SINGLE-IMPACT FICHE
MANURE PROCESSING TECHNIQUES

IMPACT: AIR POLLUTANTS EMISSIONS

Data extracted in July 2021

Note to the reader: This fiche summarises the impact of manure processing techniques on AIR POLLUTANTS EMISSION (namely: ammonia). It is based on 10 peer-reviewed synthesis research papers[1], including from 38 to 172 individual studies.

1. WEIGHT OF THE EVIDENCE

- CONSISTENCY OF THE IMPACT:

  Manure processing techniques, namely composting, anaerobic digestion and solid-liquid separation, have different effects on ammonia (NH3) emission as compared to raw manure (see **Table 1**). The number of synthesis papers reporting positive, negative or no effect is based on the statistical comparison of the intervention and the control. The number of synthesis papers reporting relevant results, but without statistical test of the effects is labelled as "uncertain":

  - Composting: Among 7 synthesis papers, 5 (4 of high quality) reported a positive effect (i.e. decrease of NH3 emission), while 2 reported negative effect and other 2 no significant effect. The variability of results mainly depends on the considered composting technique (e.g. C/N adjustment, vermicomposting, addition of bulking agents, periodical turning, forced aeration, and/or the use of either chemical or physical or microbial additives to the composting piles).
  - Anaerobic digestion: 3 out of 4 synthesis papers reported no significant effect, 1 a positive effect (i.e. decrease of NH3 emission) and 1 synthesis paper reported uncertain results. Results refer to NH3 emissions at the stage of either storage or land distribution of digested vs raw manure slurries. Results varied according to the configuration of the anaerobic digestion process, e.g. either mono-digestion (only manure) or co-digestion (manure + other substrates) or anaerobic digestion in integration to digestate-treatment technologies, such as filtration, reverse osmosis, microalgae, drying, stripping.
  - Solid-liquid separation: 2 out of 3 synthesis papers reported no significant effect, while 1 a positive effect (i.e. decrease of NH3 emission), at the stage of either storage or land application of either solid or liquid separated fractions, as compared to raw slurry.

  Among the 10 reviewed synthesis papers, 8 include data collected in Europe (see **Table 2**).

Table 1. Summary of effects. The numbers between parenthesis indicate the number of synthesis papers with a quality score of at least 50%. Details on quality criteria can be found in the next section.

Impact	Metric	Intervention (Technique)	Positive	Negative	No effect	Uncertain*
Decrease air pollutants emissions	Ammonia	Composting	5 (4)	2 (2)	2 (2)	0
		Anaerobic digestion	1 (1)	0	3 (3)	1 (0)
		Solid-liquid separation	1 (1)	0	2 (2)	0

* Number of synthesis papers that report relevant results but without statistical test comparison of the intervention and the control.

[1] Research synthesis papers include a formal meta-analysis or systematic reviews with some quantitative results

- QUALITY OF THE SYNTHESIS PAPERS: *The quality score summarises 16 criteria assessing the quality of three main aspects of the synthesis papers: 1) the literature search strategy and studies selection; 2) the statistical analysis; 3) the potential bias. Details on quality criteria can be found in the methodology section of this WIKI*.

2. IMPACTS

The main characteristics and results of the synthesis papers are summarized in **Table 2**. Summaries of the meta-analyses 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.

Table 2. Main characteristics of the synthesis papers reporting impacts of manure processing techniques on ammonia emission.

