AMMONIA VOLATILIZATION FOLLOWING CATTLE AND PIG SLURRY APPLICATION IN THE FIELD
FIRST RESULTS OF THE "VOLAT'NH$_3$" FRENCH PROJECT

Cohan J.P.[1*], Charpiot A.[2], Morvan T.[3], Trochard R.[1], Eveillard P.[4], Champolivier L.[5], De Chezelles E.[6], Génermont S.[7], Loubet B.[7]
* Corresponding author: jp.cohan@arvalisinstitutduvegetal.fr

Introduction

Atmospheric ammonia is becoming a great challenge for French agriculture, regarding its economic and environmental impacts. Tropospheric ammonia mainly originates from the agricultural livestock sector (volatilization following application of farm yard manure and slurry) (CITEPA 2011). Reducing ammonia emissions due to these practices is therefore a major objective of many applied research programs. Although scientific studies were carried out in the past two decades in France (Génermont and Cellier 1997; Morvan, 1999), there is still a lack of field experiments designed to assess the best ways to reduce ammonia emissions following livestock manure application in the field.

Funded by French State CASDAR program, the "**VOLAT'NH$_3$" research project** has been launched in 2010 with two main purposes:

1) elaborate a simple method to measure ammonia emissions based on the inverse modeling approach (Loubet et al., 2010) using batch diffusion NH$_3$ concentration sensors (alpha badges (Sutton et al. 2001))
2) use this method to test the sensitivity to ammonia emissions of various organic (and mineral) fertilizers and the effectiveness of some agricultural practices to reduce ammonia emissions following fertilization.

Material and methods

- **Four field experiments** were carried out in spring 2011 (plots of at least 400 m² statically randomized with 2 replicates per treatment) (**table 1**).
- **Ammonia emissions monitoring:** Alpha badges were placed at two heights (0.3 and 1 m from soil) in each plot and exposed sequentially during 6 periods (6 hours after application, application + 1 day, + 2 days, + 3 days, + 6 days, + 20 days) (photo 1). Other alpha badges were dedicated to background measurement on masts located away from the field and at a height of 3 m. Air ammonia concentration calculations used **equation (1)**.
- **Soil measurements:** Soil mineral N content was measured in the 0-0.3 m soil layer immediately before slurry application, and after the last alpha badge monitoring. Soil mineral N balance between the beginning and the end of experiment was calculated using **equation (2)**.

Eq (1) : $[NH_3] = \frac{QNH3}{D \times V}$

[NH$_3$] = air ammonia concentration during exposure time (µg N-NH$_3$ m^{-3} h^{-1}); QNH3 = ammonia quantity trapped in alpha badges (µg N-NH$_3$); D = exposure duration (h); V = alpha badge volume constant (m^{-3}).

Eq (2) : $\Delta R = M + X - L - Gx - Ix$

ΔR = soil mineral N content variation (kg N ha^{-1}); M = N mineral from organic matter mineralization (kg N ha^{-1}); X = mineral N from slurry (kg N ha^{-1}); L = N-NO$_3$ leaching (kgN ha^{-1});Gx = N gaseous losses from slurry (kg N ha^{-1}); Ix = N immobilization in organic matter from slurry (kg N ha^{-1}).

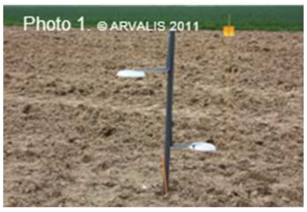

Table 1. Main characteristics of experiments carried out during spring 2011

Experiment	Soil characteristics (0-25 cm) Clay (g.kg^{-1})	Silt (g.kg^{-1})	Total C (g.kg^{-1})	pH	Treatment	Total N rate* (kgN.ha^{-1})	N-NH$_4^+$ rate** (kgN.ha^{-1})	N-NO$_3^-$ rate*** (kgN.ha^{-1})
ALL					0 N	0	0	0
Bignan	137	432	17.4	6.4	Pig slurry BSS	148	71	0
					Pig slurry IBS	148	71	0
Derval	184	507	19.9	6.4	Cattle slurry BSS	135	60	0
					Cattle slurry IBS	135	60	0
La Jaillière	189	512	13.7	6.2	Cattle slurry BSS	114	39	0
					Cattle slurry IBS	114	39	0
Trévarez	192	639			Pig slurry BSS	151	106	0
					Digested pig slurry BSS	151	106	0

0N = without N application; BSS: application on bare soil surface; IBS: incorporated on bare soil; *Organic and mineral nitrogen; **NH$_4^+$ form nitrogen; ***NO$_3^-$ form nitrogen

Results and discussion

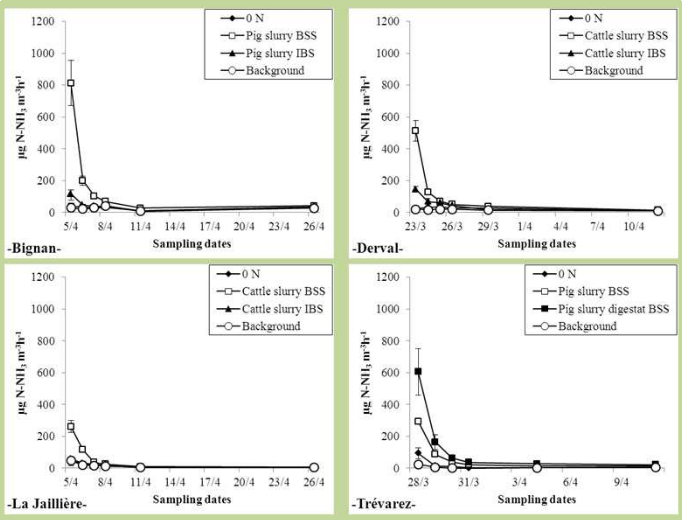

Figure 1. Ammonia concentrations at 0.3 m height following slurry applications in 2011 experiments. BSS: application on bare soil surface; IBS: incorporated in bare soil. Vertical bars are standard deviations.

