Insights into wet deposition of trace elements to central Himalayas: Spatial and seasonal variations

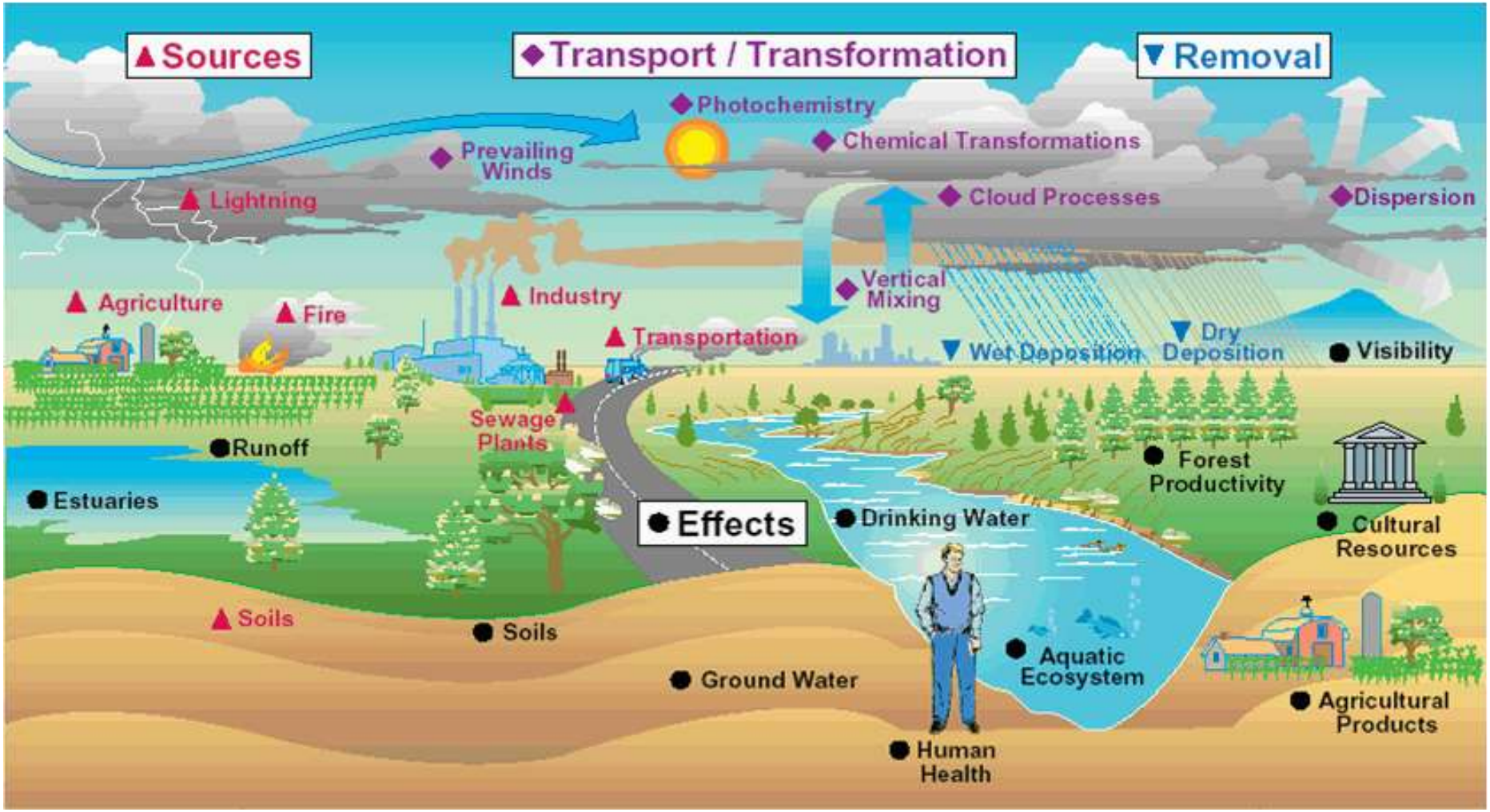
Lekhendra Tripathee and Shichang Kang

State Key Laboratory of Cryospheric Sciences, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences,
Lanzhou, China.

