frontiers | Frontiers in Environmental Science

TYPE Editorial
PUBLISHED 09 January 2023
DOI 10.3389/fenvs.2022.1127269

Check for updates

OPEN ACCESS

EDITED AND REVIEWED BY
Angela Helen Arthington,
Griffith University, Australia

*CORRESPONDENCE
Amit Kumar,
amitkdah@nuist.edu.cn

SPECIALTY SECTION
This article was submitted to Freshwater Science,
a section of the journal
Frontiers in Environmental Science

RECEIVED 19 December 2022
ACCEPTED 27 December 2022
PUBLISHED 09 January 2023

CITATION
Kumar A, Thakur TK and Yu ZG (2023), Editorial: Wetland ecosystems as important greenhouse hotspots. *Front. Environ. Sci.* 10:1127269.
doi: 10.3389/fenvs.2022.1127269

COPYRIGHT
© 2023 Kumar, Thakur and Yu. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Editorial: Wetland ecosystems as important greenhouse hotspots

Amit Kumar[1]*, Tarun Kumar Thakur[2] and Zhi Guo Yu[1]

[1]School of Hydrology and Water Resources, Nanjing University of Information Science and Technology, Nanjing, China, [2]Department of Environmental Science, Indira Gandhi National Tribal University (A Central University), Amarkantak, Madhya Pradesh, India

KEYWORDS

wetland, climate change, terrestrial ecosystem, CH4 (methane), carbon balance and management

Editorial on the Research Topic
Wetland ecosystems as important greenhouse hotspots

Wetlands are highly valued for their rich diversity (flora and fauna), hydrological attributes, ecological productivity, and ecosystem services. Furthermore, wetlands behave as a potential source/sink of atmospheric greenhouse gases (GHG, especially CH_4) as well as supporting carbon (C) sequestration, thereby contributing to the global C balance. The dense vegetation patterns, algal activity, and terrestrial soils of wetland ecosystems regulate organic matter (OM) decomposition processes, producing a significant amount of global GHG (Lian et al.). Conversely, some types of wetlands may be more efficient at capturing atmospheric C than rainforests. Pant et al. (2003) highlighted that wetlands are invaluable C sinks, contributing the highest C density among terrestrial ecosystems, while floods suppress CO_2 emissions but also generate a significant amount of methane (Zhang et al., 2020). Although wetlands occupy only 5%–8% of the earth's land surface, they regulate ~68% of terrestrial soil C reserves, thereby playing a decisive role in global C budgets. In recent decades, anthropogenic activities in numerous catchments alter the geochemical process (Khan et al.). Moreover, rapid increases in urbanization have disturbed land use and land cover (LULC), thereby increasing atmospheric GHG concentrations. Globally, carbon dioxide (CO_2) has been increasing at 1.7 ppmv yr^{-1} (equivalent to 46% yr^{-1}) resulting in global warming and numerous associated impacts on ecosystems and human societies. Thus, mitigation of global warming is a central theme of worldwide discourse (UNSECC, 2022).

Wetland ecosystems have often been neglected, despite providing a wealth of provisioning, regulatory, cultural, and supporting services valuable to humans. Recently, Peng et al. (2022) quantified changes in CH_4 sources and atmospheric sinks in 2020 compared with 2019, finding that globally, "total anthropogenic emissions decreased by 1.2 ± .1 teragrams of methane per year (Tg CH_4 yr^{-1}), fire emissions decreased by 6.5 ± .1 Tg CH_4 yr^{-1} yet wetland emissions increased by 6.0 ± 2.3 Tg CH_4 yr^{-1}". A balance between these exchanges is vital to understand how restoration or expansion of wetlands areas can help to mitigate climate change. Since the 1900s, due to LULC changes about 64%–71% of wetlands ecosystems have been degraded or lost, which has affected their nutrient concentrations and dynamics resulting in GHG emissions (Davidson, 2014). However, the state of those that remain is unclear. The prime goal of this Research Topic is to provide an opportunity for global scientists to understand wetland hydrology, the process and transport mechanism of OM degradation, and key factors influencing GHG emissions so that nature-based cimatic solutions can be implemented systematically Figure 1.

