Gas emissions during solid manure management at housing and storage stages from dairy cattle in contrasted feeding and climatic situations

Nadège Edouard, Paul Robin, Joao Gabriel Almeida, Tiago Pansard Alves, Philippe Lamberton, Elise Lorinquer

GAS EMISSIONS DURING SOLID MANURE MANAGEMENT AT HOUSING AND STORAGE STAGES FROM DAIRY CATTLE IN CONTRASTED FEEDING AND CLIMATIC SITUATIONS

EDOUARD, N.[1], ROBIN, P.[2], ALMEIDA, J.G.R.[1,3], ALVES, T.P. [1,3], LAMBERTON, P.[1], LORINQUER, E.[4]

[1] PEGASE, INRA, Agrocampus-Ouest, Rennes, France; [2] SAS, Agrocampus-Ouest, INRA, Rennes, France; [3] Universidade do estado de Santa Catarina, UDESC Centro de Ciências Agroveterinárias, 88520-000 Lages SC, Brazil; [4] Institut de l'élevage, 149 rue de Bercy, Paris, France

INTRODUCTION

French dairy systems are characterized by a large proportion of deep litter systems. However, gas emission measurements from solid manure are very scarce in the literature and also very variable in relation with contrasted litter management (fresh straw addition frequency and amount, accumulation time, animal type and feeding…). In deep-litter systems, manure is mixed with bedding material and accumulated for a few weeks in a thick layer where the oxygen level decreases with depth. This can result in several processes such as aerobic degradation of organic matter, urea hydrolysis, nitrification-denitrification, nitrogen immobilization and anaerobic degradation of organic matter (Jeppsson, 1999). These complex interactions among microbial, biochemical and physical processes lead to highly variable emissions of ammonia as well as greenhouse gases (Webb et al., 2012). The objective of this study was to acquire new knowledge about N_2O and NH_3 emissions during accumulation of a straw-based deep litter at the dairy barn level and throughout the storage of the resulting solid manure. To consider different management practices, the experiment offered contrasting diets to the dairy cows (a grass-based GD and a maize silage-based diet MD) and was conducted at two seasons (autumn and spring) leading to variable grass quality and different climatic effects during storage. This lead to 4 treatments to be compared: GDaut, MDaut, GDspr and MDspr.

MATERIAL AND METHODS

Housing

At each season, two groups of three Holstein dairy cows in late (in autumn) or mid (in spring) lactation were housed in two closed and controlled mechanically ventilated rooms, and kept on a straw-based deep litter accumulated under the animals during four weeks. The MD diet consisted in an 80-20% mixture of maize silage and concentrate while GD was 100% grass. Individual milk yields and dry matter (DM) intake were recorded daily. NH_3 and N_2O concentrations were measured continuously with an infrared photo-acoustic gas analyzer (Innova model 1412). Ventilation rate was punctually assessed with the tracer ratio method (SF_6).

Storage

After 4 weeks of accumulation in the barn, solid manure was put in pile under dynamic chamber systems and stored during 14 weeks. The MDaut and GDaut heaps were therefore monitored during winter while the MDspr and GDspr heaps were monitored during spring and summer. NH_3 and N_2O concentrations were measured with an infrared photo-acoustic gas analyzer (Innova model 1412) during the whole week following stacking and then 2 days a week (dynamic chambers uncovered the rest of the time). Ventilation rates were obtained from the fans. Leachates from manure heaps were continuously collected and analyzed for their composition.

RESULTS AND DISCUSSION

Housing

Ammonia emissions were slightly greater on GD compared to MD in autumn and were lower and quite close from each other in spring (Table 1). GDaut ammonia emissions were also observed to increase gradually over the course of manure accumulation. It appeared that NH_3 emissions were more related to variation of milk urea content than to CP content (15% for MD and 18% for GD at both season) or N intake itself (that was systematically higher in MD, because of higher DM intake). Milk urea content, good indicator of urinary urea N excretion (Burgos et al., 2007), is indeed the direct reflection of the unbalance degradable and metabolisable protein supplies of the grass, particularly important in the autumn grass. N_2O emissions were classically low at the house level and were higher on GD than on MD whatever the season. The solid manure was indeed more humid and compacted with GD, probably stimulating denitrification processes causing N_2O emissions.

Storage

The peak of ammonia emission was reached the day after manure stacking; emissions then decreased down to zero 3 weeks after. As for housing, ammonia emissions were higher (even doubled) on GDaut than on MDaut in relation with a higher NH_4-N content of the manure at the beginning of the storage period. On the contrary, NH_3 emissions were higher on MD than on GD in spring-summer. We observed that the MDspr manure heap was warmer (up to 85°C in the core of the heap) than the GDspr pile (65°C) and probably also more porous (less humid) stimulating ammonia volatilization. The GDspr heap lost consequently more N in the form of N_2O.

Table 1. Cumulated nitrogen gas emissions over the solid manure accumulation in the house and during consecutive storage. MD: maize silage diet; GD: grass-based diet; aut: autumn-winter period; spr: spring-summer period

Cumulated gas emissions over the period		MDaut	GDaut	MDspr	GDspr
Housing	NH_3-N, g/cow	406	468	354	321
(4weeks)	N_2O-N, g/cow	2.6	7.6	2.3	6.3
Storage	NH_3-N, g/cow	500	967	870	615
(14weeks)	N_2O-N, g/cow	32	34	33	53

CONCLUSION

Considering housing and storage, nitrogen gas losses represented 6, 11, 8 and 7% of the system N input (N intake + N from the straw) for MDaut, GDaut, MDspr and GDspr respectively. Feeding animals with fresh grass in the house does not seem to be relevant in term of environmental impacts with straw-based deep litter systems, especially in the autumn when grass degradable N content is high. Storage of solid manure during warm season should also be avoided because of the temperature effect stimulating ammonia volatilization. To go further, it would be interesting to compare these results with emission during grazing, to find the best way to combine grass valorization and maize yields to preserve milk production and environment.

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