**CC1: 'Comment on egusphere-2024-1047', Nasrollah Sepehrnia, 27 Jul 2024**

This study investigates the impact of nutrient enrichment on carbon gas production in subarctic peatlands. Authors have examined addition of nitrogen and phosphorus to soil samples from bogs and fens, and observed varied effects on CO2 and CH4 production, indicating complex interactions between nutrient levels and carbon cycling in these regions. The results have illustrated the importance of nutrient enrichment on microbial activity and carbon turnover in nutrient-poor subarctic soils. I think this lab experiment can provide strong evidence for conducting large-scale studies. I recommend the manuscript for publication after consideration of the following comments (minor revisions).

We thank the community reviewer for reading our preprint and providing suggestions for improvement. We have made the suggested changes in the revised manuscript. Note that this includes the pertinent remark that the lab results presented support conducting large-scale field studies. We have added this as one of our conclusions in section 4 (Future research suggestions) of the revised manuscript. "Future experiments should more systematically investigate various nutrient supply scenarios across different time scales and peatland types for conducting large-scale studies." [revised l. 433-434]

1- Introduction

Authors may provide readers with clear hypotheses (in one or two sentences) and objectives afterward " …..but the effects of sudden nutrient inputs to the peatland soils remain poorly understood….."

We have improved the phrasing of our study goals accordingly, as follows:

"In this study, our aim was to investigate the hypothesis that the addition of dissolved inorganic N and P enhances organic matter decomposition and carbon gas production in subarctic peatland soils. We further anticipated that variations in nutrient ratios (N:P, C:N, C:P) and among different soils, and the associated adaptations of the soil microbial communities would contribute to understanding the short-term responses of different types of peatlands to additional N or P (Hill et al., 2014; Hoyos-Santillan et al., 2018). A laboratory soil incubation experiment was conducted to compare the $CO_2$ and $CH_4$ production rates in the field-sampled bog or fen soils under various treatments: control, N only, P only, and both N and P (NP hereafter) addition. "Fluctuating temperatures were imposed during the month-long incubation to analyze the temperature sensitivity of the gas production rates in the different nutrient treatments." [revised l. 122-124]

-Authors may rephrase lines 60-70 to highlight the following hypotheses accordingly.

**Completed:** Thanks for this comment. We have revised the introduction section according to the specific comments from Referee #1, and believe the changes improved the expression of the hypotheses.

-Why nutrient addition in subarctic peatland soils?

The research context for the experiments with added nutrients (dissolved N and P) is explained in the introduction section of the preprint. In summary, there have been recent observations of increased nutrient levels in the study region that have been attributed to ongoing permafrost thaw. Given the accelerating permafrost thaw in the subarctic regions, more peatland soils are likely to experience nutrient enrichment, which in turn may alter the biogeochemistry of those organic rich soils (especially in regard to soil organic carbon decomposition and carbon gas release).

-Microbial Responses in the short-term and the impacts?

Given the limitations of lab-based incubation experiments, we restricted ourselves to monitoring the potential immediate responses of peatland soils to added N and P. Our short-term exploratory study can provide a basis for future research on long-term impacts of nutrient enrichments, including though in-field manipulation studies.

-Nutrient enrichment and GHG emission in subarctic peatland soils?

The impacts of nutrient enrichment in various soil environments have been studied in relation to direct human-driven pressures such as agricultural expansion and fertilizer use. However, the impacts of nutrient enrichment in remote subarctic peatland soils remain largely unexplored, despite evidence that permafrost thaw and expanding forest fires can increase the delivery of N and P. Thus, with our study, we wish to raise awareness of this issue, especially given the large amounts of organic carbon stored in northern peatlands.

2- Materials and methods

This part is organized very well.

Thank you for your positive comment about the Materials and Method section.

3- Results and discussion

The results are described very well using the illustrated figures and tables. Authors may compare their results with other relevant studies (e.g., from the cited Refs) in the following parts.

"3.1 Transient changes in the soil CO2 and CH4 production and, 3.2 Variations in the temperature sensitivity of CO2 and CH4 productions"

**Completed.** Thanks for your comment and suggestion. We have revised the manuscript, and the findings are now discussed in comparison with some recent studies we have cited. The revised text now reads:

"The temperature sensitivities estimated here suggest that the alleviation of nutrient limitation may result in either relatively high $CO_2$ production rates at the lower temperatures tested (according to the low $Q_{10}$ values for both NP, bog P, and fen N), or high $CO_2$ production rates at the higher-end temperatures (according to the high $Q_{10}$ for bog N and fen P), or some

combination of both trends. Recently, Liu et al. (2022) suggested that the catalytic efficiency of hydrolytic enzymes involved in soil N and P recycling significantly increases with increasing temperature. This would imply that microbial respiration at warmer temperature would become less dependent on the initial soil and N and P stores. However, as shown by our results, the coupled effects of nutrient limitation and temperature may be more complex than currently recognized. A better predictive understanding of the variations in $Q_{10}$ values across peatland classes remains a crucial task for the calibration of process-based C cycle models of peatlands (Bona et al., 2020). For example, the recently observed latitudinal increase of $Q_{10}$ values for $CO_2$ production in peat soils (Byun et al., 2021) could point to an increasing severity of nutrient limitation for peatlands at high latitudes." [revised l. 309-322]