frontiers | Frontiers in Environmental Science

TYPE Editorial
PUBLISHED 28 July 2025
DOI 10.3389/fenvs.2025.1668460

OPEN ACCESS

EDITED AND REVIEWED BY
Yuncong Li,
University of Florida, United States

*CORRESPONDENCE
Rui Yang,
yangrui01@caas.cn

RECEIVED 18 July 2025
ACCEPTED 21 July 2025
PUBLISHED 28 July 2025

CITATION
Yang R, Lin W, Yao Y and Zhang Y (2025) Editorial: Reduction of greenhouse gas emissions from soil.
Front. Environ. Sci. 13:1668460.
doi: 10.3389/fenvs.2025.1668460

Editorial: Reduction of greenhouse gas emissions from soil

Rui Yang[1]*, Wei Lin[1], Yuanzhi Yao[2] and Yao Zhang[3]

[1]Institute of Urban Agriculture, Chinese Academy of Agricultural Sciences, Chengdu, Sichuan, China, [2]School of Geographic Sciences, East China Normal University, Shanghai, China, [3]Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO, United States

KEYWORDS

soil, greenhouse gas, estimation, mitigation, nitrogen cycling, nutrient management

Editorial on the Research Topic
Reduction of greenhouse gas emissions from soil

Global warming has exacerbated. The year of 2024 was the first calendar year to exceed the 1.5°C warming threshold set by the *Paris Agreement* (Hansen et al., 2025). The primary driver of extreme weather events including heat waves remains climate change induced by the emission of greenhouse gases (GHGs) particularly as a result of anthropogenic activities. To avoid catastrophic climate consequences, the time for action is now.

Soil is one of the most valuable natural resources on this planet and is the ultimate defense of global food security. To meet the rapidly growing global food demand, soil has become a major contributor to GHGs emissions and climate change (Kopittke et al., 2024). On the other hand, soil plays an essential role in the global carbon cycle and also serves as a significant sink of GHGs emissions (Valujeva et al., 2024; Wu et al., 2024). Due to this complexity of terrestrial carbon cycles, accurate monitoring and estimation of GHGs emissions from the farmland is critical. In this Research Topic, Zeng et al. highlighted the potentiality of using a machine learning model (i.e., extreme gradient boosting, XGBoost) combined with hyperspectral imaging in predicting GHGs emissions from soils, which may help guide future agricultural management.

The GHGs emissions from soil are impacted by a diverse range of variables mainly including soil type, moisture, temperature, and management practices such as tillage and soil fertilization (Chataut et al., 2023; Basheer et al., 2024). Opportunities to reduce emissions and promote soil carbon sequestration could be identified following elucidation of the underlying mechanisms controlling soil GHGs emissions. In this Research Topic, Chao et al. estimated farmland carbon emissions from 2011 to 2021 in Guangdong, a province in southern China, using a classic IPCC carbon emission calculation methodology and identified the influencing factors using a decoupling model. Overall, carbon emissions decreased in Guangdong during the evaluated decade primarily as a result of decreased pesticide and fertilizer input in agricultural production. Despite the reduced carbon emissions, agricultural economic development was not significantly affected, indicating a decoupling nature between farmland carbon emissions and economic growth. That study also found spatial disparities in carbon emissions, which highlighted the essentiality of estimating regional farmland carbon emissions.

Soil organic matter is probably the most determinant factor influencing the function of natural soil (Weil and Brady, 2017). Therefore, the utilization of organic soil amendments

such as compost is a common practice to improve soil health and sustainability. However, a large quantity of CO_2 emissions is associated with the composting process. Pennell et al. identified environmental factors such as surface temperature, internal temperature, and moisture as the key factors determining CO_2 emissions during windrow composting, but such factors are hard to control under that scenario. Instead, they suggest that increasing organic nitrogen in the feedstock would facilitate the retention of carbon and thus lower total emissions.

