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Short communication

Littoral zones as the "hotspots" of nitrous oxide (N_2O) emission in a hyper-eutrophic lake in China

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Abstract

N_2O emissions were measured monthly for 1 year using the static chamber method along the littoral and pelagic zones of Meiliang Bay in hyper-eutrophic Taihu Lake. The results indicated that littoral zones were the "hotspots" of N_2O emissions ($-278\sim2\,101\,\mu g\,N_2O\,m^{-2}\,h^{-1}$). While the littoral zone accounted for only 5.4% of the area of Meiliang Bay, the N_2O emissions from the littoral zones were about 43.6% of total emissions from the bay. The importance of spatial variation on N_2O emissions was demonstrated by dividing the lake into four unique zones through cluster analysis. The eulittoral zone was the key area of N_2O emissions with an annual 5% trimmed mean $429.5\,\mu g\,N_2O\,m^{-2}\,h^{-1}$, following by supralittoral ($138.8\,\mu g\,N_2O\,m^{-2}\,h^{-1}$), infralittoral ($98.9\,\mu g\,N_2O\,m^{-2}\,h^{-1}$), and pelagic zones ($15.7\,\mu g\ N_2O\,m^{-2}\,h^{-1}$). Further, N_2O emissions showed a seasonal trend. Excessive N_2O emissions during algal bloom periods suggested that algae played a significant role in the emission of N_2O.

Keywords: Lakeshore; Greenhouse gas; Trace gas; Denitrification; Aquatic system

1. Introduction

It has been suggested that littoral zones, the transitional boundary between terrestrial and aquatic ecosystems, are potential "hotspots" of nitrous oxide (N_2O) production in the landscape (Groffman et al., 1998, 2000). However, insufficient data exist to support this hypothesis, and the currently recommended methodologies of the Intergovernmental Panel on Climate Change (IPCC) do not account for high N_2O production in these zones (Houghton et al., 2001). Complicated spatial variation of N_2O emissions in the littoral zone limits accurate assessment. Seitzinger and Kroeze (1998) estimated that China and Southeast Asia accounted for about 50% of the annual N_2O emissions from rivers, estuaries, and continental shelves based on dissolved inorganic nitrogen export by world rivers. However, field measurements of N_2O emissions from freshwater ecosystems are rare in China, with only one study, which might miss some "hotspots" of N_2O emissions, reporting low N_2O emissions from the center of Taihu Lake (Xiong et al., 2002). Global emissions from lakes have not been estimated (Seitzinger et al., 2000), and the measurement of N_2O emissions from the sensitive littoral zones is

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even more deficient. With the increasingly eutrophic conditions of lakes projected to result in increased N_2O emissions (Huttunen et al., 2003a, b), the documentation of these water systems as potential sources of N_2O is urgent. In this preliminary study, we attempted to identify the "hotspots" of N_2O emissions in a hyper-euptrophic lake and investigated how defined zones could improve field investigation methodologies in water systems.

2. Materials and methods

2.1. Site description

Taihu Lake, a shallow eutrophic lake in a zone of northern subtropical monsoonal climate in China, covers a surface area of 2 338 km^2 with average water depth of 1.9 m. The mean annual air temperature is 14.9–16.2 °C, and the growing season spans from March to November. The agricultural area covers about 48% in this catchment and about 39 100 t N is input into Taihu Lake annually. The study sites were located in hyper-eutrophic Meiliang Bay (N 31°24′–31°32′, E 120°04′–120°14′) in the north part of Taihu Lake (Fig. 1). The bay has an area of 101 km^2, encompassed by hills and 55 km of shoreline, of which 35 km was covered with macrophytes. In the bay, the average concentration of total N was 6.7 mg L^{-1}, total P 0.3 mg L^{-1}, nitrate N 1.6 mg L^{-1}, and chlorophyll-a 57 μg L^{-1} in 2004, and severe algal bloom has been taking place from 1990s. N_2O emissions were measured in two littoral sections (A & B) and two pelagic sites (C1 & C2). In this study, the littoral zone denoted the area between the highest shoreline and the outer limit of floating-leaved vegetation, and the terminology of subzones used follows that of Wetzel (2001) (Fig. 1). Section A was located in a reed-dominated littoral zone, and section B occupied a bare zone without macrophytes and contained only infralittoral zone. Nine sampling sites in section A and three in section B were established along the gradients from open water to shore, marked as A1–A9 (Fig. 1) and B1–B3, respectively. There was few submerged or floating-leaved vegetation in spring from A1 to A3, with A3 at the outer fringe of reed belt. A3–A7 were characterized by *Phragmites australis* with above-ground dry biomass density 3–4 kg m^{-2}. The dominant species in the supralittoral zone was *Miscanthus saccharifloous*. In section B, the interval was 25 m and all sites were within the infralittoral zone and contained little sediment. Sites C1 and C2 were located in the pelagic zone in the north and south part of Meiliang Bay, and they were more than 500 m away from the shore.

2.2. N_2O emissions

N_2O emission measurements were taken monthly from Aug. 2003 to Aug. 2004. The closed-chamber technique was applied, with duplicate chambers at

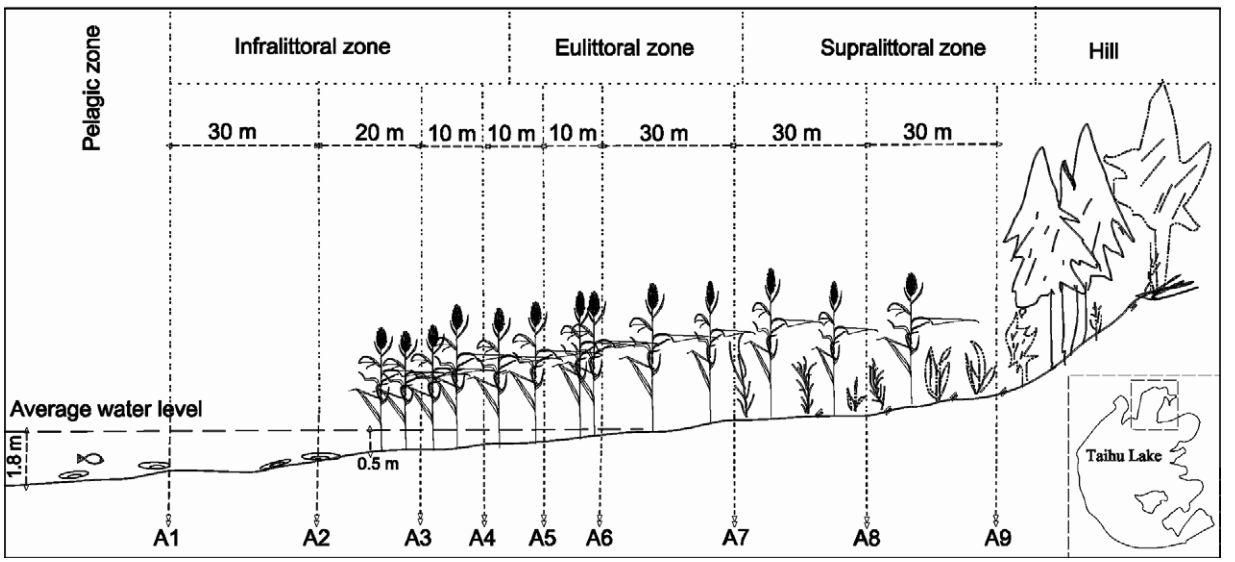

Fig. 1. A schematic of sampling sites in section A.