

Relative contributions of NH₃, NO₂, NH₄⁺ and NO₃⁻ to total Nitrogen deposition at an agricultural site in the Indo-Gangetic Plain of India

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Abstract

Atmospheric emissions of reactive nitrogen (Nr) species namely NH₃ and NO_x are at high levels in India in recent years, but only a few studies have employed nitrogen (N) deposition monitoring for gaseous and particulate N depositions together to evaluate total dry N deposition. In the present study, gaseous N pollutants (NH₃ and NO₂) and related ionic species (NH₄⁺, NO₃⁻) were determined in water-soluble fine particulates at an agricultural site in the Indo-Gangetic Plain (IGP) during July-Sept, 2013 with the aim of estimate the relative contribution of respective species to total dry N deposition. The NH₃ and NO₂ levels were recorded as 30.41 μg/m³ and 4.0 ± 2.3 μg/m³. Aerosol NH₄⁺ and NO₃⁻ concentrations were measured at 0.37 μg/m³ and 1.43 μg/m³. These values are at a relatively higher scale which might be due to high fertilizer use and biomass burning. Contribution of reduced form and oxidized form of nitrogen was also calculated.

Introduction

Atmospheric deposition of nitrogen (N) refers to the process whereby air-borne nitrogenous compounds are deposited on the earth's surface by precipitation (wet) or dry deposition. Atmospheric N deposition to the landscape of natural ecosystems (such as forests, grasslands and waterbodies) has been a subject of environmental concern because the biodiversity and productivity of these ecosystems are sensitive to elevated N inputs from the atmosphere (Aber et al., 1989; Bobbink et al., 1998; Matson et al., 2002). Accelerated N cycle induced by anthropogenic activity (increasing fertilizer use, animal husbandry and fossil fuel combustion) may explain the increase in atmospheric N deposition. In an earlier study (Singh and Kulshrestha 2014), NH₃ concentrations were recorded at a higher scale at this experimental site, probably due to fertilizer application in the agricultural fields. However, data on total dry N deposition where all the major phases of N contribution are calculated at an agricultural site is rare. Hence the objectives of the present study were to understand the relative contribution of different reactive N (Nr) species to total dry nitrogen during the July-September, 2013 at an agricultural site located in the Indo-Gangetic Plain (IGP) of India.

Methods

The present site is located in Jaunpur district of Uttar Pradesh state and is located 265 km SE of Lucknow. Its geographical coordinates are 25°62'N and 82°51'E. Most of the village people have agricultural activity as the major occupation. Wheat, paddy, pigeon pea, maize, sugarcane, legumes etc. are the main crops in this region. The area around the site is dominated by agricultural activities and thus signifies the importance for the study of Nr emissions from N-fertilizer applied to the agricultural fields.

Gaseous samples and aerosol samples were collected to study the dry deposition of Nr. Gaseous samples (NH₃ and NO₂) were collected on 8 hr. basis together with aerosol samples at a flow rate of 1LPM on monthly basis. For the chemical analyses, samples were refrigerated at 4°C in the laboratory. NH₃ was determined colorimetrically with the help of UV-Vis spectrophotometer (Perkin Elmer LAMBDA 35), using Indophenol blue method. Chemical analysis of NO₂ involves colorimetric method through determination of nitrite ion formed in aqueous NaOH absorbing solution which forms a pink colored azo dye complex by the reaction of sulphanilic acid and α-naphthylamine in an acid medium.

