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Research article

Climate, soil texture, and soil types affect the contributions of fine-fraction-stabilized carbon to total soil organic carbon in different land uses across China

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ABSTRACT

Mineral-associated organic carbon (MOC), that is stabilized by fine soil particles (i.e., silt plus clay, <53 μm), is important for soil organic carbon (SOC) persistence and sequestration, due to its large contribution to total SOC (TSOC) and long turnover time. Our objectives were to investigate how climate, soil type, soil texture, and agricultural managements affect MOC contributions to TSOC in China. We created a dataset from 103 published papers, including 1106 data points pairing MOC and TSOC across three major land use types: cropland, grassland, and forest. Overall, the MOC/TSOC ratio ranged from 0.27 to 0.80 and varied significantly among soil groups in cropland, grassland, and forest. Croplands and forest exhibited significantly higher median MOC/TSOC ratios than in grassland. Moreover, forest and grassland soils in temperate regions had higher MOC/TSOC ratios than in subtropical regions. Furthermore, the MOC/TSOC ratio was much higher in ultisol, compared with the other soil types. Both the MOC content and MOC/TSOC ratio were positively correlated with the amount of fine fraction (silt plus clay) in soil, highlighting the importance of soil texture in stabilizing organic carbon across various climate zones. In cropland, different fertilization practices and land uses (e.g., upland, paddy, and upland-paddy rotation) significantly altered MOC/TSOC ratios, but not in cropping systems (e.g., mono- and double-cropping) characterized by climatic differences. This study demonstrates that the MOC/TSOC ratio is mainly driven by soil texture, soil types, and related climate and land uses, and thus the variations in MOC/TSOC ratios should be taken into account when quantitatively estimating soil C sequestration potential of silt plus clay particles on a large scale.

1. Introduction

Soil organic carbon (SOC) is fundamental in improving the physical, chemical, and biological functions of soil to sustain its fertility and productivity (Pan et al., 2009), as well as in predicting feedback of the terrestrial carbon cycle to climate change (Kirschbaum, 2000). Management practices have been widely used in increasing SOC stocks; such practices include afforestation, fertilization of forest and grassland soils, and the application of organic amendments in cropland (Chen et al., 2012; Paul et al., 2002; Purakayastha et al., 2008; Triberti et al., 2008).

The SOC pool consists of different fractions that vary in stabilization mechanisms and turnover times. Among these fractions, labile SOC (e.g., light fraction and particulate organic C) accounts for a relatively small proportion of total SOC (TSOC) because it is easily decomposed and extremely sensitive to environmental fluctuation (Schmidt et al., 2011). In contrast, mineral-associated organic carbon (MOC) is stabilized by fine soil particles (i.e., silt and clay) and is critical to SOC persistence. Previous research has demonstrated that MOC has long turnover time (Balesdent et al., 1998; Trumbore, 2000) and accounts for 50–80% of the TSOC (Gregorich et al., 2006; Kahle et al., 2002; Zhao et al., 2006). Therefore, quantifying MOC content and its contributions to TSOC were of great importance for predicting SOC stock and dynamics.

Although persistent, MOC is influenced by numerous variables, including climate, land uses, soil mineral type, soil texture, and ecosystem management practices (e.g., fertilization and crop

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