III JORNADA GANADERÍA Y MEDIO AMBIENTE

Ganadería y gases de efecto invernadero

20 de octubre de 2016

Salón de actos del Ministerio de Agricultura, Alimentación y Medio Ambiente

Pza. San Juan de la Cruz, s/n. Madrid

GOBIERNO DE ESPAÑA

MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE

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TECNICAS DE MITIGACION DE GEI EN GANADERIA (II)

Actuaciones en instalaciones ganaderas y almacenamiento de las deyecciones

Pilar Merino Pereda, Investigadora. NEIKER-Tecnalia

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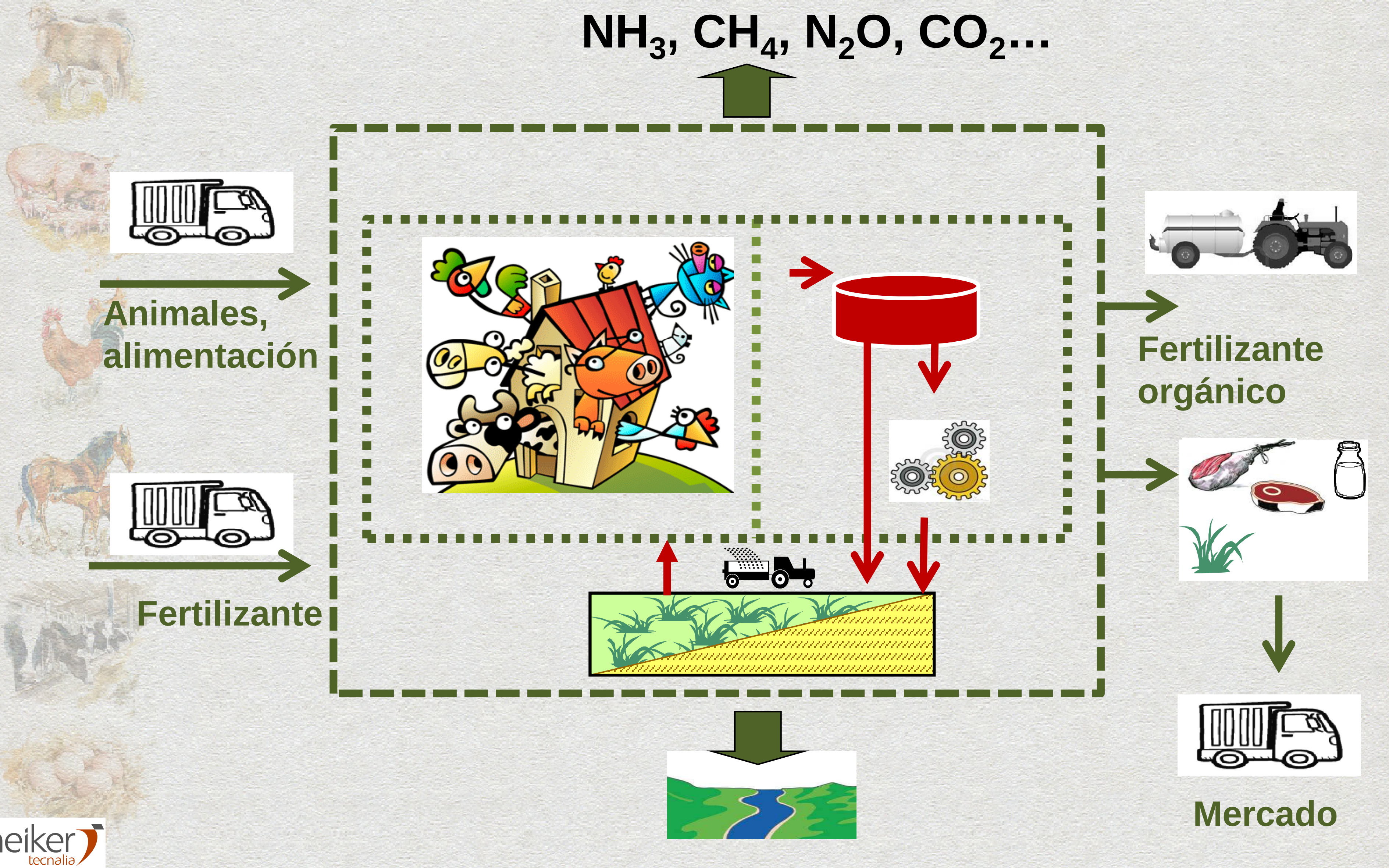
1. Consideraciones generales

2. Actuaciones en alojamiento

3. Actuaciones en almacenamiento

4. Conclusiones



neiker tecnalia

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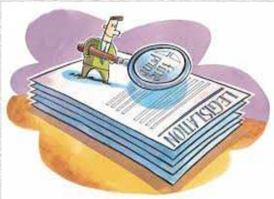


↓ NH_3

↓ GEI

94% Agricultura

64% NH_3 Ganadería

31-55% Alojamiento y Almacenamiento

nature climate change

REVIEW ARTICLE

PUBLISHED ONLINE: 21 MARCH 2016 | DOI: 10.1038/NCLIMATE2925

Greenhouse gas mitigation potentials in the livestock sector

Mario Herrero[1*], Benjamin Henderson[1], Petr Havlík[2], Philip K. Thornton[1,3], Richard T. Conant[4], Pete Smith[5], Stefan Wirsenius[1,6], Alexander N. Hristov[7], Pierre Gerber[8,9], Margaret Gill[5], Klaus Butterbach-Bahl[10,11], Hugo Valin[2], Tara Garnett[12] and Elke Stehfest[13]

The livestock sector supports about 1.3 billion producers and retailers, and contributes 40–50% of agricultural GDP. We estimated that between 1995 and 2005, the livestock sector was responsible for greenhouse gas emissions of 5.6–7.5 $GtCO_2e\ yr^{-1}$. Livestock accounts for up to half of the technical mitigation potential of the agriculture, forestry and land-use sectors, through management options that sustainably intensify livestock production, promote carbon sequestration in rangelands and reduce emissions from manures, and through reductions in the demand for livestock products. The economic potential of these management alternatives is less than 10% of what is technically possible because of adoption constraints, costs and numerous trade-offs. The mitigation potential of reductions in livestock product consumption is large, but their economic potential is unknown at present. More research and investment are needed to increase the affordability and adoption of mitigation practices, to moderate consumption of livestock products where appropriate, and to avoid negative impacts on livelihoods, economic activities and the environment.

The livestock sector is large. Twenty billion animals make use of 30% of the terrestrial land area for grazing, one-third of global cropland area is devoted to producing animal feed[1] and 32% of

Here we review the mitigation potential of a number of field-tested management options for mitigating GHG emissions in livestock production. Our Review incorporates new supply-side information,

Herrero et al., 2016

NATURE CLIMATE CHANGE DOI: 10.1038/NCLIMATE2925 REVIEW ARTICLE

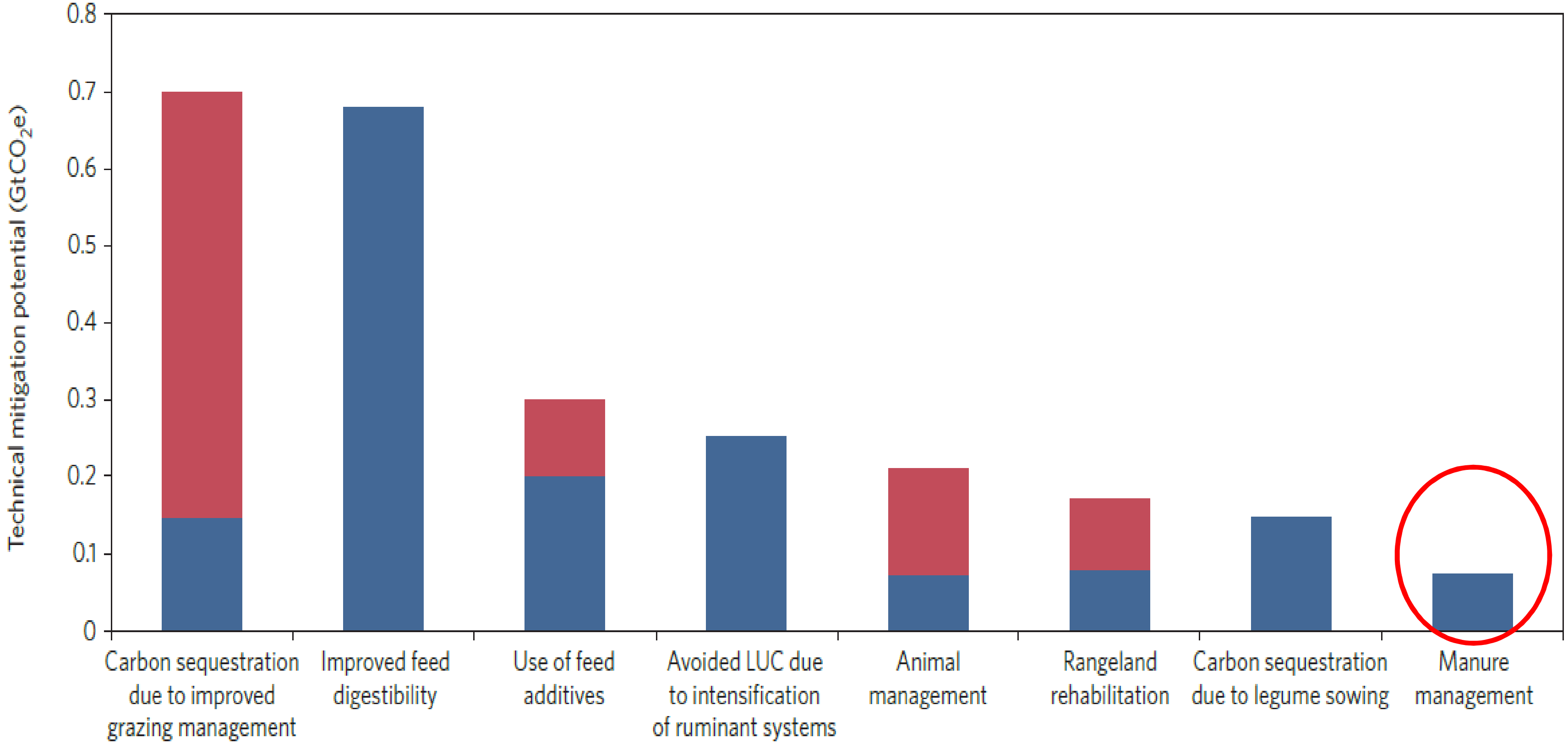
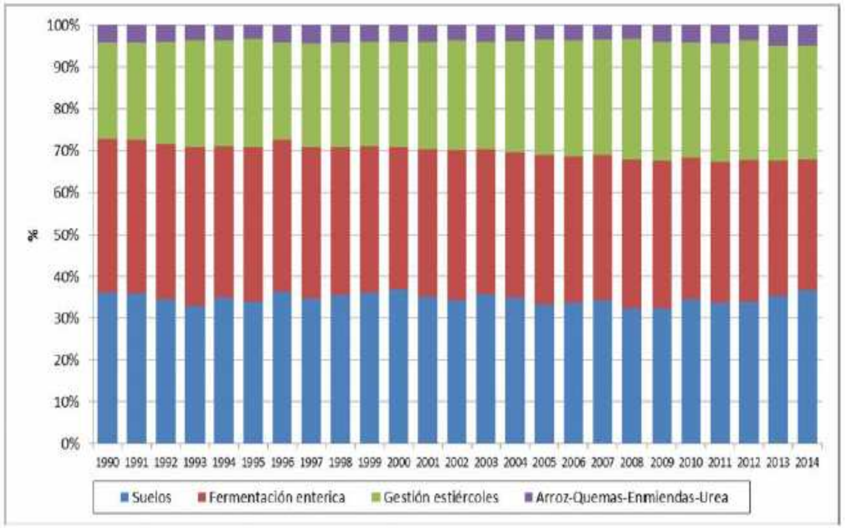


Figure 3 | Technical mitigation potentials of supply-side options for reducing emissions from the livestock sector. Red represents the range for each

Herrero et al., 2016

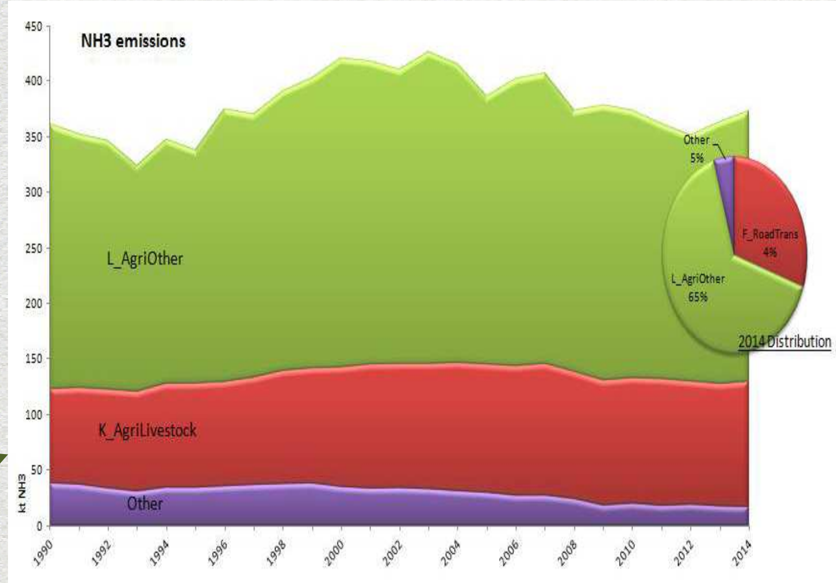
GEI

Figura 5.1.3.- Contribución porcentual de las emisiones de CO_2-eq, por categoría, respecto al total del sector de Agricultura (CRF 3)



Inventario nacional gases invernadero España 1990-2014 (Edición 2016)

NH3



Spain. Informative Inventory Report 1990-2014 (Edición 2016)

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TABLE A2
Manure handling strategies offering non-CO_2 greenhouse gas mitigation opportunities