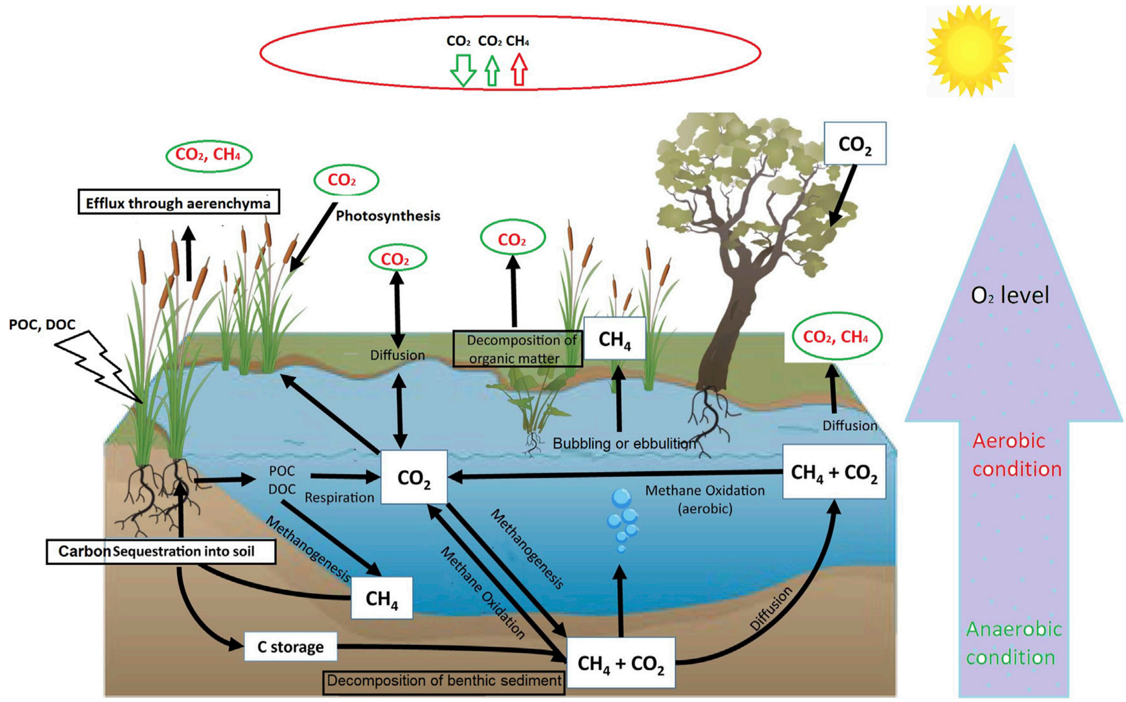

FIGURE 1
Schematic diagram of wetland emission, transport, and pathways [modified from Limpert et al., 2020; particulate organic matter (POC), dissolved organic carbon (DOC)].

A recent global meta-analysis found that natural wetlands were "net sinks of atmospheric CO_2 and net sources of CH_4 and N_2O, exhibiting the capacity to mitigate greenhouse effects due to negative comprehensive global warming potentials (GWPs; -.9 to -8.7 t CO_2 -eq ha^{-1} $year^{-1}$)" (Tan et al., 2020). This analysis and other studies further highlight that the spatio-temporal variability in GHG emission is primarily sensitive to changes in water temperature, surface water content, chlorophyll-a, soil nitrogen content, bulk density, and soil pH (Kumar et al., 2022; Liu et al.; Malyan et al., 2022; Zhou et al., 2022).

Wetlands including reservoirs are the hotspot of CH_4 emissions and accounted for about 1/3rd of total anthropogenic and natural CH_4 emissions. Wetlands located in tropical and subtropical eco-regions contribute nearly 50% of total wetland CH_4 emissions (equivalent to over 80% of natural sources), due to high temperatures, a large change in drying and wetting cycles, and large areas of inundated wetlands (Zhang et al., 2017). For example, Yang et al. found large uncertainty in the GHG measurements and predictions due to the paucity of available datasets and stated that large-scale field measurements are required in a range of environmental contexts, especially in less studied areas of tropical eco-regions, to understand the key factors impacting the GHG potential.

Zou et al. (2022) stated that between 2021 and 2100, wetlands emit ~408 gigatons (Gt) of CO_2. However, the rewetting effect could reduce GHG potential at a large scale. Notably, GHG budgets from wetland ecosystems are highly sensitive to changes in the wetland area and shallower groundwater table (Peng et al., 2022). Therefore, the resulting impact on future climates could be depending on the balance between future restoration and degradation. Bridgham et al. (2013) reveal that major uncertainties in estimating GHG emissions, in particular CH_4 emissions, from wetlands ecosystems include: i) several important controls over transport, consumption, and production of CH_4 not being inadequately considered in the existing biogeochemistry models ii) errors in the local, national and global emission estimates mainly due to large spatial-scale extrapolations from poorly mapped wetland complexes iii) limited Spatio-temporal GHG datasets and factors impacting emission loosely constrains the parameterization of process-based biogeochemistry models. Thus, long-term *in situ* measurements of CH_4 emissions from managed and natural wetlands are therefore crucial for précised GHG estimation and prediction.

Guest editors involved in this Research Topic hope that the review/research/mini articles published will help environmentalists, policymakers, water resources planners and managers to understand the carbon storage and release dynamics of natural and artificial wetland ecosystems. Guest editors further highlight that changes in LULC play a vital role in stimulating GHG fluxes, which therefore need more attention to modeling (e.g., land surface models) and the framing of new land-use and artificial wetland (e.g., reservoir) management policies at regional and global scales. Multidisciplinary approaches integrating hydrology, geomorphology, sediment dynamics, and biology, are urgently needed to resolve problems of wetland degradation and loss, and for fruitful restoration and conservation of wetland ecosystems to enhance their capacity to sequester GHGs and reduced emissions whilst also providing valued ecosystems services. Comyn-Platt et al., 2018.

