Emissions of NH_3 and greenhouse gases from pig houses: Influencing factors and mitigation techniques

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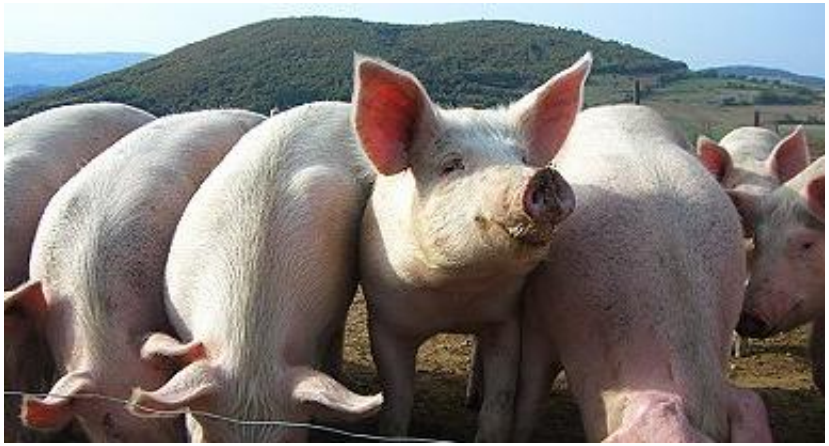
ILVO
Instituut voor Landbouw- en Visserijonderzoek

Introduction

- Pork: most consumed meat in the world (38%)
- By 2050, pig consumption + 40%
- Livestock ➔ 64% of global NH_3 emissions

  18% of global GHG emissions (CO_2, N_2O, CH_4)
- Pig production: 10-15% of livestock related emissions



(FAO, 2006 and 2011)

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Meat type	Emission intensity (kg CO_2-Eq/kg carcass)	Contribution to anthropogenic emisions
Pig	6.1	1.4%
Chicken	5.4	0.8%
Sheep/goat	21.0	0.6%
Beef	49.2	6.4%

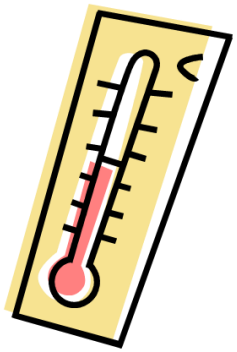
(FAO, 2006 and 2011)

Influencing factors

- Climatic conditions
- Floor type and manure management
- Dietary factors

Influencing factors

- Climatic conditions
  - Ambient temperature
  - Ventilation: Rate, type, location of the fans
  - Effect on pig behaviour
  - Bioclimatic comfort of the pigs