Category	Species[1]	Potential CH_4 mitigating effect[2]	Potential N_2O mitigating effect[2]	Potential NH_3 mitigating effect[2]	Effective[3]	Recommended[4]	Applicability to region[6]
Dietary manipulation and nutrient balance							
Reduced dietary protein	AS	?[5]	Medium	High	Yes (N_2O, NH_3)	Yes (N_2O, NH_3)	All
High fibre diets	SW	Low	High	?	Yes (N_2O)	Yes (N_2O)	All
Grazing management							
Grazing intensity[7]	AR	?	High?[7]	?[7]	Yes (N_2O)	Yes (N_2O)	All
Housing							
Biofiltration	AS	Low?	?	High	Yes (NH_3, CH_4?)	Yes (NH_3, CH_4?)	All
Manure system[8]	DC, BC, SW	High	?	High	Yes (CH_4, NH_3)	Yes (CH_4, NH_3)	All
Manure treatment							
Anaerobic digestion	DC, BC, SW	High	High[9]	Increase?[10]	Yes (CH_4, N_2O)	Yes (CH_4, N_2O)	All
Solids separation	DC, BC	High	Low?[9]	?[11]	Yes (CH_4)	Yes (CH_4)	NA, SA, EU, OC
Aeration	DC, BC	High	Increase?[12]	?[12]	Yes (CH_4)	Yes (CH_4)	NA, SA, EU
Manure acidification	DC, BC, SW	High	?[13]	High[13]	Yes (CH_4, NH_3)	Yes (CH_4, NH_3)	NA, EU, OC
Manure storage							
Decreased storage time	DC, BC, SW	High[14]	High[14]	High[14]	Yes (all)	Yes (all)	All
Storage cover with straw	DC, BC, SW	High	Increase?[15]	High	Yes (CH_4, NH_3)	Yes (CH_4)	NA, EU
Natural or induced crust	DC, BC	High	Increase?[15]	High	Yes (CH_4, NH_3)	Yes (CH_4)	NA, EU
Aeration during liquid manure storage	DC, BC, SW	Medium to High	Increase?[12]	?[12]	Yes (CH_4)	Yes (CH_4)	NA, EU
Composting	DC, BC, SW	High	?[13]	Increase[12]	Yes (CH_4)	Yes (CH_4)	All
Litter stacking	PO	Medium	N/A	?	Yes (CH_4)	Yes (CH_4)	All
Storage temperature	DC, BC	High	?	High	Yes (CH_4, NH_3)	Yes (CH_4, NH_3)	N/A[16]
Manure application							
Manure injection vs surface application	DC, BC, SW	No effect to increase?	No effect to increase[18]	High	Yes (NH_3)	Yes (NH_3)	NA, EU, OC
Timing of application	AS	Low	High[19]	High	Yes (N_2O, NH_3)	Yes (N_2O, NH_3)	All
Soil cover, cover cropping	AS	?	No effect to High[20]	Increase?[14]	Yes (N_2O?)	Yes (N_2O?)	All
Soil nutrient balance	AS	N/A	High	High	Yes (N_2O, NH_3)	Yes (N_2O, NH_3)	All
Nitrification inhibitor[21]							
Applied to manure or after urine deposition in pastures	DC, BC, SH	N/A	High	N/A	Yes (N_2O)	Yes (N_2O)?	All[22]

(Cont.)

FAO, 2013

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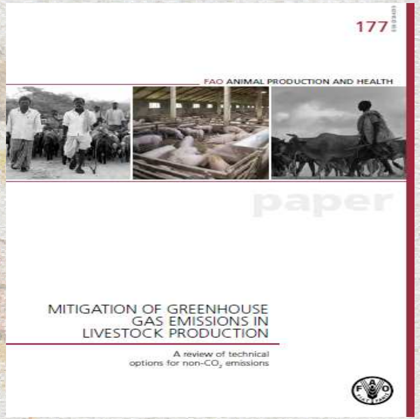
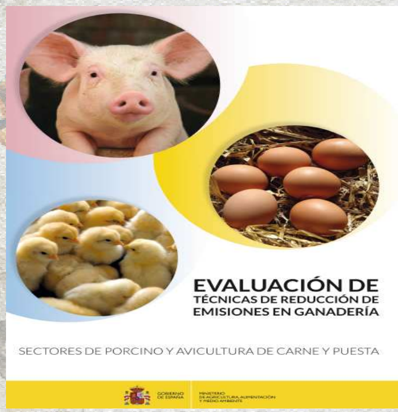
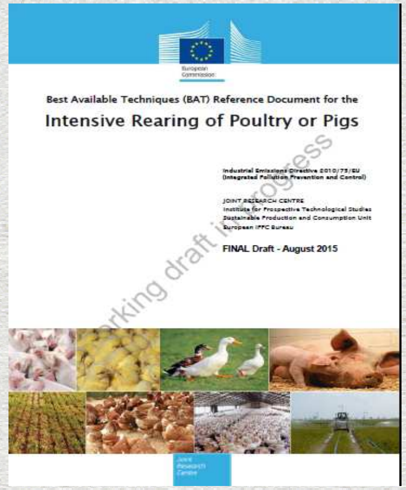


FAO, 2013

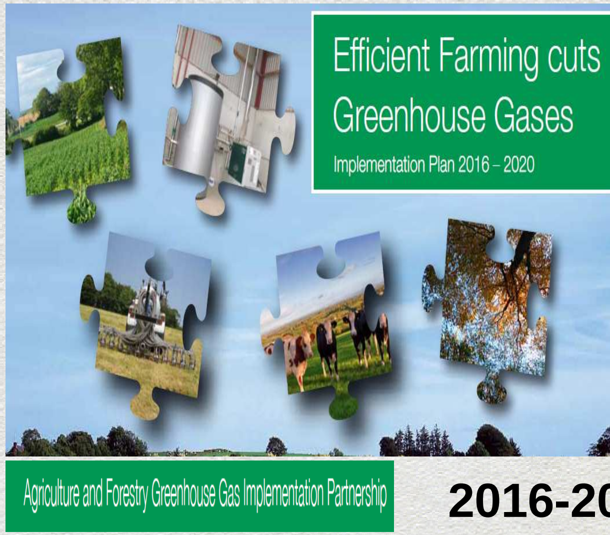
GRA, 2014



MAGRAMA, 2014



IRPP, 2015

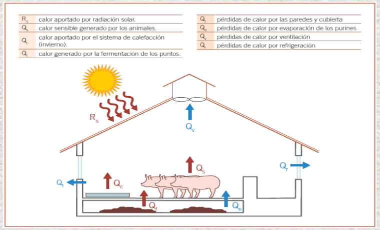


2016-2020

Categoría animal
Intensivo?
Extensivo?
Semiintensivo?

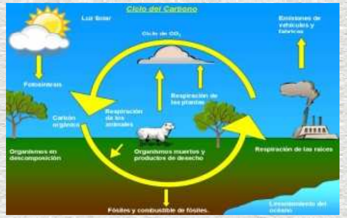
Tipo de sistema

Estrategia

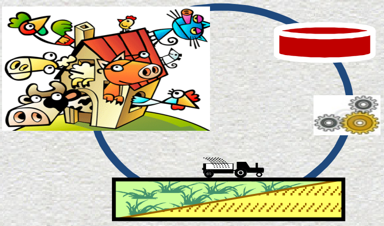


Instalaciones

Manejo ganadero



Condiciones edafoclimáticas



Combinación de estrategias

Entorno geográfico y social

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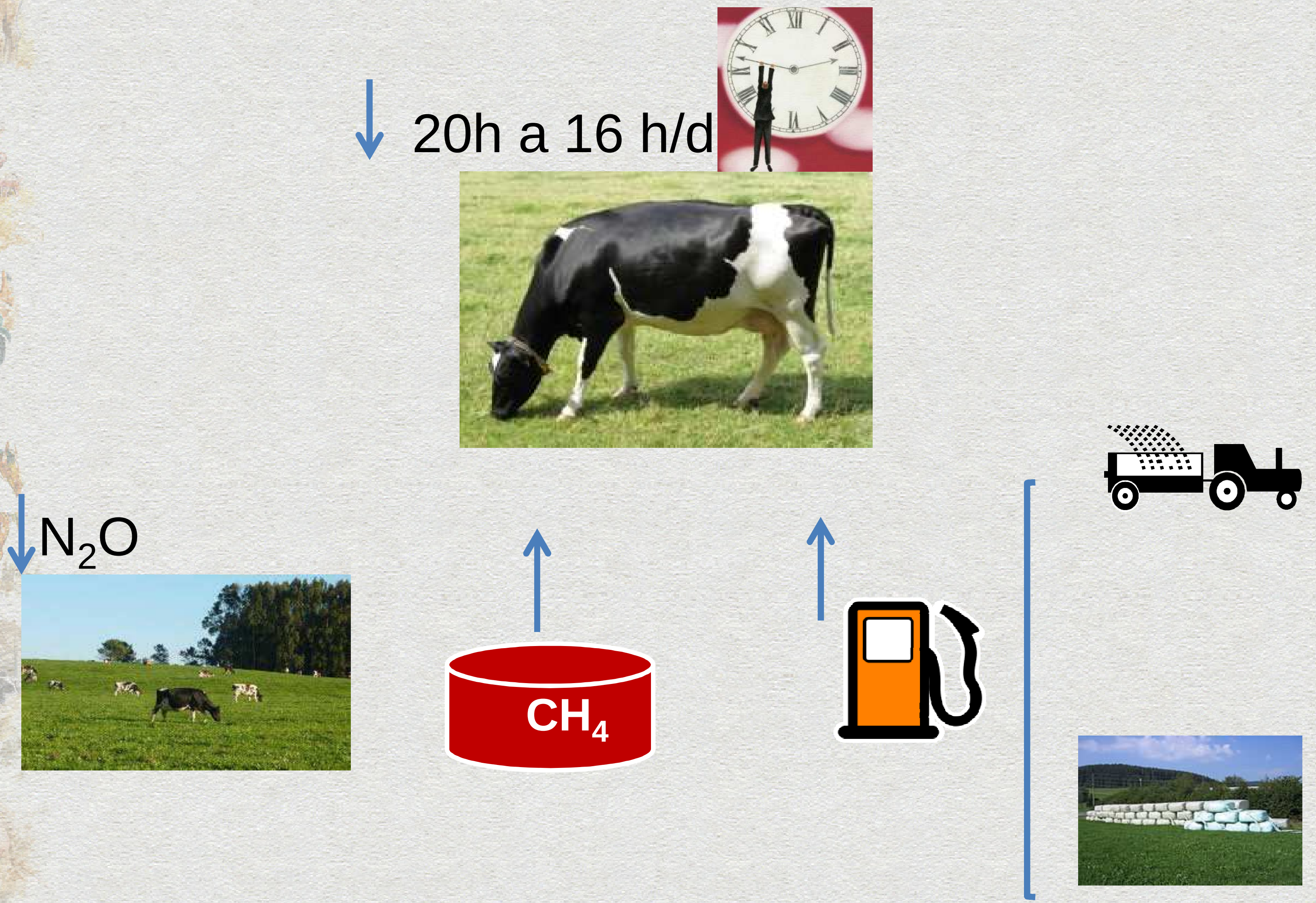
Table 4.7 Qualitative assessment of factors that affect the implementation of EU policies to decrease N_r emissions: NO_x emissions from combustion, NH_3 emissions and NO_3 leaching from agriculture, and N_{tot} discharges from urban wastes

	Combustion	Agriculture		Urban wastes
Factors	**NO_x to air**	**NH_3 to air**	**NO_3 to waters**	**N_{tot} to waters**
Policy instruments	Mixed	Regulation	Regulation	Mixed
Number of stakeholders	Few	Many	Many	Few
Technology level	Advanced	Modest	Modest	High
Level of standardization in production	High	Low	Low	High
Number of techniques involved	Few	Many	Many	Few
Development costs	High	High	High	High
Implementation costs	Modest	Modest for animal feeding and manure application; high for animal housings and manure storages	Low for optimizing fertilizer applications; high for adjusting farming systems	High
Who bears costs?	Manufacturers, but transferred effectively to consumers	Farmer	Farmer + public sector (RDP)	Water companies, but effectively transferred to consumers
Management activities & knowledge involved	Essentially no activities required by car drivers	Many activities, requires both proper techniques and information and knowledge	Many activities, requires information and knowledge	Many activities, requires both proper techniques and information and knowledge
Influence of climate & soil conditions	Absent	Large	Large	Negligible
Potential side-effects (apart from costs)	Increased N_2O and NH_3 emissions	Increased N_2O emissions and energy use; fertilizer savings	Yield loss; fertilizer saving; increased / decreased NH_3 emissions	Increased N_2O emissions and energy use

Oenema et al 2011 (ENA)


20h a 16 h/d
N_2O
CH_4

INTERACTIONS AMONG FEEDING PRACTICES, MANURE STORAGE AND LAND APPLICATION

TABLE A5 *(Cont.)*

Examples of interactions among non-CO_2 greenhouse gas mitigation practices[1]

Mitigation practice	Potential interactions	Production system to which interaction may be applicable
Anaerobic digestion	Can increase NH_3 emission during manure storage and application of manure liquor.	RC, MI, MM, MB
Grazing management (intensity, stand-off pads)	Grazing intensity – same effects as for enteric CH_4. Stand-off pads: main effect on reducing N_2O emission from urine patches, but can also increase CH_4 in manure deposited in anaerobic conditions. May reduce fertilizer use.	RM, RG
Decreased manure storage time	Directly reduces all gaseous emissions from manure storage. Possible increase in N_2O emissions when manure is applied to soil. Shorter storage time means more frequent soil application: may have both positive and negative effects on GHG emissions from soil, depending on season.	RC, RM, MI, MM, MB
Natural or induced manure crust	Direct reduction of CH_4 emission. Also reduces NH_3 emissions, but may increase N_2O emissions.	RC, RM, MI, MM
Composting	Reduces CH_4 and perhaps N_2O emissions, but increases NH_3 emissions and total manure N losses. Overall GHG emission reduction effect.	
Acidification and decreasing manure temperature (storing outside in cold climate zones)	Will generally reduce NH_3 and CH_4 emissions; interaction effects weak or not well understood.	RC, RM, MI, MM
Sealed storage with flare	Effectively mitigates CH_4 emissions, but may increase NH_3 emission during storage and soil application of manure liquor.	RC, MI, MM, MB
Subsurface manure incorporation	Main effect is to decrease N_2O emissions; it may also decrease NH_3 losses, thus reducing the need for N fertilizer. May create localized anaerobic conditions and thus result in increased CH_4 emissions.	RC, RM, MI, MM, MB
Soil cover, cover cropping	Main effect is to enhance uptake of nitrates by plants resulting in lower N_2O emissions, but results have been inconsistent; could lead to higher overall N_2O loss in high rainfall systems and there are significant interactions with other soil conservation practices (no-tillage, for example).	RC, RM, MI, MM, MB
Nitrification inhibitors	Can increase NH_3 emissions, depending on manure storage. Can increase forage and pasture production (or displace N fertilizer).	RC, RM, RG, MI, MM, MB
Urease inhibitors	Reduce NH_3 losses, but can increase N_2O emissions.	RC, MI

[1] This table is constructed on the basis of discussions about mitigation practices among FAO experts and the authors of this document.
[2] Animal production system: RC – ruminants, confined; RM – ruminants, mixed; RG – ruminants, grazing; MI – monogastrics, industrial (large scale, all concentrate feed, commercial); MM – monogastrics, intermediate (medium scale, feeding is with concentrate and by-products, commercial); MB – backyard (mostly fed on swill and browsing, not commercial).

