Options for animal manure management in Portuguese farms

José Luís da Silva Pereira
Polytechnic Institute of Viseu, Portugal, jlpereira@esav.ipv.pt

Project LIFE13ENV/ES/00027 - Xinzo de Limia, 25th June 2019

Structure of presentation

1. Introduction
2. National regulations
3. Options for animal manure management
4. Case studies
   Mechanical separation
   Nitrification inhibitors
   Acidification
5. Concluding remarks

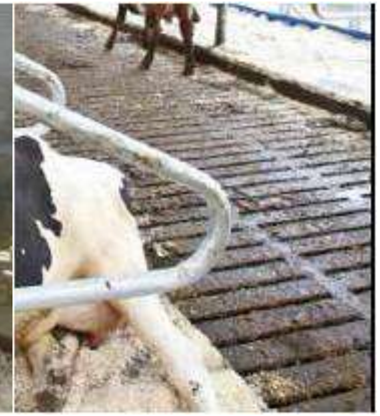
1. Introduction: Portuguese animal production

Number of animals (2017)	x1000
Cattle	1670
Pig	2165
Poultry	217270
Sheep	1665
Goat	340
Rabbit	4008

Portuguese Institute of Statistics (2018)

1. Introduction: emission sources in animal farms

Housing



Emissions:
Ammonia - NH_3
Methane - CH_4
Nitrous oxide - N_2O
Manure runoff

Storage and treatment

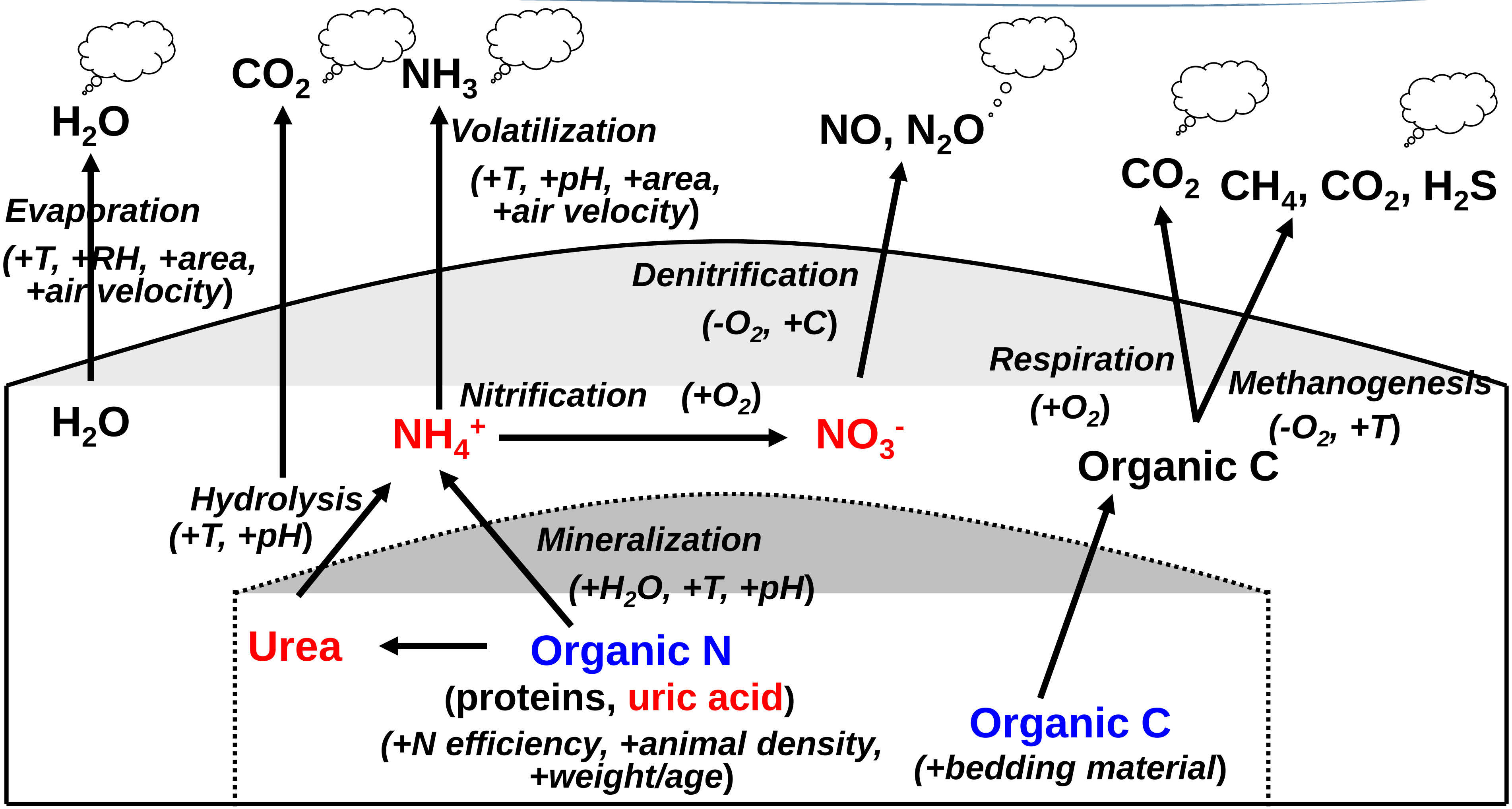
Emissions:
Ammonia - NH_3
Methane - CH_4
Nitrous oxide - N_2O
Nitric oxide – NO
Manure runoff

