

## **NATIONAL EMISSION INVENTORY -AMMONIA EMISSIONS FROM ANIMAL HUSBANDRY**

### **What is the ammonia emissions inventory from animal husbandry?**

We (EPA) estimated ammonia emissions from animal production facilities in the U.S. for the years 2002, 2010, 2015, 2020, and 2030. The inventory addresses beef, dairy, swine, poultry, sheep, goat, and horse operations that raise animals both in confined animal feeding operations or on pasture. The draft inventory dated February 2004 presents annual ammonia emissions by animal group for each county. You may obtain the inventory from EPA's national emissions inventory web site at <http://www.epa.gov/ttn/chief/net/2002inventory.html>

### **Why did we prepare this inventory?**

Under the recently promulgated Consolidated Emissions Reporting Rule (CERR), states will be required for the first time to report ammonia emission estimates to EPA. These reports are due by June 1, 2004 for a 2002 base year. Unless states submit revisions to the inventory that are improvements over the current estimates, the 2002 NEI estimates will be used. The 2002 NEI estimates also will be used in regulatory air quality modeling of particulate and regional haze and for summarizing county- and state-level NH<sub>3</sub> emissions for distribution on EPA web sites in a variety of forms for public use (for example, the AIRS website and the EPA trends report).

We revised the ammonia inventory to address some of the concerns raised by the National Research Council (NRC) Committee on Air Emissions from Animal Feeding Operations (AFOs) in the 2003 report entitled *Air Emissions from Animal Feeding Operations: Current Knowledge, Future Needs*. In this report, NRC indicated that the existing emission factors for AFOs are generally inadequate, and recommended that EPA implement a process-based modeling approach for animal feeding operations. A process-based approach would follow the fate of nitrogen step-by-step through the animal feeding process, identify the changes in manure characteristics that take place, and estimate emissions that occur at each step using a mass balance approach.

However, it may take several years of research before data are developed to support this type of modeling. In the meantime, this 2002 NEI ammonia inventory uses a process-based concept to the extent that current data allow. Despite the uncertainties and limitations associated with current ammonia emission data, we believe that the revised estimates are an improvement upon the existing inventory, which is based on approaches that are several years old.

### **How is ammonia emitted from animal husbandry?**

Ammonia is produced as a by-product of the microbial decomposition of the organic nitrogen compounds in manure. Nitrogen occurs as both unabsorbed nutrients in animal feces and as either urea (mammals) or uric acid (poultry) in urine. The term "manure" refers to the combination of feces and urine that is excreted. The potential for ammonia emissions exists wherever manure is present, and ammonia will be

emitted from confinement buildings, open lots, stockpiles, anaerobic lagoons, and land application from both wet and dry manure handling systems.

The volatilization of ammonia from any manure management operation can be highly variable depending on total ammonia concentration, temperature, pH, and storage time. Emissions will depend on how much of the ammonia-nitrogen in solution reacts to form ammonia versus ionized ammonium ( $\text{NH}_4^+$ ), which is nonvolatile. High pH and high temperature favor a higher concentration of ammonia and, thus, greater ammonia emissions. The pH of manures handled as solids can be in the range of 7.5 to 8.5, which results in fairly rapid ammonia volatilization. Manure handled as liquids or semi-solids tends to have lower pH. However, there may be little difference in annual ammonia emissions between solid and liquid manure handling systems if liquid manure is stored over extended periods of time prior to land application.

Ammonia emissions are not constant over the year, but can change seasonally. The degree of seasonal variation depends on the geographic region, animal sector, and type of animal production practices used. For example, high temperature increases ammonia volatilization. Precipitation and humidity can either increase or decrease emissions depending on how manure is managed. Higher wind speeds can increase emissions from open manure storage facilities. The population of animals on a farm also varies throughout the year. The confluence of all these factors will affect regions of the country in different ways. While some work has been conducted to study these effects, at this point, additional work is needed to develop a methodology to credibly integrate all of these factors into an ammonia inventory. We are investigating methods for developing a seasonal ammonia inventory, and seasonal patterns may be included in a later version of this inventory.

