A TEST-BENCH FOR INFRARED PHOTOACOUSTIC ANALYZERS USED TO MEASURE GAS EMISSIONS FROM ANIMAL HOUSES AND MANURE STORAGE

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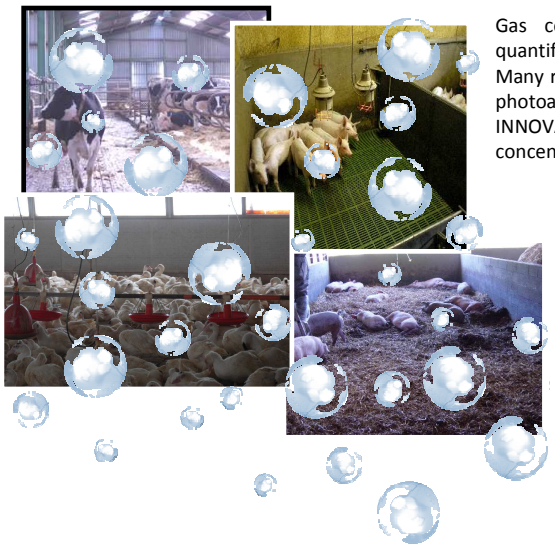
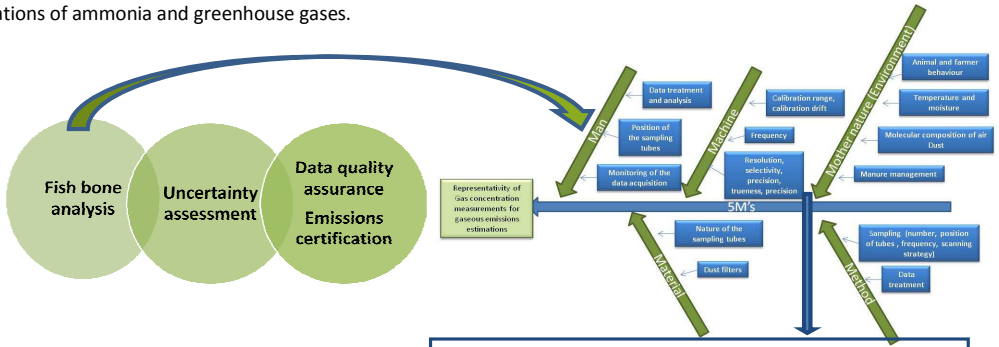


Gas concentration measurements are required to quantify gaseous emissions from agricultural sources. Many research teams in the world have chosen infrared photoacoustic spectroscopy analyzers (PAS; e.g. INNOVA® 1312 or 1412) to measure selectively the concentrations of ammonia and greenhouse gases.

Up to now, comparing data from literature is difficult because:

- ❖no intercalibration of the INNOVA devices
- ❖low information level in the measuring protocols
- ❖no uncertainty assessment (GUM; JCGM, 2008[(1)])



A part of the contribution of the INNOVA PAS in the final concentration's uncertainty must be evaluated in laboratories, in repeatability conditions.

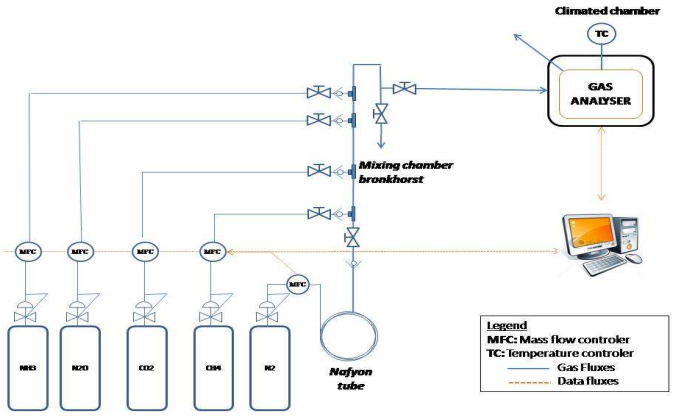


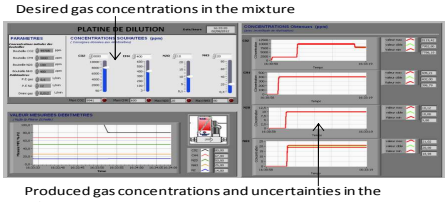
Figure 1 : The test bed is composed of mass flow controllers and gas bottles (CH_4, CO_2, NH_3 and N_2O) at diluted concentrations. N_2 is used as vector and dilution gas.

The mass flow controllers are controlled with a Labview program (Figure 2) that allows choosing and measuring the mass flows corresponding to various concentration levels in the gas mixture.

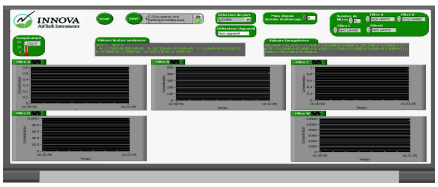
The program is also used to visualize and record the calculated concentrations in the gas mixture, the concentrations measured by the analyzer, the calibration data, the concentration uncertainties (gas mixture, analyzer).

A test bed has been developed to generate gas mixtures with chosen NH_3, CH_4, N_2O and CO_2 concentrations (Figure 1). 4 bottles of pure gases at diluted concentrations (400 ppm NH_3 ; 3000 ppm CH_4 ; 100 ppm N_2O ; 50000 ppm CO_2) are connected to mass flow controllers (Bronkhorst® F-201CV-500-RAD-11-V) with numerical control. N_2 is used as vector and dilution gas. A Nafion tube, connected to the N_2 line, is used to humidify the gas mixture. Two tubes are connected at the exhaust of the test bed in order to avoid excessive pressure at the inlet of the analyzer. One tube is connected to the inlet of the analyzer, the other one is an outlet carrying the gas mixture to outside the room.

Desired gas concentrations in the mixture



Produced gas concentrations and uncertainties in the mixture



Gas concentrations and uncertainties measured by the PAS analyser

Figure 2 : man-machine interfaces used to control the mass flow controllers, to collect data from the mass flow controllers, the gas concentrations in the mixture and the raw signals given by the PAS analyzer, and to calculate the gas concentrations in the mixture and their uncertainty.

Animal_Emissions website: http://www4.inra.fr/animal_emissions/ANGAEL

With this test bed, concentration measurements made with two analyzers can be compared simultaneously. The influence of temperature on concentration measurements can also be evaluated. The rapid generation of gas mixtures with different concentration levels makes easy the evaluation of the interferences between the measured gases.

Figure 3. Concepts of precision, trueness, accuracy (VIM; JCGM, 2012[(2)])

Precision, trueness and accuracy (Figure 3) can be evaluated with the test bed in laboratory conditions. In real conditions other interferences can appear due to the molecular composition of air. The uncertainty on gas concentrations should be completed with a component that takes into account all interferences.

In conclusion this test bed allows the production of gas mixtures with chosen NH_3, CH_4, N_2O and CO_2 concentrations. For the moment the water content in the mixture is not controlled. This influence and the corrections of the raw signals should be further studied.

This test bed is a powerful tool to check that:

- **the calibration drift of the analyzer remains negligible;**
- **the calibration range gives the expected trueness;**
- **the calibration is adapted to the concentration range that is expected for experiments in field conditions.**

(1) GUM: Guide to the expression of uncertainty in measurement - http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf
(2) VIM: International Vocabulary of Metrology - http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2012.pdf

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