Soil application

Emissions:
Ammonia - NH_3
Nitric oxide – NO
Nitrous oxide - N_2O
Nitrates - NO_3^-
Manure runoff

Pereira and Trindade (2014) Eng. Agríc.

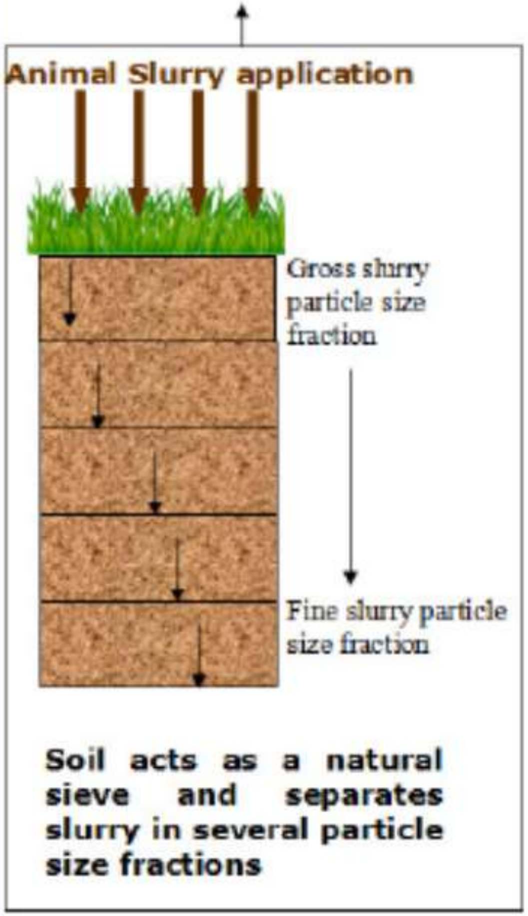
1. Introduction: decomposition of animal manure

