Manure storage techniques_GENERAL

Data extracted in July 2021
Fiche created in February 2024

Note to the reader: This general fiche summarises all the environmental and climate impacts of MANURE STORAGE TECHNIQUES found in a review of 14 synthesis papers[1]. These papers were selected from an initial number of 277 obtained through a systematic literature search strategy, according to the inclusion criteria reported in section 4. The impacts reported here are those for which there is scientific evidence available in published synthesis papers, what does not preclude the farming practice to have other impacts on the environment and climate still not covered by primary studies or by synthesis papers.

The synthesis papers review a number of primary studies ranging from 7 to 172. Therefore, the assessment of impacts relies on a large number of results from the primary studies, obtained mainly in field conditions, or sometimes in lab experiments or from model simulations.

1. DESCRIPTION OF THE FARMING PRACTICE

- Description:
  - Improved manure storage techniques 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
  - 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. EFFECTS OF THE FARMING PRACTICE ON CLIMATE AND ENVIRONMENTAL IMPACTS

(table 1)

The table below shows the number of synthesis papers with statistical tests reporting i) a significant difference between the Intervention and the Comparator, that is to say, a significant statistical effect, which can be positive or negative; or ii) a non-statistically significant difference between the Intervention and the Comparator. In addition, we include, if any, the number of synthesis papers reporting relevant results but without statistical test of the effects. Details on the quality assessment of the synthesis papers can be found in the methodology section of this WIKI.

All selected synthesis papers included studies conducted in Europe , and 11 have a quality score higher than 50%.

Table 1: Summary of effects. Number of synthesis papers reporting positive, negative or non-statistically significant effects on environmental and climate impacts. The number of synthesis papers reporting relevant results but without statistical test of the effects are also provided. When not all the synthesis papers reporting an effect are of high quality, the number of synthesis papers with a quality score of at least 50% is indicated in parentheses. Some synthesis papers may report effects for more than one impact, or more than one effect for the same impact.

				Statistically tested			Non-statistically tested
Impact	Metric	Intervention	Comparator	Significantly positive	Significantly negative	Non-significant	
Decrease Air pollutants emissions	NH_3	Compaction during storage	Conventional management	0	0	1	0
		Storage covers	Conventional management	8	0	2	3 (2)
		Storage with acidification	Conventional management	4	0	0	1 (0)
		Storage with additives	Conventional management	7	0	1	1 (0)
		Storage with biofilters	Conventional management	3	0	0	0
		Storage with microbial inocula	Conventional management	3	0	0	0
Decrease GHG emissions	CH_4	Compaction during storage	Conventional management	0	0	1	0
		Storage covers	Conventional management	0	2	5	2 (1)
		Storage with acidification	Conventional management	2	0	1	1 (0)

		Storage with additives	Conventional management	3	0	2	2 (1)
		Storage with cooling	Conventional management	1	0	0	0
		Storage with microbial inocula	Conventional management	0	0	1	0
Decrease GHG emissions	Global warming potential (CO2-eq)	Cleaning storage tanks	Conventional management	0	0	0	1 (0)
		Storage covers	Conventional management	0	0	0	1 (0)
		Storage with additives	Conventional management	1	0	0	0
Decrease GHG emissions	N2O	Compaction during storage	Conventional management	0	0	1	0
		Storage covers	Conventional management	1	3	7	2 (1)
		Storage with acidification	Conventional management	1	0	0	1 (0)
		Storage with additives	Conventional management	3	0	4	1 (0)
		Storage with microbial inocula	Conventional management	3	0	0	0
Increase Nutrients recovery	Total nitrogen loss	Compaction during storage	Conventional management	0	0	1	0
		Storage covers	Conventional management	2	0	0	0
		Storage with additives	Conventional management	3	0	0	0
		Storage with microbial inocula	Conventional management	2	0	0	0

3. FACTORS INFLUENCING THE EFFECTS ON CLIMATE AND ENVIRONMENTAL IMPACTS

The factors significantly influencing the size and/or direction of the effects on the impacts, according to the synthesis papers included in this review, are reported below. Details about the factors can be found in the **summaries of the meta-analyses** available in this WIKI.

Table 2: List of factors reported to significantly affect the size and/or direction of the effects on environmental and climate impacts, according to the synthesis papers reviewed. The reference number of the synthesis papers where those factors are explored is given in parentheses.

