# Stable isotopic composition of $\delta^{15}N-NO_3^-$ and $\delta^{18}O-NO_3^-$ in precipitation of Kathmandu valley during monsoon season

**Sujan Shrestha[1]*, S. Shrestha[2], T. Nakamura[3] and F. Kazama[3]**

[1]International Special Doctoral Course for Integrated River Basin Management, Interdisciplinary Graduate School of Medicine and Engineering, University of Yamanashi, Japan

[2]Water Engineering and Management, School of Engineering and Technology, Asian Institute of Technology, Bangkok, Thailand

[3]International Research Center for River Basin Environment, University of Yamanashi, Japan

(*corresponding email: sujan_353619@yahoo.com)

## 1. Background

- Air pollution is a serious problem in Kathmandu Valley due to land use, land cover changes, increased vehicular activities and industrialization along with rapid population growth in last decade. Corresponding effect has increased particulate matters concentration in the atmosphere that poses a significant threat to human health and ecosystem of the valley.
- While Kathmandu Metropolitan officials are encouraging its inhabitants to harvest rainwater for domestic use and recharging shallow groundwater wells in order to curb the water scarcity problem in the valley, only little is known about the atmospheric pollution and its impact on rainwater chemistry and subsequent effects. In this situation, it is very urgent to identify the concentrations of nitrate, its source and pathways to develop sound regulatory management and mitigation strategies for air and water quality in the valley.

## 2. Study area (Kathmandu Valley, Nepal)

### Kathmandu Valley

- Lies at 27 32' to 27 49' N and 85 11' to 85 31' E
- Topography & elevation: Gentle and flat land at central part: 1300-1400masl, surrounding mountain: >2000masl
- Climate: Semi-tropics, warm and temperate
- Monsoon :July-September