Influencing factors

- Climatic conditions
- Floor type and manure management

  ↳ Slatted floor systems vs. Bedded floor systems

Influencing factors

- Climatic conditions
- Floor type and manure management

  → *Slatted floor systems*

  - Slat characteristics
  - Slurry emitting surface
  - Slurry removal strategy

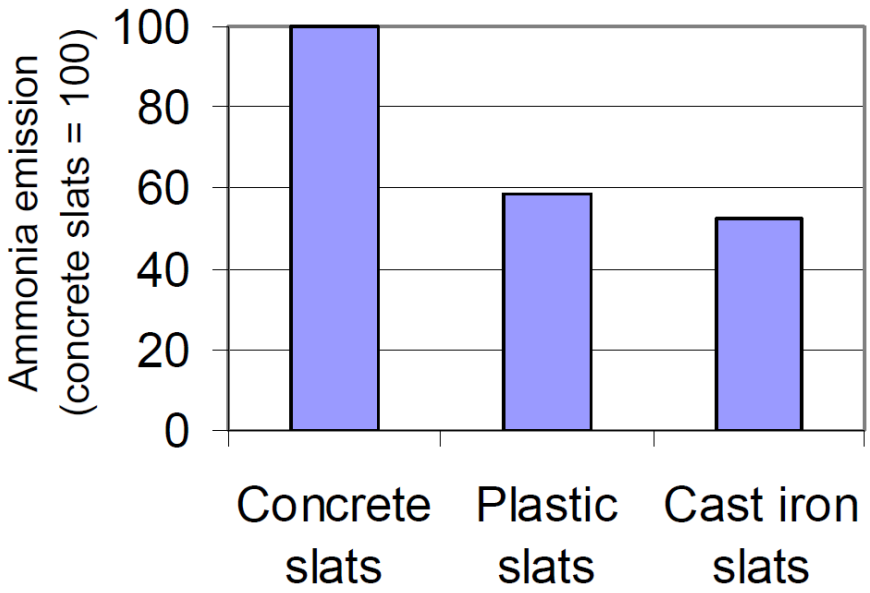
Influencing factors

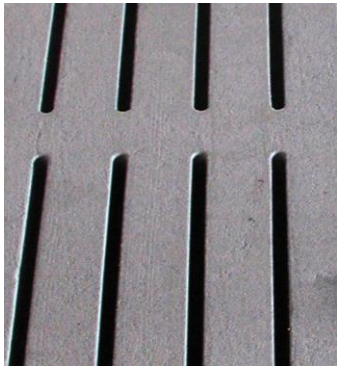
- Floor type and manure management

  → *Slatted floor systems*

  - Slat characteristics

    ① Material characteristics





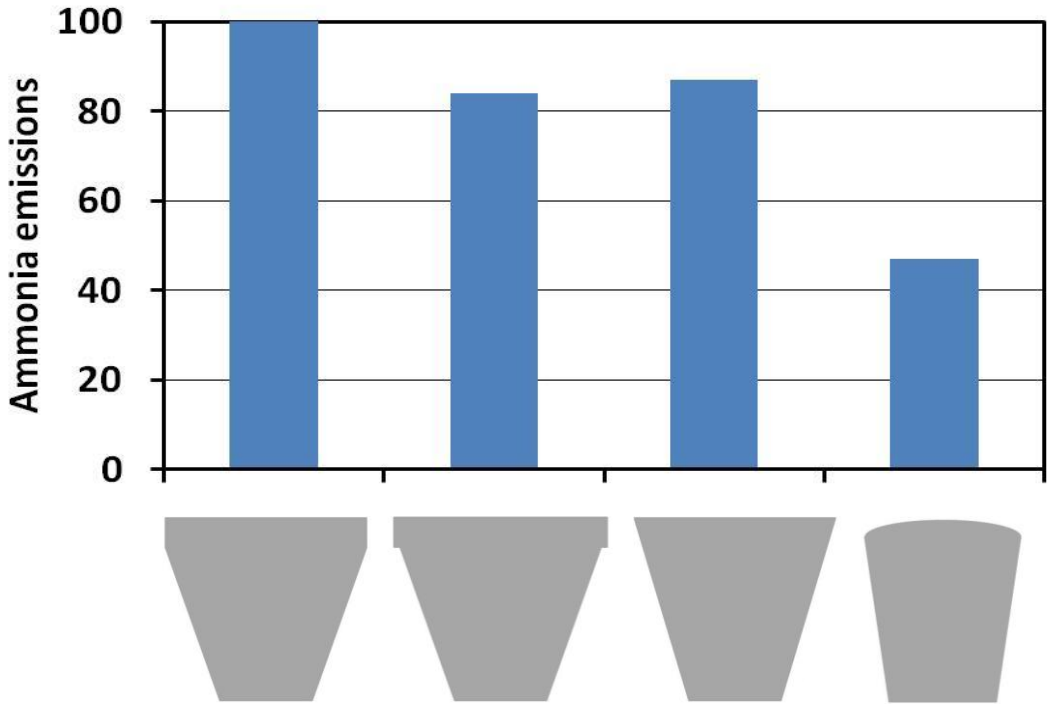
(Pedersen et al., 2008)

