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## GREEN HOUSE GASES AND AMMONIA EMISSIONS FROM TWO CONTRASTED DAIRY CATTLE DEEP LITTERS

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**ABSTRACT:** Animal housing contributes a large proportion of greenhouse gases (GHG) and ammonia emissions in livestock systems. The diversity of the French cattle systems is huge mainly because of the many manure management systems (with or without straw). The aim of this study is to provide knowledge on GHG and NH<sub>3</sub> emissions to propose mitigation options. During, respectively 4 (P1) and 6 (P2) weeks, two deep litters were accumulated beneath three dairy cows in a mechanically ventilated room, with different animal stocking densities; 9.7m<sup>2</sup> per cow in P1 and 12.4m<sup>2</sup> per cow in P2. During accumulation of the litter, we continuously measured the emissions of CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>, and NH<sub>3</sub>. The deep litter in P1 was more humid (20.1% DM) than in P2 (27.2 %DM). The deep litter in P1 produced less N<sub>2</sub>O but more CH<sub>4</sub> and NH<sub>3</sub> than in P2. Means emissions were, respectively, 8214 g/day/cow, 0.433 g/day/cow, 713 g/day/cow, and 97 g/day/cow for CO<sub>2</sub>-C, N<sub>2</sub>O-N, CH<sub>4</sub>-C and NH<sub>3</sub>-N in P1 and 8048 g/day/cow, 0.468 g/day/cow, 627 g/day/cow, and 56 g/day/cow in P2. These results (i) improve our understanding of emitting processes related to deep litters; (ii) highlight that too high animal stocking density on deep litter will lead to higher GHG and ammonia emissions. In that sense, both animal welfare and environmental issues recommend lower stocking densities for dairy cattle.

**Keywords:** emissions, NH<sub>3</sub>, GHG, deep litter, dairy cow

**INTRODUCTION:** Animal housing contributes a large proportion of GHG and ammonia emissions in livestock systems. French cattle systems show a large diversity of housing, most of them based on litter (55% of dairy cows in 2008, France). Many studies have already been done on slurry systems but data regarding farm yard manure (FYM) systems are lacking. The aim of this study is to better understand GHG and ammonia emissions from deep litters to find mitigation options that reduce polluting emissions.

### 1. MATERIAL AND METHODS:

**1.1. Description of the experimental design:** During, respectively 4 (P1) and 6 (P2) weeks, two deep litters were accumulated beneath three dairy cows in a climatic room with dynamic ventilation, with different animal stocking densities: 9.7m<sup>2</sup> per cow in P1, 12.4m<sup>2</sup> per cow in P2 (which is close to the recommended values for dairy cows on deep litters; 10 m<sup>2</sup> per cow). At the end of the accumulative period, after the three cows left the room, the litters remained in the room for a few days. More details on the two experimental periods are given in Table 1.

Table 1: Main characteristics of the 2 experimental periods, P1 and P2.

	Period 1 (P1)	Period 2 (P2)
Duration (days)	37	49
Beginning of the measurement	14/09/2010	01/11/2010
End of the measurement	20/10/2010	19/12/2010
Duration of accumulation of the litter under the cows (days)	29	44
Number of cows	3	3
Area of the litter (m <sup>2</sup> )	29.24	37.22
Straw supply (kg/day)	37.8	40.0

**1.2. Emissions measurement devices** During accumulation of the litter, we continuously measured the emissions of CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>, and NH<sub>3</sub>. Ventilation rates were estimated using the gas (SF<sub>6</sub>) tracer method (Phillips et al., 2000). Gas concentrations were continuously measured outside and inside the rooms with an infrared photo-acoustic gas analyzer (INNOVA 1412) and a multiplexer (1303). The configuration of the analyzer is given in table 2.

Table 2: Optical filters and detection limits of the photo acoustic infrared analyzer used in the experiment.