FAO, 2013

Dieta y emisiones de NH_3 y N_2O

Concentration	LP	MP	HP
NH_3, mg m^{-3}	7.1^{a}	10.4^{b}	10.8^{b}
N_2O, mg m^{-3}	1.21^{a}	1.08^{a}	1.11^{a}

Effect of diet manipulation in dairy cow N balance and nitrogen oxides emissions from grasslands in northern Spain

H. Arriaga [a,*], G. Salcedo [b], S. Calsamiglia [c], P. Merino [a]

Agriculture, Ecosystems and Environment 123 (2008) 88–94

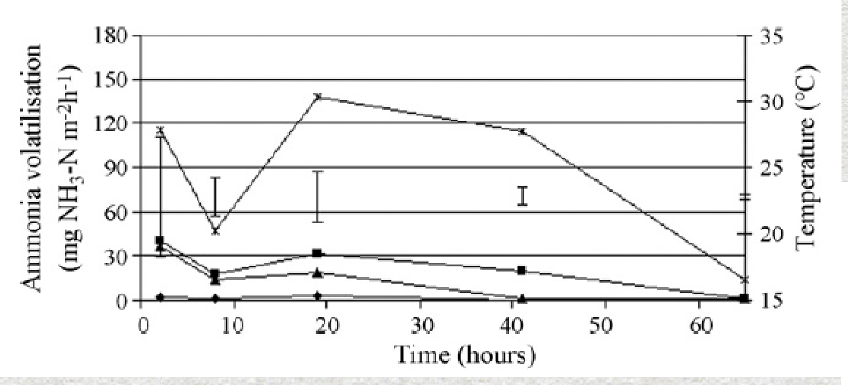
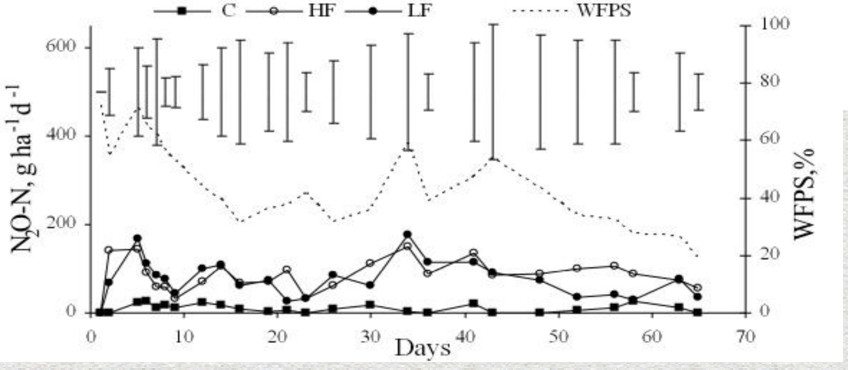


Table 3
N excretion in milk, urine and faeces

	Diet A	Diet B
Urine (total N) (g d^{-1})	128.5b	153.5a
Faeces (total N) (g d^{-1})	144.8b	162.8a
Urine urea-N, (g d^{-1})	91.2a	104.9a
MUN (mg of N d l^{-1})	7.7a	8.2a
[a]MP from bact (g d^{-1})	962b	1207a
Milk N (g d^{-1})	87.6b	103a
Milk (l d^{-1})	17.7b	20.8a



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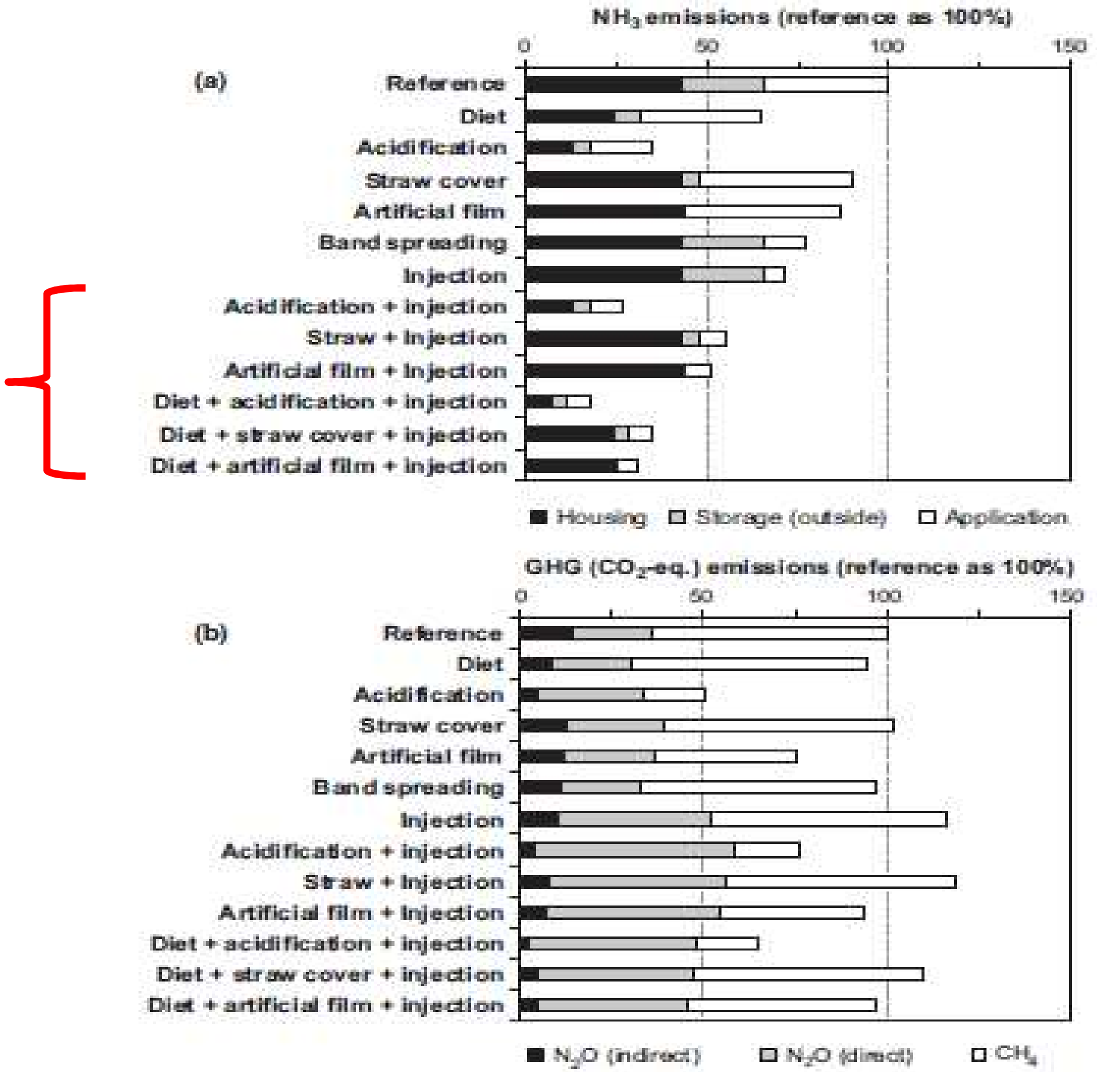

Fig. 4 Impacts of mitigation measures on NH_3 (a) and GHG (b) emissions from slurry-based systems, expressed as percentage of the reference system. See Table 2 for description of scenarios.

Hou et al., 2015

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2. ALOJAMIENTO GANADERO. MITIGACION NH_3

1. **Limpieza frecuente**, reducción área deposiciones
2. Reducir velocidad aire y temperatura
3. Reducir pH y temperatura
4. **Secado**
5. Lavado del aire de salida
6. Aumentar tiempo en pastoreo

Bittman, S., Dedina, M., Howard C.M., Oenema, O., Sutton, M.A., (eds), 2014, *Options for Ammonia Mitigation: Guidance from the UNECE Task Force on Reactive Nitrogen*, Centre for Ecology and Hydrology, Edinburgh, UK

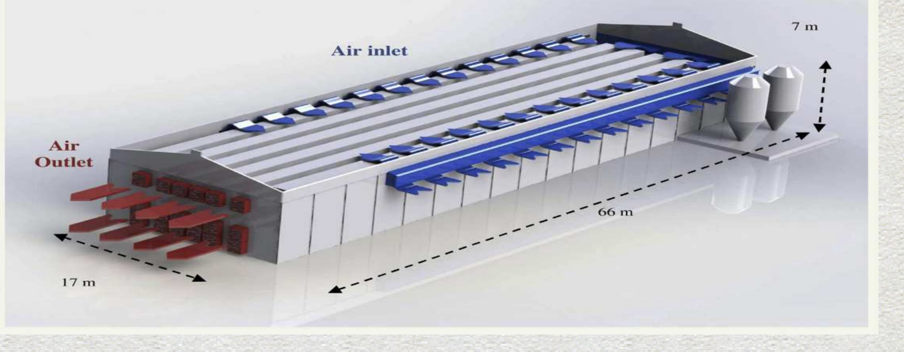
Emisiones de NH_3 y GEI en un alojamiento avícola de puesta

Alberdi O, Arriaga H, Calvet S, Estelles F, Merino P

Bios ystems Engineering144 (2016) 1-12

- •Granja comercial
- •250.000 gallinas
- •Alimentación por fases

- •Nave monitorizada
- •52.000 gallinas
- •Recogida de deyecciones en cintas



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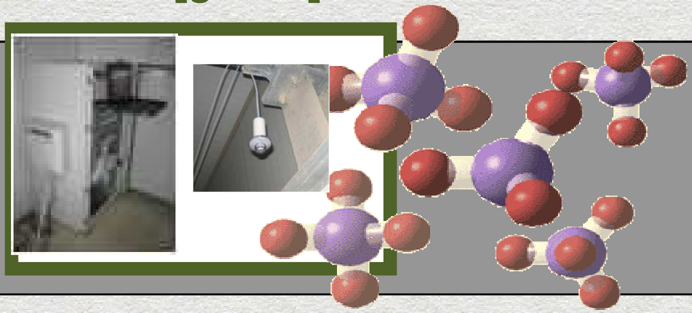
ALOJAMIENTO

1.Medidas [gases]



