Cleaner air and better fertilizer value – evidence and experiences from Denmark

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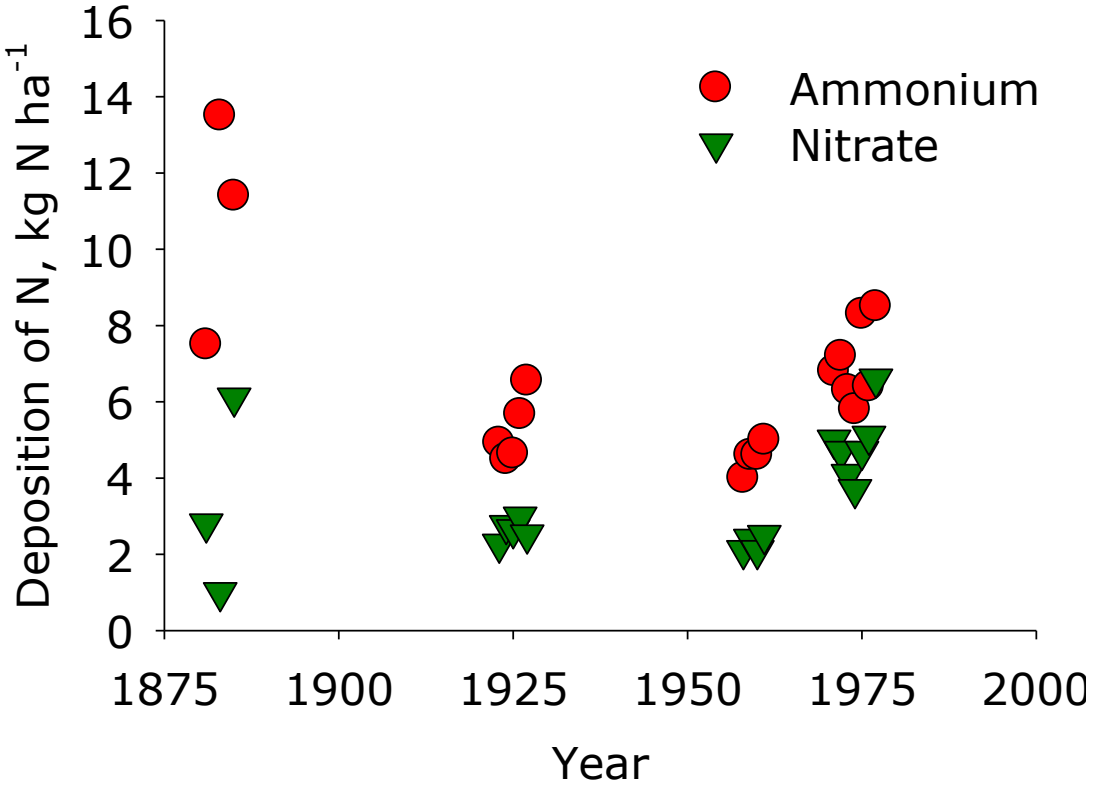
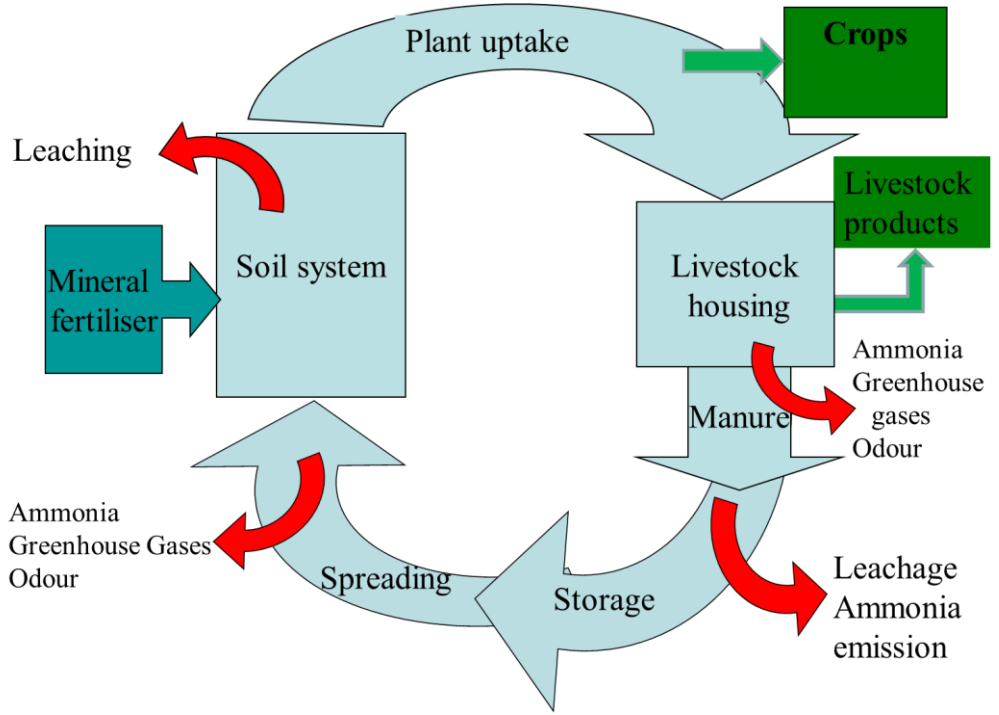
Much more ammonium than nitrate in the 1980'ies with ACID RAIN on the agenda