Influencing factors

- Floor type and manure management

  → *Slatted floor systems*

  - Slat characteristics
    - ② Slat profile



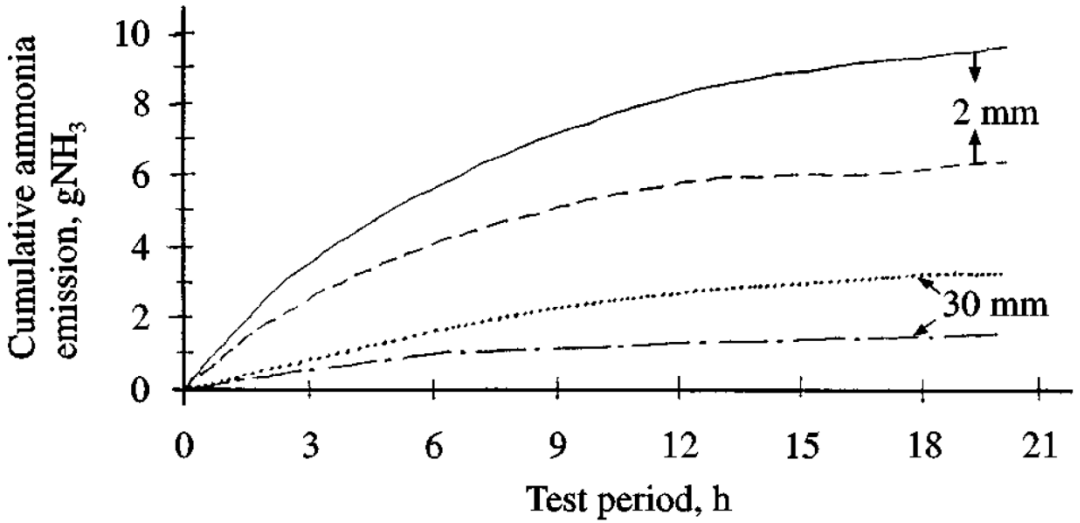
(Hamelin et al., 2010)

Influencing factors

- Floor type and manure management

  → *Slatted floor systems*

  - Slat characteristics
    - ③ Opening size



(Svennerstedt, 1999)

Influencing factors

- Floor type and manure management

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    ① Partly slatted floor system

Influencing factors

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    ① Partly slatted floor system

	Slatted area	
	100%	**37%**
NH_3 (g/day.pig)	16.1	9.7

(Sun et al., 2008)

	Slatted area	
	50%	**25%**
NH_3 (g/day.pig)	6.4	5.7

(Aarninck et al., 1996)

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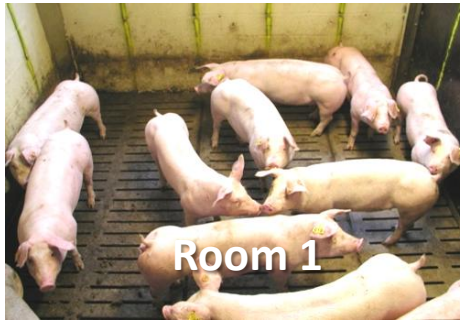

	Room 1 Fully slatted floor	Room 2 Partly slatted floor
Emissions (g/day.pig)		
NH_3	5.57	5.75
N_2O	0.18	0.21
CH_4	4.64	4.77

(Philippe et al., 2012)

Influencing factors

- Floor type and manure management

  → *Slatted floor systems*

  - Slurry emitting surface

    ① Partly slatted floor system

	Slatted area	
	100%	50%
NH_3 (g/day.pig)		
- Winter	10.1	10.6
- Summer	7.7	13.6

(Guingand and Granier, 2001)

Influencing factors

- Floor type and manure management

  → *Slatted floor systems*

  - Slurry emitting surface

    ① Partly slatted floor system

→ Reduction of emissions provided the soiling of the solid floor is prevented

≠

Influencing factors

- Floor type and manure management

  → *Slatted floor systems*

  - Slurry emitting surface

    ② Pit designs : – Sloped pit walls

    – Manure gutters

	Pit surface	NH_3 emissions	Mean
Piglets	- 67%	-35%	Sloped pit wall
Fattening pigs	-28%	-28%	Manure gutter
Gestating sows	-64%	-43%	Manure gutter

(Van Zeeland and den Brok, 1998; Steenvoorden et al., 1999; Doorne et al., 2002)

