DYNAMICS OF NITROUS OXIDE EMISSIONS FROM AQUATIC SYSTEMS

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ABSTRACT
Nitrous oxide (N\textsubscript{2}O) is one of the most important non-CO\textsubscript{2} greenhouse gases with a global warming potential 265 times greater than that of CO\textsubscript{2} over a 100-year time span, making it a major contributor to climate change. Recent studies have shown the importance of aquatic systems, including rivers and estuaries, as a major potential source of N\textsubscript{2}O. Global estimates of N\textsubscript{2}O emissions from aquatic systems are 0.25 to 1.26 Tg N yr\textsuperscript{-1} but clarification remains necessary. To consider the effects of vegetation on water flow and sediment transport, N\textsubscript{2}O measurements were conducted at three different points (with dense, sparse, and no vegetation) of the hyporheic zone in a straight channel on October 10\textsuperscript{th}, 2018. To determine the nitrogen dynamics in aquatic systems, the physical properties of water such as water temperature, pH, dissolved oxygen (DO) and electrical conductivity (EC) were measured simultaneously at the same points, while N\textsubscript{2}O measurements and water samples were collected to analyze the concentrations of total nitrogen (TN), ammonia-nitrogen (NH\textsubscript{3}-N), and nitrate nitrogen (NO\textsubscript{3}-N) in surface water.

Keywords: Aquatic systems; greenhouse gas; nitrous oxide; nitrogen dynamics.

1 INTRODUCTION
Nitrous oxide (N\textsubscript{2}O) has a high global warming potential (GWP) of 265 (IPCC, 2013) contributing to climate change and ozone depletion with an estimated approximately 10% of anthropogenic N\textsubscript{2}O coming from the hyporheic zone of rivers and streams (Beaulieu et al., 2011; Reeder et al., 2018; Turner et al., 2015). However, few studies have addressed the significance of N\textsubscript{2}O emissions from the hyporheic zone due to the difficulties associated with the measurement of N\textsubscript{2}O emissions in aquatic systems, given the interactions between atmospheric and terrestrial systems. Therefore, in the present study, measurements of the N\textsubscript{2}O emissions from the hyporheic zone of a stream were conducted to demonstrate that aquatic systems are potentially significant sources of N\textsubscript{2}O emissions.

2 SITE DESCRIPTION
The study site was located in the River Experiment Center of the Korea Institute of Civil Engineering and Building Technology (KICT-REC), Andong-si, Gyeongsangbuk-do, South Korea. According to the meteorological observations made by the automatic weather station of the Andong Meteorological Observatory (N 36.57293°, E 128.70732°; 140.1 m a.s.l.), the annual average air temperature is about 11.9°C (max. 18.0°C and min. 6.6°C) and the annual precipitation is approximately 1,066.4 mm (KMA, 2019).
3 FIELD MEASUREMENTS

The N$_2$O field measurements were conducted in three different patches (with dense, sparse, and no vegetation) in the hyporheic zone of a straight channel measuring 560 m (L) × 11 m (W), with a flow velocity of 10 m$^3$. The distance between the patches in the channel was about 4 m. Using the anchored chamber method with the GC-Headspace Equilibration Technique (RSKSOP-175), the N$_2$O emissions were measured using a floating PVC chamber with a diameter of 16.5 cm and a height of 25 cm at 0, 20, 40, and 60-min intervals (with three repetitions for each patch) on October 10th, 2018. The daily average air temperature, wind speed and relative humidity were about 14.5°C, 1.1 m s$^{-1}$, and 87%, respectively, and there was no precipitation on the day on which the measurements were acquired.

4 RESULTS AND DISCUSSION

The observed N$_2$O emissions from the hyporheic zone in the straight channel varied considerably depending on the location. The patch with no vegetation was revealed to be the largest source of N$_2$O emissions with an average value of 10.4±16.7 μg N$_2$O-N m$^{-2}$ h$^{-1}$, whereas that with sparse vegetation exhibited the lowest N$_2$O emissions with an average value of -0.84±10.3 μg N$_2$O-N m$^{-2}$ h$^{-1}$, followed by that with the dense vegetation at 4.9±7.5 μg N$_2$O-N m$^{-2}$ h$^{-1}$. The effect of the vegetation on the water flow and sediment transport results in these variations in the N$_2$O emissions. In addition, the negative correlation between the N$_2$O emissions and nitrate concentrations in the stream water showed that a denitrification process is the main pathway leading to these N$_2$O emissions in the three patches. The lowest nitrate concentration of 3.05 mg L$^{-1}$ was observed in the patch with no vegetation, which also had the highest N$_2$O emissions. Meanwhile, the highest nitrate concentration (3.35 mg L$^{-1}$) was observed in the patch with sparse vegetation and the lowest N$_2$O emissions. These findings were supported by the results of recent studies by Fu et al. (2018) and Quick et al. (2016), who identified that NO$_3$-N is the dominant factor controlling the amount of N$_2$O in stream water.

5 CONCLUSIONS

In the present study, field observations of N$_2$O emissions from the hyporheic zone of a straight channel were conducted while considering the effects of vegetation on the water flow and sediment transport. Additional field measurements should be undertaken to determine the nitrogen dynamics and thus attain a better understanding of the global N$_2$O budget of aquatic systems.

ACKNOWLEDGEMENTS
This research was carried out as a part of Analysis on Bed Configuration and Hyporheic Flow using Distributed Temperature Sensing for Prediction of Potent Greenhouse Emission and Ecology Habitat Assessment in Fluvial System Project supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. NRF-2017R1A2B4007131).

REFERENCES


KMA. (2019). Observed meteorological data from the automatic weather stations (AWS), Korea Meteorological Administration.

