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Data Article

Summary of performance data for technologies to control gaseous, odor, and particulate emissions from livestock operations: Air management practices assessment tool (AMPAT)



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ABSTRACT

The livestock and poultry production industry, regulatory agencies, and researchers lack a current, science-based guide and data base for evaluation of air quality mitigation technologies. Data collected from science-based review of mitigation technologies using practical, stakeholders-oriented evaluation criteria to identify knowledge gaps/needs and focuses for future research efforts on technologies and areas with the greatest impact potential is presented in the Literature Database tab on the air management practices tool (AMPAT). The AMPAT is web-based (available at www.agronext.iastate.edu/ampat) and provides an objective overview of mitigation practices best suited to address odor, gaseous, and particulate matter (PM) emissions at livestock operations. The data was compiled into Excel spreadsheets from a literature review of 265 papers was performed to (1) evaluate mitigation technologies performance for emissions of odor, volatile organic compounds (VOCs), ammonia (NH₃), hydrogen sulfide (H₂S), particulate matter (PM), and greenhouse gases (GHGs) and to (2) inform future research needs.

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Specifications Table

Subject area	<i>Agricultural and Biological Sciences, Engineering, Environmental Sciences</i>
More specific subject area	<i>Air Pollution Control, Livestock Production Systems</i>
Type of data	<i>Figures, tables</i>
How data was acquired	<i>Literature Review of 265 articles up to 2014 [1–265]</i>
Data format	<i>Raw</i>
Experimental factors	<i>The literature database construction started with compiling literature with the use of online scientific databases, such as Web of Science. Database searches were performed with the keywords: odor, air quality, livestock, poultry, swine, dairy, beef, volatile organic compounds, ammonia, hydrogen sulfide, greenhouse gas, emissions, mitigation, housing, manure storage, and manure land application.</i>
Experimental features	<i>The literature review consisted of four steps including (1) compilation of literature, (2) review of experimental information (reference, experimental design, technology performance, scope of study, etc.), (3) compilation and organization of study information into standardized spreadsheets, and (4) evaluation of technology and coding for mitigation performance.</i>
Data source location	<i>Department of Agricultural and Biosystems Engineering at Iowa State University, Ames, Iowa 50011, USA</i>
Data accessibility	<i>Data is within this article.</i>

Value of the data

- This data is the most comprehensive performance summary of air pollution control technologies applicable to livestock production systems. This data was collected from 265 published sources [1–265].
- Researchers and regulatory agencies need a summary and repository of air pollution mitigation technologies data.
- This data can help livestock producers make better decisions on technologies that are available to solve their emissions problems.
- Air pollution mitigation data is grouped by livestock and poultry species, and laboratory, pilot, and farm scale proven performance. This data shows where the knowledge gaps are in regards to emissions mitigation.
- This data shows what tradeoffs may have to be considered in implementing a particular mitigation technology.

1. Data

The data presented here is organized reduction values from the literature in regards to livestock emissions mitigation technologies. The data is organized in three Excel files based on the source of emissions: Animal Housing, Land Application and Manure Storage and Handling. Within each file there are four worksheet tabs corresponding to an individual livestock species: Swine, Poultry, Dairy and Beef. Under each species tab there are multiple tables corresponding to a mitigation technology. Within each table there are multiple literature references pertaining to that technology along with the observed reductions in emissions from each reference. Emission reductions in each table correspond to one of six emissions areas: Ammonia, Hydrogen Sulfide, Odor, Dust/Particulates, Volatile Organic Compounds, and Greenhouse Gases.

The data contains 467 technology entries with 670 emissions inputs from 265 papers [1–265]. Many papers contained data on more than one animal/poultry species, technology and/or an air

Table 1

Farm/Field Scale-Tested Technologies with Emissions Reductions Greater Than 66%. (See Tables 2–5 and Supplemental Material for more detailed data).

