Book of Abstracts
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Modeling and prediction of ammonia emission from field-applied animal manure

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1. Summary

Ammonia emission from field-applied pig manure slurry is studied using Michaelis-Menten equation. The two model parameters (total emission of ammonia and time to reach half of the total emission) of the Michaelis-Menten equation are estimated using a multivariate linear regression (MLR) method and a feedforward-backpropagation artificial neural network (ANN) approach on the basis of ALFAM (Ammonia Loss from Field-applied Animal Manure) database in Europe.

The MLR method well describes the ammonia emission tendency with variation in the emission factor. However, ammonia emission from manure slurry is too complex to be captured in a linear regression model. This necessitates a model which can describe complex nonlinear effects between the ammonia emission variables such as soil and manure states, climate and agronomic factors. In the present study, a ANN approach is proposed to account the complex nonlinear effects.

The ammonia emission is predicted with precision by the 11 emission factors, using the nonlinear ANN approach. The relative importance among the 11 emission factors is identified using the elasticity analysis in the MLR method and using the ANN approach. The relative significance obtained quantitatively by the ANN approach in the present study gives an excellent explanation of the most important processes controlling NH_3 emission.

Keywords: Ammonia emission; livestock manure; Michaelis-Menten equation; Multivariate linear regression (MLR), Artificial neural network (ANN).

2. Extended Abstract

The Michaelis-Menten type equation is one of the widely used model to predict the ammonia emission from field-applied manure (Lim et al., 2007). The Michaelis-Menten equation is:

$$N_{\mathrm{NH3}}(t) = N_{\max} \frac{t}{t + K_m} \qquad (1)$$

where N_{NH3} $[kg/ha]$ is the accumulated ammonia loss at a time (t), $N_{\max}$ $[kg/ha]$ is the maximum ammonia loss, and K_m $[hr]$ is the time to reach half of the maximum ammonia loss ($\frac{N_{max}}{2}$). Here, the quantity of ammonia loss is based on the nitrogen weight. The two model parameters (N_{max} and K_m) can be estimated by an empirical equation regressed from experiments.

In this study, the two model parameters are estimated on the basis of ALFAM (Ammonia Loss from Field-applied Animal Manure) database (Sommer, 2000) in Europe, using the feedforward-backpropagation artificial neural network (ANN) approach.

2.1. Artificial neural network approach

The ANN approach is composed of one input layer, one or several hidden layers and one output layer. The neuron numbers of the input and output layers are equal to the input and output variable numbers, respectively. In this work, the neuron numbers of the input and output layers correspond to the 11 independent variables influencing the ammonia loss and the two model parameters of the Michaelis-Menten equation, respectively.

2.2. Results and Discussion

The calculation is performed on the statistics and neural network toolboxes of Matlab (Mathworks, USA, 2005). Table 1 shows the correlation coefficients (R^2) of the two model parameters and the mean square errors (MSE) using the two model parameter estimation methods (MLR and ANN methods). The nonlinear regression method (i.e., ANN approach) shows a higher correlation coefficient value than the MLR method, because nonlinearity between the independent variables (p_i) and the model parameters (K_m and N_{max}) is better considered. It is noted that the ANN approach predicts quasi perfectly the measured K_m and N_{max} values (see Fig. 2) even without information of NH_3 emission factors excluded in the model (e.g., soil moisture, radiation, total nitrogen in manure, etc.). However, the prediction is valid for the used 83 datasets.

Table 1. Correlation coefficient (R^2) and mean square error (MSE) in MLR and ANN approaches.

model		R^2 for K_m	R^2 for N_{max}	MSE
MLR	This study	0.3680	0.6631	141.04
	DIAS	0.77	0.80	-
PWA 11-10-26-2		0.9941	0.9985	0.8333

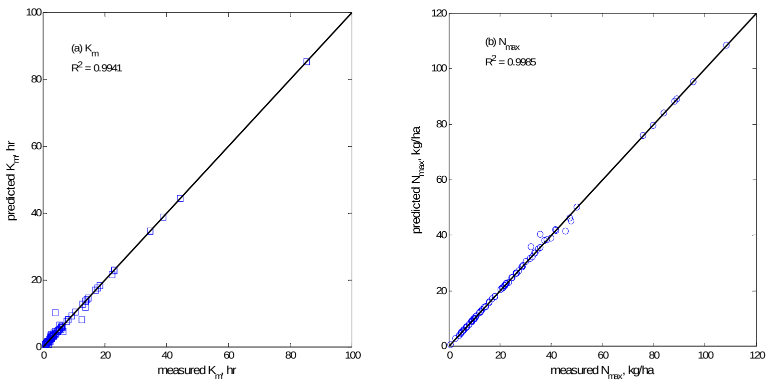

Fig. 1 Comparison of measured and predicted model parameters (K_m and N_{max}).

References

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