Influencing factors

- Floor type and manure management

  → *Slatted floor systems*

    - Slurry removal strategy

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    ① Frequent manure removal

Removal frequency	Effects compared to deep-pit system	Reference
1 X/2 week	NH_3: -20%	Guingand, 2000
1 X/week	NH_3, CH_4, N_2O: -10%	Osada et al., 1998
1 X/week	NH_3: -38%; CH_4: -19%; N_2O: X2	Guarino et al., 2003

Provided lower outside temperature than inside or specific manure storage conditions/treatments

Influencing factors

- Floor type and manure management

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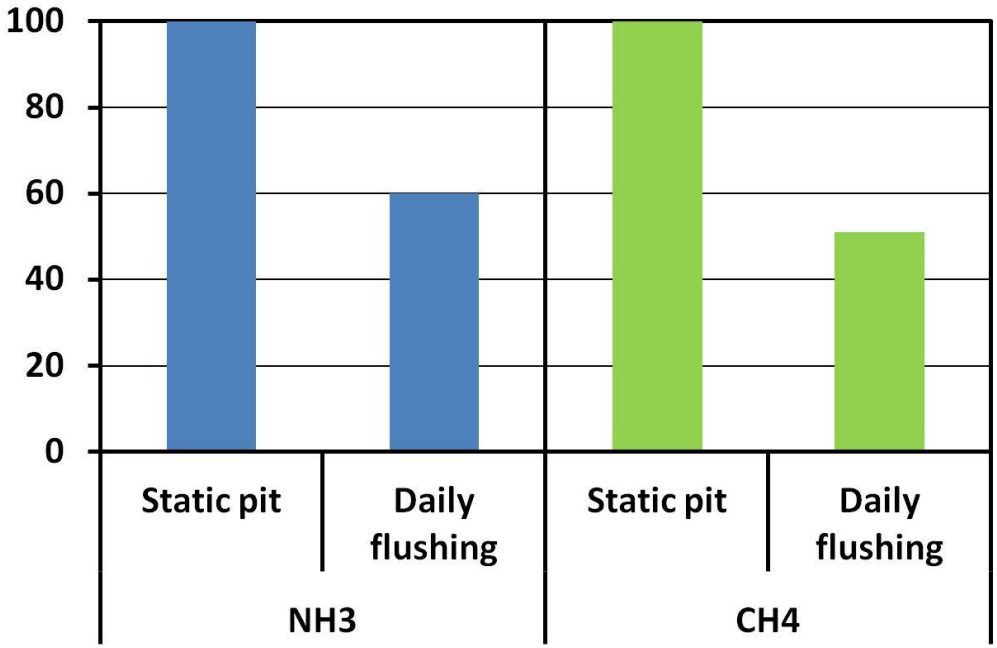
    ② Pit flushing



(Lim et al., 2004;
Sommer et al., 2004)

Influencing factors

- Floor type and manure management

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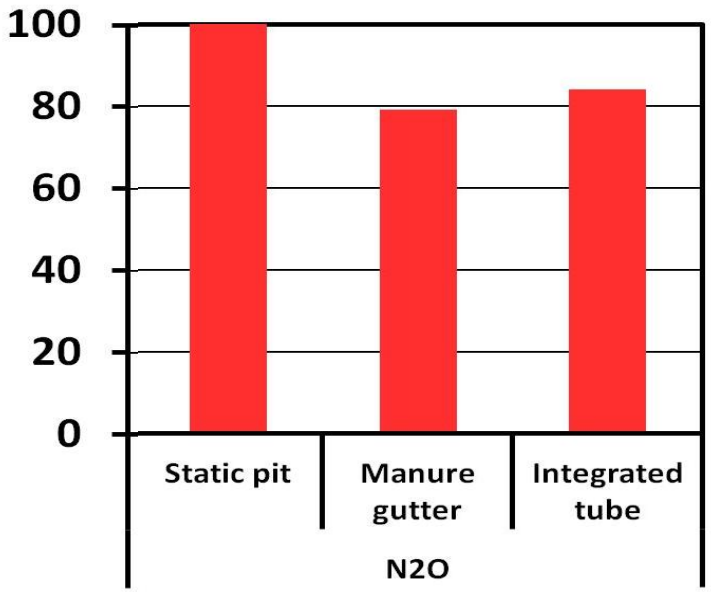
    ② Pit flushing (6X/day)



