Modelling manure production by pigs

Effects of feeding, storage and treatment on manure characteristics and emissions of ammonia and greenhouse gazes

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SESSION 5 / ABSTRACT 0474 / 26/08/2007

SENAH

1. **Context and objectives**
2. **Construction of the model**
   1. Animal
   2. Housing / Storage
   3. Manure treatment
3. **Validation**
4. **Scenario comparison**
   1. Manure management systems
   2. Effects of feeding and other farmer practices

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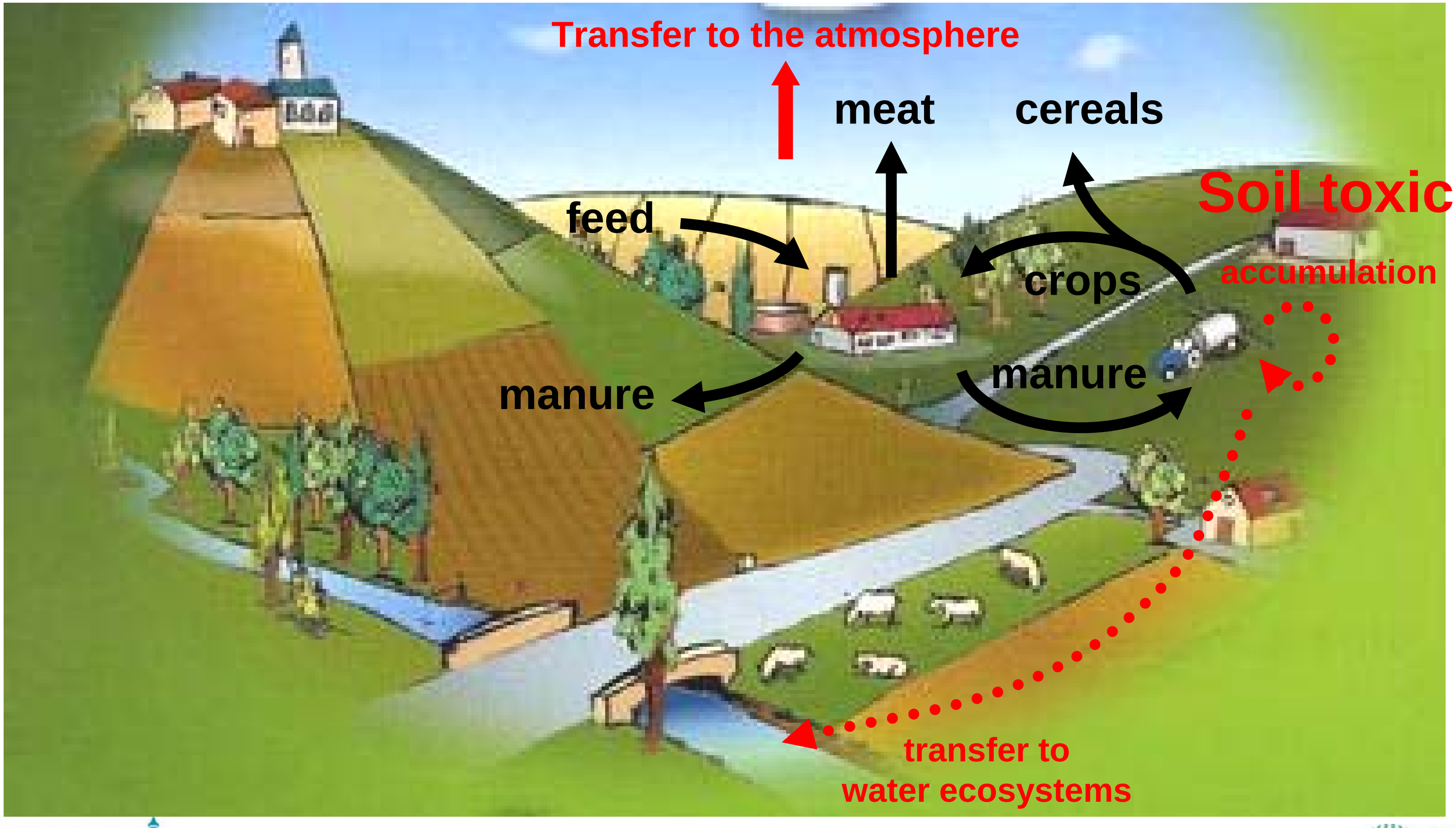
Nutrient flow at farm level

Greenhouse effect (CH_4, N_2O), Acidification (NH_3)



Eutrophisation

Scope of the study :

Manure production chain :

from feed to manure before spreading/export

=> Direct impacts on air emissions :

– CH_4, N_2O, NH_3

=> Indirect impacts on manure use :

– Manure type (DM, OM …)

– Nutrient amount and bioavaibility (N, P, K, Cu, Zn)

Context

- Diversity of feeding, housing and treatment practices => **Diversity of products and gaseous emissions**

- **Increasing number of gaseous assessment in literature**

- **Few comprehensive studies at farm level**
  - variability of emissions and variation factors
  - diversity of units (/pig, /m^2, /m^3, % N excreted…)
  - measurement method

Objectives of the study

A model to predict :

- **NH_3, N_2O and CH_4 emissions**
- **Manure characteristics**
  - Mass, Volume
  - DM, OM
  - N (Org. and Am.), P, K, Cu, Zn

