SINGLE-IMPACT FICHE
MANURE PROCESSING TECHNIQUES

IMPACT: ANTI-MICROBIAL RESISTANCE

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Note to the reader: This fiche summarises the effects of Manure processing techniques on ANTI-MICROBIAL RESISTANCE . It is based on 1 synthesis paper[1] containing 98 primary studies.

1. WEIGHT OF THE EVIDENCE

CONSISTENCY OF THE IMPACT

Different manure processing techniques showed different effects on antimicrobial resistance, at the stage of land application of treated manure, as compared to raw manure (**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.

- Either manure drying, composting, or anaerobic digestion, have positive effects on antimicrobial resistance (i.e. decrease of antimicrobial resistance, measured as the concentration of antibiotic resistant microbes and genes in environmental compartments after treated vs untreated manure land application) according to the 1 available synthesis paper.
- Other techniques, namely pasteurization, anaerobic lagoon, storage, aerobic lagoon storage and (solid manure) pile storage showed non-significant effect on antimicrobial resistance.

The selected synthesis paper 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	
Decrease anti-microbial resistance	Antibiotic resistant microbes/genes	Anaerobic digestion	Conventional management	1	0	0	0
		Composting	Conventional management	1	0	0	0
		Drying	Conventional management	1	0	0	0
		Land application of aerobic lagoon stored manure	Conventional management	0	0	1	0
		Land application of anaerobic lagoon stored manure	Conventional management	0	0	1	0
		Land application of pile-stored solid manure	Conventional management	0	0	1	0
		Pasteurization	Conventional management	0	0	1	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.

[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. IMPACTS

The main characteristics and results of the 1 synthesis paper is 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 paper reporting effects on anti-microbial resistance .

Reference number	Population	Scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
Ref5	Livestock waste and sewage sludge	Global	98	Six types of treatments were considered: aerobic and anaerobic digestion, aerobic and anaerobic lagoon storage, composting, drying, pasteurization and pile storage.	No treatment	Relative abundance of antibiotic resistance markers (e.g., number of antibiotic resistance genes copies in total microbial biomass estimated by number of 16S rRNA copies in environmental sample).	The authors obtained significant results for composting, drying and a (non-significant) trend for anaerobic digestion in reducing ARG/MGE relative abundance, when organic waste treatments were compared together in the same model. Thermophilic treatments showed greater reductions in ARG/MGE relative abundance than mesophilic ones after anaerobic digestion. Consequently, treatments with thermophilic phases should be implemented before the application of organic waste products on agricultural soils. Pasteurization resulted in non-significant effect, due to a large variability and low number of observations (N=4). Anaerobic or aerobic lagoon storage and solid manure pile storage have no significant effect on antibiotic resistance genes.	100%

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	
Decrease anti-microbial resistance	Antibiotic resistant microbes/genes	Anaerobic digestion	Conventional management	Ref5			
		Composting	Conventional management	Ref5			
		Drying	Conventional management	Ref5			
		Land application of aerobic lagoon stored manure	Conventional management			Ref5	
		Land application of anaerobic lagoon stored manure	Conventional management			Ref5	
		Land application of pile-stored solid manure	Conventional management			Ref5	
		Pasteurization	Conventional management			Ref5	

3. FACTORS INFLUENCING THE EFFECTS ON ANTI-MICROBIAL RESISTANCE

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

Factor	Reference number
NA	Ref5, Ref5, Ref5, Ref5, Ref5 and Ref5
Temperature	Ref5
Type of manure	Ref5

4. KNOWLEDGE GAPS

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

Ref Num	Gap
Ref5	Variability of confidence intervals across studies could be explained at least by the diversity of substrates (manure, sludge, milk or mixtures), the abundances of antibiotic-resistant bacteria before treatment, the diversity of microbial community, and/or the diversity and concentrations of antibiotics tested. To address those hypotheses, more replicates of studies are needed and deeper chemical and microbial characterization of the environmental matrices is needed. The authors also identified a knowledge gap on possible other interventions.

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
Ref5	Goulas, A; Belhadi, D; Descamps, A; Andremont, A; Benoit, P; Courtois, S; Dagot, C; Grall, N; Makowski, D; Nazaret, S; Nelieu, S; Patureau, D; Petit, F; Roose-Amsaleg, C; Vittecoq, M; Livoreil, B; Laouenan, C	2020	How effective are strategies to control the dissemination of antibiotic resistance in the environment? A systematic review	Environmental Evidence 9, 1–32	10.1186/s13750-020-0187-x

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