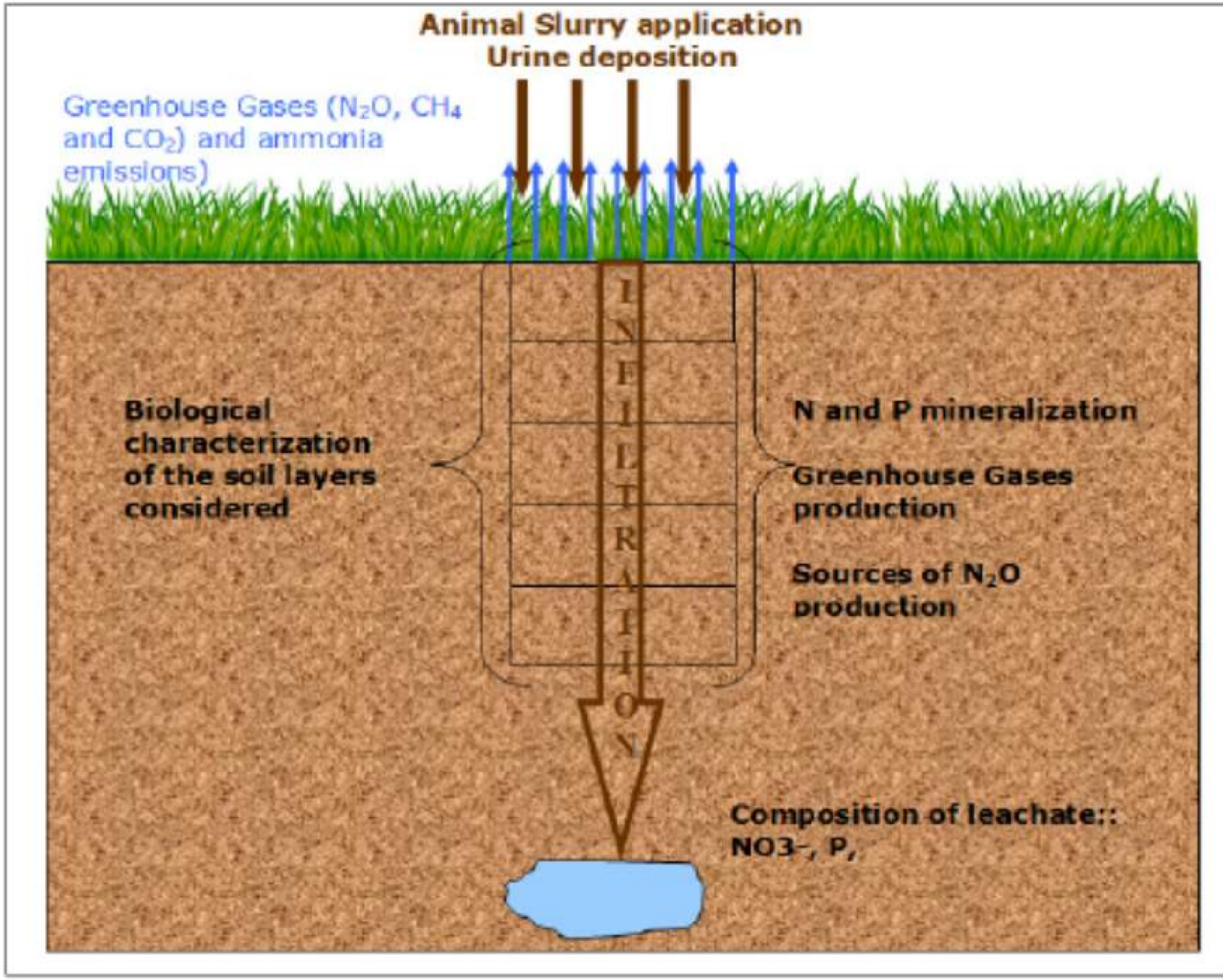


T: temperature; RH: relative humidity of air; C: carbon; N: nitrogen.
( ): main factors controlling processes.
+: directly proportional; -: inversely proportional.

Méda *et al*. (2011) World`s Poultry Sci. J.

1. Introduction: animal manure infiltration into the soil





Water pollutants:

- ❑ **Nitrates, phosphates, zoonotic bacteria and viruses,**
- ❑ **Estrogens and veterinary antibiotics.**

Sommer et al. (2003) Europ. J. Agronomy; Fangueiro et al. (2012) Chemosphere; Krog et al. (2017) Hydrogeol. J .

2. National regulations: mandatory in animal farms