2.Registro de la ventilación

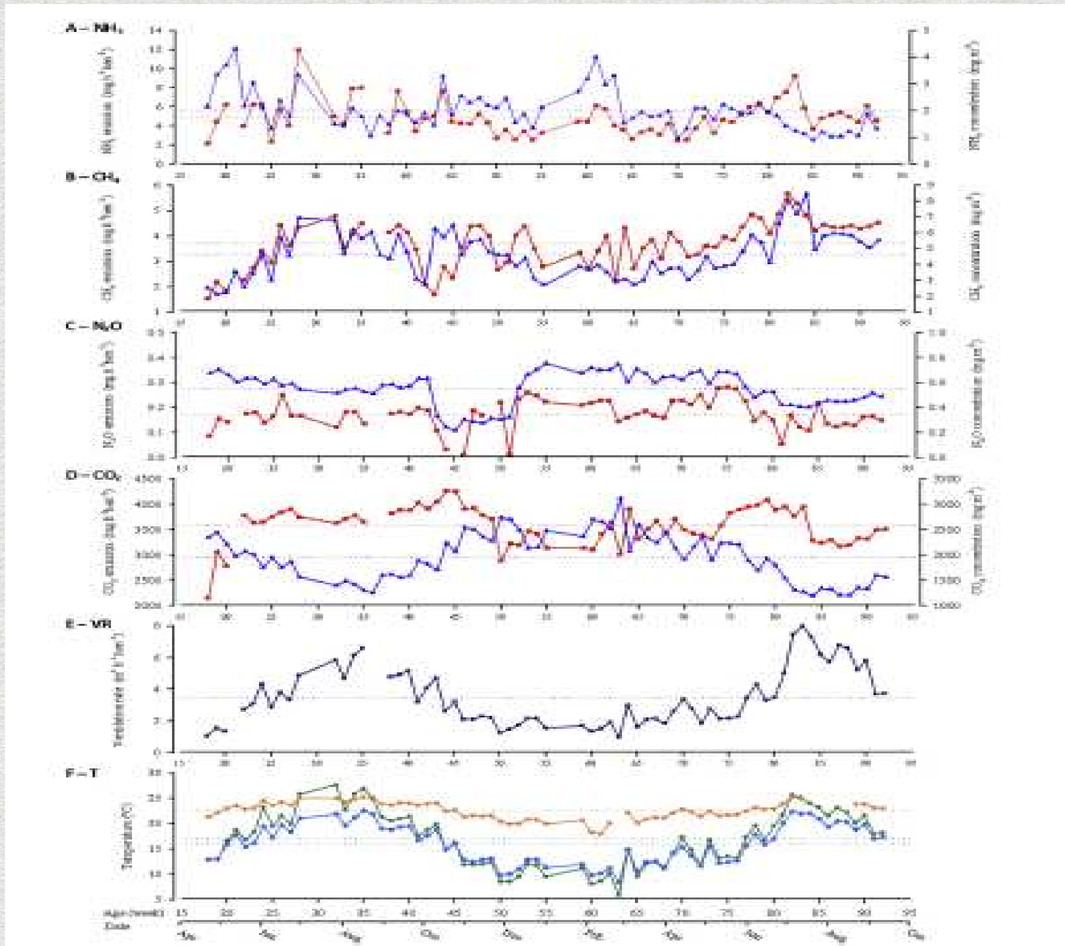
3. Registro Tª y humedad

4. Registro de presión diferencial

5.Análisis excretas

6. Registro de manejo y producción

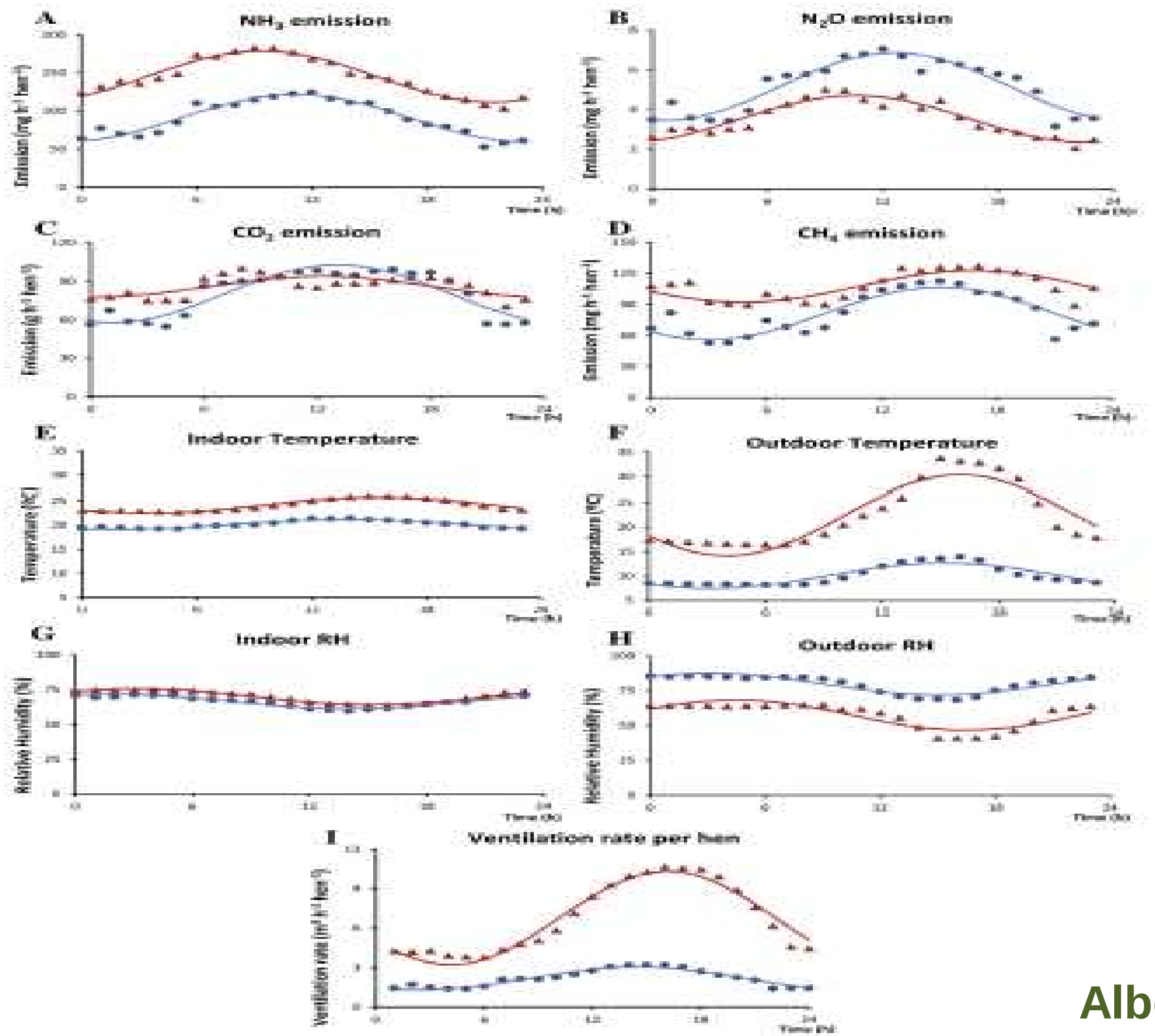
Patrón diario de emisiones a lo largo del ciclo



Tª, dias acumulación, ventilación

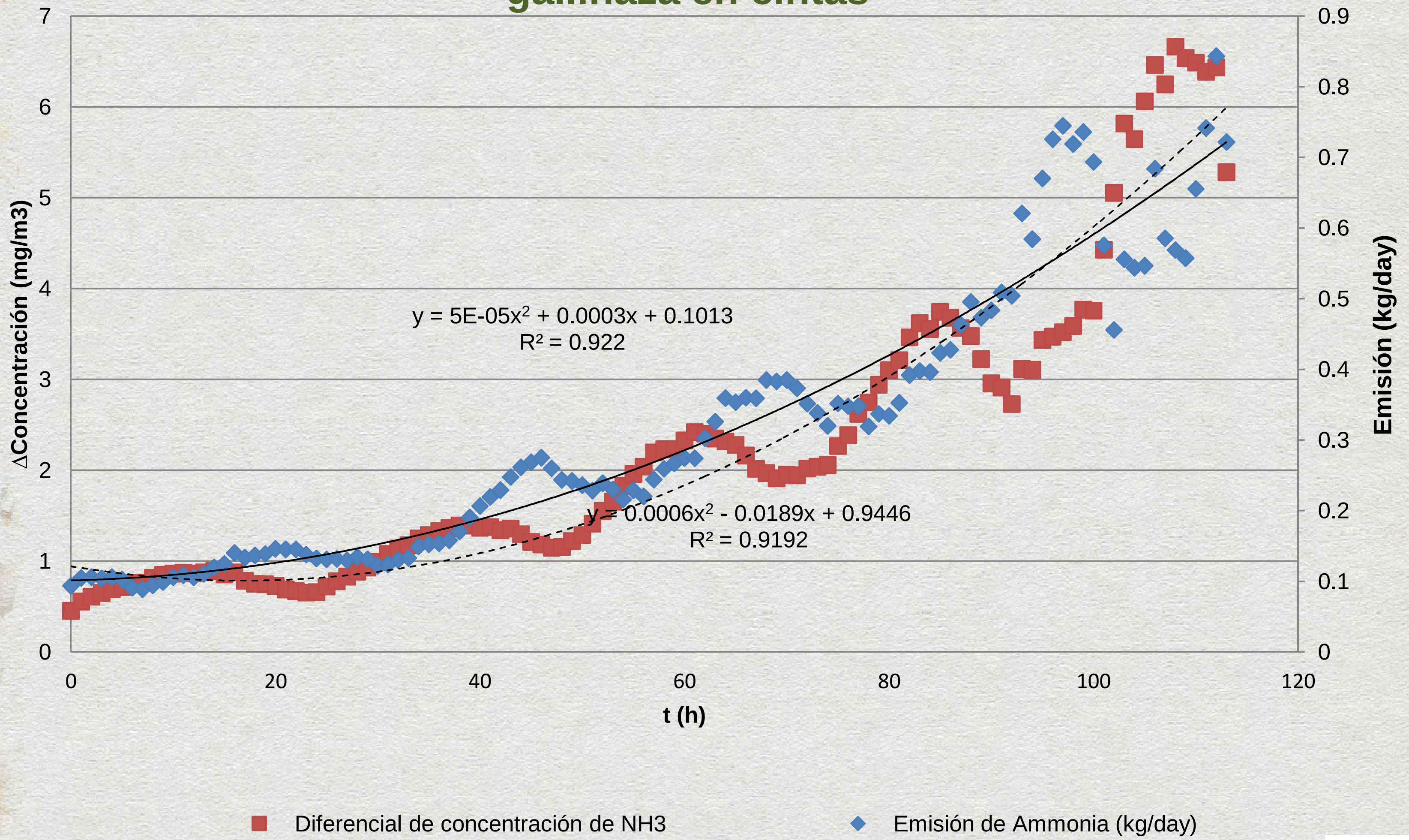
Alberdi et al 2016

Patrón diario de emisiones en verano e invierno



Alberdi et al 2016

Evolución del NH_3 respecto a tiempo acumulación gallinaza en cintas



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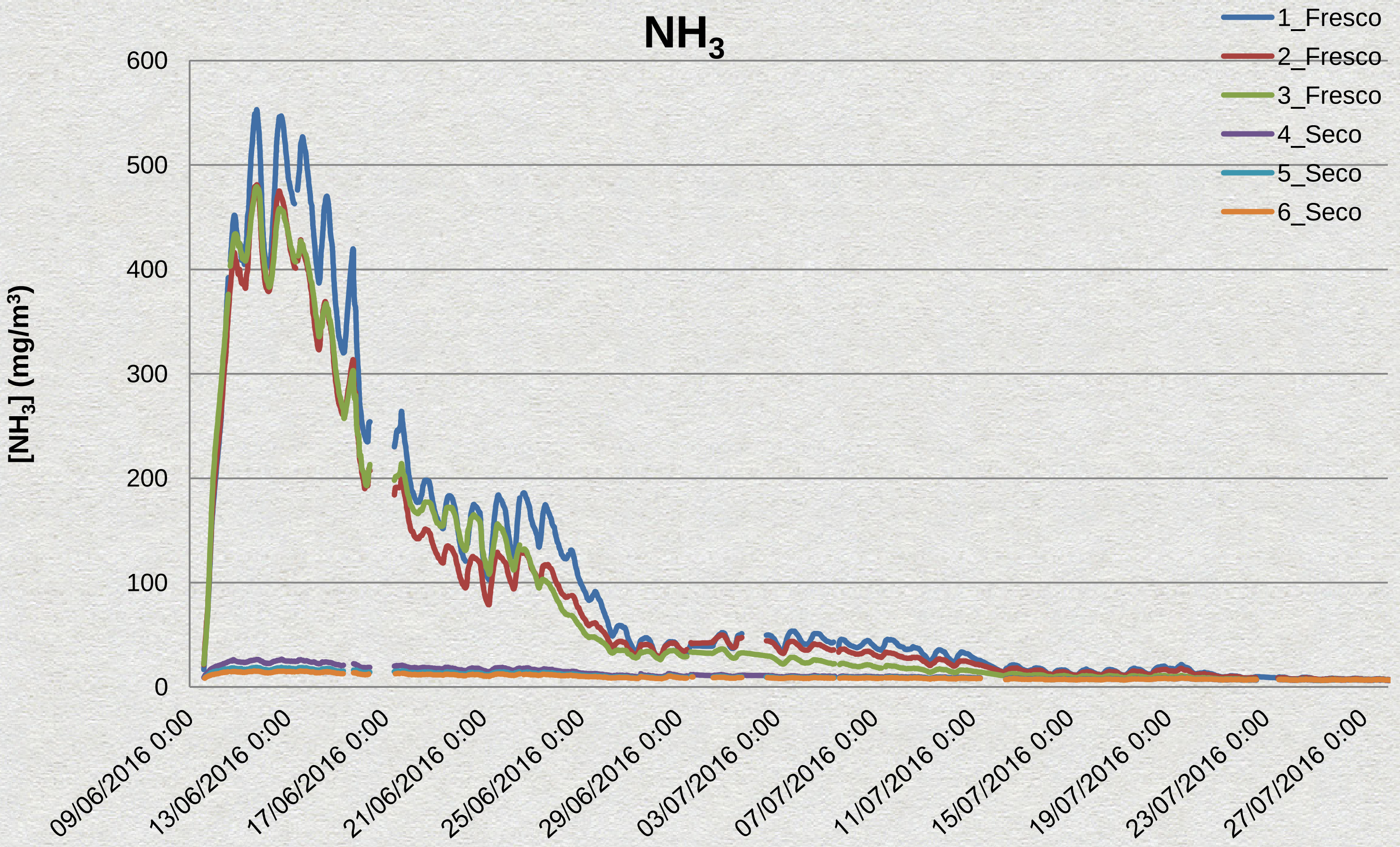
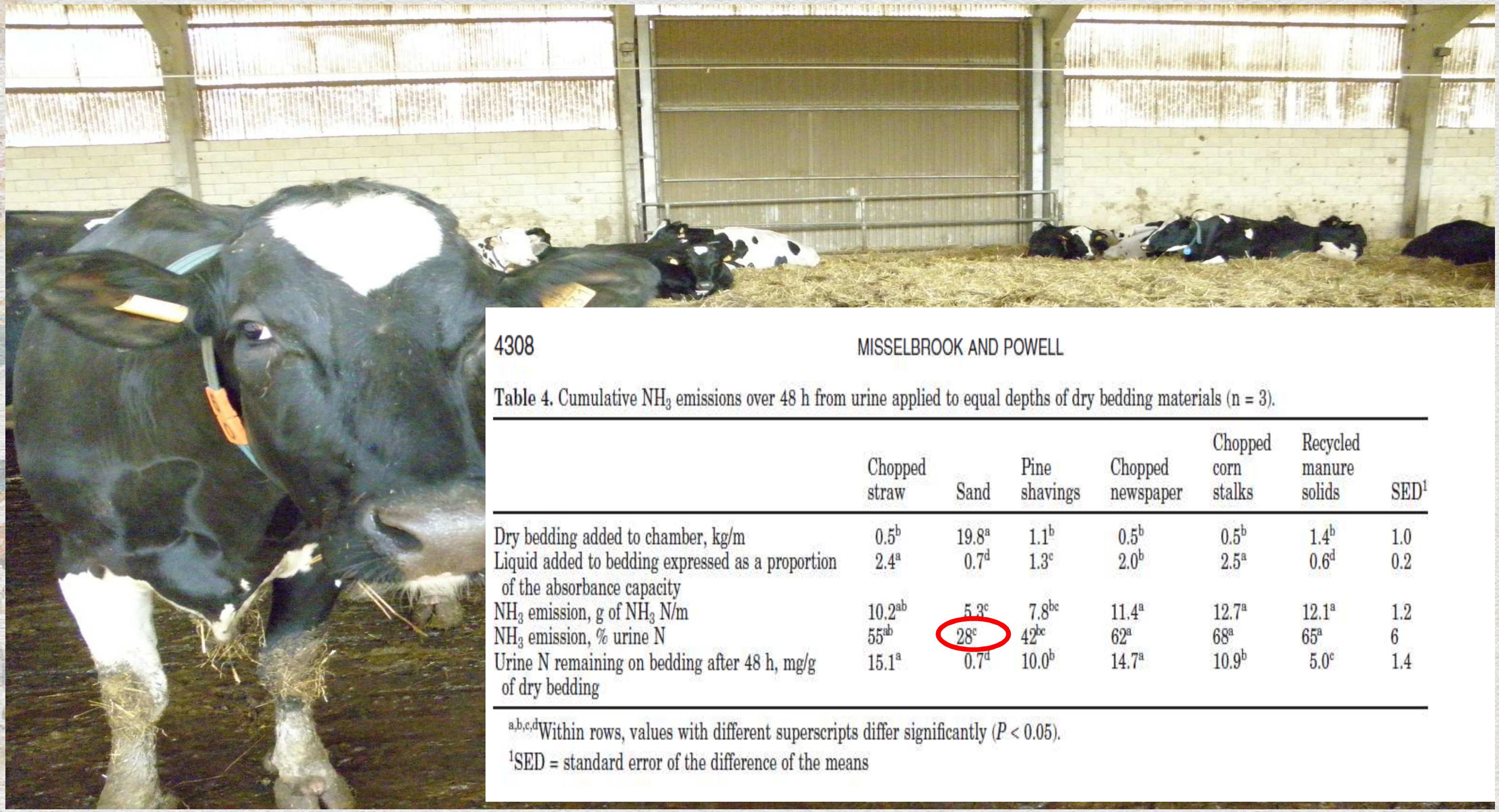
Emisiones gallinaza fresca *vs* gallinaza seca



neiker tecnalia

Alojamiento-Material de cama



4308 MISSELBROOK AND POWELL

Table 4. Cumulative NH_3 emissions over 48 h from urine applied to equal depths of dry bedding materials (n = 3).