Objectives of the model

For each physiological stage

For 6 of the main systems in France

- **Slurry (S)**
  - Biological treatment (Nitrification / Denitrification) (SBT)
  - Slurry composting with straw (SC)
  - Slurry anaerobic digestion (SAN)
- **Solid manure (M)**
  - Composting (MC)

Objectives of the model

Integrating the effects of farmer practices and climatic conditions

- **Feeding**
  - *nutrient content*
  - *feed conversion ratio*
  - *water supply…*
- **Housing conditions**
  - *Floor / litter type*
  - *Animal density…*
- **Temperature, Rain**

Approach

- **Valorisation of existing data**
- **Robust -> Empirical model**
- **Expert panel**

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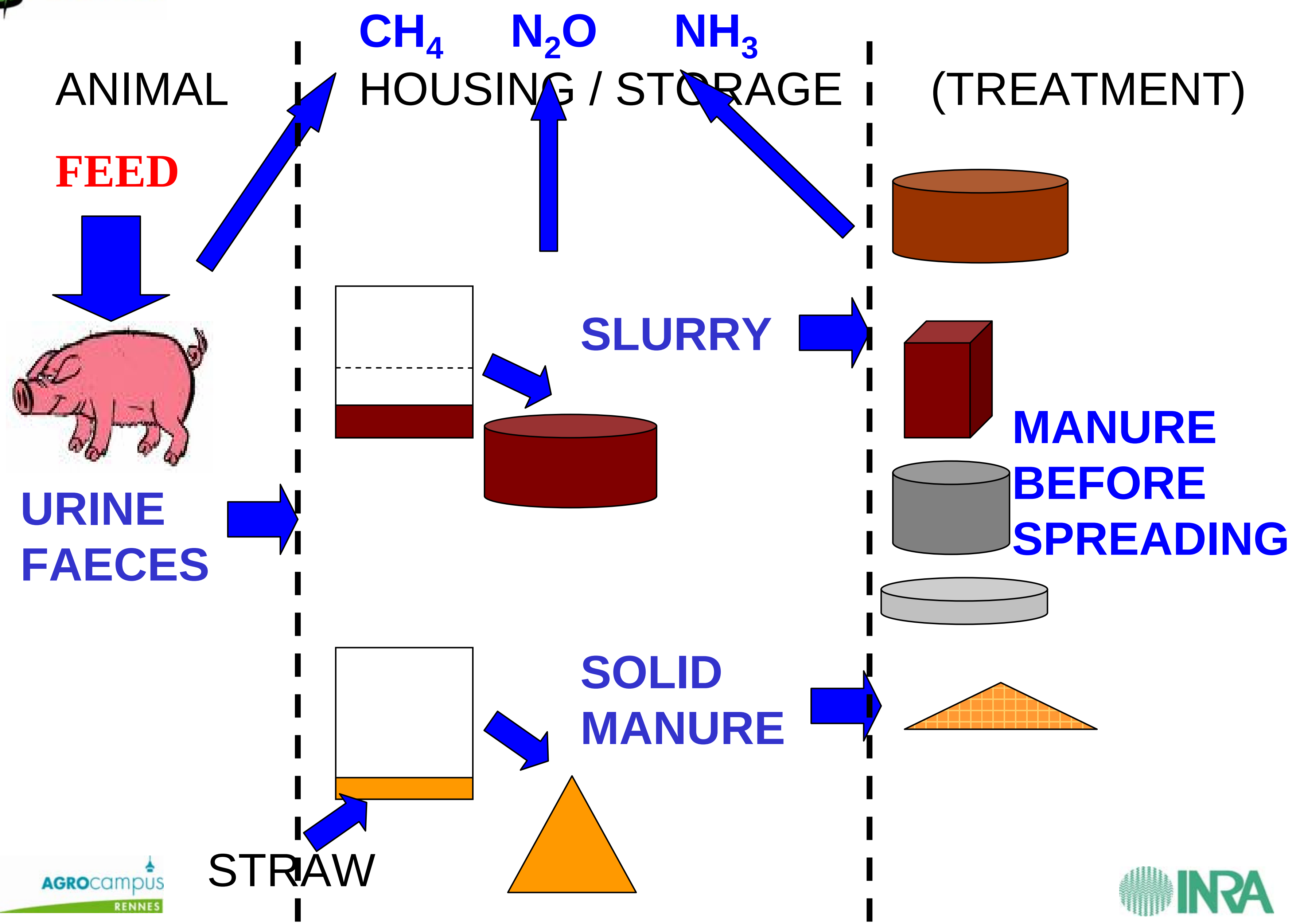

SENAH
CH4
N2O
NH3
ANIMAL
HOUSING / STORAGE
(TREATMENT)
FEED
SLURRY
MANURE
BEFORE
SPREADING
URINE
FAECES
SOLID
MANURE
STRAW
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1- Animal

- **Excretion of nutrients, DM, OM and water**

=> Mass balance :

Excretion = Intake – Retention
(+ Endogen – Evaporation)

- **Methane emission**

CH_4 = f (Ingested digestible fibre)