The focus on ammonia



1980'ies

- NPO – research and action plan
- general code of good agricultural practice

1990'ies - ---

Availability of plant nutrients in manure and fertilizers – matching crop needs - a central tool to reduce emissions to waters and atmosphere

Ammonia emission reduction should result in higher fertilizer value and reduced cost for mineral fertilizer

Regulation

- Technology list (Teknologi-listen) – approved by ministry of environment accepted by public authorities and farmers.
  - Test prove the efficiency
  - In house acidification was proven efficient (Poul Pedersen 2004)
  - In house acidification reduced ammonia emission from the manure management chain – article in peer reviewed journals (Kai et al. 2008)
- From ca. 2010 test are carried out according to the VERA protocols – then results are accepted in The Netherlands and Germany. Acidification stored and applied slurry tested and proven efficient

VERA – Fundamentals

VERification of Environmental Technologies for **A**gricultural production

Effective validation of environmental technologies

Mutual recognition by

✓ common test protocols for verification with scientific experts

✓ International collaboration of authorities

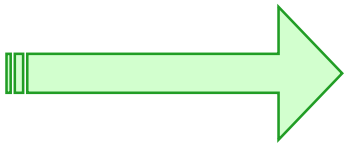
<u>Basic principle:</u>

Credibility by

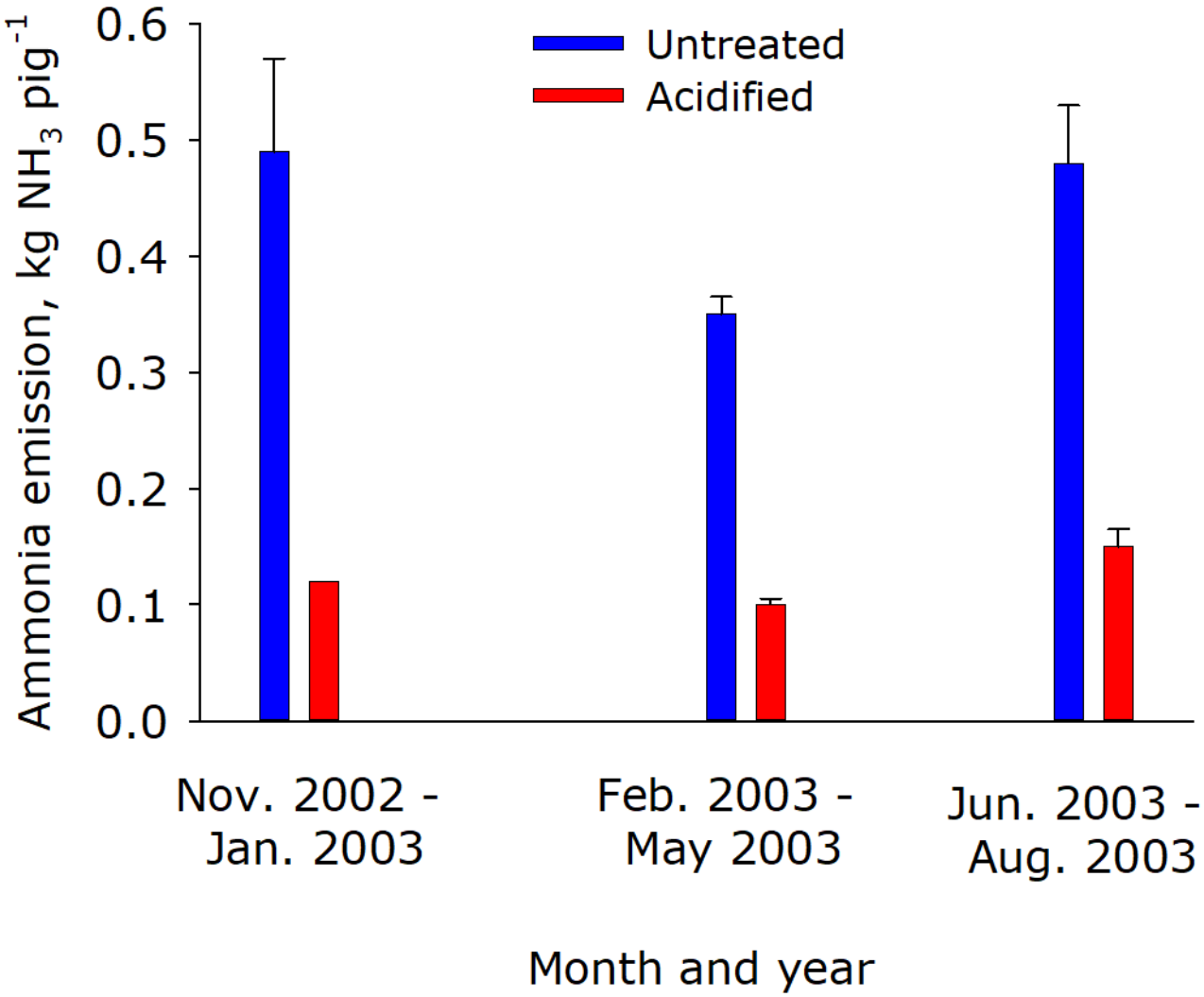
✓ High measurement quality

✓ Transparency

For: farmers manufacturers authorities

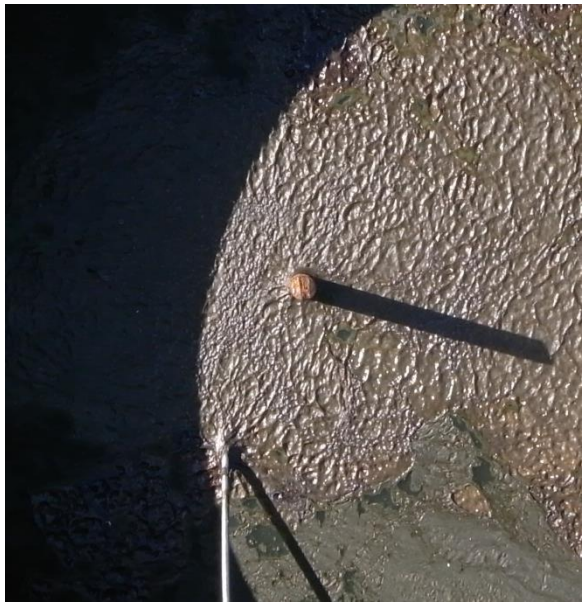


Ammonia emission from pig buildings, Inhouse acidified slurry- Ammonia reduction 70% (Kai et al. 2008)

