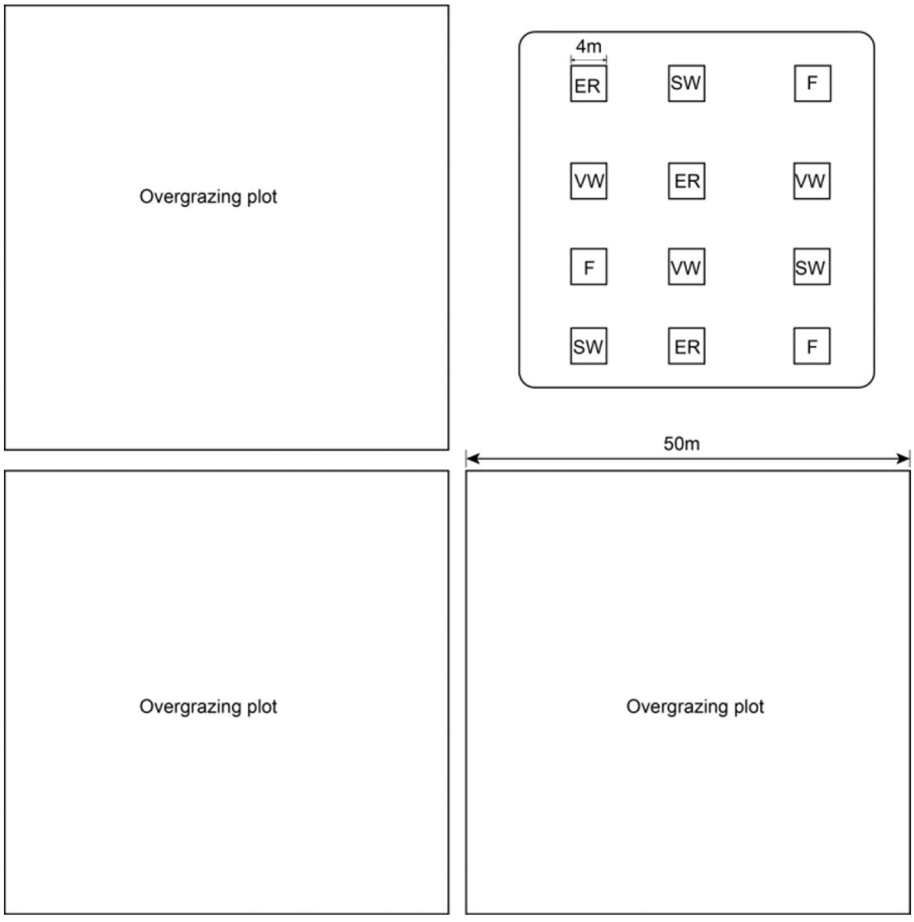

Fig. 1. The schema of experimental designs for each grassland type.