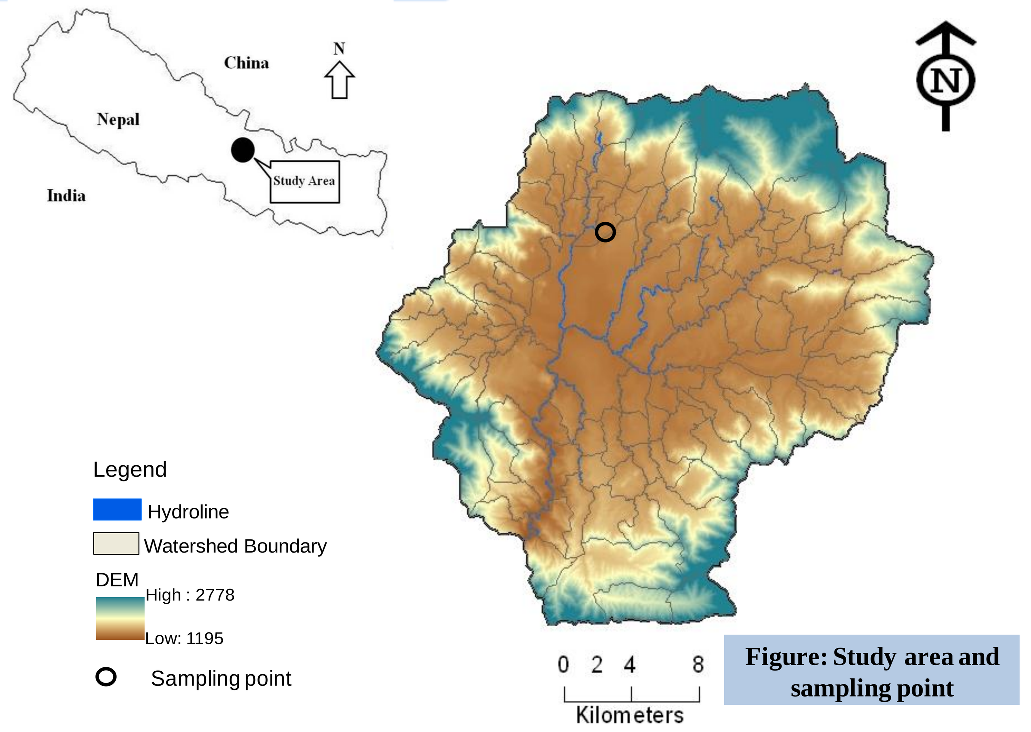



Figure: Study area and sampling point

## 3. Research methodology

**Sampling:** Rainwater samples were collected during monsoon season ( July –August ,2011)

**Analysis**

- Major cation & anion : 761 Compact IC, Metrohm
- $NH_4^+$ : Indophenol method
- $NO_3^-$ : Flow injection analysis
- $\delta^{15}N-NO_3^-$ and $\delta^{18}O-NO_3^-$ : Denitrifier method (Sigma et al., 2001; Casciotti et al., 2002)
- Stable isotopes (D and $^{18}O$) : by Cavity Ring Down Spectrometer (CRDS)- (Picarro;L-1102i)

## 4. Results and discussion

**Monsoon precipitation characteristics in the Kathmandu valley, Nepal during 2011.**

| Parameters | Min | Max | VWM |
|---|---|---|---|
| pH | 5.70 | 7.70 | 6.32 |
| EC | 1.00 | 226 | 12.4 |
| $Cl^-$ | 4.17 | 1555 | 49.0 |
| $NO_3^-$ | 6.37 | 167 | 17.1 |
| $SO_4^{--}$ | 4.19 | 55.4 | 13.7 |
| $HCO_3^-$ | 18.3 | 229 | 65.9 |
| $Na^+$ | 2.31 | 54.4 | 7.60 |
| $NH_4^+$ | 14.3 | 194 | 35.7 |
| $K^+$ | 3.73 | 1344 | 42.2 |
| $Mg^{++}$ | 1.65 | 43.0 | 5.03 |
| $Ca^{++}$ | 15.2 | 368 | 47.1 |
| $\delta^{18}O-H_2O$ ‰ | -16.7 | -5.8 | -12.1[a] |
| $\delta^{15}N-NO_3^-$ ‰ | -5.9 | 3.3 | -1.1[a] |
| $\delta^{18}O-NO_3^-$ ‰ | 12.2 | 44.5 | 24.9[a] |
| Precipitation (mm) | 1.77 | 61.0 | 17.5[b] |

Volume weighted mean (VWM) concentration (in $\mu eql^{-1}$), electrical conductivity (EC in $\mu Scm^{-1}$) , pH (n=37) and (n=33) for stable isotopes

