Ammonia Assessment from Agriculture: U.S. Status and Needs

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Recent studies suggest that human activities accelerate the production of reactive nitrogen on a global scale. Increased nitrogen emissions may lead to environmental impacts including photochemical air pollution, reduced visibility, changes in biodiversity, and stratospheric ozone depletion. In the last 50 yr, emissions of ammonia (NH_3), which is the most abundant form of reduced reactive nitrogen in the atmosphere, have significantly increased as a result of intensive agricultural management and greater livestock production in many developed countries. These agricultural production practices are increasingly subject to governmental regulations intended to protect air resources. It is therefore important that an accurate and robust agricultural emission factors database exist to provide valid scientific support of these regulations. This paper highlights some of the recent work that was presented at the 2006 Workshop on Agricultural Air Quality in Washington, D.C. regarding NH_3 emissions estimates and emission factors from agricultural sources in the U.S. and Europe. In addition, several best management practices are explored as the scientific community attempts to maximize the beneficial use of reactive nitrogen while simultaneously minimizing negative environmental impacts.

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Biologically active, photochemically reactive, and radiatively active nitrogen compounds in the atmosphere, hydrosphere, and biosphere are collectively referred to as reactive nitrogen (Galloway et al., 2003). Over the past few decades, human activities leading to the production of reactive nitrogen from diatomic nitrogen (N_2) exceed that of nitrogen fixation in the natural terrestrial ecosystem at the global scale (Galloway et al., 2004).

Ammonia (NH_3) is the most reduced form of reactive nitrogen. It is also the most abundant alkaline constituent in the atmosphere (Aneja et al., 2006a). Figure 1 illustrates the major processes (emissions, chemical transformation, transport, and removal) that drive the global cycle of NH_3 in the atmosphere (Aneja et al., 2006b,c). In the past 50 yr, emissions and subsequent deposition of NH_3 have increased significantly in parallel with the development of intensive agricultural management and increased livestock numbers (Sutton et al., 1993). Globally, domestic animals are the largest source [32×10^{12} g NH_3–N (ammonia-nitrogen) yr^{-1}] of atmospheric NH_3, comprising approximately 40% of natural and anthropogenic emissions combined (Schlesinger and Hartley, 1992). Synthetic fertilizers and agricultural crops together contribute 9×10^{12} g NH_3–N yr^{-1} (12% of total emissions) (Schlesinger and Hartley, 1992). The first Workshop on Agricultural Air Quality: State of the Science (Aneja et al., 2006a) was structured to help scientists, industry, policymakers, and regulators make optimal choices about issues confronting agricultural practices to maximize the benefits and reduce the detrimental environmental effects of current food, fiber, and feed production activities. This paper focuses on issues surrounding ammonia emissions, its transport, transformation, and fate.

Ammonia Emissions

Emissions of air pollutants, particularly ammonia, during agricultural operations are an important emerging research area in the U.S., best studied with interdisciplinary approaches that can inform policymakers of the costs and benefits of various mitigation options. Data on agricultural emissions of regulated pollutants, nuisance odors, and fugitive dust often either do not exist or are insufficient to develop appropriate policy nationally. Emissions estimates from

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