### **How did we estimate ammonia emissions?**

Ammonia emissions were estimated using a process-based inventory model. Emissions were estimated at the county level based on annual average animal populations for each county. For the beef, dairy, swine, and poultry sectors, emissions were estimated for animal confinement; manure handling and storage; and land application processes (total facility emissions were estimated for the sheep, goat, and horse sectors). The ammonia emission calculation methodology consisted of four general steps, as follows:

- Determine county-level population of animals (beef, dairy, swine, poultry, sheep, goats, horses) for 2002.
- For each county, apportion animal populations for beef, dairy, swine, and poultry to one or more manure management trains (MMTs). A MMT consists of an animal confinement area (e.g., housing, drylot, pasture); components used to store, process, or stabilize the manure (e.g., anaerobic lagoons, solid separators); and a land application site where manure is applied as a fertilizer source. Several different MMTs were developed for this inventory.
- Estimate county-level emissions from each MMT using a process-based inventory model that applies mass balance principles. A single emission factor was used for sheep, goats, and horses. The inventory estimates assume no emission controls to limit ammonia emissions.
- Forecast the future animal populations and ammonia emissions for 2010, 2015, 2020, and 2030,

using current projections and a regression analysis. The forecast covers only the beef, dairy, swine and poultry sectors.

County-level populations were obtained from U.S. Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) and the *1997 Census of Agriculture*, and data from the Food and Agriculture Organization of the United Nations. The Agency developed and apportioned MMTs using data from a variety of sources including USDA, the *Census of Agriculture*, and EPA's Office of Water rulemaking records. Emission factor data were obtained from a series of literature reviews.

### **What are the limitations of this inventory?**

The tools and methodologies to estimate national emissions from animal agriculture are limited at this time. The major limitations include limited published data on ammonia emission factors for animal husbandry and county-level data on animal populations and manure management practices; an inability to conduct a full process-based modeling approach using a nitrogen mass balance; and an inability to address seasonal and regional influences on ammonia emissions from animal husbandry.

In particular, the availability of credible emission measurements upon which to develop ammonia emission factors is very limited. Because of the large number of variables that influence emissions from animal husbandry, emissions can vary substantially from site to site. These variables include climate and geography, diurnal and seasonal emission patterns, feeding practices, animal life stage, and individual animal management practices. The emission factors developed for this inventory do not account for all of these variables. Accordingly, it is not appropriate to use these emission factors to estimate emissions from individual farms. While the methods used for this inventory can be used for assessing emission trends and for general air quality planning, the information presented in this report should not be used for making regulatory determinations or for permitting of any particular facility.

### **What are the inventory emission estimates?**

The table below summarizes the U.S. ammonia estimates by animal group. Overall, these estimates are about 33 percent lower than those presented in the 1999 NEI even though the population estimates for the 2002 NEI were about 19 percent higher than those used in the 1999 NEI. This difference is largely due to the differences in the emission estimation methodologies. The 1999 NEI primarily used a single emission factor for each animal type whereas the this inventory apportioned the beef, dairy, swine, and poultry animal populations into the different types of farms and used multiple emission factors.

## Summary of Ammonia Emissions from U.S. Animal Husbandry Operations

Animal Group	Ammonia Emissions (tons/year)				
	2002	2010	2015	2020	2030
Dairy <sup>1</sup>	558,094	565,892	547,874	545,155	546,666
Beef <sup>2</sup>	656,648	691,174	689,669	705,659	733,662
Poultry <sup>3</sup>	664,238	648,200	720,449	770,068	869,348
Swine <sup>4</sup>	429,468	485,223	512,458	529,288	518,082
Sheep	24,835	NE	NE	NE	NE
Goats <sup>5</sup>	14,028	NE	NE	NE	NE
Horses	71,285	NE	NE	NE	NE
<b>Total</b>	<b>2,418,595</b>	<b>2,390,489</b>	<b>2,470,449</b>	<b>2,550,171</b>	<b>2,667,758</b>

<sup>1</sup> Includes dairy cows and dairy heifers.

<sup>2</sup> Includes beef cattle, bulls, and calves.

<sup>3</sup> Includes chickens and turkeys.

<sup>4</sup> Includes breeding and market pigs.

<sup>5</sup> Includes milking and Angora goats.

NE- Not estimated.

### Where can I find more information?

The report, *National Emission Inventory - Ammonia Emissions from Animal Husbandry*, January 30, 2004, describes in detail the methodology and emission factors used for this inventory. You may download the report EPA's national emissions inventory web site at <http://www.epa.gov/ttn/chief/net/2002inventory.html>

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