	Chopped straw	Sand	Pine shavings	Chopped newspaper	Chopped corn stalks	Recycled manure solids	SED[1]
Dry bedding added to chamber, kg/m	0.5^{b}	19.8^{a}	1.1^{b}	0.5^{b}	0.5^{b}	1.4^{b}	1.0
Liquid added to bedding expressed as a proportion of the absorbance capacity	2.4^{a}	0.7^{d}	1.3^{c}	2.0^{b}	2.5^{a}	0.6^{d}	0.2
NH_3 emission, g of NH_3 N/m	10.2^{ab}	5.3^{c}	7.8^{bc}	11.4^{a}	12.7^{a}	12.1^{a}	1.2
NH_3 emission, % urine N	55^{ab}	28^{c}	42^{bc}	62^{a}	68^{a}	65^{a}	6
Urine N remaining on bedding after 48 h, mg/g of dry bedding	15.1^{a}	0.7^{d}	10.0^{b}	14.7^{a}	10.9^{b}	5.0^{c}	1.4

^{a,b,c,d}Within rows, values with different superscripts differ significantly ($P < 0.05$).

[1]SED = standard error of the difference of the means

Influence of Bedding Material on Ammonia Emissions from Cattle Excreta. Journal of Dairy Science. Volume 88, Issue 12. 2005

Table 7
Category 1 and 2 techniques: reduction and costs of low-emission housing systems for pigs

Category 1 technique (unless specified cat. 2)	*NH_3 emission (kg NH_3/place/year)*	*Emission reduction (%)*	*Extra cost (€/place/year)[a]*	*Extra cost (€/kg NH_3-N reduced)*
Gestating sows	**4.20**			
Frequent manure removal with vacuum system		25	0[b]	0[b]
Flushing gutters		40	33	23
Cooling manure surface		45	19	12
(Group) housing with feeding stalls and manure pit with slanted walls		45	16	10
Floating balls on manure surface (cat. 2)		25	14	16
Air scrubbing techniques		70–90	22–30	8–10
Lactating Sows	**8.30**			
Water and manure channel		50	2	0.5
Manure pan underneath		65	40–45	9
Cooling manure surface		45	45	15
Floating balls on manure surface (cat. 2)		25	14	8
Air scrubbing techniques		70–90	35–50	7–10
Piglets after weaning	**0.65**			
Partially slatted floor with reduced pit		25–35	0	0
Frequent manure removal with vacuum system		25	0[b]	0[b]
Partly slatted floors and flushing gutters		65	5	14
Partly slatted floor and collection in acidified liquid		60	5	15
Partly slatted floor and cooling manure surface		75	3–4	7–10
Partly slatted floor and manure channel with slanted walls		65	2	5–6
Floating balls on manure surface (cat. 2)		25	1	6–7
Air scrubbing techniques		70–90	4–5	8–12
Growers-finishers	**3.0**			
Partially slatted floor with reduced pit		15–20	0	0
Frequent manure removal with vacuum system		25	0[b]	0[b]
Partially slatted floor with water and manure channel		40	2	2
Partially slatted floor with water channel and manure channel with slanted walls		60–65	3–5	2–3
Flushing gutters		40	10–15	10–15
Partially slatted floor and cooling manure surface		45	5–7	4–6
Floating balls on manure surface (cat. 2)		25	2	4
Partially slatted floors and separated removal of liquid and solid manure fraction by V-shaped belt (cat. 2)		70	0–5	0–3
Air scrubbing techniques		70–90	10–15	5–9

Note: For economic cost of the abatement techniques, see Reis (forthcoming).
[a] Prices are calculated based on new buildings. Only cooling systems, floating balls and scrubbers can be installed in existing buildings, see text for explanation about retrofitting.
[b] If vacuum manure removal system is already installed.

Bittman et al., 2014

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Van der Heyden et al., 2015

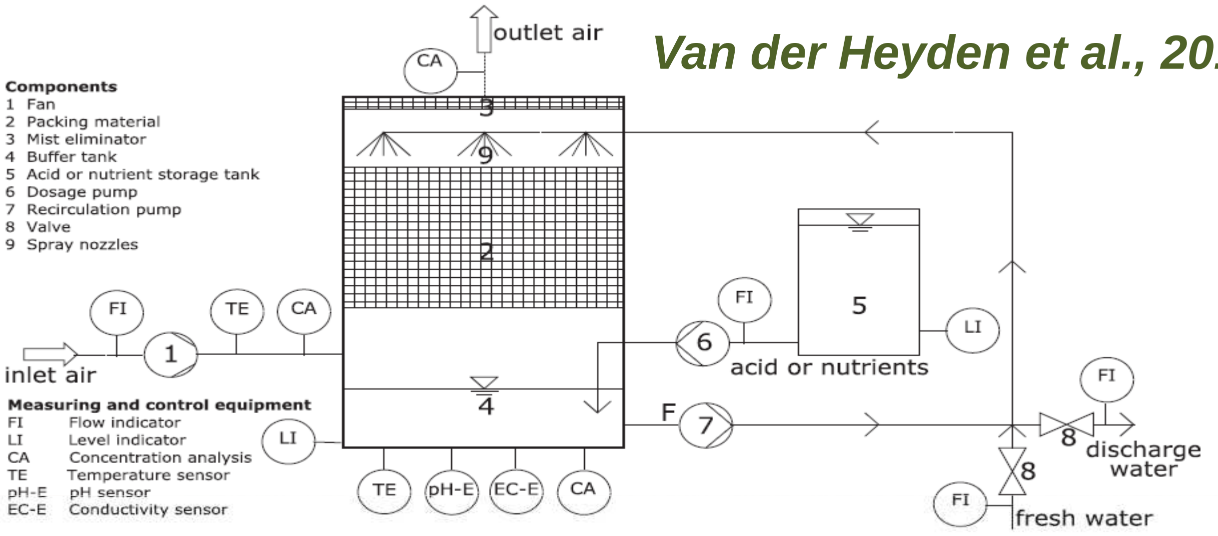


Fig. 1 – Simplified process diagram of a counter-current air scrubber. The storage tank of a chemical air scrubber contains acid. For a biological air scrubber a storage tank is optional and may contain necessary nutrients for the microorganisms.

Table 3 – Reported pollutant removal efficiencies for different types of air scrubbers and biofilters for pig and poultry housing facilities.

ID	Type of air scrubber	Country animals	EBRT (s) range mean ± stdev	NH_3 (%) range mean ± stdev	Odour (%) range mean ± stdev	N_2O (%) range mean ± stdev	CH_4 (%) range mean ± stdev	PM_{10} (%) range mean ± stdev	$PM_{2.5}$ (%) range mean ± stdev	Reference
1	Chemical	NL Pigs	>0.9	77 to 97 91	27 to 66	–	–	–	–	Vrielink, Verdoes, and van Gastel (1997); Melse and Ogink (2005)
2	Chemical	NL Poultry	–	40 to 99 90	–	–	–	–	–	Hol and Satter (1998); Melse and Ogink (2005)
3	Chemical	NL Pigs	>0.5	90 to 100 99	–	–	–	–	–	Verdoes and Zonderland (1999); Melse and Ogink (2005)
4	Chemical	NL Poultry	>0.4	76 to 100 95	–	–	–	–	–	Hol, Wever, and Groot Koerkamp (1999); Melse and Ogink (2005)
5	Chemical[a]	NL Poultry	>0.4	96 to 100 98	–	–	–	–	–	Wever and Groot Koerkamp (1999); Melse and Ogink (2005)
6	Chemical (90% ammonia)	NL Poultry	0.2–2	30 to 99 77 ± 31	−10 to 80 48 ± 22	−30 to 20 1 ± 12	−60 to 50 −1 ± 25	5 to 60 33 ± 17	0 to 55 28 ± 22	Mosquera et al. (2011); Melse, Hofschreuder et al. (2012)
7	Chemical (70% ammonia)	NL Pi/Po	0.2–1.8	45 to 99 76 ± 20	−20 to 80 19 ± 28	−25 to 25 −1 ± 12	−90 to 20 −5 ± 31	20 to 65 41 ± 20	0 to 80 33 ± 23	Mosquera et al. (2011); Melse, Hofschreuder et al. (2012)
8	Chemical	DE Pigs	0.5–2.9	87 to 89 88 ± 1	–	–	–	81 to 99[b] 89 ± 8	–	DLG5957 (2011)
9	Chemical (pH < 7) (biological)	NL Poultry	0.56	48 to 85 69 ± 13	−23 to 43 17 ± 25	−17 to 3 −5 ± 7	−9 to 12 2 ± 8	11 to 84 44 ± 26	13 to 46 31 ± 17	Melse, van Hattum et al. (2012) Melse, Hofschreuder et al. (2012)
10	Biological (70% ammonia)	NL Pigs	0.4–1.8	50 to 85 76 ± 16	5 to 65 42 ± 30	−120 to −20 −70 ± 42	−5 to 10 4 ± 7	45 to 50 48 ± 4	10 to 50 37 ± 16	Mosquera et al. (2011); Melse, Hofschreuder et al. (2012)
11	Biological (70% ammonia)	NL Pi/Po	3.2–4.5	10 to 99 59 ± 33	−60 to 60 −3 ± 49	−400 to −5 −208 ± 154	−5 to 50 10 ± 17	45 to 90 74 ± 13	60 to 90 75 ± 11	Mosquera et al. (2011); Melse, Hofschreuder et al. (2012)

↑ N_2O

Energía

Table 1 | Current global greenhouse gas emissions from livestock (~1995–2005).

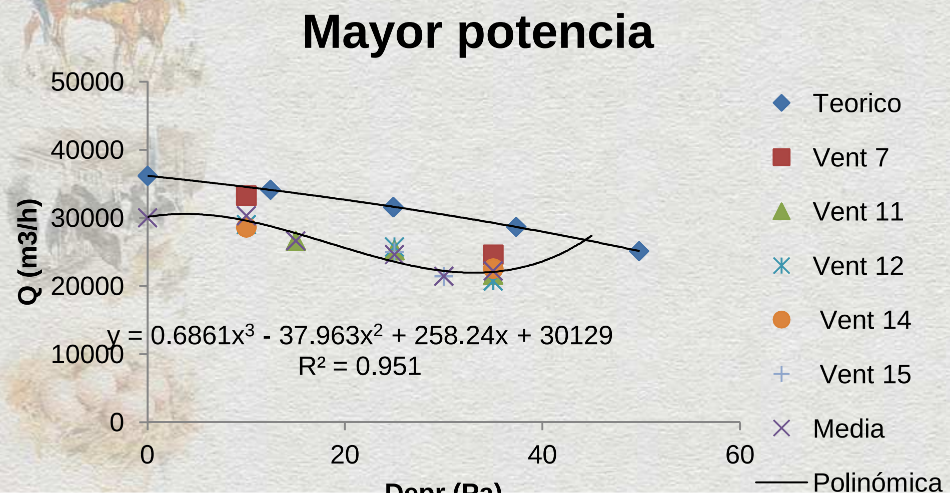
Emissions source	Emissions ($GtCO_2e$)	Reference
Feed N_2O	1.3–2.0‡	9,13,15,16–18
Feed CO_2 (LUC excluded)	0.92	15,17,18
Feed CO_2 (LUC)	0.23	15,17,18
Pasture expansion CO_2 LUC	0.43	15,17,18
Feed CH_4 rice	0.03	15,17,18
Enteric CH_4*	1.6–2.7	9–13,15,17
Manure CH_4*	0.2–0.4	9–13,15,17,18
Manure N_2O*	0.2–0.5	9–13,15–18
Direct energy CO_2	0.11	15,17,18
Embedded energy CO_2	0.02	15,17,18
Post-farm gate CO_2	0.023	15,17,18
Non-CO_2 emissions* (IPCC guidelines)	2.0–3.6	This Review
Total emissions (LCA approach)†	5.6–7.5	This Review

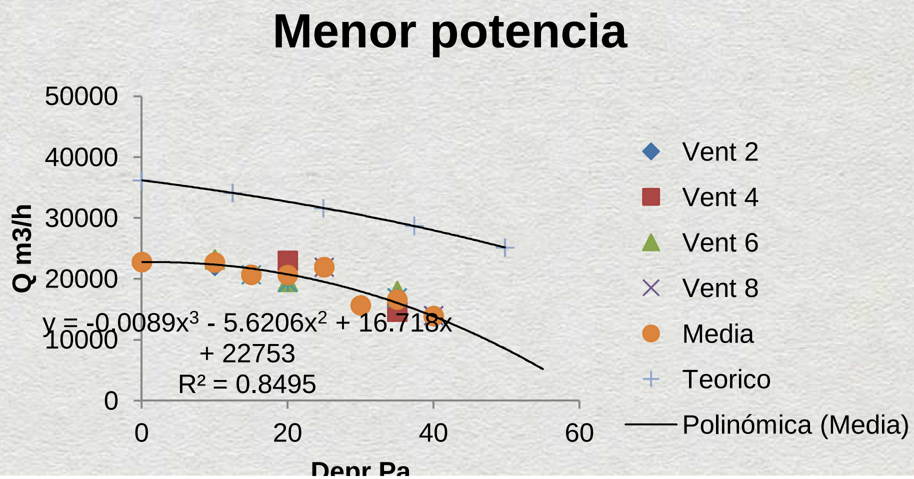
*Livestock emissions according to IPCC emissions guidelines[8]. †Range estimated using information from global analyses for key emissions source categories. LCA as implemented by FAO[15]. ‡Includes N_2O emissions from manures applied to pastures, and from fertilizers to croplands for both feed and pasture. Emissions from manure applied to pastures ranges from 0.42–0.95 $GtCO_2e$. LUC, land-use change.

