AIR POLLUTION IN BANGLADESH: CHALLENGES AND STRATEGIES FOR MITIGATION

International Meeting on Air Pollution in Asia – Inventories, Monitoring and Mitigation, February 1-3rd, Hanoi, Vietnam

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PRESENTED BY -

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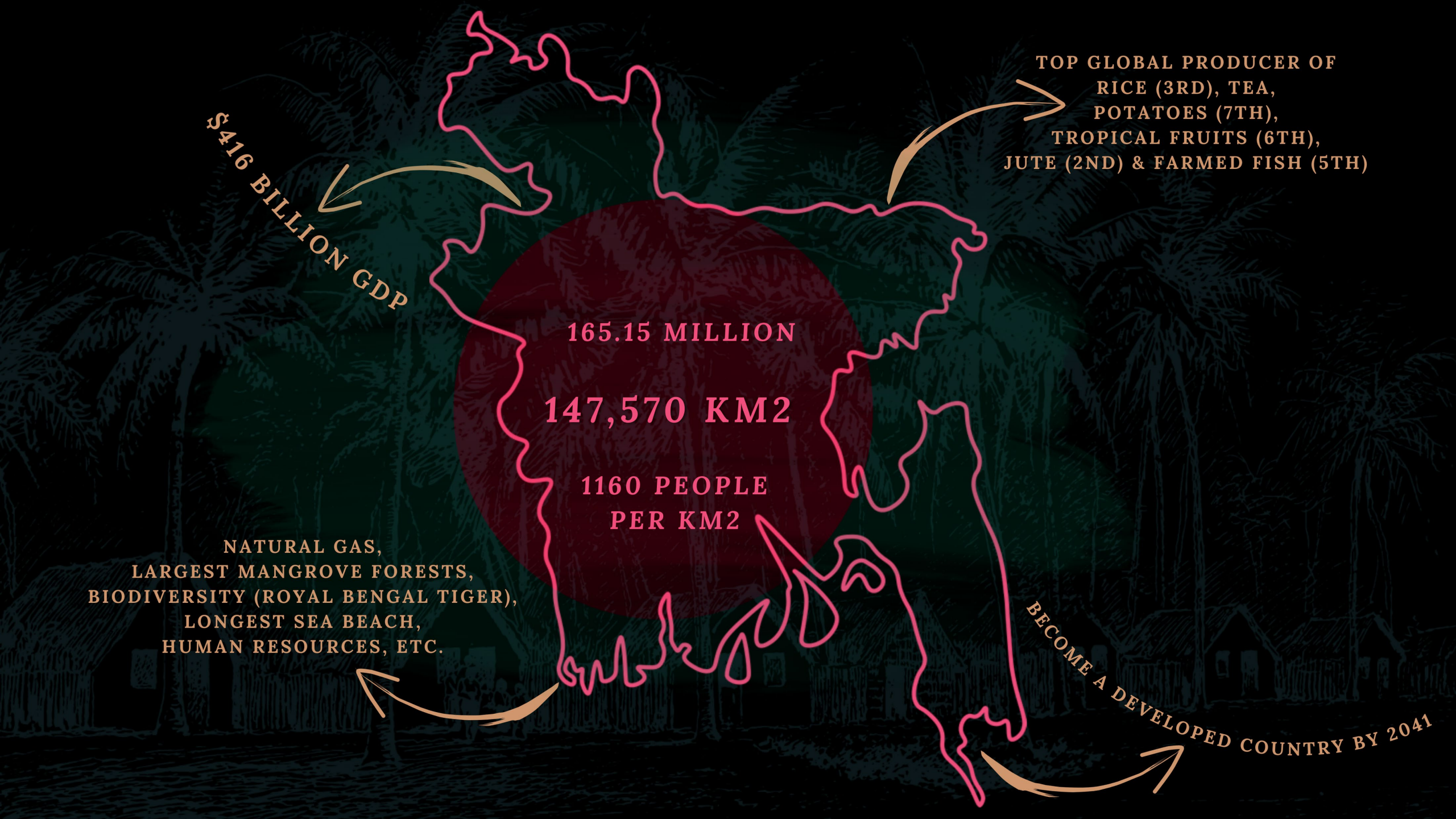
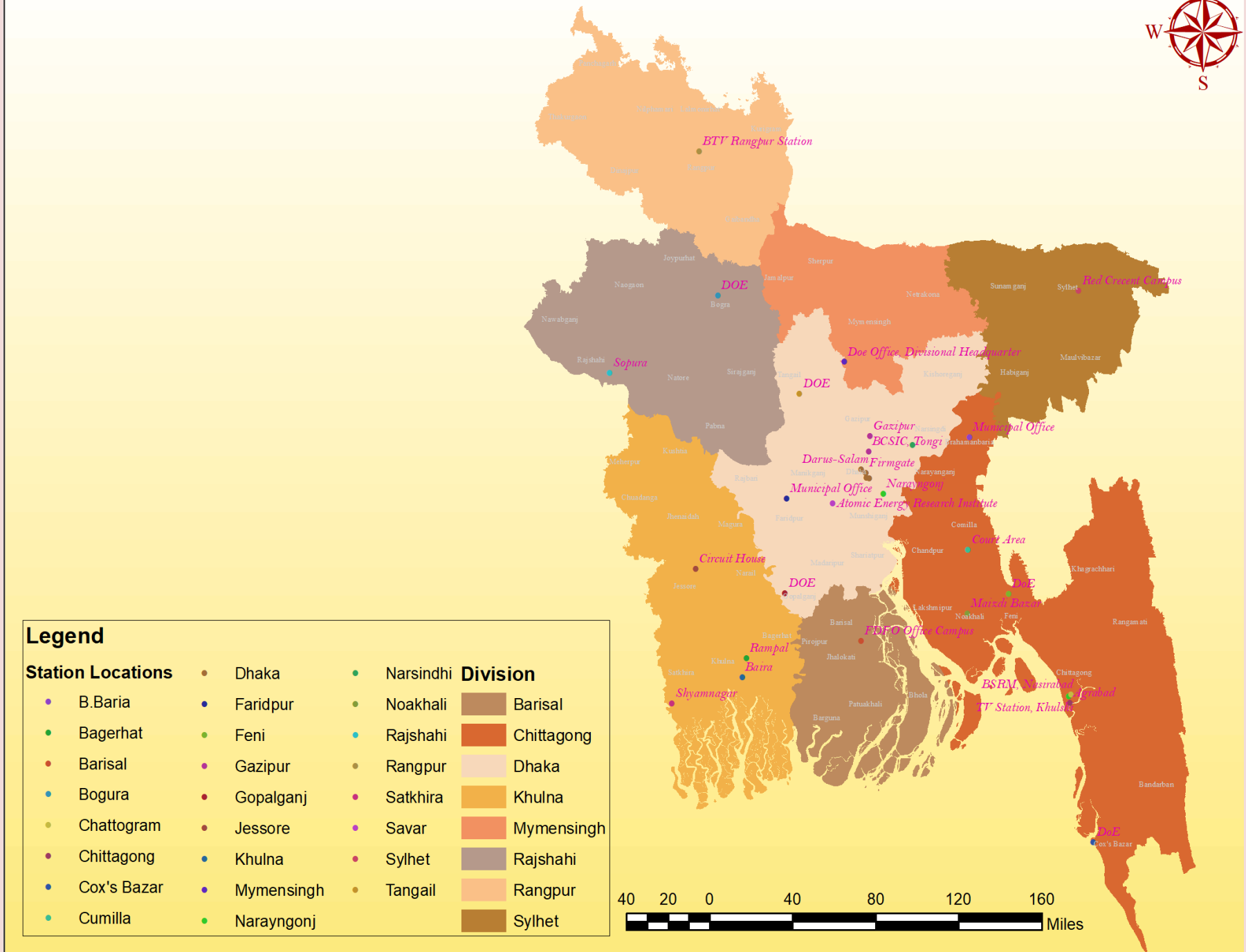

