Improved Method for Measurement of Ammonia Volatilization in the Field

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ABSTRACT

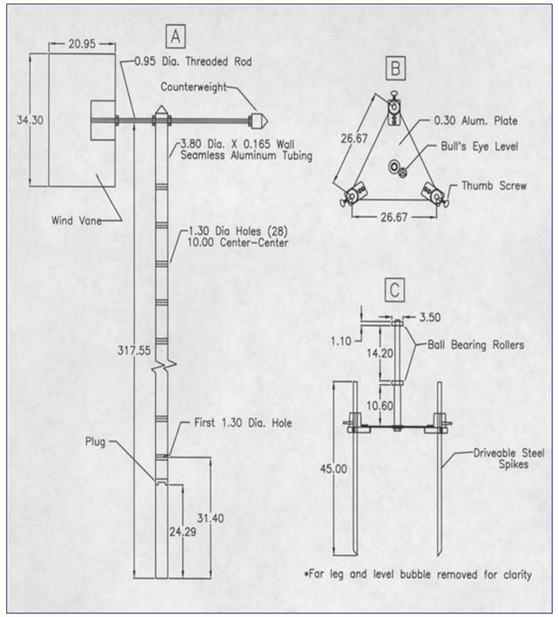
We developed a method for determination of ammonia (NH_3) volatilization from land applied nitrogen (N). The method is a modification of proven passive flux methods, and is an improvement owing to reduced cost, labor and analytical requirements. The method uses a rotating mast centered in a circular plot. Samplers we use are glass tubes (7 by 200-mm) coated on the inside with oxalic acid to trap NH_3. The method was tested against one of the proven methods. A circular plot (15-m radius) was established, urea applied (200 kg N ha^{-1}), and NH_3 volatilization measured for six days thereafter. Linear relationships existed between our method and the reference method, as indicated by r^2 of 0.92 and 0.86 for horizontal and vertical fluxes, respectively. The glass tubes we use consistently measured more NH_3 volatilization than samplers of the reference method. However, given that most micrometeorological methods underestimate NH_3volatilization, we feel that our method improves accuracy. Thus, our method for field scale determination of NH_3 volatilization reduces initial costs as well as labor and analytical requirements, without sacrificing accuracy.

INTRODUCTION

Ammonia (NH_3) volatilization can be a significant pathway for nitrogen (N) loss from many agricultural systems. To improve estimates of N budgets, accurate measurements of NH_3 volatilization from field-scale studies in typical systems are needed. Currently, however, there is no method for field-scale measurement of NH_3 volatilization that is user-friendly with respect to initial costs, and time and labor requirements. We have developed and tested a new passive flux NH_3 collection method for determining NH_3-N loss from land-applied animal waste that combines the best aspects of the Leuning et al. (1985) and Schjoerring et al. (1992) proven methods, i.e. low analytical and labor requirements (Leuning et al., 1985) and low initial cost (Schjoerring et al., 1992).

MATERIALS AND METHODS

- Location: Turfgrass Research Unit on campus of Auburn University, AL
- Urea applied at a rate of 200 kg N ha^{-1}.
- Rotating Mast in center of 15m radius plot with glass tubes and NH_3 sampler (Leuning et al., 1985) mounted side by side.
- Glass Tubes – 7-mm diameter by 200-mm length
  - inside coated with oxalic acid (3% w/v in acetone)
  -stainless steel disk with 1-mm hole
- 4 Heights - 0.63, 1.42, 2.21, 3.00 m
- NH_3 collected for 6 days after application
- NH_3 extracted with deionized water and analyzed for NH_4-N colorimetrically using a microplate technique (Sims et al., 1995).
- Vertical flux of NH_3 from plot area was determined by calculating the horizontal flux at each of the four heights and summing the horizontal fluxes from each height.



Schematic diagram of the aluminum rotating mast and base constructed for this study. (A) Side view of the rotating mast and wind vane assembly. (B) Top view of the base. (C) Side view of the base. All numbers given are in centimeters.

