Ammonia emission reduction options for dairy housing

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COST meeting Ghent 16-4-2019

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Outline

- Introduction: brief outline of emission processes
- Mitigation options
    - Floors
    - Manure scraping and use of water
    - Urease inhibitors
    - Slurry mixing
    - Grazing & feed management
    - Others?
- Discussion: improvement of mitigation performance, role of emission models could play

Reasons to reduce ammonia emission

- Ammonia emission leads to:
  - N deposition => affecting biodiversity
  - Precursor of particulate matter (secondary), associated with public health concerns
  - Loss of minerals = economic loss for farmer
  - Dairy sector main livestock emission source in EU

Therefore:

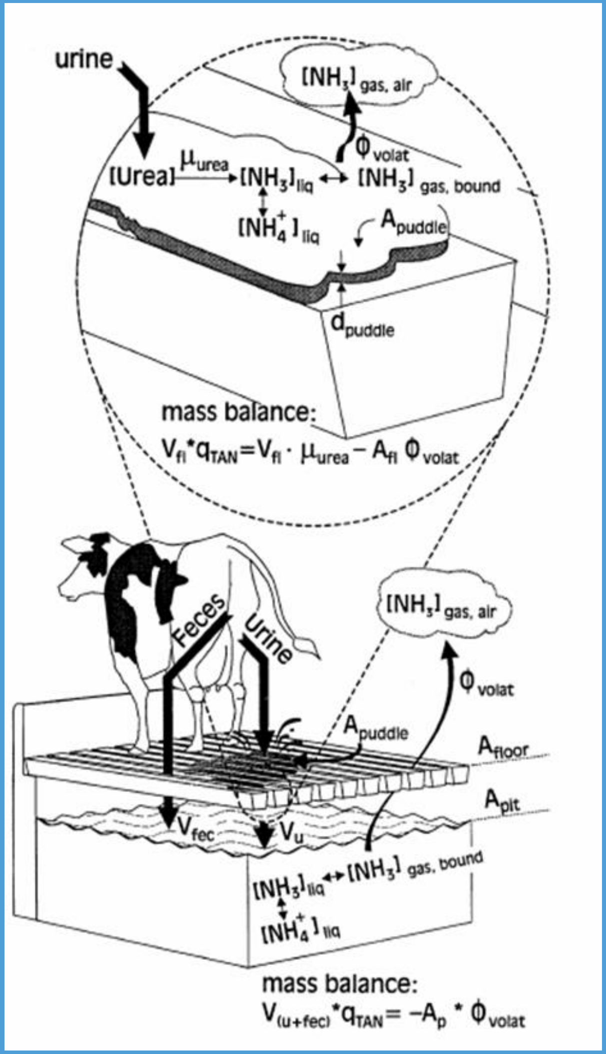
- Need for mitigation options in dairy barns
  - Understanding of ammonia emission processes
  - Development and evaluation of mitigation options

Ammonia reduction research since 1990-ties

Emission from dairy houses

- Two sources of ammonia emission from dairy houses:
  - Slurry storage (internal/ext.)
  - Floor
- Emission from floor is the sum of emissions from urine puddles.

Source: Monteny *et al.*,1998

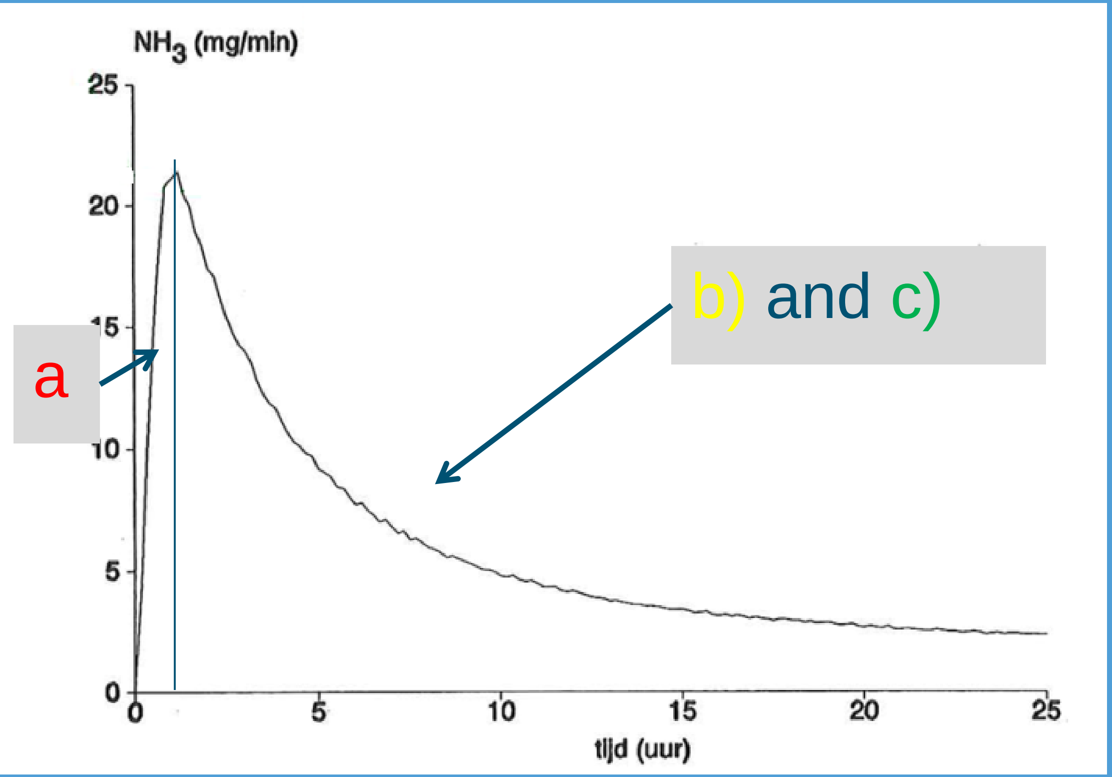


Emission process of one puddle

a) Enzymatic conversion of urea (urease)

b) Chemical equilibrium of ammonia/ium ([NH_4^+], pH, T)

c) Physical evaporation of ammonia to air (T, v)