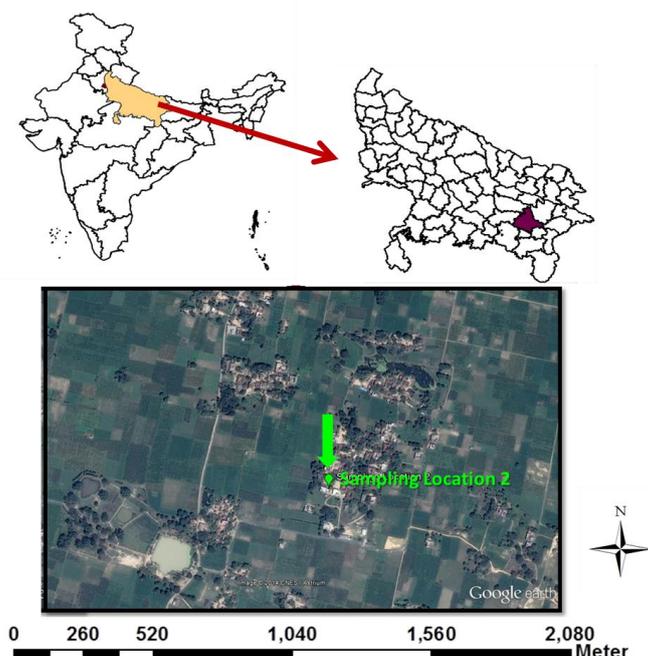


Fig.1. Study site Map

Chemical analysis of aerosols was done by IC (Metrohm 883 Basic IC Plus) and before analysis each filter was extracted for their water soluble fraction through ultrasonic bath. Water soluble extract were analyzed for major anions (F^- , Cl^- , NO_3^- and SO_4^{2-}) and major cations (Na^+ , NH_4^+ , K^+ , Ca^{2+} and Mg^{2+}) by ion chromatography (Metrohm 883 Basic IC Plus).

Results & Discussion

N content in Dry deposition

For estimation of dry deposition N content, aerosol phase and gaseous phase was considered. N content in aerosol phase and gas phase were found to be $0.61 \mu\text{g}/\text{m}^3$ and $26.26 \mu\text{g}/\text{m}^3$ which were 2.27 % and 97.7 % of total dry deposited N (aerosol and gas). Reduced N contribution was $25.33 \mu\text{g}/\text{m}^3$ (94.26 % of total dry deposited) whereas oxidized form of N was found to be $1.54 \mu\text{g}/\text{m}^3$ (5.7 % of total dry deposited N).

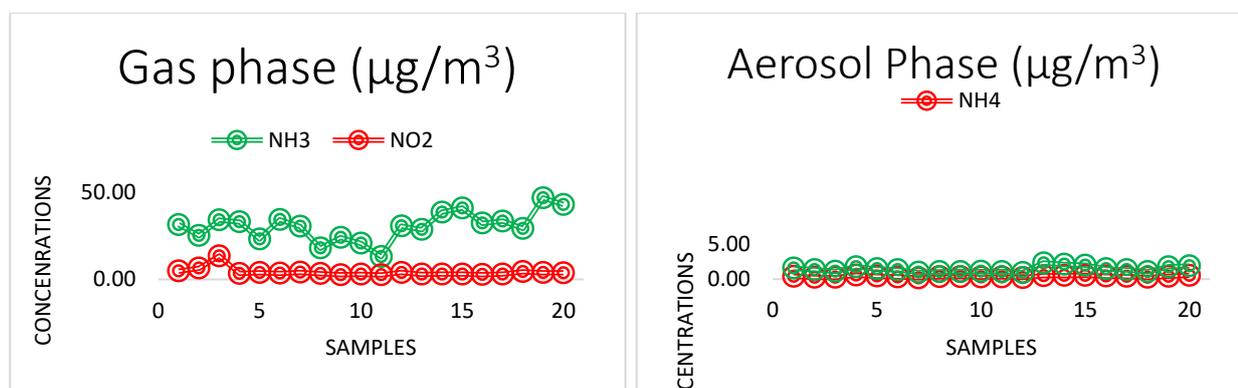


Fig. 2. Time series of (a) gas phase nitrogen species

(b) aerosol phase of nitrogen species

Dry deposition flux and relative contribution of N species

Dry deposition flux was calculated as the product of the atmospheric concentration and deposition velocity of a given a given compound. (Horii et al., 2005; Shen et al., 2013).

$$F = V_d * C$$

Where V_d is deposition velocity of gas or aerosol and C is concentration ($\mu\text{g}/\text{m}^3$) in ambient atmosphere. For gaseous Nr, V_d is taken as 0.2 cm/sec while for aerosol Nr the value was 0.15 cm/sec. (Kulshrestha et al., 2005; Zhang et al., 2012).

Total dry deposition flux for the given period was found to be 16.84 kgN/ha/yr. Relative contribution of reduced form of nitrogen ($N-NH_3 + N-NH_4^+$) was 94.54 % whereas oxidized form of nitrogen was found 5.46 %. The abundance of ammonia at the present site was mainly due to fertilizer application specially urea and

DAP in the field (Singh and Kulshrestha, 2014). Deposition in gas phase was dominant with 98 % and relative contribution of individual species i.e. N-NH₃, N-NO₂, N-NH₄⁺ and N-NO₃⁻ to total dry N deposition were 93.7 %, 4.57 %, 0.8 % and 0.9 %.

Conclusion

Reduced N content contribution was higher (94.54 %) as compared to oxidized one due to fertilizer application in agricultural site. In dry phase, reactive nitrogen preferred to deposit in gaseous form rather than particulate form. The results of this study are highly important not only to strengthen our understanding about Nr deposition in India but also for necessary abatement measures.

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