GENERAL FICHE
IMPROVED MANURE STORAGE TECHNIQUES

Data extracted in June 2021

Note to the reader: This *general fiche* summarises all the environmental and climate impacts of IMPROVED MANURE STORAGE TECHNIQUES found in a systematic review of 14 synthesis research papers These papers were selected, according to our inclusion criteria, from an initial number of 277 yielded by a systematic literature search strategy[1].

The general fiche provides the highest level of synthesis – symbolised by the top of the pyramid . As each synthesis research paper involves a number of individual papers ranging from 7 to 172, the assessment of impacts relies on a large number of results obtained mainly in field experiments (carried out in situations close to real farming environment), and sometimes in lab experiments or from model simulations.

In addition to this general fiche, *single-impact fiches* provide a deeper insight in each individual impact of IMPROVED MANURE STORAGE TECHNIQUES (Ammonia emission, GHG emissions, Nutrients loss), with more detailed information – medium part of the pyramid .

Finally, *individual reports* provide fuller information about the results reported in each synthesis paper, in particular about the modulation of effects by factors related to soil, climate and management practices – base of the pyramid .

This general fiche on IMPROVED MANURE STORAGE TECHNIQUES is part of a set of similar fiches providing a comprehensive picture of the impacts of farming practices on climate and the environment.

1. DESCRIPTION OF THE FARMING PRACTICE

Description	• <u>Improved manure storage techniques</u> are used to avoid nutrients losses and emissions release from manure storage facilities (storage tanks, solid manure heaps, etc.) [2].
Key descriptors	This review **includes** the following improved manure storage techniques: • Additives: Physical (e.g. zeolite, biochar, medical stone, grape seeds and physical mixtures), chemical (e.g. acidic substances, metal salts, phosphogypsum, Mg-P salts, Ca-superphosphate and chemical mixtures) or microbial (e.g. nitrite oxidizing bacteria, nitrogen turnover bacteria and other compound microbial agents). • Covers of either solid or liquid manure storage facilities, including plastic membranes, floating biomass or inert materials, natural crusts. • Storage with biofilters (intercepting and treating air emissions from storage facilities). • Manure acidification during storage. • Manure cooling during storage. • Compaction of solid manure heaps. • Periodical cleaning of storage tanks

[1] For further details on the search strategy and inclusion criteria, see section 4 in single-impact fiches.

	Please, note that this is not an exhaustive list of improved manure storage techniques but of those found in the literature that meet the requirements to be included in our review. This review **does not include** techniques related to manure processing (e.g. anaerobic digestion, improved composting, solid-liquid separation, etc.), which are included in another group of fiches (Manure processing techniques).

2. DESCRIPTION OF THE IMPACTS OF THE FARMING PRACTICE ON CLIMATE AND THE ENVIRONMENT

We reviewed the impacts of improved manure storage techniques compared to conventional storage techniques.

The table below shows the number of synthesis papers reporting positive, negative or no effect, based on the statistical comparison of the intervention and the control. In addition, we include the number of synthesis papers reporting relevant results, but without statistical test of the effects (uncertain). For each impact, the effect with the higher score is marked in bold and the cell coloured. The numbers between parentheses indicate the number of synthesis papers with a quality score of at least 50%. Details on quality criteria can be found in this document →.

Out of the 14 synthesis papers selected, 11 reported studies conducted in Europe and 11 have a quality score higher than 50%. Some synthesis papers reported more than one impact.

Impact	Metric	Intervention	Positive	Negative	No effect	Uncertain*
Decrease ammonia (NH_3) emission*		Storage with additives	7 (7)	0	1 (1)	1 (0)
		Storage with microbial inocula	2 (2)	0	0	0
		Storage covers	7 (7)	0	2 (2)	3 (2)
		Storage with biofilters	3 (3)	0	0	0
		Acidification during storage	4 (4)	0	0	1 (0)
		Compaction during storage	0	0	1 (1)	0
Decrease GHG emissions	CH_4 **	Storage with additives	3 (3)	0	2 (2)	2 (1)
		Storage with microbial inocula	0	0	1 (1)	0
		Storage covers	0	2 (2)	4 (4)	2 (1)
		Acidification during storage	2 (2)	0	1 (1)	1 (0)
		Cooling during storage	1 (1)	0	1 (1)	0
		Compaction during storage	0	0	1 (1)	0
	CO_2-biogenic**	Storage with additives	0	0	2 (2)	0
		Storage covers	3 (3)	1 (1)	0	0
		Acidification during storage	1 (1)	0	0	0
		Compaction during storage	1 (1)	0	0	0
	N_2O **	Storage with additives	3 (3)	0	3 (3)	1 (0)
		Storage with microbial inocula	1 (1)	0	1 (1)	0
		Storage covers	1 (1)	3 (3)	7 (7)	2 (1)
		Acidification during storage	1 (1)	0	0	1 (0)
		Compaction during storage	0	0	1 (1)	0
	Global warming potential (CO_2-eq)***	Storage with additives	1 (1)	0	0	0
		Cleaning storage tanks	0	0	0	1 (0)
		Storage covers	0	0	0	1 (0)
Decrease nutrients (total nitrogen) loss		Storage with additives	3 (3)	0	0	0
		Storage covers	2 (2)	0	0	0

Storage with microbial inocula	1 (1)	0	0	0
Compaction during storage	0	0	1 (1)	0

* Number of synthesis papers that report relevant results but without statistical test comparison of the intervention and the control.
** accounting only for emissions on site.
***Accounting for the contribution of all GHGs (N_2O, CH_4, CO_2), each one with its specific global warming potential, expressed as CO_2-equivalents

DESCRIPTION OF THE KEY FACTORS INFLUENCING THE SIZE OF THE EFFECT

Only the factors explicitly studied in the reviewed synthesis papers with a significant effect are reported below. Details regarding the factors can be found in the *individual reports* following the hyperlinks ( ).

