

#### Manure management for greenhouse gas mitigation

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#### ► To cite this version:

S O Petersen, Mélanie Blanchard, D Chadwick, A del Prado, Nadège Edouard, et al.. Manure management for greenhouse gas mitigation. Greenhouse Gases & Animal Agriculture Conference (GGAA), Jun 2013, Dublin, Ireland. Cambridge University Press, Animal, 7 (Suppl. 2), 2013, Animal. hal-01210507

#### HAL Id: hal-01210507 https://hal.science/hal-01210507

Submitted on 3 Jun 2020

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# GREENHOUSE GASES & ANIMAL AGRICULTURE

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# Manure Management for Greenhouse Gas Mitigation

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Nadège



Julio



Agustin



Sven

Melanie



David



# GHG balance, livestock production

	GHG emissions (CO <sub>2</sub> eq)		
	10 <sup>9</sup> tonnes	%	
Land use, land use change	2.5	36	
Feed production	0.4	7	
Enteric fermentation, energy	1.9	25	
Manure management	2.2	31	
Processing, transport	0.03	]	

(Steinfeld et al., 2006)

# N surplus: an indicator of GHG emissions

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1.2612

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> Diversity of livestock production and manure management

- $\ >$  Sources of CH $_4$  and N $_2O$  in manure environments
- > Mitigation measures and strategies
- > Quantifying effects of mitigation
- > Global trends, conclusions



# Diversity of livestock production Case: Sub-Saharan Africa

Blanchard (2010)	Area	Farms
	ha	%
Crop production w. livestock	5-11	68
Livestock, grazing	11-24	30
Specialist breeders	<1	2

# Diversity of livestock production Case: Sub-Saharan Africa

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Losses, manure management

N excreted % 46 13 24 17



# AARHUS UNIVERSITY Diversity of livestock production Case: Southeast Asia

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	Ave. farm size	Farms <2 ha	3	Ave. farm size
	ha	%	2	(India)
Bangladesh	0.5	96 و	—	
Nepal	0.8	93	1	
India	1.4	81		
Pakistan	3	58	0	a50, a80, a95, a00
	Sol	urce: Thapa (2009)		1, 1, 1, 1, 10
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## AARHUS UNIVERSITY Diversity of livestock production Case: Southeast Asia

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Vietnam:





Vietnam China

110,000 digesters 30,000,000 digesters

Discharge 9-15% of N intake

Leakage losses of CH<sub>4</sub>?<sup>10</sup>

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# Diversity of livestock production Case: China

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## Diversity of livestock production Case: European Union

Increasing adoption of regulations to reduce N surplus and GHG emissions:

- > Manure storage capacity
- > Manure storage conditions
- > Limits to N application rates
- > Assign manure N fertiliser value





## Diversity of livestock production Case: European Union



More confinement, higher productivity

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(Eurostat)

#### Livestock production systems (solid $\rightarrow$ liquid)



#### Manure storage (aerobic $\rightarrow$ anaerobic)





Regulation of  $CH_4$  and  $N_2O$  emissions in manure environments?



# Methane emissions from (liquid) manure

#### IPCC: Temperature a key control of manure CH<sub>4</sub> emissions

						1	MCF	VALUE	S BY T	EMPER	TA	BLE 10	).17 MANUR	E MAN	AGEME	NT SYS	TEMS			
								М	CFs b	y aver	age an	nual t	emper	ature (	(°C)					
System <sup>a</sup>				Cool							3	Tempe	erate					Warm		
		≤ <b>1</b> 0	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	≥ 28
Liquid/Slurry	With natural crust cover	10%	11%	13%	14%	15%	17%	18%	20%	22%	24%	26%	29%	31%	34%	37%	41%	44%	48%	50%
	Without natural crust cover	17%	19%	20%	22%	25%	27%	29%	32%	35%	39%	42%	46%	50%	55%	60%	65%	71%	78%	80%

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IPCC (2006)

AARHUS UNIVERSITY 2653 Methane emissions Role of methanogens?

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Elsgaard et al. (unpubl.)



# Methane emissions Role of methanogens?



Hydrogenotrophs

Elsgaard et al. (unpubl.)