(Lagadec et al., 2012)

Influencing factors

- Floor type and manure management

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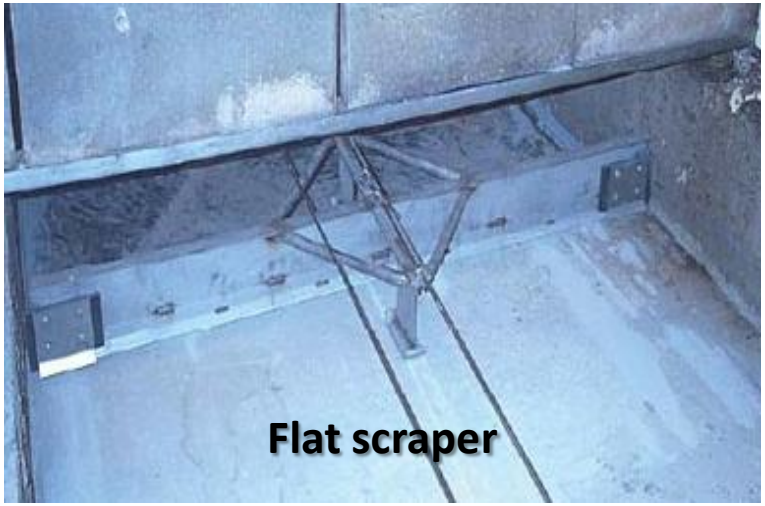
    ③ Under slat scraping



→ Ineffective to reduce emissions

Faeces and urine spreading over the pit

(Predicalo et al., 2007;
Kim et al., 2008;
Lagadec et al., 2012)

Influencing factors

- Floor type and manure management

  → *Slatted floor systems*

  - Slurry removal strategy

    ③ Under slat scraping

→ Separation of urine from faeces

Significant reduction of emissions

→ NH_3 : - 40-50 %

N_2O : - 40 %

CH_4 : - 20 %

→ Facilitation of manure handling

(Godbout et al., 2006; Lagadec et al., 2012)

Influencing factors

- Climatic conditions
- Floor type and manure management

  → *Bedded floor systems*

Influencing factors

- Floor type and manure management

  → *Bedded floor systems*

    - Bedded systems vs. Slatted floor systems

with bedded systems …

Reference	NH_3	CH_4	N_2O
Kermarrec and Robin (2002)	↘	-	↗
Kim et al. (2008)	↘	-	-
Philippe et al. (2011)	↘	↘	↗
Kavolelis (2006)	→	-	-
Balsdon et al. (2000)	↗	-	-
Philippe et al. (2007a)	↗	→	↗
Cabaraux et al. (2009)	↗	↘	↗

Influencing factors

- Floor type and manure management

  → *Bedded floor systems*

→ Wide range of rearing techniques

→
- Type of substrate: straw, sawdust, woodshaving,…
- Amount of substrate
- Space allowance
- Litter management

→ Impact on physico-chemical properties of the litter

Influencing factors

- Floor type and manure management

  → *Bedded floor systems*

  - Type of substrate : Sawdust vs. Straw

with sawdust …

Reference	NH_3	CH_4	N_2O	CO_2-Eq
Nicks et al. (2003) → 5 batches of 80 weaned piglets	- 62 %	- 51 %	↗↗↗	x 3
Nicks et al. (2004) → 3 batches of 36 fattening pigs	- 11 %	- 33 %	↗↗↗	x 4
Cabaraux et al. (2009) → 2 batches of 80 weaned piglets	- 10 %	- 30 %	↗↗↗	x 4

