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Characteristics and influencing factors of greenhouse gas emissions from *Takifugu fasciatus* pond aquaculture

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Abstract

Greenhouse gas (GHG) emissions from aquaculture have garnered global attention. *Takifugu fasciatus* is an important high-value fish species in aquaculture in China. During a 182-day study, GHG emissions from the water-gas interface of *T. fasciatus* aquaculture ponds were measured by the static floating chamber-gas chromatography. The average emission fluxes for CO_2, CH_4, and N_2O were respectively 34.56 ± 31.24 $mg \cdot m^{-2} \cdot h^{-1}$, 1.271 ± 1.365 $mg \cdot m^{-2} \cdot h^{-1}$, and 0.0218 ± 0.0386 $mg \cdot m^{-2} \cdot h^{-1}$. By monitoring water quality and meteorological factors, we conducted correlation analysis and discovered that chlorophyll a (Chla) and total ammonia nitrogen (TAN) were the primary environmental drivers of GHG emissions, with a positive association to CO_2, CH_4, and N_2O emissions. In correlation analysis, 16S rDNA sequencing of pond sediment microorganisms indicated that Proteobacteria and *Desulfococcus* stand as the primary contributors to CO_2 emissions, Proteobacteria and *Synechococcaceae* were found to be the main contributors to CH_4 emissions, while Actinobacteria were mainly contributors to N_2O emissions. The comparison results showed that *T. fasciatus* aquaculture ponds produced less GHG emissions than the inland freshwater pond aquaculture. These findings give statistical support for evaluating the *T. fasciatus* aquaculture ponds ecosystems' greenhouse effect and designing targeted emission reduction strategies.

Introduction

China is the largest aquaculture country in the world, with aquaculture production reaching 58,096,100 tons in 2023.

Global warming caused by the greenhouse effect poses a great Threat to the sustained economic and social development of mankind.

Takifugu fasciatus has high nutritional and economic values and is pond cultured in the eastern provinces of China.

Preparation Method

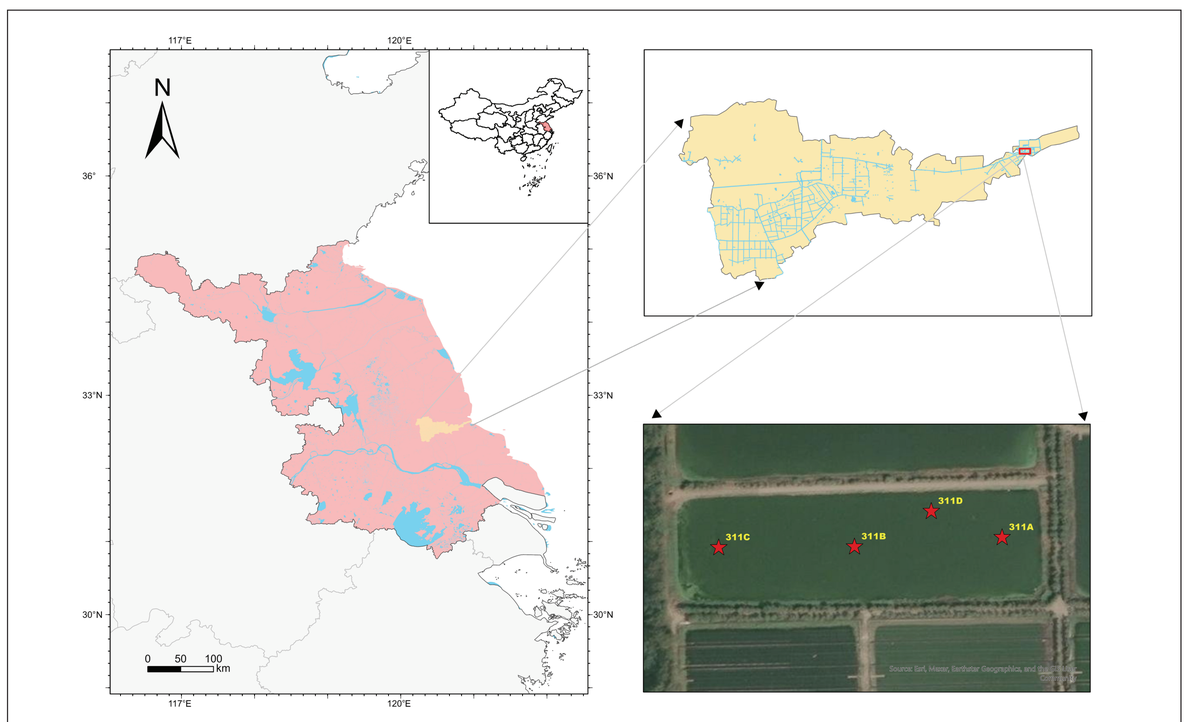

Figure 1. Sampling site for greenhouse gases, water and Sediment samples.

