Temperature Sensitivity of Soil Greenhouse Gases Production in a Subtropical Wetland Ecosystem in Hong Kong

Lee Sung Ho
Advisor: Prof. Derrick LAI Yuk Fo
Department of Geography and Resource Management, CUHK

BACKGROUND

Global greenhouse gases (GHGs) emissions have been increasing unprecedentedly throughout the past century. The biosphere has an important role in regulating atmospheric composition through terrestrial uptake and release of GHGs. Warmer global temperatures might boost microbial respiration rate, accelerating the release of GHGs into the atmosphere, generating potential positive feedback. Wetlands are one of the largest carbon reservoirs among rest of the soils in the world, carrying more than 30% of the world's soil carbon, storing 5 to 50-fold greater amount of soil carbon their upland counterparts. Wetland methane emissions are the largest natural source of the global CH_4 budget. Together with the anaerobic emission of N_2O, their high global warming potentials has an important contribution towards global climate change. The temperature sensitivity of wetland GHG emissions is therefore important in enhancing our understanding and modelling on climate change.

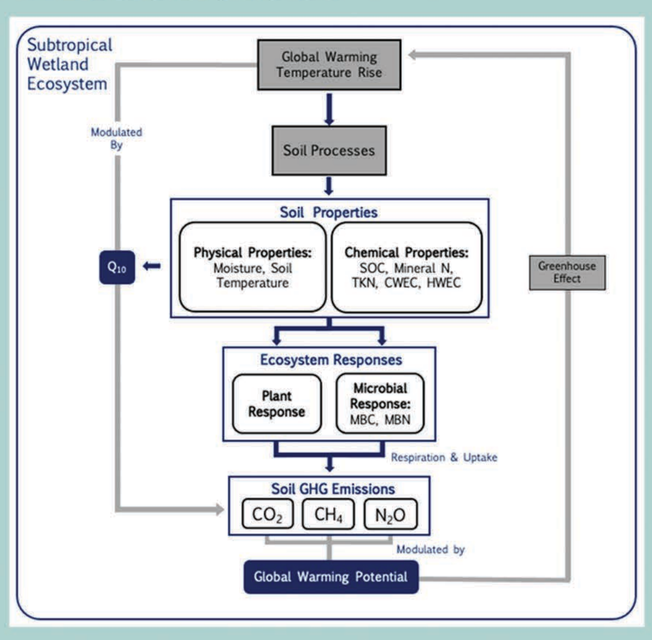
OBJECTIVES

1. To investigate GHG production across the soil profiles at different parts of the wetland
2. To assess the effect of different scenarios of temperature increase in GHG production across the soil profile of the wetland
3. To evaluate the effect of temperature increase on the ratio between various GHGs thus global warming potential (GWP)
4. To study the impact of temperature change on soil physiochemical properties and microbial activity
5. To relate the trends of GHG production in wetland under warming through soil physiochemical properties and microbial activities

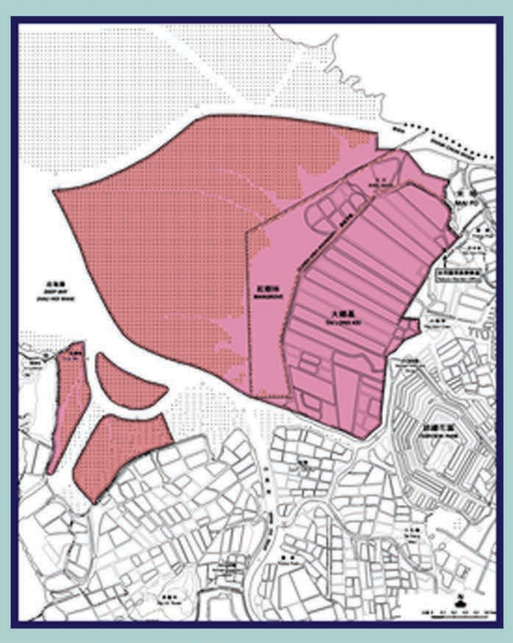
SIGNIFICANCE

1. Filling the research gaps in the field of understanding the interactions of wetland ecosystems with the atmosphere
2. Few studies have focused on subtropical wetlands potential effects of warming on the GHG productions in various forms of wetlands globally

METHODOLOGY



RESEARCH FRAMEWORK



STUDY AREA: Mai Po Nature Reserve

DATA COLLECTION

Sampling:

Open mudflat, soil depths 0-10, 30-40, 50-75, 75-100cm

Data measurement:

1. Soil Incubation
   - 31 days, at T=15,25,35°C reflecting Hong Kong's climate
2. Gas chromatography on soil GHG production
   - CO_2, CH_4, N_2O: most commonly generated in wetland and terrestrial ecosystems, major influential biogenic GHGs towards climate change
3. Measurement of soil physiochemical and microbial properties
   - TOC, TKN, DOC, DON, CWEC, HWEC, Mineral N, MBC, MBN

Statistical Analysis:

