AMMONIA EMISSIONS FROM A VOLCANIC SOIL AFTER DAIRY SLURRY APPLICATION

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1 INTRODUCTION

Within agriculture, livestock production, especially problems arising from an inadequate manure management practices, have been associated with pollution problems. One of the most important pathways following manure application to soil is due to ammonia (NH_3) losses, which represents an important source to the total emission of this gas from agriculture.

Dairy production systems of southern Chile are based on all year around grazing on permanent pastures, which results in the production of important volumes of dairy slurry. These systems have intensified over the last years, resulting in the frequent use of dairy slurry all the year around, with pollution risks for air and water resources when applied at inappropriate times of the year.

Soils used for dairy production in the area are of volcanic origin, having low pH. This condition could reduce NH_3 losses, however, no evaluation have been carried on nationally to evaluate the effect of dairy slurry application to grassland soils.

The objective of this work was to determine the amount of N lost as ammonia after the overcast application of fertilizers to permanent pastures in a volcanic soil.

2 METHODOLOGY

A field experiment was carried out from March 2008 to March 2010 at the National Research Institute, Remehue Research Centre (40º35' S, 73º12' W) on a permanent grassland of an Andisoil of the Osorno soil series (Typic Hapludands). The soil at the experimental site has more than 1 m depth and high organic matter content (17%). According to the meteorological station place at the site, the 33 years average rainfall for the area is 1,280 mm yr^{-1} and the mean ambient temperature of 11.3 °C (7.2 to 15.6 °C).

This experiment is part of a larger project which aims to evaluate the effect of high rates and different sources of N fertiliser on N losses from two contrasting volcanic soils. The specific experiment was carried out during the spring of 2009. Dairy slurry and urea were applied to the soil by hand at a target rate of 50 and 100 kg of total N ha^{-1} to 2 m^2 plots as dairy slurry and urea, respectively. There were three plots for each treatment on a randomised block design.

Ammonia losses were evaluated using the wind tunnels methodology (Lockyer, 1984). Briefly, the system of wind tunnels comprises two parts; 1) a transparent section formed from a polycarbonate sheet (2.0 x 1.2 x 0.002 m) which is flexed and pinned to the ground along each 2 m edge to form a tunnel covering an area of 1 m^2 (0.5 x 2 m), and 2) a circular steel duct which contains a co-axial fan to draw air through the transparent section. The fan is fitted with speed control and the air flow rate is measured by a vane anemometer mounted in the steel duct and coupled to an air-speed indicator. The concentrations of NH_3 in air entering and leaving the tunnels were measured by drawing air continuously, at 1 m s^{-1}, from the inlet and outlet of each tunnel and trough an absorption flask containing orthophosphoric acid (0.002 M). Each absorption flask consisted of a test-tube (100 cm^3) with a ground glass neck fitted with a dreschel head and a sintered glass dispersion tube.

The tunnels were not moved during the measurement. Samples were taken 2 times during first two days following manure application, and then every 24 h, replacing the orthophosphoric solution in the flask each time. Samples from the flask were diluted with deionised water and sub-samples were taken and stored < -15 °C waiting analysis of NH_4^+-N. Ammonia lost beneath the tunnel was calculated as the product of the total volume flow of air during a period and the difference between NH_3 concentrations in the air entering and leaving the tunnel. Ammonium was determined through the indophenol methodology using and automated sample analyser (Skalar SA 1050).

3 RESULTS AND DISCUSSION

Results from this study for dairy slurry application to grassland are the first data for Chilean conditions. Previously there were only few studies published on NH_3 losses for urea application. This local information is very important to determine emission factors that can be used on national inventories.

There was a large effect of the N source on the NH_3 emissions when manure was surface applied to grassland. Total NH_3-N losses were high after urea fertiliser application compared with dairy slurry. During the experimental period the overall losses were 25 and 9 kg N ha^{-1} (Fig. 1) for the urea and the dairy slurry treatment, respectively. This was related to the different rates applied. However, expressed as the proportion of the total ammoniacal N (TAN) applied, emissions were higher for dairy slurry (62%) compare to urea (25%), despite the different rates used. These values are in the range of studies carried out elsewhere (e.g. Sommer and Olesen, 1991).

The highest peaks of NH_3 emission were obtained on dairy slurry treated plots, occurring within the first six hours after manure application, declining progressively in the successive hours and becoming low after the first day of evaluation (Fig. 2). This resulted in a high proportion of the NH_3-N being lost within the first 24 hours, which was equivalent to *c.*75% of the total N applied in the dairy slurry treatment. Pain et al. (1989) reported approximately 40-50% of the total loss often occurs within 6 hours, 70% within 24 h and more than 90% over 5 days, which agreed with the results observed in the present study. For urea there were three peaks during the measuring period, which were lower than the one observed with slurry and 75% of the N applied was loss by the 11th day of evaluation. They were probably associated with the transformation process of this fertiliser in the soil.