Acetotrophs,



# Methane emissions Potential CH<sub>4</sub> mitigation strategies

#### Reduce CH<sub>4</sub> production by:

- > Lower storage temperature
- > Avoid mixing with adapted slurry
- > Remove volatile solids
- > Additives to inhibit methanogens





		AOB	NOB	
		Nitrosomonas sp.	Nitrobacter sp.	
<	Oxygen affinity , K <sub>m</sub> (kPa)	5-15	22-108	>
	$NH_3$ (free) (mg N L <sup>1</sup> )	10-150	0.1-1.0	
	$HNO_2$ (free) (mg N L <sup>-1</sup> )	0.1-0.4	0.011-0.023	



		AOB	NOB	
		Nitrosomonasso.	Nitrobacter sp.	
<	Oxygen affinity , K <sub>m</sub> (kPa)	5-15	22-108	$\supset$
	$NH_3$ (free) (mg NL <sup>1</sup> )	10-150	0.1-1.0	
	$HNO_2$ (free) (mg N L <sup>-1</sup> )	0.1-0.4	0.011-0.023	



## Nitrous oxide emissions Via denitrification





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#### Reduce N<sub>2</sub>O emissions by:

 Minimising the extent of oxicanoxic interfaces

(oxic <u>or</u> anoxic)

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 Uncoupling C and N turnover (treatment before storage)



#### AARHUS UNIVERSITY MALAGRICULTURE MITIGATION MEASURES Housing

Liquid manure vs. solid management



#### AARHUS UNIVERSITY MARKAUSE DASES A MINIMAL AUGRICULTURE MINIMAL AUGRICULTURE Housing





#### AARHUS UNIVERSITY MARKAN AGRICULTURE Mitigation measures Storage

Solid manure	N2O	CH4
Active vs. passive composting	<b>I</b> t	Ļ
Extra straw	Ļ	Ļ
Plastic sheet	ļ†	ļţ
Liquid manure		
Crust	1	<b>I</b> t
Solid cover	ļ1	Ļ



#### AARHUS UNIVERSITY MARKAL ADRICULTURE Mitigation measures Treatment





#### AARHUS UNIVERSITY

# Methane mitigation by slurry acidification



#### Reduction in $CH_4$ emissions:

	Storage period	Fresh	Aged
Cattle slurry	95 d	67%	87%
Pig slurry	83 d	99%	94%

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Petersen et al. (2012; submitted)

#### AARHUS UNIVERSITY MARKAGENEULTURE Mitigation measures Treatment

	N <sub>2</sub> O	CH <sub>4</sub>
Manure separation	11	
Anaerobic digestion	t t	l
(Dilution)		Ì
Additives, e.g. acidificaton	Ļ	Ì

#### "Down-stream" effects



#### AARHUS UNIVERSITY AMIRAL AGRICULTURE Mitigation measures Treatment effects













# Mitigation measures Field application

- > Application method
- > Application rate
- > Timing

(soil-manure contact) (avoid large pools of mineral N) (mineral N residence time)



Soil type Soil wetness Tillage practice



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Example: Three diets (early grass, late grass, maize) w/wo rapeseed

Chadwick et al. (2011)

#### UNIVERSITY Strategies for GHG mitigation The "manure management continuum"

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MCF = 10%



**Evaluating GHG mitigation** requires a whole-farm approach

# GHG mitigation at farm level Criteria for evaluating farm models

- Ability to simulate temporal, spatial, genetic variability, and farmer decision making
- > Coupling of nutrient, water, energy flows
- > Economy
- > Uncertainties

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- Data availability for parameterisation
- 1) Temperature; 2) O<sub>2</sub> status; 3) Manure handling/treatment/

application



# Global trends

#### Livestock populations, by region



Growth mainly in developing countries At least 75% of the growth in confined systems (FAO scenario) How to achieve sustainable intensification?

Source: Bouwman et al. (2012)

# How to achieve sustainable intensification?

#### Subsistence agriculture

- > Containment of manure nutrients during storage
- > Recycling of manure nutrients for crop production
- > Increasing market orientation



# How to achieve sustainable intensification?

#### Mixed farms > farms specialised in crops or livestock

- > Less external inputs (fertilisers, feed)
- > Lower costs

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- > Diversification = less sensitivity to fluctuating prices
- > Lower risk of N pollution
- > Greater biodiversity



## How to achieve sustainable intensification?

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#### Industrialised production systems

- Recycling rather than discharge of manure nutrients >
- Treatment technologies Σ
- Need for regulation/incentives >



# Conclusions

- > Treatment and management to improve N use efficiency will also promote GHG mitigation
- Higher N use efficiency can improve farm profitability while also reducing GHG emissions per unit product
- Future increases in livestock production mainly in confinement systems – effective recycling of nutrients should be ensured via regulations/incentives
- > A whole-farm approach is needed to identify costeffective GHG mitigation measures





# Acknowledgements



#### AnimalChange (FP7) Danish Strategic Research Council Basque Dept. Education

Thank you!



# Nitrous oxide mitigation by separation?

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## N<sub>2</sub>O emission from soil-manure system Interactions between manure OM and soil conditions

- O<sub>2</sub> demand affected by: > manure OM composition > infiltration
- O<sub>2</sub> supply affected by :
- > texture
- > compaction
- > moisture







Van Groenigen et al. (2010)

(Brozyna et al., in prep.)





**0** – no slurry

**INJ** – injection **TH** – trail hose application

