EFFECT OF DIFFERENT SAMPLING FREQUENCIES ON ESTIMATES OF N_2O FLUX FROM A TEMPERATE GRASS FIELD USING A MICROMETEOROLOGICAL METHOD[1]

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1. INTRODUCTION

There is a need for continuous, long-term measurements of flux to obtain adequate sets of data that will produce reliable estimates of global N_2O emissions. The temporal variability of N_2O fluxes has been reported in many studies, mostly related to rainfall and fertilization events. Micrometeorological methods are ideally suited for continuous flux measurements without interfering with the environment (Lapitan et al., 1999).

The importance of sampling frequency was evaluated by Crill et al. (2000), when measuring N_2O fluxes from a tropical agricultural soil. Gradually decreasing the data set used to calculate a N_2O mean flux from four measurements a day (initial data set) down to one measurement every other day, they observed that the uncertainties of calculated mean flux could vary by as much as 40% or more. The effect of sampling frequency can vary depending on the diurnal cycle of N_2O flux. In their study, Crill et al. (2000) did not observe a diurnal pattern, and their results at lower sampling frequencies varied from larger to smaller than the mean N_2O flux calculated using the whole data set. In contrast, Brumme and Beese (1992) observed a constant overestimated N_2O emission rate using a low sampling rate (once a week, sampled in the morning), and related this to the strong diurnal cycle measured at their site, which was a temperate forest.

The objective of this study was to determine effect of the sampling frequency on monthly estimates of N_2O flux from a fertilized grass field, measured using the flux gradient method.

2. MATERIAL AND METHODS

The data used in this study were collected from June 1997 to March 1998, at the Guelph Turfgrass Institute (GTI), in Guelph, Ontario, Canada. A detailed description of experimental setup is given in Maggiotto et al., 2000.

The site was divided into four plots that received different fertilizer treatments. Close to the centre of the experimental site, four cup anemometers (901-LED, C.W. Thornthwaite Assoc., Elmer, NJ) were placed at 0.30, 0.75, 1.35 and 2.1 m above the ground surface, and a sonic anemometer (CSAT3, Campbell Scientific Inc., Logan, UT) was installed at 1 m. Weather data were collected at the GTI weather station.

Nitrous oxide concentration differences were measured using a tunable diode laser trace gas analyzer (TDLTGA - TGA100, Campbell Scientific Inc., Logan, UT) described in Edwards et al. (1994). The laser used was operated with an absorption line at wavenumber 2201.7 cm^{-1} (serial number 4074-08, Laser Analytics, Inc.), with sensitivity of ± 28 ng N_2O m^{-3}.

The hourly N_2O flux was calculated using the flux gradient method (Arya, 1988), as follows:

$$F = -K_z \frac{\partial C}{\partial z}$$

where F is the flux of the gas (ng m^{-2} s^{-1}), K_z is the eddy diffusivity coefficient at height z (m^2 s^{-1}), $\partial C/\partial z$ is the gas concentration difference that occurs over the distance z (ng m^{-3} m^{-1}). Assuming constant fluxes of momentum and scalars with height within the boundary layer, the gas flux was obtained by the product of the integrated eddy diffusivity and a finite concentration difference ΔC (ng m^{-3}) occurring over a vertical distance Δz (m).

Different sampling frequencies were simulated and compared in terms of average N_2O-N flux, and calculated total N lost as N_2O. Data of only one experimental plot were used, and the monthly loss was estimated using one hourly measurement of the flux as a daily average. The simulated sampling frequencies in this comparison were: continuously, once a day, once every 3 days, and once every 7 days. The hour of measurement was chosen with the objective of simulating a sampling routine in field experiments, with the sample taken at 9:00 h (or 13:00 h when the morning sample was not available).

Comparisons were done for every month when the measurements occurred for more than 50% of the time. This limiting criterion excluded the months of July and December of the analysis.

3. RESULTS AND DISCUSSION

The comparison of the different sampling frequencies simulated for the experimental plot showed a trend of increasing the calculated loss with decreasing number of samples per month for September and October, but there was no clear trend for other months. Table 1 shows the number of hours used for each average. Total monthly losses of N_2O-N for each sampling frequency was calculated using the average flux, and are presented in Fig. 1.