1- Animal

INPUT DATA	CALCULATED DATA	OUTPOUT DATA
FEED - Amounts - N, P, K, Cu, Zn - Water supply - Digestible fibre		**CH_4** **URINE &FAECES** -Masse, Volume -N, P, K, Cu, Zn -OM, DM
TEMPERATURE	**RETENTION** **EVAPORATION** **ENDOGEN** *(literature review)*	
ANIMAL PERFORMANCE - Body weight - Lean meat content - Litter size		

2- Housing / Storage

Methodology depending on existing knowledge :

1 : Relationships directly taken from **literature**

2 : Relationships developed from **literature survey and expert judgment**

$$EmissionFactor \times \prod_{i=1}^{n} (Variation\,Factor_i)$$

3 : **Simple emission factors**

2- Housing / Storage

Slurry

a- Building

$N\text{-}NH_3$ = 24% N Excreted x Effect *Dilution*
x Effect *Temperature*
x Effect *Air Renewal*
x Effect *Floor type*
x Effect *Frequency*

b- Outside storage

$NH_3 = 0.6 \times e^{(\text{Manure Temperature})}$ x Surface Area
x Storage time
x Effect *Cover*

Pelletier et al., 2006

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2- Housing / Storage

Slurry

N_2, N_2O : Simple emission factors (< 1%)

IPCC, 2006

$$CH_4 = CH_4[20°C] \times \phi^{(\text{Manure temperature} - 20)} \times \text{Volume} \times \text{Storage Time} \times \text{Effect } \textit{Cover}$$

Vedrennes, 2006

2- Housing / Storage

<u>Deep litter systems</u> :

N gazes

$N\text{-}NH_3$ = 20 %		**x Effect *Litter Type***
		x Effect *Animal Density*
$N\text{-}N_2O$ = 8 %		**x Effect *Moisture***
		x Effect *Litter Amount*
N_{Losses} = 64 %		**x Effect *Mixing***

CH_4 : simple emission factor *(IPCC, 2006)*

3- Treatment

Simple emission and repartition factors for :

- **Biological treatment** *(Loyon et al., 2005)* **(SBT)**
  - Without phase separation
  - Compacting screw
  - Decanter centrifuge
- **Slurry composting with straw (SC)**

  © Guernevez Method *(Paillat et al., 2005)*
- **Slurry anaerobic digestion** *(Vedrennes, 2006)* **(SAN)**

3- Treatment

Emission depending on practices for :

- **Solid manure composting (SM)**

$$EmissionFactor \times \prod_{i=1}^{n} (Variation\ Factor_i)$$

  - ***Manure type (Moisture and C/N Ratio)***
  - ***Turning number***
  - ***Composting duration***

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Validation method

Excretion and slurry characteristics

- Validation with external data
- 19 experimental studies (most of them for growing pigs)