ACAM-2017- Guangzhou

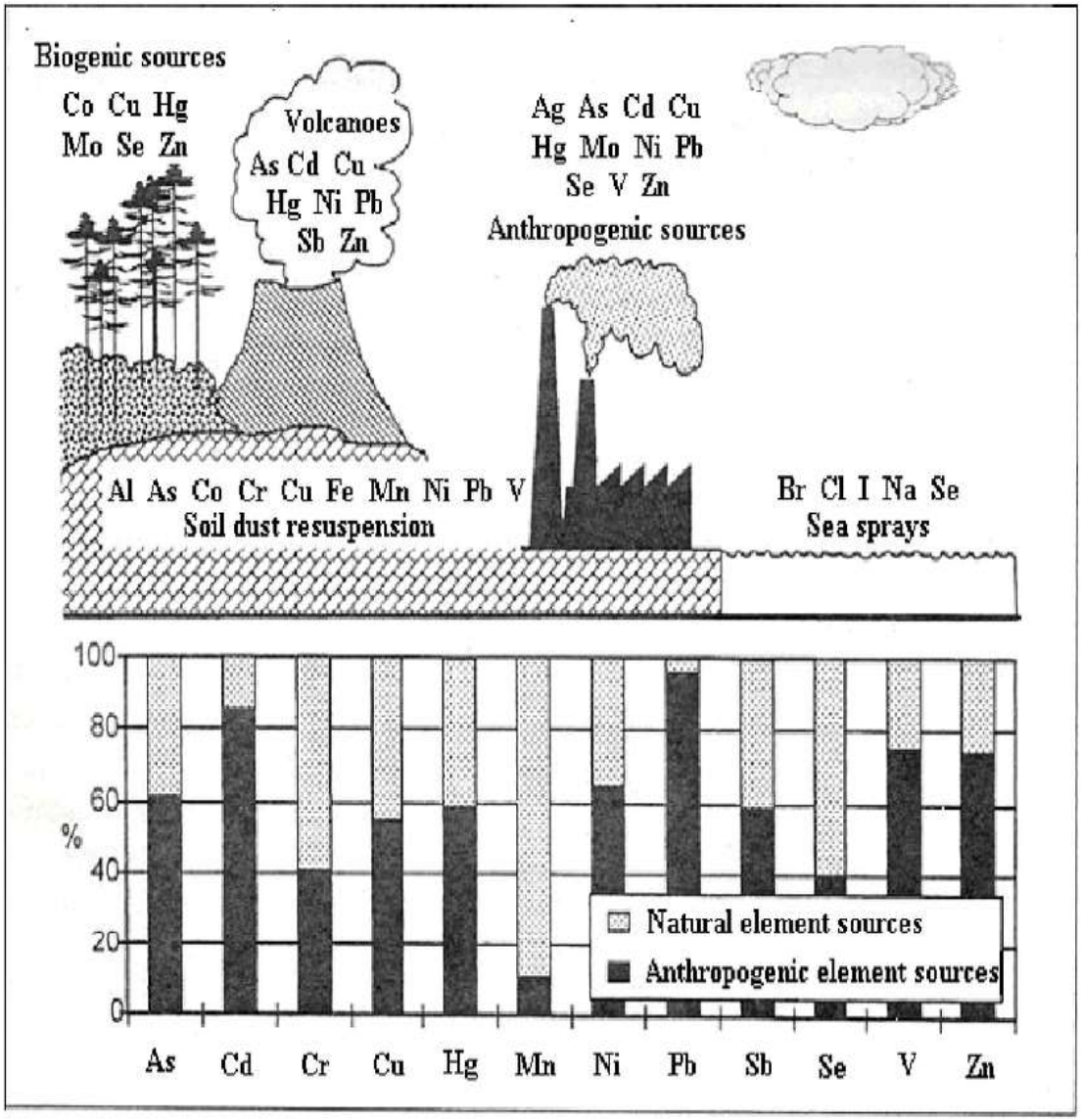
E-mail: lekhendra.t@gmail.com

Sources and transport pathways of pollutants in the environment



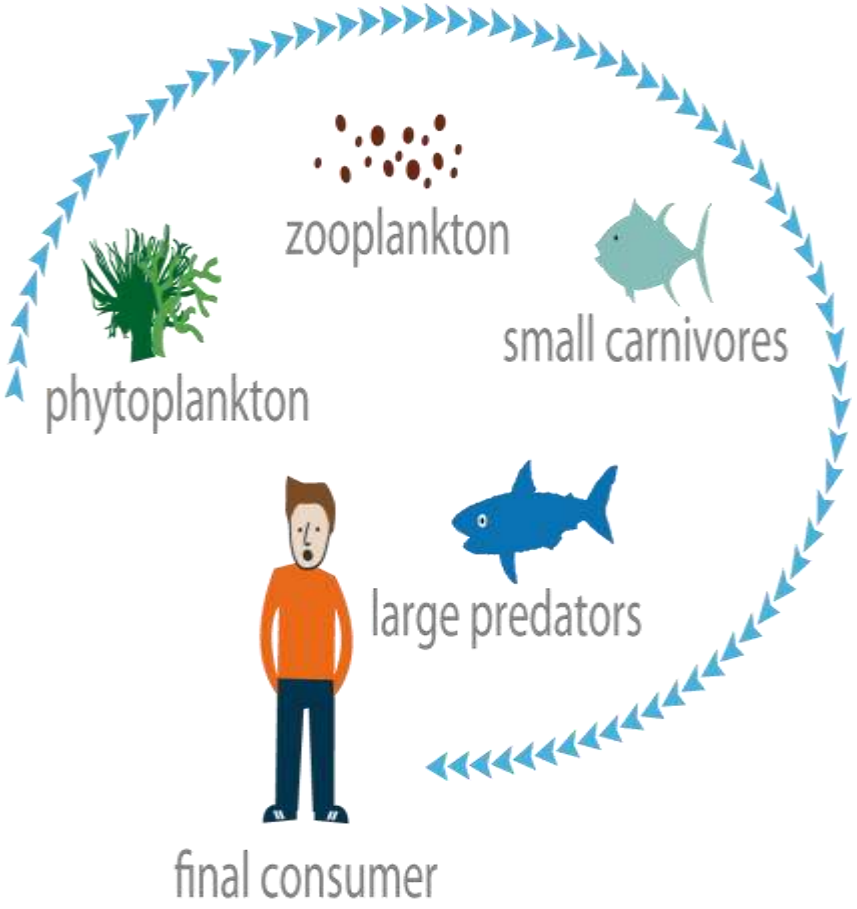
Precipitation composition studies *Why??*

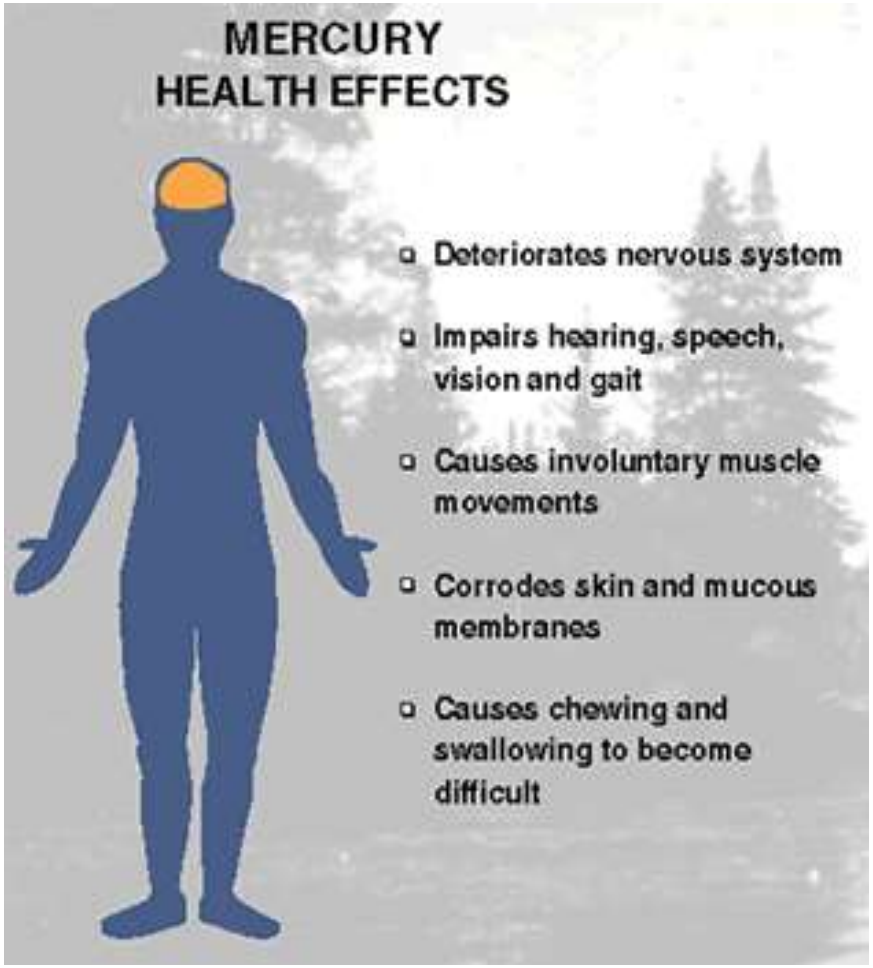
- Precipitation is considered as the natural pathway for removal of atmospheric pollutants
- Data of the wet deposition of trace elements are useful for assessment of pollutant emission
  - **Bioaccumulation**
  - **toxic and risk to human and the ecosystem health**
  - **persistence and can be long-range transported**



Mercury???

