An Approach to Riverine Pollutants and Water Quality of China Lake

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Abstract. Economic growth and urbanization in the past decades have resulted in large quantity of riverine pollutants transferring to the significant lakes worldwide, giving rise to serious contamination of the water system and posing significantly harmful effects on the human environment health around the region. Hereinto, as one of the most eutrophic lakes in China, Chaohu lake riverine pollutants influenced greatly the quality of Chaohu Lake water, though it is still playing a critical role in potable water supply and environmental regulation. In this study, three rivers contaminated by agricultural runof (Fengle River and Hangbu River) and by urban wastewater (Nanfei River) in the Lake Chaohu watershed were selected to study the discrepancy of dissolved N2O concentrations and emissions from different types of polluted rivers. The environmental effects exploration of riverine pollutants transported by tributaries might provide useful quantitative information for policy debating to improve pollution measures for the similar lakes.

1. Introduction

Lake water system can provide biodiversity and ecosystem services to human being globally [1, 2]. Economic growth and urbanization in the past decades have resulted in large quantity of riverine pollutants transferring to the significant lakes worldwide, giving rise to serious contamination of the water system and posing significantly harmful effects on the human environment health around the region, causing heavy pollution of the waters, posing significantly harmful effects on the human environment health around the region [2, 3]. Around 90% of the lakes of China are from medium to high eutrophication [1-3]. Hereinto, riverine pollutants influenced greatly the quality of Lake Chaohu, nearly one of the most eutrophic lakes in China, although it still plays an important role in potable water supply and environmental health regulation [3]. The environmental effects exploration of riverine pollutants transported by tributaries on Chaohu water quality might provide useful quantitative information for policy debating to improve environmental health and pollution control measures for the similar lakes in the world. There are few studies related to this pollution analysis around this area [3-5].
As in figure 1 and 2, it is difficult to examine the quantity of pollutants transferred into the lake water system [6-10]. Many rivers of the world are saturated with N₂O due to the increasing nitrogen loads, which have become the potential sources of atmospheric N₂O. It would be great benefited to understand the nitrogen transformation and the contribution of riverine ecosystem to N₂O from the study on the spatial and temporal variations of N₂O production and emissions [8, 9]. Unfortunately, though great deals of researches have been conducted on the N₂O emissions from the terrestrial ecosystems, including forestry, grassland, agricultural fields, and plateau ecosystems in China, however, the data for the riverine ecosystem are sparse. Especially, few studies on the discrepancy of N₂O emissions from different types of polluted rivers of China, the production processes of N₂O, and emissions have been conducted at present [10, 11].

![Figure 1](image1.png)

**Figure 1.** Nitrogen concentration and N₂O dissolved concentration in different levels of tributaries [3, 5, 9].

![Figure 2](image2.png)

**Figure 2.** Response relationship between watershed nitrogen output and river denitrification process [1-3].

In this study, the rivers related to agricultural runoff and urban wastewater in the Lake Chaohu watershed were selected to study the discrepancy of dissolved N₂O concentrations and emissions from
different types of polluted rivers, using the target of Class III water quality. The study might present useful quantitative information for the similar lake water environment globally.

Figure 3. The flux box assay methods.

Figure 4. Location of sampling sites.

2. Models and methods
The Nanfei (NFR), Hangbu (HBR) and Fengle (FLR) Rivers are the major tributaries that contribute most of the total water discharges into Chaohu Lake. In this study, sampling points were set up near the inlet of each river downstream for observation during 2017.

N$_2$O release flux determination is based on flux box assay methods and diffusion model estimation. N$_2$O determination is based on gas and water sample dissolved N$_2$O concentration determination method. Method for determining the concentration of dissolved N in water is by Membrane Inlet Mass Spectrometer. After collecting the water samples on sites, the water samples were filtered into a 60 ml plastic bottle with a 0.45 μm filter, sealed and stored frozen. After the samples were shipped back to the laboratory, the concentrations of NO$_3$- and NH$_4^+$, dissolved oxygen, pH and water temperature were measured.