Species	NH ₃	H ₂ S	Odor	PM	VOCs	CO ₂	CH ₄	N ₂ O	CO ₂ eq
Swine	scrubbers, urine/feces separation, aeration, solids removal, injection/incorporation and timing	biogas collection/purification	barriers, aeration, impermeable covers, permeable covers	biofilters	biofilter, injection/incorporation	NA	urine/feces separation, aeration, solids removal	solids removal	injection/incorporation
Poultry	landscaping	NA	barriers	NA	NA	NA	NA	NA	NA
Dairy	NA	biofilters, aeration, impermeable covers	aeration, impermeable covers	NA	aeration, impermeable covers	NA	NA	NA	NA
Beef	injection/incorporation	NA	NA	stocking density	NA	NA	NA	manure treatment	NA

Note: NA=None available or not performing at this level.

pollutant emission. Of those 670 emissions inputs, only ~35% of data pertain to farm/field-scale testing. Similarly, ~19% of data in the manure storage and handling category, ~63% in the manure land application category, and ~43% in the housing category pertain to farm/field-scale. Technologies that were tested at farm/field-scale and had reported emissions reduction > 66% shown in Table 1. These technologies are also highlighted with green color in data (i.e., in three Supplemental Material spreadsheets for Animal Housing, Land Application, and Manure Storage & Handling, respectively). Selected summary of data for the average % reductions in this database is shown in Tables 2–5. Table 1 summarizes technologies that had % reductions > 66% for at least one target air pollutant. The following list is a count of specific data categories out of the 467 technology inputs:

- 243 for Swine
- 81 for Poultry
- 86 for Dairy
- 57 for Beef
- 191 for Housing
- 199 for Storage and Handling
- 77 for Land Application

The 670 emission inputs consisted of:

- 207 for Ammonia
- 57 for Hydrogen Sulfide
- 102 for Odor
- 50 for Dust/PM
- 36 for VOCs
- 52 for Carbon Dioxide
- 82 for Methane
- 71 for Nitrous Oxide
- 13 for Carbon Dioxide Equivalents

Table 2 (continued)

		Scale								
Manure Additives	All Scales	49	67	47	64	3	64			
	Farm/Field Scale									
Permeable Covers	All Scales	54	50	54	25	3	12	-183		
	Farm/Field Scale	0		78	49					
Solids	All Scales	75		31	25	25	64	75		
	Farm/Field Scale	87		56	25		100	75		
Urine/Feces Segregation	All Scales	66		51					0	
	Farm/Field Scale	73		60			71			
Manure Land Application	Injection/Incorporation	All Scales	78		74	74	0	-969	-101	63
		Farm/Field Scale	76		49	74	0	-969	-116	74
	Timing	All Scales	69				0	0	65	
		Farm/Field Scale	69				0	0	55	

Note: Only technologies for which emissions reduction > 66% were reported for at least one target air pollutant category were included in this table. Values are averages of comparable data across literature in the database. Percent reductions color coded in gray scale by 33% intervals with > 66%: White, < -66%: Dark Gray and No Data: Black. Negative values indicate increase in emissions.

spreadsheets, and (4) evaluation of technology and coding for mitigation performance. The literature database construction started with compiling literature with the use of online scientific databases, such as Web of Science.

Database searches were performed with the keywords:

1. Odor, air quality, livestock, poultry, swine, dairy, beef, volatile organic compounds, ammonia, hydrogen sulfide, greenhouse gas, emissions, mitigation, housing, manure storage, and manure land application.

The compiled literature was then reviewed and relevant information regarding the experiments conducted, technologies used, emission that were measured, reduction of those emissions, year of publication, DOI or link to literature, cost of implementing the technology, and full reference were extracted. The extracted information was then compiled in standardized spreadsheets according to species and source of emission: housing, manure storage and handling, or manure land application (Fig. 2). If percent emission reductions were not explicitly given in the literature it was calculated if enough other information was available using Eq. (1).

$$\%Reduction = \left(1 - \frac{Treated}{Control} \right) \times 100 \tag{1}$$

The % reductions for each target emission were color coded in the spreadsheets for quick visual indication of relative effectiveness.

The color coding was broken down into three air pollution mitigation technology performance sections:

1. red = < 33% reduction,

Table 3
Poultry – selected data summary

Table 3. Poultry - Selected Data Summary

Species	Source	Technology	Scale	Target Emission Percent Reduction								
				NH ₃	H ₂ S	Odor	PM	VOCs	CO ₂	CH ₄	N ₂ O	CO ₂ eq
Poultry	Animal Housing	Barriers	All Scales		-200	65	60					
			Farm/Field Scale		-200	70	60					
		Biofilters	All Scales	51	80	67	68		10			
			Farm/Field Scale									
		Landscaping	All Scales	66		18	59					
			Farm/Field Scale	76		26	65					
	Scrubbers	All Scales	77		42	52						
		Farm/Field Scale				64						
	UV Light	All Scales	28	55	69	16	52	11	21	4		
		Farm/Field Scale	16			16		11	21	4		
	Manure Storage and Handling	Acidification	All Scales	70								
			Farm/Field Scale									
Composting		All Scales	35				90					
		Farm/Field Scale	40									
Impermeable Covers		All Scales	75					0				
		Farm/Field Scale										
Scrubbers	All Scales	79										
	Farm/Field Scale	79										
Manure Land Application	Injection/Incorporation	All Scales	70					0				
		Farm/Field Scale	70					0				