Influencing factors

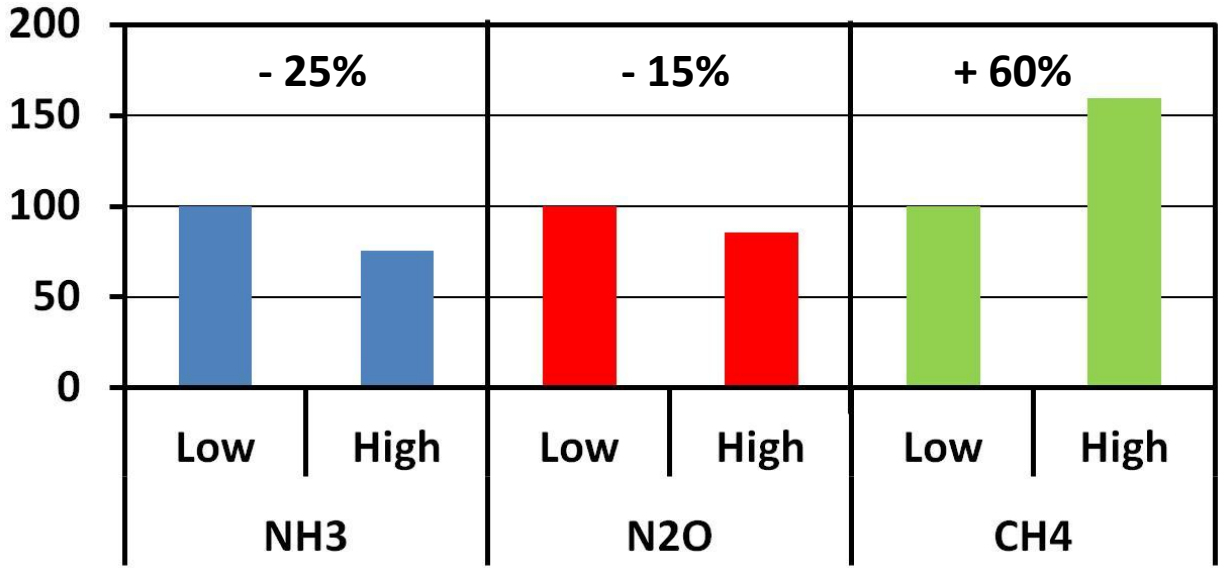
- Floor type and manure management

  → *Bedded floor systems*

  - Amount of substrate

    Low : 0.5 kg/day.pig

    High : 1.0 kg/day.pig



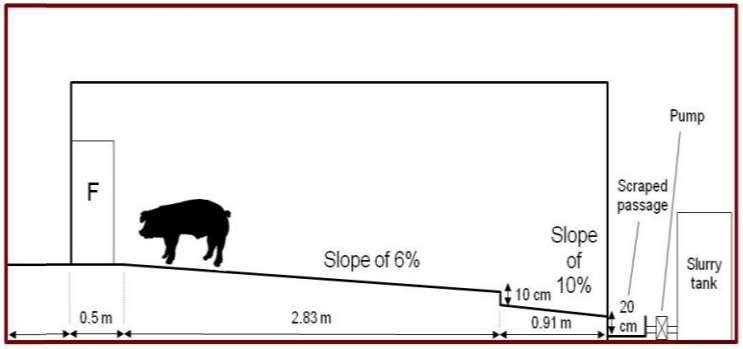
Influencing factors

- Floor type and manure management

  → *Bedded floor systems*

  - Litter management – Removal strategy

    Frequent manure removal – Straw flow system



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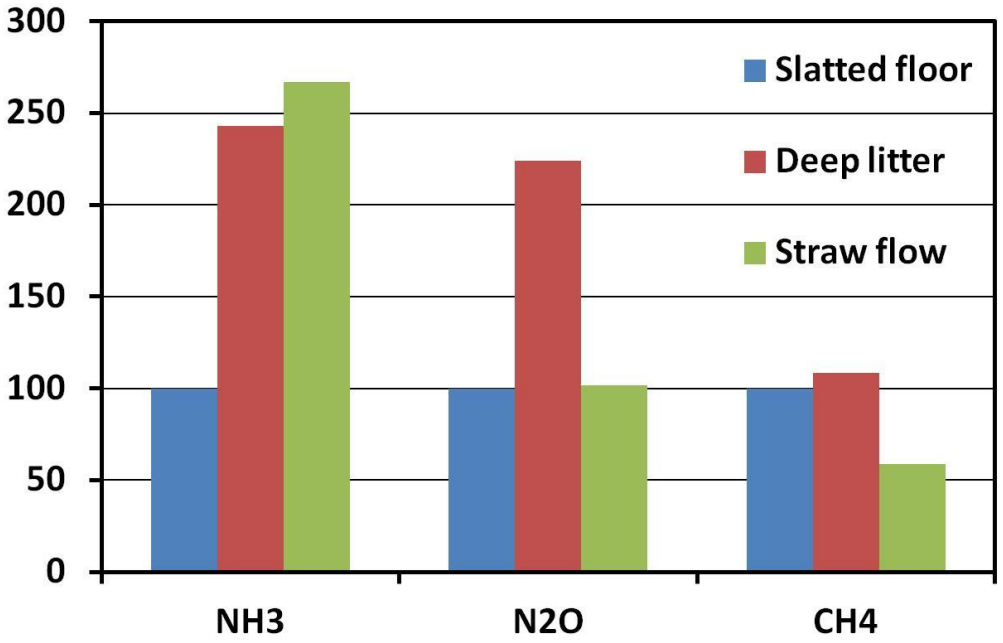

(Philippe et al., 2007 and 2012)

Influencing factors

- Floor type and manure management

  → *Bedded floor systems*

  - Pen design – Combination of bedded, slatted and/or solid floor

Influencing factors

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- Floor type and manure management
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  → *Reduced crude protein*

  Dietary fibres

\+
- Electrolyte balance
- Acidifying salts
- Yucca extracts
- Zeolites
- Probiotics

Influencing factors

- Dietary factors

  → *Reduced crude protein*

N balance (g/day)	Crude protein content		Reduction
	20%	15%	
N intake	57.3	42.8	25%
N-NH_3	6.0	3.1	48%
N retention	22.7	22.8	=
N excretion	34.7	20.0	42%
Faecal N	9.4	8.1	14%
Urinary N	25.2	11.9	53%
Manure pH	9.08	8.46	7%

(O'Shea et al., 2009)

Influencing factors

- Dietary factors

  → *Reduced crude protein*

	Crude protein content		Reduction
	15%	12%	
NH_3 (g/h.m²)	1.26	0.90	29%
N_2O (ppm)	0.20	0.21	NS
CH_4 (ppm)	359	239	NS

(Le et al., 2009)