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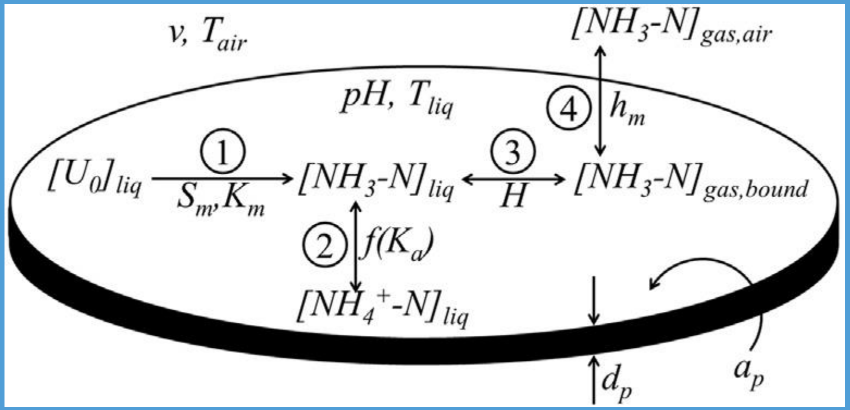
Factors influencing emission from puddles

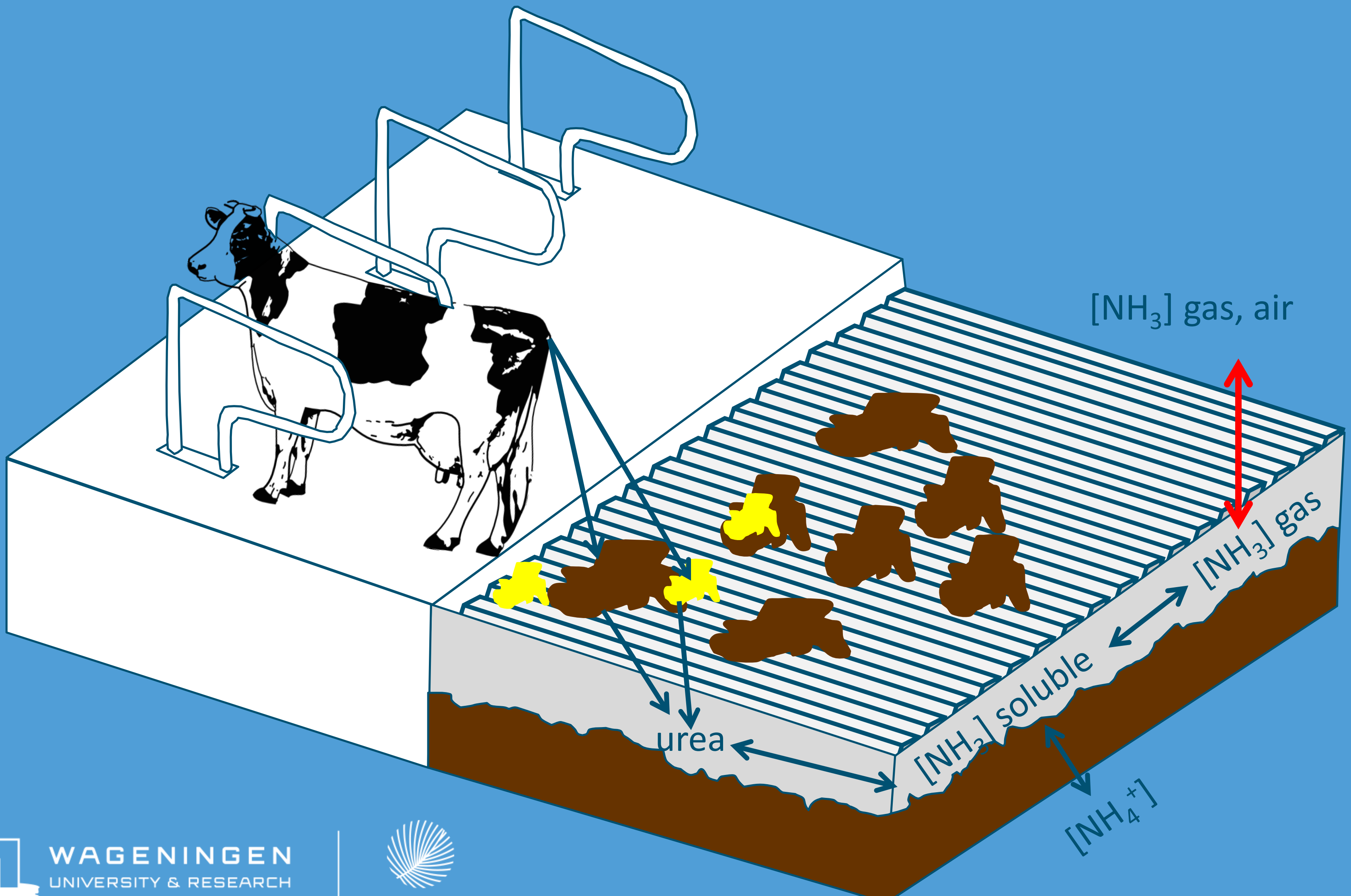
- Mechanistic emission models contain numerous input parameters to describe successive emission processes
- The five input parameters describing the majority of variation in calculated NH_3 emission from floor puddles are:
  - pH
  - Depth
  - Initial Urea content
  - Area
  - Temperature

  (Snoek *et al.*, 2014)



Source: Snoek et al., 2014

Ammonia from slurry storage: depends on air exchange barn & headspace pits



Outline

- Introduction: brief outline of emission process
- Mitigation options
  - Floors
  - Manure scraping and use of water
  - Urease inhibitors
  - Slurry mixing, reduction of ventilation rate
  - Grazing & feed management
  - Others?
- The role of models in evaluation and improving mitigation options

Low emission floor systems

- Working principle:
  - Improve direct drainage of urine to pits => grooved floors, sloped floor
  - Reduce air exchange barn & pit headspace of conventional slatted floors => solid floors

Low emission floor systems available in the Netherlands: many variations on the same theme