These results suggest that ammonia emissions from slurry and urea also can be significant when applied to acid volcanic soils of southern Chile, where management practices should be implemented to reduce the risk of pollution to air. Therefore, good management practices on these swards should target the reduction of losses through volatilisation. Low emission slurry application equipment is now available (e.g. Chambers et al., 1999) but, it is necessary to increase the adoption of these ‘environmentally friendly’ technologies by farmers. In addition, it is important to take into account that the use of this equipment could represent an increase in the application costs for farmers.

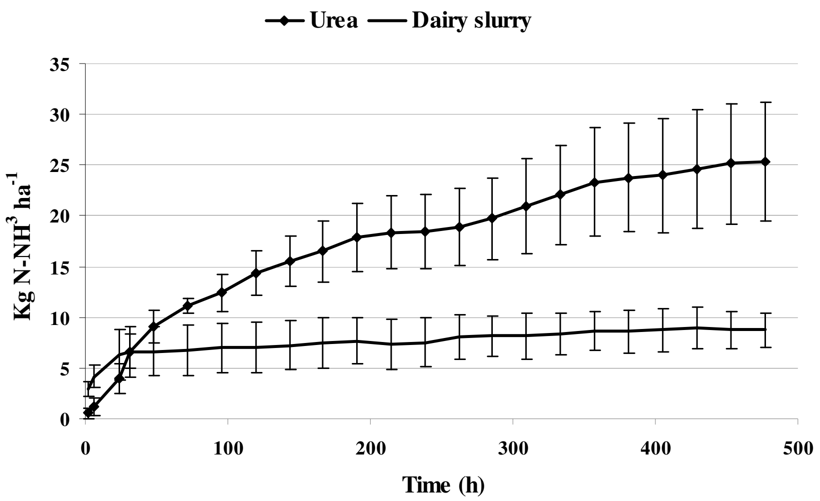

FIGURE 1 **Accumulated N-NH_3 losses (kg N ha^{-1}) for the experimental period following dairy slurry and urea application to a pasture on a volcanic soil.**

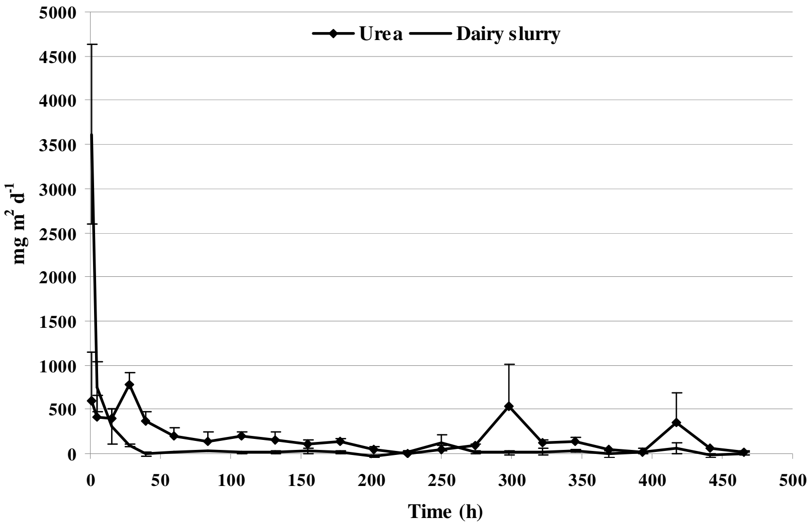

FIGURE 2 **Ammonia emission rate over time (mg m^{-2} d^{-1}) after dairy slurry application to a volcanic grassland soil.**

4 CONCLUSIONS

Ammonia losses can be high in volcanic soils when using urea or dairy slurry as the N fertilizer source during late spring. Nitrogen losses represented 25% of the total N applied for urea and dairy slurry. However, as a percentage of the TAN, the loss reached an equivalent to 62% of the TAN applied dairy slurry. Mismanagement of urea fertiliser or dairy slurry could be an important pathway for N losses in Southern Chile, where N fluxes will affect pristine temperate forest areas. However, incorporation of Best Management Practices (e.g. use of more efficient equipment) could reduce N losses due to NH_3 volatilisation and increase dry matter yields, due to a more efficient use of the available nitrogen.

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