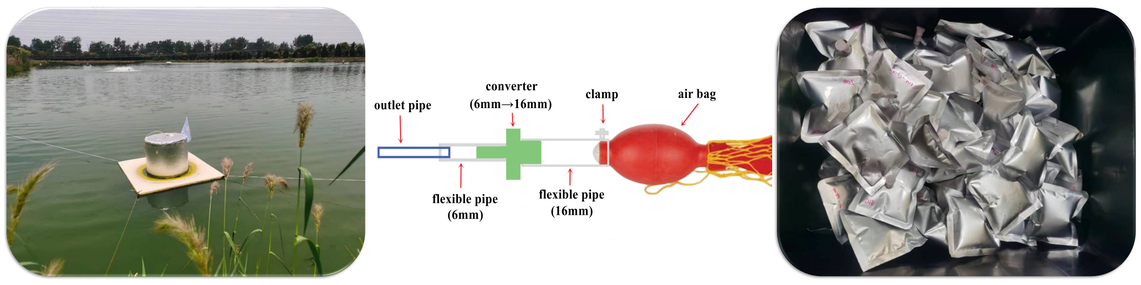

Figure 2. Greenhouse gas collection. CO_2, CH_4, and N_2O fluxes were measured by static floating chamber-gas chromatography. The gas concentrations were analyzed within 24 hours after sampling using a 7890B gas chromatograph (Agilent, USA)

Result & Discussion

The three greenhouse gases, CO_2, CH_4 and N_2O, were the emission sources.

CO2 > CH4 > N2O

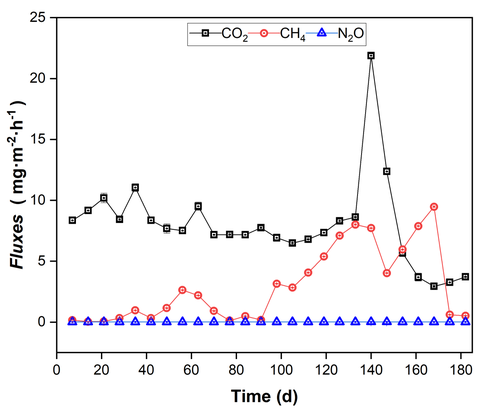

Figure 3. Emission fluxes of CO2, CH4, and N2O from Takifugu fasciatus aquaculture ponds. Data are presented as means ± SD (n = 3).

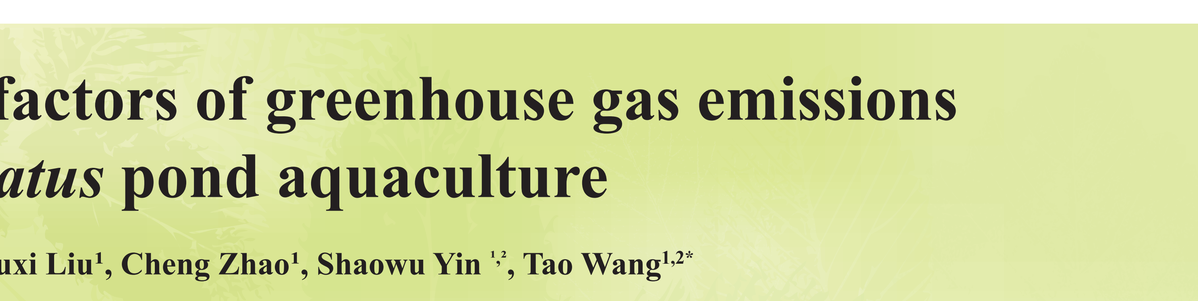

Figure 4. Diurnal variation of greenhouse gas emission flux in tidal flat pond culture. The diurnal variation of CO_2 is mild, and the emission level maintained high throughout the day. The CH_4 emission fluxes during the day were higher than at night.The N_2O flux emission level was low, but varied dramatically from day to night.