	Optical filter reference	Detection limit (ppm)
Ammonia	973	0.2
Carbon dioxide	982	1.5
Methane	969	0.4
Nitrous oxide	985	0.03

Strong interferences between ammonia and volatile fatty acids and alcohols emitted by maize silage distributed in the rooms were observed, mainly due to the configuration used for the gas analyzer. This caused large peaks of NH<sub>3</sub> concentration during feeding phases (Hassouna et al., 2012). Therefore, we decided to correct over-estimated ammonia emissions by suppressing these peaks. The subsequent NH<sub>3</sub> emissions are consequently potential ones. Finally, temperatures and humidity were continuously measured inside and outside the room.

**2. RESULTS AND DISCUSSION:** The deep litter in P1 was more humid (20.1% DM) than in P2 (27.2 %DM). This was also confirmed by the quantity of liquids produced by the FYM and collected, which were 471.65 kg in P1 and 267.05 kg in P2. This high moisture in P1 led us to remove the animals after only 4 weeks and explained the reason we did not have the same accumulation time for the two periods. For P1, emission values for weeks 5 and 6, and for P2, emission values for week 7 correspond to the litter alone as the cows were removed from the room (figures 1, 2, 3 and 4). Obviously, the litter emitted much more when cows were present than the litter alone. Without new input of elements from fresh manure, such as nitrogen or carbon, emissions of NH<sub>3</sub>, CO<sub>2</sub> and CH<sub>4</sub> from the FYM rapidly decreased.

We observed more CH<sub>4</sub> emissions in P1 than in P2 (Table 3, Figure 3). This high level of CH<sub>4</sub> could be an indicator of anaerobic fermentation. As the liquid filled all the gaps in the litter (due to the high moisture), anaerobic conditions could occur. Moreover, no aerobic layer could have existed in P1 due to the moisture of the litter: oxidation of CH<sub>4</sub> into CO<sub>2</sub>, which should occur in the top aerobic layer or during the rise of CH<sub>4</sub>, was therefore prevented. CO<sub>2</sub> emissions, which were higher in P2 than in P1 (Table 3, Figure 1), validated these hypotheses. Regarding CH<sub>4</sub>, as in Hansen et al.

(2002), we would also consider that the higher animal stocking density resulted in a higher emission of CH<sub>4</sub>, because of both higher compaction of the litter and excretion by the animals.

High temperature in the litter was assumed because of (i) high fermentation and (ii) a mean temperature of the litter of 34°C at only 10 cm during P2 (we would expect a higher temperature in depth). The considerable moisture of the litter combined with the high temperature in the litter could explain the reason ammonia emissions were higher in P1 than in P2 (Table 3, Figure 4).

Finally, the full anaerobic conditions in P1 were validated by lower N<sub>2</sub>O emissions in P1 compared with P2 (Table 3). As we could see a beginning increase of nitrous oxide emissions between weeks 3 and 5 in P2, we could imagine this was also the case between week 5 and 6 for P1 (Figure 2). Measurements at a longer time period would have confirmed this certainty. Anaerobic conditions in P1 seemed to slow down nitrification and therefore nitrous oxide formation.

Table 3: Mean emissions of GHG and ammonia according to the length of the period (measures with the litter alone are not included here).

	P1 (4 weeks)	P2 (4 weeks)	P2 (6 weeks)
CO <sub>2</sub> -C (g/day/cow)	8214±0.46	8048 ±1.67	9003±1.61
N <sub>2</sub> O-N (g/day/cow)	0.433±0.213	0.468±0.157	0.909±0.504
CH <sub>4</sub> -C (g/day/cow)	712.7±45.4	627.4±82.6	645.8±80.0
NH <sub>3</sub> -N (g/day/cow)	97.2±13.9	56.0±11.63	60.2±11.8

In Figure 1 to 4, vertical bars indicate the standard deviation.