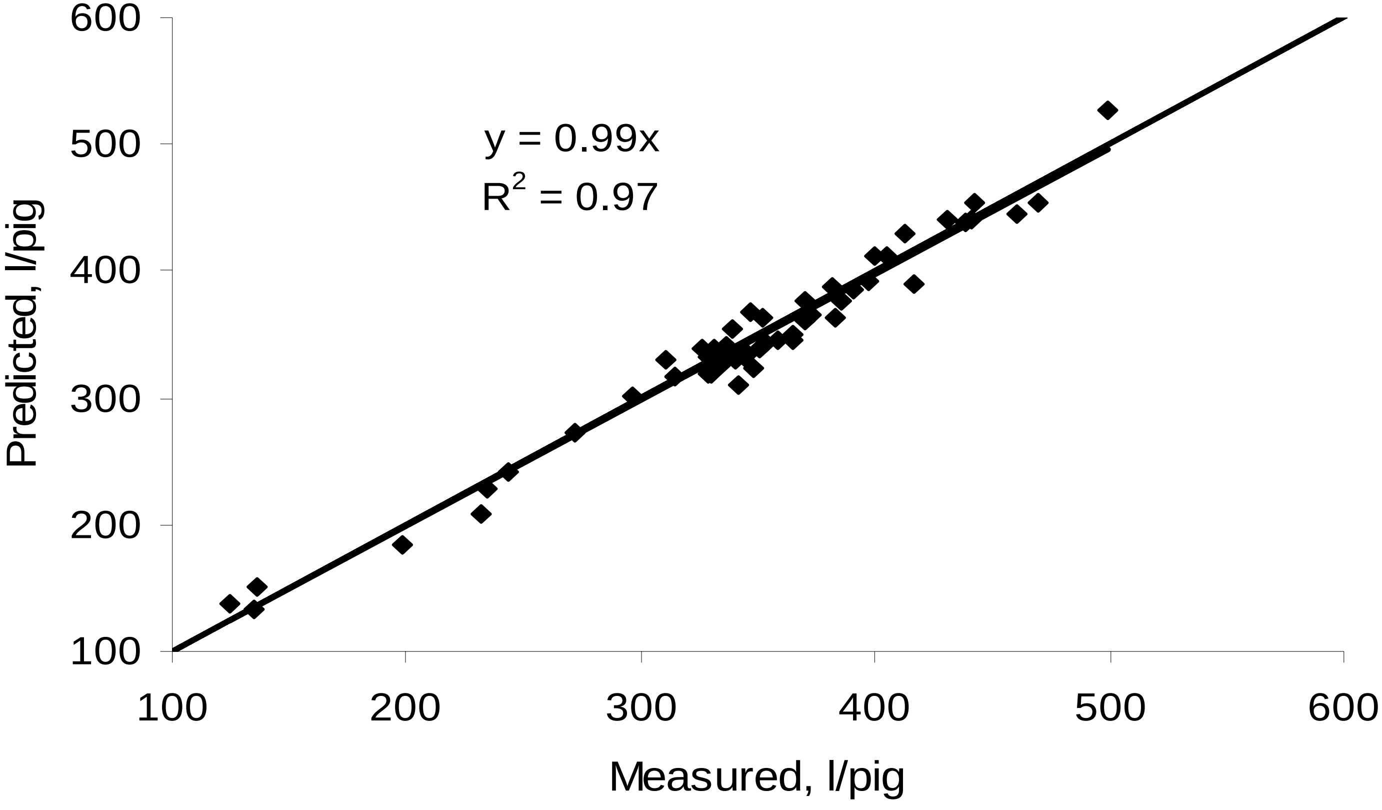
Solid manure systems and treatment

- Internal validation
- Coherency verification

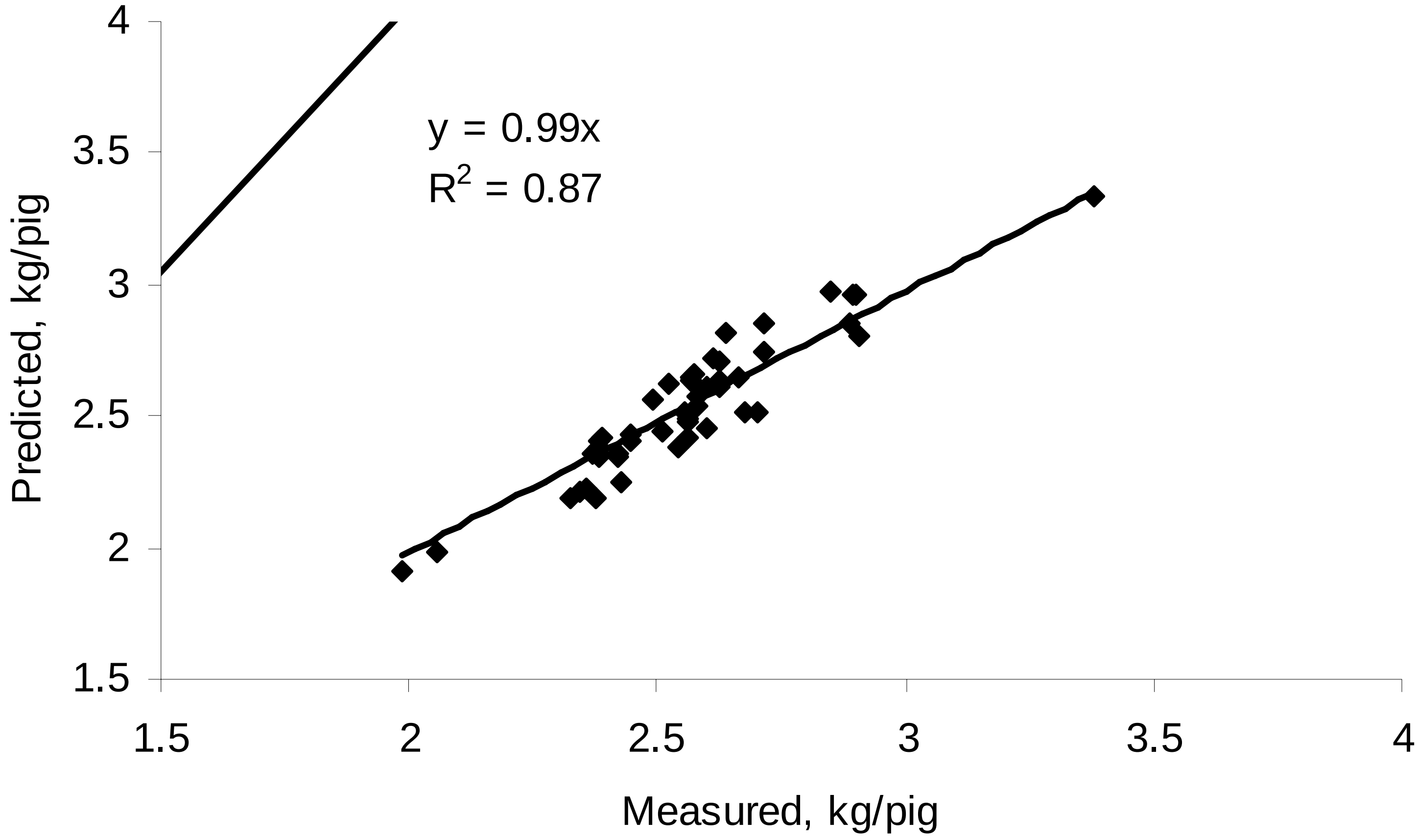
(100% > N losses > N-N_2O + N-NH_3)

