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Session 5 - Environmental pollution through pig production

A dynamic model of ammonia emission and concentration in fattening pig buildings

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Abstract

The control of gas emissions from livestock buildings, especially ammonia, is important to limit the environmental impact, which depends primarily on the total emission, and to improve the welfare and health of the animals and the stockmen, which is affected by the concentration in the air. Modelling is an essential tool for a global approach of the different processes involved in the emissions. The model developed in this work aims at integrating the information and models already available in the literature in order to predict, in a dynamic way (with a 1 min time step), the gas emissions and the concentrations inside the fattening rooms. The model was validated with data from the literature. The results of this validation indicated that the model predicted in a coherent way as well the cumulated flows as the concentrations. However, we identified some lacks in knowledge, in particular concerning the estimate of the pH of the liquid manure according to the characteristics of the feed and the evolution of manure composition with time. Likewise, it appeared that the phenomena of exchanges between the air located above and below the slats must also be better specified, because they strongly influence ammonia concentration. The simulations indicated that total emission and concentration are not well correlated and are highly dependant on the ventilation system and the temperature.

A dynamic model of ammonia emission and concentration in fattening pig buildings

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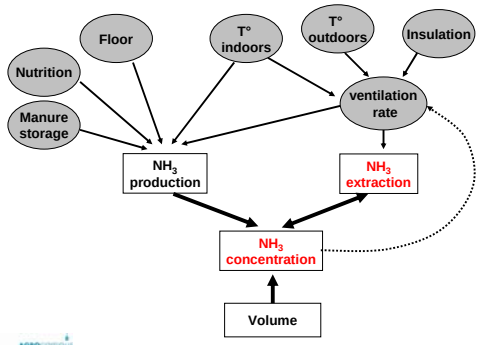
Ammonia emissions from pig buildings

- Animal production : main source of NH_3 emission
- Environmental impact of NH_3
  - Acidification
  - Eutrophication
- Air quality
  - Human health
    - Legislation on working conditions
  - Animal health and welfare
    - Effect on performance

⌧ Simultaneous optimisation of both aspects !

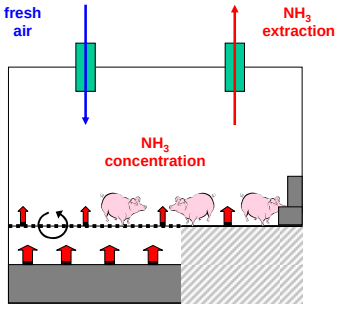
Ammonia in pig buildings

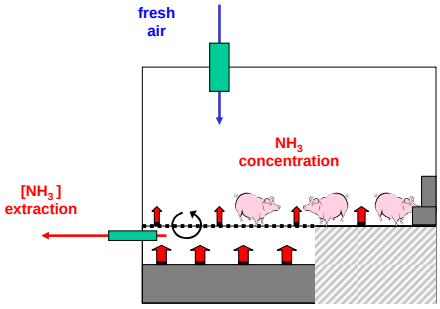


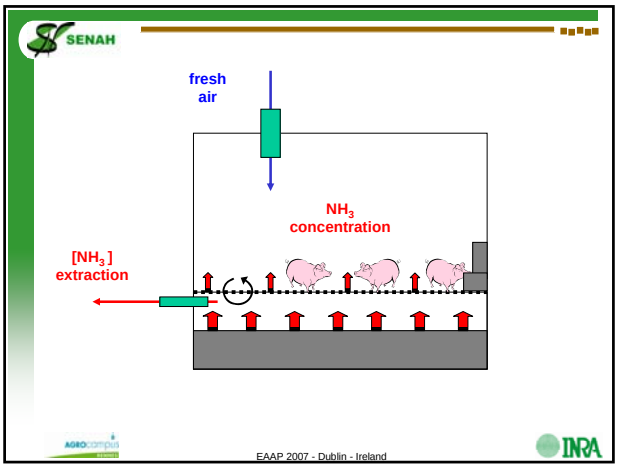
Dynamic modelling approaches available in litterature

- Models to predict animal excretion and characteristics of manure
- Models to predict ammonia release from manure
- Models to predict the indoor climate and ventilation rate

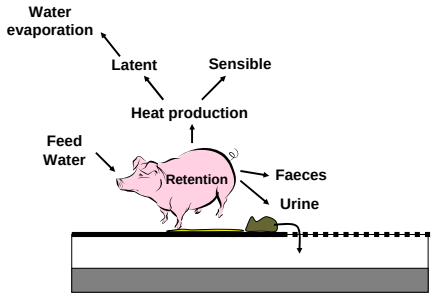
⌧ **Objective : integrated dynamic model of ventilation, climate, emissions and concentrations in a room for fattening pigs**