$416 BILLION GDP
TOP GLOBAL PRODUCER OF
RICE (3RD), TEA,
POTATOES (7TH),
TROPICAL FRUITS (6TH),
JUTE (2ND) & FARMED FISH (5TH)
165.15 MILLION
147,570 KM2
1160 PEOPLE
PER KM2
NATURAL GAS,
LARGEST MANGROVE FORESTS,
BIODIVERSITY (ROYAL BENGAL TIGER),
LONGEST SEA BEACH,
HUMAN RESOURCES, ETC.
BECOME A DEVELOPED COUNTRY BY 2041

Continuous Air Monitoring Stations (CAMS) in Bangladesh



SUB TOPIC 1 :
FUNDAMENTAL IN AIR POLLUTION & AEROSOL - METEOROLOGY INTERACTIONS

AIR POLLUTION HOTSPOT

in South Asian Region

THE WORLD BANK

WHO WE ARE | WHAT WE DO | WHERE WE WORK | UNDERSTANDING POVERTY | WORK WITH US | COVID-19

Who We Are / News

PRESS RELEASE | DECEMBER 14, 2022

Urgent Action Needed in South Asia to Curb Deadly Air Pollution

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Home / Cities / Delhi / Delhi most polluted capital in world, finds air report

Delhi most polluted capital in world, finds air report

The city is topping the list for the fourth consecutive year. Delhi topped a list of 92 capital cities in 2020, 85 such cities in 2019, and 62 such cities in 2018.

