Contrasting Pattern of PM$_{2.5}$ Concentrations in Urban-Rural Pair Sensors from Nepal

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• Introduction – Context
• Objectives
• Materials and Methods:
  - Sampling Sites
  - BlueSky Air Quality Monitor
• Results
• Conclusions
Introduction

Area: 147,516 km²
Capital: Kathmandu (population density= 5108 persons/km² ·Terai = 461 persons/km²)
Urbanization rate: 6.4%

Nepal among countries with highest PM$_{2.5}$ exposure

Nepal is ranked as a second most polluted country in the world in terms of PM$_{2.5}$ concentration (i.e., annual average of 83.1 µg/m$^3$) for the year 2019 (HEI, 2020).
Introduction contd...

18% of pollutants from the low laying plain region advected to Kathmandu as background pollution during 2015.

Mahapatra et al. (2020)

Figure: Time series of diurnal average of PM$_{2.5}$ (μg m$^{-3}$) concentration at different places in Nepal

Highest emissions flux occurred in the Terai region (90.7%)
Das et al. (2020)
Episodes of transboundary air pollution in the central Himalayas
A coordinated South Asian effort is necessary to better understand the processes governing transboundary air pollution and severity of the regional air pollution (ICIMOD, 2019)

Source: IQAir
• Air quality management in the Terai is encumbered by a lack of ambient measurements and significant uncertainty in the local vs. transboundary pollutant contributions.

• The Government of Nepal is expanding its air pollution monitoring network to the Terai but faces technological limitations to keep their expensive equipment calibrated and fully operational.
Regulatory-grade monitors (e.g. GRIMM EDM) are a challenge to maintain.

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Percent of monthly missing data for PM$_{2.5}$

- <25%
- 25-50%
- 50-75%
- >75%
- No data

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Objectives

• To determine the difference in PM$_{2.5}$ concentrations across the Terai which includes urban sites that are each paired with a nearby rural sites.

• Assess transboundary contributions of PM$_{2.5}$ concentrations in the Terai.
BlueSky Air Quality Monitor

- Real-time Particulate Matter (PM) sensor that provides accurate measurements of PM$_{2.5}$ mass concentration, temperature and humidity

- Can be used at altitudes up to 3000 m (10,000 feet)

- Designed to be used outdoors in highly polluted areas where particulate concentrations can be as high 1000 ug/m$^3$

- Helpful for air quality model evaluation (e.g., WRF-Chem or CMAQ)
Sampling Sites

12 urban-rural pairs in Terai - transboundary
Sampling Duration:
- Nov 1 2021-Feb 1 2022 (Urban)
- Nov 1 2021-Jan 2 2022 (Rural)
- April 2022- two weeks

Mahendranagar (Urban)
Mahendranagar (Rural)
Birgunj (Urban)
Birgunj (Rural)
Results

Birgunj

Fig: Hourly average PM$_{2.5}$ at (a) Urban and (b) Rural Birgunj
Fig: Diurnal variation of PM$_{2.5}$ at (a) Urban and (b) Rural Birgunj

Note: Sharp rise and fall in PM concentration during morning and evening hours is observed in the rural area.
PM$_{2.5}$ concentrations at various sites urban and rural Birgunj and Mahendranagar

**Birgunj**

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<th>Attributes</th>
<th>Unit</th>
<th>Urban Birgunj</th>
<th>Rural Birgunj</th>
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<tr>
<td>Mean</td>
<td>μg m$^{-3}$</td>
<td>140.26</td>
<td>101.3</td>
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<td>NAAQS non-compliance days</td>
<td>% days</td>
<td>98 %</td>
<td>95 %</td>
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**Mahendranagar**

- Urban: 98
- Rural: 95

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Conclusions

• Urban sites were prone to higher levels PM$_{2.5}$ exposures, compared to rural sites.

• Higher noncompliance to NAAQS at both Urban and Rural measurements suggests the possible transboundary pollution sources.

• Research ongoing: Additional pairs of BlueSky sensors deployed in the Terai will show the trend and pattern of PM$_{2.5}$ and also the status of transboundary pollution.

• Efforts needed in future to reduce concentrations of PM$_{2.5}$ would be discoursed by findings of this research.
THANK YOU

Acknowledgements

Project—“Building Capacity to Improve Air Quality in South Asia: Reducing PM$_{2.5}$ Through Low-Cost Sensor Network Driven Policy Decisions”