rombou.nl/dbdownload/2183/Stallenboek%20201801

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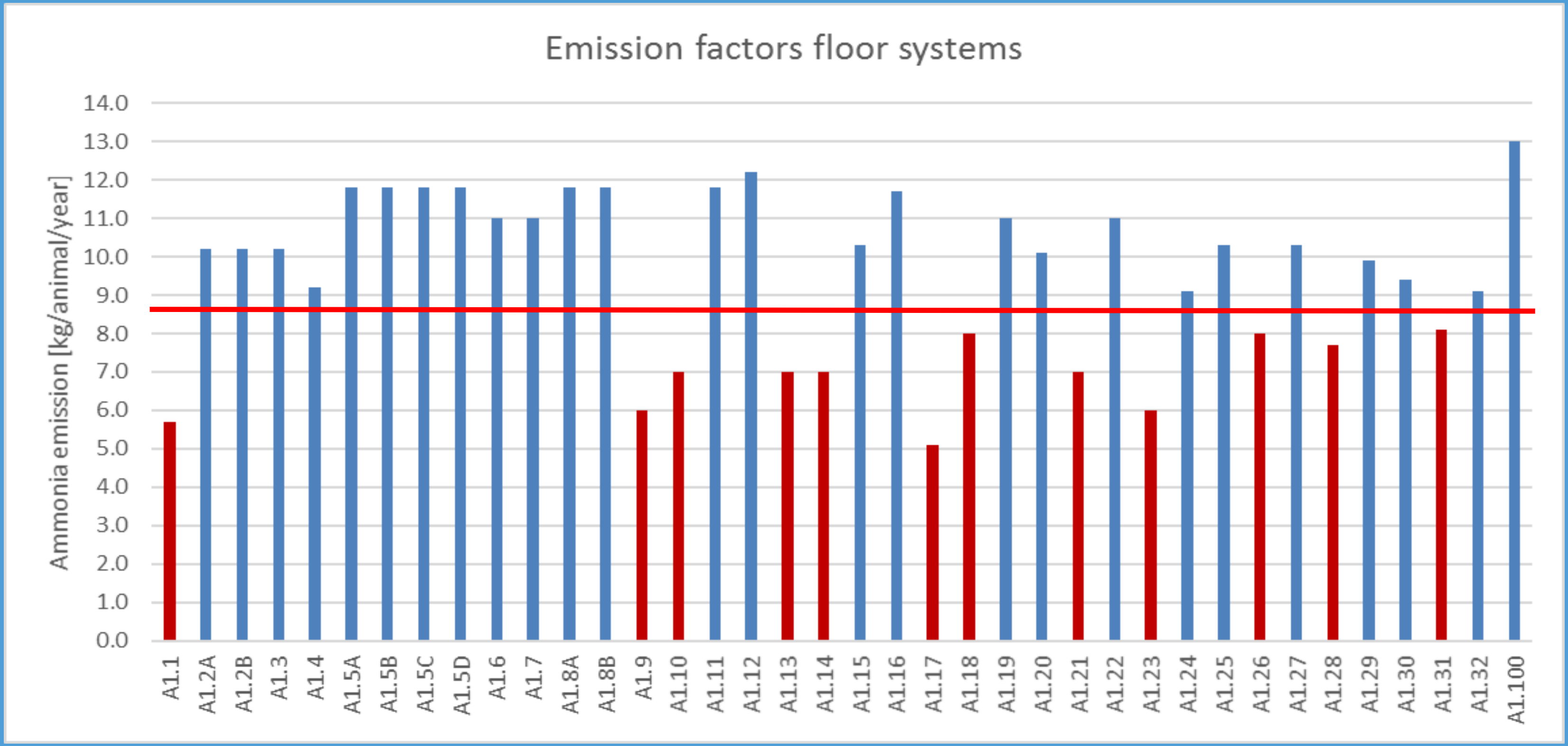
Emission levels of 32 recognized reduction options



- Not half of them meet the currently required level of 8.6 kg/ap/year

Pros en cons of low emission floors to reduce ammonia emission

- Pro
  - One time investment
  - Simple in technology?

- Contra
  - Expensive
  - Limited effect (10-50%)
  - In practice problems with slippery surfaces, poor drainage of urine

Field survey of low emission floors (Snoek et al, 2016) :

poor performance due to insufficient drainage and poor manure scraping management

Optimisation of manure scraping to mitigate ammonia

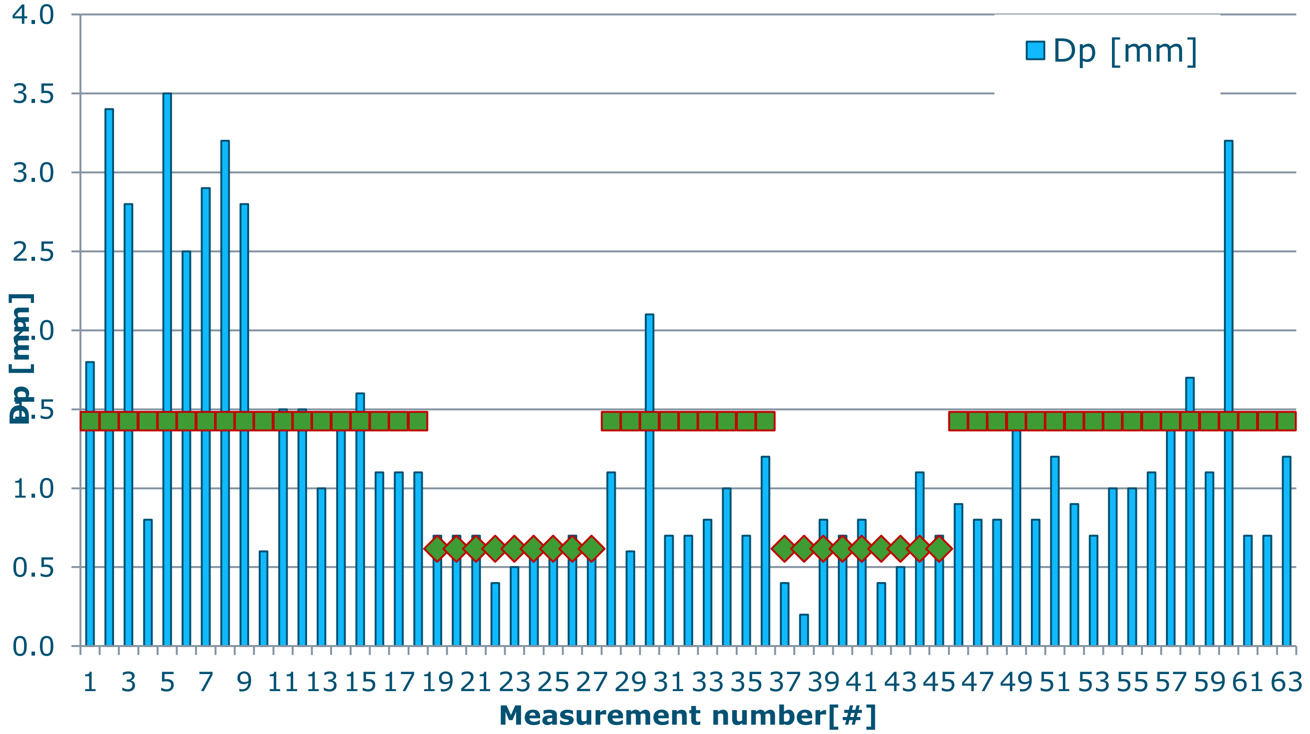
Potential beneficial effect of manure scraping:

- Direct removal of emitting urine puddles to manure pit
- Cleaning the floor surface => improving urine drainage and decreasing puddles size

Potential adverse effects of manure scraping:

- Poor scraper designs, worn out surface of scrapers => expanding puddles over larger areas, risks of increasing emission (solid floors)

Effects of prescraping on puddle depth



Overall effect of prescraping: 50% less depth

Efficient scraping, less remaining urine volume:
high potential for mitigation floor emission

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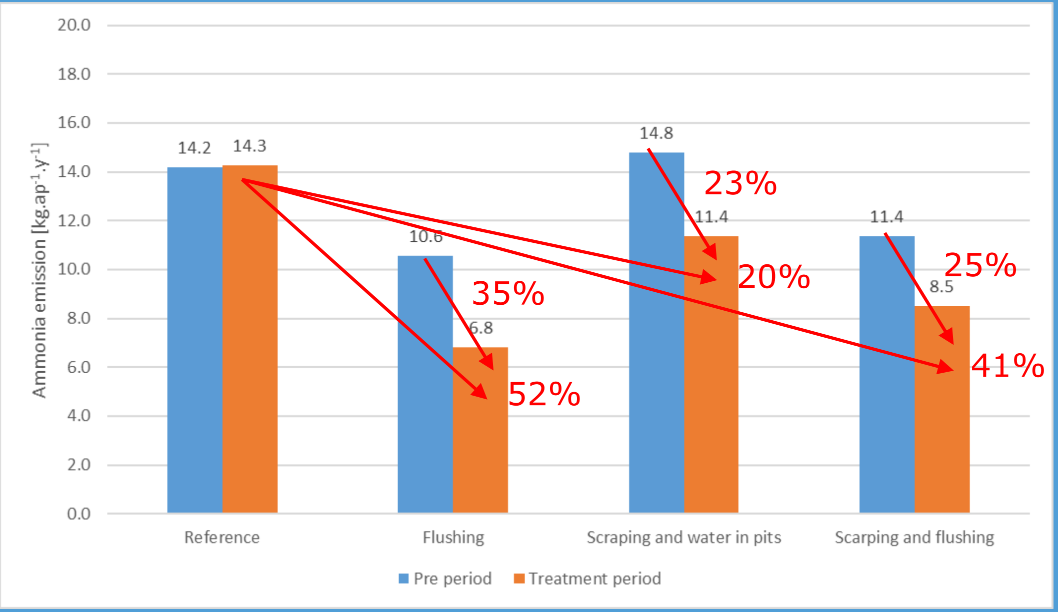
Using water in combination with scraping

- https://www.youtube.com/watch?v=_fy-UAFBCsU&feature=youtu.be

- Relatively easy and effective but: reduction of slurry storage capacity



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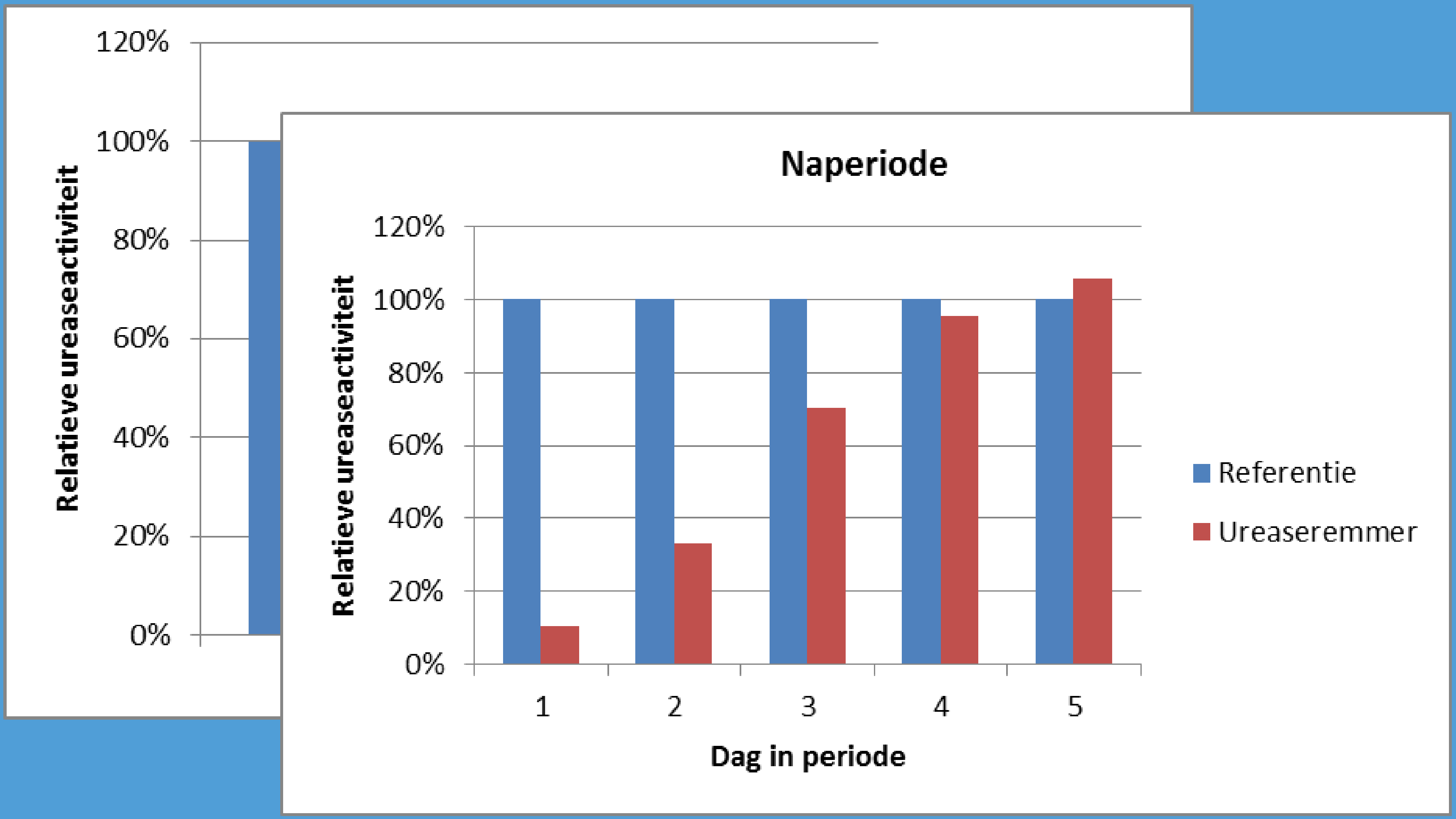
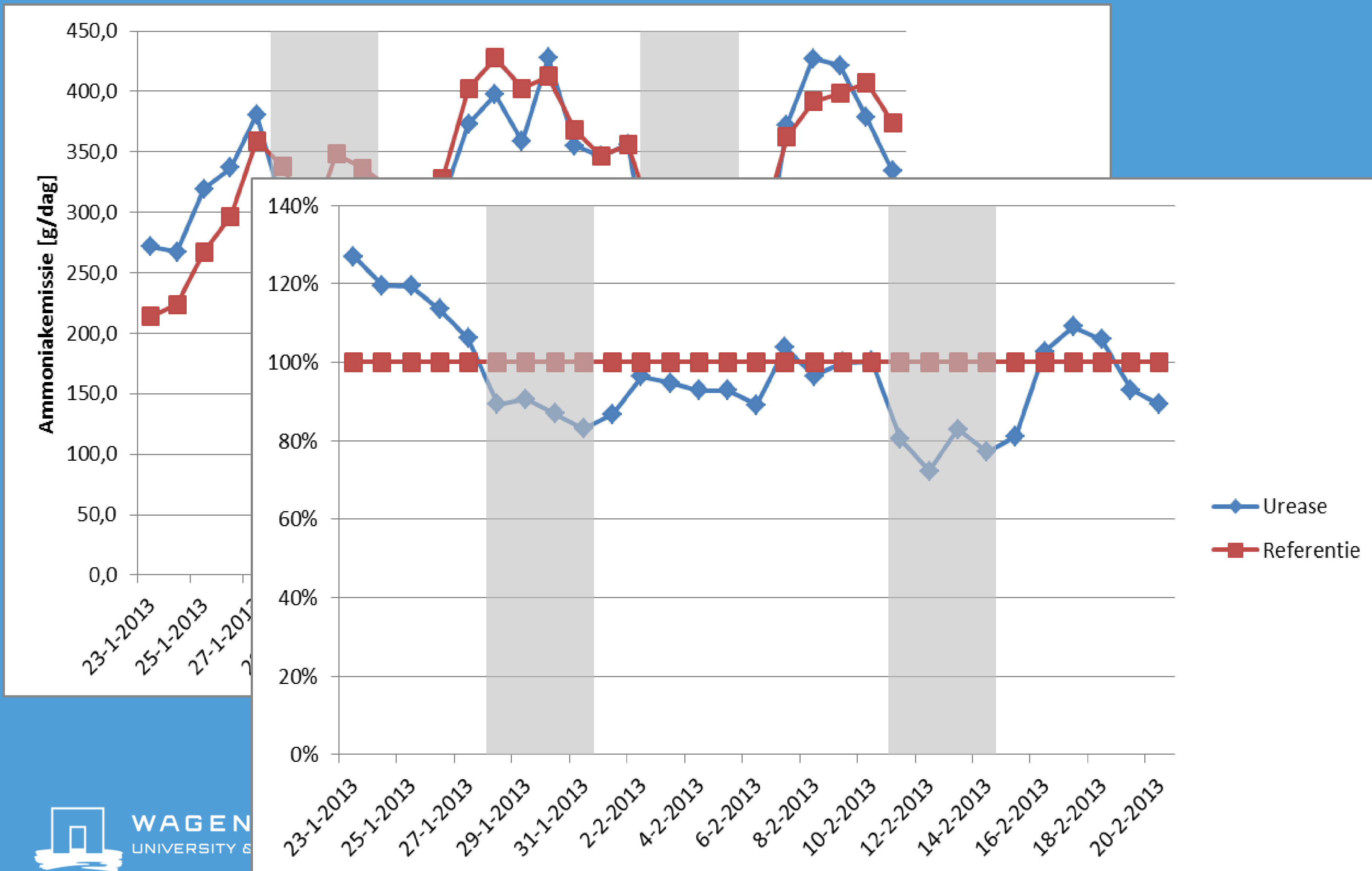
Urease inhibitors