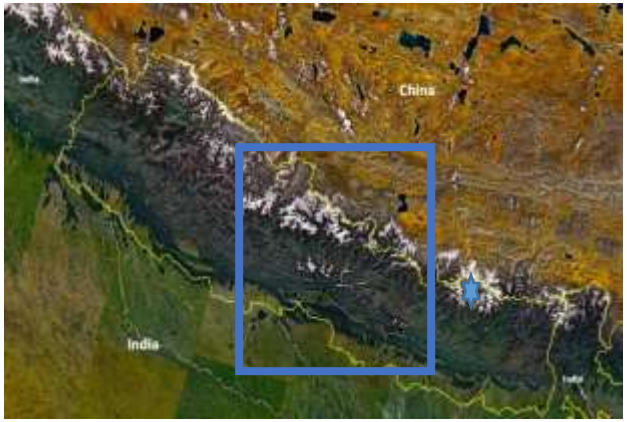
- High toxicity, volatility
- Long range transport
- Long atmospheric residence
- bio-accumulate in human body





Status in southern side of the central Himalayas

- Lack of studies
- Long term monitoring

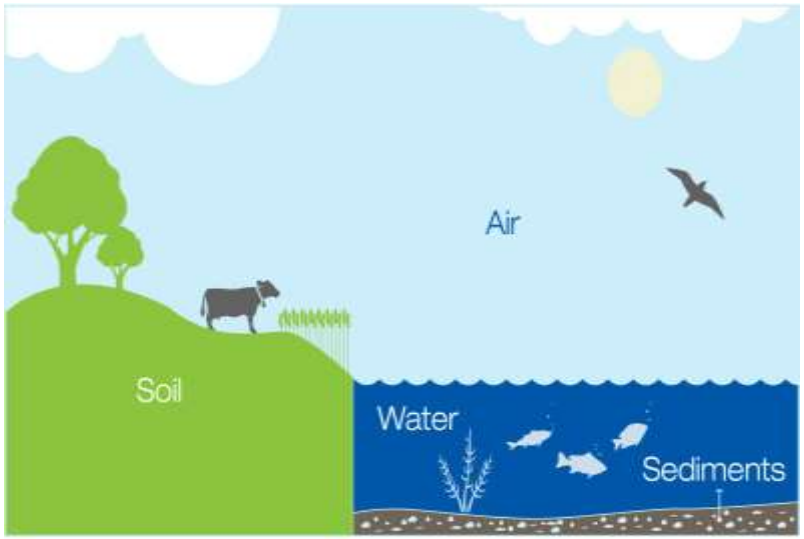


Objectives

Precipitation Composition Central Himalayas

Long term Observation:
Inorganic Elements and Hg

- **Understand the distribution, seasonality and sources of inorganic pollutants**
- **Baseline database**



Sampling sites

- Kathmandu, Dhunche, Dimsa and Gosainkunda on the southern side of central Himalayas.
- Urban, semi-urban and rural with different elevation transect and geographical features

Stations sites, elevation and average annual rainfall

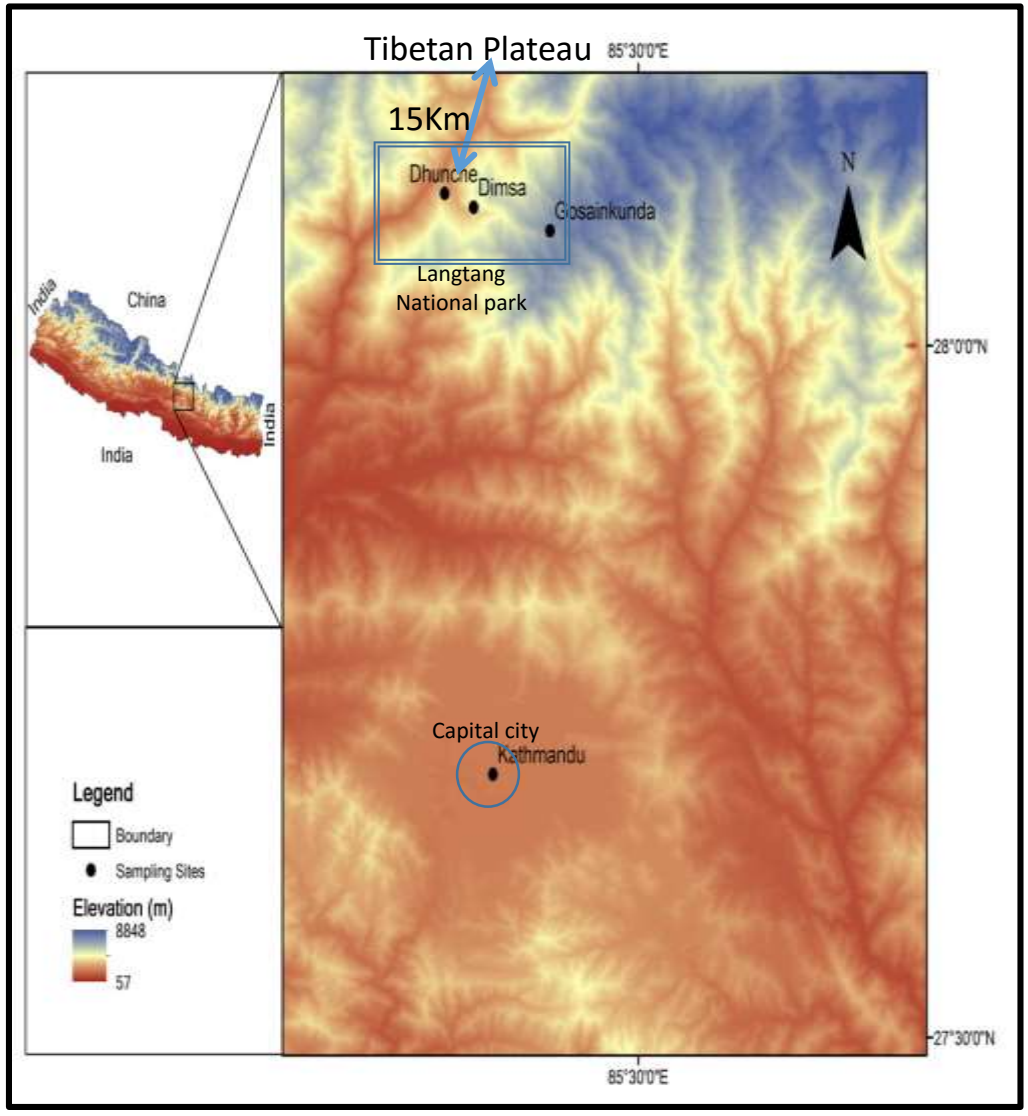
Sites	Latitude (˚N)	Longitude (˚E)	Altitude (m)	Rainfall (mm)
Kathmandu	27.68	85.35	**1314**	**1445.22**
Dhunche	28.11	85.30	**2065**	**1883.92**
Dimsa	28.10	85.33	**3078**	-
Gosainkunda	28.08	85.40	**4417**	-

