LETTER

Livestock methane emissions in the United States

The recent study by Miller et al. (1) provides a comprehensive, quantitative analysis of anthropogenic methane sources in the United States using atmospheric methane observations, spatial datasets, and a high-resolution atmospheric transport model. The authors conclude that "...emissions due to ruminants and manure are up to twice the magnitude of existing [i.e., US Environmental Protection Agency (US EPA); www.epa.gov/climatechange/ghgemissions/usinventoryreport.html] inventories" (1). The validity of this "top-down" approach can be verified by a relatively simple "bottom-up" method using current livestock inventories and enteric or manure methane emission factors. Animal scientists have generated large datasets of enteric methane production estimates per unit of feed or energy intake. Methanogenesis in the rumen is substrate-dependent and methane production data derived from studies using respiratory chambers (or other techniques) expressed on feed intake basis are representative of field emissions, if feed intake is known. We used the US Department of Agriculture-National Agricultural Statistics Service (USDA-NASS) livestock inventory estimates for 2013 (www.nass.usda.gov) and methane emission rates per unit of feed dry matter intake from two large datasets [Hristov et al. (2) and Hales et al. (3)] to estimate total methane emission from enteric fermentation for the United States. Total cattle inventories for 2013 were 89,299,600 head (including 29,295,200 beef cows, 9,219,900 dairy cows, and 13,351,700 cattle on feed, among other categories). Feed dry matter intake was estimated based on beef and dairy cattle requirements and ranged from 3.8 (calves $<$ 500 lbs live weight), to 9–10 (cattle on feed or other steers and heifers $>$ 500 lbs), 11 (beef cows), and 22 kg/d (dairy cows). Methane production rates were estimated at 8–13 (cattle on feed) or 20 g/kg (all other categories; SD = 4) feed dry matter intake. Contributions to methane emissions by other ruminants or nonruminant herbivores (sheep, goats, wild ruminants, horses, and so forth) are small in the United States and were not included in this analysis. With the above assumptions, total methane emissions from enteric fermentation were estimated at 6.241 Tg/yr (minimum = 4.972 and maximum = 7.511), which is comparable to the current, 2011 US EPA estimates of 6.542 Tg/yr and was also independently verified using equations proposed by Moraes et al. (4). USDA-NASS inventories for cattle, swine (59,387,000 market swine and 5,834,000 breeding swine), and poultry (a total of 8.562 billion birds) and Intergovernmental Panel on Climate Change (5) manure methane emission factors [from 0.02 (most poultry categories), to 1 (beef cattle) and 53 (dairy cows) kilograms per head per year] were used to estimate emissions from manure management. Using this approach, manure emissions in the United States were estimated at 1.604 Tg/yr, which is lower than the 2011 US EPA estimate of 2.478 Tg/yr (with the latter figure perhaps being more representative of manure systems in the United States). Thus, the conclusions by Miller et al. (1) that US EPA estimates for livestock methane emissions are grossly underestimated appears to be unsubstantiated by the above "bottom-up" approach. There is a need for a detailed inventory of manure systems for all farm animal species and categories, which will help to more accurately estimate greenhouse gas (and ammonia) emissions from animal manure in the United States.

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1 Miller SM, et al. (2013) Anthropogenic emissions of methane in the United States. *Proc Natl Acad Sci USA* 110(50): 20018–20022.

2 Hristov AN, et al. (2013) Mitigation of greenhouse gas emissions in livestock production—A review of technical options for non-CO2 emissions. *FAO Animal Production and Health Paper No. 177.* eds Gerber P, Henderson B, Makkar H (FAO, Rome, Italy).

3 Hales KE, Cole NA, MacDonald JC (2013) Effects of increasing concentrations of wet distillers grains with solubles in steam-flaked, corn-based diets on energy metabolism, carbon-nitrogen balance, and methane emissions of cattle. *J Anim Sci* 91(2):819–828.

4 Moraes LE, Strathe AB, Fadel JG, Casper DP, Kabreab E (2013) Prediction of enteric methane emissions from cattle. *Glob Change Biol*, 10.1111/gcb.12471.

5 IPCC (Intergovernmental Panel on Climate Change) (2006) Chapter 10. Emissions from livestock and manure management. *Guidelines for National Greenhouse Inventories. Vol. 4. Agriculture, Forestry and Other Land Use*, eds Apps M, Plume H, Schlamadinger B, Sok Appadu SN (IPCC, Geneva, Switzerland).

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