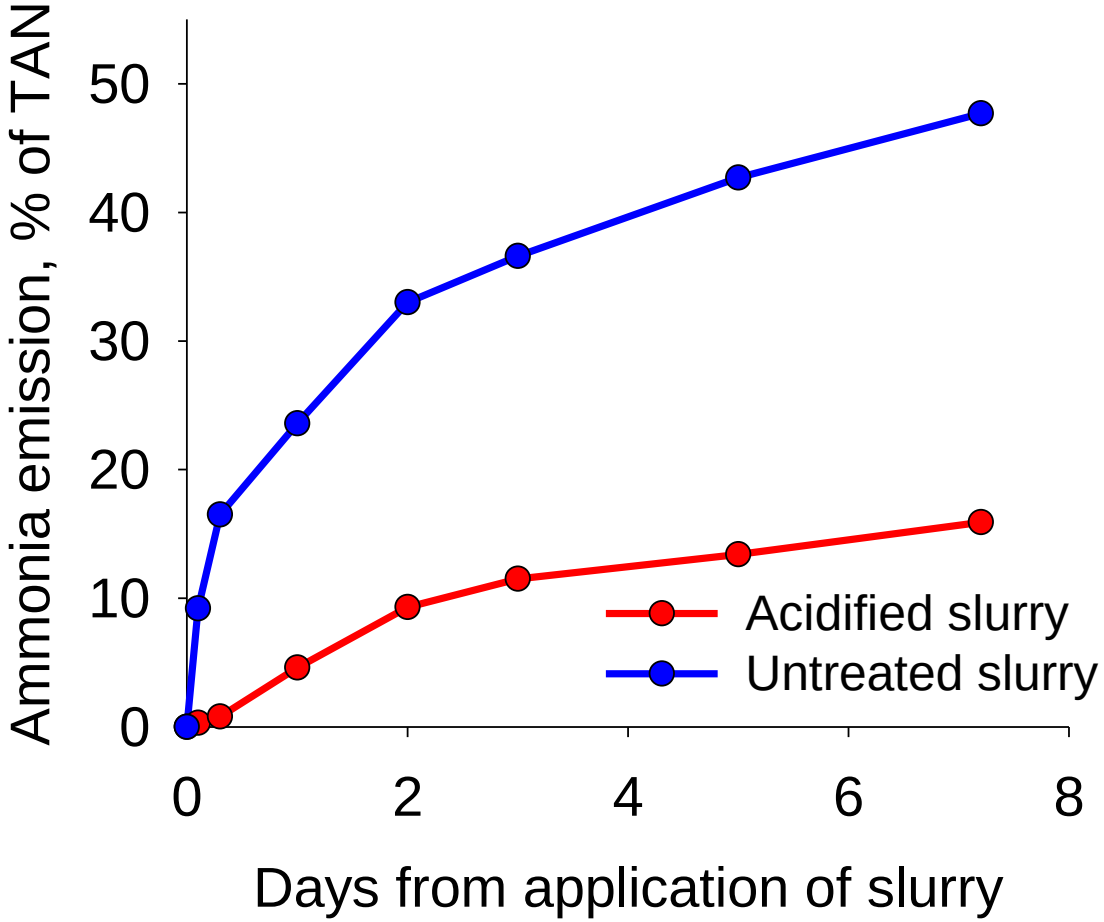


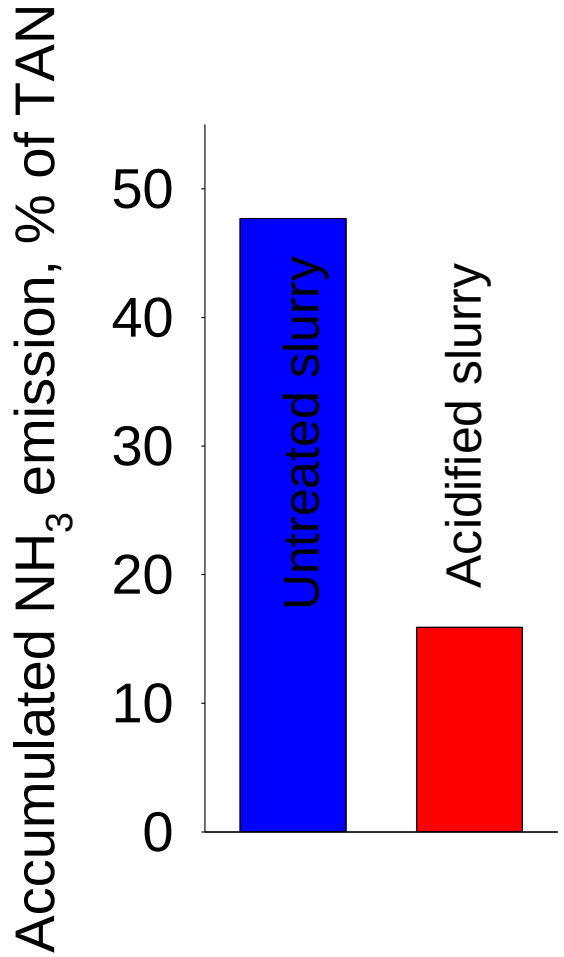
Outdoor slurry store – reduction efficiencies

Reduction efficiency, %	Reference
67	Petersen et al. 2014
90	Reguero et al. 2016
90	Al-Kanani et al. 1992
62	Sommer et al. 2017
59	Owusu-Twum et al. 2017