Dhaka Tribune

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Home / Bangladesh / Environment

Dhaka again ranked world's most polluted city

JUST IN

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Lahore once again sets unique record of world's most polluted city

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Hindustan Times

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Home / World News / China's Hotan most polluted city in 2020, Ghaziabad at 2n...

China's Hotan most polluted city in 2020, Ghaziabad at 2nd place: Report

World News
Published on Aug 11, 2021 04:17 PM IST

Of the 50 most polluted cities worldwide, 49 are in Bangladesh, China, Pakistan, and India, according to the report.

The Daily Star

THURSDAY, January 26, 2023 | Journalism Without Fear or Favour

News | Opinion | Sports | Business | Entertainment | Life & Living | Youth

Air pollution

Dhaka tops list of cities with most polluted air in the world today

UNB, Dhaka
Wed Jan 25, 2023 12:26 PM Last update on: Wed Jan 25, 2023 12:32 PM

Star file photo

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Chronic air pollution and health burden in Dhaka city

Shafayet Ahmed Siddiqui, Md Jakaria, Mohammad Nurul Amin, Abdullah Al Mahmud, David Gozal
European Respiratory Journal 2020 56: 2000689; **DOI:** 10.1183/13993003.00689-2020

Thursday, January 26, 2023

NEWAGE Bangladesh

In Focus | 11th JS Elections | Dhaka's Pollution Focus | Classroom in focus | Politics | Foreign affairs

TRENDING: politics | FIFA World Cup 2022

Dhaka becomes world's most pollute AQI score of 323

United News of Bangladesh . Dhaka | Published: 10:37, Dec 15,2022

Air Pollution!

Is this a new 'silent spring' for the people in South Asia

AIR POLLUTION (WH QUESTIONS)

WHAT IT IS

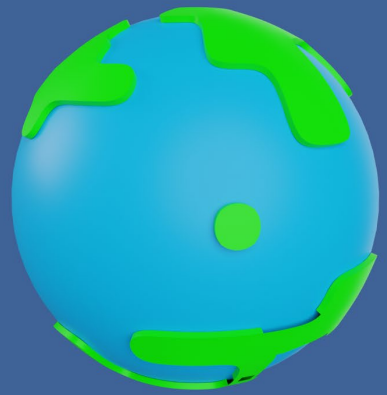
Air pollution occurs when harmful or excessive quantities of substances are introduced into Earth's atmosphere near surface.

HOW IT OCCURS

A mixture of solid particles, liquid particles and gases are suspended in the air.

WHICH SUBSTANCES

Substances include:
Gases: SO_2, NO_x, CO, O_3, Biogenic organics, hydrocarbons, etc.
Particulate matter: smoke, dust, fumes, fly ash aerosols, BC, BrC, etc.
Radioactive materials and many other toxic metals.
Airborne pathogens.



ANNOUNCEMENT

WHO reported that 9 out of 10 people breathe air containing high levels of pollutants.

WHAT IT CAUSES

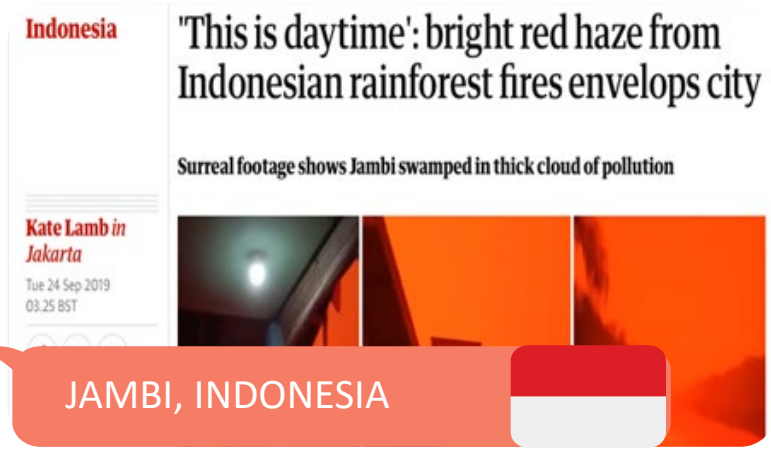
Air pollution kills an estimated 9 millions people worldwide every year. Life expectancy lost 6.7 years in Bangladesh.
(Vohra et al., 2022; HEI, 2022)