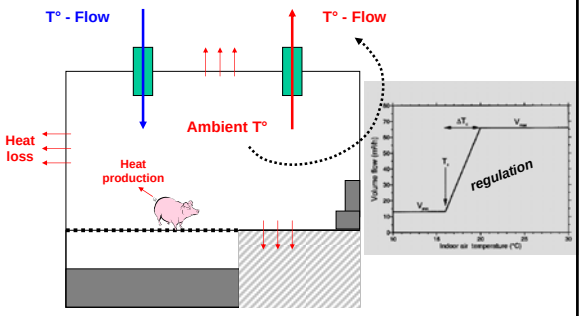




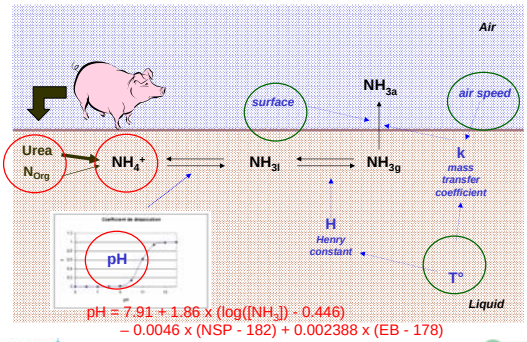
Animal and excretion



Climate and building



Ammonia emission

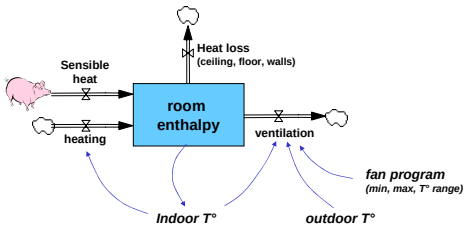


$pH = 7.91 + 1.86 \times (\log([NH_3]) - 0.446) - 0.0046 \times (NSP - 182) + 0.002388 \times (EB - 178)$

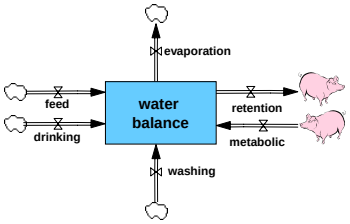
Development of the model

- Using «vensim»® modeling platform
- Time step of 1 mn
- Inputs
  - Housing design (type of floor, type of ventilation, animal density, …)
  - Animal performance (ADG, FCR) and feeding
  - Outdoor climate
- Outputs
  - Flow and concentration of NH_3
  - Indoor climate

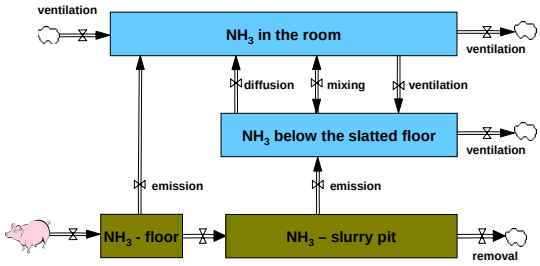
Description of the model (indoor climate)



Description of the model (water balance)



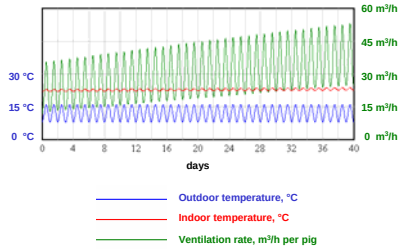
Description of the model (NH_3 emission)



Results
-
Sensitivity analysis

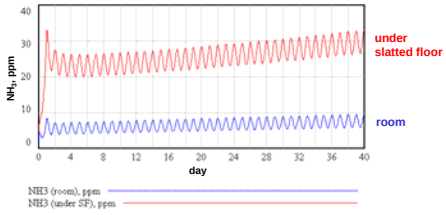
Predictions of variations in ambient temperature and ventilation rate

Totally slatted floor – air extraction under SF

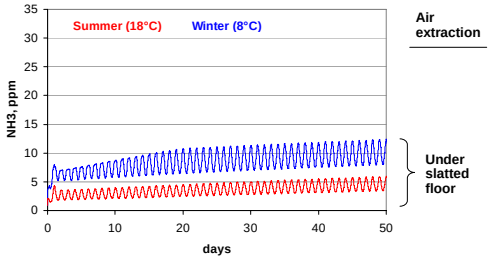


Predictions of variations in NH_3 concentration in the room and under the slatted floor

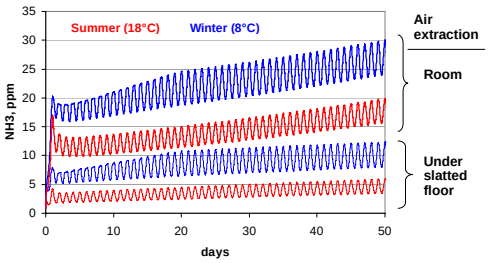
Totally slatted floor – air extraction under SF