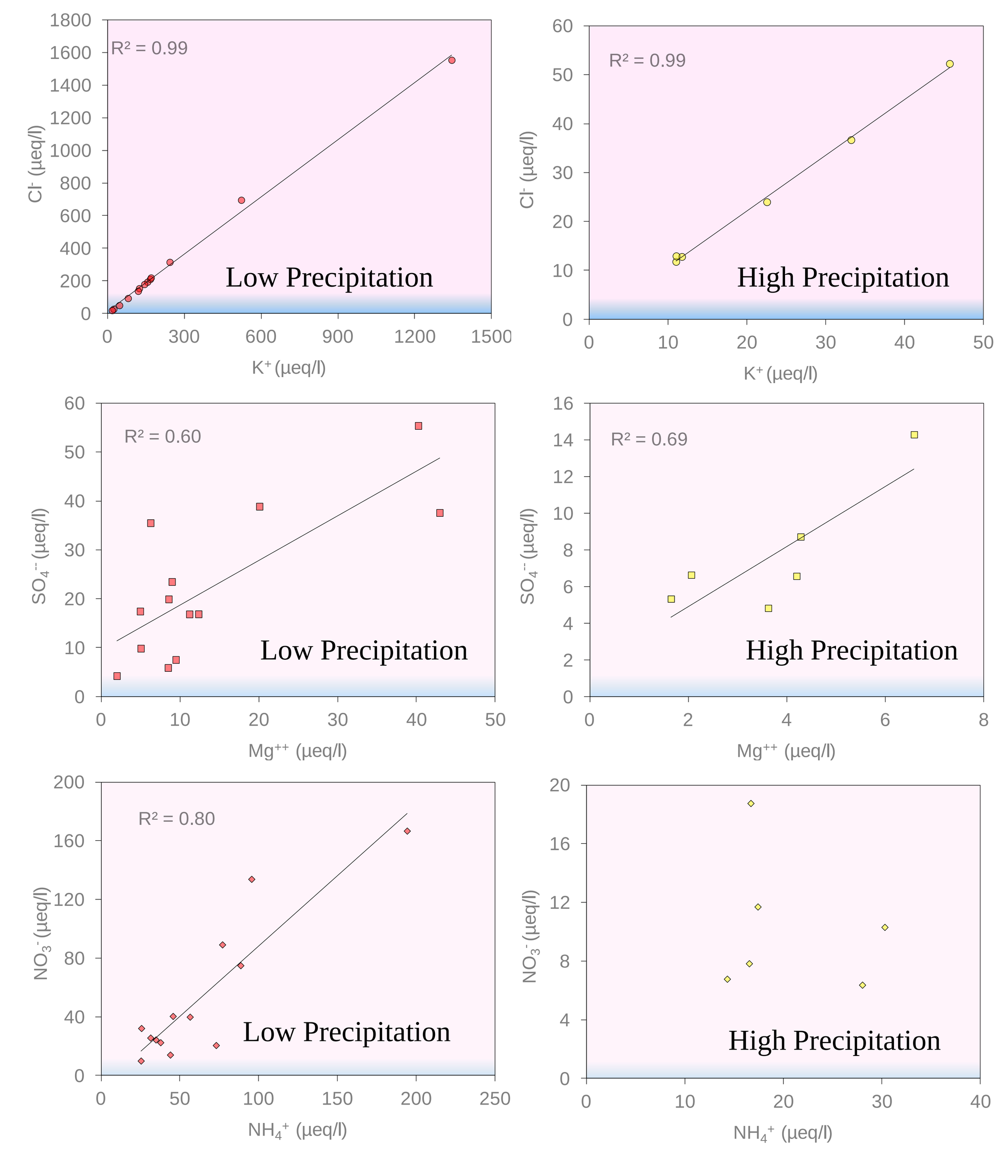
[a] mass weighted mean
[b] mean

- Bicarbonates , calcium and chloride are the major ions showing dust as a major sources

**Table showing the enrichment factor (EF) relative to the seawater in Kathmandu valley during monsoon 2011.**

| | $SO_4^{--}/Na^+$ | $Ca^{++}/Na^+$ | $Cl^-/Na^+$ | $K^+/Na^+$ | $Mg^{++}/Na^+$ |
|---|---|---|---|---|---|
| Seawater ratio | 0.125 | 0.044 | 1.16 | 0.022 | 0.23 |
| Rainwater ratio | 1.54 | 6.63 | 11.6 | 9.74 | 0.71 |
| EF seawater | 12.3 | 150 | 10.1 | 442 | 3.12 |

High EF suggesting strong influence of local sources such as anthropogenic as well as dust sources




Certain low and high precipitation events shows well correlation indicating towards the same sources i.e., fertilizers or other anthropogenic sources . Though there exist no good correlation between $NO_3^-$ & $NH_4^+$ , washout of gaseous particles in the atmosphere will bring additional nitrate in the precipitation.