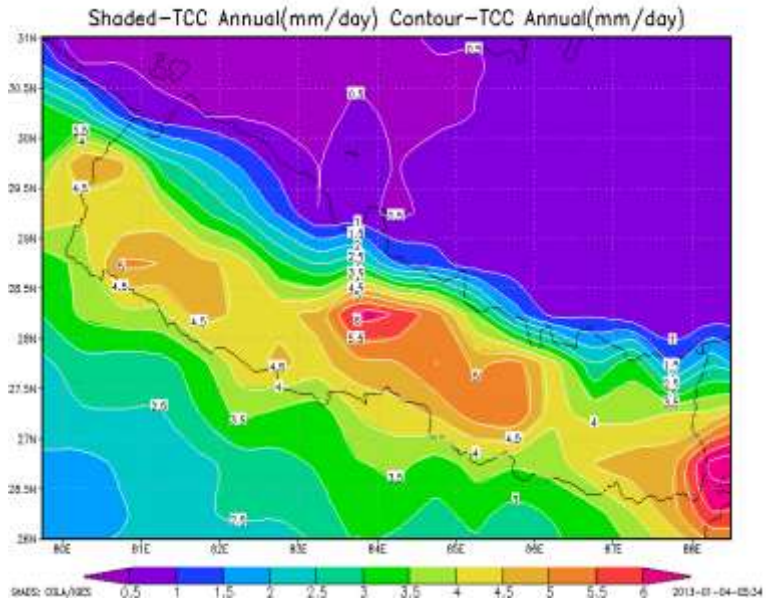
Sampling sites

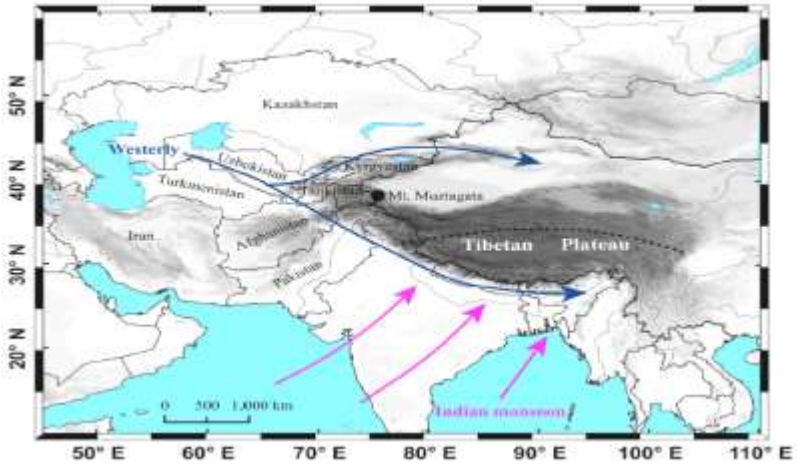
The major human activities around the Kathmandu are vehicles emission, industries, unmanaged urbanization and agricultural activities around the valley

In Dimsa and Gosainkunda, the major human activities are tourism and limited agricultural activities, local emissions are only due to burning of biomass for cooking and making the houses warm.

Sampling Sites







Laboratory analysis

- **Inductively coupled plasma-mass spectrometry (ICP-MS, X-7 Thermo Elemental)**
- **Trace elements (e.g. Al, Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb)**

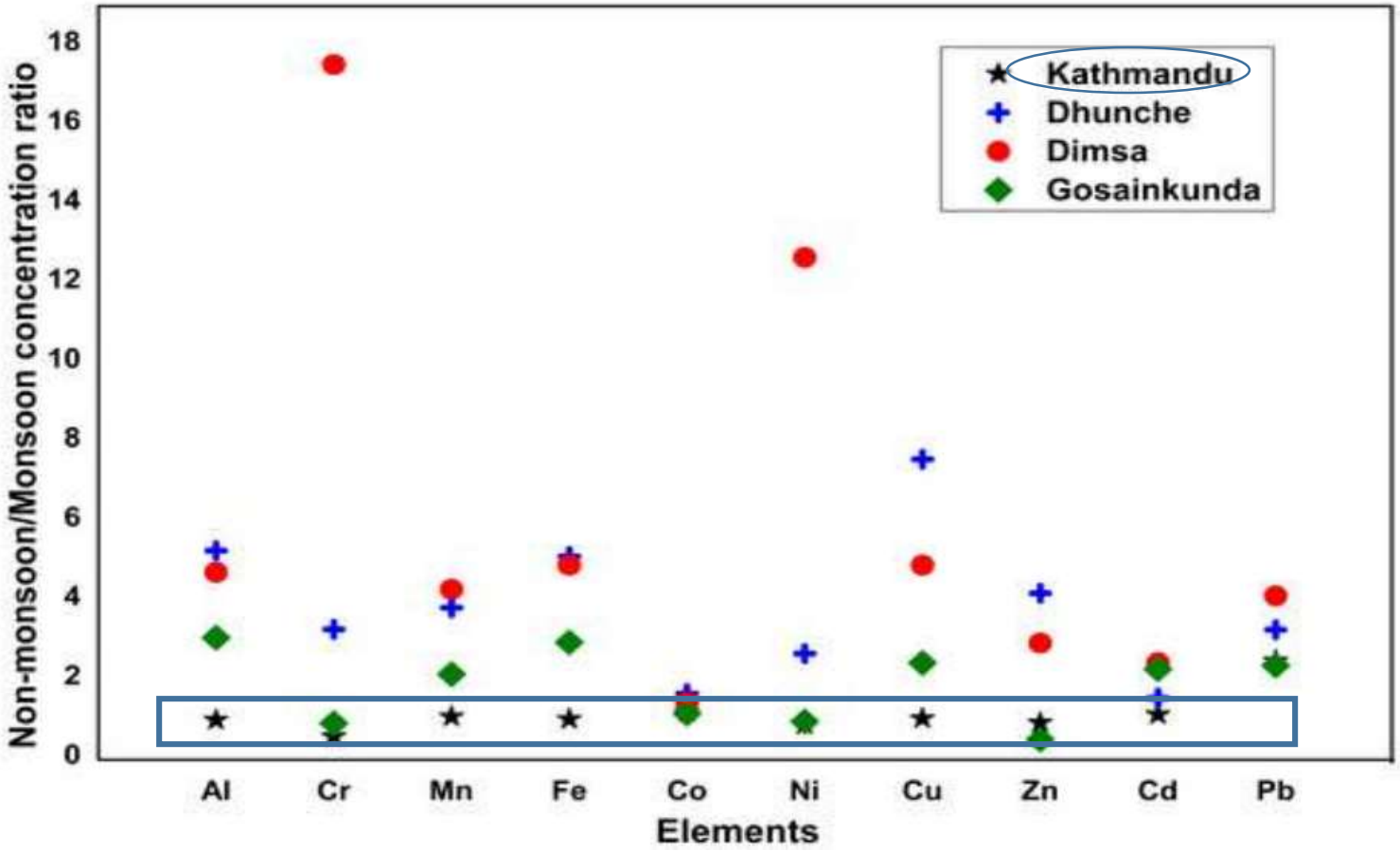
- **Mercury : cold and vapor atomic fluorescence spectroscopy (CVAFS)**
- **Tekran (Model 2600 mercury analysis system**

Results: concentration of elements in Precipitation

Element	Kathmandu N=68	Dhunche N=69	Dimsa N=45	Gosainkuna N=40
Al	145.05	52.25	84.71	40.36
Cr	1.11	0.20	1.06	0.95
Mn	5.76	2.25	4.67	2.08
Fe	170.58	52.49	85.44	43.41
Co	0.69	0.38	1.18	0.79
Ni	0.49	1.02	1.03	0.47
Cu	1.35	0.87	0.92	0.45
Zn	16.91	9.78	8.40	13.15
Cd	0.071	0.061	0.018	0.01
Pb	0.981	0.908	0.589	0.357

- **Higher mineral particle loading in urban site (Kathmandu)**
- **Cd and Pb showed a trend "higher/lower in south/north"**

Seasonal variations of TEs



- Kathmandu was not clear
- Local sources were dominant over the regional sources
- Other three stations exhibited a clear seasonal variation