The other five studies in this Research Topic are all related to reduction of soil GHGs emissions through nutrient management practices. Regarding nitrogen cycling, Matse et al. systematically reviewed field efficacy of urease inhibitors for mitigation of ammonia emissions. They found that disparity in efficacy existed among urease inhibitors and itaconic acid co-polymer (MIP) is barely effective compared to other urease inhibitors. Canatoy et al. emphasized the importance of tailored N rate and deeper N placement in reducing ammonia loss in rice cultivation. Nitrous oxide (N_2O) is a potent GHG. Jin et al. found that organic fertilizer mixed with N fertilizer can effectively reduce N_2O emissions, increase both the grain yields and quality in wheat field compared with N fertilizer alone. Following a combined analysis using laboratory, field, and modeling approaches, Khalifah et al. found that biosolids could mitigate GHGs emissions in agricultural practices over the long term even though an initial surge existed. Silicon is a "quasi-essential" nutrient for higher plant and has been widely reported to mitigate a range of biotic and abiotic stresses (Souri et al., 2021). In this Research Topic, Hoffman et al. found that supplemental silicon could decrease seasonal N_2O emissions by ~30%, but underlying mechanisms are still unknown and need future study.

Taken together, this Research Topic provides insight into the latest findings and developments that contribute to our growing understanding of approaches to estimate and reduce soil GHGs emissions. Mitigation of soil GHGs emissions through optimization of nutrient management practices remains a hot topic. Soil is a highly heterogeneous and complex system and soil GHGs emissions are influenced by both natural and anthropogenic factors, leading to varied soil GHGs emissions across regions and agricultural practices. Therefore, development of site-specific and advanced techniques that could mitigate soil GHGs emissions are necessary to achieve the goal of "net zero".

Author contributions

RY: Funding acquisition, Writing – original draft, Conceptualization. WL: Writing – review and editing. YY: Writing – review and editing. YZ: Writing – review and editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This work was partly financed by the Open Project of the Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of Natural Resources (grant No. SXDJ2024-18) and Agricultural Science and Technology Innovation Project of the Chinese Academy of Agricultural Sciences (grant No. 34-IUA-04).

Acknowledgments

We thank all contributing authors for their participation in the Research Topic.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

Publisher's note

References

Basheer, S., Wang, X., Farooque, A. A., Nawaz, R. A., Pang, T., and Neokye, E. O. (2024). A review of greenhouse gas emissions from agricultural soil. *Sustainability* 16, 4789. doi:10.3390/su16114789

Chataut, G., Bhatta, B., Joshi, D., Subedi, K., and Kafle, K. (2023). Greenhouse gases emission from agricultural soil: a review. *J. Agric. Food Res.* 11, 100533. doi:10.1016/j.jafr.2023.100533

Hansen, J. E., Kharecha, P., Sato, M., Tselioudis, G., Kelly, J., Bauer, S. E., et al. (2025). Global warming has accelerated: are the united nations and the public well-informed? *Environ. Sci. Policy Sustain. Dev.* 67, 6–44. doi:10.1080/00139157.2025.2434494

Kopittke, P. M., Dalal, R. C., McKenna, B. A., Smith, P., Wang, P., Weng, Z., et al. (2024). Soil is a major contributor to global greenhouse gas emissions and climate change. *SOIL* 10, 873–885. doi:10.5194/soil-10-873-2024

Souri, Z., Khanna, K., Karimi, N., and Ahmad, P. (2021). Silicon and plants: current knowledge and future prospects. *J. Plant Growth Regul.* 40, 906–925. doi:10.1007/s00344-020-10172-7

Valujeva, K., Pilecka-Ulcugaceva, J., Darguza, M., Siltumens, K., Lagzdins, A., and Grinfelde, I. (2024). Environmental parameters and management as factors affecting greenhouse gas emissions from clay soil. *Acta Agric. Scand. B Soil Plant Sci.* 74. doi:10.1080/09064710.2023.2290828

Weil, R. R., and Brady, N. C. (2017). *The nature and properties of soils*. 15th edition. Harlow, England: Pearson Education Limited.

Wu, H., Cui, H., Fu, C., Li, R., Qi, F., Liu, Z., et al. (2024). Unveiling the crucial role of soil microorganisms in carbon cycling: a review. *Sci. Total Environ.* 909, 168627. doi:10.1016/j.scitotenv.2023.168627