- Reduces the enzymatic conversion of urea to ammonium
- Blockage of receptors on enzymes
- Delay of ammonia emission
- Effect on urease activity and ammonia emission

Results UA-measurements



Results ammonia emission



Effect urease inhibitors

- Reduction urease activity during treatment: 96%
- Reduction NH_3 emission during treatment: 21%
- Effect 1ste day after treatment: ~ 17%

Slurry mixing

- Slurry Aeration System (Ireland) of Aeromix (UK)
- Compressed air is distributed to outlets at the bottom of the slurry pits
- Large air bubbles agitate the slurry

- Aim is to avoid odour, H_2S and ammonia emission
- Interest in NL to get it recognized as ammonia emission reduction option.

Preliminary results

- There seems to be an reduction effect of slurry air mixing on ammonia emission of 50% in the first experiment.
- No effect in further experiments
- Signs of lower H_2S concentrations
- Signs of lower CH_4 emission
- No increased N_2O emission

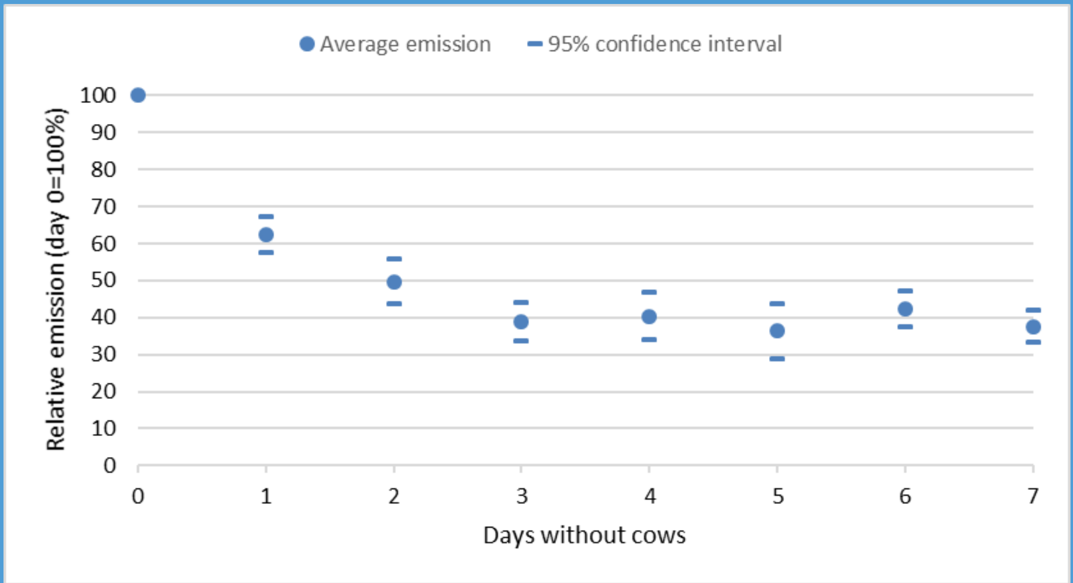
Mixing: questions

- Possible reduction processes:
  - Frequent disturbance of surface layer?
  - Constant mixing, no crust layer that acts as a 'floor'?
  - Less anaerobic circumstances?
- Questions to be answered
  - Can the effect be repeated (better design)?
  - Would the same effect take place at frequent mechanically mixing?
- To be continued...