Enrichment Factor: Natural crustal Vs anthropogenic contribution

The EF can be defined as:

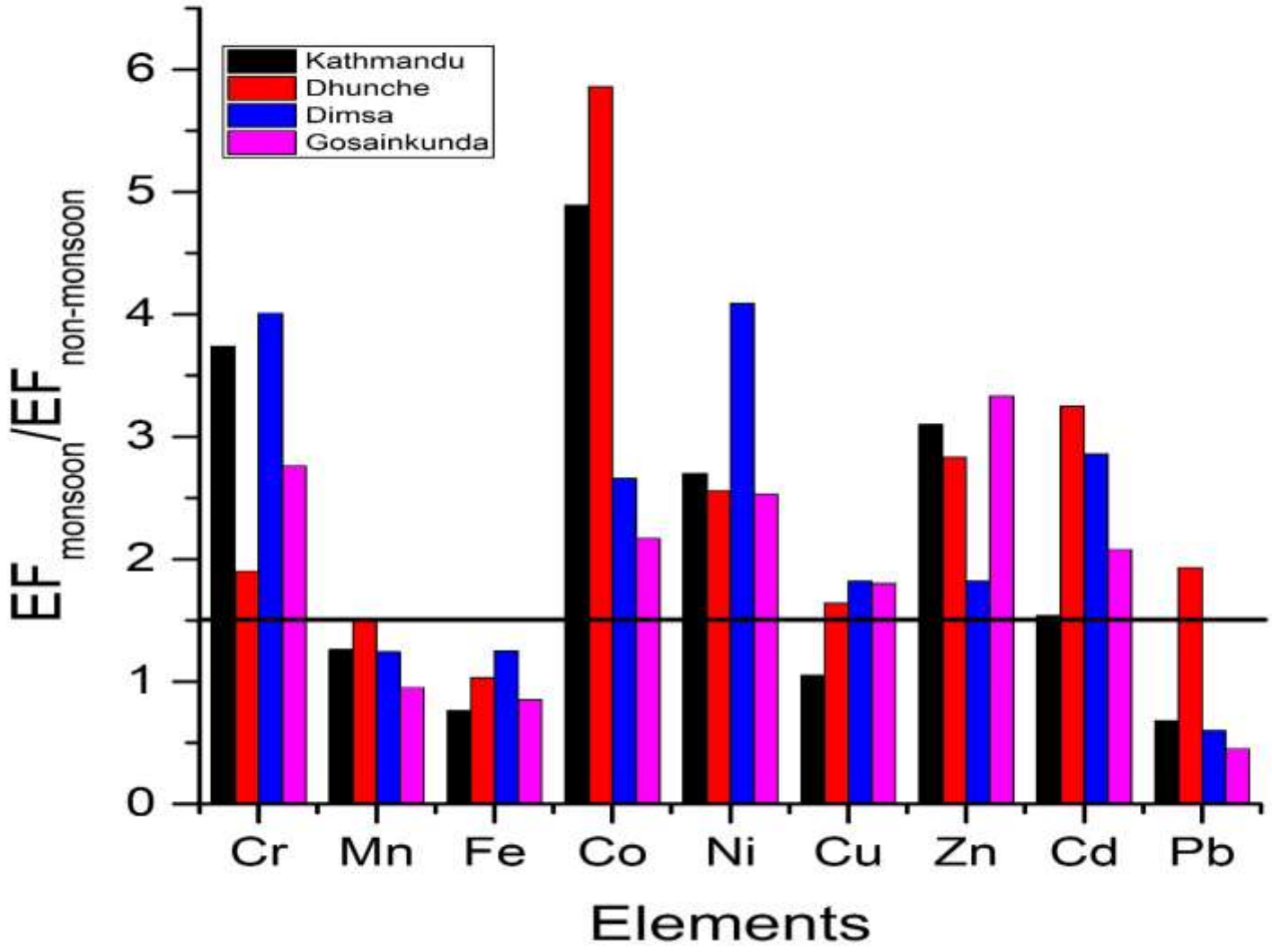
$$EF_x = \frac{(C_x/C_R)_{Precipitation}}{(C_x/C_R)_{soil}}$$

- **Where X represents the element of interest**
- **EF_x is the enrichment factor of X; C_x is the concentration of X; and C_R**
- **The concentration of a reference element (e.g. Al)**

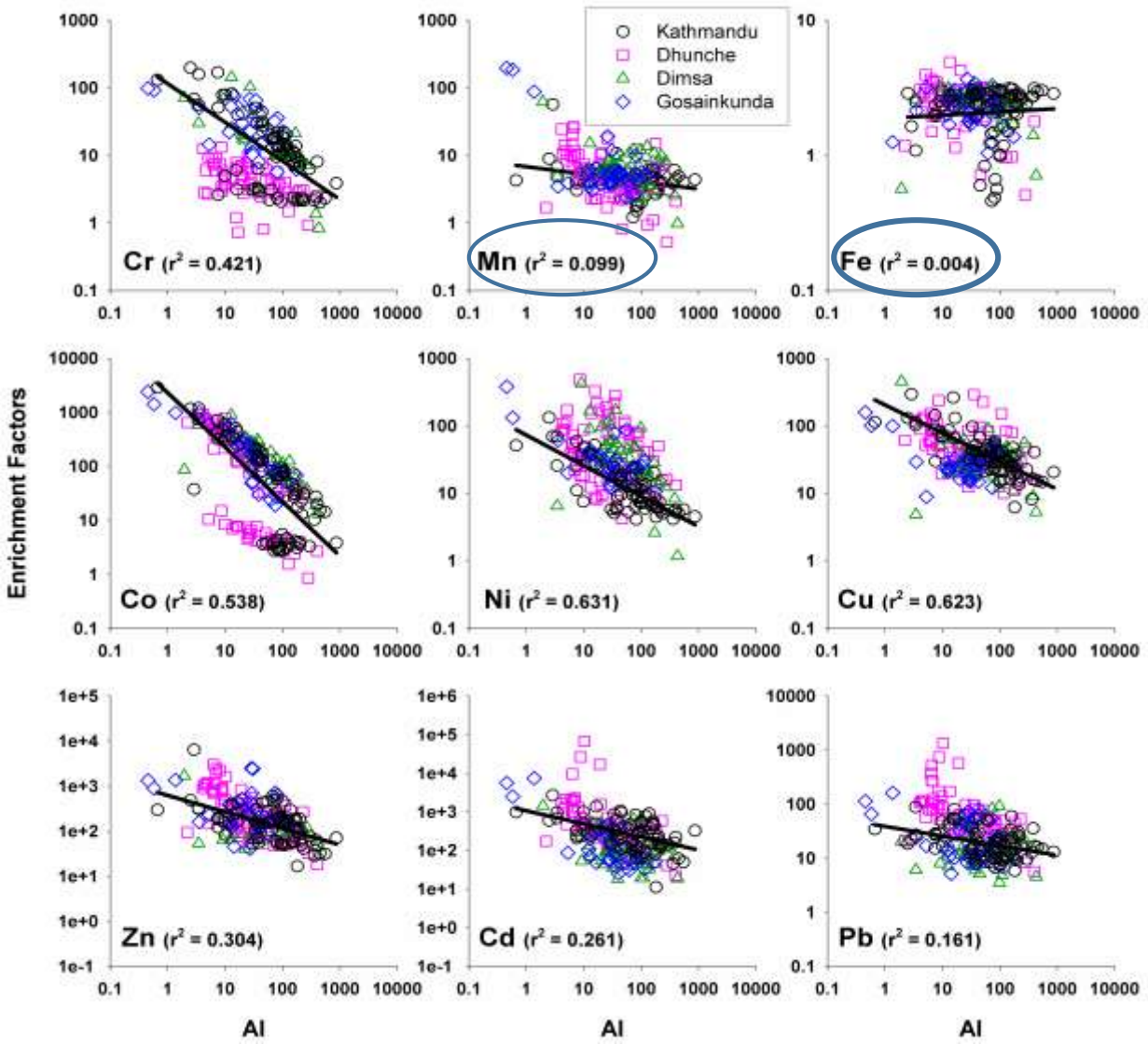
- The average top soil composition from the Tibetan Plateau (Li et al., 2009)