Influencing factors

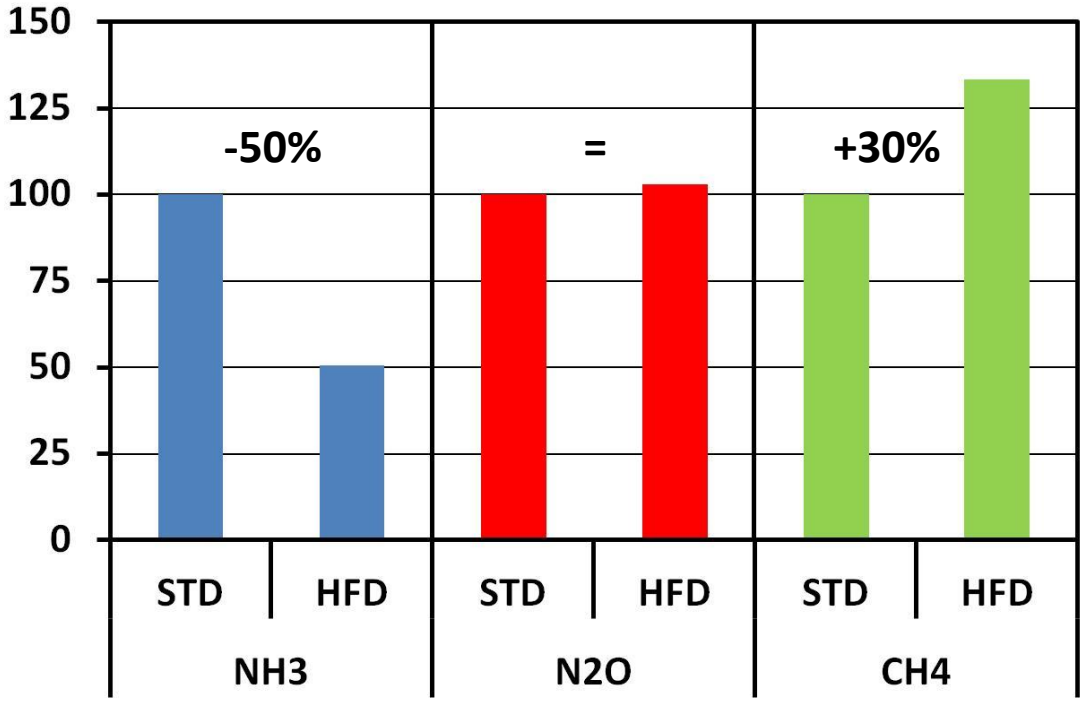
- Dietary factors
  - *Dietary fibres*

N balance (g/day)	NSP content	
	12%	18%
N intake	51.5	48.6
N-NH_3	5.0	3.9
N retention	23.5	22.1
N excretion	28.1	26.5
Faecal N	7.8	9.7
Urinary N	20.3	16.8
Manure pH	8.95	5.59

Influencing factors

- Dietary factors

→ *Dietary fibres* : *18% NSP (STD) vs. 30% NSP (HFD)*

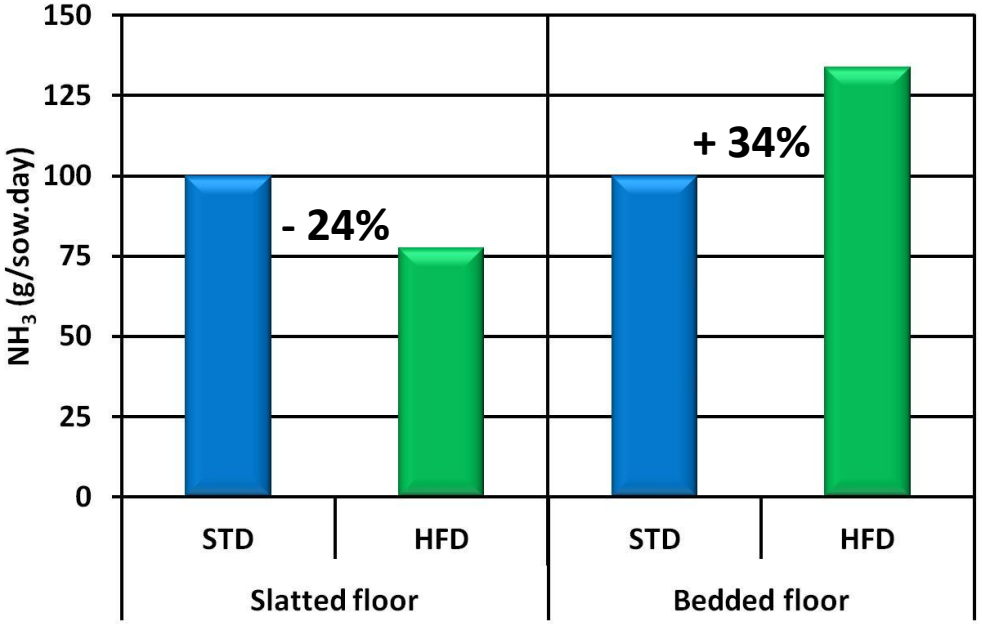


(Philippe et al., 2012)

Influencing factors

- Dietary factors

→ *Dietary fibres :* *Interactions with the floor type*



(Philippe et al., 2012)

Conclusion

- Numerous techniques to reduce emissions, whatever the floor type

BUT <u>contradictions</u> depending on the circumstances and the gas

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  - Sawdust : ↘ NH_3, ↘ CH_4, ↗ N_2O
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  + Solid/liquid separation : opportunity for further reductions

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- Complete evaluation of the manure management process



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