Herrero et al., 2016

- -Aislamiento
- -Equipos eficientes
- -Registro de consumos
- -Control y mantenimiento de la ventilación
- -Limpieza ventiladores. Ventiladores nuevos/ viejos
- -Control de las tarifas

10% ahorro potencial por registro regular en sectores porcino y avícola en UK (Warwick, 2.0.07)





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3. ALMACENAMIENTO GANADERO. MITIGACION NH_3

1. **Minimizar agitación, volteos.**
2. **Reducir pH**
3. **Reducir superficie emisión (cubiertas, costra, profundidad)**
4. **Bajas temperaturas**

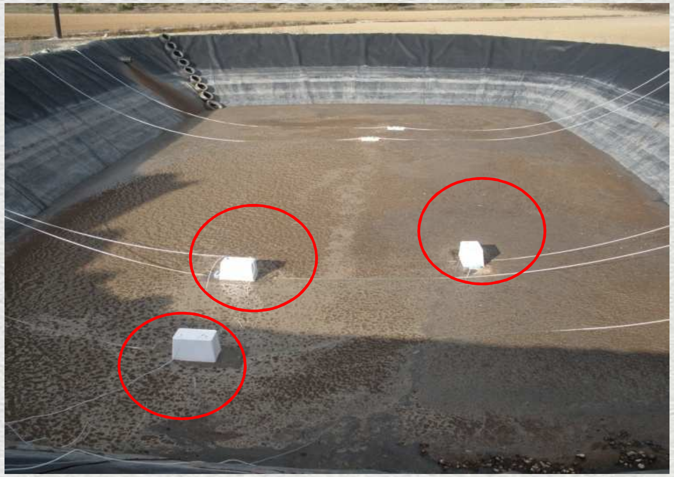
Table ES4

Ammonia emission reduction techniques for manure storages, their emission reduction levels and associated costs

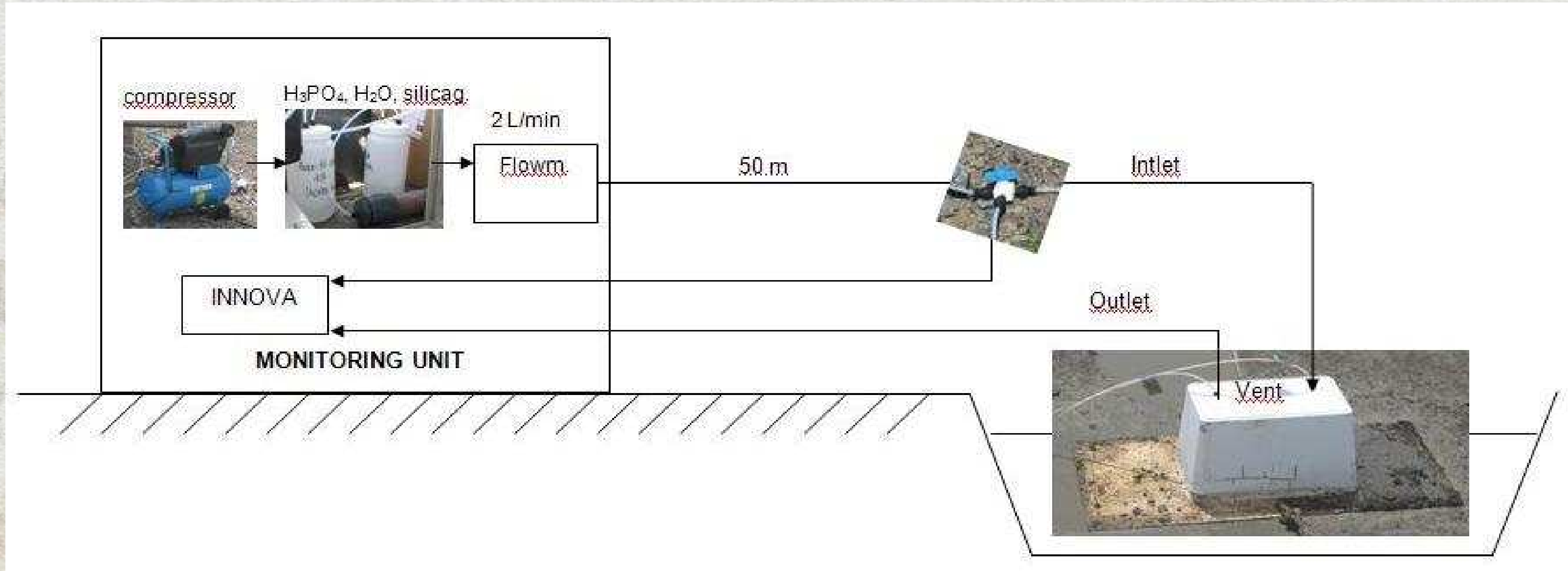
Techniques	*Emission reduction (%)*	*Cost (€ per m^3 per year)*	*Cost (€ per kg NH_3-N saved)*
Tight lid	> 80	2–4	1–2.5
Plastic cover	> 60	1.5–3	0.5–1.3
Floating cover	> 40	1.5–3[*)]	0.3–5[a]

[a] Not including crust; crusts form naturally on some manures and have no cost, but are difficult to predict.

Bittman et al., 2004



Peu et al., 1999. *Journal of Agricultural Engineering Research*.



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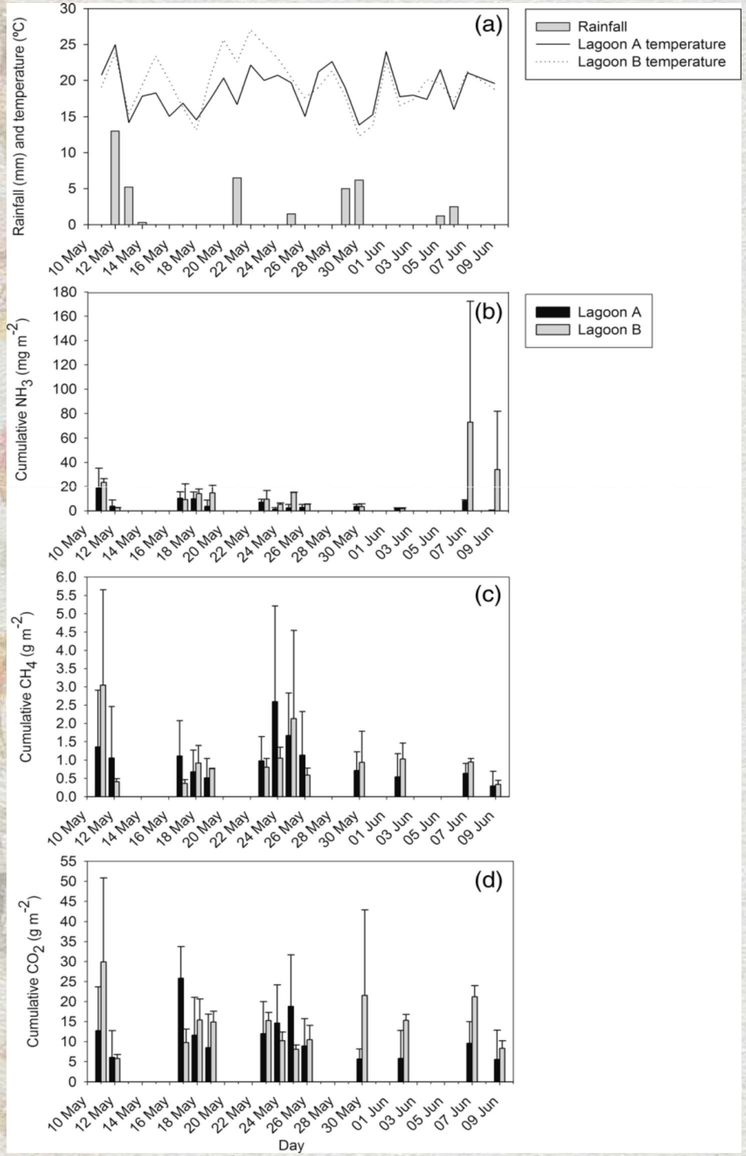

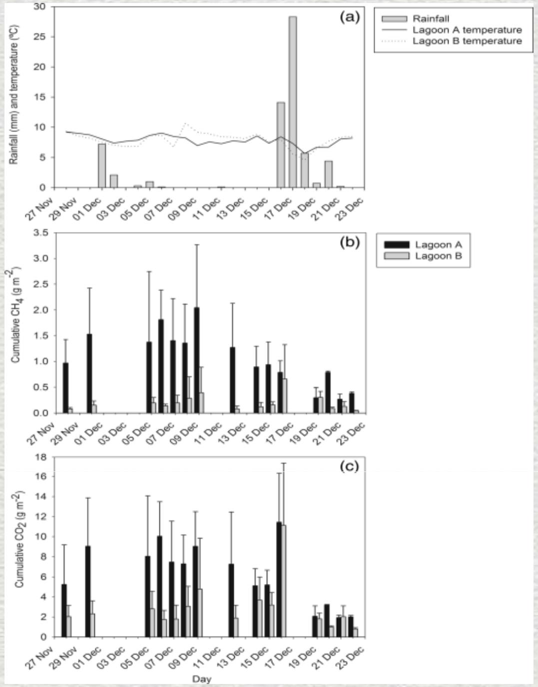

Table 1 Ammonium-nitrogen (NH_4^+–N) concentration, slurry temperature, pH, and free ammonia (FA) concentration estimation from literature (stored pig slurry) and the current spring and autumn studies

Reference		NH_4^+–N (g N l^{-1})	Temperature (ºC)	pH	FA (mg NH_3–N l^{-1})
Blunden and Aneja (2008)		0.57	15	8.1	18.8
James et al. (2012)		0.55	20	8.0	20.7
Lim et al. (2003)		2.06	25	8.1	137.4
Current spring study[a]	Lagoon A	3.48	19	6.7	7.7
	Lagoon B	5.00	20	6.5	6.1
Current autumn study[b]	Lagoon A	2.33	8	6.9	2.6
	Lagoon B	4.23	8	6.8	4.5

[a] Average value in lagoon A and B, respectively, during spring study

[b] Average value in lagoon A and B, respectively, during autumn study

Viguria et al., 2015

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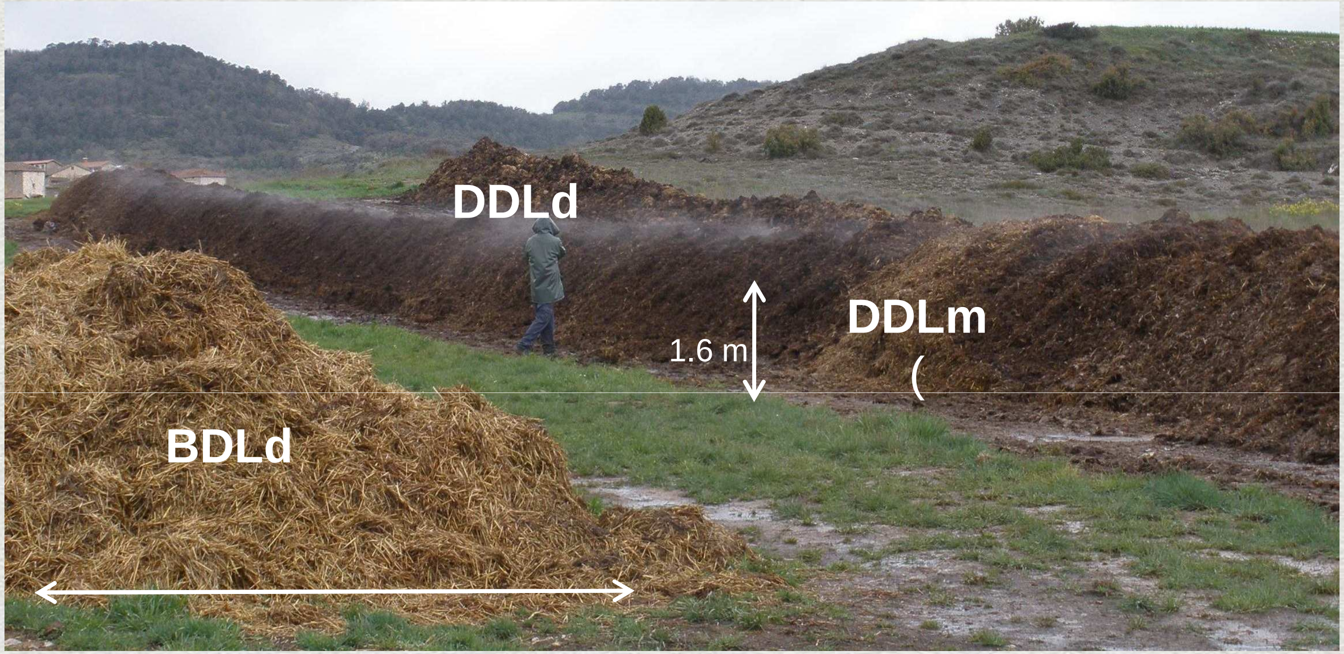
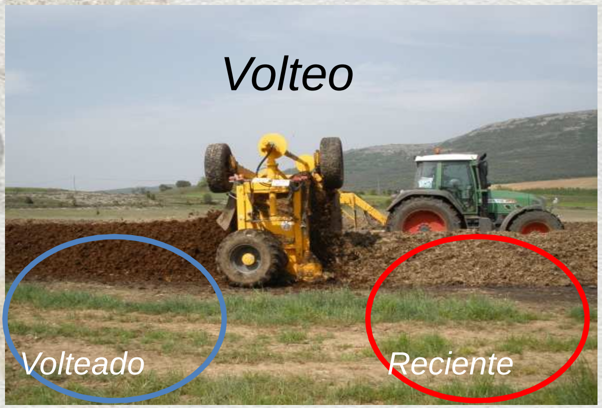
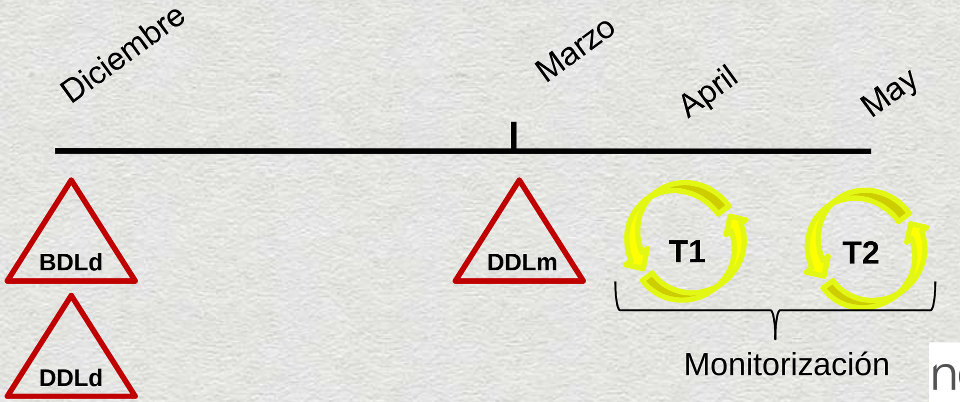
Almacenamiento de material de cama y volteos