- ❖ **Portuguese Environment Agency https://www.apambiente.pt**
- ❖ **Ministry of Agriculture http://www.drapc.min-agricultura.pt**

Portuguese regulations:

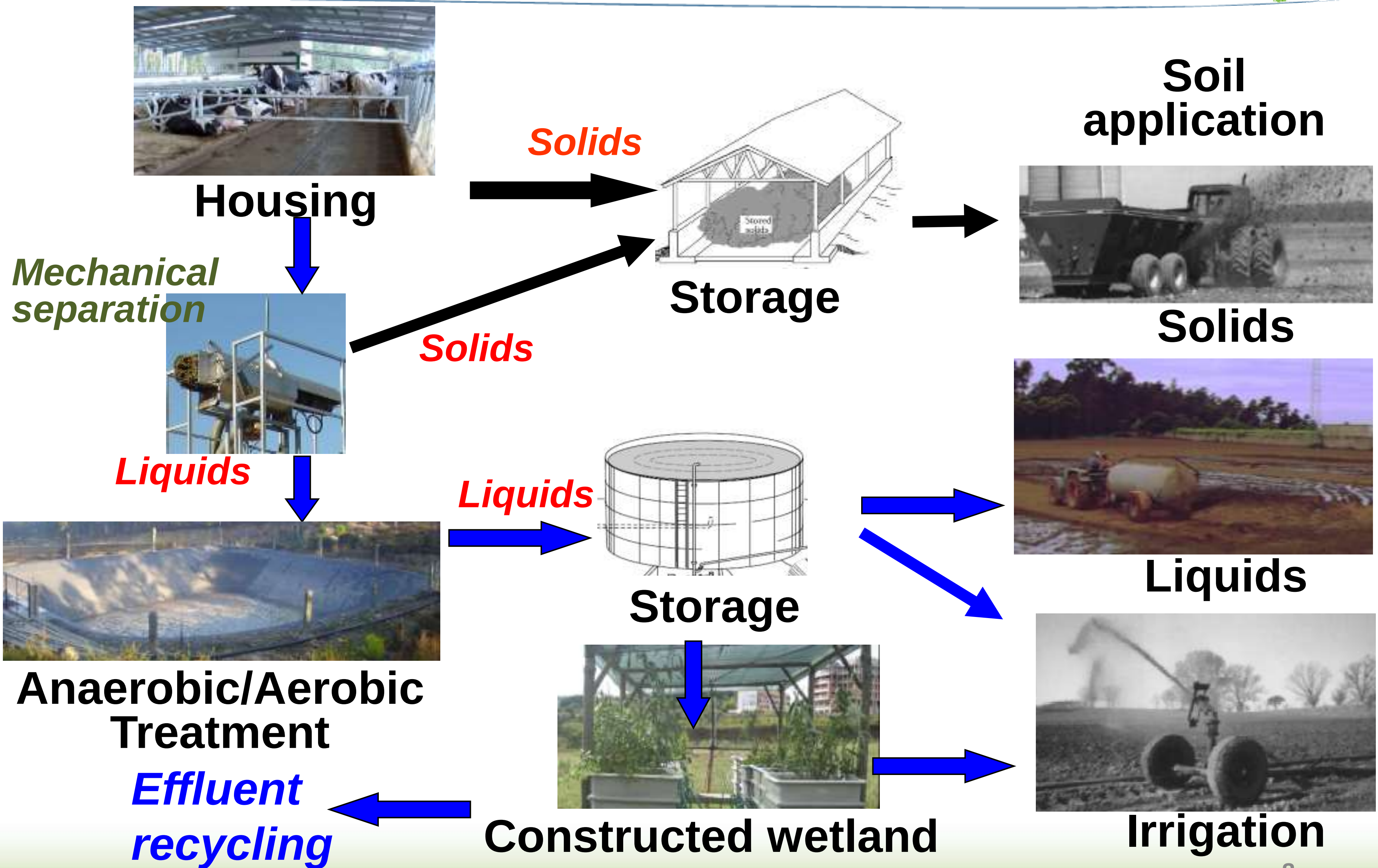
Law nº 81/2013 - Licence for animal production,
Law nº 127/2013 - Environmental licence,
Law nº 631/2009 - Animal manure management (farm plan),
Law nº 259/2012 - Vulnerable areas (water protection, <170 kg N ha^{-1} y^{-1}),
Law nº 1230/2018 - Code of good agricultural practice (crop fertilization),
Law nº 84/2018 - National emission ceilings (ammonia mitigation).