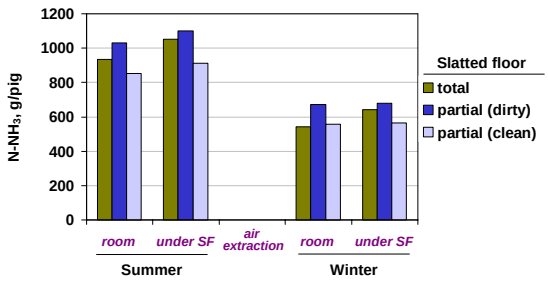
Effect of season and type of air extraction on NH_3 concentration in the room



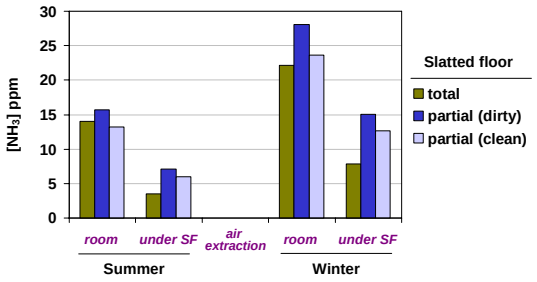
Effect of season and type of air extraction on NH_3 concentration in the room



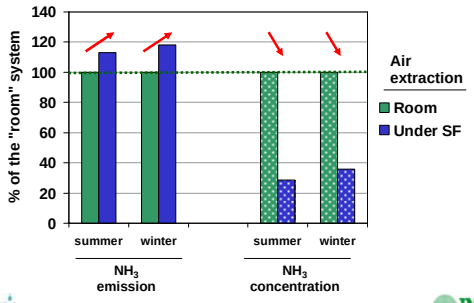
Predicted effects of season, slatted floor and ventilation on cumulated N-NH_3 emission



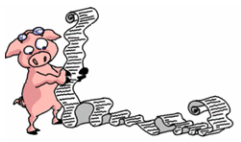
Predicted effects of season, slatted floor and ventilation on NH_3 concentration in the room



Effect of ventilation system on ammonia concentration and total emission

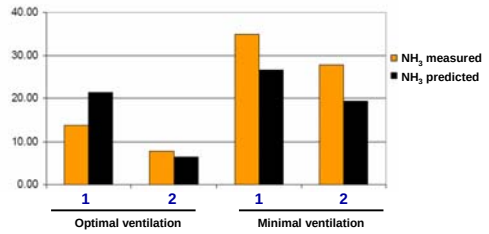


Validation



Effect of ventilation and type of slatted floor on NH_3 concentration in the room

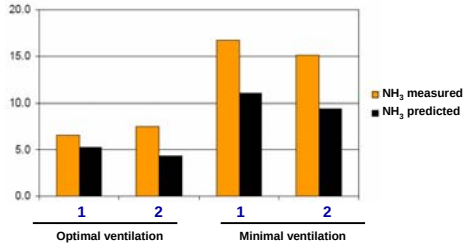
Guingand et al. (2001)



1 : Partially slatted floor – air extraction room & under SF
2 : Totally slatted floor – air extraction below SF

Effect of ventilation and type of slatted floor on NH_3 concentration in the room

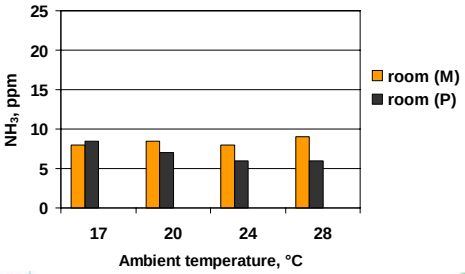
Massabie et al. (2005)



1 : Concrete slatted floor
2 : Metallic slatted floor

Effect of temperature on NH_3 concentration in the room and in the extracted air

Granier et al. (1996)



Effect of temperature on NH_3 concentration in the room and in the extracted air

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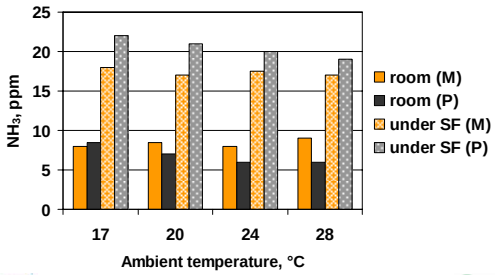

Conclusions

- **Interesting approach**
  - **Short term variations – Cumulated effects**
  - **Concentration – total emission**
- **Validation**
  - **Concentration (room, extracted air)**
  - **Total emission**
- **Antagonism between**
  - **Reduction of total emission**
  - **Improvement of air quality**
- **Aspects to be improved**
  - **Prediction of slurry pH**
  - **Take better account of animal behaviour and floor dirtiness**
  - **Air exchanges between different areas (under SF – room)**

Than you for your attention !

« Year of the pig » – Vietnam - Ho Chi Minh - 2007