Causes of air pollution from Iran to Indonesia

BEIJING, CHINA

HAZE / URBAN SMOG

NEW DELHI, INDIA



JAMBI, INDONESIA

DHAKA, BANGLADESH

LONDON, UK

COMBUSTION GENERATED SMOKE EMISSIONS

NON FOSSIL FUEL

FOSSIL FUEL

WILD FOREST

PEAT SOIL

COAL

COMBUSTION PROCESS

PARTICULATE MATTER

- BC/EC
- OC
- BrC
- POC
- SOC

METALS

- Pb
- Cd
- Hg
- Cs
- As
- Se

GASES - INORGANIC ACIDS

- CO
- Ozone
- NOx
- SO_2
- CH_4
- CO_2

HYDROCARBONS

- BTEX
- Alkanes
- PAHs
- Dicarboxylic acid

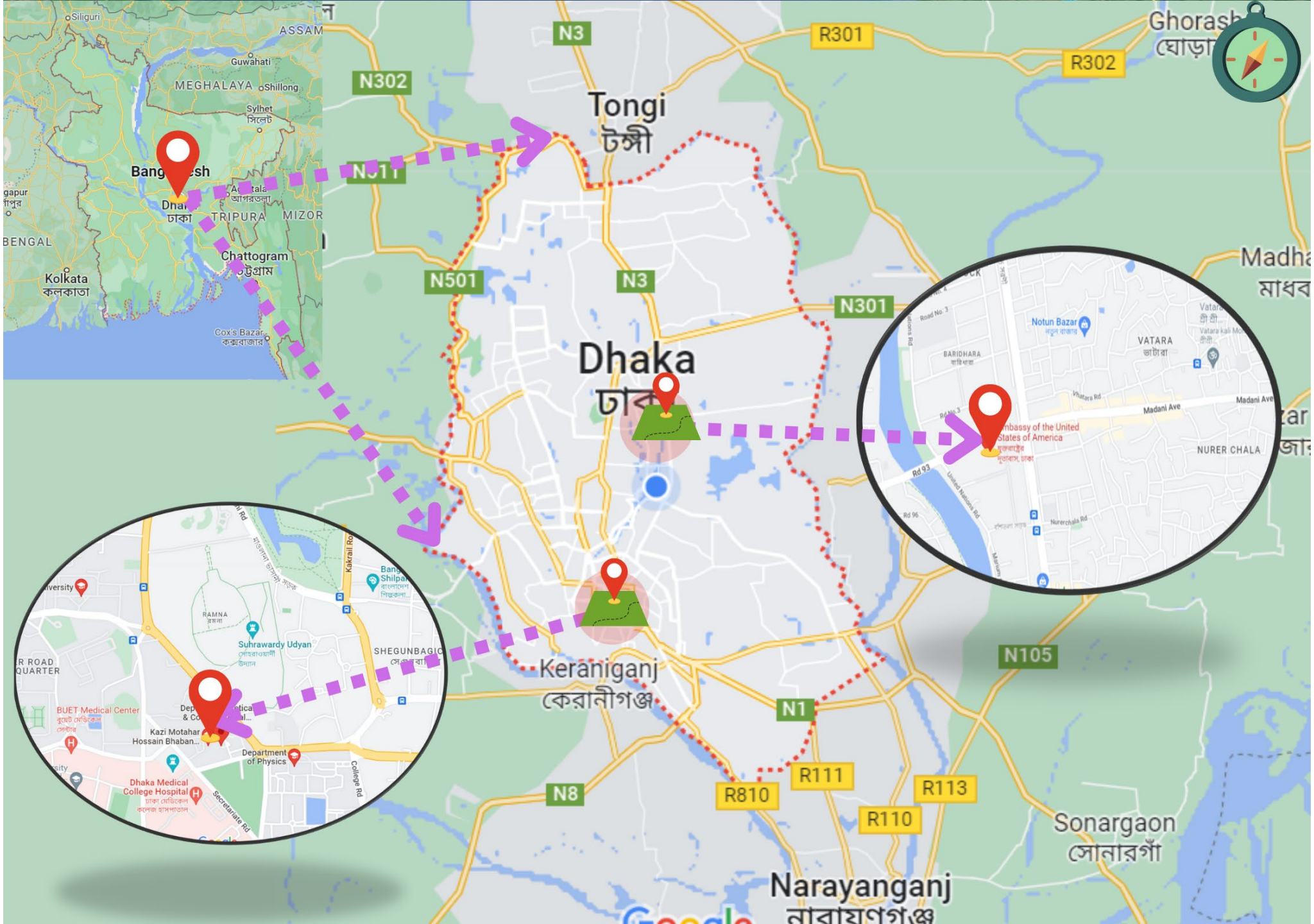
ORGANIC MOLECULES

- Aldehydes
- Phenols
- PAHs
- Biomass tracers

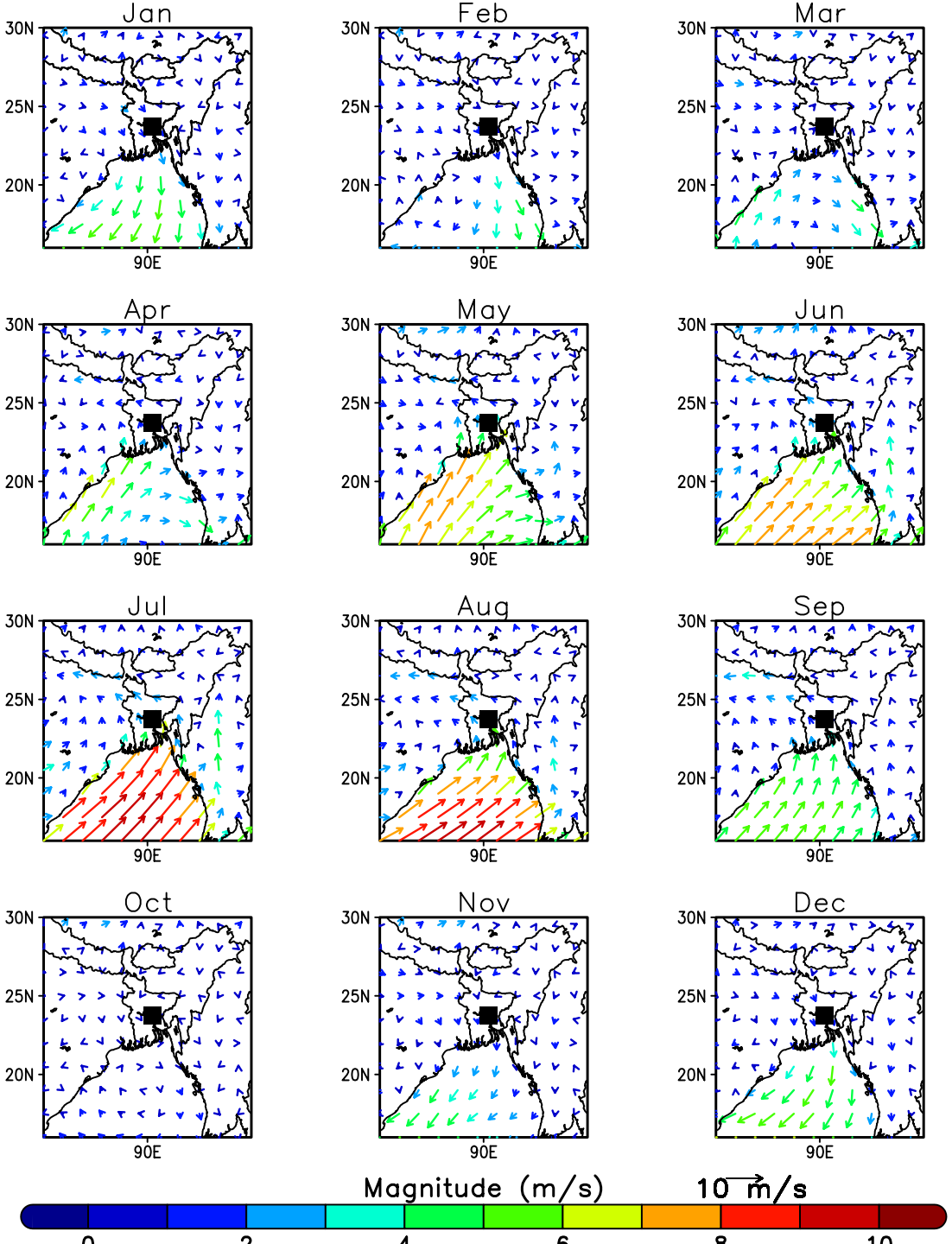
Air pollution in Bangladesh:

Local or Transboundary effects???

Anthropogenic or natural causes???