Key techniques for animal manure management:

- ✓ **Reduction of the total amount of manures,**
- ✓ **Reduction of nitrogen and phosphorus excreted by animals (feed),**
- ✓ **Mechanical separation,**
- ✓ **Addition of nitrification inhibitors,**
- ✓ **Slurry acidification,**
- ✓ **Plan of fertilization of the cultures (crop nutrient balance).**

Official journal of the Portuguese Republic “Diário da República”

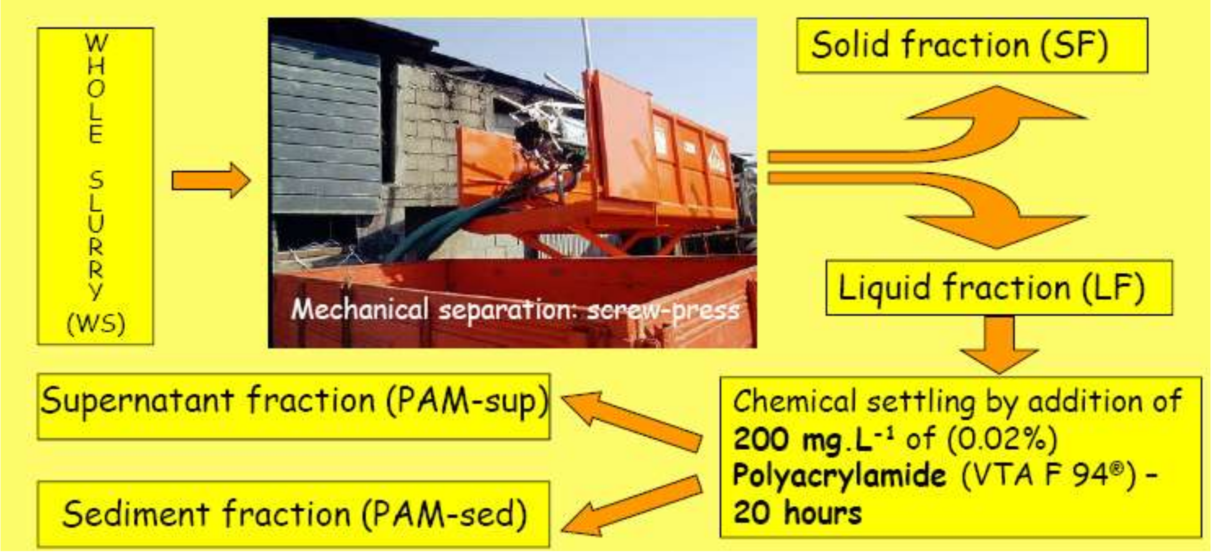
2. Options for animal manure management



USDA (2012) Part 651 Agricultural Waste Management Field Handbook

3. Case studies: solid-liquid separation of animal slurry

Animal slurry separation by mechanical and chemical methods

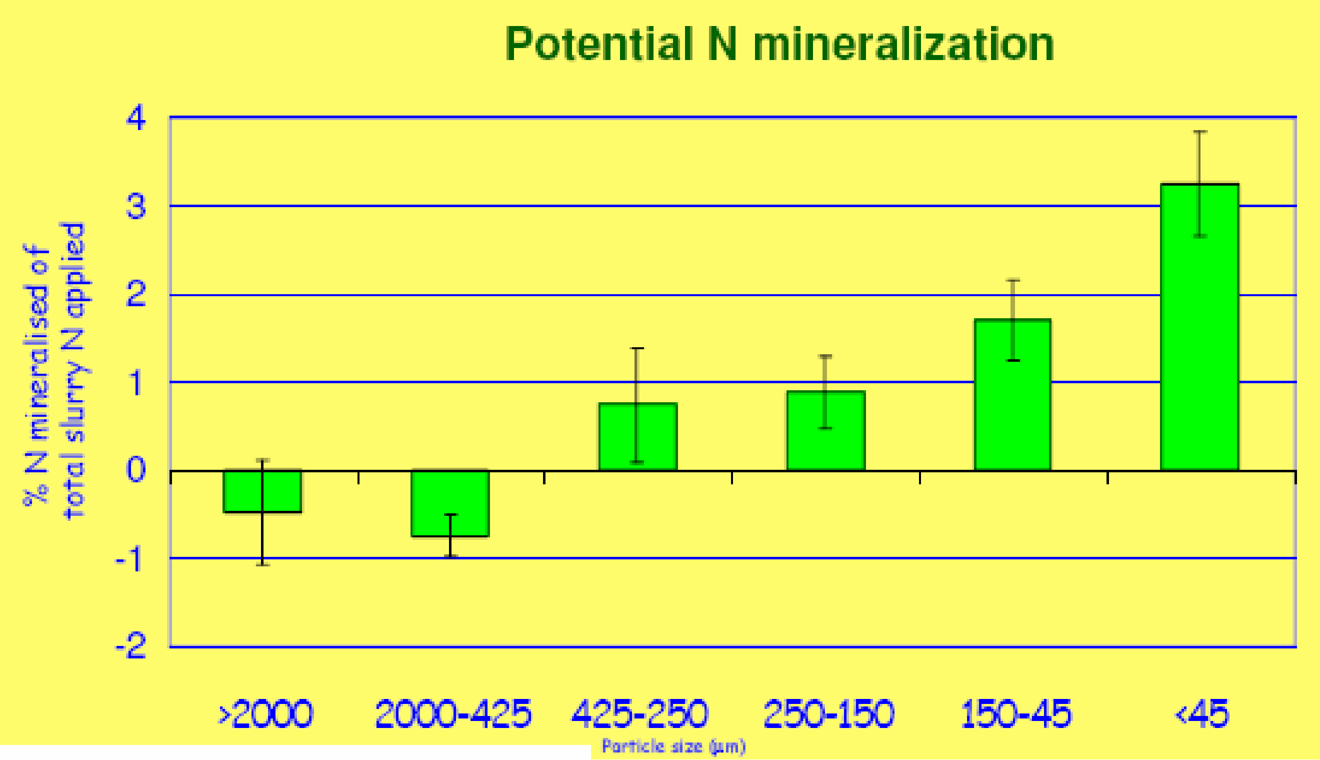


Parameters	Raw pig-slurry (mg L^{-1})*	Mechanical separation (%)	Mechanical + chemical separation (%)
Total Suspended Solids	12600	-15	-89
Biological Oxygen Demand	31300	-8	-65
Organic N	1280	-13	-80
Organic P	510	-11	-85
Yields		-20	-66

*Vanotti et al. (1999) J. Environ. Qual.; Fangueiro et al. (2008) Nutr. Cycl. Agroecosyst.

3. Case studies: solid-liquid separation of animal slurry

- *1 mm = 1000 µm*
- *20% of raw slurry*



Advantages of animal slurry separation:

- **N mineralization vs immobilization,**
- **C mineralization,**
- **Enzymatic activity,**
- **P fractionation,**
- **Ammonia and greenhouse gas emissions,**
- **Nitrate leaching,**
- **Crop yields,**
- **Nutrient uptake and composition.**

Pereira et al. (2010) Chemosphere; Fangueiro et al. (2010) Biosyst. Eng.; Fangueiro et al. (2014) Biol. Fertil. Soils