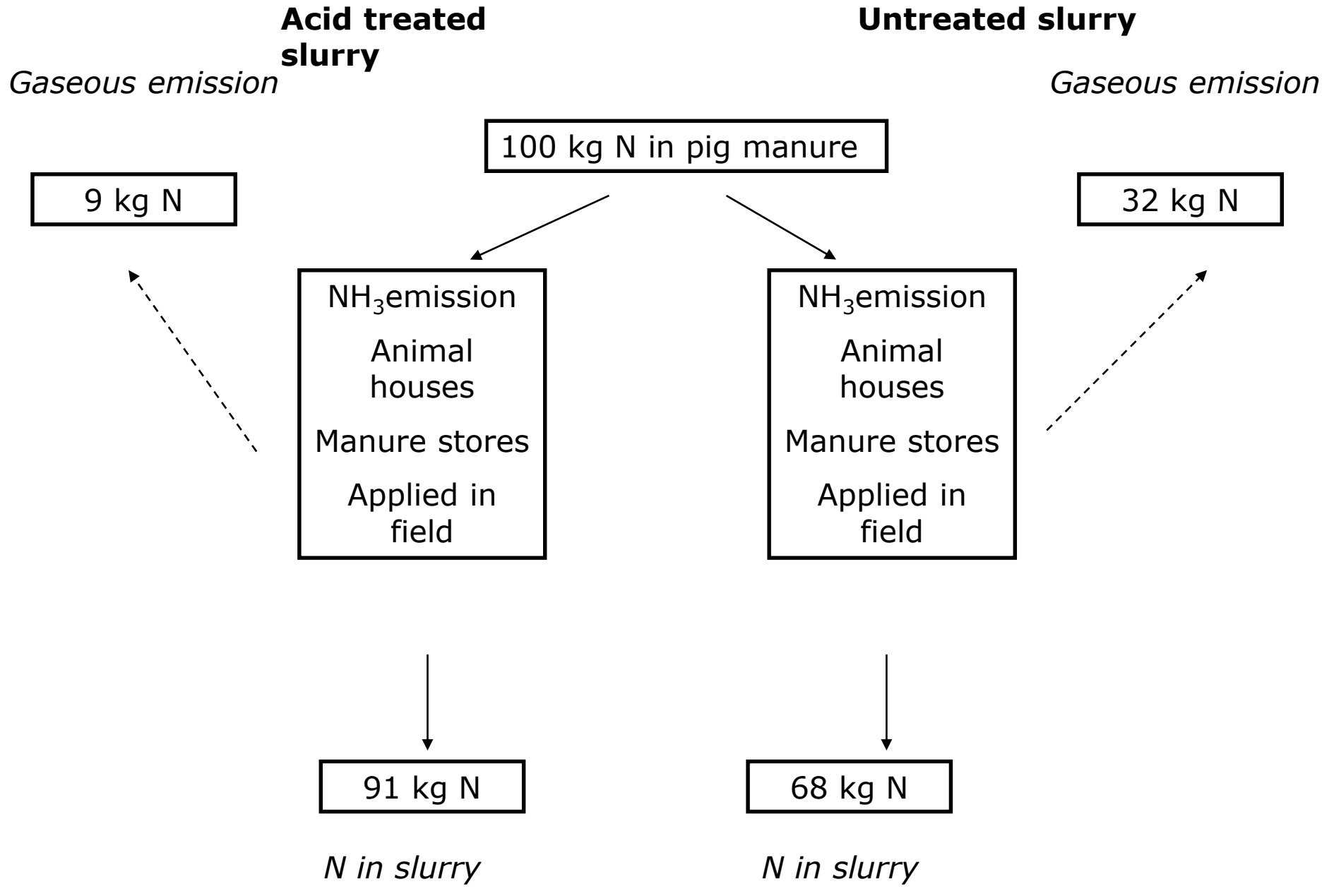


Ammonia emission from field applied slurry - inhouse acidification of slurry (Kai et al. 2008)





Whole system effect of acidification in house (Kai et al. 2008)