Impact	Factors
Air pollutants emissions	Additive type (Ref6), Application dosage (Ref6), Bulk density (Ref14), Initial C/N ratio (Ref6), Initial moisture content (Ref6), Initial pH (Ref6), Livestock type (Ref7), Manure characteristics (Ref8), NA (Ref1, Ref1, Ref1, Ref1, Ref1, Ref1, Ref4, Ref4, Ref4, Ref4, Ref4, Ref4, Ref4, Ref4, Ref2, Ref2, Ref2, Ref2, Ref2, Ref2, Ref2, Ref2, Ref3, Ref3, Ref3, Ref3, Ref3, Ref3, Ref3, Ref3, Ref7, Ref7, Ref7, Ref7, Ref7, Ref7, Ref7, Ref8, Ref8, Ref8, Ref8, Ref8, Ref8, Ref8, Ref6, Ref6, Ref6, Ref5, Ref5, Ref5, Ref5, Ref5, Ref5, Ref5, Ref5, Ref9, Ref9, Ref9, Ref9, Ref9, Ref9, Ref9, Ref9, Ref10, Ref10, Ref10, Ref10, Ref10, Ref10, Ref10, Ref10, Ref11, Ref11, Ref11, Ref11, Ref11, Ref11, Ref11, Ref11, Ref13, Ref13, Ref13, Ref13, Ref13, Ref13, Ref13, Ref13, Ref14, Ref14, Ref14, Ref14, Ref14, Ref14), Temperature in the heap (Ref14), Type of additive (Ref1) and Type of technology (Ref1)
GHG emissions	Additive properties (Ref6), Additive type (Ref6), Bulk density (Ref14), Initial moisture content (Ref6), Moisture content (Ref14), NA (Ref1, Ref1, Ref1, Ref1, Ref1, Ref1, Ref4, Ref4, Ref4, Ref4, Ref4, Ref4, Ref4, Ref4, Ref2, Ref2, Ref2, Ref2, Ref2, Ref2, Ref2, Ref2, Ref3, Ref3, Ref3, Ref3, Ref3, Ref3, Ref3, Ref3, Ref6, Ref6, Ref6, Ref6, Ref6, Ref5, Ref5, Ref5, Ref5, Ref5, Ref5, Ref5, Ref5, Ref9, Ref9, Ref9, Ref9, Ref9, Ref9, Ref9, Ref9, Ref10, Ref10, Ref10, Ref10, Ref10, Ref10, Ref10, Ref10, Ref11, Ref11, Ref11, Ref11, Ref11, Ref11, Ref11, Ref11, Ref12, Ref12, Ref12, Ref12, Ref12, Ref12, Ref12, Ref12, Ref13, Ref13, Ref13, Ref13, Ref13, Ref13, Ref13, Ref13, Ref14, Ref14, Ref14, Ref14, Ref14, Ref14), Type of additive (Ref1) and Type of technology (Ref1)
Nutrients recovery	Additive properties (Ref6), Additive type (Ref6), Application dosage (Ref6), Initial C/N ratio (Ref6), Initial moisture content (Ref6) and NA (Ref4, Ref4, Ref4, Ref4, Ref4, Ref4, Ref4, Ref4, Ref6, Ref6, Ref6, Ref14, Ref14, Ref14, Ref14, Ref14, Ref14, Ref14, Ref14)

4. SYSTEMATIC REVIEW SEARCH STRATEGY

Table 3: Systematic review search strategy - methodology and search parameters.

Parameter	Details
Keywords	WOS: TOPIC: (manure OR slurry OR digestate OR (digested near/3 manure)) AND TOPIC: (management OR storage OR lagoon* OR "anaerobic digest*" OR tank* OR treatment OR process* OR technolog* OR techni* OR (soil near/3 application) OR (soil near/3 distribution) OR (soil near/3 amend*) OR biogas OR precision) AND TOPIC: ("meta-analy*" OR "systematic* review*" OR "evidence map" OR "global synthesis" OR "evidence synthesis" OR "research synthesis") and SCOPUS: TITLE_ABS_KEY: (manure OR slurry OR digestate OR (digested near/3 manure)) AND TITLE_ABS_KEY: (management OR storage OR lagoon* OR "anaerobic digest*" OR tank* OR treatment OR process* OR technolog* OR techni* OR (soil near/3 application) OR (soil near/3 distribution) OR (soil near/3 amend*) OR biogas OR precision) AND TITLE_ABS_KEY: ("meta-analy*" OR "systematic* review*" OR "evidence map" OR "global synthesis" OR "evidence synthesis" OR "research synthesis")
Time reference	No time restriction.
Databases	Web of Science and Scopus: run on 01 July 2021
Exclusion criteria	The main criteria that led to the exclusion of a synthesis paper are: 1) The topic of the meta-analysis is out of the scope of this review., 2) The paper is neither a systematic review nor a meta-analysis of primary research., 3) The analysis is not based on pairwise comparisons, 4) The paper is not written in English., 5) The full text is not available, 6) The analysis did not deal with improved manure storage techniques or dealt with other stages of manure management (e.g. processing, land application, animal housing techniques) and 7) The paper reported studies with absolute values of emission factors, without comparing storage techniques with a reference management scenario. The search returned 263 synthesis papers from WOS and SCOPUS on Manure storage techniques plus other 14 retrieved in the search of other farming practices, potentially relevant for the practice object of our fiche. From the potentially relevant synthesis papers, 96 were excluded after reading the title and abstract, and 40 after reading the full text according to the above-mentioned criteria. Finally,14 synthesis papers were selected.

5. SYNTHESIS PAPERS INCLUDED IN THE REVIEW

Table 4: List of synthesis papers included in this review. More details can be found in the summaries of the meta-analyses.

Ref Num	Author(s)	Year	Title	Journal	DOI
Ref1	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
Ref2	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
Ref3	Emmerling, C; Krein, A; Junk, J	2020	Meta-Analysis of Strategies to Reduce NH3 Emissions from Slurries in European Agriculture and Consequences for Greenhouse Gas Emissions	Agronomy 10, 1633	10.3390 /agronomy10111633
Ref4	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

Ref5	Akdeniz, N	2019	A systematic review of biochar use in animal waste composting	Waste Management	10.1016/j.wasman.2019.03.054
Ref6	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
Ref7	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
Ref8	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
Ref9	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
Ref10	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
Ref11	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
Ref12	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
Ref13	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
Ref14	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

[1] Synthesis research papers include either meta-analysis or systematic reviews with quantitative results. Details can be found in the methodology section of the WIKI.

[2] AMEC – Environment & infrastructure UK limited, in partnership with BIO intelligence service. Collection and analysis of data for the control of emissions from the spreading of manure - Final report 2014 for The European Commission. Available at https://ec.europa.eu/environment/air/pdf/Final%20Report.pdf