3. Case studies: nitrification inhibitors in animal slurry

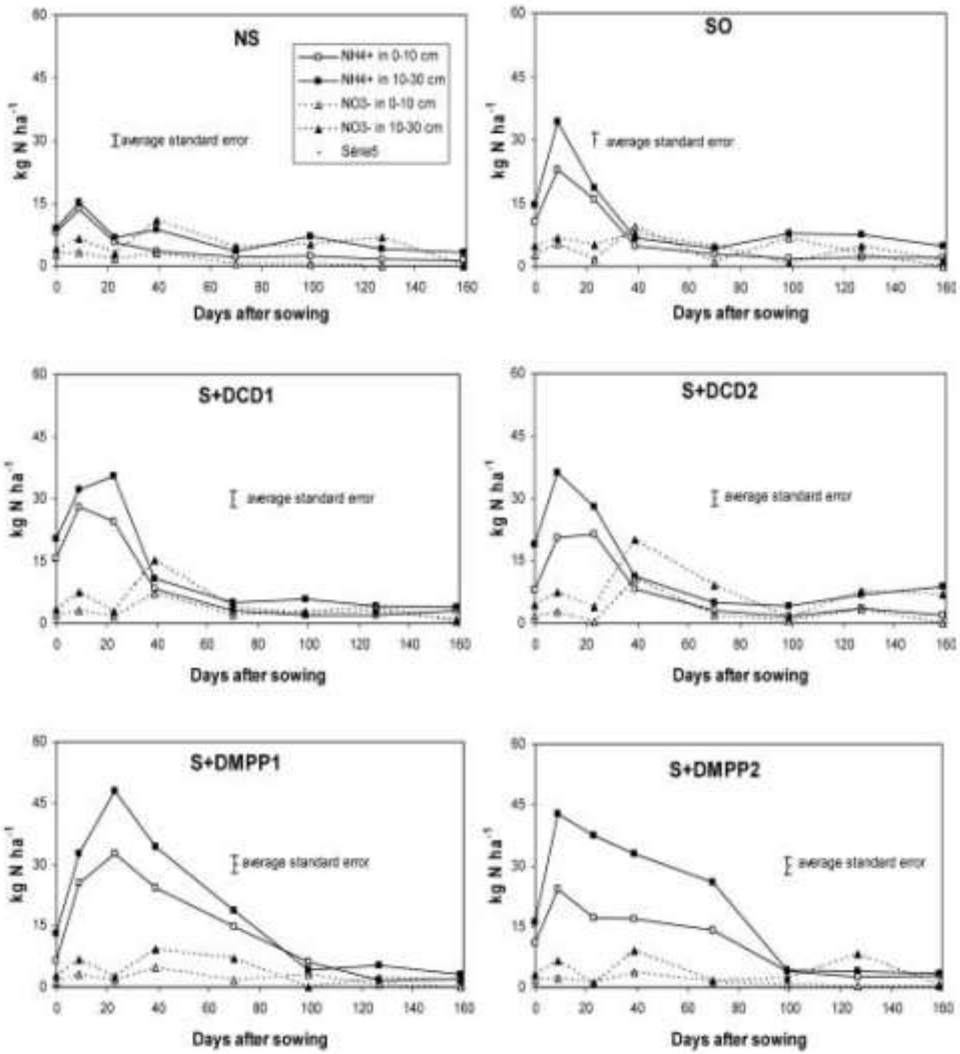


Figure 2. Time course of the amount of N-NH_4^+ and N-NO_3^- in the 0- to 10- and 10- to 30-cm soil layers observed on the different treatments studied; mean values of three replicates; standard error bars were removed for clarity.

Fangueiro et al. (2010) Commun. Soil Sci. Plant Anal.

Nitrification inhibitors:

- **Dicyandiamide (DCD),**
- **3,4-dimethyl pyrazole phosphate (DMPP).**

Nitrification inhibitor applied to raw cattle-slurry (autumn-winter seasons)

- **NS (no slurry), a control not fertilized;**
- **SO (slurry only), 50 m^3 of cattle-slurry ha^{-1};**
- **S + DCD1, 50 m^3 of cattle-slurry ha^{-1} + 10 kg DCD ha^{-1};**
- **S + DCD2, 50 m^3 of cattle-slurry ha^{-1} + 20 kg DCD ha^{-1};**
- **S + DMPP1, 50 m^3 of cattle-slurry ha^{-1} + 4 L of 25% DMPP solution ha^{-1};**
- **S + DMPP2, 50 m^3 of cattle-slurry ha^{-1} + 8 L of 25% DMPP solution ha^{-1}.**

3. Case studies: nitrification inhibitors in animal slurry

Table 2. Effect of treatments under study on forage DM yield and forage N removal (mean values of three replicates)

Treatment	DM yield ($kg\ ha^{-1}$)	Forage N removal ($kg\ ha^{-1}$)	Apparent N recovery (%)
NS	4059 [d]*	64 [c]	
SO	4767 [d]	66 [c]	2 [c]
S + DCD1	6272 [c]	98 [b]	34 [b]
S + DCD2	7444 [b]	118 [ab]	53 [ab]
S + DMPP1	7310 [b]	106 [b]	41 [b]
S + DMPP2	8698 [a]	138 [a]	72 [a]

*Data followed by the same letters do not differ at the $P < 0.05$ level, LSD test.

