Environmental impacts of housing and manure management in European pig production systems

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Introduction

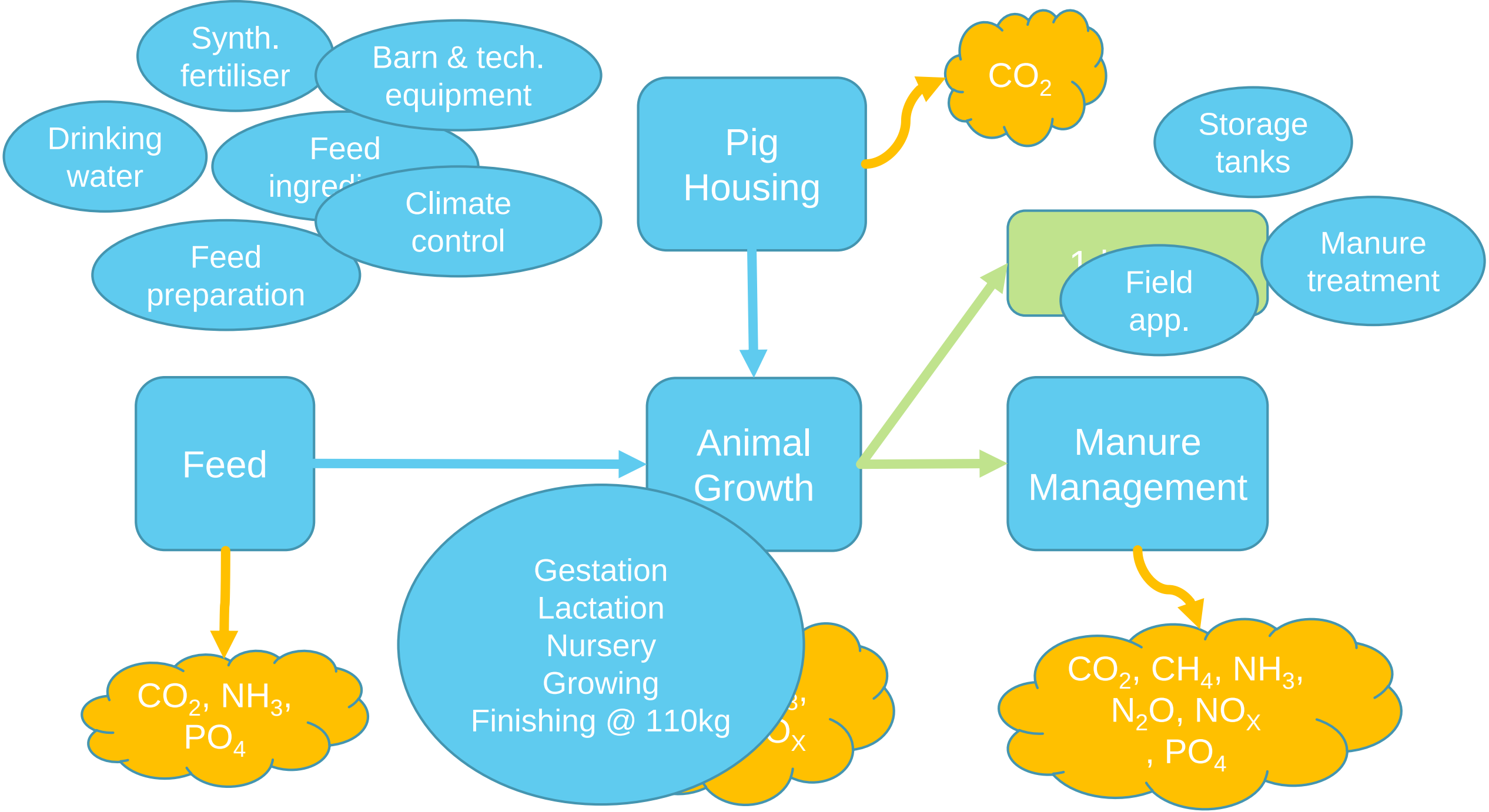
- Pig production systems significantly contribute to the environmental impacts arising from livestock
- Manure management is regarded as an important source of GHG emissions
- A great variety of factors affect manure composition at pig housing and consequently the environmental impact of pig systems
- There is a need to evaluate environmental impact of pig production systems from a whole farm perspective, considering all the components and their interactions

Aim & Objectives

- Assess the environmental performance of a European pig production system through a holistic approach
- Identify potential environmental impact hotspots associated with the pig housing and manure management components, through a sensitivity analysis
- Assess the potential for environmental impact reductions of modifications in the pig housing and manure management components, through an alternative scenario analysis

