EPA METHOD FOR ESTIMATING LIVESTOCK NH₃ AND VOC EMISSIONS FOR VERSION 2 OF THE 2014 NATIONAL EMISSIONS INVENTORY (NEI)

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August 16, 2017
Ammonia ($\text{NH}_3$) emissions attributable to livestock production derive from the manure produced during the grazing/housing of the animals and from the storage and application (as fertilizer) of the livestock manure.

Volatile Organic Compounds (VOCs) emitted by livestock can be defined as any compound of carbon that can participate in atmospheric photochemical reactions and is emitted by livestock. Note: This excludes carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate.
Introduction

Ammonia Emissions by Source (from 2014 NEI v1)

- Agriculture - Fertilizer Application (nitrogen-based compound, not just livestock waste)
- Agriculture - Livestock Waste
- Fires
- Residential/Commercial/Industrial Fuel Combustion
- Mobile Sources
Livestock NH₃ NEI estimates for 2011 and 2014 were derived from Carnegie Mellon University’s (CMU) livestock ammonia process-based model.

2011 NEI estimates were based on an earlier CMU model version, in which 42 disaggregated source classification codes (SCCs) were used to describe a comprehensive set of animal types.

2014 NEI v1 estimates are based on a newer CMU model, in which only 5 SCCs are used to report emissions from a comprehensive set of major animal types: beef, swine, chickens (layers and broilers separated), and dairy.

- CMU model produces daily-resolved, county-level NH₃ emissions based on a particular distribution of management practices for each county and animal type.
- Model emission factors generated from literature-based emission factors and observations from the National Air Emissions Monitoring Study (NAEMS).

EPA received comments from SLTs regarding the uncertainty in the animal counts used for v1 and some errors were found and corrected in v2 pertaining to how animal counts/emissions were assigned to counties.
2014 NEI V2

- Used NH$_3$ emission factors (EFs in kg/head/year) derived from CMU’s process-based livestock ammonia emissions model. These EFs are uniform by state and animal type.
- Multiplied the county animal populations by the estimated NH$_3$ EF for each state and animal type to compute emissions per year.
- Derived VOC emissions by multiplying a ratio of VOC to NH$_3$ by the NH$_3$ inventory.
- For every county and animal type, NH$_3$ emissions are estimated as: animal population * EF (tons of emission/animal/year)
Updated animal population/livestock count data were obtained primarily from the USDA National Agricultural Statistics Service (NASS) Quick Stats program:

- The 2014 USDA Survey was used to obtain the livestock count for as many counties as possible across the United States.
- Animal populations of a particular type in counties with only one farm of that type are not reported (NR) by USDA due to confidentiality.
- Because it is not clear if county populations listed as NR in the 2014 Survey are that way for confidentiality or they are 0, the USDA 2012 Census was used to augment the 2014 Survey.
- For counties with NR in 2014, but not in 2012, a 2014 population was estimated by dividing the state 2014 population by the state 2012 population and applying this factor to the 2012 county population.
- For counties that did not report (NR) animal populations in 2012 or 2014, a “gap filling” procedure was used. The animal counts from counties in a given state that did report were totaled and subtracted from the 2014 state total. The balance was equally apportioned to the missing counties.
## Details – Animal Populations

<table>
<thead>
<tr>
<th>Animal Type</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken Broilers</td>
<td>The inventory reflects the 2012 state level totals, because no 2014 data is available in the Survey at either the county or state level. County level populations were adjusted to ensure that the county totals match the 2012 state level totals.</td>
</tr>
<tr>
<td>Chicken Layers</td>
<td>The inventory is based primarily on the 2012 Census. There were 30 states with 2014 state level population data, and the 2012 county level populations for those states were adjusted to reflect the change in population between 2012 and 2014 state level totals.</td>
</tr>
</tbody>
</table>
### Details – Animal Populations

<table>
<thead>
<tr>
<th>Animal Type</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swine</td>
<td>The NEI 2014 v1 inventory had four states with 2014 county level data (MT, NC, ND, OK). These states were not changed for v2. The other 46 states were updated to reflect the 2014 state level total. The county populations were adjusted to reflect the change in population between 2012 and 2014 state level totals.</td>
</tr>
</tbody>
</table>
### Details – Animal Populations

<table>
<thead>
<tr>
<th>Animal Type</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy Cattle</td>
<td>Counts are based on 2014 Survey data where available, and counties with missing data are “gap filled” using the algorithm described on the bottom of slide 6. Data for each state matches the 2014 NASS state inventory totals.</td>
</tr>
<tr>
<td>Beef Cattle</td>
<td>Counts are based on 2014 Survey data where available, and counties with missing data are “gap filled” using the algorithm described on the bottom of slide 6. Data for each state matches the 2014 NASS state inventory totals.</td>
</tr>
</tbody>
</table>
## Details – Population Gap Filling

<table>
<thead>
<tr>
<th></th>
<th>Beet Cattle</th>
<th>Dairy Cattle</th>
<th>Swine</th>
<th>Chicken Layers</th>
<th>Chicken Broilers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Counties with Gap Filling (3,071 counties in database)</td>
<td>776 (25%)</td>
<td>973 (32%)</td>
<td>643 (21%)</td>
<td>433 (14%)</td>
<td>621 (20%)</td>
</tr>
<tr>
<td>Number of States with no Gap Filling</td>
<td>5</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>
Details – Emission Factors

- **NH₃ Emission Factors:**
  - Back-calculated from CMU’s 2014 NEI v1 inventory (emissions/animal counts) for each county and animal type.

