IS THERE AN INFLUENCE OF ANIMAL BEHAVIOUR ON INDOOR GAS CONCENTRATION ?

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Introduction

Indoor air quality results first from indoor production of gases, dust, and pathogens, and second, on dilution by fresh air input. Ventilation depends mostly on inside air temperature. As a consequence, indoor air quality should depend on climate, building thermal insulation, animals, and emitting surfaces. It is of common sense in animal production that emitting surfaces, animals, management practices and ventilation interact, and that these interactions can lead to various irreversible changes in the emitting surfaces. Therefore, the influence of animal behaviour on indoor air quality can be obviously assumed.

Observations confirmed this assumption in the case of feeding behaviour, and ammonia, carbon dioxide, or dust (Hinz & Linke, 1998b; Jeppsson, 2002; Groenestein *et al*, 2003), while diurnal variations of nitrous oxide and methane emissions were not observed (Nicks *et al,* 2003). Ammonia emission has received many attention since decades. However, animal behaviour is not accounted for explicitly in modelling concentrations and emissions from livestock buildings (Aarnink & Elzing, 1998; Ni, 1999; Pinder *et al*, 2004). Filling this knowledge gap can help to improve management practices, building conception, and mitigation strategies through a finer tuning to climate, farmer, and animals.

The pig-on-litter system is a suitable example for this objective because the pigs choose a defecating area, they explore the litter, they adapt their behaviour to the air temperature (Ducreux *et al*, 2002), while the litter evolution is affected by this behaviour (manure surface and manure amount in the litter: Jeppsson, 2002; the exploring behaviour also influences the gas exchanges within the litter and the microbial transformations), the methods of air or behaviour monitoring have been already discussed (Hinz & Linke, 1998a; Phillips *et al*, 1998; Jensen *et al*, 1986). Therefore, short-term as well as long-term changes can be observed. We focused here on short-term relationships. We chose warm conditions, assuming the ammonia concentration to rise when the pigs stand on. During warm periods they lie on the dirty part of the litter and the warm emitting surface increases as soon as they stand up. The number of standing animals can be a key variable to link the behaviour to air concentrations (Groenestein *et al*, 2003).

Material and Methods

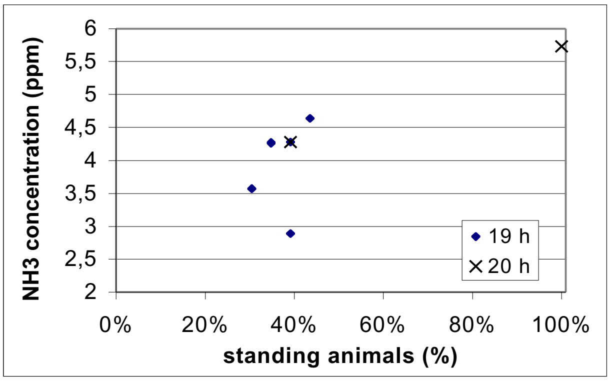
We chose a building with low animal density (2,6 m^2/pig) in order to have contrasted lying and excreting areas. The room contained 23 pigs between 80 and 120 kg. We recorded the animal behaviour with a camera and 24h-video recorder between 6h and 23h. We measured continuously the NH_3, CH_4, and N_2O concentrations with a multigas photo-acoustic analyser connected to a sampler (INNOVA, 1312+1303) and controlled by a computer. We monitored four different sampling points inside and two outside a commercial building with natural ventilation during two weeks in july 2003. We also monitored the air flow rate with the SF_6 dosing-tracer method, and inside and outside air temperature and humidity (all details are given in Robin *et al*, 2003). We studied time sequences of some minutes where the air flow rate and the outside and inside climates were stable, the animal and litter metabolisms were assumed stable, so that the animal behaviour was assumed to be the main variable influencing the inside gas concentrations. We chose sequences where the gas concentration changed and all animals could be counted. We measured the number of standing and digging animals on the video records for each concentration measurement during those sequences.