Note: Only technologies for which emissions reduction > 66% were reported for at least one target air pollutant category were included in this table. Values are averages of comparable data across literature in the database. Percent reductions color coded in gray scale by 33% intervals with > 66%: White, < -66%: Dark Gray and No Data: Black. Negative values indicate increase in emissions.

Table 4
Dairy – selected data summary

Table 4. Dairy - Selected Data Summary

Species	Source	Technology	Scale	Target Emission Percent Reduction								
				NH ₃	H ₂ S	Odor	PM	VOCs	CO ₂	CH ₄	N ₂ O	CO ₂ eq
Dairy	Animal Housing	Biofilters	All Scales	44	81					0	40	1
			Farm/Field Scale	59	81					0	15	3
		Acidification	All Scales	97	-1705	0				75		
			Farm/Field Scale									
		Aeration	All Scales	-86	96	80		67	43	2		
			Farm/Field Scale		96	80		94				
	Manure Storage and Handling	Composting	All Scales						-102	70	-388	
			Farm/Field Scale									
		Impermeable Covers	All Scales		96	80		94				
			Farm/Field Scale		96	80		94				
	Manure Additives	All Scales	44	90					48	29		
		Farm/Field Scale										
Permeable Covers	All Scales	40	72	50				26	-3	-30		
	Farm/Field Scale											
Manure Land Application	Injection/Incorporation	All Scales	65		90			45		14		
		Farm/Field Scale	58							14		

Note: Only technologies for which emissions reduction > 66% were reported for at least one target air pollutant category were included in this table. Values are averages of comparable data across literature in the database. Percent reductions color coded in gray scale by 33% intervals with > 66%: White, < -66%: Dark Gray and No Data: Black. Negative values indicate increase in emissions.

Table 5
Beef – selected data summary

Species	Source	Technology	Scale	Target Emission Percent Reduction								
				NH ₃	H ₂ S	Odor	PM	VOCs	CO ₂	CH ₄	N ₂ O	CO ₂ eq
Beef	Manure Storage and Handling	Permeable Covers	All Scales	75		62			-6	-16		
			Farm/Field Scale									
		Stocking Density	All Scales				80					
	Farm/Field Scale					80						
	Manure Land Application	Injection/Incorporation	All Scales	79		90						
			Farm/Field Scale	73						60	67	
Timing		All Scales									69	
	Farm/Field Scale											
Manure Treatment	Manure Treatment	All Scales	48						57	75		
		Farm/Field Scale	48						57	75		

Note: Only technologies for which emissions reduction > 66% were reported for at least one target air pollutant category were included in this table. Values are averages of comparable data across literature in the database. Percent reductions color coded in gray scale by 33% intervals with > 66%: White, < -66%: Dark Gray and No Data: Black. Negative values indicate increase in emissions.