Effect of grazing on ammonia emissions

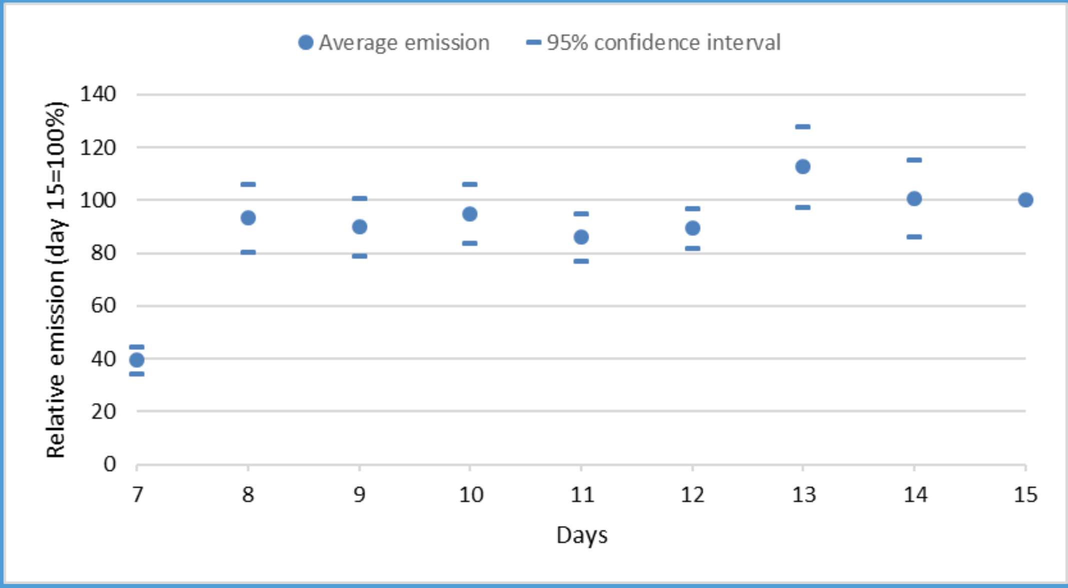
- ‘Cows leave the barn’ - effect
  - *Emission from housing will decrease*
- ‘Cows do urinate at pasture’ - effect
  - *Emission from pasture will slightly increase compared to zero-grazing*
- ‘Cows graze at pasture’ - effect
  - *Ration will changes and ammonia emission accordingly*

Relative emission development in barn



- Slow decrease
- At day 3 a stable emission
- Pit contribution around 40%

- Fast increase
- Within 1 day
- Return to initial level



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Effect grazing per year on barn emission

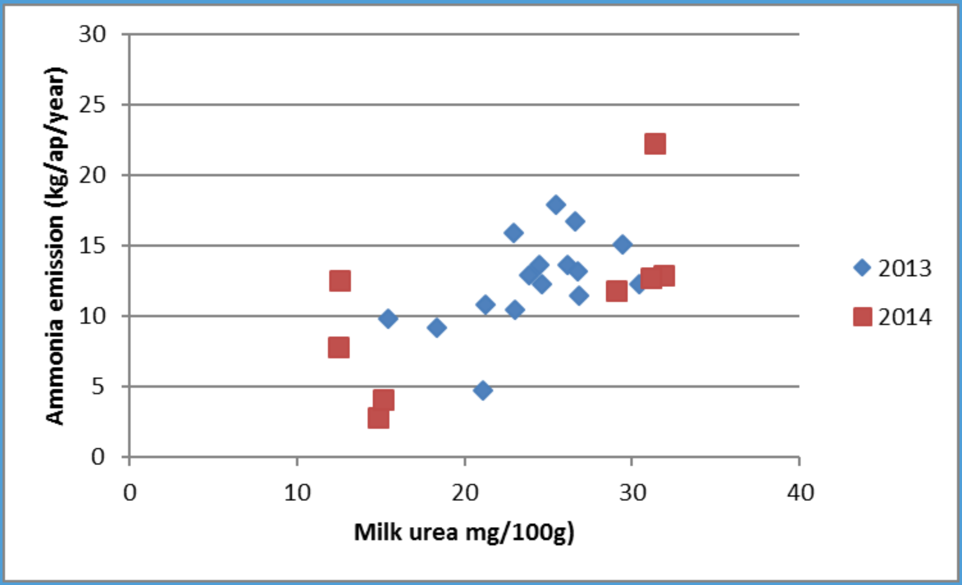
	Hours per day				
Days per year	**4**	**6**	**8**	**10**	**12**
120	1.3%	2.0%	2.6%	3.3%	4.0%
150	1.6%	2.5%	3.3%	4.2%	5.1%
180	1.9%	2.9%	4.0%	5.0%	6.1%

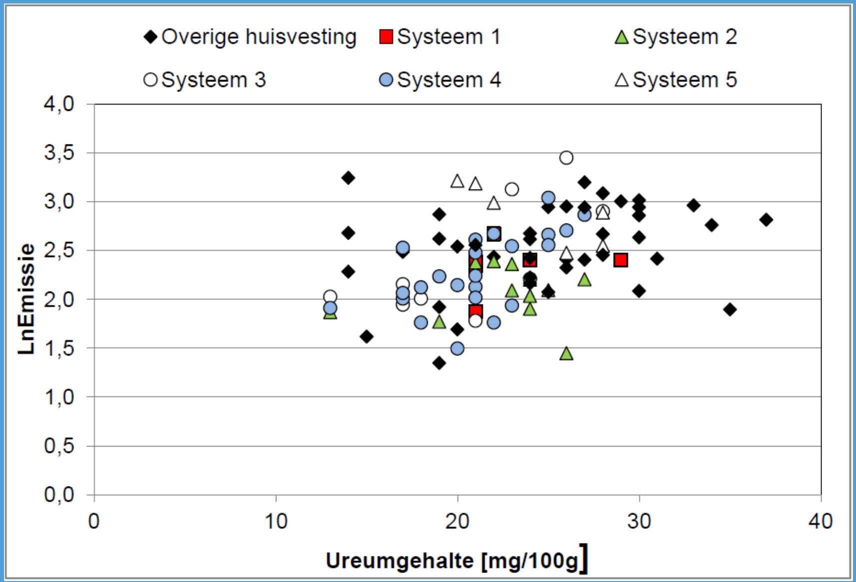
- Effects from 1.3-6.1% depending on grazing time
- Emission effect for slatted floors (at 720 h/y)
  - was 0.65 kg NH_3/animal place/year
  - becomes 0.26 kg NH_3/animal place/year
- Without pits serious option to reduce