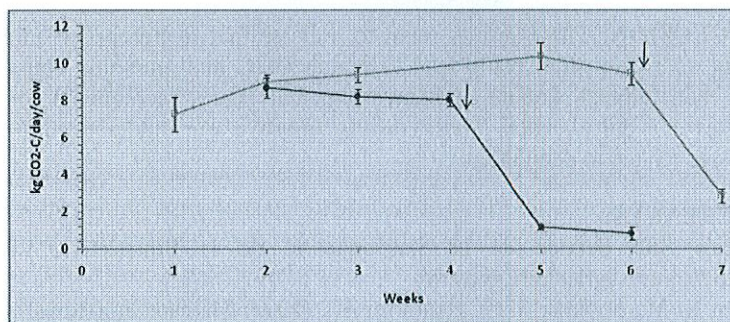


Figure 1. Mean CO<sub>2</sub>-C emissions for P1 (•) and P2 (□); ↓ indicates when the cows left the room.

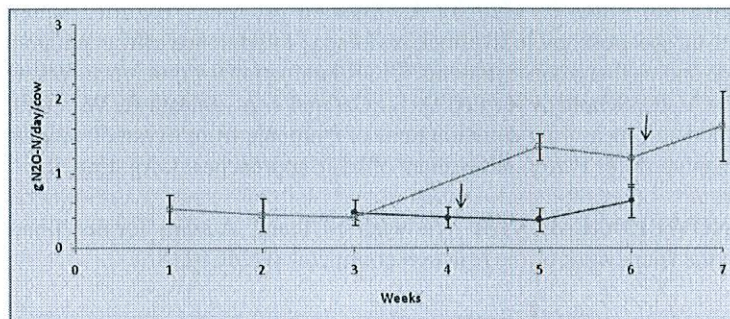


Figure 2. Mean N<sub>2</sub>O-N emissions for P1 (•) and P2 (□); ↓ indicates when the cows left the room. (Values in week 2 are lacking).

### Mitigation strategies

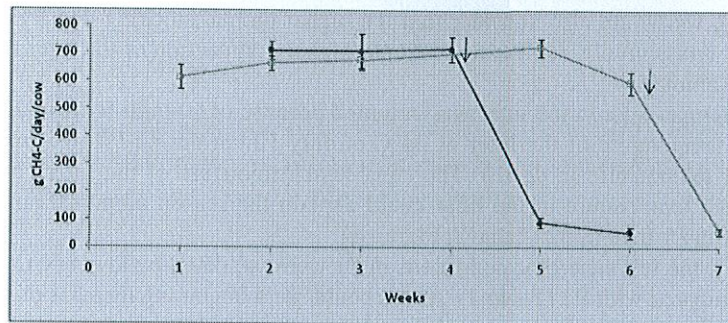


Figure 3. Mean CH<sub>4</sub>-C emissions for P1 (•) and P2 (□); ↓ indicates when the cows left the room.

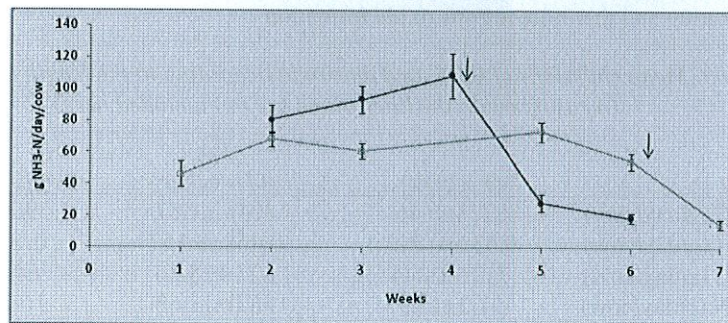


Figure 4. Mean NH<sub>3</sub>-N emissions for P1 (•) and P2 (□); ↓ indicates when the cows left the room.

**CONCLUSION:** These results seem to indicate that inappropriate animal stocking density on a deep litter could lead to higher GHG and ammonia emissions. In this sense, both animal welfare and environmental issues recommend lower stocking densities for dairy cattle. These results improve our understanding of emitting processes related to deep litters.

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