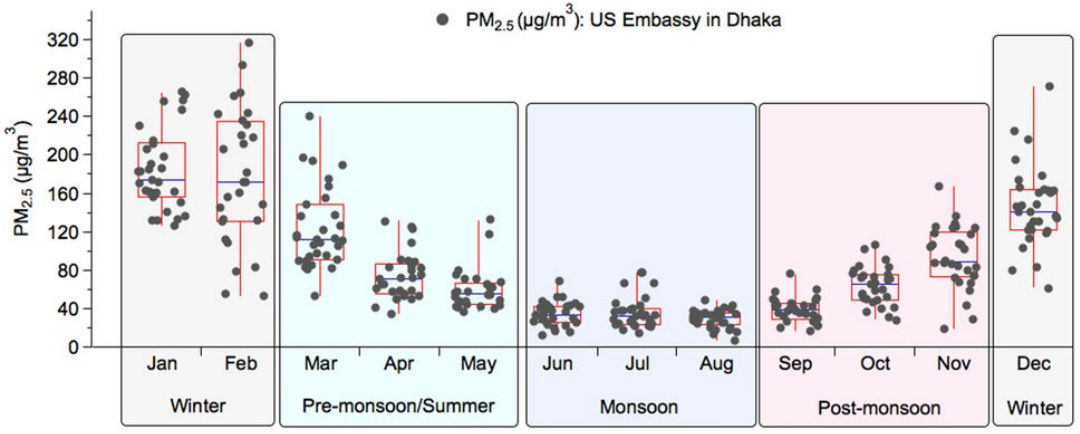

Siliguri
ASSAM
Guwahati
MEGHALAYA
Shillong
Sylhet
সিলেট
Bangladesh
Dhaka
ঢাকা
TRIPURA
MIZOR
BENGAL
Chattogram
চট্টগ্রাম
Kolkata
কলকাতা
Cox's Bazar
কক্সবাজার
N3
R301
R302
N302
Tongi
টঙ্গী
N501
N3
N301
Dhaka
ঢাকা
Notun Bazar
VATARA
ভাটারা
BARIDHARA
বারিধারা
Madani Ave
NURER CHALA
Rd 93
Rd 96
Suhrawardy Udyan
RAMNA
SHEGUNBAGICHA
BUET Medical Center
Kazi Motahar Hossain Bhaban
Department of Physics
Dhaka Medical College Hospital
Secretariate Rd
College Rd
Keraniganj
কেরানীগঞ্জ
N105
N1
R111
R810
R113
R110
N8
Sonargaon
সোনারগাঁ
Narayanganj
নারায়ণগঞ্জ

The synoptic level of wind vector over the study site changes monthly in 2019:

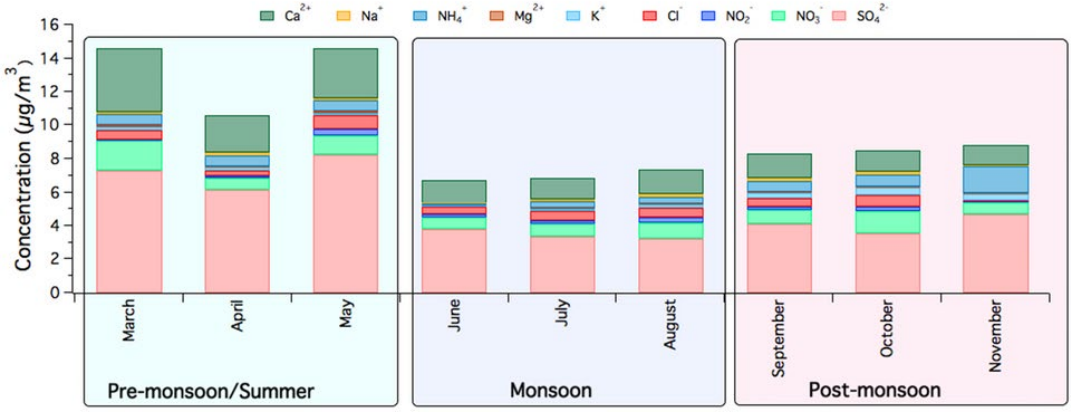


Local Meteorology and Regional Circulation Impact on Aerosol Load over Dhaka City (Adapted from Norazman et. al. 2021 ACS Earth and Space Chem)

a)