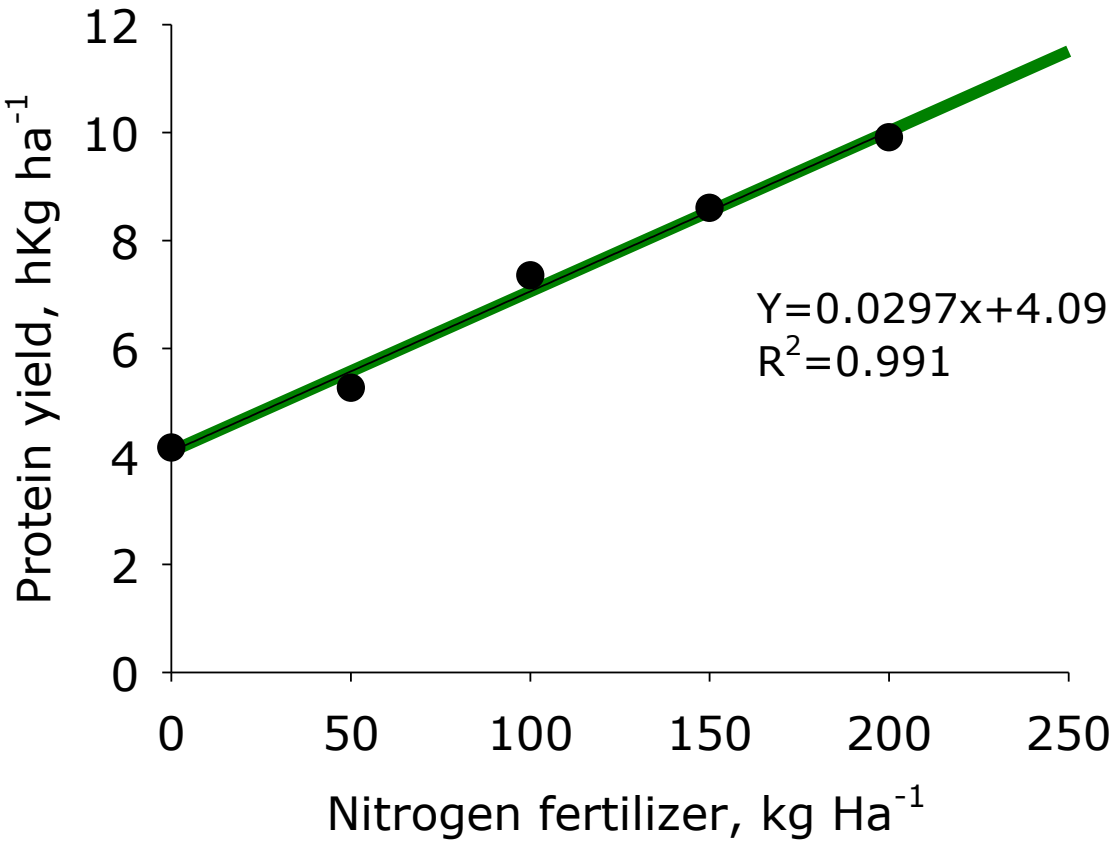
Most important

farmers must know the fertilizer equivalents of the acidified slurry

- Standard N fertilizer:
  - Yield response: 0 kg N, 50 kg N, 100 kg N, 150 kg N, 200 kg N per hectare
- Manure plot:
  - Yield response: 150 kg N total + 50 kg fertilizer N