Author contributions

AK: conceptualization, writing initial draft, review, and editing; TT and ZY: review and editing. All the authors read the final version and approved it for publication.

Funding

Present work has been supported by the National Science Foundation of China (Project No. 52150410400).

Acknowledgments

Editors are thankful to the contributors and reviewers for the timely review and feedback.

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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Bridgham, S. D., Cadillo-Quiroz, H., Keller, J. K., and Zhuang, Q. (2013). Methane emissions from wetlands: Biogeochemical, microbial, and modeling perspectives from local to global scales. *Glob. Change Biol.* 19, 1325–1346. doi:10.1111/gcb.12131

Comyn-Platt, E., Hayman, G., Huntingford, C., Chadburn, S. E., Burke, E. J., Harper, A. B., et al. (2018). Carbon budgets for 1.5 and 2 °C targets lowered by natural wetland and permafrost feedbacks. *Nat. Geosci.* 11, 568–573. doi:10.1038/s41561-018-0174-9

Davidson, N. (2014). How much wetland has the world lost? Long-term and recent trends in global wetland area. *Mar. Freshw. Res.* 65, 934–941. doi:10.1071/mf14173

Kumar, A., Mishra, S., Bakshi, S., Upadhyay, P., and Thakur, T. K. (2022). Response of eutrophication and water quality drivers on greenhouse gas emissions in lakes of China: A critical analysis. *Ecohydrology* 10, 2483. doi:10.1002/eco.2483

Limpert, K. E., Carnell, P. E., Trevathan-Tackett, S. M., and Macreadie, P. I. (2020). Reducing emissions from degraded floodplain wetlands. *Front. Environ. Sci.* 8, 8. doi:10.3389/fenvs.2020.00008

Liu, Y. X., Abdela, K. A., Tang, Z. N., Yu, J. Y., Zhou, X. D., Kumar, A., et al. (2022). Impacts of surface water interchange between urban rivers and fish ponds in chu river of nanjing, China: A potential cause of greenhouse gas emissions. *Front. Environ. Sci.* 10, 1084623. doi:10.3389/fenvs.2022.1084623

Malyan, S. K., Singh, O., Kumar, A., Anand, G., Singh, R., Singh, S., et al. (2022). Greenhouse gases trade-off from ponds: An overview of emission process and their driving factors. *Water* 14, 970. doi:10.3390/w14060970

Pant, H. K., Rechcigl, J. E., and Adjei, M. B. (2003). Carbon sequestration in wetlands: Concept and estimation. *Food Agric. Environ.* 1 (2), 308–313.

Peng, S., Lin, X., Thompson, R. L., Xi, Y., Liu, G., Hauglustaine, D., et al. (2022). Wetland emission and atmospheric sink changes explain methane growth in 2020. *Nature* 612, 477–482. doi:10.1038/s41586-022-05447-w

Tan, L., Ge, Z., Zhou, Z., Li, S., Li, X., and Tang, J. (2020). Conversion of coastal wetlands, riparian wetlands, and peatlands increases greenhouse gas emissions: A global meta-analysis. *Glob. Chang. Biol.* 26 (3), 1638–1653. doi:10.1111/gcb.14933

Unsecc (2022). *United nations sharm el-sheikh climate change conference november 2022*. Egypt: UN Framework Convention on Climate Change – UNFCCC. https://enb.iisd.org/sharm-el-sheikh-climate-change-conference-cop27-summary20. Dec, 2022).

Zhang, D., Feng, J., Yang, F., Wu, J., Jia, W., and Cheng, X. (2020). Shift in functional plant groups under flooding impacted ecosystem C and N dynamics across riparian zones in the three gorges of China. *Sci. Total Environ.* 724, 138302. doi:10.1016/j.scitotenv.2020.138302

Zhang, Z., Zimmermann, N. E., Stenke, A., Li, X., Hodson, E. L., Zhu, G., et al. (2017). Emerging role of wetland methane emissions in driving 21st century climate change. *Proc. Natl. Acad. Sci. U. S. A.* 114, 9647–9652. doi:10.1073/pnas.1618765114

Zhou, X. D., Kumar, A., Wang, H. Y., Knorr, K. H., Chen, Y., Liu, Y., et al. (2022). Greenhouse gas emissions hotspots and drivers of urban freshwater bodies in areas of the Yangtze River delta, China. *Ecohydrology* 2. 2498. doi:10.1002/eco.2498

Zou, J., Ziegler, A. D., Chen, D., McNicol, G., Ciais, P., Jiang, X., et al. (2022). Rewetting global wetlands effectively reduces major greenhouse gas emissions. *Nat. Geosci.* 15, 627–632. doi:10.1038/s41561-022-00989-0