Advantages of nitrification inhibitors on slurry and mineral fertilisers:

- **Reduction of N_2O and NO emissions,**
- **Reduction of nitrate leaching,**
- **Increase of crop yield .**

*Fangueiro et al. (2010) Commun. Soil Sci. Plant Anal. ; Carneiro et al. (2012) Agric. Ecosyst. Environ.; Pereira et al. (2015) Span. J. Agric. Res.

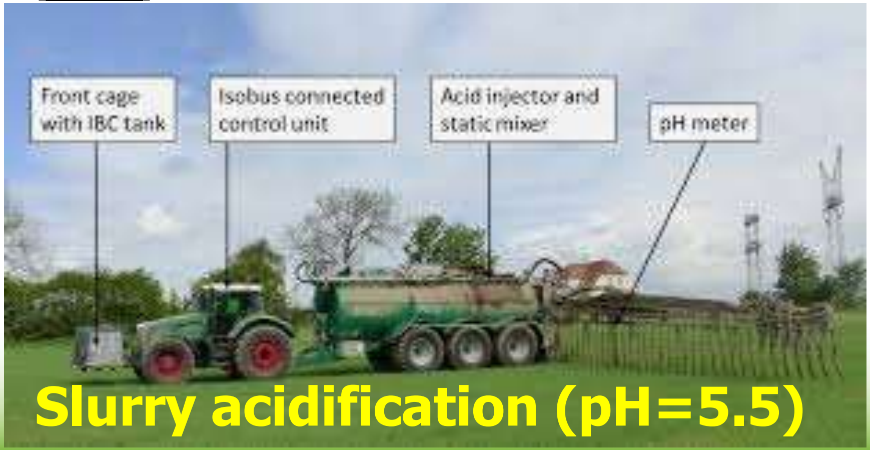
3. Case studies: acidification of animal slurry

Double-cropping system (3 years): oats (80 kg N ha^{-1}) x maize (170 kg N ha^{-1})

- **Non-amended soil (<u>Control</u>);**
- **Injection of raw cattle-slurry (100 mm depth) (<u>IS</u>);**
- **Band application of raw cattle-slurry followed by soil incorporation (20 mm depth) (<u>SS</u>);**
- **Band application of acidified (pH=5.5) cattle-slurry followed by soil incorporation (20 mm depth) (<u>AS</u>);**
- **Band application of acidified (pH=5.5) cattle-slurry without soil incorporation (<u>ASS</u>).**


Slurry injection (>50 mm)


Band application of slurry



Slurry acidification (pH=5.5)

Fangueiro et al. (2018) Agric. Ecosyst. Environ.

