Ammonia Volatilization Reduction From Mineral N Fertilizers In The Veneto Region: Combining Modeling And Field Approach

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Introduction

Ammonia (NH_3) losses from nitrogen mineral fertilizers is a debated issue in Europe due to their contribution to fine particulate matter formation (PM2.5 and PM10 fractions). In particular, urea-based fertilizers can be lost as NH_3 up to 70% under broadcast application. A number of Best Available Techniques (BATs) for preventing and reducing emissions have been recommended (NEC Directive 2016/2284/EU) even if large uncertainties still occur about their effectiveness at the site-specific level. The Life PREPAIR project aims to study reduction methods for NH_3 emissions from urban to agricultural sources in the Po river basin, northern Italy, one of the most air-polluted area in Europe. Within the PREPAIR framework, the present study aimed to identify site-specific based BATs in the Veneto region, which allow to satisfy the UNECE benchmark for mineral fertilizers, namely a NH_3 emission reduction of at least 30% compared to urea surface broadcast.

Materials and Methods

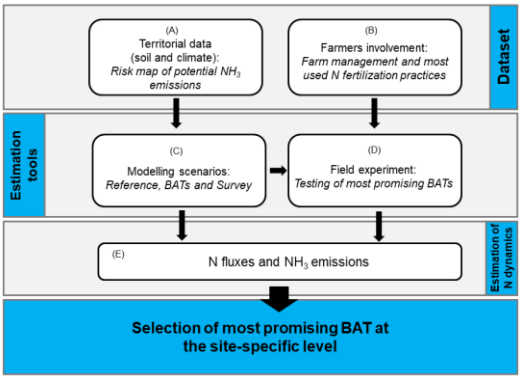
The study area is the Veneto region, northeastern Italy. Figure 1 reports a flow chart of the step approach used in the present study.

Firstly, a potential risk map of NH_3 volatilization (Fig. 1A) was created by overlapping soil information with climatic conditions, which are well-known to affect NH_3 losses. Veneto soils were grouped into five classes which identified pH and CEC threshold levels of potential NH_3 emissions.

After that, nitrogen fluxes across the Veneto region (e.g. NH_3 and N_2O volatilization, N leaching, etc..) were estimated using the modified version of DNDC v.CAN (Dutta et al., 2016) biogeochemical model. Data collected with a questionnaire conducted among farmers (Fig. 1B) was used to identify business-as-usual practices for different crops, as well as feed DNDC v.CAN model. Alternative BATs (Fig. 1C), such as NH_4NO_3 (AN), organic fertilizers (e.g. beef digestate, liquid manure) and different incorporation methods, were compared to urea broadcast distribution in maize (*Zea mais L.*) and winter wheat (*Triticum aestivum L.*).

The most promising BATs were further tested in a field experiment (Fig. 1D) using a wind tunnel combined with a FTIR gas analyzer (Gasmet DX4015) for continuous gas measurements. Wind speed, soil water content, and both air and soil temperature were also continuously monitored and used to improve prediction of NH_3 volatilization dynamics. Fluxes obtained from each plot were interpolated to

calculate the cumulative NH_3 loss by implementing the equation proposed by Demeyer et al. (1995) and then compared to modeled results (Fig. 1E).



Outline of steps and processes adopted during the study.

Results

Modeling results showed that AN closed-slot injection and deep incorporation of organic fertilizers significantly reduced ammonia loss both for maize (-75% and -96% respectively) and winter wheat (-87% and -98%). Nevertheless, some increase in nitrate leaching was observed, mostly in case of winter wheat (+24% for injection of AN and +89% for organic fertilizers). Field results corroborated the effectiveness of closed-slot injection, being able to bring a reduction up to 68% compared to NH_3 emissions after surface broadcast. Contrasting results were observed with urea incorporation or mixing only, showing that NH_3 emissions can increase by up to 50% (Rochette et al., 2009).

Conclusions

The present study proposed a methodological approach, where BATs to limit NH_3 emissions from agricultural soils must be tailored to each management and pedo-climatic condition. Results showed that NH_3 loss can be highly reduced, and that N injection practices are the most effective solutions in Veneto region according to both modeling and field results. Anyway, our approach also highlighted that all N fluxes must be included in the BATs evaluation, such that NH_3 mitigation strategies do not not worsen, e.g., the N leaching or N_2O emissions in the environment.
Hence, a site-specific approach is highly recommended to reduce N losses in air and water, which are strongly related to soil and climatic properties and their interactions with the agricultural management.

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