Ganado vacuno leche y carne
Cama de paja
Dos volteos





neiker tecnalia

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Fracción sólida y volteo

Vacuno de leche

3 volteos

Marzo
Abril
Mayo
Agosto

SMS

T3

Monitorización

neiker tecnalia

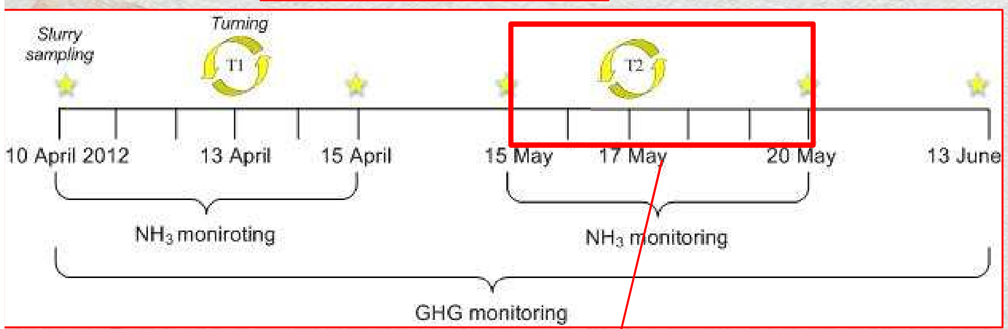
Flushing

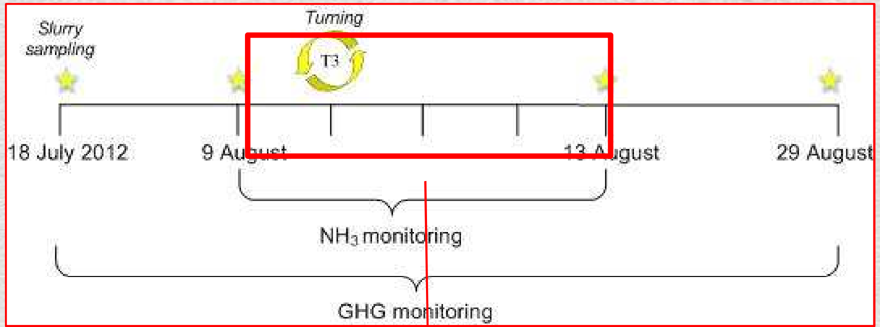
Vacuno de leche.
Separación no mecáncia
Flushing

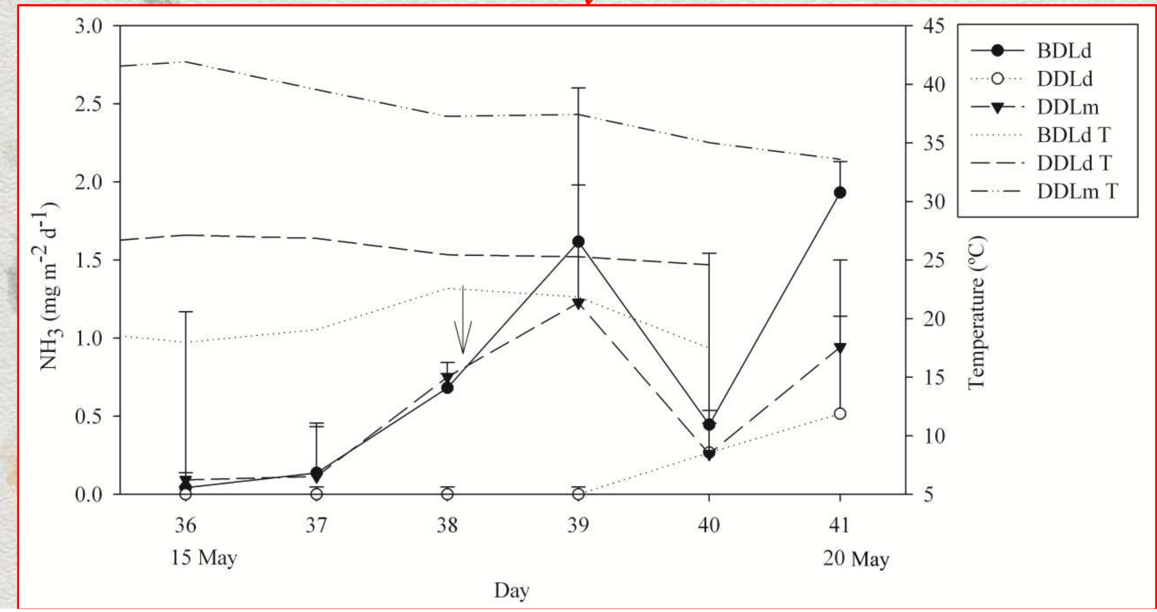
NH_3

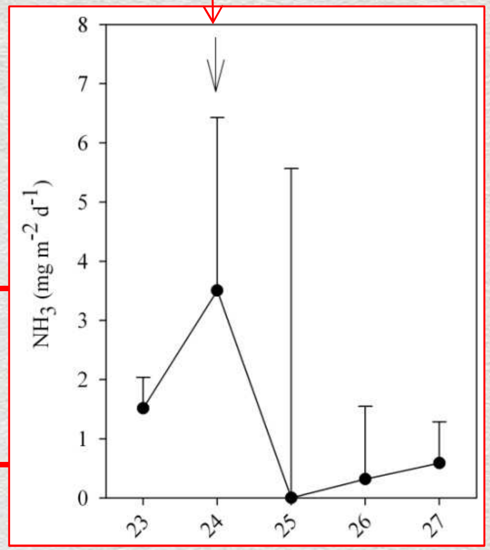
Deep litter (DL)

Fracción sólida (SMS)



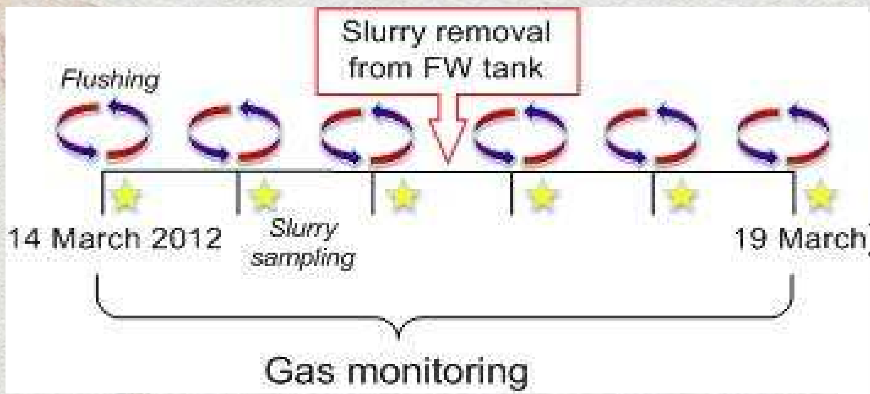


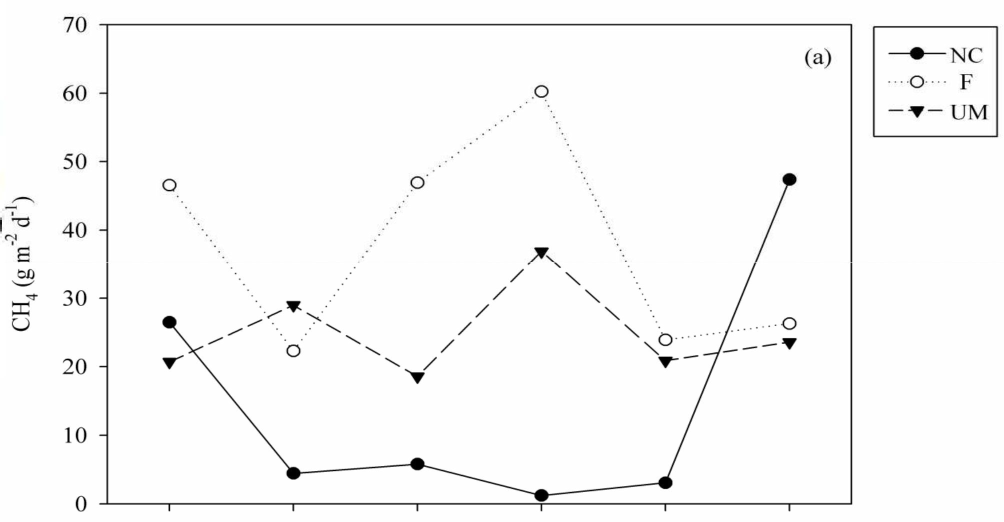




CH_4

Separated fractions from non-mechanical separation (FW and LM)





UM = Uncovered manure

F = Wastewater receiving zone after flushing

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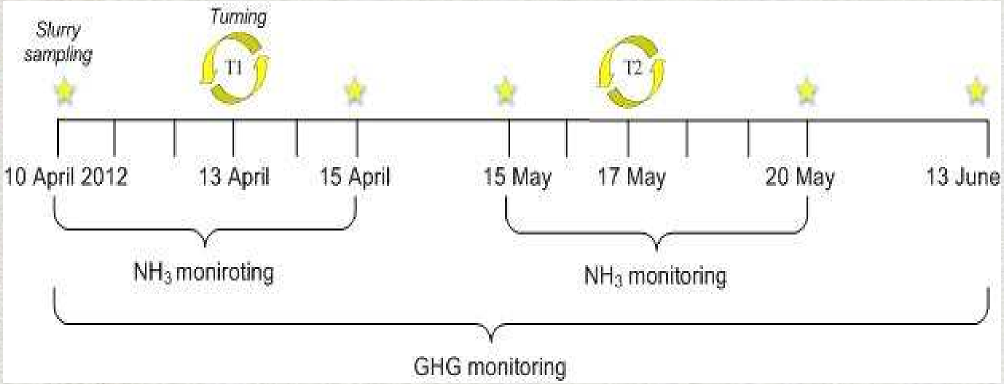
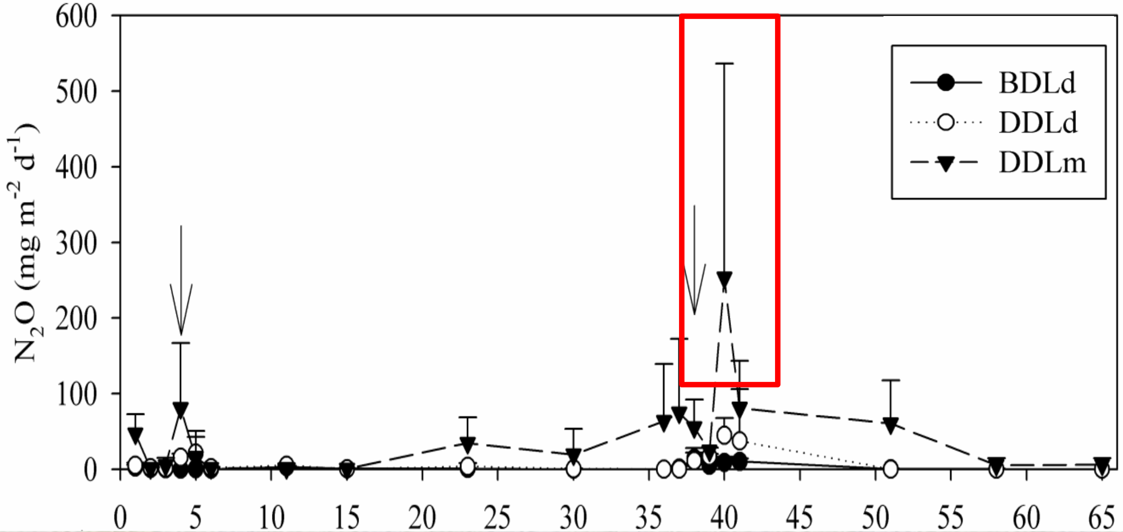
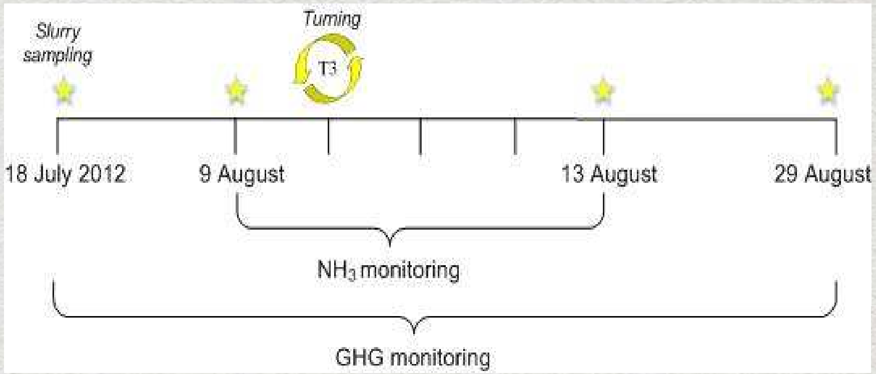
N_2O

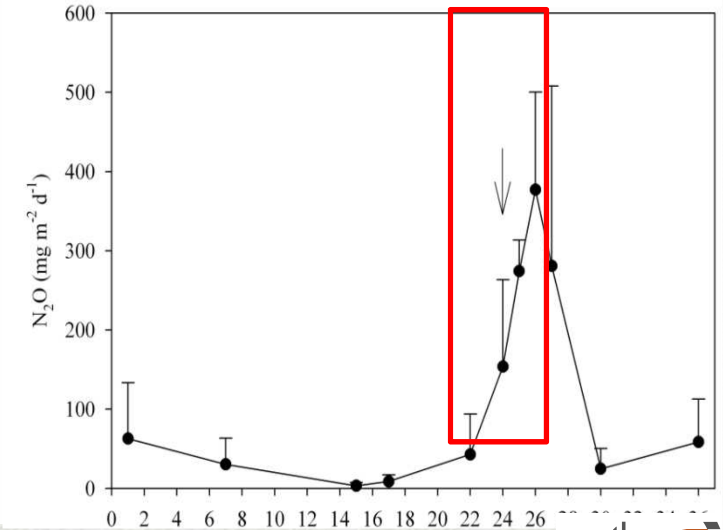
Deep litter (DL)





Fracción sólida(SMS)





CUBIERTAS


Costra


Paja


Cubierta flexible

Hexacover

Ammonia emission reduction techniques for manure storages, their emissio[n] reduction levels and associated costs

Techniques	*Emission reduction (%)*	*Cost (€ per m³ per year)*	*Cost (€ per kg NH_3- save[d])*
Tight lid	> 80	2–4	1–2.5
Plastic cover	> 60	1.5–3	0.5–1.3
Floating cover	> 40	1.5–3*)	0.3–5[a]

[a] Not including crust; crusts form naturally on some manures and have no cost, but are difficul[t to] predict.

