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Gaps in Nitrogen Deposition Measurements in South Asia

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The growing demand of energy and food has resulted in increased consumption of fossil fuels giving rise to huge emissions of NOx and NH_3 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 NH_3[1-2]. Urea is produced through Haber-Bosch process during which inert nitrogen (N_2) is converted into urea. When we apply urea in the agricultural fields, its thermal dissociation gives rise to NH_3 and CO_2 in air. For every one molecule of NH_3, one molecule of CO_2 is emitted.[3] Globally, urea fertilizer consumption has increased from 50 million tons in 1961 to 215.37 million tons in 2019. Similarly, in India, the urea consumption is increased from 1 million ton in 1960s to around 33.5 million tons in 2019-20 (https://factly.in/data-chemical-fertilizer-consumption-increased-by-about-16-in-the-last-six-years/). Global consumption of fossil fuels such as petroleum oil is increased from 17790 TWh in 1965 to 51170 TWh in 2021, coal is increased from 16140 TWh in 1965 to 44473 TWh in 2021 and gas from 6304 TWh in 1965 to 40375 TWh in 2021 (https://ourworldindata.org/fertilizers). these increasing trends of energy consumption which are reflected in the study reporting increasing atmospheric NOx trends in different regions in India.[4] Most of south Asian countries have geared up their fossil fuel usage for energy production after 1990.

Both NH_3 and NO_x are deposited from the atmosphere through wet and dry deposition processes and are generally estimated as NH_4^+ and NO_3^- respectively. Chemical composition of atmospheric deposition is an indicator of air pollution of the region. In the process of wet deposition, the pollutants are deposited through rain, snow and hails. In the dry deposition process, the pollutants are removed through dry deposition process during dry weather conditions. Dustfall is also a kind of dry deposition of coarse particles taking place during dry weather conditions. Dustfall is very common phenomenon in the south Asian region.[5]

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The atmospheric dust being alkaline in nature, controls acid rain occurrence through buffering action.[6] However, high loadings of particulate matter due to atmospheric dust are considered responsible for poor air quality.

According to the reports, the Himalayan snow is highly affected by the impact of long range transport of reactive nitrogen species.[7] In an another study,Singh and co-workers[8] have reported that NO_3^- content in rain water was increased by 11.7 times in 2011 as compared to 1994 values. Significantly large increase in ambient NOx in air and NO_3^- concentrations in rain water in Delhi during past two decades indicates an increase in fossil fuel consumption. Among NH_3-N NH_4^+ N and NO_3^- N, gaseous NH_3 contributes maximum fraction of Nr in the atmosphere in the region. The Indo-Gangetic region experiences the highest wet deposition of NH_4^+ due to very high population density and the related anthropogenic activities. At rural sites, the high NH_3 levels can be attributed to the fertilizers and biomass burning while at urban sites, major sources of gaseous NH_3 include human excreta, municipality waste and vehicular traffic etc.[9] In addition, the high temperature of the tropics and the alkaline nature of aerosols also favour the building up of NH_3 in the atmosphere in this region.[10] Abundance and phase distribution studies show that particulate NH_4^+ is noticed lower than gaseous NH_3 in Delhi during all the seasons.

A total of 1.97 Tg of wet deposition and 1.67 Tg of dry deposition of Nr species takes place in India.[11] Emissions vs deposition budget still needs more measurements of atmospheric deposition through systematic dense network of sites. In general, the number of reactive nitrogen studies of wet and dry deposition from South Asia is very limited. Also, there are very few measurements about the throughfall deposition in the south Asian region. However, there has been an appreciable development about the measurements of nitrogen assessment from individual groups in the region. At present, UKRI-GCRF-South Asian Nitrogen Hub, WMO-Global Atmospheric Watch (GAW) and DRS Net-India programs are carrying out measurements of atmospheric deposition of reactive nitrogen species in south Asia. Earlier atmospheric deposition studies in the region have been carried out under Composition of Asian Deposition (CAD), Composition of Aerosol and Precipitation in India and Nepal (CAAP)programs of Swedish Development Authority (SIDA).[12-14]

The long term data limited to rain water chemistry are available from the WMO GAW sites.[15] Other important reports in this regard include the studies reported by Dentener and co-workers[16] and other groups.[17-18] Deposition fluxes of coarse mode NH_4^+ and NO_3^- particles on the indoor plants have been reported highlighting their impacts on the biochemical properties of the plants.[19]`The Indian Nitrogen Assessment' is a very recent compilation of various studies about different aspects of reactive nitrogen in India.[20] However, forest N is not much covered in this report. In Nepal, the precipitation is found to have significant influence of pollution even at a remote site in the Khumbu region of the Himalayas where relatively high value of scavenging ratio of NO_3 was noticed as compared to other ions.[21] NO_3^- concentrations in aerosols were one third of NH_4^+ but in precipitation, the NO_3^- concentrations were greater than NH_4^+ due to the presence of gaseous HNO_3 in the air. This feature was more dominant when air was blowing from more polluted areas.