Results

The final number of moments where the gas concentration changed, all the animals could be counted, and the overall conditions were stable was very low because of the data rejected due to difficulties with the material or uncertainties with the synchronisation of the video-recorder and the gas equipment.

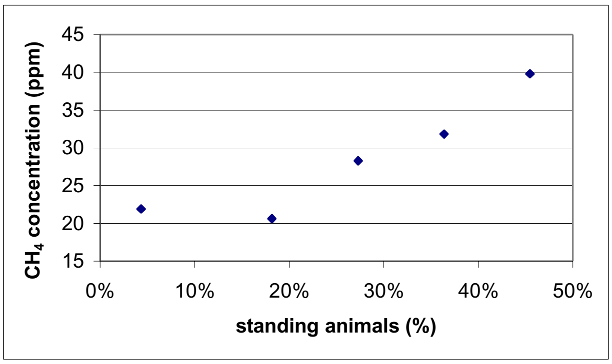
NH_3 concentrations increased above the excreting area but not above the lying area. On the contrary, concentrations of N_2O and CH_4 increased above the lying area and not above the excreting area.

Figure 1: variation of NH_3 concentration above excreting area when the proportion of standing animals increases.



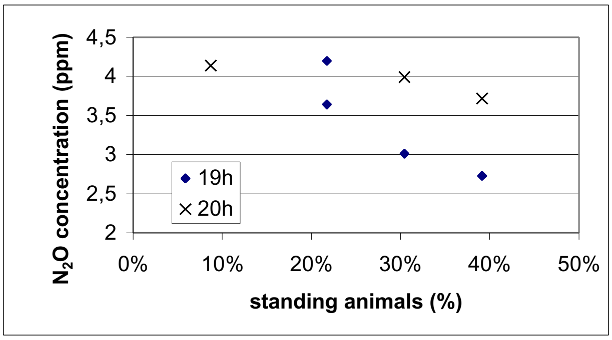
NH_3 concentration increase was not related to the number of standing animals when it varied slightly but a relationship was observed when the number varied strongly (Fig. 1).

Figure 2: variation of CH_4 concentration above lying area when the proportion of standing animals increases.



The CH_4 concentration increased with the number of standing pigs when both increased (Fig. 2) but the points were scattered during the decrease of the concentration. The N_2O concentration increased when the number of standing animals decreased, i.e. when the pigs began to lie and dig the litter around them (Fig. 3). As for CH_4 no relationship was observed during the decrease of the concentration.

Figure 3: variation of N_2O concentration above lying area when the proportion of standing animals decreases.



Discussion

We assumed from previous work that relationships could be observed for ammonia and not for methane or nitrous oxide (Groenestein *et al*, 2003; Hinz & Linke, 1998; Jeppson, 2002; Nicks *et al,* 2003). In our experiment, relationships were observed for all gases, while the relationship for ammonia was not as clear as assumed initially. In the case of ammonia, this result can be explained by a lower ammonia concentration in the excreting area and a relative lower surface of the animals. As a matter of fact, the animal density was low in our case. It can have induced a higher organisation or adsorption of excreted nitrogen in the litter, and a higher excreting area not covered by lying animals regarding the surface variation that occurred when a small proportion of animals stood up. It shows that modelling this relationship should account for the type of breeding system.

The increase in methane concentration can be explained by the emission of gas from the porosity closed by the lying pigs. The lack of relationship above the excreting area can be explained by a to small free air space in this area. The lack of relationship during the concentration decrease can be explained by new processes such as some emitting sites becoming aerobic.

In the case of nitrous oxide the same increase as methane is not observed because the redox conditions where methane accumulates in the free air space are not favourable to nitrous oxide accumulation. When more pigs lie and dig around themselves, increasing sites with enough oxygen for nitrification and too much for complete denitrification can release the produced nitrous oxide. It can explain the increase in concentration of nitrous oxide.

Conclusion

The existence of relationships between gas concentration and animal behaviour at the scale of the livestock room can be obviously assumed though they are absent of most models of gas emission developed since decades.

We looked for short-term relationships between ammonia, methane and nitrous oxide, and the number of standing animals in the case of the pig-on-litter system. Relationships were observed when the gas concentration increased but not during the decrease.

