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

**Abstract**
The livestock and poultry production industry, regulatory agencies, and researchers lack a current, science-based guide and database for evaluation of air quality mitigation technologies. Data collected from a 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.

**Keywords**
Air pollution, Mitigation, Livestock production, Odor, Volatile organic compounds, Ammonia, Hydrogen sulfide, Greenhouse gases, Particulate matter, Manure, Literature review

**Disciplines**
Agriculture | Bioresource and Agricultural Engineering

**Comments**
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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)

Devin L. Maurer, Jacek A. Koziel*, Jay D. Harmon, Steven J. Hoff, Angela M. Rieck-Hinz, Daniel S. Andersen

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Hydrogen sulfide
Greenhouse gases
Particulate matter
Manure
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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                          | Agricultural and Biological Sciences, Engineering, Environmental Sciences
| More specific subject area           | Air Pollution Control, Livestock Production Systems
| Type of data                         | Figures, tables
| How data was acquired                | Literature Review of 265 articles up to 2014 [1–265]
| Data format                          | Raw

**Experimental factors**

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.

**Experimental features**

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.

Data source location

Department of Agricultural and Biosystems Engineering at Iowa State University, Ames, Iowa 50011, USA

Data accessibility

Data is within this article.

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...
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>
<thead>
<tr>
<th>Species</th>
<th>NH3</th>
<th>H2S</th>
<th>Odor</th>
<th>PM</th>
<th>VOCs</th>
<th>CO2</th>
<th>CH4</th>
<th>N2O</th>
<th>CO2eq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swine</td>
<td>scrubbers,</td>
<td>biogas collection/</td>
<td>barriers,</td>
<td>biofilters</td>
<td>biofilter,</td>
<td>solids removal</td>
<td>injection/</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>urine/feces separation,</td>
<td>purification</td>
<td>aeration,</td>
<td>incorporation</td>
<td>injection/</td>
<td>incorporation</td>
<td>incorporation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>aeration,</td>
<td>impermeable covers,</td>
<td>impermeable covers,</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>solids removal,</td>
<td>permeable covers</td>
<td>permeable covers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>injection/</td>
<td>timing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poultry</td>
<td>landscaping</td>
<td>NA</td>
<td>barriers</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Dairy</td>
<td>NA</td>
<td>biofilters,</td>
<td>aeration,</td>
<td>NA</td>
<td>aeration,</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<td></td>
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<td>impermeable covers</td>
<td>impermeable covers</td>
<td></td>
<td>impermeable covers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td>injection/</td>
<td>NA</td>
<td>stocking density</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>manure treatment</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>

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

2. Experimental design, materials and methods

The literature review consisted of four steps (Fig. 1) 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

| Table 2 |
| Swine – selected data summary |

<table>
<thead>
<tr>
<th>Species</th>
<th>Source</th>
<th>Technology</th>
<th>Scale</th>
<th>NH₃</th>
<th>H₂S</th>
<th>Odor</th>
<th>PM</th>
<th>VOCs</th>
<th>CO₂</th>
<th>CH₄</th>
<th>N₂O</th>
<th>CO₂eq</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Barriers</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>-200</td>
<td>65</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-200</td>
<td>70</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Biofilters</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>57</td>
<td>63</td>
<td>66</td>
<td>78</td>
<td>61</td>
<td>0</td>
<td>24</td>
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<td></td>
<td></td>
<td>57</td>
<td>59</td>
<td>59</td>
<td>78</td>
<td>77</td>
<td>0</td>
<td>17</td>
<td>-10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Landscaping</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>50</td>
<td>85</td>
<td>48</td>
<td>45</td>
<td>25</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Oil Sprinkling/Spraying/Additives</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>39</td>
<td>30</td>
<td>38</td>
<td>70</td>
<td>64</td>
<td>25</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Urine/Feces Segregation</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>38</td>
<td>18</td>
<td>28</td>
<td>66</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Scrubbers</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>79</td>
<td>33</td>
<td>67</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Urine/Feces Segregation</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>78</td>
<td></td>
<td>64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>UV Light</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>63</td>
<td>51</td>
<td>12</td>
<td>69</td>
<td>-100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Biogas Collection/Purification</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>73</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Aeration</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>28</td>
<td>55</td>
<td>69</td>
<td>16</td>
<td>52</td>
<td>11</td>
<td>21</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>Anaerobic Digestion</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>16</td>
<td></td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Manure Storage and Handling</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>95</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Composting</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>56</td>
<td>0</td>
<td>72</td>
<td>43</td>
<td>79</td>
<td>38</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Diet Manipulations</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>84</td>
<td>72</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Impermeable Covers</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>0</td>
<td>58</td>
<td>0</td>
<td>75</td>
<td>43</td>
<td>41</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Landscaping</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>6</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td>34</td>
<td>-685</td>
<td>68</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Impermeable Covers</strong></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>28</td>
<td>27</td>
<td>35</td>
<td>83</td>
<td>15</td>
<td>4</td>
<td>-30</td>
<td>13</td>
<td>-21</td>
</tr>
</tbody>
</table>
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).

\[
\text{\% Reduction} = \left(1 - \frac{\text{Treated}}{\text{Control}}\right) \times 100
\]  

(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>
<thead>
<tr>
<th>Species</th>
<th>Source</th>
<th>Technology</th>
<th>Scale</th>
<th>NH$_3$</th>
<th>H$_2$S</th>
<th>Odor</th>
<th>PM</th>
<th>VOCs</th>
<th>CO$_2$</th>
<th>CH$_4$</th>
<th>N$_2$O</th>
<th>CO$_2$eq</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Barriers</td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>-20</td>
<td>65</td>
<td>60</td>
<td></td>
<td></td>
<td>10</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>-20</td>
<td>70</td>
<td>60</td>
<td></td>
<td></td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Animal Housing</td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>51</td>
<td>80</td>
<td>67</td>
<td>68</td>
<td></td>
<td>10</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>51</td>
<td>80</td>
<td>67</td>
<td>68</td>
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<td>10</td>
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<tr>
<td></td>
<td>Landscaping</td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>66</td>
<td>18</td>
<td>59</td>
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<tr>
<td></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>77</td>
<td>42</td>
<td>52</td>
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<tr>
<td></td>
<td>Scrubbers</td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td>77</td>
<td>42</td>
<td>52</td>
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<tr>
<td></td>
<td>UV Light</td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
<td></td>
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<td></td>
<td></td>
<td>11</td>
<td>21</td>
<td>4</td>
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<tr>
<td></td>
<td></td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
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<td></td>
<td></td>
<td>11</td>
<td>21</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>Species</th>
<th>Source</th>
<th>Technology</th>
<th>Scale</th>
<th>NH$_3$</th>
<th>H$_2$S</th>
<th>Odor</th>
<th>PM</th>
<th>VOCs</th>
<th>CO$_2$</th>
<th>CH$_4$</th>
<th>N$_2$O</th>
<th>CO$_2$eq</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Animal Housing</td>
<td>Biofilters</td>
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<td>44</td>
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<td></td>
<td>0</td>
<td>40</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Farm/Field Scale</td>
<td></td>
<td>59</td>
<td>81</td>
<td></td>
<td></td>
<td>0</td>
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<td>3</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Acidification</td>
<td>All Scales</td>
<td>Farm/Field Scale</td>
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<td>1705</td>
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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

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

Acknowledgments

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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.

References