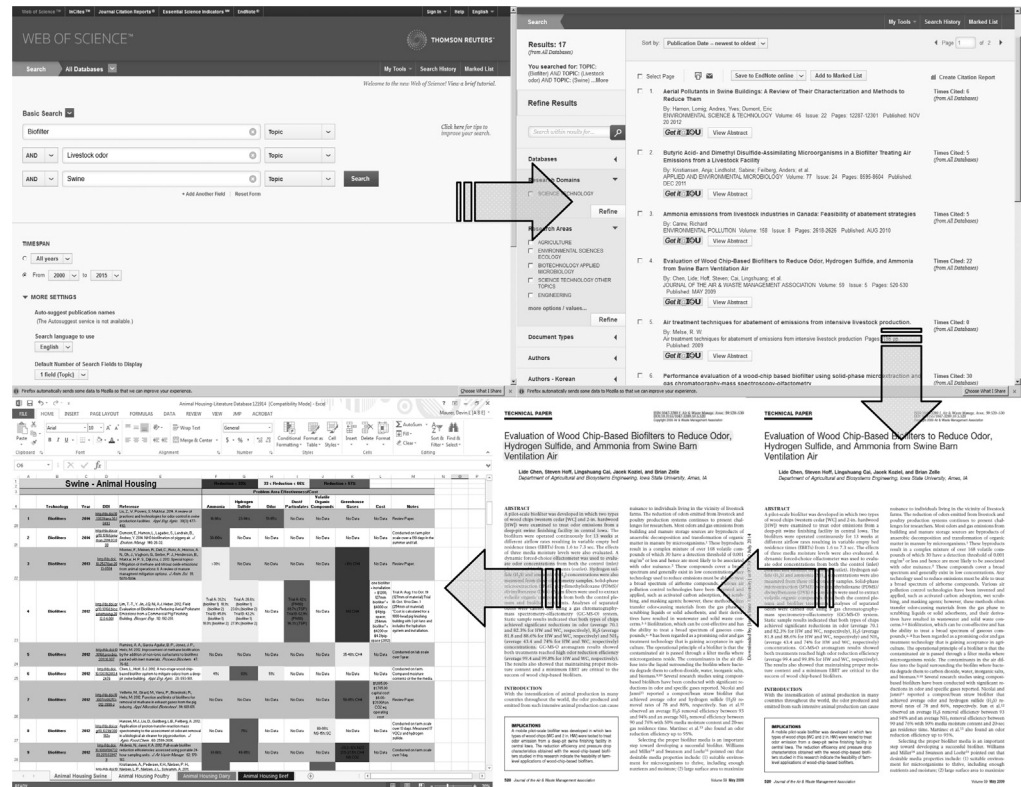


Fig. 1. Literature review and information acquisition flow chart.