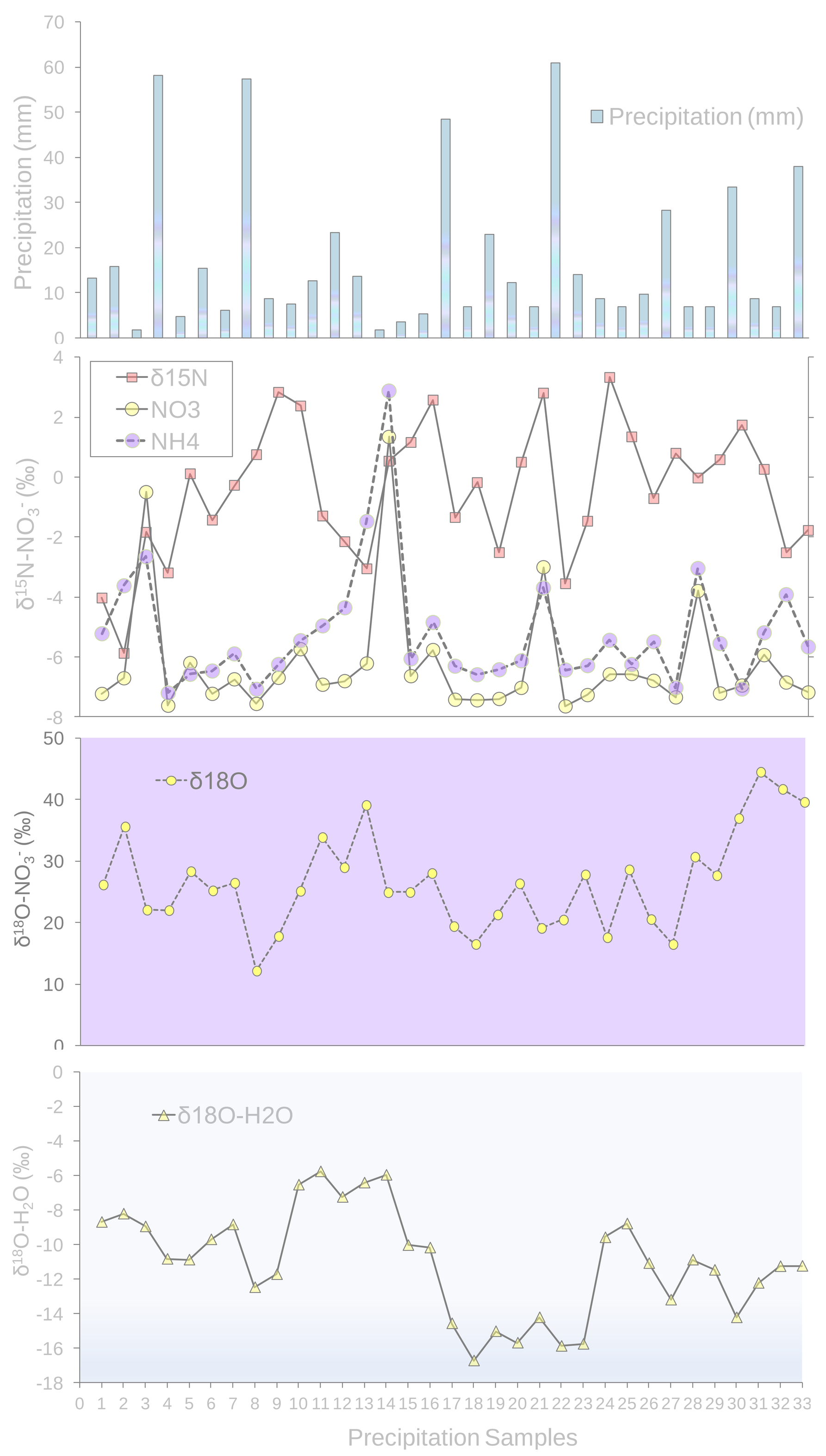



Figure: Monsoon precipitation, $\delta^{15}N-NO_3^-$, $NH_4^+$ and $NO_3^-$ concentration , $\delta^{18}O-NO_3^-$ and $\delta^{18}O-H_2O$ in Kathmandu valley during monsoon 2011.