- Expert validation

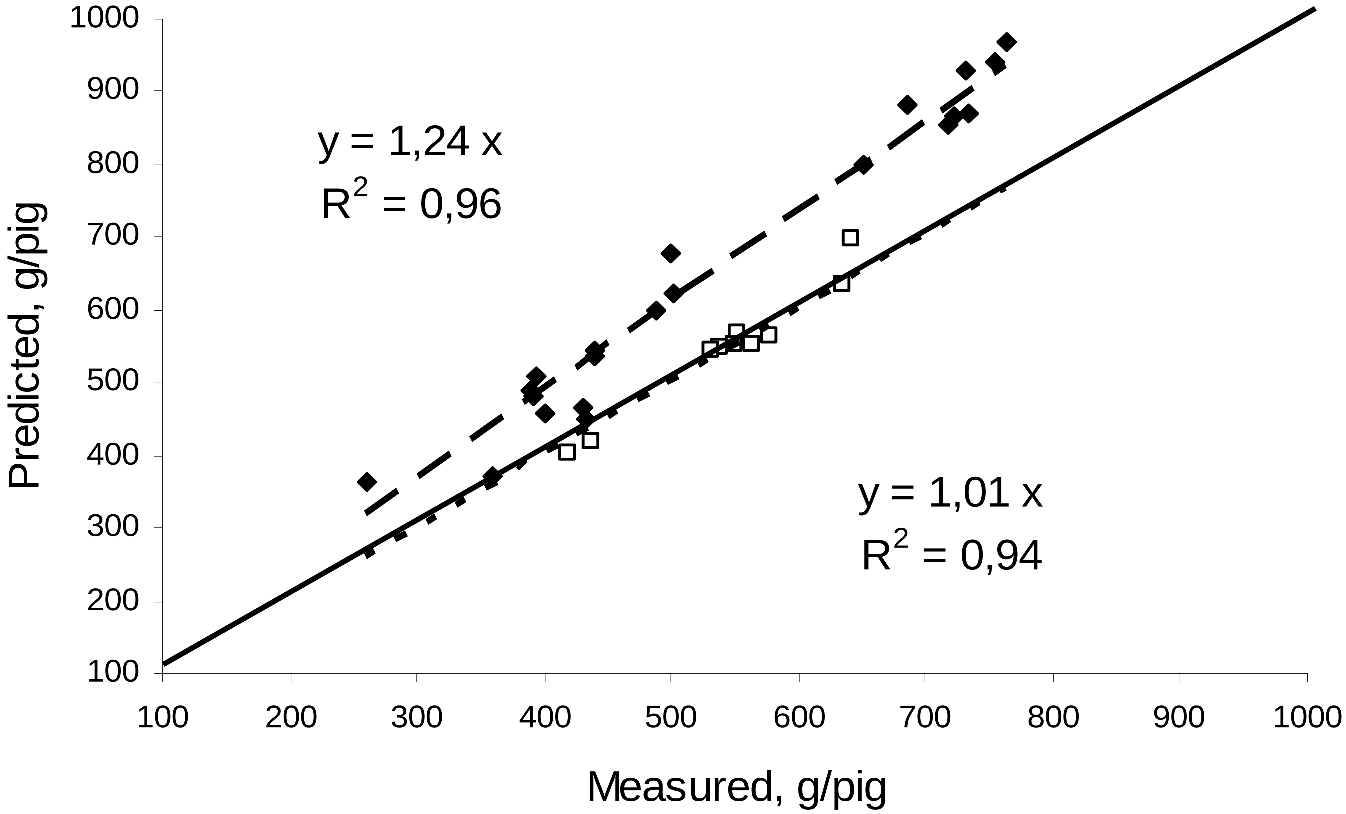
Relationship between predicted and measured values of slurry volume