The variability of the NH$_3$ concentrations between replicates is small, indicating a rather good accuracy of the method (figure 1). Although there is still work to be done to get nitrogen fluxes from ammonia concentrations, using the inverse method developed and presented in Loubet et al. (2010 and 2011), the first attempt of calculation seem to be promising (Loubet et al. 2012). This can also be compared to the great variability of N losses determined using the soil mineral N balance. N losses calculated using soil mineral N balance seem to be consistent with ammonia concentration kinetics measured, in ranking the emissions (figure 2). For example, the highest point in figure 1 concern the application of pig slurry BSS in Bignan, and it is also the treatment with the highest N losses compared with pig slurry IBS in figure 2.The climatic context of spring 2011 in France with almost no rainfall and with warm temperatures during the experiments was in favor of rapid ammonia emissions: the volatilization occurred mainly during the 2 days following slurry application, for the 4 experimental sites. It could also explain that the effect of slurry incorporation and slurry anaerobic digestion on ammonia concentrations was so strong. These results are consistent with those already published in France and elsewhere.

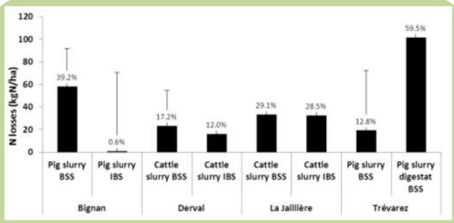

Figure 2. N losses during 2011 experiments estimated by soil mineral N balance. Labels indicate ammonia losses expressed in percentage of total-N applied. Vertical bars indicate the standard deviations.

Conclusion

These preliminary results using a new method of ammonia volatilization measurement easy to use in the field are promising. Other experiments will be carried out during the spring 2012 experimental campaign with the same protocols. The method should help elaborating strategies of ammonia emission reduction after slurry applications in various French agricultural contexts.

References

CITEPA, 2011. Inventaire des émissions de polluants atmosphériques et de gaz à effet de serre en France. Séries sectorielles et analyses étendues. CITEPA Ed.

Génermont, S., Cellier P., 1997. A mechanistic model for estimating ammonia volatilization from slurry applied to bare soil. Agricultural and Forest Meteorology 88:145-167.

Loubet, B., Génermont, S., Ferrara, R., Bedos, C., Decuq, C., Personne, E., Fanucci, O., Durand, B., Rana, G., Cellier, P., 2010. An inverse model to estimate ammonia emissions from fields. European Journal of Soil Science, 61: 793-805.

Loubet B., Génermont S., Personne E., Massad R.S., 2011. Can we estimate ammonia emissions by inverse modelling with time averaged concentrations? Poster presented at the "Nitrogen and Global Change. Key findings and future challenges" Conference, Edinburgh, 11-14 April 2011.

Loubet B., Génermont S., Cohan J.P., Charpiot A., Morvan T., Trochard R., Eveillard P., Champolivier L., De Chezelles E., Espagnol S., 2012. A new method for estimating ammonia volatilization from slurry in small fields using diffusion samplers. Poster presented at EMILI conference, Saint-Malo France,11-13 june 2012.

Morvan, T. 1999. Quantification et modélisation des flux d'azote résultant de l'épandage de lisier. Thèse de doctorat de l'Université, Université Paris 6, Paris.

Sutton, M.A., Tang, Y.S., Miners, B., Fowler, D., 2001. A new diffusion denuder system for long-term regional monitoring of atmospheric ammonia and ammonium. Water Air and Soil Pollution: Focus(1): 145-156.

[1]ARVALIS-Institut du végétal, Station expérimentale de La Jaillière, 44370 La Chapelle St Sauveur, France; [2]Institut de l'élevage, Monvoisin- BP 85225, 35652 Le Rheu Cedex, France; [3]INRA UMR1069 Soil Agro and hydroSystems, 65 rue de Saint Brieuc, CS 84215, F-35042 Rennes Cedex 1, France; [4]UNIFA, Le diamant A, 92909 Paris La Défense, France; [5]CETIOM, BP 52627, 31326 Castanet Tolosan Cedex, France; [6]ACTA, 149 rue de Bercy, 75595 PARIS Cedex 12, France; [7]INRA, UMR INRA-AgroParisTech, 1091 Environnement et Grandes Cultures, F-78850 Thiverval-Grignon, France.

Acknowledgements. This study was financed by the French state CASDAR program.

ARVALIS Institut du végétal · INRA UMR EGC · INSTITUT DE L'ÉLEVAGE · INRA UMR SAS · unifa · CETIOM · ACTA · ifip

EMILI June 11-13 2012, Saint-Malo France.