The variability of the estimated loss using different sampling frequencies can be an indicator of a variation of the diurnal fluctuation of N_2O flux, as discussed by Crill et al. (2000) and Brumme and Beese (1992). Less frequent sampling resulted in missed periods of high emissions during fertilizer or rain events, decreasing the average flux for the period in relation to continuous sampling (Fig. 2A versus 2D). On the other hand, the sampling can be done only when emission peaks are occurring. In this case, the calculated average was higher than the continuous sampling average (Fig. 3A versus 3D). To decrease the differences between estimates calculated using different sampling frequencies it would be necessary to use measurements obtained during emission events, as well as during periods when no events occur, so that the basal fluxes are included in calculated averages. In this study, the sampling frequencies simulated were fixed.

4. CONCLUSIONS

The different sampling frequencies simulated resulted in different average N_2O fluxes. The difference in values was mainly because the sampling simulation did not consider the occurrence of emissions events, indicating that using a fixed sampling scheme can result in underestimated or overestimated N loss, depending on specific conditions. This indicates that in case of a non-continuous study, soil and atmospheric conditions should be observed when sampling, rather than defining a fixed sampling frequency, since these factors are the most important affecting fluxes.

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Table 1. Number of hours of measurement (n) for four different sampling frequencies

	Continuous	Every day	Every 3 days	Every 7 days
June	104	27	9	5
Aug	108	29	10	5
Sept	124	29	9	5
Oct	126	28	11	5
Nov	143	29	10	5
Jan	123	26	9	5
Feb	114	26	10	4
Mar	149	30	10	5

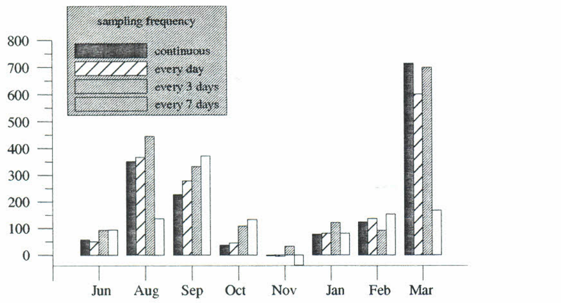

Figure 1. Calculated N lost as N_2O from an experimental using different sampling frequencies

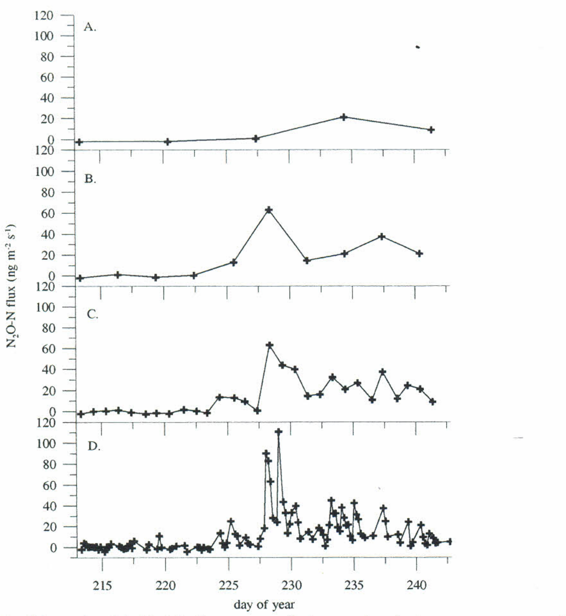

Figure 2. Hourly N_2O-N flux used to calculate average of different sampling frequencies, during Aug: A. sampling every 7 days; B. sampling every 3 days; C. sampling every day; D. continuous sampling

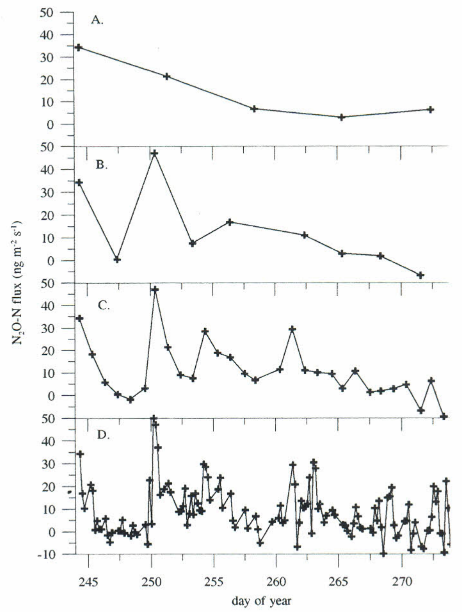

Figure 3. Hourly N_2O-N flux used to calculate average of different sampling frequencies, during September: A. sampling every 7 days; B. sampling every 3 days; C. sampling every day; D. continuous sampling

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