Relationship between predicted and measured values of nitrogen amounts

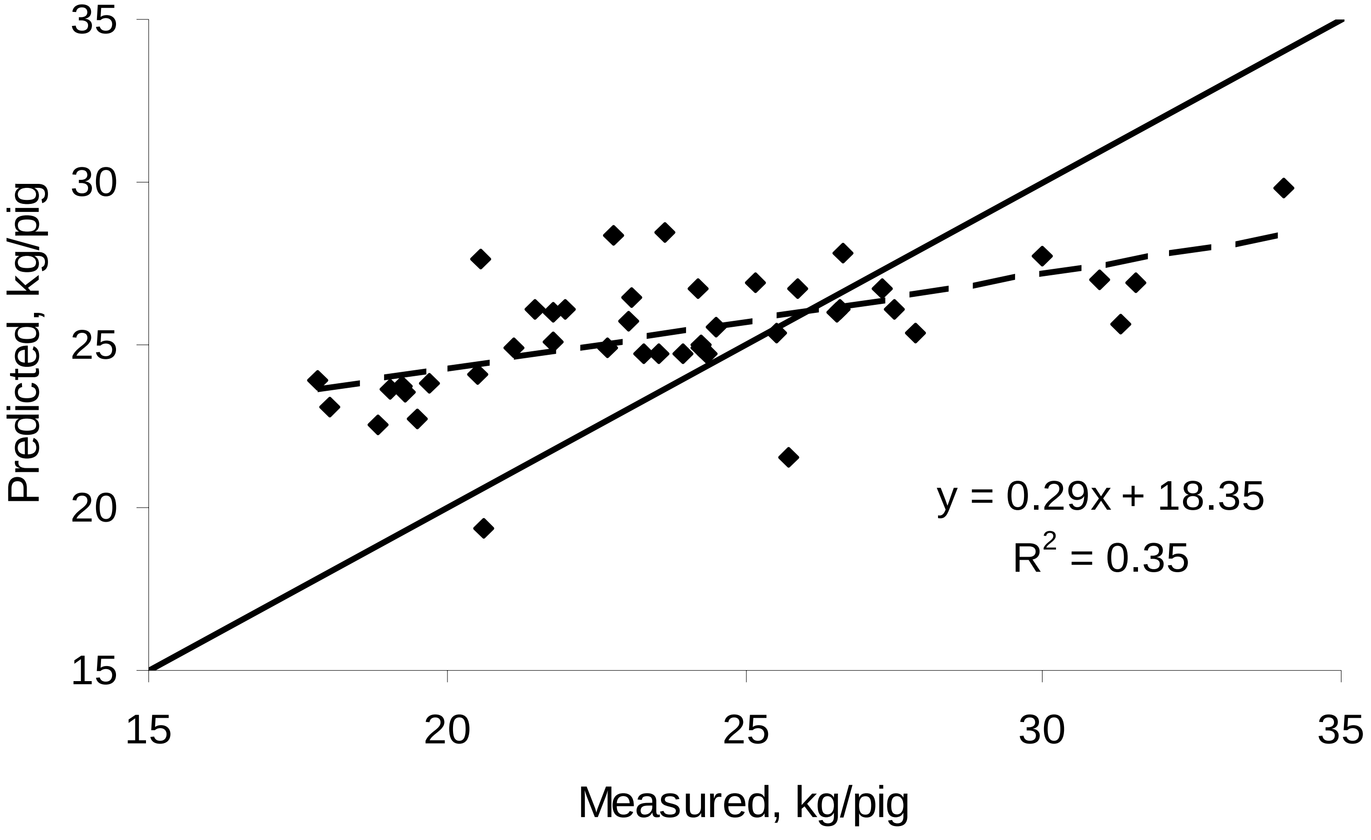


Relationship between predicted and measured values of phosphorus amounts



(■ core sampling, □ sampling after mixing)

Relationship between predicted and measured values of dry matter amounts



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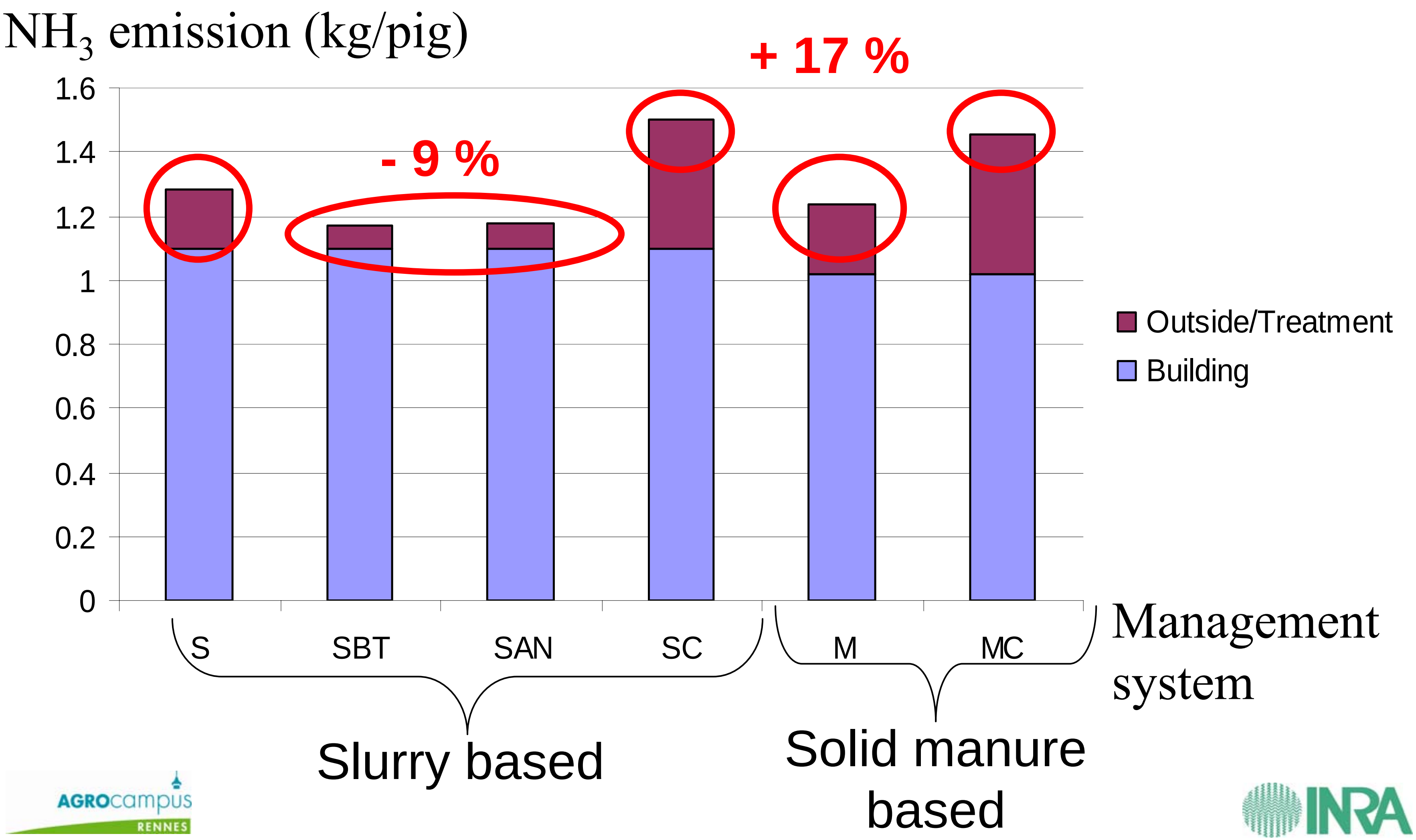
Comparison of 6 manure management systems (S, SBT, SAN, SC, M, MC)

