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Nitrogen budget of a headwater wetland

LI, Xing[1*] ; TANG, Changyuan[1] ; HAN, Zhiwei[1] ; CAO, Yingjie[1] ; PIAO, Jingqiu[1]

[1]Graduate School of Horticulture, Chiba University

As human activities continue to alter the global nitrogen cycle, understanding of the impact of increased nitrogen loading to freshwater systems is becoming more and more important. The study area is a typical headwater wetland, located at Ichikawa City (35.76oN, 139.97oE), Chiba Prefecture, Japan. The wetland valley is U-shaped with an elevation of about 16 m above sea level. The wetland receives discharge (both groundwater and overland flow) from an adjacent upland (elevation 26-31m) area with vegetation consisting of mostly pear orchard. A stream flowing through the wetland valley is recharged by spring water and groundwater in the wetland. Average flow rate of the stream all around a year is 21.7 L S-1 at the export of the wetland. The wetland is with surface area of 48000 m2, corresponding to 4.7% of the watershed. The uplands are covered by pear orchard, whereas the lowland is wetland. The average nitrate load is 501.9 mg S-1 at export of stream and average dissolved N2O load is 151.9 ug S-1 at export around a year. Ammonia and nitrite were nearly undeletable in the upland groundwater stream water in this study.

For the upland, annual nitrogen inputs refer to the sum of fertilizer application and atmospheric deposition, whereas the outputs refer to root absorption, N2O emission from soil surface and leaching of nitrogen. Nitrogen fertilizer is 346 kg ha-1yr-1 which is relative high to other studies. Annual average N deposition by precipitation over Japan was from 7 to 10 kg ha-1yr-1(with a mean value of 8.5 kg ha-1yr-1) during the past few decades (Hara, 1995). The composition in leaching nitrogen is only nitrate and the leached nitrate is 202 kg ha-1 yr-1in upland. The annual N2O emission was 5.77 kg ha-1 from the upland area.

For the wetland, annual nitrogen inputs refer to the sum of nitrate leaching from upland and atmospheric deposition of wetland. Annual nitrogen outputs refer to the sum of export by stream, and gas emission. The wetland receives 20652 kg-N yr-1 from atmospheric deposition and groundwater which recharge from agricultural upland. The nitrogen exports by stream were 15359.8 kg yr-1. The measured emission of N2O was 61.6 kg yr-1 and the calculated emission of N2 was 5218.6 kg yr-1. As a result, our estimate of N retention for the wetland watershed was 26.5%. Valigura (1996) and Whitall and Paerl (2001) estimated that N retention in urban watersheds ranges from 25% to 95%, with a best estimate of 40%. From the view of literature, the nitrate-nitrogen retention by mass was extremely low in this study. It is assumed that the high loading of nitrogen is a limit factor of nitrogen retention in wetland. The reason that the low percentage of nitrate-nitrogen retention may due to the extremely high load of nitrate input of groundwater (430 g-N m-2yr-1 or 4300 kg ha-1 yr-1). However, the nitrate-nitrogen retention was 110 g-N m-2yr-1 which is much higher than that (39 g-N m-2yr-1 and 46 g-N m-2yr-1) in study of William J. Mitsch (2005) and reach the retention level of constructed wetland.

Direct emission factor EF1 was 0.017 which is higher both than the default values of IPCC 1996 and 2006, but was still in agreement with the range of uncertainty. Indirect emission factor EF5-g was 0.003 which is much lower than the default value of IPCC 1996, whereas it was agreement with the default value of IPCC 2006. EF5-g value in this study was also consistent with the result of (0.0025) another study in Japan (Sawamoto, 2005). Ratio of dissolved N2O and NO3- in groundwater ranged from 0.00026 to 0.0157, with an average value of 0.0025. Using 0.0025 as the EF5-g value would revise the estimation of the indirect emission from this wetland, resulting of 51.5 kg yr-1. The measured emission of wetland was 61.5 kg yr -1 which is the same order of magnitude with calculated value, indicating that the method advised by IPCC could reasonable predict the indirect emission of wetland.

Keywords: nitrogen budget, dissolved N2O, wetland