The gas concentrations varied very little and could be explained by local interactions between the pigs and the litter porosity. It shows that acting on short term behaviour will not change the level of the gas concentrations and can be neglected in models. However, the long term interaction between pig behaviour and litter management practices can change the biological transformations within the litter and have a much stronger influence on the gas concentrations and emissions from the building. Modelling this process to improve management practices requires to characterise the feed-back between behaviour and surface heterogeneity within the breeding room. This modelling needs a coupled description of the nitrogen, carbon and water cycles within the system, more complete than it is generally done in modelling livestock buildings.

Acknowledgements

We gratefully acknowledge INRA and the GIS « Porcherie Verte » for the financial support, Mr and Mrs Daucé for the field facilities, Solenn Guillaume, Jean-Marie Paillat, Jean-Claude Ferren, Rémy Dubois, and Yannick Bénard for their experimental help, and the organising committee of the congress.

References

1. Aarnink A.J.A., A. Elzing, 1998. Dynamic model for ammonia volatilization in housing with partially slatted floors for fattening pigs. *Livestock Production Science*, 53, 153-169.
2. Ducreux E., B. Aloui, P. Robin, J.Y. Dourmad, V. Courboulay, M.C. Meunier-Salaün, 2002. Les porcs affichent leurs préférences vis-à-vis du type de sol en fonction de la température. *Journées de la Recherche Porcine*, 34, 211-216.
3. Groenestein C.M., M.M.W.B. Hendricks, L.A.den Hartog, 2003. Effect of feeding schedule on ammonia emission from individual and group-housing systems for sows. *Biosystems Engineering,* 85 (1), 79-85.
4. Hinz T., S. Linke, 1998a. A comprehensive experimental study of aerial pollutants in and emissions from livestock buildings. Part 1: methods. *J. Agricultural Engineering Research*, 70, 111-118.
5. Hinz T., S. Linke, 1998b. A comprehensive experimental study of aerial pollutants in and emissions from livestock buildings. Part 2: results. *J. Agricultural Engineering Research*, 70, 119-129.
6. Jensen P., Algers B., Ekesbo I., 1986. *Methods of sampling and analysis of data in farm animal ethology.* Birkhaüser Verlag ed., Basel, Boston, Stuttgart, 86p.
7. Jeppsson K.H., 2002. Diurnal variation in ammonia, carbon dioxide and water vapour emission from an uninsulated, deep litter building for growing/finishing pigs. *Biosystems Engineering,* 81 (2), 213-223.
8. Ni J., 1999. Mechanistic models of ammonia release from liquid manure: a review. *J. Agricultural Engineering Research*, 72, 1-17.
9. Nicks B., M. Laitat, A. Desiron, M. Vandenheede, B. Canart, 2003. Emissions d'ammoniac, de protoxyde d'azote, de méthane, de gaz carbonique et de vapeur d'eau lors de l'élevage de porcs charcutiers sur litières accumulées de paille et de sciure. *Journées de la Recherche Porcine*, 35, 7-14.
10. Phillips VR, Holden MR, Sneath RW, Short JL, White RP, Hartung J, Seedorf J, Schroder M, Linkert KH, Pedersen S, Takai H, Johnsen JO, Koerkamp PWGG, Uenk GH, Scholtens R, Metz JHM, Wathes CM, 1998. The development of robust methods for measuring concentrations and emission rates of gaseous and particulate air pollutants in livestock buildings. *J. Agricultural Engineering Research*, 70, 11-24.
11. Pinder R.W., N.J. Pekney, C.I. Davidson, P.J. Adams, 2004. A process-based model of ammonia emissions from dairy cows: improved temporal and spatial resolution. *Atmospheric Environment*, 38, 1357-1365.
12. Robin P., M. Hassouna, C. Texier, 2004. Maîtrise des émissions gazeuses en bâtiments sur litière (validation en élevages des résultats acquis en station expérimentale). Convention MEDD-INRA n° CV03000073, 36p.

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