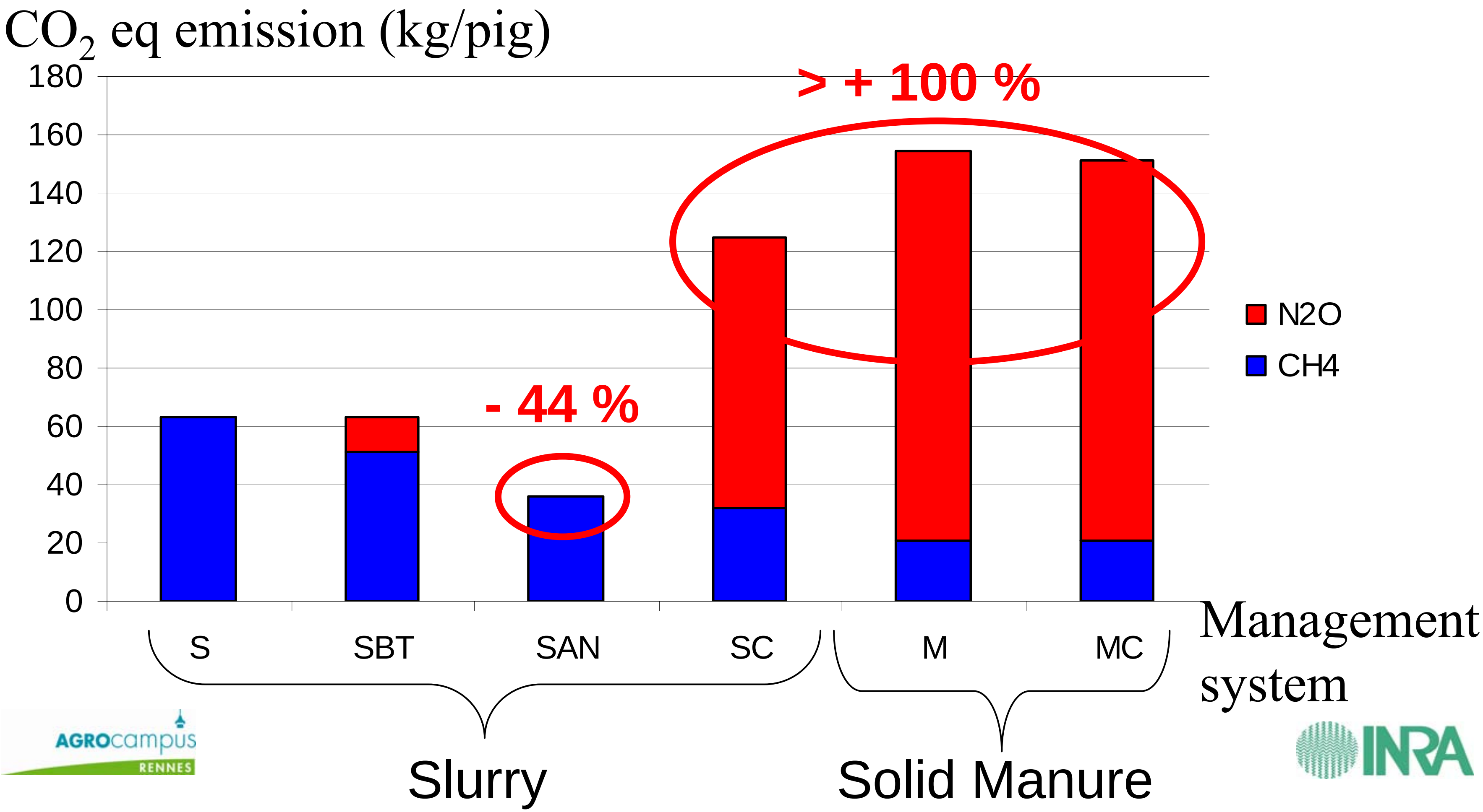
- **For a growing period (30-110kg)**
- **With « standard » practices :**
  - **Feeding :** 165 g CP/kg feed; FCR = 2.85
  - **housing :**
    - Slatted floor : 100 days; 22°C
    - Deep litter : 60kg straw /pig; 1.2 m²/pig
  - **Outside storage and treatment :** 120 days; 13°C

Results : Ammonia (kg/pig)



Results : Greenhouse gazes ($kg\ CO_2$ eq/pig)

CO_2 eq = 21 x CH_4 + 310 x N_2O



Results : Manure characteristics

	Products	Mass	OM	N amount
Slurry	1	=	=	=
Biological Treatment	3	=	-	--
Anaerobic digestion	1	=	-	=
Slurry composting	1	--	+	--
Solid manure	1	-	++	--
Solid manure composting	1	-	++	--