3. Results and discussion
DIN concentrations in the Nanfei River that receiving substantial urban wastewater was significantly higher than those in the Fengle and Hangbu Rivers that receiving agricultural runoff and leaching. Accordingly, the dissolved N$_2$O concentrations and emissions from the Nanfei River were significantly higher than those of the other two rivers. Regression analysis showed that, both dissolved N$_2$O and emissions were significantly correlated with DIN concentrations. Additionally, dissolved N$_2$O in the Fengle and Nanfei Rivers was positively correlated with DO, while a contrary correlation was detected in the Hangbu River. We did not study the mechanism of N$_2$O production in the three rivers, thus we expected that N$_2$O production could be dominated by nitrification in the Fengle and Nanfei Rivers, while denitrification could be mainly responsible for the N$_2$O production in the Hangbu River. Based on other research results, we can also find that as the river nitrogen load increases, the N$_2$O release flux will increase accordingly.
Table 1. Dissolved inorganic nitrogen and N$_2$O flux in rivers.

| River name  | DIN, mg N L$^{-1}$ | N$_2$O flux, μg N-N$_2$O m$^{-2}$ h$^{-1}$ |
|------------|-------------------|---------------------------------|
| Hudson     | 0.84              | 6.48                            |
| Swale-Ouse | 0.06              | 0.8                             |
| Couesnon   | 10.00             | 63                              |
| Changjiang | 1.18              | 16                              |
| South Platte | 11.20            | 62.1                            |
| Colne      | 7.00              | 36.6                            |
| Schelde    | 2.45              | 2.00                            |
| Seine      | 6.01              | 33                              |
| Lower Seine | 4.49             | 92                              |

$y = 5.52x$ (DIN) + 8.16, $R^2 = 0.49$, $P = 0.04$

The diurnal variation (consecutive 24 hours, 4 hours intervals) study conducted in the Fengle, Hangbu, and Nanfei Rivers in Jun 2017 showed that, dissolved N$_2$O showed no obvious diurnal patterns, while exhibited significant differences at different measurement times. However, the diurnal (consecutive 60 hours, 6h intervals) variation study showed that, an obvious diurnal pattern, lower during daytime while higher at night, on dissolved N$_2$O was detected both in the summer and autumn observations. This result may be resulted by the diurnal variations of DO, NO$_3$-, and the water temperature. In the seasonal variation study, dissolved N$_2$O observed in the three rivers of the Lake Chaohu watershed showed lower values in winter than summer than autumn. However, it is important to note that, N$_2$O emissions across the water-air interface showed no diurnal and seasonal patterns. This is because N$_2$O emissions are regulated by many environmental factors that have no patterns over diurnal and seasonal timescales, like water flow velocity, water surface turbulence. As a result, N$_2$O emissions often showed no diurnal and seasonal patterns.

Table 2. The flux observation significance test (Independent Samples T Test).

| River name | F     | Sig | t    | df  | 2 tailed sig |
|------------|-------|-----|------|-----|--------------|
| Fengle     | 0.54  | 0.48| 3.34 | 10  | 0.008        |
| Hangbu     | 15.48 | 0.003| 4.12| 10  | 0.002        |
| Nanfei     | 3.01  | 0.11| 0.31 | 5.79| 0.77         |
| Total      | 0.29  | 0.60| 0.91 | 34  | 0.42         |

4. Conclusion

It is important to estimate the emissions from different polluted rivers and the variations of dissolved N$_2$O, for resolving river pollutants transports and lake environmental issues. On the seasonal and diurnal variation scales, the N$_2$O dissolved concentrations in the three rivers of Fengle River, Hangbu River and Nanfei River ranged from 0.27-40.66 and 0.28-3.47 μg N-N$_2$O L$^{-1}$, respectively. The saturation range was 128-17434%, 148-1850%, indicating that all three rivers are in level of super-saturation. The dissolved concentration of N$_2$O in the three rivers was slightly higher in autumn, and the concentration of N$_2$O in the three rivers on the diurnal variation scale did not show obvious diurnal law. On the whole, the concentration of dissolved inorganic nitrogen in the Nanfei River polluted by urban wastewater is significantly higher than that of the Fengle River and Hangbu River polluted by agricultural non-point source. Correspondingly, the concentration and saturation of N$_2$O are also significantly higher than that of Fengle River and Hangbu River. There is a significant linear positive correlation between N$_2$O dissolved concentration and released flux and DIN on both seasonal and diurnal variations. Under the influence of
human activities, the increase of river nitrogen load will significantly increase the concentration of N$_2$O dissolved in rivers and release flux. It is critical to reduce the yields of pollutants in the watershed and improve environment issues in the relative rivers around the lake watershed region for the ecosystem of the lake.

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