Multi-element combined methods (MECM) increase the reliability of emission factor measurement

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Introduction

Inventories or Life Cycle Assessment use emission factors for livestock buildings but their results are sensible to the variation range of the emission factors. At the farm scale, technique improvement needs to quantify their effect on the emission factors.

Present variability depends either on system characterisation (i.e. intra-class variability) or on measuring method (gradient measurement, air flow rate measurement, time extrapolation). Therefore, there is a need to develop robust methods that will lead to quantify the accuracy of emission factor estimates. In the case of livestock buildings, the measurement period should take several months, it should be adapted to both short-term and mid-term variability of the climate and the farmer practices, and it should allow simplifications for

Meteorological station (detailed and continuous climate characterisation) + **T-HR** (sensor+logger: minimum climate characterisation)
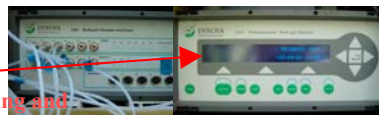
Materials and Methods

The measuring equipment (Fig. 1) associates devices allowing the use of methods considered as reference ones (tracing gas), completed by devices allowing the use of simplified methods (indirect ventilation estimates) or the cheapest method: default of mass balance.

Each method has its own pros and cons: technical advantages, assumption validity, price.

T-HR (sensor+logger: detailed or minimum climate characterisation)
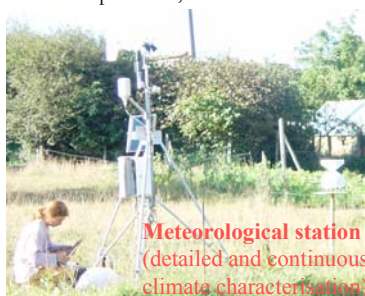
Mixing system (homogeneity of gas concentrations and tracer injection)

Gas analyser, coupled with sampling and dosing multiplexer and computer

effluent (sampling and weighing + information on food, water, and straw inputs, and on animals)

Fig. 1: MECM measuring system: the tracer gas method is checked against indirect ventilation measurement and mass balance of H_2O, C, N, P, K; it allows a two-level simplification.

Results

Fig. 2: Kinetics of SF_6-tracer concentrations: several successive measurements on the same channel and at least two channels outside and inside are necessary to evaluate the measurement accuracy

constant dose period

decreasing period

Débit d'air mesuré par traçage

constant dose estimates (x;-) and hourly median (squares)

decreasing estimates (+) and hourly median (squares)
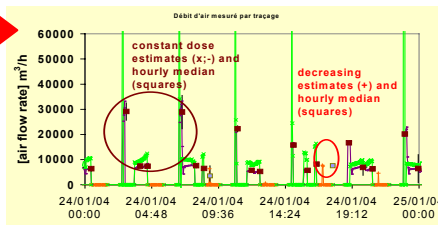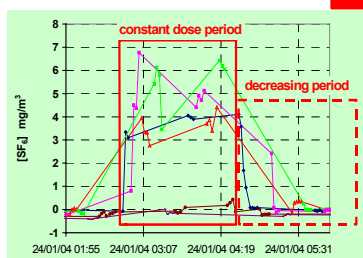
Fig. 3: air flow rate estimates show the sensitivity of the methods to the given dose and the observed concentration variability.
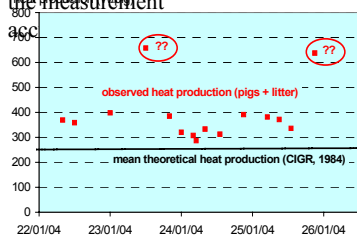
Fig. 4: heat production, (total, sensible or latent) also used in indirect ventilation estimates, reveals unrealistic air flow rate estimates.

heat production (W/a)

??   ??

observed heat production (pigs + litter)

mean theoretical heat production (CIGR, 1984)

Mass balance examination (after temporal extrapolation)
- P and K excreted should be found in the effluent (correct sampling);
- H_2O emitted should be slightly higher than lost water (metabolic water);
- CO_2+CH_4 emitted should be slightly less than lost C (VOC);
- N_2O+NH_3 emitted should be less than lost N (N_2).

Discussion and conclusion

- Multi-element approach (H_2O, C, N, P, K) allows the verification of the estimates and the simplification of the reference method, because the various elements have contrasted behaviours.
- Combined methods ("constant dose" and "decreasing" tracer methods; indirect ventilation measurement; mass balance of the effluent) make it easier to check the observations against realistic values of heat production within the building (instantaneous observations) or realistic values of gaseous losses (mass losses after some weeks or months).
- Gas concentration measurements can lead to both simplified instantaneous estimates, when combined with T-HR measurements, and simplified integrated estimates, when combined with effluent mass balance (see Paillat et al, same session).
- Increasing the redundancy of the data set increases the possibilities to reduce the uncertainty in the emission factor estimates.

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