Life Cycle Assessment

- **Model**: *"Cradle*-to-*gate" life cycle assessment (LCA)*
- **Data**: Danish, integrated, pig farming systems
- **Functional unit**: 1 kg pig live weight
- **Environmental impact categories (EICs)**:
  - Global Warming Potential (GWP): kg CO_2 eq.
  - Acidification Potential (AP): kg SO_2 eq.
  - Eutrophication Potential (EP): kg PO_4^{---} eq.
  - Non Renewable Resource Use (NRRU): kg Sb eq.
  - Non Renewable Energy Use (NREU): MJ
- **Uncertainty Analysis**: Monte Carlo simulations


Synth. fertiliser
Barn & tech. equipment
Drinking water
Feed ingredi
Climate control
Feed preparation
Pig Housing
CO_2
Storage tanks
Manure treatment
Field app.
Feed
Animal Growth
Manure Management
Gestation
Lactation
Nursery
Growing
Finishing @ 110kg
CO_2, NH_3, PO_4
CO_2, CH_4, NH_3, N_2O, NO_X , PO_4

Sensitivity Analysis

- Local, “one-at-a-time”, Min & Max values (Chiu & Lo, 2018)
- Relative sensitivity > 1% ⟶ **Environmental Impact Hotspot (EIH)**

Parameter - EIH	Variation	% Relative sensitivity		
Barn insulation	Max	NREU: 5.21% ↓	AP: 1.36% ↓	GWP: 1.26% ↓
In-barn temperature	Max	AP: 1.06 - 5.15% ↑	NREU: 1.30 - 4.40% ↑	GWP: 1.15 – 1.30% ↑
Slurry dilution	Max	AP: 40.4% ↓	EP: 19.1% ↓	NRRU: 5.17% ↓
Ventilation system efficiency	Min	NREU: 23.1% ↑	GWP: 8.78% ↑	AP: 1.21% ↑
Frequency of slurry removal	Max	AP: 10.3% ↓	EP: 3.81% ↓	NRRU: 1.04% ↓

Manure management alternative scenarios

Baseline

- 9 months storage
- Slurry tanker with trailing hose
- N 75%
- P 90%
- K 100%

In-house slurry acidification

- + H_2SO_4 and $CaCO_3$
- Operation of acidification plant

Screw press slurry separation

- 100km from farm for application
- Broadcast spreading & rapid incorporation
- N 65% solid fraction

Anaerobic digestion of slurry

- Centralised AD plant
- 25 days pre-storage
- N 85% digestate

Manure management alternative scenarios

Comparison to baseline - % change in environmental performance

Parallel Monte Carlo simulations, 1000 runs

	In-house slurry acidification	Screw press slurry separation	Anaerobic digestion of slurry
GWP	+8.40%	+6.44%	-9.24%
AP	-28.1%	+62.6%	+6.47%
EP	-14.2%	+4.47%	+8.13%
NRRU	+45.3%	+35.0%	-34.1%
NREU	+2.26%	-2.26%	-40.1%

Pig housing alternative scenarios

4 manure management scenarios **X** 5 pig housing scenarios

"**Good**" & "**Poor**" farm management practices

Pig housing scenario / Parameter	Baseline pig housing	± Level of slurry dilution		± Frequency of slurry removal		± Ventilation efficiency		± Barn insulation		± In-barn temperature	
Total Ammoniacal Nitrogen (%)	70.5	62.5	78.5								
Slurry removal regime (days)	30			1	>30						
Fan efficiency (m^3 / h W)	20.4					24.5	16.3				
Barn insulation (U-value)	1							0.26	4		
Temperature (C°)	Average T									Min	Max

Pig housing – manure management “interactions”

Pig housing scenario	EIC	Mean % change in EI across all manure management scenarios	
		“Poor” management	“Good” management
Barn insulation	NRRU	+ 6.64 - 16.0%	- 1.60 - 4.20%
	NREU	+ 8.99 - 15.8%	- 2.21 - 3.88%
Ventilation system efficiency	NREU	+ 1.83 – 4.61%	- 1.85 - 3.08%
	GWP	+ 1.22 – 1.55%	- 0.82 – 1.43%
Slurry dilution	AP	+ 1.98 – 6.74%	- 1.95 – 5.31%
	EP	+ 0.26 – 2.51%	- 0.39 – 1.06%
Frequency of slurry removal	AP	N.A	- 0.51 – 5.45%
	EP	N.A	- 0.07 – 3.26%

Conclusions

- In house slurry acidification can potentially be applied in a variety of pig production systems and effectively reduce their environmental impact for AP & EP
- Modifications in pig housing related parameters can significantly affect the environmental performance of the manure management component, across all EICs considered in this study.
- If it is not possible to improve farm management practices, it is important to maintain the “typical” standards
- Primary data collection efforts should be intensified to allow for better modelling of the alternative strategies

Thank you for your attention!

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Related websites

- http://pigsys.eu/
- https://www.ncl.ac.uk/nes/research/projects/pigsys.html