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Observational Gaps in South Asian Nitrogen Deposition

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Introduction

The growing demand of energy and food has resulted in increased consumption of fossil fuels giving rise to huge emissions of NOx and NH3 gases. Both these gases are important reactive nitrogen species. Coal, petrol and diesel are the major sources of NOx while urea fertilizer is the major source of NH3 1-2.Urea is produced through Haber-Bosch process during which inert nitrogen (N2) is converted into urea.The thermal dissociation of urea when applied to agricultural fields produces NH3 and CO2 in the atmosphere.One CO2 molecule is released for every one NH3 molecule.3 In 2019, there were 215.37 million tonnes of urea fertiliser consumed globally, up from 50 million tonnes in 1961.

Similar to this, India has grown its urea usage from 1 million tonnes in the 1960s to approximately 33.5 million tonnes in 2019–20 (https:// factly. in/data-chemical-fertilizer-consumption-increasing-by-about-16-in-the-last-six-years/).Oil usage climbed from 17790 TWh in 1965 to 51170 TWh in 2021, while coal consumption increased from When urea is sprayed to agricultural areas, thermal dissociation of the chemical results in the atmospheric emissions of NH3 and CO2. For each NH3 molecule released, one CO2 molecule is also released.3 Global urea fertiliser consumption increased from 50 million tonnes in 1961 to 215.37 million tonnes in 2019.

In a similar vein, India increased its urea use from 1 million tonnes in the 1960s to roughly 33.5 million tonnes in 2019–20 (https://factly. in/data-chemical-fertilizer-consumption-increasing-by-about-16-in-the-last-six-years/).The amount of oil used grew from 17790 TWh in 1965 to 51170 TWh in 2021, while the amount of coal used increased from hail, rain, and snow.

In the dry deposition method, contaminants are eliminated during dry weather conditions through dry deposition.Another type of dry deposition of coarse particles that occurs in dry weather is dustfall. The phenomena of dustfall is highly prevalent in the south Asian region. Due to its alkaline makeup, air dust prevents acid rain from occurring by acting as a buffer.6 Poor air quality is thought to be caused by large particulate matter loadings brought on by atmospheric dust.

According to reports, the long-distance transfer of reactive nitrogen species has a significant impact on the Himalayan snow.7

Singh and coworkers8 reported that the NO3 level in rainwater increased by 11.7 times in 2011 compared to 1994 values in another investigation. An increase in the usage of fossil fuels is indicated by changes in ambient NOx levels in the air and NO3 concentrations in rainwater in Delhi during the past 20 years.

Gaseous NH3 delivers the largest fraction of Nr to the atmosphere in the area, followed by NH3 -N, NH4 + N, and NO3 - N. Due to its extremely high population density and associated anthropogenic activities, the Indo-Gangetic area has the largest wet deposition of NH4 +.Fertilizers and biomass burning are to blame for the high NH3 levels in rural areas, whereas automobile traffic, municipal trash, and human excrement are the main sources of gaseous NH3 in urban areas.9

The high temperature is another factor. NH3 builds up in the atmosphere in this region due to the influence of the tropics and the alkaline nature of aerosols. 10 Studies on abundance and phase distribution demonstrate that particulate NH4 + is consistently found to be less prevalent than gaseous NH3 in Delhi throughout the year. India experiences 1.97 Tg of wet deposition and 1.67 Tg of dry deposition of Nr species.11 More observations of air deposition through a methodical, dense network of sites are still required for the emissions vs. deposition budget.

In general, there are very few studies of South Asian wet and dry deposition of reactive nitrogen. Additionally, there aren't many measurements of throughfall deposition in south Asia.
However, there has been a noticeable change in the region's readings of nitrogen assessment from different organisations.
Currently, South Asian Nitrogen, UKRI-GCRF, South Asian atmospheric deposition of reactive nitrogen species is being measured by the Hub, WMO-Global Atmospheric Watch (GAW), and DRS Net-India programmes.

