Manure land application techniques_GENERAL

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Note to the reader: This general fiche summarises all the environmental and climate impacts of MANURE LAND APPLICATION TECHNIQUES found in a review of 10 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 21 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 land application techniques are used to limit nutrients losses and emissions release during land application of manure (either solid or liquid manure fractions)
- Key descriptors:
  - Here, the main types of improved manure land application techniques considered are:
  - Liquid manure (shallow or deep) placement/injection or solid manure (e.g. poultry litter, cattle manure) immediate incorporation
  - Manure band application by trailing hoses or other equivalent systems
  - Land application with additives (including mainly nitrification inhibitors, lava meal, biochar, superphosphate, sawdust)
  - Land application of processed manure fractions (e.g. digestate, composted, solid fraction, liquid fraction, etc.)
  - Irrigation coupled to manure application
  - Avoid manure application to paddy rice fields.
  - This list is not exhaustive, but covers the improved manure land application techniques found in the meta-analyses meeting the selection criteria of our review.
  - Note that the overall impacts of manure processing techniques (e.g. anaerobic digestion, improved composting, solid-liquid separation, etc.) are not considered here but addressed 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.

Out of the 10 selected synthesis papers, 8 included studies conducted in Europe, and 9 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	NH3	Irrigation coupled to manure application	Conventional management	1	0	0	0
		Land application with additives	Conventional management	0	0	2	1
		Land application with banding	Conventional management	2	0	1	0
		Land application with deep placement or immediate incorporation	Conventional management	5	0	1	2 (1)
Decrease GHG emissions	CH4	Land application with banding	Conventional management	0	1	0	0
		Land application with deep placement or immediate incorporation	Conventional management	1	0	1	0
		No manure on paddy rice fields	Conventional management	1	0	0	0
Decrease GHG emissions	N2O	Land application with additives	Conventional management	1	0	1	0
		Land application with banding	Conventional management	0	0	1	0

		Land application with deep placement or immediate incorporation	Conventional management	1	2	3	1 (0)
		No manure on paddy rice fields	Conventional management	1	0	0	0
Increase Crop yield	Crop yield	Land application with banding	Conventional management	0	0	1	0
		Land application with deep placement or immediate incorporation	Conventional management	1	0	2	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	Livestock type (Ref2) and Manure characteristics (Ref3)

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 land application techniques or dealt with other stages of manure management (e.g. processing, storage, animal housing techniques) and 7) The paper reported studies with absolute values of emission factors, without comparing processing techniques with a reference management scenario. The search returned 263 synthesis papers from WOS and SCOPUS on Manure land application 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 171 after reading the full text according to the above-mentioned criteria. Finally,10 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	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
Ref2	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
Ref3	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
Ref4	Lin, YR; Watts, DB; van Santen, E; Cao, GQ	2018	Influence of Poultry Litter on Crop Productivity under Different Field Conditions: A Meta-Analysis	Agron. J. 807–18	10.2134/agronj2017. 09.0513
Ref5	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
Ref6	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
Ref7	Han, Z; Walter, MT; Drinkwater, LE	2017	N2O emissions from grain cropping systems: a meta-analysis of the impacts of fertilizer-based and ecologically-based nutrient management strategies	NUTRIENT CYCLING IN AGROECOSYSTEMS, 107, 335-355.	10.1007/s10705-017-9836-z
Ref8	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
Ref9	Nkebiwe, PM; Weinmann, M; Bar-Tal, A; Muller, T	2016	Fertilizer placement to improve crop nutrient acquisition and yield: A review and meta-analysis	Field Crops Research 196, 389-401	10.1016/j.fcr.2016.07.018
Ref10	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

[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.