The collected samples shows fluctuation in $\delta^{15}N-NO_3^-$, value, in general the $NH_4^+$ conc. increases compared to $NO_3^-$ showing $NH_3$ soil, fertilizer & animal excreta emission associated with warm weather (agricultural practices). The amount effect is more visible where $\delta^{18}O-H_2O$ is depleting .

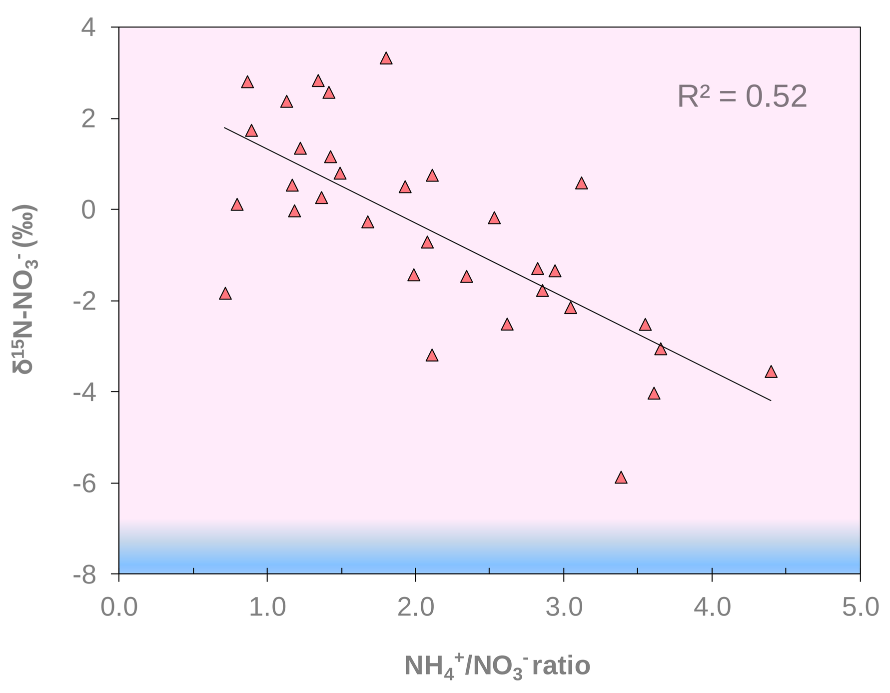



**Figure: The regression of $NH_4^+/NO_3^-$ vs. $\delta^{15}N-NO_3^-$ during the sampling period in monsoon.**

- The medium correlation of $\delta^{15}N$ with $NH_4^+/NO_3^-$ corresponds lighter nitrogen isotopes.
- The weak correlation among crustal ions ( $Ca^{++}$ and $Mg^{++}$ ) indicates that lighter nitrogen isotopes and associated nitrate originated locally.