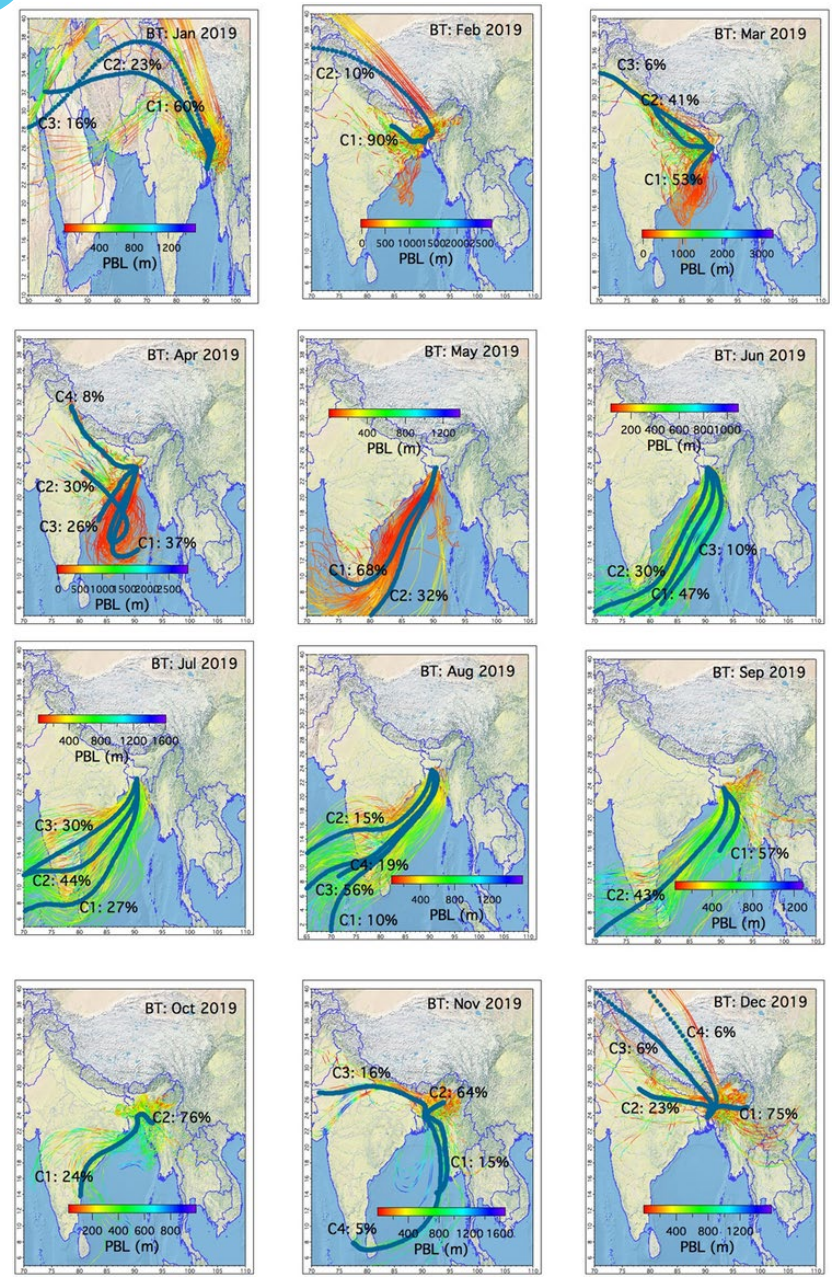


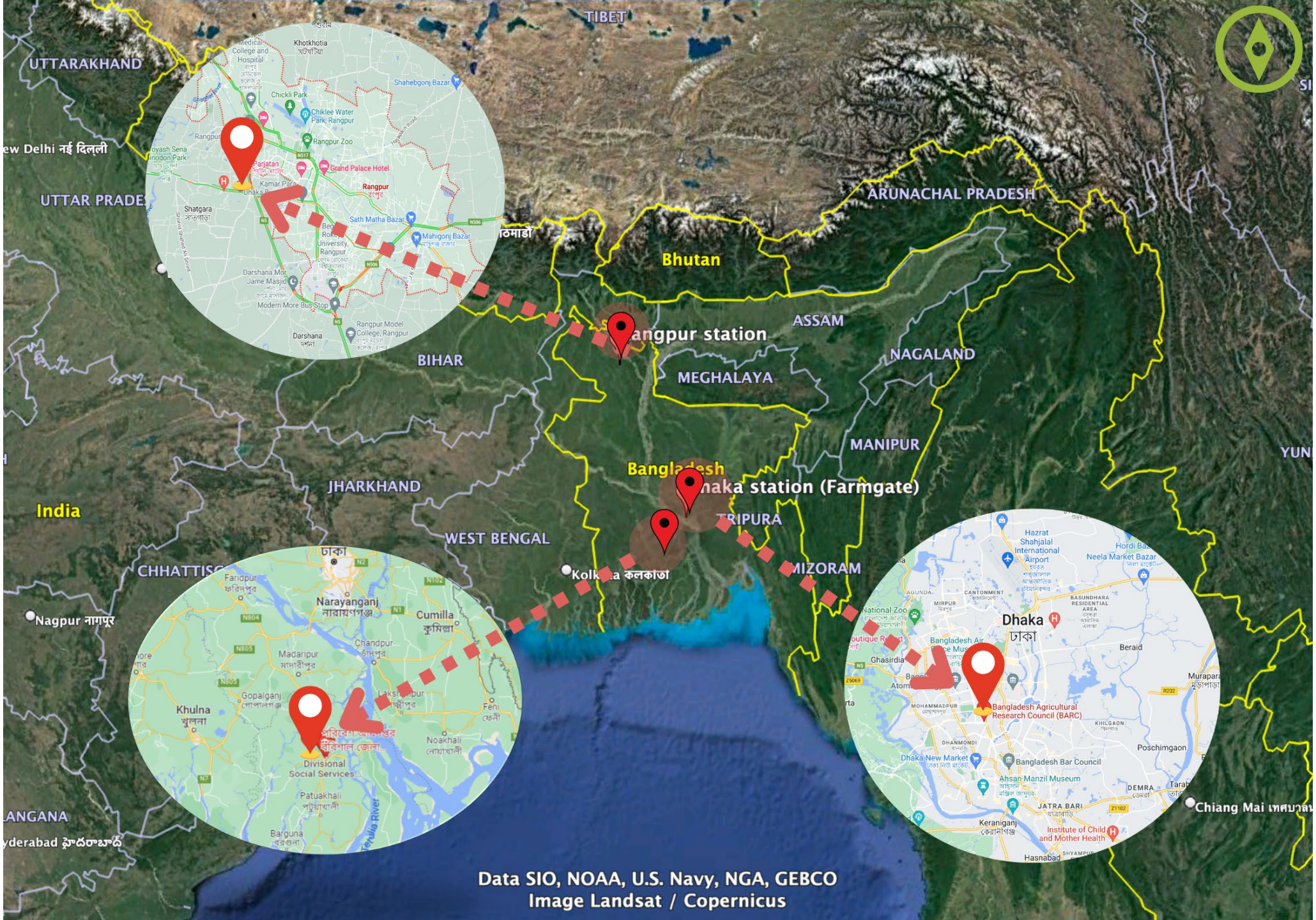
b)