Swine - Animal Housing				Reduction < 33%		33 < Reduction < 66%		Reduction > 67%			
Technology	Year	DOI	Reference	Problem Area Effectiveness/Cost							
				Ammonia	Hydrogen Sulfide	Odor	Dust/ Particulates	Volatile Organic Compounds	Greenhouse Gases	Cost	Notes
10	Biofilters	2011	http://dx.doi.org/10.1016/j.syst.2010.11.022 Kristiansen, A., Pedersen, K.H., Nielsen, P.H., Nielsen, L.P., Nielsen, J.L., Schwamm, A. 2011. Bacterial community structure of a full-scale biofilter treating pig house exhaust air. <i>Syst. Appl. Microbiol.</i> 34: 344-352	70-97%	No Data	No Data	No Data	70-94%	No Data	No Data	Conducted on farm scale.
11	Biofilters	2011	http://dx.doi.org/10.1016/j.appl.2011.01.05 Kristiansen, A., Lindstedt, S., Feilberg, A., Nielsen, P.H., Neufeld, J.D., Nielsen, J.L. 2011. Sulfate acid and dimethyl disulfide-accumulating microorganisms in a biofilter treating air emissions from a livestock facility. <i>Appl. Environ. Microb.</i> 77: 8595-8604.	90%	~9%	No Data	No Data	>70% VFAs 29-50% S VOCs 81% phenol 89% p-cresol 88% 4-ethylphenol 48% indole 69% stearic	No Data	No Data	Conducted on farm scale.
12	Biofilters	2011	http://www.oxonkroon.pl/files/dok_pap2010_m.com_confir03black-wednesday-3003.htm#i=749 Tymoczko, L., Chmielowiec-Koczonowska, A., Raczynska, J., Dabak, A. 2011. Removal of microbial contaminants from pig house air using biofilter organic media. <i>Ann. Anim. Sci.</i> 11: 453-464.	No Data	No Data	No Data	No Data	No Data	No Data	No Data	Conducted on farm over 6 months. Compared different media on microbial removal. 36-100% bacteria and fungi reduction.
13	Biofilters	2011	http://dx.doi.org/10.1016/j.biortech.2011.01.058 Akdemir, N., Janni, K.A., Saitnikov, I.A. 2011. Biofilter performance of pine needles and lava rock as media. <i>Biosour. Technol.</i> 102: 4974-4989.	56%	88%	<48%	No Data	87%	25% CH ₄ 0.7% N ₂ O	No Data	Conducted on farm over 6 months. Compared pine chips and lava rock media. Value for VOCs is total reduced sulfur.
14	Biofilters	2009	http://dx.doi.org/10.13031/2013.26330 Hoff, S.J., Hamon, J.D., Chen, L., Janni, K.A., Schmidt, D.R., Nicols, R.E., Jacobsen, L.D. 2009. Partial biofiltration of exhaust air from a hybrid ventilated deep pit swine finisher barn. <i>Appl. Eng. Agric.</i> 25: 269-280.	58%	No Data	37%	No Data	No Data	No Data	No Data	Conducted on farm scale over 5 months.
15	Biofilters	2009	http://dx.doi.org/10.1016/j.biortech.2009.05.020 Chen, L., Hoff, S., Cai, L., Korad, J., Zelle, B. 2009. Evaluation of wood chip-based biofilters to reduce odor, hydrogen sulfide, and ammonia from swine barn ventilation air. <i>J. Air Waste Manage.</i> 59: 520-530.	74%, 43.4%	88.6%, 81.9%	82.3%, 70.1%	No Data	99.6%, 99.4%	No Data	No Data	Conducted on farm over 13 weeks. Compared western cedar and hardwood wood chips respectively.
16	Biofilters	2008	http://dx.doi.org/10.13031/2013.25267 Ho, K.S., McCormick, L.L., Johnson, M.H., Hart, P.G., Parker, D. 2008. Limestone treatment using PVA coated powdered activated carbon biofilter. <i>Appl. Eng. Agric.</i> 24: 791-798.	80%	91%	No Data	No Data	No Data	increased H ₂ O NO, CH ₄	No Data	Conducted on lab scale over 37 days.
17	Biofilters	2008	http://dx.doi.org/10.1016/j.biortech.2008.01.085 Chen, L., Hoff, S.J., Korad, J.A., Cai, L., Zelle, B., Sun, G. 2008. Performance evaluation of a wood-chip based biofilter using solid phase microextraction and gas chromatography-mass spectrometry-oligonucleotide. <i>Biosour. Technol.</i> 99: 770-778.	No Data	No Data	No Data	No Data	76-93%	No Data	No Data	Conducted on farm over 13 weeks. Compared western cedar and hardwood wood chips.
18	Biofilters	2007	http://dx.doi.org/10.1016/j.biortech.2007.07.081 Riz, A.L., Lyngby, M. 2007. Odour and ammonia reductions in ventilation air from growing finishing pig units using wettable biofilters. <i>BioTechniques for Air Pollution Control II</i> . 77-83.	60-14%	No Data	58-60%	No Data	No Data	No Data	No Data	Conducted on farm scale in winter and summer.
19	Biofilters	2004	http://www.lwa-ponline.com/webContent/04090293.htm Malow, R.W., Mol, G. 2004. Odour and ammonia removal from pig house exhaust air using a biofiltering filter. <i>Water Sci. Technol.</i> 50: 275-282.	79%	No Data	49%	No Data	No Data	No Data	No Data	Conducted on farm scale over 72 days.
20	Biofilters	2002	http://dx.doi.org/10.1016/S0969-8596(02)00034-5 Shepherd, B.A., Cuman, T.P., Dodd, V.A. 2002. Assessment of the influence of media particle size on the biofiltration of odorous exhaust ventilation air from a piggery facility. <i>Biosour. Technol.</i> 94: 129-143.	64-93%	No Data	88-95%	No Data	-147-66% SO ₂	No Data	No Data	Conducted on pilot scale over 63 days.
21	Biofilters	2002	http://dx.doi.org/10.1006/biot.2002.02083 Shepherd, B.A., Cuman, T.P., Dodd, V.A., Calligan, J. 2002. Biofiltration of odour and ammonia from a pig unit: a pilot-scale study. <i>Biosyst. Eng.</i> 82: 441-453.	54-93%	No Data	77-95%	No Data	No Data	No Data	No Data	Conducted on pilot scale.
22	Biofilters	2002	http://www.eng.oxonkroon.pl/files/dok_pap2002_m.com_confir03black-wednesday-3003.htm#i=749 Marr, D. D., DeBayer, J. C., Zhang, Q. 2002. Design and evaluation of an open biofilter for treatment of odour from swine barns during sub-zero ambient temperatures. <i>Can. Biosyst. Eng.</i> 44: 21-26.	No Data	No Data	60-94%	No Data	No Data	No Data	No Data	Conducted on farm scale over 6 months.

Fig. 2. Example of literature database spreadsheet. [7,35,37,78,107,108,134,141,199,201,208,209,231] (web link: <http://www.agnronex.iastate.edu/ampat/database/homepage.html>).

2. yellow > 33% and = < 67% reduction, or
3. green = > 67% reduction.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.dib.2016.03.070>.

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