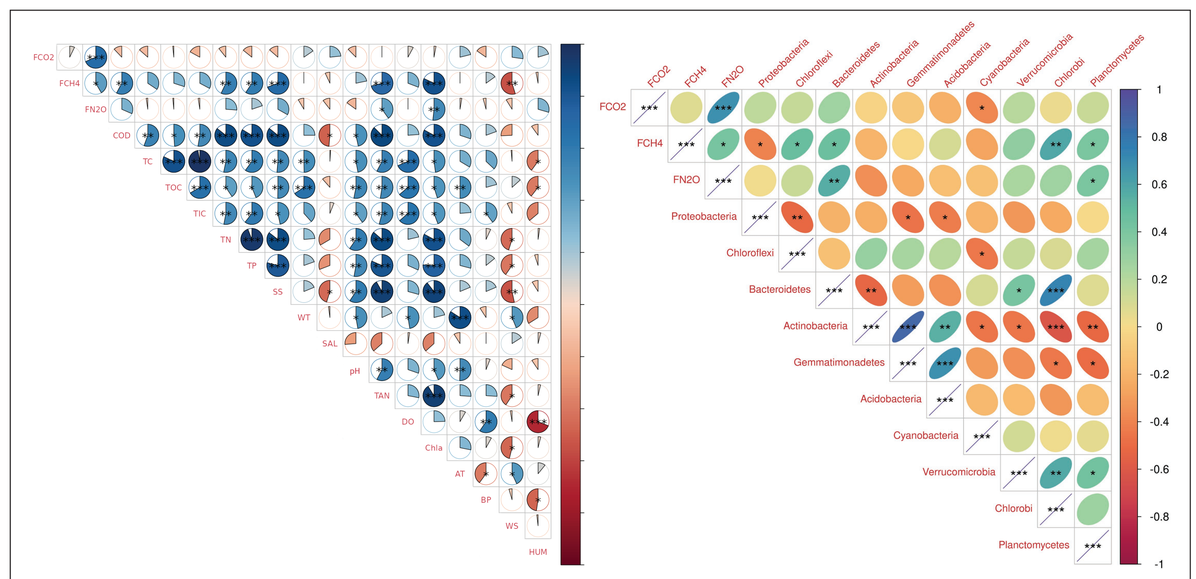

Figure 5 (left). The correlation between greenhouse gas emission flux and environmental factors in *Takifugu fasciatus* aquaculture ponds.
Figure 6 (right). The correlation between greenhouse gas emission flux and sediment microorganisms in *Takifugu fasciatus* aquaculture ponds.
Blue=Positive correlation. Red=Negative correlation. The size of the fan is proportional to the r value. The '*' indicates the significance level (*p < 0.05; **p < 0.01; ***p < 0.001).

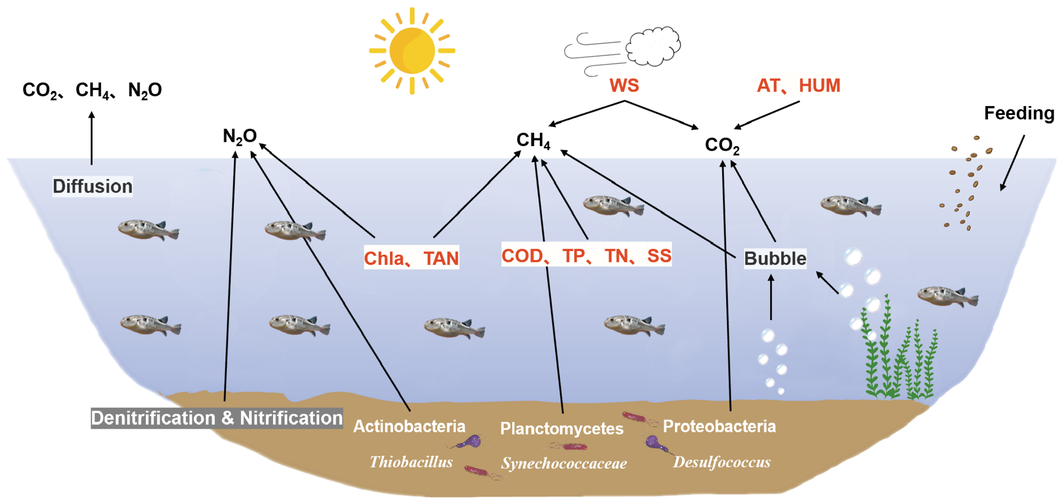

Figure 7. Environmental factors influencing greenhouse gas emission flux in tidal flat pond aquaculture. Wind speed (WS), air temperature (AT), humidity (HUM), and Proteobacteria and *Desulfococcus* in sediments affect CO_2 emission. Chlorophyll a (Chla), total ammonia nitrogen (TAN), chemical oxygen demand (COD), Total phosphorus (TP), total nitrogen (TN), suspended solids (SS), and Planctomycetes and *Synechococcaceae* in sediments affect CH_4 emissions. Chla, TAN, denitrification, nitrification, and Actinobacteriota and *Thiobacillus* in sediments affect N_2O emissions. Feeding of feeds leads to organic matter content in culture water. Bubbling is also a source of CO_2 and CH_4 emissions.

Conclusion

The aquaculture processes in *Takifugu fasciatus* ponds were significant sources of GHG emissions. This study provides basic data for optimizing tidal flat pond aquaculture models and sustainable low-C fishery.

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