Reference	Population	Scale	Num. papers	Intervention (technique)	Comparator	Metric	Conclusion	Quality score
Zhang, Z; Liu, D; Qiao, Y; Li, S; Chen, Y; Hu, C 2021	Pig manure composts	China	68	Optimized composting techniques. Optimal C/N ratios, optimal moisture, turning once weekly, intermittent aeration or optimized aeration rates, and using air-dry or hyperthermophilic pretreatment.	No application of technology	NH_3-N loss	Overall, the studied technologies can reduce NH_3 emissions by 32.7%. Controlling feedstock, including the C/N ratio and moisture, could be regarded as N conservation technology.	69%
Zhao, SX; Schmidt, S; Qin, W; Li, J; Li, GX; Zhang, WF 2020	Soild manure and organic waste	Global	52	Mitigation strategies in solid manure composting, i.e. C/N ratio regulation (C/N RR), optimized aeration rate or turning frequency (OAT).	No mitigation technique	NH_3-N loss	Carbon/nitrogen regulation in composting did not reduce NH_3 losses, but optimized aeration rate or turning frequency significantly reduced NH_3-N loss (by 26.9%).	69%
Ba, SD; Qu, QB; Zhang, KQ; Groot, JCJ 2020	Dairy manure composts	Global	41	vermicomposting	No mitigation measure	NH_3emission	Results showed vermicomposting can mitigate NH_3 emission with a ME median value of -33.5% ($p = 0.002$).	69%
Emmerling, C; Krein, A; Junk, J 2020	European agricultural systems with slurry fertilisation	Europe	38	Biological treatment (anaerobic digestion); Solid-liquid separation	No slurry treatment, no storage cover, or band spread application	NH_3 emission	Anaerobic digestion was effective to varying degrees for the abatement of NH_3emission, but also resulted in the increased emission of at least one other greenhouse gas. Solid-liquid separation showed no effect on NH_3 emissions.	50%
Wang, Y; Xue, W; Zhu, Z; Yang, J; Li, X; Tian, Z;Dong, H; Zou, G; 2019	Broiler and layer production (chicken)	Global	96	Manure additives for compost (mineral additives, e.g. H_3PO_4, alum, calcium superphosphate, zeolite; or biochar)	A reference litter based or layer manure belt based system (diet: conventional, in house: no treatment, outdoor: composting, land	NH_3 emission factor	Overall, manure additives during composting (mineral additives, e.g. H_3PO_4, alum, calcium superphosphate, zeolite; or biochar) led to reduce NH_3 emissions of chicken manure treatment and storage in broiler or	62%

Reference	Population	Scale	Num. papers	Intervention (technique)	Comparator	Metric	Conclusion	Quality score
					application: spreading)		layer based systems.	
Ti, CP; Xia, LL; Chang, SX; Yan, XY 2019	European agricultural systems with slurry fertilisation	Global (including EU)	172	Manure aeration, manure turning, anaerobic digestion, solid-liquid separation	No measure	NH_3 emission	Manure aeration and turning showed no significant effect on NH_3 emissions. Anerobic digestion and solid-liquid separation showed no significant effect.	69%
Sajeev, EPM; Winiwarter, W; Amon, B 2018	Pig and cattle manure	Not reported	89	Anaerobic digestion	No abatement options	NH_3 emission	Estimates showed an increase in NH_3 emissions by 13 ± 76% during the storage of anaerobic digested manure and a decrease of 8 ± 34% when applied to the soils. These results are uncertain, because based only on descriptive statistics and not on a model taking into account between-studies variability.	44%
Wang, Y; Dong, HM; Zhu, ZP; Gerber, PJ; Xin, HW; Smith, P; Opio, C; Steinfeld, H; Chadwick, D 2017	Swine manure	Global	142	Anaerobic digestion; Composting with additives	No mitigation strategy	NH_3 emission	Land application of digested slurry as compared to raw manure was not efficient in reducing NH_3 emissions ($p > 0.05$). Composting with additives significantly reduced NH_3 emissions.	62%
Hou, Y; Velthof, GL; Oenema, O 2015	Liquid manure of dairy cows and swine stables	Global	126	Solid-liquid separation, Anaerobic digestion of slurry	Conventional storage technique, surface spreading with broadcast, Raw slurry	NH_3 emission	Emissions of NH_3 were not significantly different between digestates and raw slurry following field application. Significantly lower NH_3 emissions (18%) were found for separated liquid fraction, relative to raw slurry.	88%
Pardo, G; Moral, R; Aguilera, E; del Prado, A 2015	Solid manure (dairy cows, swine, poultry, green waste)	Global	76	Solid manure storage/treatment techniques (turning, forced aeration, compaction, covering, bulking agents, additives)	Solid manure conventional storage (heaps)	NH_3 emission	Turning and forced aeration involve an increase in NH_3 emissions.	69%

3. KNOWLEDGE GAPS

Zhang et al., 2021	The effects of an air-dry pre-treatment on nitrogen losses could be further explored because the losses were not considered during the pre-treatment phase.
Ba et al. 2020	The number of studies quantifying NH_3 emission from dairy manure aerobic composting

	was limited. More attention should be paid to reducing NH_3 losses and improving nitrogen retention in composted products from dairy manure composting process in the future.
Hou et al. 2015	The results collected did not allow comparing management options across animal species (e.g. pigs vs. cattle). Data from both field-and laboratory-scale studies were included in our database as data solely from field-scale studies were insufficient.