Bittman et al., 2004

Costra natural: ↓ 60% NH_3

Posible ↑ N_2O, según grosor y permeabilidad nitrificación en capas superiores y desnitrificación a profundidad (Nielsen et al., 2010, Hansen et al., 2009)

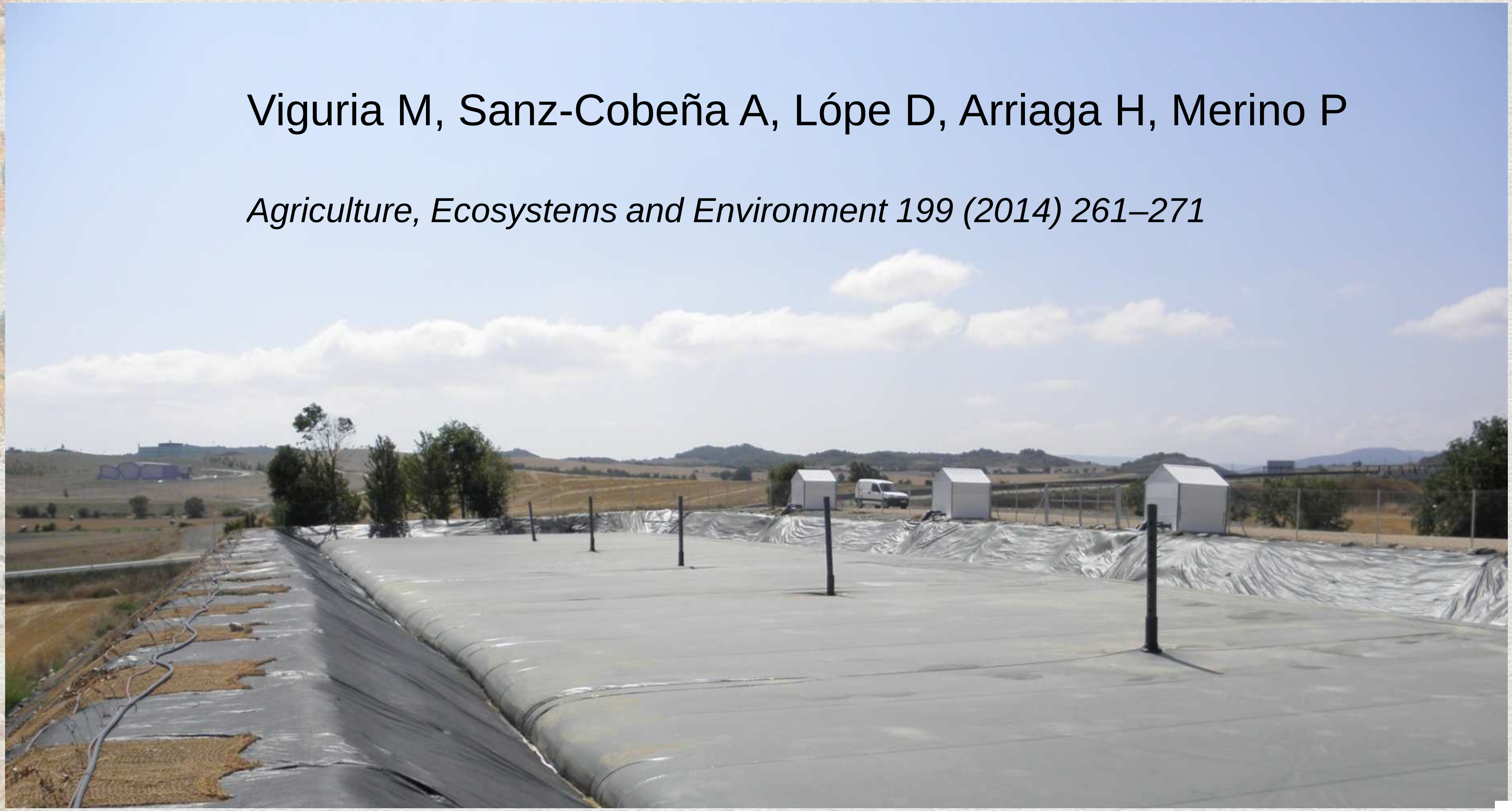
Table 5 – Summary of the performances of permeable and impermeable covers in abating ammonia emissions from livestock manure storages

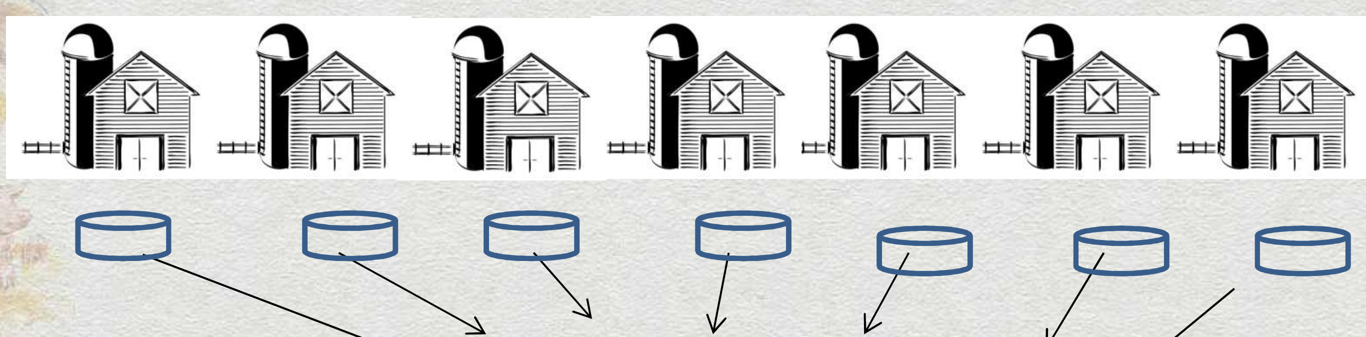
Cover type (s)	Emission reduction (%)	References
Polyethylene	80–100	Funk et al. (2004), Scotford and Williams (2001), Miner et al. (2003)
Tarpaulin	99.5	Funk et al. (2004)
Oil films	40–100	Heber et al. (2005), Guarino et al. (2006), Portejoie et al. (2003), Hornig et al. (1999)
Geotextile cover	44	Bicudo et al. (2004)
Straw covers	37–90	Clanton et al. (2001), Sommer et al. (1993), Hornig et al. (1999), Guarino et al. (2006), Xue et al. (1999), Miner and Pan (1995)
Surface crust, peat, & PVC foil	24–32	Sommer et al. (1993)
Leca rock	14–87	Sommer et al. (1993), Balsari et al. (2006)
Polymer composite	17–54	Zahn et al. (2001)
Pegulit	91	Hornig et al. (1999)
Wood chips	17–91	Guarino et al. (2006)
Corn stalks	37–60	Guarino et al. (2006)
Zeolite on permeable cover	90	Miner and Pan (1995)
Polystyrene foam	45–95	Miner and Suh (1997)

Emisiones de NH_3 y GEI desde una cubierta flexible

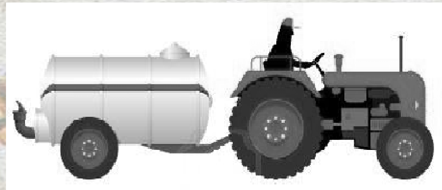
Viguria M, Sanz-Cobeña A, Lópe D, Arriaga H, Merino P

Agriculture, Ecosystems and Environment 199 (2014) 261–271





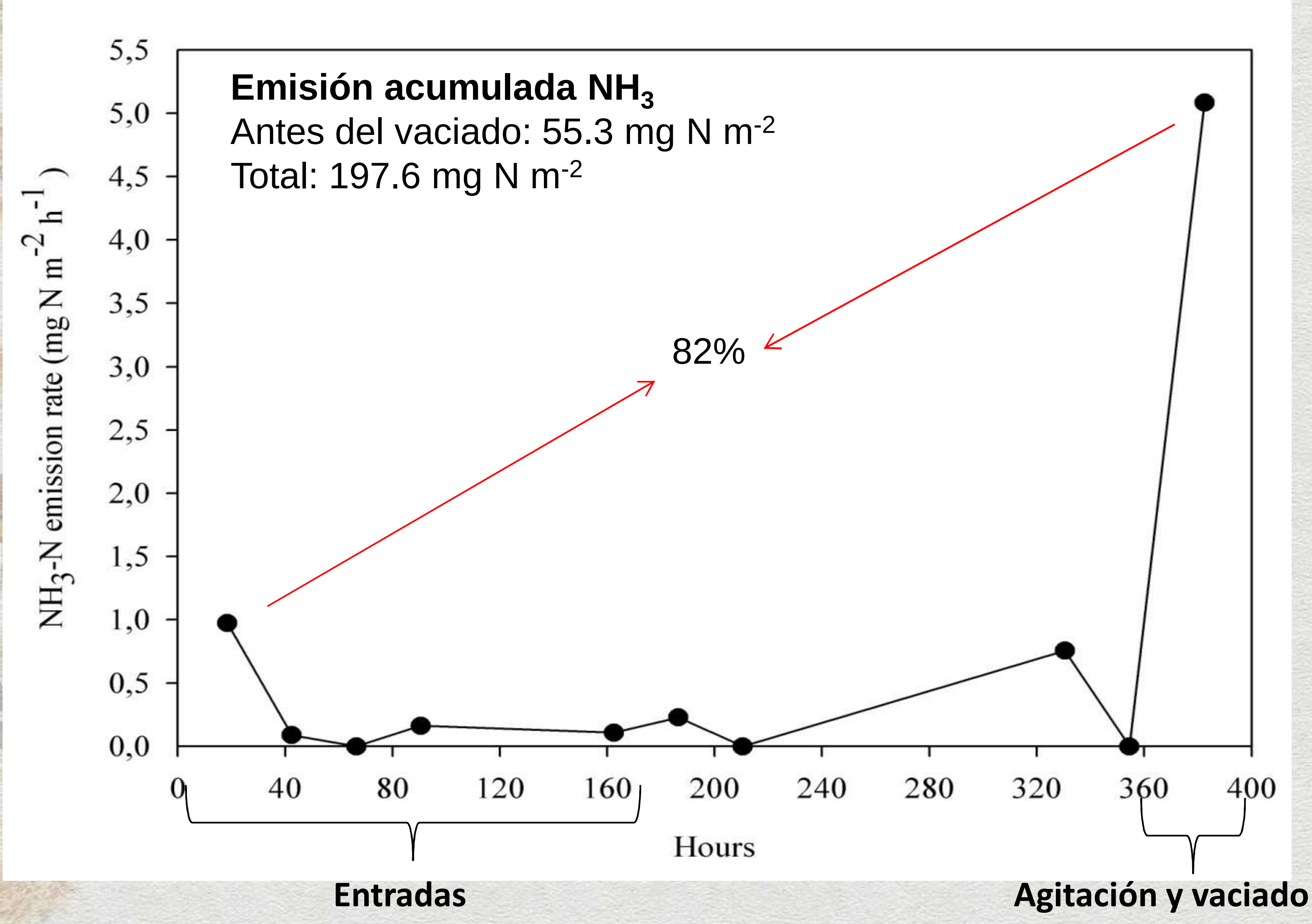
57,105 m^3 slurry/y
756 ha



Gestión agroganadera

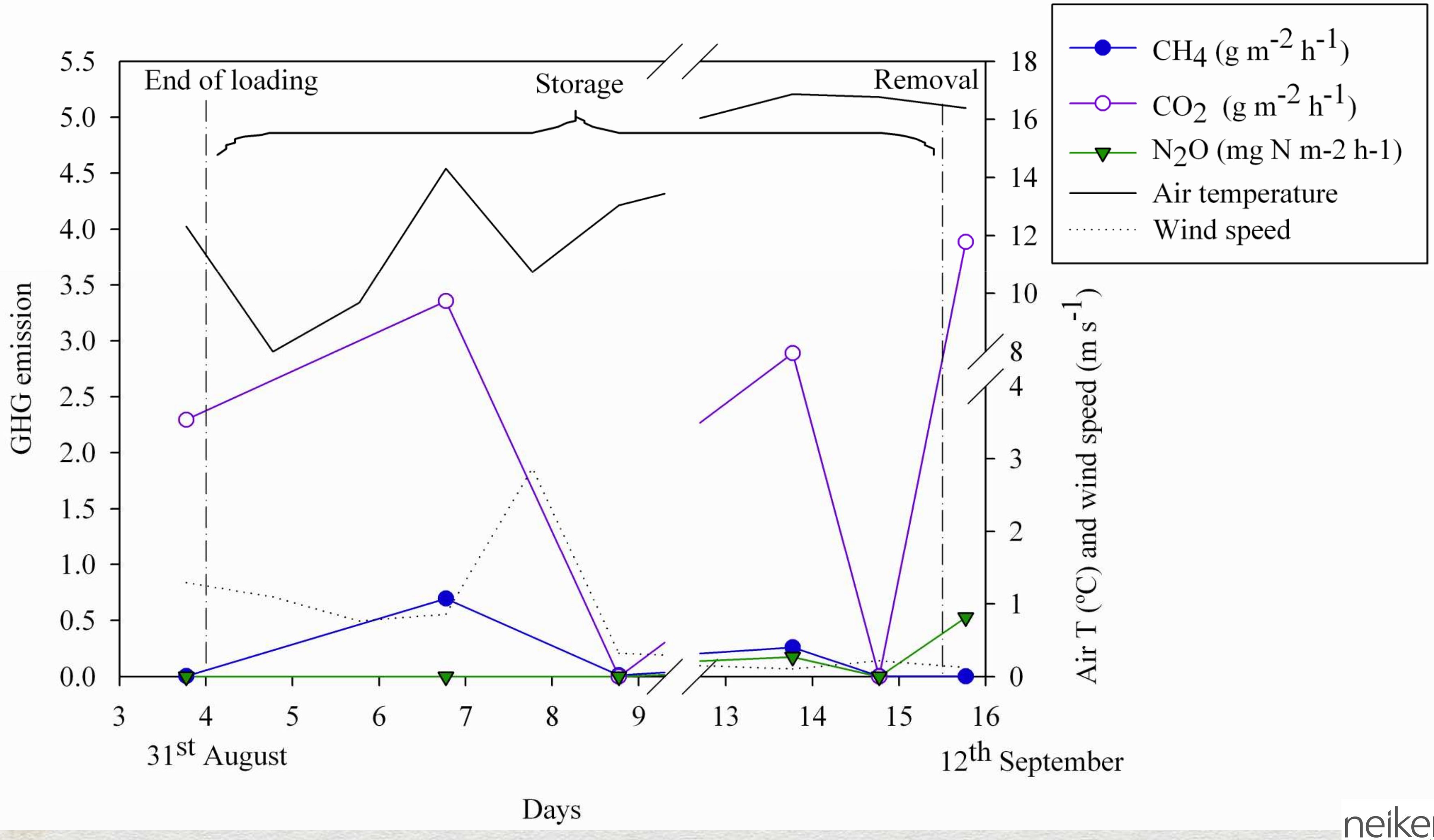
3 km

EMISION DE NH_3



GEI

CH_4 range 0.01 - 0.69 g m^{-2} h^{-1}
CO_2 range 0.01 - 4.0 g m^{-2} h^{-1}
N_2O peak 0.53 mg N m^{-2} h^{-1}



4. CONCLUSIONES

- Existen buenas prácticas aplicables a sistemas productivos de pequeña escala
- Colaboración con los productores para identificar el potencial de mitigación de diferentes manejos
- Reflejar progresivamente en los inventarios cambios en las prácticas ganaderas que permitan considerar las mejoras implantadas.

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MUCHAS GRACIAS POR SU ATENCION!