Feeding effects on ammonia emission

- Feeding experiment
  - Dairy Campus
  - TAN-excretion
  - TAN-concentration

- Field survey
  - Conventional and low emission systems





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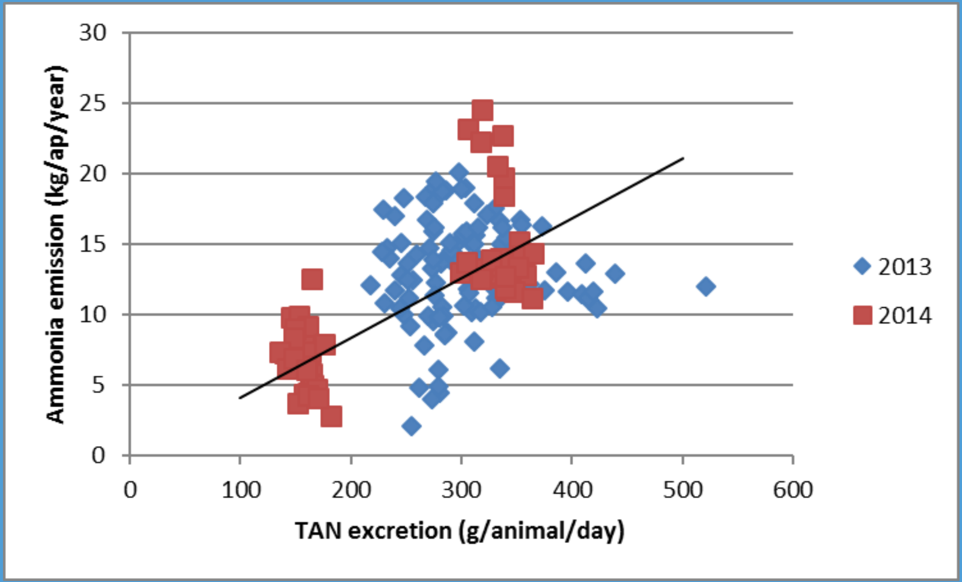
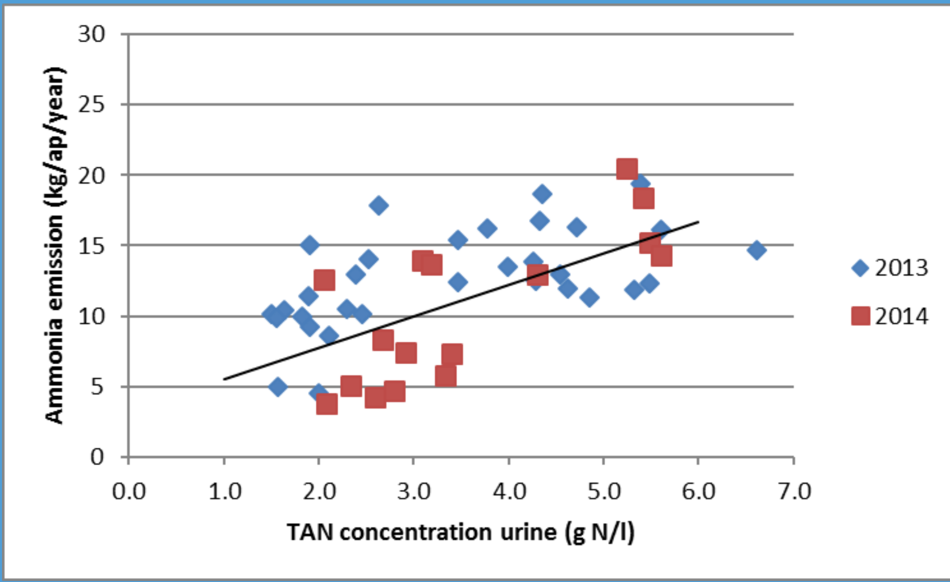
Excretion and concentration both influence emission

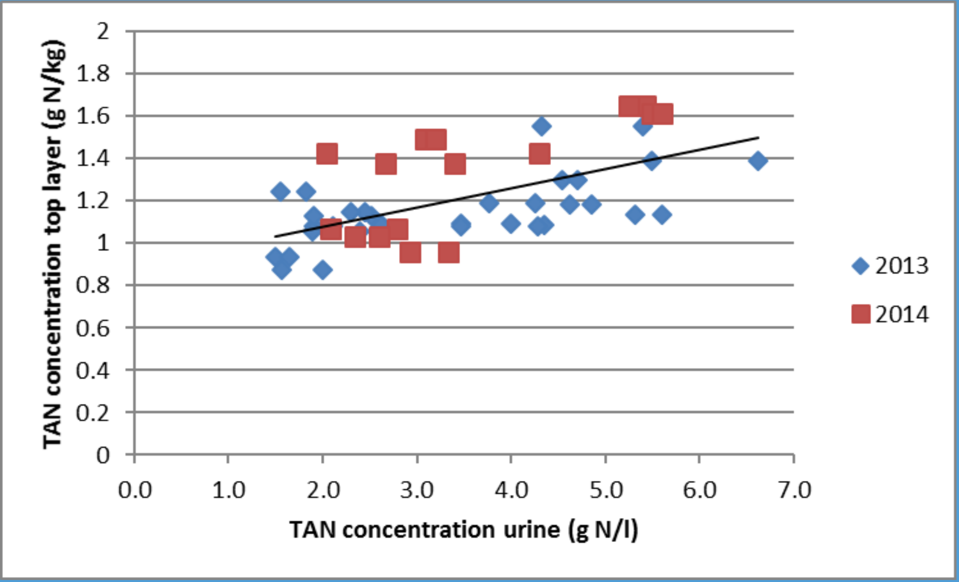
- Effect of TAN excretion
  - Less CP intake
  - Affects floor contribution
- Effect of TAN concentration
  - Water consumption
  - Affects pit contribution

