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Preface

Soil Organic Carbon in a Changing World

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Soil contains more than three times as much carbon (C) as either the atmosphere or terrestrial vegetation. Soil organic C (SOC) is essentially derived from inputs of plant and animal residues, which are processed by the microbiota (bacteria, archaea, protists, fungi and viruses) that dominates SOC transformation and turnover in complex terrestrial environments. A tiny change in the SOC pool would have profound impacts on global climate, soil fertility and ecosystem productivity, food security and sustainable development goals. Consequently, SOC has been one of the central themes in Pedosphere. In fact, more than one quarter of the total articles published in Pedosphere have been related to soil C and soil organic matter since its establishment in 1991.

This special issue in Pedosphere is the first devoted to SOC studies. It contains 19 articles, which collectively address a wide range of topics including, but not limited to, cutting-edge methods, microbial transformation mechanisms, land-use change impacts, agricultural sustainability, global change and model predictions. The organization of this thematic issue allows a retrospective review of SOC studies in Pedosphere and helps identify the emerging topics in the field.

Extraction and identification of SOC is a longstanding challenge (Guigue *et al.*, 2014), because soil is arguably considered the most complicated biomineral materials on the planet (Young and Crawford, 2004). The extraction efficiency of SOC largely depends on the target components (Xing *et al.*, 2005). In this special issue, Xie *et al.* showed that the three-dimensional excitation-emission (EEM) fluorescence spectroscopy could be a powerful means to characterize the components of dissolved organic matter, and that the extraction methods need to be optimized for in-depth analysis of such groups as protein-, fulvic-, and humic-like compounds. By characterizing soil organic matter species using solid-state ^{13}C cross polarization magic angle spinning (CPMAS) nuclear magnetic resonance (NMR) (^{13}C CPMAS-NMR) spectroscopy of humic substances and density-based fractions in a forest ecosystem, Ranatunga *et al.* observed greater fractions of alkyl C, O-alkyl C, and carbohydrate functional groups in response to burning. This implies that burning might have stimulated soil process of dehydrogenation, de-oxygenation and decarboxylation, despite the fact that low-intensity fire appeared to cause limited structural changes in the soil organic matter fractions. As soil harbors numerous elements other than C that could combust (Pribyl, 2010; Jansen *et al.*, 2011), the classic loss on ignition (LOI) method may overestimate SOC due to co-combustion of other elements (Salehi *et al.*, 2011). Touch *et al.* assessed LOI for organic C measurement, and concluded that littoral sediment C was better represented by burning at 200, 300, and 600 °C for 4 h using the index of $LOI_{200-300}/LOI_{600}$, where $LOI_{200-300}$ and LOI_{600} are the LOI at 200–300 and 600 °C, respectively.

Microbial communities are the engines that drive cycles of C, N and most other nutrients (Schimel and Schaeffer, 2012). The fixation of atmospheric CO_2 and decomposition of organic C constitute the turnover of SOC and are primarily driven by plant and microbial communities, respectively (Kuzyakov and Gavrichkova, 2010; Schmidt *et al.*, 2011; El-Mahrouky *et al.*, 2015). Due to the rapid advance in molecular techniques, microbially mediated C processing is increasingly resolved at the individual and population levels (Sofi *et al.*, 2016) rather than at the entire community level (Liu *et al.*, 2008). Kumar and Ghoshal used phospholipid fatty acid composition to investigate the relationship of microbial community structure with SOC following conversion of natural forest to degraded forest and agroecosystems in India, and found that the changes in fungal and bacterial abundance could explain 73% and 91% of the SOC variations, respectively, across all the land-use types. Using high-throughput pyrosequencing techniques, Lucheta *et al.* assessed fungal community structure in an attempt to relate its diversity with SOC transformation in Amazonian Dark Earth (ADE) and charred black carbon (BC) particles in ADE. This study showed phylogenetically distinct fungal populations inhabiting ADE and BC. Nevertheless, direct evidence is still scarce regarding the relative contribution of fungi and bacteria to the formation of specific soil organic matter in complex soil environment (Throckmorton *et al.*, 2012; Kallenbach *et al.*, 2016).

