Determination of Initial Denitrification in Intact Cores under Various Freshwater Wetland Types

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Denitrification rate was determined for various freshwater wetland types in the Mississippi River Coastal delta plain. Site 1 and 4 were collected from forested-tupelo dominated wetland, and site 2 and 3 were from floating emergent marsh. The maximum N2O emission was 7.47 mg N m⁻² for site 1 at day 6 after the addition of nitrate, 6.96 mg N m⁻² for site 2 at day 4, 6.63 mg N m⁻² for site 3 at day 3, and 9.64 mg N m⁻² for site 4 at day 4. The denitrification rate was determined using the acetylene inhibition method 1.24 mg N m⁻² d⁻¹ for site 1, 1.93 mg N m⁻² d⁻¹ for site 2, 2.24 mg N m⁻² d⁻¹ for site 3, and 2.78 mg N m⁻² d⁻¹ for site 4. The maximum denitrification rate was in the order of site 4 > site 3 > site 2 > site 1.

Key words: Denitrification, Nitrous oxide emission, Intact core, Acetylene inhibition

Introduction

Denitrification, which removes nitrogen in such systems, is important because it represents a direct loss to the atmosphere (Knowles, 1982). Nitrogen gas is the major product of denitrification, with N₂O as an intermediate product some of which is released to the atmosphere (Firestone et al., 1980). Denitrification occurs mainly at the sediment-water interface. Nitrate in river water entering Louisiana Wetlands, when in contact with anaerobic soil or sediment surface, can be biologically reduced to gaseous nitrogen (Gale et al., 1993). However, the sediment may also serve as a source of nitrate to the water column. Mineralization of organic-N to ammonium-N and the subsequent nitrification in the surface oxidized layer can also be a source of nitrate to the water column (Miao et al., 2006).

Previous studies have used the acetylene inhibition method or stable isotopic techniques to quantify nitrate removal and denitrification in wetland sediment (Herrman and White, 2008; Miao et al., 2006; Seo and DeLaune, 2010). None of these studies considered the influence of wetland type and removal velocity in intact core on denitrification and nitrate removal. Especially, the removal velocity of nitrate is an important parameter for estimating the amount of nitrate removal with considering the influence of various wetland types in Louisiana marsh.

The objective of this study was to evaluate the denitrification rate under various wetland types in intact core from Louisiana Marsh. The specific objectives were to determine the N₂O emission and denitrification rate in intact cores under different wetland types using acetylene inhibition method.

Materials and Methods

Study site

The Bayou Boeuf Basin is located in southern Louisiana in the Barataria Basin approximately 50 km southwest of New Orleans (Fig. 1). The Boeuf Basin includes a network of bayous and streams with a combined area of approximately 311 km². The overall drainage pattern is towards Lac des Allemands, with inflow from outside the basin occurring at the western end of Grand Bayou (a distributary of Bayou Citamon), and to some extent through Bayou Boeuf via Lac des...
Fig. 1. Major waterways in the Boeuf Basin. The red dashed line indicates watershed boundary, and red arrows indicate breaches in the boundary where water exchange occurs with the greater Barataria Basin (direction of arrows indicates net flow). White circles indicate the location of core sampling sites (1 and 4) in forested wetlands, and Black circles indicate the location of core sampling sites (2 and 3) in floating emergent wetlands.

Allemands during storms or wind induced high water in the greater Barataria Basin. The riot Canal connects to Bayou Lafourche, but hydrological exchange is limited by a gated structure that is normally closed during low flow periods except to allow boats to pass through its opening, which is approximately 8 ft wide. The basin is predominantly forested wetland, with emergent floating marsh at the interior surrounding Lake Boeuf, and agriculture dominating the surrounding uplands. Panicum hemitomon and Sagittaria lancifolia-dominated floating marshes occupy regions in the upper Barataria Basin near Lake Boeuf and Lake Salvador (Swarzenski et al., 1991). Since much of Lake Boeuf is covered by relatively thick densities of floating and/or rooted vegetation, a large portion of Lake boeuf (over 67%) was classified as marsh rather than water (LDEQ, 2004).

The soil cores collected for this investigation were from four sites (Site 1: N29°47′6.09″, W90°41′1.44″; Site 2: N29°46′51.02″, W90°37′27.08″; Site 3: N29°47′49.63″, W90°36′11.86″; Site 4: N29°46′9.20″, W90°36′14.75″; Fig. 1). Sites 1 and 4 were forested-tupelo dominated wetlands, and sites 2 and 3 were from floating emergent marshes.

**Preliminary preparations** Intact soil cores for nitrous oxide emission and denitrification experiments were taken from the four study sites on May, 2009. PVC columns (40 cm in height × 15 cm inside diameter) with sharpened ends were inserted approximately 20 cm into the sediment or plant root complex with emphasis on minimizing compaction. Four cores were taken, stored on ice, and immediately transported back to the laboratory for incubation. The heights of the sediment/root in all cores were adjusted to the same height (17 cm) in the laboratory. The sediment/root-water columns were preincubated at 23°C for one week in order to allow for equilibration and establishment of a thin surface-oxidized layer at the sediment/root-water interface. After the sediment/root-water columns had equilibrated, overlying water was removed.

**Denitrification experiments** The denitrification experiment consisted of four cores are shown in Fig. 2. To provide a nitrate source for measuring nitrous oxide emission and denitrification in cores, 2 mg NO₃-N L⁻¹ was added to the all cores. In all cores, initial NO₃-N + NH₄-N concentrations in the water were mostly below the detection limit (0.01 mg L⁻¹). Denitrification potential of sediment was measured using the acetylene (C₂H₂) inhibition technique, which inhibits reduction of N₂O to N₂ (Tiedje, 1982; Yoshinari et al., 1977). The cores were sealed with a lid containing a septum for sampling and pure C₂H₂ was injected replacing 250 mL (10% C₂H₂ based on the volume of headspace) of the headspace volume of each core. The