- Proximity of our sampling sites with the TP

Average Enrichment Factors of Trace elements



EFs vs. log Al

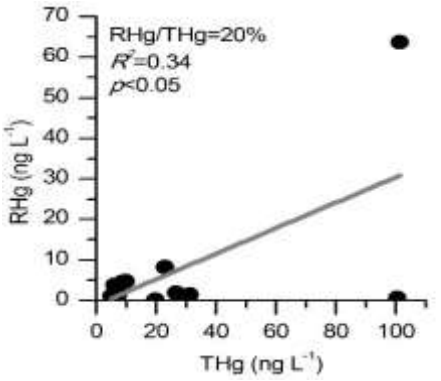


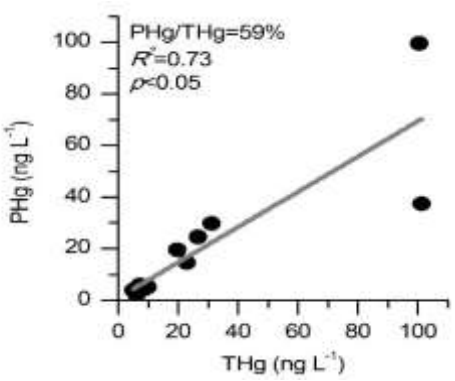
- ❑ EF of non-crustal elements would decrease with increasing Al concentration

- Fe and Mn do not show good correlations
- Remaining elements have a more defined inverse relationship, indicating a source other than crustal.

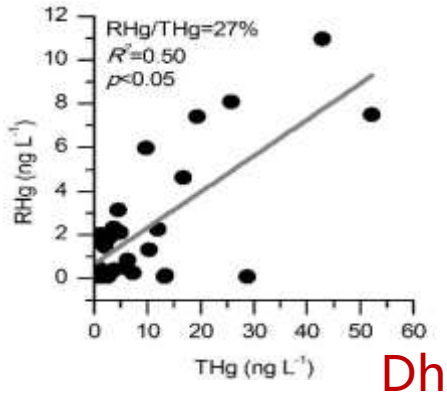
Results: Mercury in precipitation

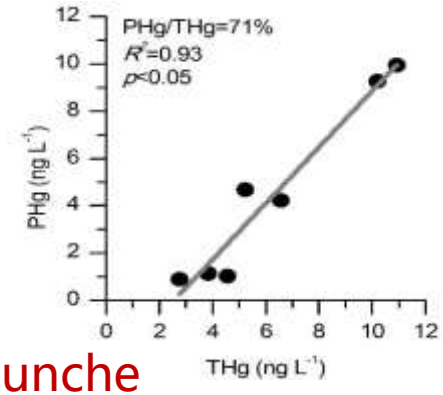
Sites	THg (ng L^{-1})	RHg/THg (%)	PHg/THg (%)
Kathmandu	20.6	20	59
Dhunche	10.1	26	60
Dimsa	7.7	19	80
Gosainkunda	6.5	5	63