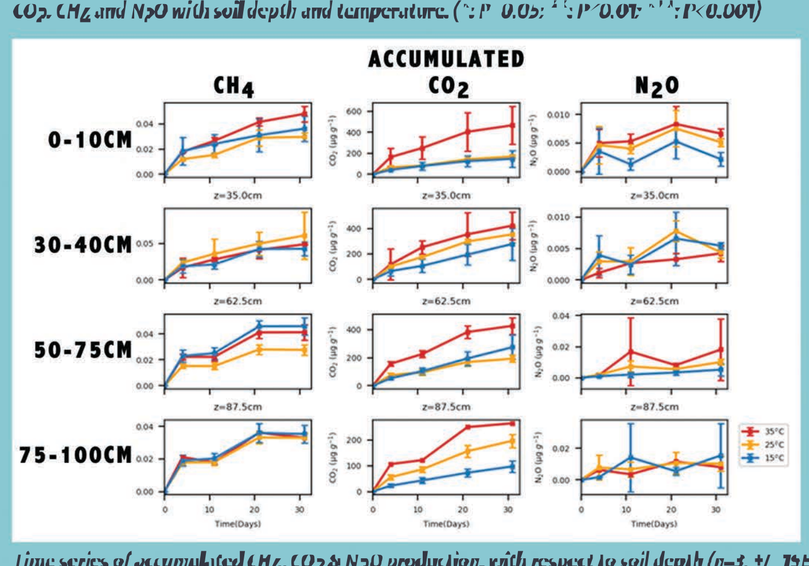
- Two-way ANOVA with regrssion: analyze R_{20} & Q_{10} difference in temperaure and depth
- Correlation analysis: analyze relationship between R_{20} & Q_{10} and soil properties
- Multiple linear regression: analyze relative importance of soil properties on R_{20} & Q_{10}

RESULTS

1. Net emissions of CO_2 increased with temperature ($p = 0.019$),
   Temperature sensitivity Q_{10} of CO_2 R_{20} is 1.33-1.84.
2. No significant CH_4 and N_2O net production change with warming temperature ($p > 0.05$)

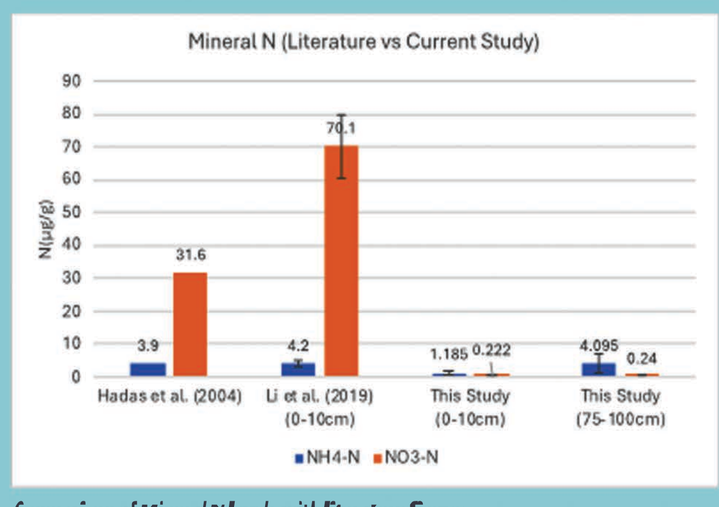
		R_S CO_2		R_S CH_4		R_S N_2O	
Factors	*df*	*F*	*p*	*F*	*p*	*F*	*p*
Temperature (T)	2	11.006	<0.001***	1.145	0.358	1.834	0.179
Soil Depth (z)	3	0.599	0.624	0.352	0.708	0.425	0.660
T x z	6	0.403	0.967	0.954	0.483	0.188	0.976

Two-way Analysis of Variance (ANOVA) via regression for the changes in soil microbial respiration rate of CO_2, CH_4 and N_2O with soil depth and temperature. (: P< 0.05; **: P<0.01; ***: P<0.001)*



Time series of accumulated CH_4, CO_2 & N_2O production, with respect to soil depth (n=3, +/- SE)

3. No significant difference in GHG producton rate across soil profile
4. CO_2 production rate significantly correlated with MBC and C:N ratio (p=0.010 and p=0.019)
   - No correlation with other soil parameters ($p > 0.05$)
   - MBC negatively correlated with CO_2 R_{20}, contradicting previous studies
   - Labile C fractions did not directly contribute towards microbial growth
5. Q_{10} positively correlated to MBC (p=0.37)
6. N deficiency restricted microbial growth and metabolism in soils, leading to low CO_2 production
   - High microbial C:N (36-60) limited microbial metabolism
   - Limited increase in R_{20} under warming, small Q_{10} obtained



Comparison of Mineral N levels with literature figures

Properties	CO_2 R_{20}	CO_2 Q_{10}
Substrate		
CWEC	-0.209	0.185
HWEC	-0.104	0.034
DOC	0.228	-0.377
DON	0.312	-0.428
TKN	-0.034	0.184
TOC	0.518	-0.268
NH_4^+	-0.011	0.317
NO_3^-	0.266	0.044
Microbe		
MBC	-0.736**#	0.632*#
MBN	-0.358	0.412
Ratio		
C:N	0.688*#	-0.583#

Correlation between soil microbial respiration rate at 20°C (R_{20}) and temperature sensitivity (Q_{10}) related to soil substrate, microbial properties and ratios (: P 0.05; **: P<0.01; ***: P<0.001; #: C.I. excludes 0)*

LIMITATIONS

- Disrupted experiment during COVID19, led to prolonged storage of soil samples and depletion of nutrients
- Absence of water-logged conditions and anaerobic environment, causing no CH_4 and N_2O production
- Limited spatial and temporal coverage of the experiment

FUTURE STUDIES

- Influence of individual soil properties on soil GHG production
- Soil microbial responses under global warming from biological perspective
- Carry out similar studies incorprating field measurements of soil GHG fluxes