SINGLE-IMPACT FICHE
MANURE STORAGE TECHNIQUES

IMPACT: NUTRIENTS RECOVERY

Data extracted in July 2021
Fiche created in February 2024

Note to the reader: This fiche summarises the effects of Manure storage techniques on NUTRIENTS RECOVERY. It is based on 3 synthesis papers[1], including from 76 to 114 primary studies.

1. WEIGHT OF THE EVIDENCE

CONSISTENCY OF THE IMPACT

The literature review shows that generally manure storage techniques can decrease overall the nitrogen losses (**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.

- Storage with additives (either chemical or physical), compared to no substance addition: all 3 synthesis papers reported positive effect (i.e. decrease of total nitrogen loss) for several types of physical additives (zeolite, biochar, medical stone, grape seeds and physical mixtures) and chemical additives (acidic substances, metal salts, phosphogypsum, Mg-P salts, Ca-superphosphate, nitrification inhibitors, and chemical mixtures), as described in Table 2.
- Storage covers, compared to uncovered storage: 2 out of 2 synthesis papers reported positive effect (i.e. decrease of total nitrogen loss), for different types of cover (e.g. plastic films, floating inert materials, floating biomass, floating oil layers, natural crusts, etc.) see Table 2.
- Storage with microbial inocula, compared to no inoculation: 2 synthesis papers reported positive effect (i.e. decrease of total nitrogen loss) for microbial inocula addition to solid manure heaps such as nitrite oxidizing bacteria, nitrogen turnover bacteria and compound microbial agents (see Table 2).
- Compaction during storage, compared to no compaction: the only synthesis paper reported non-significant effects for compaction of (solid) manure heaps.

All selected synthesis papers included studies conducted in Europe (see **Table 2**).

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. The reference numbers of the synthesis papers reporting each of the effects are provided in **Table 3**. 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	
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

QUALITY OF THE SYNTHESIS PAPERS

The quality of each synthesis paper was assessed based on 16 criteria regarding three main aspects: 1) the literature search strategy and primary studies selection; 2) the statistical analysis conducted; and 3) the evaluation of potential bias. We assessed whether authors addressed and reported these criteria. Then, a quality score was calculated as the percentage of these 16 criteria properly addressed and reported in each synthesis paper. Details on quality criteria can be found in the methodology section of this WIKI.

2. IMPACTS

[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.

The main characteristics and results of the 3 synthesis papers are reported in **Table 2** with the terminology used in those papers, while **Table 3** shows the reference numbers of the synthesis papers reporting for each of the results shown in **Table 1**. Comprehensive 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, are provided in the **summaries of the synthesis papers** available in this WIKI.

Table 2: Main characteristics of the synthesis papers reporting effects on nutrients recovery. The references are ordered chronologically with the most recent publication date first.

Reference number	Population	Scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
Ref4	Soild manure and organic waste	Global	114	Mitigation strategies in solid manure storage, i.e. microbial inoculation (MI), physical additives (PA), chemical additives (CA), covering (CO). Physical additives were classified into clay, zeolite and biochar. Chemical additives were classified into six types: acidic substances (apple pomace, citric acid, elemental sulphur, phosphoric acid, bamboo vinegar), metal salts ($FeCl_3$, $CaCl_2$, $MgCl_2$, $MgSO_4$), gypsum, Mg-P salts ($Mg(OH)_2 + H_3PO_4$, $MgSO_4 + H_3PO_4$, $MgO + H_3PO_4$, $MgCl_2 + H_3PO_4$, $MgSO_4 + KH_2PO_4$, $MgCl_2 + KH_2PO_4$, $Ca(H_2PO_4)_2 + MgSO_4$), Ca-superphosphate ($Ca(H_2PO_4)_2$), and nitrification inhibitor DCD.	No mitigation technique	Total nitrogen loss	The reduction of total nitrogen losses across all technologies was statistically, and averaged chemical additives 38.1%, physical additives 28.6%, C/N regulation 27.9%, covering 27.8%, optimized aeration 26.9%, and microbial inocula 20.1%. Biochar and magnesium-phosphate salts emerged as the most effective N-conserving strategies.	69%
Ref6	Livestock manure, food waste, sewage sludge and/or green waste	Global	105	Additives (chemical additives, e.g. phosphate, magnesium salts, superphosphate, gypsum etc.; physical additives, e.g. biochar, zeolite, bentonite, etc.; microbial additives, e.g. nitrite-oxidizing bacteria (NOB), NTB (ammonifiers, nitrobacteria, azotobacter) agent, etc.)	No additive	TN losses, in terms of cumulative TN losses as a proportion of the TN of the initial composting material	This first global meta-analysis establishes that the use of additives can significantly reduce the TN loss during composting.	62%
Ref14	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)	Total-N losses	Covering and compaction have positive and no effect, respectively. The use of specific additives reduces total nitrogen losses. Nevertheless, their effectiveness varies depending on the substance, dosage, and operational conditions.	69%

Table 3: Reference numbers of the synthesis papers reporting for each of the results shown in **Table 1**.

				Statistically tested			Non-statistically tested
Impact	Metric	Intervention	Comparator	Significantly positive	Significantly negative	Non-significant	
Increase nutrients recovery	Total nitrogen loss	Compaction during storage	Conventional management			Ref14	
		Storage covers	Conventional management	Ref4 and Ref14			
		Storage with additives	Conventional management	Ref4, Ref6 and Ref14			
		Storage with microbial inocula	Conventional management	Ref4 and Ref6			

3. FACTORS INFLUENCING THE EFFECTS ON NUTRIENTS RECOVERY

Table 4: List of factors reported to significantly affect the size and/or direction of the effects on nutrients recovery, according to the synthesis papers reviewed.

Factor	Reference number
Additive properties	Ref6
Additive type	Ref6
Application dosage	Ref6
Initial C/N ratio	Ref6
Initial moisture content	Ref6
NA	Ref4, Ref4, Ref4, Ref4, Ref4, Ref4, Ref4, Ref4, Ref6, Ref6, Ref6, Ref14, Ref14, Ref14, Ref14, Ref14, Ref14, Ref14 and Ref14

4. KNOWLEDGE GAPS

Table 5: Knowledge gap(s) reported by the authors of the synthesis papers included in this review.

Ref Num	Gap

5. SYNTHESIS PAPERS INCLUDED IN THE REVIEW

Table 6: 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
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
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
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