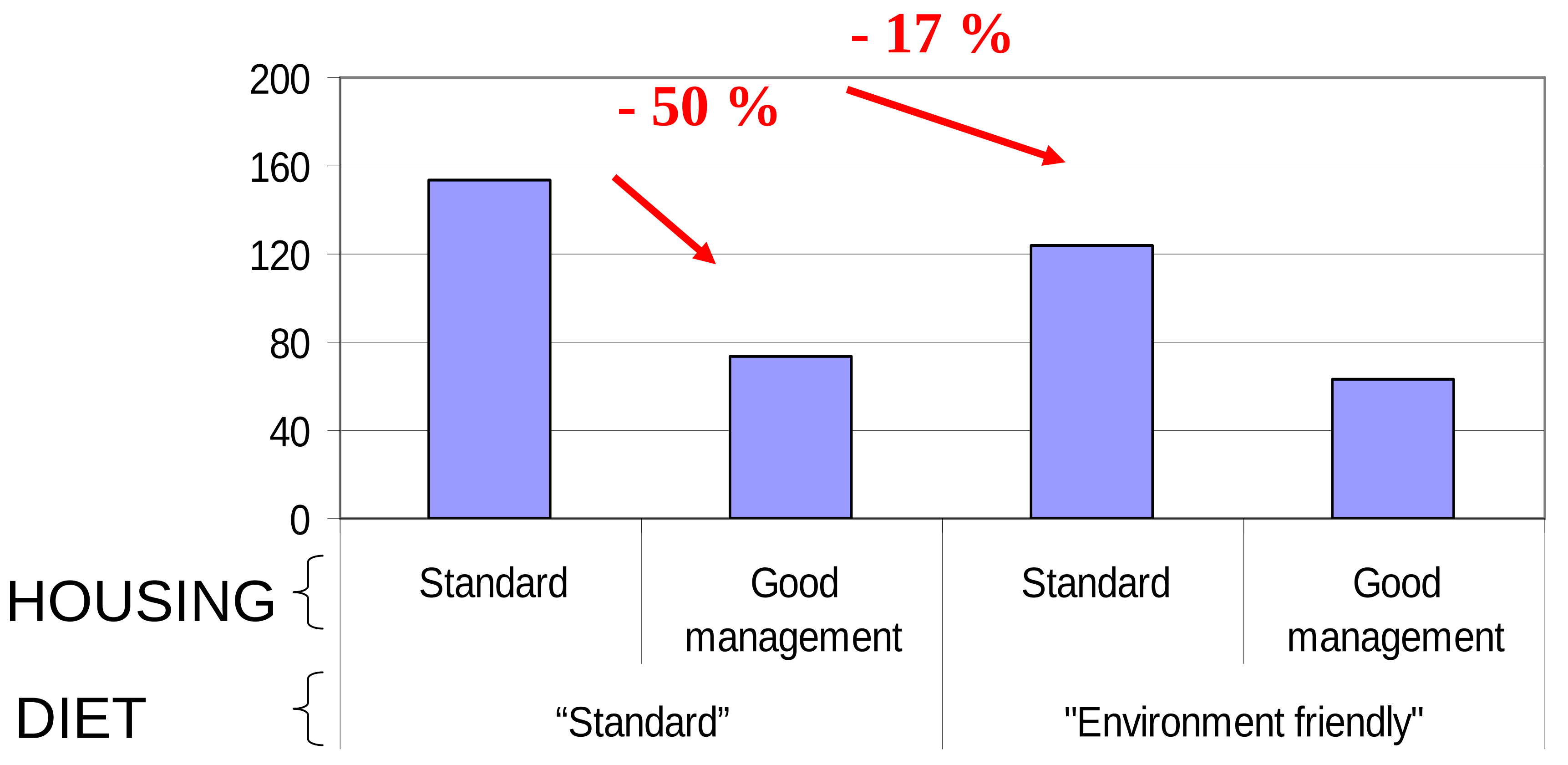
Effects of feeding and other farmer practices

Example in Solid Manure (SM) systems

- **2 diets :**
  - **« Standard »:** 165 g CP/kg feed
  - **« Environment friendly » :** 140 g CP/kg feed

- **2 housing scenarios :**
  - **« Standard » :** Density 1.2 m²/pig;
    Litter moisture 70%
  - **« Good management » :** Density 2 m²/pig;
    Litter moisture 60%

Results : Greenhouse gazes (kg CO_2 eq/pig)



Conclusions

Review of recent knowledge :

- For contrasted manure management systems

- Integrating the effects of farmer practices and climate

Conclusions

Good predictions of excretion, but few possibilities to validate gaseous emissions, particularly in litter based systems

-> **Lake of knowledge**

- Lake of studies
- Missing information in protocols
- Measurement accuracy ?

Conclusions

Each system has advantages and weak points

Trade off between environmental impacts

« Intra-systems » variations might be more important than intersystem variations

-> Interest to take into account farmer practices in gaseous assessment

-> Improvements achievable without important structural changes

Conclusions

Finally, the best choice for manure management will also depend on :

– Agronomic and environmental context

– Other considerations: Labour, economics, animal welfare

- > Integration of this study in a model at farm level : *Melodie Project*

Thank you !