Model vs measurement comparison studies are very important for developing deposition prediction capabilities. In a pioneering effort, the measurements of the reactive nitrogen species such NH_4^+ and NO_3^- in rain water in India have been compared with the modeling output by Kulshrestha and co-workers[14] by using MATCH model.[22] The output of the model was helpful in providing an interpretation of the observational data of NH_4^+ and NO_3^-. However, such exercises are further needed to reduce the uncertainties of the model outputs.

This is to mention that there have been some issues of QA/QC of the data in south Asiaregion mainly due to the problems associated with sampling and chemical analysis of the reactive nitrogen species such as NH_4^+ and NO_3^-. Kulshrestha and co-workers have reviewed the precipitation chemistry data in the region.[14] These workers found that in most of the studies, NH_4^+ was under estimated due to analytical problems such as delay in analysis, no addition of preservative, improper storage of the samples etc. while NO_3^- was over estimated due to its additional contribution from local soil. Ion balance and conductivity balance approaches are supposed to be reported to support the analytical assurance. But most of the earlier studies lack such estimates of errors. Most of the measurements included F^-, Cl^-, NO_3^-, SO_4^{2-}, Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+ in ionic and conductivity balance calculations.The pH of rain water in India is relatively high having high concentrations of HCO_3 ion due to the influence of calcareous soils of this region. Hence, ion balance and conductivity balance checks without HCO_3^- do not really assure the data quality. Sometimes the results are influenced by the shape and material type (steel, plastic, glass) of the collection assembly. Improper transport, preservation and delay in analysis are also very important factors affecting the quality of the data.[23-24] In order to have good quality measurements, it is necessary to select sites which can represent larger areas. Overall, an adherence to QA/QC of data is mandatory for ensuring reliable and robust data sets in the long run.

Gaps and Recommendations

The south Asia region needs the following actions to fill the existing knowledge gaps related to N cycle-

i) Need to develop an integrated assessment plan for various Nr species including their emissions, abundance, transport, transformations, scavenging, impacts, forest pool etc.

ii) Good quality data availability is limited for Nr depositions in Indian region which needs a dedicated data and parameter specific protocol, inter-lab comparison exercises and a reference standards development initiative.

iii) A long term measurement network covering a number of sites of different charateristics with the aim to use its research findings in the policy making.

iv) In order to understand local, trans-boundary and long range transport of Nr species, the deposition studies need to be coupled with the trajectory analysis. It will be a good idea to constitute a program to monitor an import and export of pollution within south Asian countries under The South Asian Association for Regional Cooperation (SAARC).

v) We need to focus on the impact studies of various Nr species.

vi) Budgets of dry deposition of gases and aerosols especially NH_3 and NH_4^- in indoor environment will be highly useful.

vii) In order to understand the process involving in gas-aerosol interactions, scavenging, transport, evapo-transpiration, deposition and uptake etc., we need to develop a separate task force. Appropriate emphasis needs to be given on dry deposition studies of Nr in order to reduce uncertainties in Nr budget of this region.

viii) Also, there is a need to develop a common modeling group involving active scientist/groups. It would be more appropriate if we include some socio-economic expert(s) which will help in translating the scientific findings into an impactful report needed for the policy makers.

References

1. Galloway, J.N. Townsend, A.R., Erisman, J.W., Bekunda, M., Cai, Z., Freney, J.R., Martinelli, L.A., Seitzinger, S.P. Sutton, M.A.2008.Transformation of the nitrogen cycle: recent trends, questions, and potential solutions. Science. 320, 889-892.
2. Murugan AV, DADHWAL VK. 2007. Indian agriculture and nitrogen cycle. In ‘Agricultural Nitrogen Use & Its Environmental Implications’, YP Abrol, N Raghuram and MS Sachdev, eds., IK International Pub., N Delhi, pp 7-28.
3. Boerner L K. 2019. Industrial ammonia production emits more CO2 than any other chemical-making reaction. Chemists want to change that. 2019.https://cen.acs.org/environment/green-chemistry/Industrial-ammonia-production-emits-CO2/97/i24. Accessed on September 9, 2022.
4. Ramachandran A., Jain N K, Sharma S A and Pallipad J. 2013. Recent trends in tropospheric NO2 over India observed by SCIAMACHY: Identification of hot spots, Atmospheric Pollution Research, 4, 354-361.

