# 論文 / 著書情報
# Article / Book Information

| | |
|---|---|
| 題目(和文) | |
| Title(English) | Influencing factors and driving mechanisms for greenhouse gas emissions in eutrophic lakes of the middle and lower Yangtze River Basin |
| 著者(和文) | ZhouChuanqiao |
| Author(English) | Chuanqiao Zhou |
| 出典(和文) | 学位:博士(工学),<br>学位授与機関:東京科学大学,<br>報告番号:甲第343号,<br>授与年月日:2025年3月26日,<br>学位の種別:課程博士,<br>審査員:木内 豪,吉村 千洋,中村 恭志,藤井 学,中村 隆志 |
| Citation(English) | Degree:Doctor (Engineering),<br>Conferring organization: Institute of Science Tokyo,<br>Report number:甲第343号,<br>Conferred date:2025/3/26,<br>Degree Type:Course doctor,<br>Examiner:,,,, |
| 学位種別(和文) | 博士論文 |
| Category(English) | Doctoral Thesis |
| 種別(和文) | 論文要旨 |
| Type(English) | Summary |

（博士課程）
Doctoral Program

# 論 文 要 旨

THESIS SUMMARY

| 系・コース： Department of, Graduate major in | 融合理工学 地球環境共創 | 系 コース | 申請学位（専攻分野）： Academic Degree Requested | 博士 Doctor of | （ 工学 ） |
|---|---|---|---|---|---|
| 学生氏名： Student's Name | Zhou Chuanqiao | | 審査員主査： Chief Examiner | | |

要旨（英文 800 語程度）
Thesis Summary (approx.800 English Words )


Lake ecosystems are interconnected with multiple ecosystems on the Earth's surface, playing a crucial role in the circulation of carbon and other substances on the regional and global scale. With the continuous impact of human activities and climate warming, eutrophication has become a severe environmental issue facing lake ecosystems. The intensification of lake eutrophication has led to the cyanobacteria blooms, which through subsequent biochemical processes, has increased greenhouse gas (GHG) emissions and altered the role of lakes as sources or sinks. However, the factors driving GHG emissions in eutrophic lakes and the potential mechanisms remain unclear. This study focuses on the lake groups in the middle and lower reaches of the Yangtze River Basin in China, an area with a high potential for increased eutrophication. Through field investigation and laboratory simulation experiments, this study tracked the spatiotemporal patterns of eutrophication and GHG emissions in typical lakes of this region, identified the potential influencing factors, and elucidated the mechanism of the eutrophication-altered GHG emission. These findings provide a theoretical and policy basis for lake management and GHG emission assessment.

The main conclusions were summarized as follows:

(1) Results indicated that GHG production and emissions from lake ecosystems in this region are significantly higher than in other areas and positively correlated with eutrophication levels. On the spatial scale, the average $CH_4$ production potential, dissolved $CH_4$ concentrations, and $CH_4$ release fluxes in eutrophic lakes were 268.6, 0.96 $\mu mol \cdot L^{-1}$, and 587.6 $\mu mol \cdot m^{-2} \cdot h^{-1}$, respectively, while they were 215.8, 0.79 $\mu mol \cdot L^{-1}$, and 548.6 $\mu mol \cdot m^{-2} \cdot h^{-1}$ on the temporal scale. Factors including physical and chemical conditions, and nutrient concentrations significantly influence GHG emission. The study revealed that ignoring temporal and spatial variations in factors such as DO and temperature can result in inaccuracies in gross carbon emission estimates, and using summer data leads to an overestimation of gross carbon emissions.

(2) The multiple sources of dissolved organic matter (DOM) in typical eutrophic lakes contribute to the complexity of DOM composition. Lignins constituted the majority of DOM compounds, surpassing 40% of the total, while the organic carbon content was predominantly composed of humic acids (1.02-3.01 g kg 1). The high amounts of lignin oxidative cleavage led to CHO being the main molecular structure in the DOM of the Lake Taihu basin. The elevated DOM concentration, coupled with its intricate composition, contributed to the increases in GHG production and emission. Experiments showed that the unit carbon emission efficiency was highest in the mixed group, reaching 160.9 $\mu mol \cdot C_g^{-1}$, which also exhibited a significantly different carbon pool. The co-metabolic processes induced by the decomposition of multi-source DOM are considered potential driving factors.

(3) Unexpectedly high concentrations of dissolved GHG were observed in the overlying water, accompanied by a significant amount of particulate organic carbon (POC). The carbon isotopic analysis showed that the $\delta^{13}C_{poc}$ ranged from -30.28‰ to -21.14‰, indicating that cyanobacteria-derived carbon is an important source of POC. Therefore, the intensification of eutrophication and the resulting increase in POC concentration is a potential driver for the increased GHG flux. Additionally, the methane paradox was observed, characterized by high concentrations of dissolved $CH_4$ in oxic waters.

(4) Cyanobacteria decomposition in eutrophic lakes altered the carbon storage structure in sediments, leading to the shift of hotspot areas for GHG production. In lakes with hyper-eutrophic conditions, a slight increase in the dissolved $CO_2$ concentrations in the pore-water of surface sediments (-4-0 cm) was observed. Isotope tracing in simulation experiments indicated that cyanobacteria-derived carbon altered the physicochemical environment and organic carbon concentration in surface sediments, resulting in significantly higher $CH_4$ and $CO_2$ concentrations in the pore-water of surface sediment compared to the deeper layer. In the microcosm simulation with the most severe cyanobacteria

accumulation, average $CH_4$ and $CO_2$ concentrations in surface sediments reached 6.9 and 2.3 $mol \cdot L^{-1}$, respectively, surpassing the 4.7 and 1.4 $mol \cdot L^{-1}$ observed in bottom sediments, indicating upward migration of $CH_4$ and $CO_2$ hotspots from deeper to surface layers, which improved emission efficiency. (5) Sulfate ($SO_4^{2-}$) concentration in the overlying water of lakes in the middle and lower reaches of the Yangtze River basin is on the rise and showed a positive correlation with the lake eutrophication levels across spatiotemporal scales. The increasing sulfate concentrations intensify sulfate reduction reactions, leading to the proliferation of sulfate reduction bacteria (SRB). A random forest model was applied to assess the impact of $SO_4^{2-}$ concentrations on $CH_4$ emissions, revealing a significant negative effect. Microcosmic experiments showed a strong negative correlation between $CH_4$ concentrations and initial $SO_4^{2-}$ levels ($R^2$=0.83), indicating that higher initial $SO_4^{2-}$ concentrations led to lower final $CH_4$ concentrations. This was attributed to the competition for cyanobacteria-supplied substrates between SRB, and methane production archaea (MPA).

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

注意：論文要旨は、東京科学大学リサーチリポジトリ(T2R2)にてインターネット公表されますので、公表可能な範囲の内容で作成してください。

Attention: Thesis Summary will be published on Science Tokyo Research Repository Website (T2R2).