- **VOC Emission Factors:**
  - Calculated using the ratio of VOC to NH₃ emissions from livestock waste.
  - Since EPA estimates do not include VOC, state-submitted VOC emissions were used to estimate this ratio.
VOC Emissions

- VOC emissions had not previously been estimated by EPA for the livestock sector.

- VOC emissions are from two primary sources on a farm: livestock and silage. The EPA method for the 2014 NEI v2 does not include silage. Silage VOCs are expected to be much higher than livestock VOCs.

- Calculated VOC emissions using the ratio of VOC to NH₃ emissions from livestock waste.

- Calculated an average VOC/NH₃ ratio of 0.08 using data at the county level where both VOC and NH₃ were reported in 2014 NEI v1 by SLTs (from 3 states)

- Applied this ratio to the 2014 NEI v2 NH₃ livestock inventory to develop the county and animal type specific VOC inventory.
### NH₃ Emissions Summary

<table>
<thead>
<tr>
<th>Animal Type</th>
<th>2014 NEI v2 NH₃ Emissions (tons/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef Cattle</td>
<td>590,424</td>
</tr>
<tr>
<td>Dairy Cattle</td>
<td>225,919</td>
</tr>
<tr>
<td>Swine</td>
<td>722,621</td>
</tr>
<tr>
<td>Layers</td>
<td>73,492</td>
</tr>
<tr>
<td>Broilers</td>
<td>228,723</td>
</tr>
</tbody>
</table>
Map of Population – 2014 NEI V2

2014 Beef Cattle Population

Count
- 0
- 0 - 10,000
- 10,000 - 50,000
- 50,000 - 100,000
- 100,000 - 250,000
- > 250,000
Map of Population – 2014 NEI V2
Map of Population – 2014 NEI V2

2014 Chicken Layer Population

Count
- 0
- 0 - 100,000
- 100,000 - 500,000
- 500,000 - 1,000,000
- 1,000,000 - 3,000,000
- > 3,000,000
Map of Population – 2014 NEI V2

2014 Chicken Broiler Population

- Count:
  - 0
  - 0 - 500,000
  - 500,000 - 2,000,000
  - 2,000,000 - 5,000,000
  - 5,000,000 - 10,000,000
  - > 10,000,000

United States Map showing the distribution of chicken broiler population for 2014.
Map of Emissions – 2014 NEI V2

2014 NEI V2 Beef Cattle NH3

Tons/Year

- 0
- 0 - 250
- 250 - 1,000
- 1,000 - 2,500
- 2,500 - 5,000
- > 5,000
Map of Emissions – 2014 NEI V2
Map of Emissions – 2014 NEI V2
Map of Emissions – 2014 NEI V2

2014 NEI V2 Chicken Broiler NH3

Tons/Year
- 0
- 0 - 100
- 100 - 500
- 500 - 1,000
- 1,000 - 2,000
- > 2,000
Map of Emissions – 2014 NEI V2
Next Steps/Future Actions

- For 2017 NEI:
  - Acquire CMU model code
  - Increase collaboration and science for this sector
  - Clean up SCCs as appropriate
  - Rethink and revise methods for VOC estimates (resources permitting)
  - Include silage VOC emissions as appropriate (resources permitting)
  - Update non-CMU model animal types, as possible (resources permitting)
  - Develop method for AK, HI, PR and VI
## NH$_3$ Emissions

<table>
<thead>
<tr>
<th>Animal Type</th>
<th>States Submitting NH$_3$ Emissions</th>
<th>2014 State NH$_3$ (tons/year)</th>
<th>2014 v2 EPA NH$_3$ in these States (tons/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef Cattle</td>
<td>CA, GA, ID, IL</td>
<td>110,107</td>
<td>102,717</td>
</tr>
<tr>
<td>Dairy Cattle</td>
<td>GA, ID, IL</td>
<td>38,400</td>
<td>14,116</td>
</tr>
<tr>
<td>Swine</td>
<td>CA, GA, ID, IL</td>
<td>35,154</td>
<td>50,227</td>
</tr>
<tr>
<td>Chicken Layers</td>
<td>CA, GA, ID</td>
<td>12,424</td>
<td>8,804</td>
</tr>
<tr>
<td>Chicken Broilers</td>
<td>CA, GA, ID</td>
<td>56,240</td>
<td>45,559</td>
</tr>
</tbody>
</table>