A NEW APPROACH FOR MEASURING AMMONIA VOLATILIZATION IN THE FIELD: FIRST RESULTS OF THE FRENCH RESEARCH PROJECT “VOLAT’NH_3”

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Introduction

Atmospheric ammonia is becoming a great challenge for French agriculture, regarding its economic and environmental impacts. Tropospheric ammonia mainly originates from the agricultural sector included volatilization following applications of farm yard manure, slurry and mineral fertilizer (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; Le Cadre 2004), there is still a lack of field experiments designed to assess the best ways to reduce ammonia emissions following livestock manure and mineral fertilizer 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

	Experiment	Soil characteristics (0-25 cm): Clay	Silt	Total $CaCO_3$	pH	Treatment	Total N rate*	$N\text{-}NH_4^+$ rate**	$N\text{-}NO_3^-$ rate***	Total rainfall during experiment
		($g.kg^{-1}$)					($kgN.ha^{-1}$)			(mm)
Slurry on bare soil	All					0 N	0	0	0	
	Bignan	137	432	0	6.4	Pig slurry BSS	148	71	0	1.6
						Pig slurry IBS	148	71	0	
	Derval	184	507	0	6.4	Cattle slurry BSS	135	60	0	9
						Cattle slurry IBS	135	60	0	
	La Jaillière	189	512	0	6.2	Cattle slurry BSS	114	39	0	8.4
						Cattle slurry IBS	114	39	0	
	Trévarez	192	639			Pig slurry BSS	151	106	0	18.5
						Digested pig slurry BSS	171	123	0	
Mineral fertilizer on winter wheat (GS Z30@)	Bernienville	132	770	0	6.9	0N	0	0	0	12.2
						AN	100	50	50	
						UAN	100	25	25	
	Vraux	121	223	572	8.3	0N	0	0	0	3
						AN	100	50	50	
						UAN	100	25	25	
	Faux 1	150	100	717	7.8	AN	100	50	50	16.4
						UREA	100	0	0	
	Faux 2	150	100	717	7.8	AN	50	25	25	30.1
						UREA	50	0	0	

0N = without N application; BSS: application on bare soil surface; IBS: incorporated on bare soil; AN=Ammonium nitrate; UAN=Urea Ammonium Nitrate; *Organic and mineral nitrogen (urea included) **NH4+ form nitrogen; ***NO3- form nitrogen; @ = GS Z39 in Faux 2 experiment

Table 1: experiments main characteristics

- **Seven field experiments** were carried out in spring 2011 (plots of at least 400 m² statically randomized with 2 replicates per treatment) (**see 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 **ammonia concentration trapped, exposure duration and alpha badge volume.**
- **Soil measurements (in 5 experiment):** Mineral N content was measured in the 0-0.3 m soil layer and in wheat immediately before fertilizer application, and after the last alpha badge monitoring. Soil mineral N balance between the beginning and the end of experiment was calculated.

Results and discussion

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). Except for Faux-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. Concerning slurry, 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. Concerning mineral fertilizer, the kinetics of atmospheric concentration are rather different with the highest point 3 to 6 days after application. Some differences seem to exist between fertilizer type interacting with soil pH. Nevertheless, we must be careful and wait for flux calculations to confirm (or not) these trends.

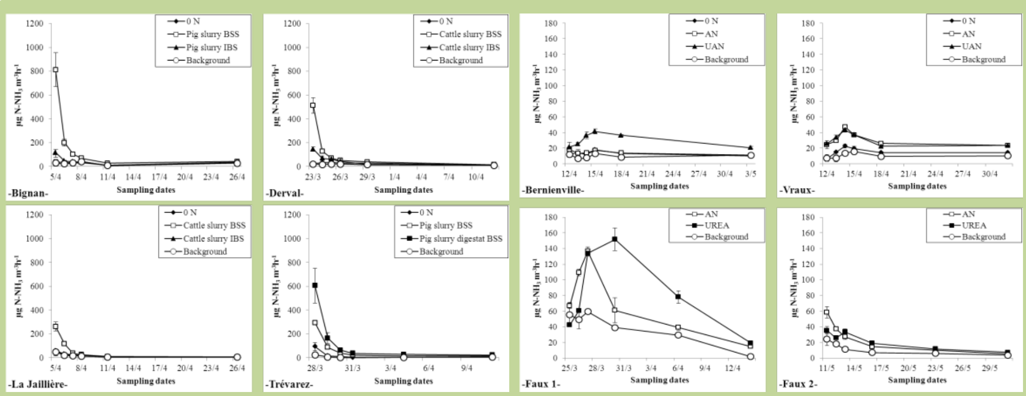
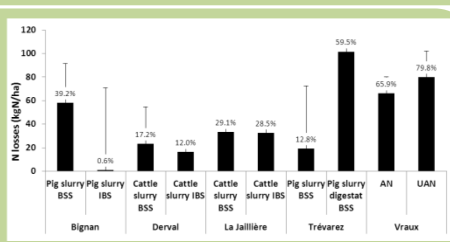


Figure 1. Ammonia concentrations at 0.3 m height following slurry or mineral fertilizer applications in 2011 experiments.
0N = without N application; BSS: application on bare soil surface; IBS: incorporated on bare soil; AN=Ammonium nitrate; UAN=Urea Ammonium Nitrate.

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 and flux calculations will be done to confirm (or not) the first trends drawn by concentration kinetics. These method and results should help elaborating strategies of ammonia emission reduction after slurry an mineral fertilizer applications in various French agricultural contexts.

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