ALFAM2: a database and model for ammonia emission from field-applied slurry

Sasha D. Hafner

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The ALFAM2 project has two main products

1. ALFAM2 database
   - 12 countries
   - 1800 plots
   - Public in 2017
   - [www.alfam.dk](http://www.alfam.dk)

2. ALFAM2 model
   - New model
   - Average parameter set
   - [https://github.com/sashahafner/ALFAM2](https://github.com/sashahafner/ALFAM2) (now)
   - [www.alfam.dk](http://www.alfam.dk) (soon)
The ALFAM2 database. What’s the point?

- Multiple uses, multiple users
  - Model development or evaluation
  - Emission factor determination or evaluation
- Are experimental data accessible if not entered in some type of structured database?
  - Value in prevention of data loss
- Database = transferred ownership of data
  - Trust, respect, and access are important
In particular, the help of Martin Chantigny, Shabtai Bittman, Derek Hunt, Tavs Nyord, Tom Misselbrook, Martin Hansen, Christoph Haeni, Jörg Sintermann, Albretch Neftel, Thomas Kupper, Polina Voylokov, Benjamin Loubet, Marco Carozzi, Gary Lanigan, Jack Miesinger, Bert Vermeulen, Jan Huijsmans, Andreas Pacholski, and Sven Sommer in contributing data and ideas is greatly appreciated.

Data were originally collected by individuals at the following institutes and were generously contributed to this project: Agriculture and Agri-Food Canada, ADAS, Rothamsted Research, Aarhus University, AgroTech, Leuphana University, Bern University of Applied Sciences, Milan University, the French National Institute for Agricultural Research, the Irish Agriculture and Food Development Authority, the United States Department of Agriculture-Agricultural Research Service, and Wageningen University.
Data collection

Eight categories of data and two observational levels (plot, interval)

<table>
<thead>
<tr>
<th>Identification</th>
<th>Location</th>
<th>Soil</th>
<th>Weather</th>
<th>Slurry</th>
<th>Application</th>
<th>Crop</th>
<th>Emission</th>
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<tbody>
<tr>
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<td>Type</td>
<td>Timing</td>
<td>Type</td>
<td>Interval time</td>
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<td>Publication</td>
<td>Longitude</td>
<td>Moisture</td>
<td>Radiation</td>
<td>Bedding</td>
<td>Method</td>
<td>Height</td>
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<tr>
<td>Experiment</td>
<td>Topography</td>
<td>pH</td>
<td>Wind speed</td>
<td>Dry matter</td>
<td>Rate</td>
<td>Coverage</td>
<td>Plot size</td>
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<tr>
<td>Field code</td>
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<td>Rain</td>
<td>Total N</td>
<td>Incorporation</td>
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<td>Back- ground</td>
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<td></td>
<td>pH</td>
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</table>

Data were entered into spreadsheet templates by each institute
## Data preview

### Show 5 entries

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<th>pid</th>
<th>pmid</th>
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<th>proj</th>
<th>exper</th>
<th>exper2</th>
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</table>

Showing 1 to 5 of 109 entries

### Plot Counts

Total number of plots: 109

- Source by crop
- Source by application method
- Country by application method
Example: data analysis on effects of slurry, application method, and weather on emission

1. **Application method**
   - Trailing shoe and trailing hose application reduce emission by 30% to 60%
   - Trailing hose shows greater reduction than trailing shoe in mixed-effects models, but not in experiment-wise models
   - Open slot injection provides a reduction > 70%

2. **Slurry characteristics**
   - +4% (broadcast) to +40% (injection) per 1% increase in dry matter
   - 2.4-fold change per unit increase in pH (but due to acid)

3. **Weather**
   - +2% to +7% per °C increase in air temperature
   - Up to +20% per 1 m s⁻¹ increase in wind speed
Analysis also shows large differences among institutes (data sources)

- Institute standard deviation estimate ~ 2x
- We can estimate random-effects coefficients ("institute effects") but they are estimates only, and this analysis cannot identify the causes
- We need to understand these differences in order to have confidence in emission measurements
Magnitude of institute effects are large
The ALFAM2 model. Why?

We need accurate, flexible, reliable models for calculating emission in order to:

1. Estimate emission for inventories
2. Construct field-level N budgets
3. Plan application timing and methods
4. Demonstrate effects of management
5. Evaluate emission measurements
The ALFAM2 model is semi-empirical and relatively simple.

$r_i = \text{first-order rate constant (0-infinity)}$
$f_i = \text{instantaneous partition coefficient (0-1)}$

Diagram:

- Applied TAN A
  - $A(1 - f_0)$
  - $Af_0$

- Fast F
  - $r_1 F$
  - $r_2 F$
  - $f_5 F$

- Slow S
  - $r_3 S$

- Emission from F
- Emission from S
Model structure was selected to match observed patterns

- First-order pattern ½ day
- Continued decline, lower rate

30 000 observations
1 800 plots
from ALFAM2 database
alfam.dk
Primary parameters link to management and environment by secondary parameters

- Primary parameters \( (f_0, r_1, r_3) \) are (transformed) linear functions of predictors (slurry characteristics, weather, etc.)
- Secondary parameters are used to calculate primary parameters from predictors
  - e.g., \( \log r_1 = \beta_0 + \beta_1 \times \text{wind speed} + \beta_2 \times \text{temp} + ... \)
  - \( \beta_0, \beta_1, \beta_2 \) = secondary parameters
- Categorical variables enter as dummy variables
- Transformation (log and logit) affect response (relative and odds)
- 19 secondary parameters in “average” model
  - Fit to subset of ALFAM2 database (6 countries)
The links provide a way to control how a variable affects emission.
Error in fraction of applied TAN lost is moderate

- Predictions within 20% of applied TAN for 80% of observations
- Model accuracy may have an intrinsic limit because of the complexity of emission and limitations in measurements
How does it work? Plausible predictions for effects of application methods
There are no limits on combinations. . .

- Weather and slurry characteristics can together affect emission.
- Acidification and incorporation can substantially reduce emission, and effects will depend on slurry characteristics and weather.
Application TAN A

**Applied TAN A**

- Application rate, application method, slurry dry matter
- Incorpotation
  - Rain
  - Application method, slurry dry matter, slurry pH, air temperature, wind speed
- Slow S
  - Application method, air temperature, slurry pH, incorporation

**Fast F**

- Application method, slurry dry matter, slurry pH, air temperature, wind speed

Thank you for your attention!