5. Kulshrestha, U.C., Kulshrestha, M.J., Sekar, R., Sastry, G.S.R., Vairamani, M.: 2003 Chemical characteristics of rainwater at an urban site of south-central India. Atmos. Environ. 37, 3019–3026.
6. KulshresthaU and Sharma D. 2015.Importance of atmospheric dust in India: Future scope of research. *J. Indian Geophysical Union*, 19, 2, 205-209.
7. Kumar, B., Singh, S., Gupta, G. P., Lone, F. A., Kulshrestha, U. C., 2016. Long range transport and wet deposition fluxes of major chemical species in snow at Gulmarg in north western Himalayas (India). Aerosol and air quality research, 16: 606–617.
8. Singh S., Kumar B, Gupta G P, Kulshrestha U C. 2014. Signatures of Increasing Energy Demand of Past Two Decades as Captured in Rain Water Composition and Airmass Trajectory Analysis at Delhi (India). *Journal of Energy*, Environment & Carbon Credits, 2014, 4(3), 43-61.
9. Singh, S., Kulshrestha, U. C., 2014. Rural versus urban gaseous inorganic reactive nitrogen in the Indo-Gangetic plains (IGP) of India. Environmental Research Letters, 9(12), 125004. http://doi.org/10.1088/1748-9326/9/12/125004.
10. Singh, S. and Kulshrestha, U. C., 2012. Abundance and distribution of gaseous ammonia and particulate ammonium at Delhi , India. Biogeosciences, 9, 5023–5029. http://doi.org/10.5194/bg-9-5023-2012.
11. Kulshrestha U. 2017. Assessment of Atmospheric Emissions and Deposition of Major Nr Species in Indian region. In The Indian Nitrogen Assessment (Eds.: Y P Abrol and T K Adhya), Elsevier, pp 422-444.
12. Parashar D. C., GranatL, Kulshrestha U C, Pillai A G, Naik M S, Momin G A, Rao P S P, Safai P D, Khemani L T, Naqvi S W A, Narvekar P V, Thapa K B and Rodhe H. 1996. Chemical composition of precipitation in India and Nepal- A preliminary report on Indo-Swedish project on atmospheric chemistry. Report CM-90, Stockholm University, Sweden.
13. Kulshrestha U. C., Granat L and Rodhe H. 2003.Precipitation chemistry studies in India- a search for regional patterns.Report CM-99, Stockholm University, Sweden.
14. Kulshrestha, U. C., Granat, L., Engardt, M., & Rodhe, H. 2005. Review of precipitation monitoring studies in India—a search for regional patterns. Atmospheric Environment, 39(38), 7403-7419.
15. Vet, R., Artz, R.S., Carou, S., Shaw, M., Ro, C.U., Aas, W., Baker, A., Bowersox, V.C., Dentener, F., Galy-Lacaux, C. and Hou, A., 2014. A global assessment of precipitation chemistry and deposition of sulfur, nitrogen, sea salt, base cations, organic acids, acidity and pH, and phosphorus. Atmospheric Environment, v.93, pp: 3-100.
16. Dentener, F., Drevet, J., Lamarque, J.F., Bey, I., Eickhout, B., Fiore, A.M., Hauglustaine, D., Horowitz, L.W., Krol, M., Kulshrestha, U.C. and Lawrence, M et al., 2006. Nitrogen and sulfur deposition on regional and global scales: a multimodel evaluation. Global biogeochemical cycles, v. 20(4), pp: 1 – 21.
17. Kulshrestha, U.C., Kulshrestha, M.J., Satyanarayana, J. and Reddy, L.A.K., 2014. Atmospheric deposition of reactive nitrogen in India. In Nitrogen Deposition, Critical Loads and Biodiversity (pp. 75-82). Springer Netherlands.
18. Saxena A., Kulshrestha U. C., Kumar N., Kumari K. M., Prakash S. and Srivastava S. S. 1997. Dry deposition of sulphate and nitrate to polypropylene surfaces in a semi-arid area of India. Atmospheric Environment, 31, 2361-2366.
19. Katoch A. and Kulshrestha U. C. 2022. Seasonal Variations of Dustfall Fluxes and Biochemical Parameters in the Foliage of Selected Indoor Plants in Delhi, India.International Journal of Phytoremediation, DOI: 10.1080/15226514.2022.2122394.
20. Abrol Y. P, Adhya T K, Aneja V P, Raghuram N, Pathak H, Kulshrestha U, Sharma C and Singh B. (Eds). 2017. The Indian Nitrogen Assessment'. Elsevier, USA, ISBN: 9780128118368.
21. Shrestha A. B., Wake C P, Dibb J E, Whitlow S I. 2002.Aerosol and precipitation chemistry at a remote Himalayan site in Nepal. Aerosol Sci Tech,36, 441–56.
22. Engardt, M., Leong, C.P., 2001. Regional modelling of anthropogenic sulphur in Southeast Asia. Atmospheric Environment, 35, 5935–5947.

23. Gillett R. and Ayers G. 1991. The use of thymol as a biocide in rain water samples. Atmospheric Environment, 24A, 2677-2681.
24. Granat, L., 1997. Acid and alkaline rains in India—spatial distribution and measurements. In: Das, S.N., Thakur, R.S. (Eds.), IGBP Symposium on Changes in Global Climate Due to Natural and Human Activities, January 15–17. Allied Publishers Limited, New Delhi.