Prior atmospheric deposition investigations in the area were conducted as part of the Swedish Development Authority's Composition of Asian Deposition (CAD) and Composition of Aerosol and Precipitation in India and Nepal (CAAP) programmes (SIDA).12- The WMO GAW locations have long-term data on only the chemistry of rainwater.15 The studies described by Dentener and colleagues16 and other groups are additional significant reports in this regard.17-18 It has been found that coarse mode NH4 + and NO3 - particle deposition fluxes on indoor plants have an impact on those plants' metabolic characteristics.A relatively recent compilation of many studies about various facets of reactive nitrogen in India is called "The Indian Nitrogen Assessment." 20 The report does not, however, cover much of forest N. In Nepal, it has been discovered that the weather has a significant impact on pollution. even at a distant location in the Himalayas' Khumbu region where a comparatively high value of NO3's scavenging ratio was noted in comparison to other ions.

Journal on Environmental Sciences

The NO_3^- concentrations in aerosols were one-third that of NH_4^+, but because gaseous HNO_3 was present in the air, the NO_3^- concentrations in precipitation were higher than NH_4^+.
When air was coming from more polluted places, this characteristic was more pronounced. Studies comparing models and measurements are crucial for improving deposition prediction abilities.

The measurements of reactive nitrogen species, such as NH_4^+ and NO_3^- in rainwater in India have been compared with the modelling results by Kulshrestha and coworkers14 using the MATCH model in a ground-breaking effort.22 The model's output proved useful in providing an explanation for the NH_4^+ and NO_3^- observational data.

To lessen the uncertainty of the model outputs, these activities are still required. It should be noted that there have been some challenges with the quality assurance and control of the data in the South Asian region, mostly because of concerns with sampling and chemical analysis of the reactive nitrogen species such as NH_4^+ and NO_3^-.Kulshrestha and colleagues have examined the local precipitation chemical data.14

These researchers discovered that NO_3^- was overestimated due to its additional contribution from local soil, whereas NH_4^+ was underestimated due to analytical issues such as delay in analysis, no addition of preservative, improper storage of the samples, etc. Balances in conductivity and ions The reporting of techniques is required to support the analytical assurance.
But such estimates of errors are absent from the majority of preceding investigations.

Ionic and conductivity balance estimates for the majority of the measurements took F^-, Cl^-, NO_3^-, SO_4^{2-}, Na^+, K^+, Ca^{2+}, Mg^{2+}, and NH_4^+ into account.

Because of the region's calcareous soils, the pH of rainwater in India is relatively high and contains high amounts of the ion HCO_3.Therefore, conductivity and ion balance tests without HCO_3 do not work. truly ensure the accuracy of the data.The collecting assembly's shape and material composition (steel, plastic, glass) can occasionally have an impact on the outcomes.

A number of other significant issues that have a big impact on data quality include improper transit, poor preservation, and delayed analysis.23-24 Selecting sites that can accurately represent wider areas is crucial for having measurements of high quality.Overall, QA/QC of data must be followed to provide dependable and solid data sets in the long term.

Recommendations and Gaps:

To close the existing knowledge gaps surrounding the N cycle, the south Asian region needs to take the following steps: I Need to create an integrated assessment plan for various Nr species, including their emissions, abundance, transport, transformations, scavenging, impacts, and forest pool, among other things.

1. There is a lack of good quality data available for Nr depositions in the Indian region, necessitating the creation of reference standards as well as a particular data and parameter

2. A long-term measuring network that includes several sites with various characteristics and aims to employ its research findings in the formulation of policy.

3. The deposition studies and the trajectory analysis must be combined in order to comprehend local, trans-boundary, and long-distance transit of Nr species.

4. The South Asian Association for Regional Cooperation should establish a mechanism to track the import and export of pollution within South Asian nations (SAARC)

5. We must concentrate on research on the effects of diverse Nr species.

6. Estimates of the dry deposition of gases and aerosols, particularly NH_3 and NH_4, in interior environments will be very helpful.

7. A distinct task force needs to be established in order to better understand the processes involved in gas-aerosol interactions, scavenging, transport, evapo-transpiration, deposition, and absorption, among other things.To lessen uncertainty in this region's Nr budget, proper emphasis needs to be placed on dry deposition studies of Nr.
8. Active scientist/groups must also work together to create a shared modelling group. The inclusion of some socioeconomic specialists who can assist in transforming the scientific findings into the kind of compelling report that policymakers need would be more appropriate.

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