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FOREWORD

Stable isotopes for the study of soil C and N under global change

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Carbon (C) and nitrogen (N) are key elements governing soil productivity and sustainability in terrestrial ecosystems including croplands, forests, and wetlands. The sustainable productivity of soils is affected by global change impacts that include climate change, land-use change, and environmental change. Therefore, understanding the changes in soil C and N processes under global change are critical for sustainable soil management (Batlle-Aguilar et al. 2011). Stable C ($^{13}C/^{12}C$) and N ($^{15}N/^{14}N$) isotope techniques (both natural abundance and enrichment studies) have been widely used in understanding C and N dynamics and cycling in ecosystems (Tiunov 2007). Using the stable N isotope technique, it is possible to trace N derived from many sources and pools and thus quantify the gross N transformation rates and plant N uptake, and the processes of gaseous N emissions (Choi et al. 2020). The stable C isotope technique is used to understand sources (C3 vs. C4), decomposition, and stabilization of organic C in soils (Krull et al. 2006). The coupling of C and N isotopes should further provide undiscovered information on the linkage of C and N in the biogeochemical cycling of these elements (Han et al. 2020). The use of stable isotopes in understanding of C and N processes is of particular importance when it comes to predicting the effects of global change on C and N dynamics in ecosystems. Global change affects C and N dynamics in many ways via changed atmospheric CO_2, temperature, and moisture conditions and their influences on the above and belowground processes of ecosystems. However, our understanding of these interacting effects of global and environmental changes on the C and N processes in ecosystems is still developing.

This special issue collects six papers (including one review) that investigate C and N dynamics in different ecosystems of different land use and management under climate change using stable C and N isotopes. The ecosystems include croplands, forests, and wetlands in China, the UK, and New Zealand. In a data synthesis study combining the natural abundance of stable C ($\delta^{13}C$) and N ($\delta^{15}N$) isotopes, Park et al. (2023) analyzed co-variations of the $\delta^{13}C$ and $\delta^{15}N$ in soils with land-use types, management, and disturbance. This is a very unique review that compiled the $\delta^{13}C$ and $\delta^{15}N$ data obtained from cropland, grasslands, and forests that had different degrees of land management intensity. It was found that in intensively managed soils such as croplands and grasslands, the soil application of ^{13}C- and ^{15}N-enriched organic inputs such as manure and compost led to co-elevation of $\delta^{13}C$ and $\delta^{15}N$. In forest sites under less site disturbance, the $\delta^{13}C$ and $\delta^{15}N$ co-varied by isotope fractionation associated with the decomposition of soil organic matter. Park et al. (2023) also found indications of the changes in the $\delta^{13}C$ and $\delta^{15}N$ by land management and disturbance such as tillage (croplands), grazing (grasslands), and fire (forests). He et al. (2023) recommended fertilization management for climate-smart agriculture (CSA) by investigating crop yields and soil organic C (SOC) sequestration in a long-term maize-wheat rotation experiment (30 years) with treatments of chemical fertilization (CF), organic fertilization (OF), and combined CF-OF. Gross N transformation and nitrous (N_2O) emission were also examined by applying ^{15}N to the soils collected from the experimental plots. The findings of He et al. (2023) suggested that combining CF-OF is a better strategy to achieve the multiple goals (crop yield, N_2O mitigation, and SOC sequestration) of CSA. Wang et al. (2023) provided experimental evidence on the coupling of

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C and N in soil C and N processes through studies on the effects of root-derived ^{13}C on the fate of fertilizer-^{15}N for paddy rice and upland wheat. They found that the transport and transformation of N were regulated by the spatial distribution of root-derived C and the associated microbial activities. Due to a larger bulk soil area under the influence of root-derived C for paddy rice than that for upland wheat, more soil N was activated and primed by microbes that were activated by root-derived C, leading to a greater plant N uptake and N loss (including gaseous loss) in the rice paddy. Zhang et al. (2023), who compared alkaline Chinese and acidic UK soils, reported that pathways (nitrification vs. denitrification) of N_2O emission in croplands were critically affected by soil pH; autotrophic nitrification and denitrification was the dominant pathway of N_2O emission in alkaline and acidic soils, respectively. It was further suggested that increased SOC by application of manure and crop residue for enhanced SOC sequestration may increase N_2O emission through denitrification. N_2O emission was also studied for coastal wetlands by Jiang et al. (2023), who investigated the effects of saltwater incursion on the N_2O emission for sediments collected from coastal freshwater wetlands of Yangtze Estuary, China. The sediments have been incubated for different days after the addition of artificial seawater at different salinity levels. Though N processes and N_2O emission were quite variables with the treatments, saltwater tended to enhance N mineralization and thus loss of N, indicating that saltwater incursion into freshwater wetlands might reduce the N sink capacity of the coastal wetlands. In forests, Garrett et al. (2023) showed that the $\delta^{15}N$ can be used as an indicator of N availability status and thus as a predictor of site productivity responses to N fertilizer in New Zealand. Though the $\delta^{15}N$ has been widely used to estimate the degree of N saturation of forests, this study is unique as it extended the use of $\delta^{15}N$ in predicting forest responses to N fertilization.

This special issue contains a wide range of stable C and N applications in the study of C and N cycling in different land-use types such as paddy, upland, forest, and wetland. The synthesized and experimental data published in the articles of this issue provides novel insights into the use of stable C and N isotopes in the study of C and N dynamics in different land uses under global change. We sincerely appreciate all contributors who have submitted their studies to this special issue and thank Melania Ruize, a senior editor of Springer Nature, to organize this special issue.

Declarations

Conflict of interest The authors declare no competing interests.

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