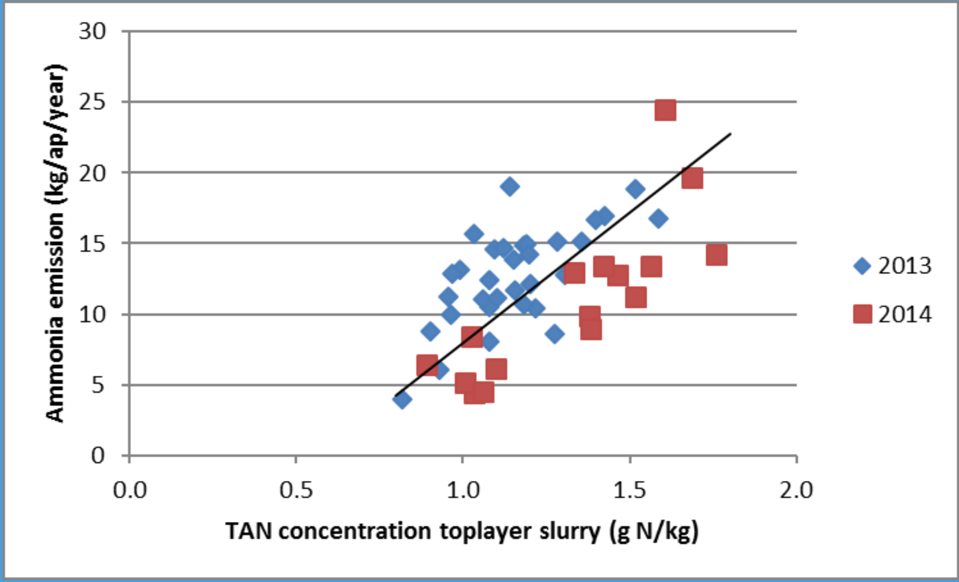




Pit contribution

- Urine N-concentration relates to top layer N-concentration
  - Surface process dominates emission from pit (?)



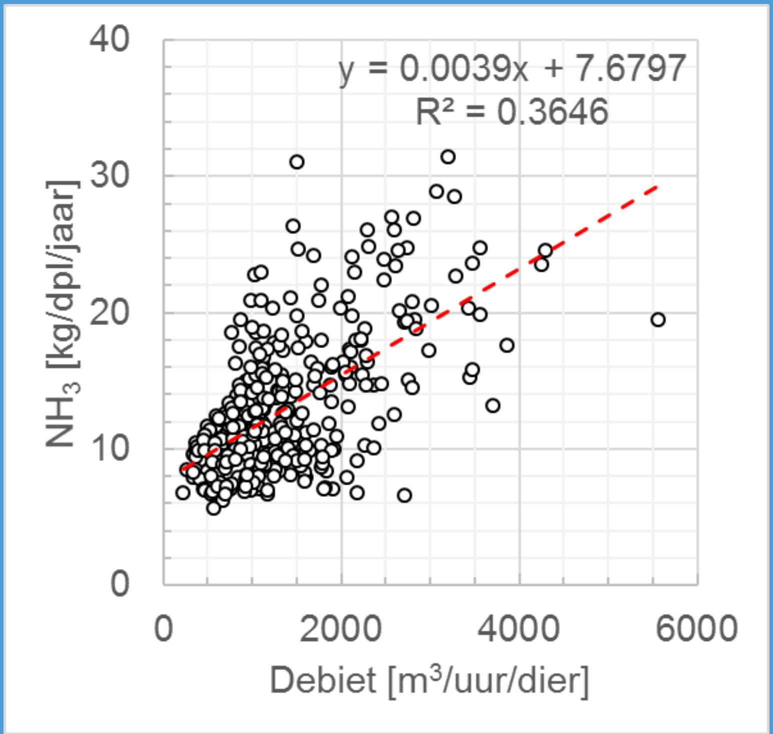


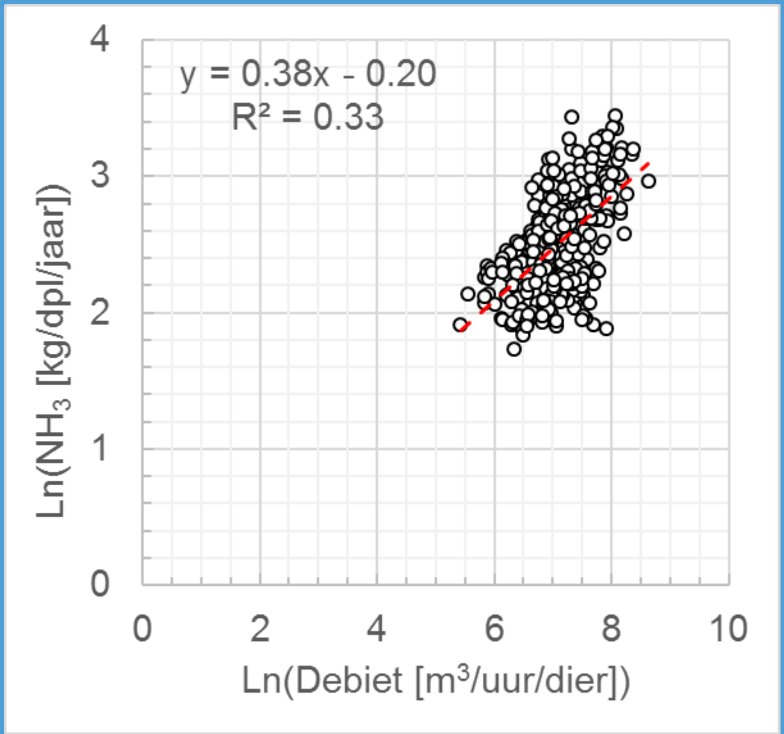
Other options?

- Air cleaning => requires modification into (partial) mechanical ventilation system
- Slurry acidification => reduces both emission of barn and field application, but introduces extra S-flow when using sulphuric acid
- Manure additives: more claims than evidence
- Ventilation management?

Relation ventilation rate - ammonia emission: correlation or causality

- Long term measurements NV dairy barn





Increasing mitigation performance

- To increase reduction of ammonia emission to >50% combinations of measures are necessary
- To be taken into account:
  - Integral approach (climate, animal, economics a.o.)
  - Societal demands: grazing, NV barns
  - Regulatory demands
    - Quantification effect combined measures
    - Performance enforcement
- Direct farm monitoring of emission could provide a new road to reach higher levels of ammonia mitigation

Role of models in improvement of mitigation options

- Modelling stimulates understanding of processes and key variables

- Models support optimisation of mitigation options and their combinations: feed and manure management, floor layout

- Models are helpful in a better dissemination of research results to industry and farmers

Role of models in evaluation of mitigation options

- Measurement protocols for NV dairy barns (like VERA):
  - methodological issues, limited accuracy
  - relatively expensive and time-consuming
- Alternative model approach:
  - measure key process variables under practical conditions (low emission versus reference)
  - Use key parameters in modelling mitigation effects
  - Essential prerequisite: thorough validation of applied model in practice

Thank you!

Questions?