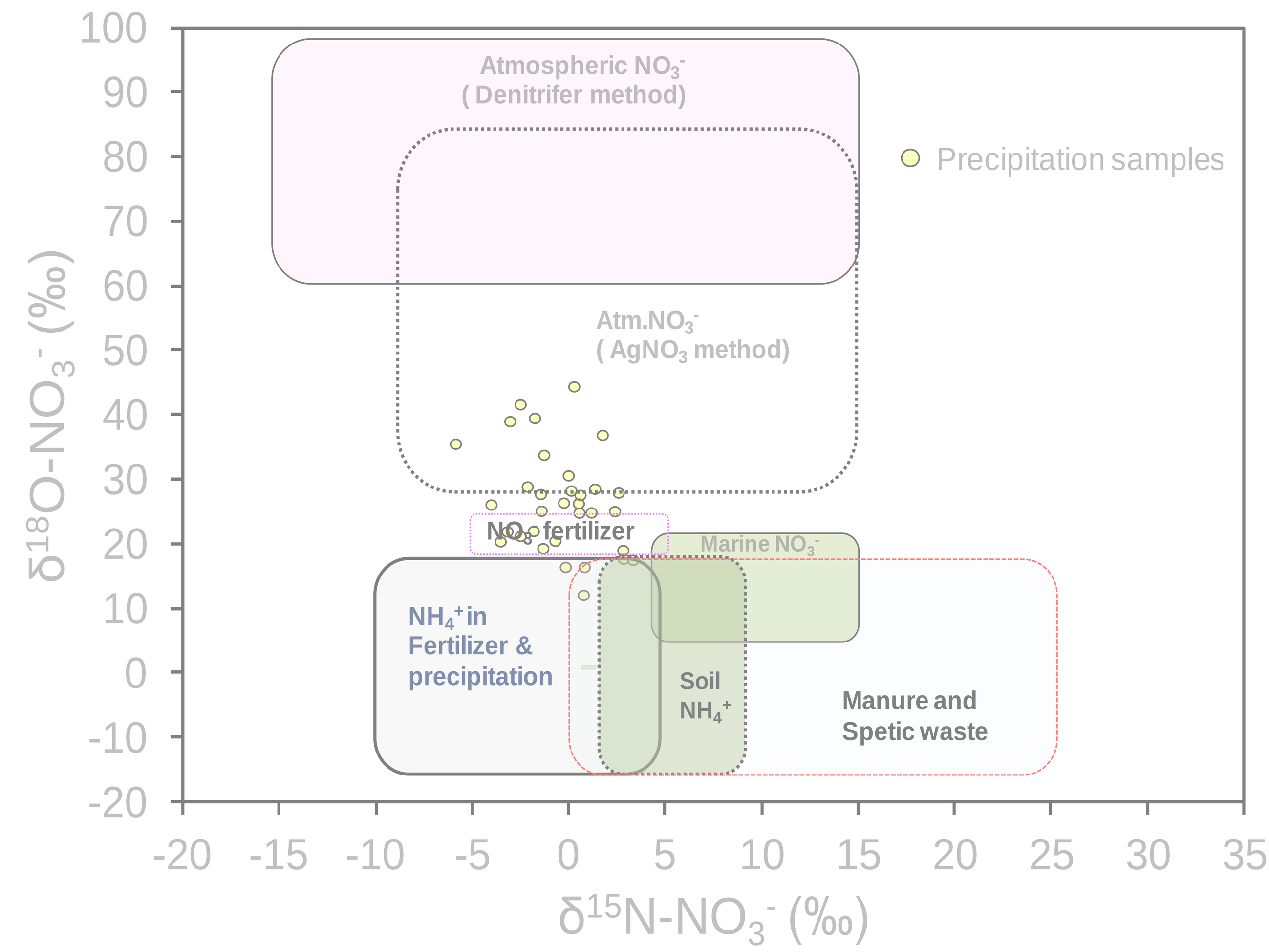



**Figure: The $\delta^{15}N-NO_3^-$ and $\delta^{18}O-NO_3^-$ in precipitation of Kathmandu valley during monsoon 2011. Areas show the range of $\delta^{15}N-NO_3^-$ and $\delta^{18}O-NO_3^-$ values in Kendall et al. (2007).**

- Our $\delta^{15}N-NO_3^-$ value are close to the fertilizer sources ranging from -5.9 to 3.3 ‰ .
- Relatively low $\delta^{18}O-NO_3^-$ in precipitation shows synthetic fertilizers sources which range from +17 to +25 ‰, higher value above this could be the mixture of both type fertilizers.

## 5. Summary

- The precipitation character during monsoon is affected by dust sources and the mixture of agricultural as well as vehicular sources .
- Atmospheric contribution of nitrate in precipitation is not so much in Kathmandu valley during monsoon season.