NH_3 Sampler (Leuning et al., 1985) and Glass Tube
Cost: US$250.00 versus US$1.35

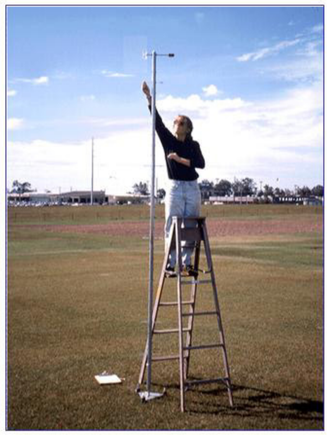
The equations used were modified as follows from Schjoerring et al. (1992):

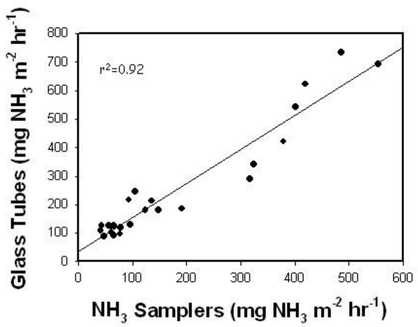
$$\text{Horizontal Flux} = \frac{M}{\pi * r^2 * \Delta t}$$

where: M = mass of NH_3 captured
r = radius of opening to tube or sampler
Δt = time length of measurement

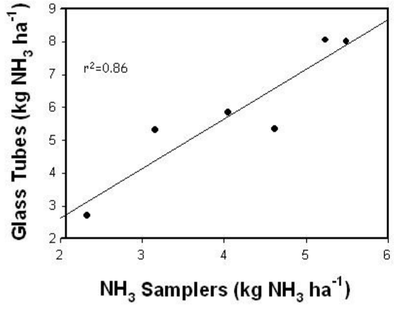
$$\text{Vertical Flux} = \frac{1}{2r} \sum_{h=1}^{h=n} (HF)\ \Delta h$$

where: r = radius of plot in m
n = number of measurement heights
h = height of measurement
HF = horizontal flux from each height
Δh = height interval between samples





Regression of horizontal NH_3 flux measured in glass tubes vs. horizontal NH_3 flux measured in NH_3 samplers.



Regression of cumulative vertical NH_3 flux measured in glass tubes vs. cumulative vertical NH_3 flux measured in NH_3 samplers.

GLASS TUBE INFORMATION

Glass tube dimensions: 200-mm length, 7-mm id, 10-mm od

Company that supplies the stainless steel disks and snap caps for the glass tubes: Mikrolab Aarhus A/S
Axel Kiers Vej 34
DK-8270 Hojbjerg, DENMARK
FAX: 011-45-86-29-61-22
PHONE: 011-45-86-29-61-11

Snap caps: # ML 330062 for tubes 10-mm od
price in 1995: 0.55 DKK each

Stainless steel disk: 0.05-mm disc, 10-mm diam., 1-mm hole in center
price in 1995: 10 DKK each

CONCLUSIONS

- Strong linear relationships between our method and the Leuning et al. (1985) method for both horizontal and vertical fluxes.
- Because of simple cylindrical shape, tubes can be more completely extracted.
- Our method results in an 8X reduction in NH_3 analyses/plot/measurement time compared to the Schjoerring et al. (1992) method.
- Each glass tube costs US$1.35 which is 185X less than the US$250.00 NH_3 sampler (Leuning et al. 1985).
- The experiment showed that our method absorbed more (18.1%) of the N applied as urea than did the Leuning et al. (1985) method. Past research has shown that micrometeorological methods can underestimate true ammonia volatilization. Given this, our method, which recorded higher ammonia losses, more accurately measured ammonia volatilization compared to the Leuning et al. (1985) method.
- We have devised and tested a new method of measuring field-scale NH_3 volatilization from land-applied N that is less expensive, less complex, and more accurate than methods previously available.

REFERENCES

Leuning, R., J.R. Freney, O.T. Denmead, and J.R. Simpson. 1985. A sampler for measuring atmospheric ammonia flux. Atmos. Environ. 19:1117-1124.

Schjoerring, J.K., S.G. Sommer, and M. Ferm. 1992. A simple passive sampler for measuring ammonia emission in the field. Water, Air, and Soil Pollut. 62:13-24.

Sherlock, R.R., J.R. Freney, N.P. Smith, and K.C. Cameron. 1989. Evaluation of a sampler for assessing ammonia losses from fertilized field. Fert. Res. 21:61-66.

Sims, G.K., T.R. Ellsworth, and R.L. Mulvaney. 1995. Microscale determination of inorganic nitrogen in water and soil extracts. Commun. Soil Sci. Plant Anal. 26(1&2):303-316.