Plant residue characteristics influence the quantity and quality of soil organic matter, and soil physiochemical properties contribute significantly to its speciation and turnover (Schmidt *et al.*, 2011). Jin B S *et al.* showed increased SOC sequestration in a tidal marsh following the invasion of the exotic C_4 plant *Spartina alterniflora* owing to its greater biomass amount and lower proportion of labile SOC fractions compared to the native C_4 plant *Cyperus malaccensis.* Jin W H *et al.* demonstrated that rice-wheat rotation system stimulated SOC accumulation to a greater extent than poplar plantations in the coastal reclaimed flatlands of eastern China. Mavi and Marschner established a gradient of salinity and sodicity by manipulating non-saline soils with salts, and found that osmotic potential is a better parameter to evaluate the salt effects on dissolved organic matter and microbial activity than electrical conductivity (EC). Intriguingly, Melas *et al.* showed no protective effect of biochar on mineralization of SOC, but glucose mineralization strongly depended on nutrient availability.

Soil organic matter forms essential basis of soil fertility and agricultural productivity (Lal, 2004; Kurganova *et al.*, 2014). Intensified agricultural management results in changes of SOC stocks and composition that are often considered as important indexes of soil fertility (Tiessen *et al.*, 1994; Williams *et al.*, 2005; Benbi *et al.*, 2015). Wang Y X *et al.* conducted a county-wide survey of SOC density under intensive cultivation of citrus orchards from 1982 to 2010, which showed that current management practices enhanced SOC sequestration. The integrated soil-crop system management (ISSM) was invented to generate high crop yield while achieving high nutrient use efficiency, and Zhang *et al.* revealed higher SOC, water-soluble organic C, easily oxidizable organic C, particulate organic C and humic acid C under ISSM than under conventional regimes in a Fluvisol in Northeast China. They also showed that the ISSM had a positive effect on aggregate structure and stability, and improved the quantity and quality of SOC based on solid-state ^{13}C NMR analysis. It should be noted that N availability often constrains agricultural productivity, and Srivastava *et al.* reviewed recent advances in studies on interactions between organic C and inorganic N transformations and associated microbial processes, and highlighted the multiple effects of abiotic and biotic factors on the generation and decomposition of SOC in the context of a changing climate.

The changes of SOC pools can readily amplify global climate changes by regulating the sink and source of greenhouse gases including CO_2, CH_4 and N_2O (Lal, 2004). The generation of these gases in soils results solely from decomposition of SOC that serves as microbial substrates (Serrano-Silva *et al.*, 2014). Nevertheless, the mechanisms that enable practical and theoretical scaling up from microbial biogeochemical process to global change remain poorly understood (Lai, 2009; Guillaume *et al.*, 2015). Wang Y H *et al.* demonstrated that simulated global change of drought had significantly negative impacts on SOC and soil enzyme activities in a Stangic Anthrosol, while this negative feedback could be counteracted to some extent by elevated CO_2 and soybean cultivation. Heintze *et al.* found that cattle slurry application resulted in greater emissions of CO_2 and N_2O than biogas digestate application, but CH_4 flux was unaffected, and the magnitude of these effects varied among the three soil types that were studied. Thapa *et al.* further evaluated the effects of EC and moisture content on CO_2 and N_2O emissions from naturally occurring sulfate-based saline soils, and revealed that potential N mineralization rate and CO_2 emissions decreased with increasing soil EC. Both soil moisture and EC played important roles for denitrification and, thus, for N_2O emission.

Despite numerous studies of SOC modeling across different scales, there exist large uncertainties on the global SOC budget (Amundson, 2001; Tian *et al.*, 2015). The SOC stock and sink could be better approximated by optimizing model performance and reducing the uncertainties of key variables such as soil area estimates, annual temperature variability, ground vegetation and microbial communities (Cheng *et al.*, 2004; Yu *et al.*, 2007). Were *et al.* employed a novel evolutionary genetic optimization-based adaptive neuro-fuzzy inference system (ANFIS-EG) for mapping the spatial patterns of SOC stocks, and revealed marginally higher SOC stocks in the forested ecosystems than in the agroecosystems in Kenya. Qin *et al.* performed analysis of sensitivity and uncertainty of DeNitrification-DeComposition (DNDC) model, and revealed the distinct dynamic changes of SOC under different climate-soil-management combinations in four typical counties across China during the period from 1980 to 2008. Guo *et al.* observed a 12.5% increase of soil organic matter in six counties of the Yangtze River Plain from 1980 to 2011, and quantified relative contributions of various factors including agricultural management, soil properties, climate, and terrain. Chen *et al.* established a quantitative relationship among soil organic matter, pH and bulk density; they observed that integration of soil pH significantly improved prediction of soil bulk density than using organic matter alone.

Soil sustains life on Earth. Approximately 2 300 Gt of C (Stockmann *et al.*, 2013) in soil safeguards food production, water resource and environmental sustainability. Given that, we hope this special issue will inspire further researches toward mechanistic understandings of global soil C turnover and its impact on human welfare.

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