Impact	**Factors**
Decrease ammonia emission	Type of technology (ref 1),Type of additive (ref 1),Livestock type (ref 5),Manure characteristics (ref 6),Additive type (ref 7),Application dosage (ref 7),Initial moisture content (ref 7),Initial pH (ref 7),Initial C/N ratio (ref 7),Temperature in the heap (ref 14),Bulk density (ref 14)
Decrease GHG emissions	Type of technology (ref 1),Type of additive (ref 1),Initial moisture content (ref 7),Additive type (ref 7),Additive properties (ref 7),Moisture content (ref 14),Bulk density (ref 14)
Decrease nutrients loss	Additive type (ref 7), Additive properties (ref 7),Application dosage (ref 7),Initial moisture content (ref 7),Initial C/N ratio (ref 7)

3. IMPLEMENTATION IN THE PERIOD 2014-2020

GAEC Cross compliance	
Greening	
Rural development measure – submeasure	

5. PICTURES

Pictures are not relevant in this case.

6. LINKS TO OTHER RELEVANT COMPLEMENTARY INFORMATION

We include in this section the links to other complementary sources of information (not peer-reviewed meta-analyses or systematic reviews), provided by AGRI or other stakeholders

7. LIST OF SYNTHESIS PAPERS INCLUDED IN THE REVIEW OF THE FARMING PRACTICE IMPACTS

Ref. Num	Authors	Year	Title	Reference	DOI
1	Zhang Z., Liu D., Qiao Y., Li S., Chen Y., Hu C.	2021	Mitigation of carbon and nitrogen losses during pig manure composting: A meta-analysis	Science of the Total Environment 783 147103	10.1016/j.scitotenv.2021.147103
2	Zhao, SX; Schmidt, S; Qin, W; Li, J; Li, GX; Zhang, WF	2020	Towards the circular nitrogen economy - A global meta-analysis of composting technologies reveals much potential for mitigating nitrogen losses	Sci. Total Environ. 704, 135401	10.1016/j.scitotenv.2019.135401
3	Ba, SD; Qu, QB; Zhang, KQ; Groot, JCJ	2020	Meta-analysis of greenhouse gas and ammonia emissions from dairy manure composting	Biosystems engineering	10.1016/j.biosystemseng.2020.02.015
4	Emmerling, C; Krein, A; Junk, J	2020	Meta-Analysis of Strategies to Reduce NH_3 Emissions from Slurries in European Agriculture and Consequences for Greenhouse Gas Emissions	Agronomy 10, 1633	10.3390/agronomy10111633
5	Ti, CP; Xia, LL; Chang, SX; Yan, XY	2019	Potential for mitigating global agricultural ammonia emission: A meta-analysis	Environ. Pollut. 245, 141–148	10.1016/j.envpol.2018.10.124
6	Wang, Y; Xue, W; Zhu, Z; Yang, J; Li, X; Tian, Z;Dong, H; Zou, G;	2019	Mitigating ammonia emissions from typical broiler and layer manure management - A system analysis	Waste Management	10.1016/j.wasman.2019.05.019
7	Cao Y, Wang X, Bai Z, Chadwick D, Misselbrook T, Sommer SG, Qin W, Ma L	2019	Mitigation of ammonia, nitrous oxide and methane emissions during solid waste composting with different additives: A meta-analysis	Journal of Cleaner Production	10.1016/j.jclepro.2019.06.288
8	Akdeniz, N	2019	A systematic review of biochar use in animal waste composting	Waste Management	10.1016/j.wasman.2019.03.054
9	Sajeev, EPM; Winiwarter, W; Amon, B	2018	Greenhouse Gas and Ammonia Emissions from Different Stages of Liquid Manure Management Chains: Abatement Options and Emission Interactions	Journal of environmental quality	10.2134/jeq2017.05.0199
10	Wang, Y; Li, XR; Yang, JF; Tian, Z; Sun, QP; Xue, WT; Dong, HM	2018	Mitigating Greenhouse Gas and Ammonia Emissions from Beef Cattle Feedlot Production: A System Meta-Analysis	Environmental Science & Technology	10.1021/acs.est.8b02475

Ref. Num	Authors	Year	Title	Reference	DOI
11	Wang, Y; Dong, HM; Zhu, ZP; Gerber, PJ; Xin, HW; Smith, P; Opio, C; Steinfeld, H; Chadwick, D	2017	Mitigating Greenhouse Gas and Ammonia Emissions from Swine Manure Management: A System Analysis	ENVIRONMENTAL SCIENCE & TECHNOLOGY	10.1021/acs.est.6b06430
12	Jayasundara, S; Appuhamy, JADRN; Kebreab, E; Wagner-Riddle, C	2016	Methane and nitrous oxide emissions from Canadian dairy farms and mitigation options: An updated review	CANADIAN JOURNAL OF ANIMAL SCIENCE	10.1139/cjas-2015-0111
13	Hou, Y; Velthof, GL; Oenema, O	2015	Mitigation of ammonia, nitrous oxide and methane emissions from manure management chains: a meta-analysis and integrated assessment	Glob. Chang. Biol. 21, 1293–1312	10.1111/gcb.12767
14	Pardo, G; Moral, R; Aguilera, E; del Prado, A	2015	Gaseous emissions from management of solid waste: a systematic review	Glob. Chang. Biol. 21, 1313–1327	10.1111/gcb.12806