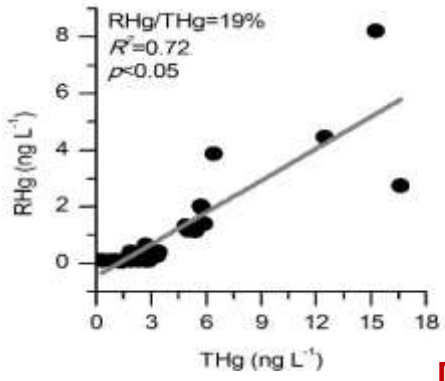


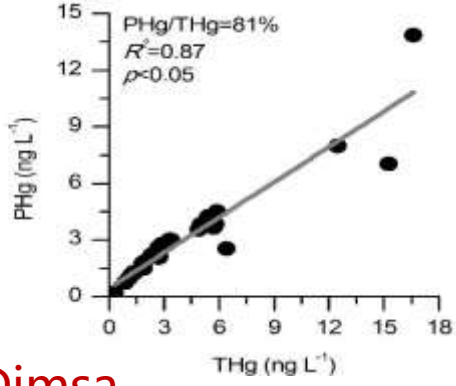
Kathmandu



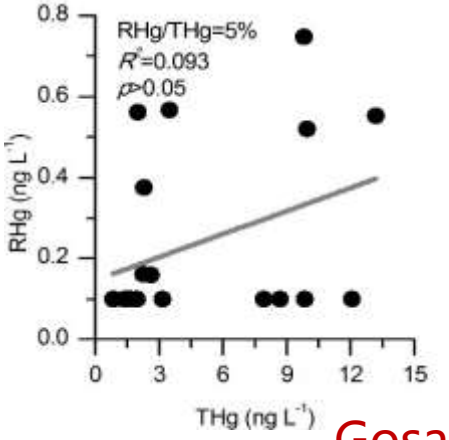


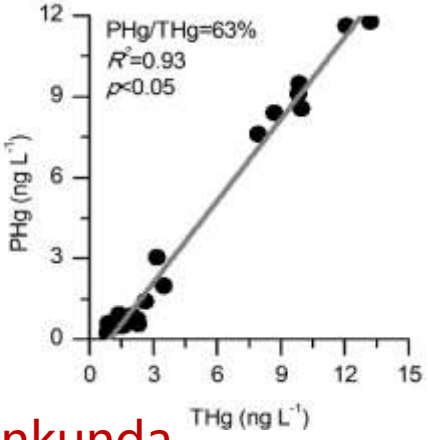
Dhunche





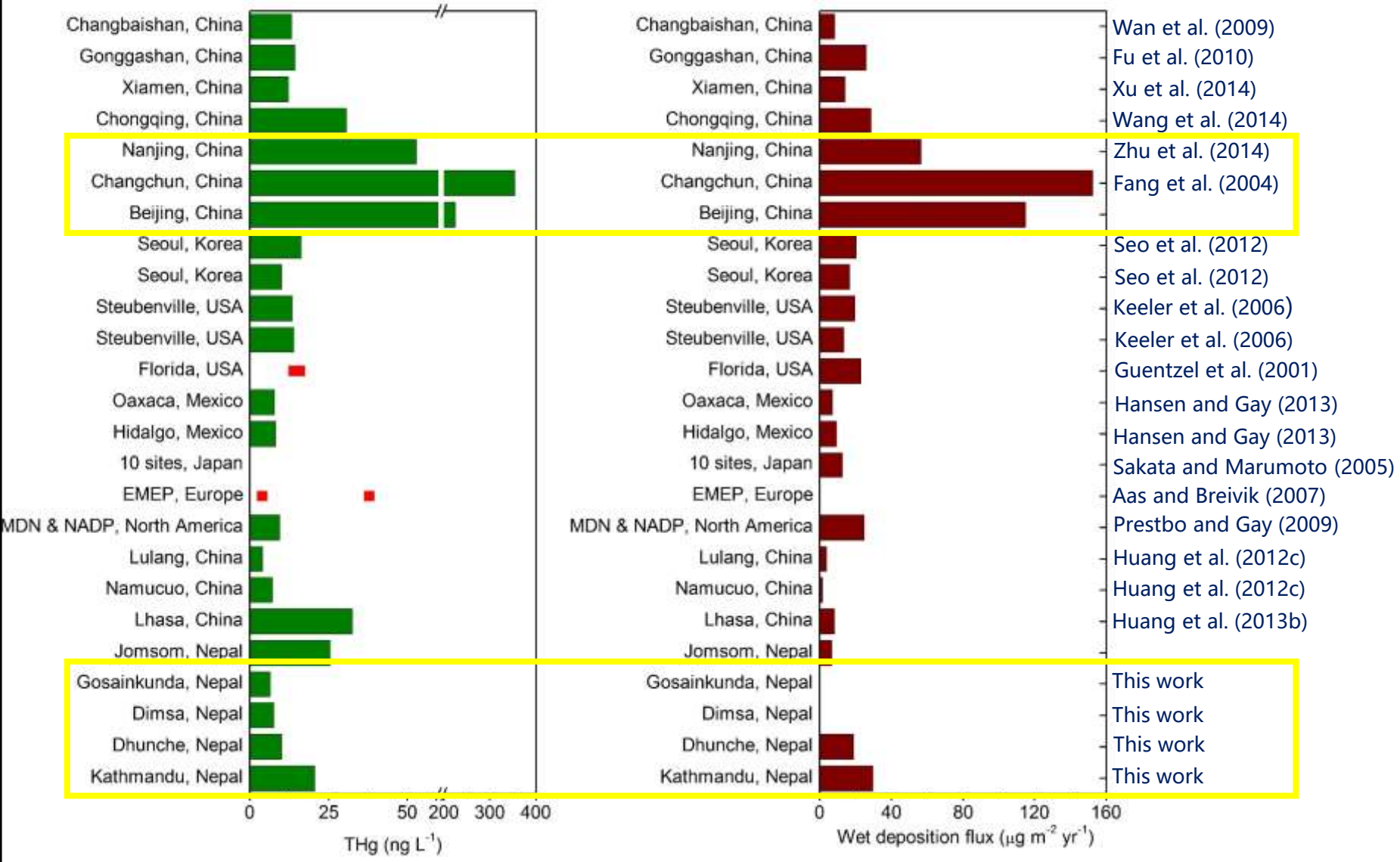
Dimsa



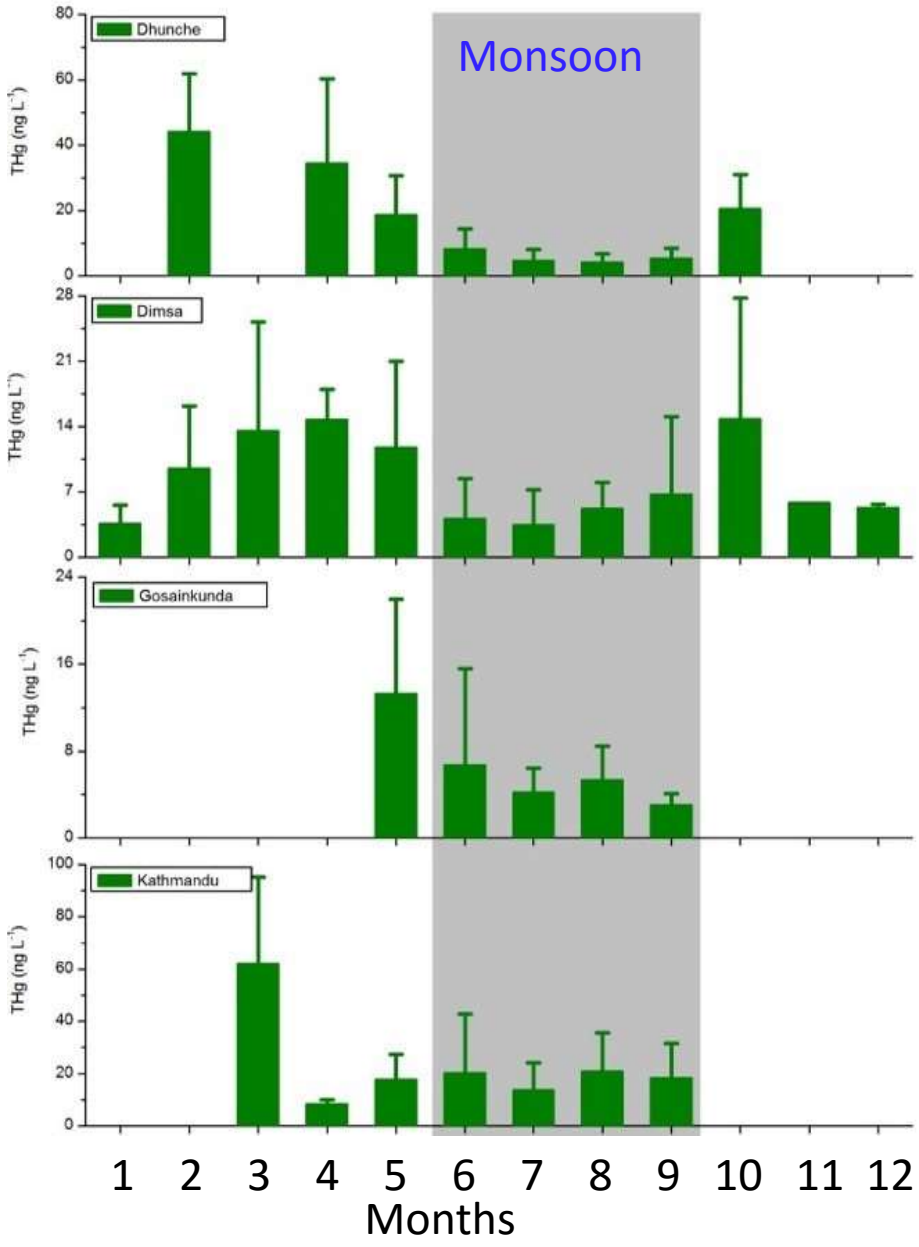


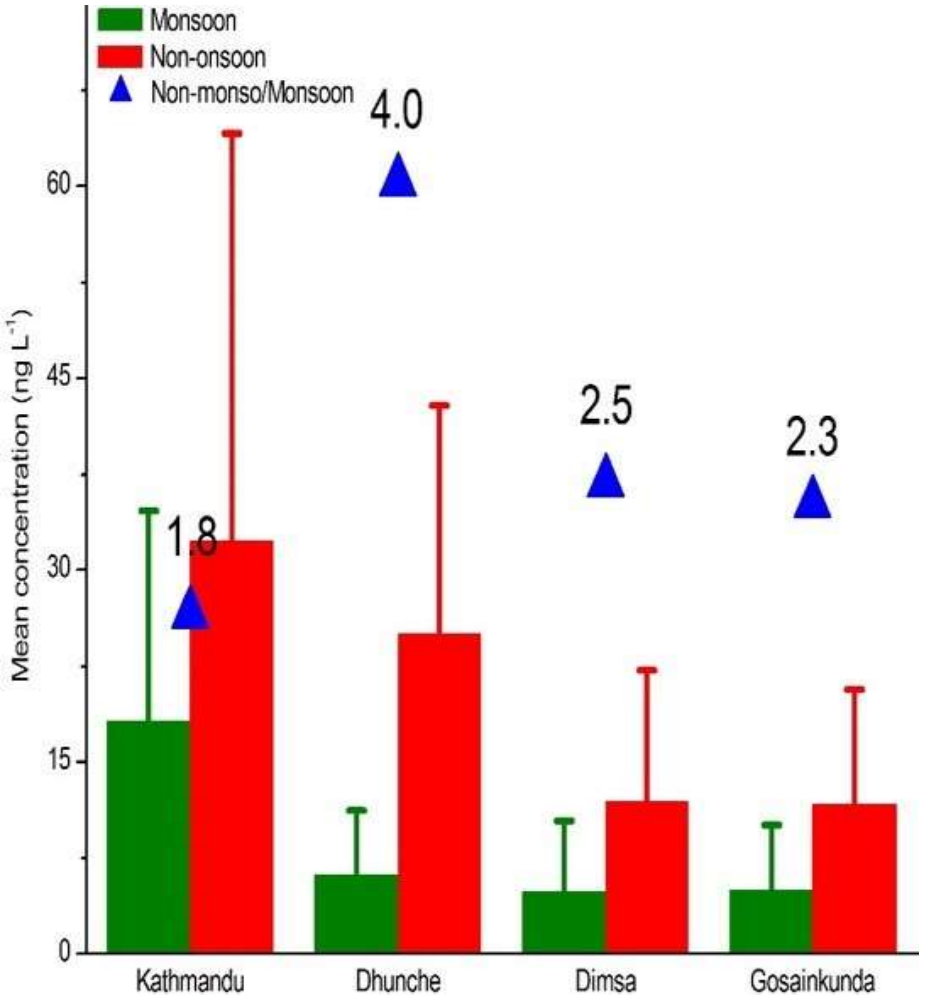
Gosainkunda

Comparison (Concentrations and Flux)
Total mercury (THg)

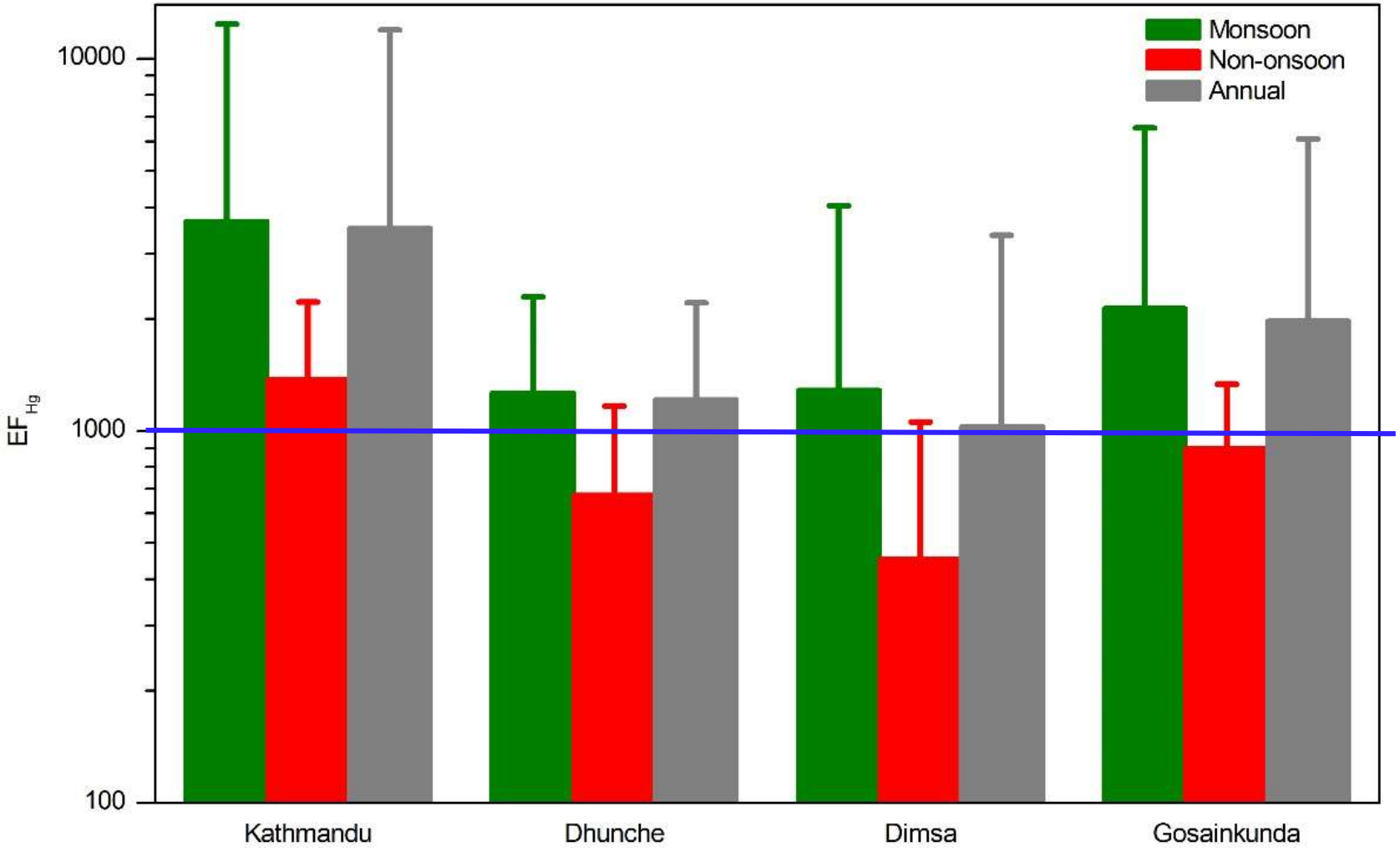


Seasonal variations of total Mercury





Enrichment of Mercury in precipitation



Conclusions

- Elemental composition mainly controlled by regional crustal dust and anthropogenic emissions
- Elements (Cr, Co, Ni, Cu, Zn, Cd, Pb and Hg) were from anthropogenic sources and Al, Fe and Mn were from crustal origin
- Major anthropogenic metals had decreasing trend from urban to remote and lower to higher altitude
- No clear seasonal variation at urban location
- Remote sites are still ideal place to monitor background concentrations
- Baseline database established
- Need for more long-term spatial monitoring to better understand the long-range transport of pollutants from South Asia and other regions to Himalayas


Thank you