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1. INTRODUCTION

Most of the 151 to 186 Tg of N used in agriculture world-wide end up in other ecosystems (Galloway and Cowling 2002). The transport of NH₃ via the atmosphere is a significant path of this N cycling to non-agricultural systems. Asman and van Jaarsveld (1992) estimated that 44% of the volatilized NH₃ from a source is deposited following an exponential distribution pattern that decreases with distance from the source. Loubet et al. (2006) reviewed the literature on local deposition of NH₃ and concluded that 2 to 60% of the NH₃ from a source is deposited within 2 km.

The objectives of our study was first to report NH₃ emissions over a summer period from dairy cow manure (slurry) stored in a lagoon, secondly to evaluate wind speed and temperature as driving forces of NH₃ emission from this source, and thirdly to document the apparent deposition of NH₃ in the proximity of the lagoon.

2. MATERIALS AND METHODS

Site: A 300-head dairy farm near Lethbridge, Alberta, was used where a manure-storage lagoon was 290 m from the nearest building or trees. The lagoon had a surface area of 41 x 78 m and was surrounded by a berm 2-m in height and was approximately 17-m wide on all sides. The surface of the lagoon typically had a mat of organic material; however, on windy days a portion of the underlying slurry was exposed. The slurry was sampled and the total ammoniacal-N (TAN), NO_x-N, and NO₂-N was evaluated using standard laboratory practices.

Lagoon NH₃ Flux: Wind speed and direction were monitored using a sonic anemometer (CSAT3, Campbell Scientific, Logan, UT). The sonic was positioned 1 m above the surface of the lagoon.

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The NH₃ mixing ratio (μmol mol⁻¹) was measured using an open-path laser (GasFinder, Boreal Laser, Edmonton, Alberta) over a path length of 38 m across the eastern section of the lagoon. An infrared thermometer (4000 ALCS, Everst Interscience Inc., Tucson, AZ) was used to record surface temperature of the lagoon.

All data were filtered and averaged over 15-min intervals. These data were used in a dispersion model (WindTrax, Thunder Beach Scientific, Nanaimo, BC) to predict lagoon NH₃ flux.

NH₃ Field Deposition: A second site was set up containing a sonic anemometer and NH₃ laser over an alfalfa field at a distance of 50 m from the lagoon. The sonic anemometer was located at a 2-m height above the surface and the laser path was 1.5 m above the surface. Previously, a side-by-side comparison of the field and lagoon lasers was made by placing the lasers side-by-side over the lagoon. The regression slope was used to correct the relationship between the two laser concentration values during the study.

The same filtering criteria of the data were applied to the field data as was done for the lagoon data. Only periods where the wind was coming from the direction of the lagoon were considered when determining deposition. The WindTrax model was used to predict NH₃ fluxes from the lagoon and downwind datasets. The difference between the concurrent lagoon and downwind NH₃ fluxes was assumed to be deposition between the lagoon and downwind site.

Statistical Analysis: A path-coefficient analysis was used to determine the impact of wind speed and surface temperature on NH₃ flux (Dewey and Lu 1959).

3. RESULTS AND DISCUSSION

The entire data were summarized by constructing a composite 24-h curve using data from all days. On average, the NH₃ flux density over our study

period was $5.1 \pm 1.6 \text{ g m}^{-2} \text{ d}^{-1}$. The nighttime NH_3 flux density was on average $3.6 \text{ g m}^{-2} \text{ d}^{-1}$ whereas the daytime values were low in the morning and evening, and peaked at midday at $8.6 \text{ g m}^{-2} \text{ d}^{-1}$. These results agree with the NH_3 fluxes from other studies of 4.2 to $6.3 \text{ g m}^{-2} \text{ d}^{-1}$, (Sommer et al. 1993) and $5.3 \text{ g m}^{-2} \text{ d}^{-1}$ (Misselbrook et al. 2005).

The correlation (r) between NH_3 flux and surface temperature was 0.69, while that for wind speed was 0.67. However, surface temperature was also correlated with wind speed ($r = 0.25$). The path-coefficient analysis indicated the direct influence of surface temperature accounted for 31% of the variability in NH_3 flux, while wind speed was directly responsible for 28% of the variability in NH_3 emissions. Including the indirect effects, surface temperature could explain 45% of the variation in NH_3 emissions, and wind speed 42% of the variation. The tendency is for NH_3 to increase during the daylight as surface temperature and wind speed increase. The importance of temperature as a main factor controlling NH_3 emissions is a result of higher temperature favoring the formation of NH_3 over that of NH_4^+ in solution; decreasing the solubility of NH_3 , and promoting more mineralization of organic matter (Voorburg and Kroodsma 1992). All these changes increase the abundance of gaseous NH_3 at the surface, which increases the surface-to-air NH_3 concentration gradient and therefore the NH_3 emission. The importance of high wind speed is to increase the surface mixing and maintain a surface to air NH_3 concentration gradient that promotes NH_3 emission.

Over the short duration that both the lagoon and downwind laser/sonic units were in place, there were only a few periods that met the criteria of the filtering process and where the wind direction was such that the lagoon was upwind of the laser positioned in the field. In total only 20 values between 19 July and 11 September were available. For these concurrent times, the lagoon NH_3 flux density averaged $5.0 \pm 1.1 \text{ g m}^{-2} \text{ d}^{-1}$ while the downwind value was $4.0 \pm 1.0 \text{ g m}^{-2} \text{ d}^{-1}$. These data suggest that about 19% of the emitted NH_3 was captured by the alfalfa crop within 50 m of the lagoon. Close to the lagoon there was an apparent high deposition of NH_3 equivalent to $6.6 \text{ kg NH}_3\text{-N ha}^{-1} \text{ d}^{-1}$. If this is extrapolated to a longer period of time, it becomes apparent that it would not take many days for the deposited $\text{NH}_3\text{-N}$ to meet the surrounding crops N requirements for growth.

4. CONCLUSIONS

Quantifying the pathways of NH_3 transfer in agriculture allows evaluation of 'hot-spots' in support of national inventories, and the evaluation of 'net' farm emissions. A key to getting the emissions inventory right is the adoption of accurate emission factors, which should consider net NH_3 emissions (gross emission minus local deposition) from the farm. Making this determination is difficult because the locally deposited NH_3 may be re-emitted as the ambient air NH_3 concentration declines with a change in wind direction, i.e., not associated with a source. Further research is warranted to understand the underlying net effect over time on the long range transport from intensive sources and the immediate area surrounding these sources.

5. REFERENCES

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