3. Case studies: acidification of animal slurry

Effects of slurry application techniques on nitrate leaching

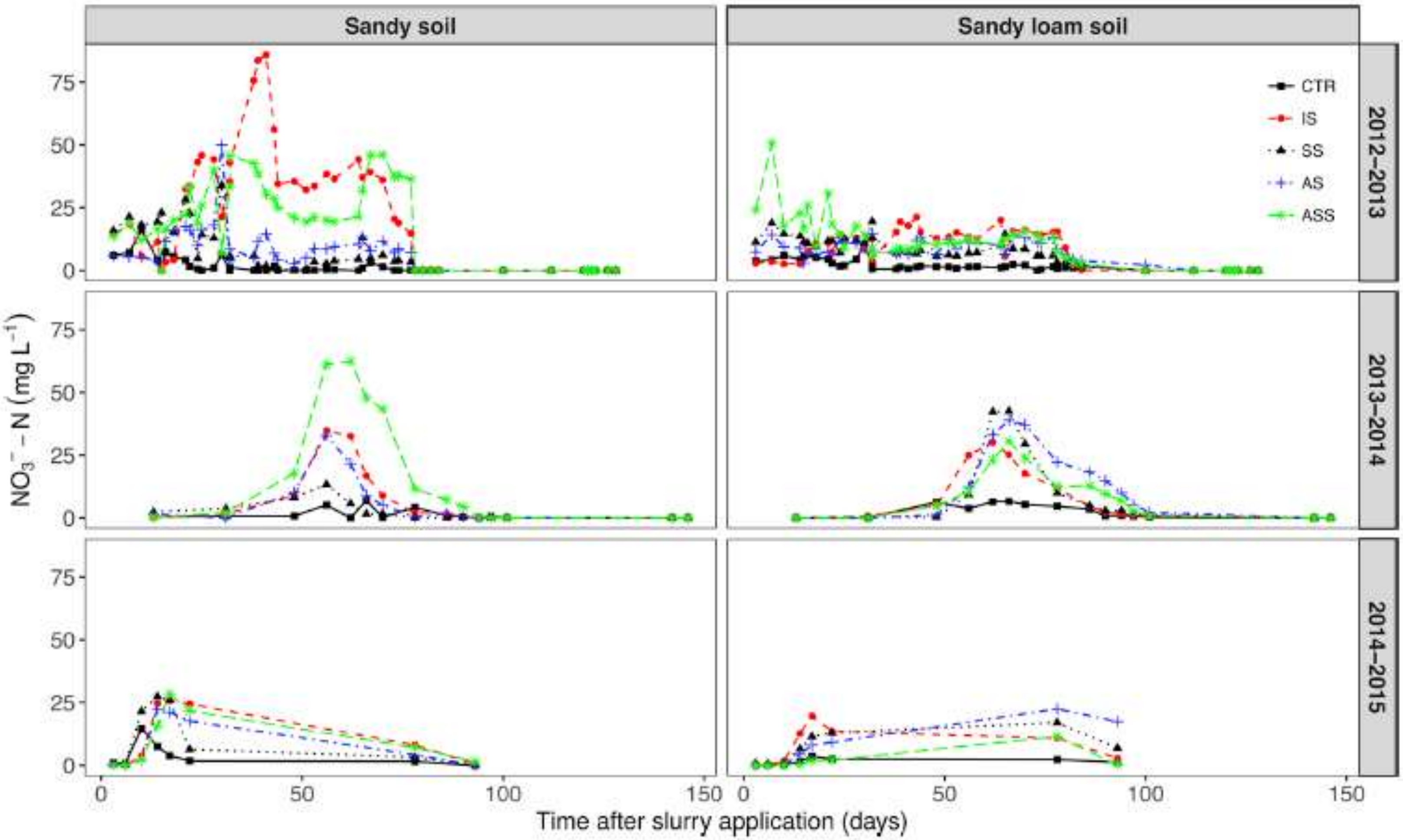


Fig. 3. Dynamics of the average NO3–N concentration in the soil solution collected at the depth of 70 cm in both soil types and for the five studied treatments (see text for description).

Cameira et al. (2019) Soil Till. Res.

3. Case studies: acidification of animal slurry

Comparison of soil slurry application techniques

Parameters	Injection (>50 mm)	Incorporation (20 mm)	Acidification (pH=5.5)
NH_3 emission	+	++	+
N_2O emission	++	+	+
CH_4 emission	++	+	+
Nitrification	++	++	+
Nitrate leaching	+++	++	+
E. Coli leaching	+	+	++
N and P crop uptake	++	+	+++
S crop uptake	+	+	++

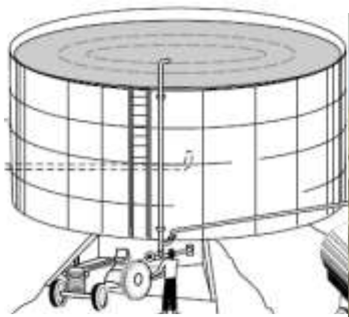
Fangueiro et al. (2018) Agric. Ecosyst. Environ.; Cameira et al. (2019) Soil Till. Res.; Fangueiro et al. (2016) Geoderma

3. Concluding remarks: animal manure management

Field-studies:

- Double-sloped solid floors with central gutter?
- Grooved floors?
- Solid systems?
- More manure and less slurry?

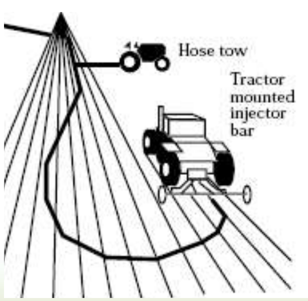
Housing



Field-studies:

- Urine storage?
- Faeces storage?
- Additives (biochar)?
- Valorisation (struvite, zeolite)?
- Composting?
- Anaerobic digestion?

Storage



Field-studies:

- Untreated urine?
- Treated urine (additives, acidification)?
- Untreated faeces?
- Treated faeces (e.g. composting)?

Soil application

Pereira and Trindade (2014) Eng. Agríc.; Pereira et al. (2013) Biosyst. Eng.

3. Concluding remarks: animal manure management

Thank you!

www.regeneralimia.org

info@regeneralimia.org
Tel. 988 242 402
C/ Curros Enríquez, nº 4 - 2º
32003 OURENSE

GOBIERNO DE ESPAÑA | MINISTERIO AGRICULTURA, ALIMENTACIÓN Y MEDIOAMBIENTE | CONFEDERACIÓN HIDROGRÁFICA DEL MIÑO-SIL

Life