Calculation - Fertilizer equivalents

kg N per ha	Protein yield hkg
0	4.16
50	5.27
100	7.35
150	8.6
200	9.91

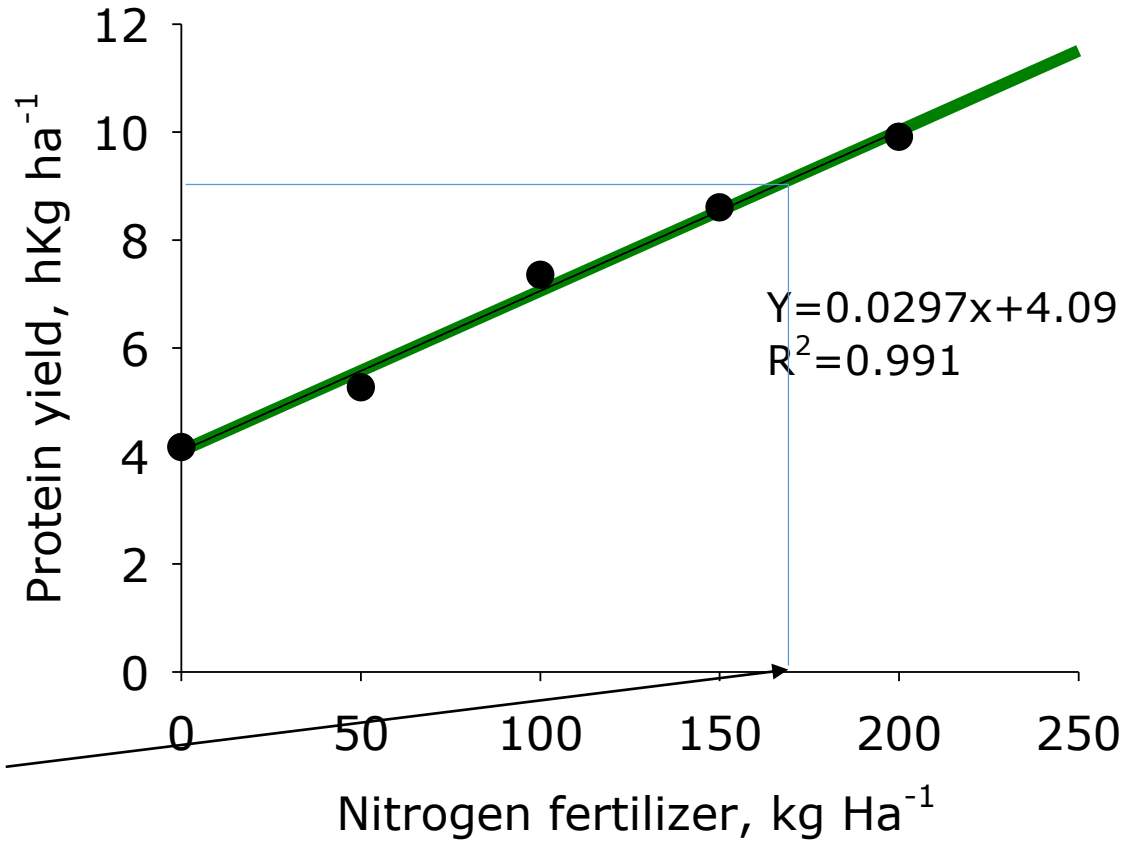


$$E = \frac{Y - 4.09}{0.0297}$$

E is the fertilizer equivalent of N added in manure and in mineral fertilizer kg N/Ha
4.09 is inception with Y axis (Hkg/Ha)
0.02897 inclination Hkg(protein)/kg(N-fertilizer)
Y is protein yield hgk/Ha

Yield plots – ca. 150 kg N in manure + 50 kg N start fertilizer

	Yield protein slurry	N application Slurry	Start N mineral fertilizer
	hKg protein	kg N in manure	kg N
Untreated	8.74	155	50
Acidified	9.09	148	50

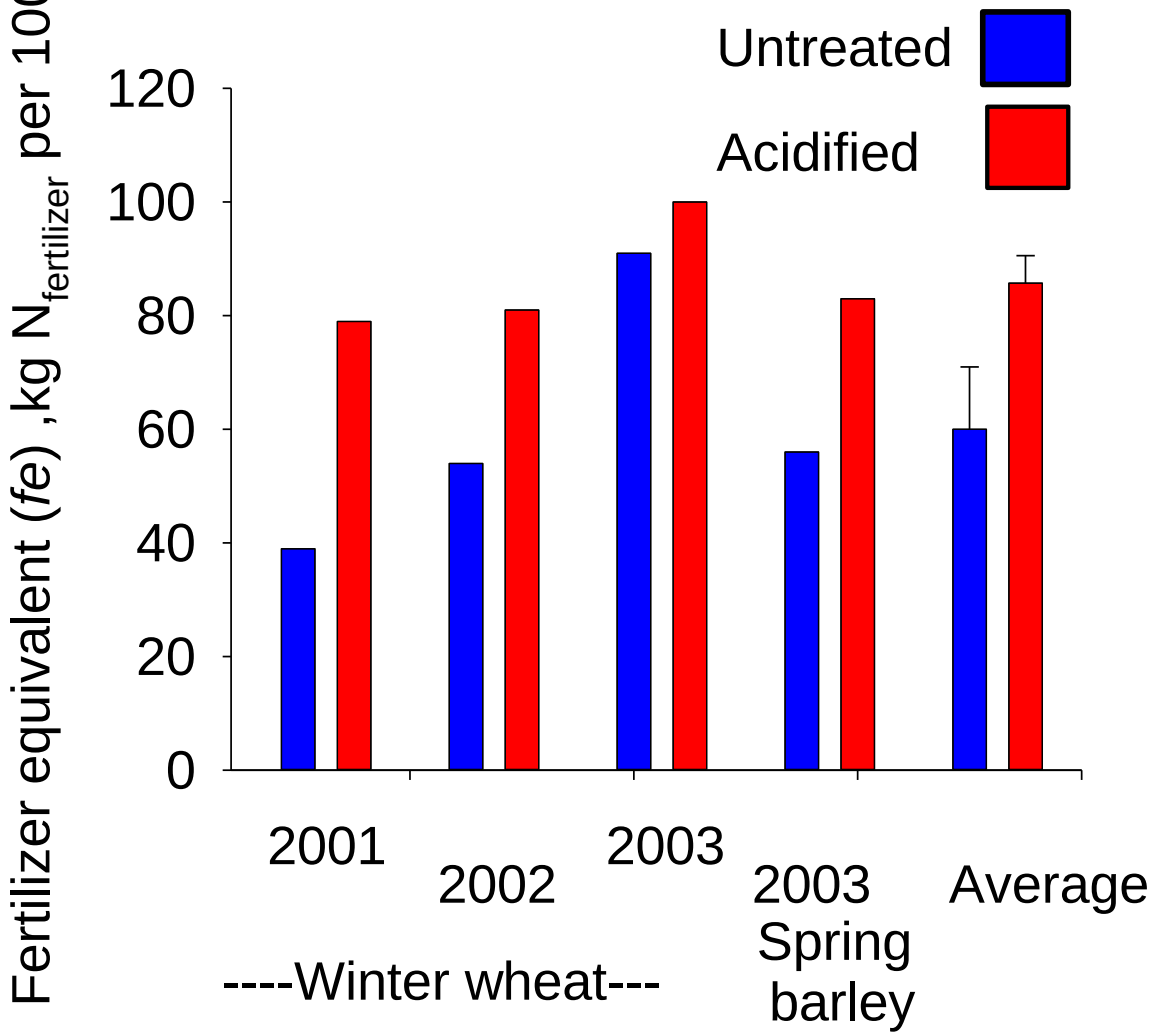


$$E = \frac{9.09-4.09}{0.0297} = 168$$

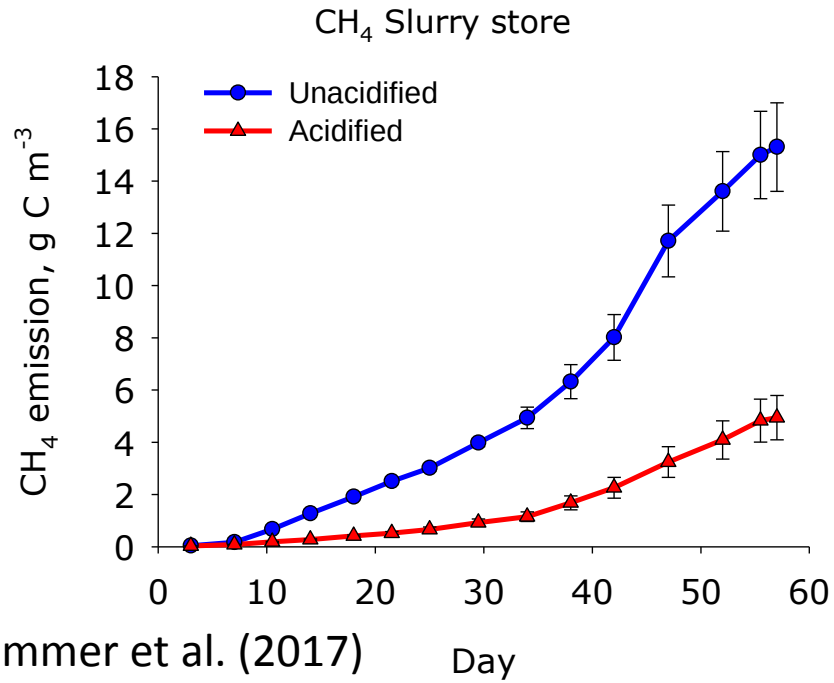
E is the fertilizer equivalent of N added in manure and in mineral fertilizer (kg N/Ha)

MFE for acidified = (169-50)/148=**0.80 (Non acid: MFE=0.69)**

Fertilizer equivalent of in house acidified slurry (Kai et al. 2008)



Reduced Greenhouse Gas Emission



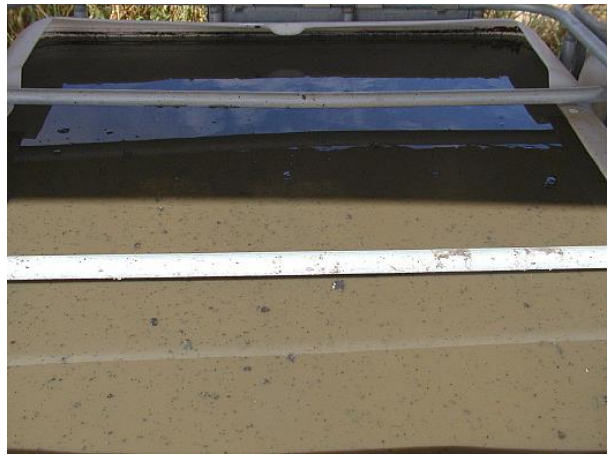
Sommer et al. (2017)

Fattening pig house:

- 50% reduction (Spring Petersen et al. 2016)

Outside slurry store:

- 68% (Sommer et al. 2017)
- >90 % (Petersen et al. 2014)
- >90% (Regueiro et al. 2016)



Summing up

- reduce ammonia emission significantly
  - in-house more than 70%
  - Store more than 60 %
  - Field more than 40%
- reduce methane emission from stored slurry
- inhouse – cost efficient for large units
- slurry store – need for novel regulations and management

Considered a valid technology

Acidification compartment	Governmental approval as an efficient technology
In-house	Pig house (Valid) Cattle house (await validation from ongoing studies)
Store	Pig and cattle slurry (Valid) mostly acid is added immediately before application in field
Field	Pig and cattle slurry (Valid)