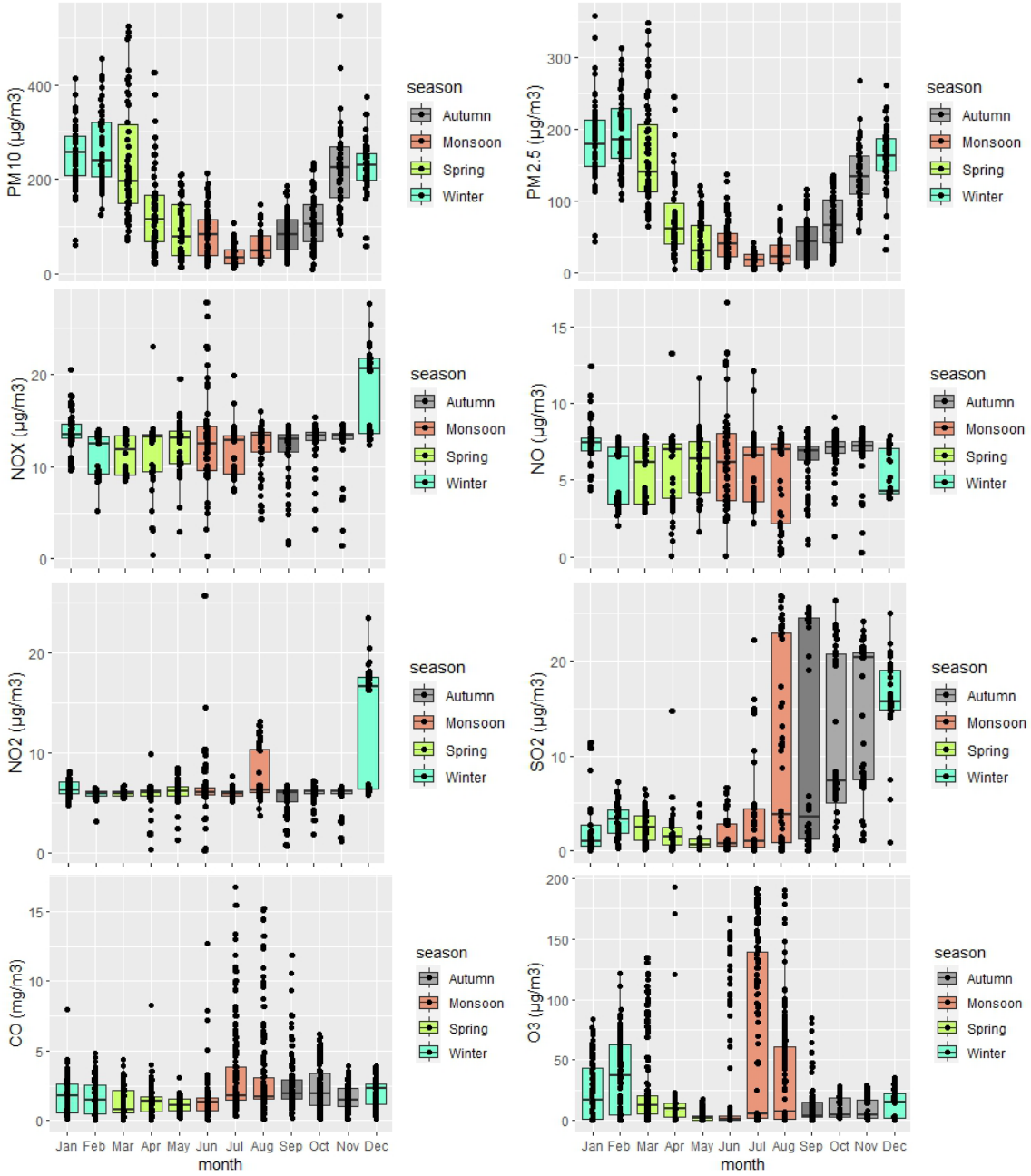
- Transport of air mass carry water vapour and pollutants
- Seasonal changes over Dhaka is very strong
- Himalaya during winter and Bay of Bengal during monsoon play significant role on the aerosol load over Dhaka
- The precursors of secondary aerosol are reported higher during dry winter months

Backward Trajectory Modeling

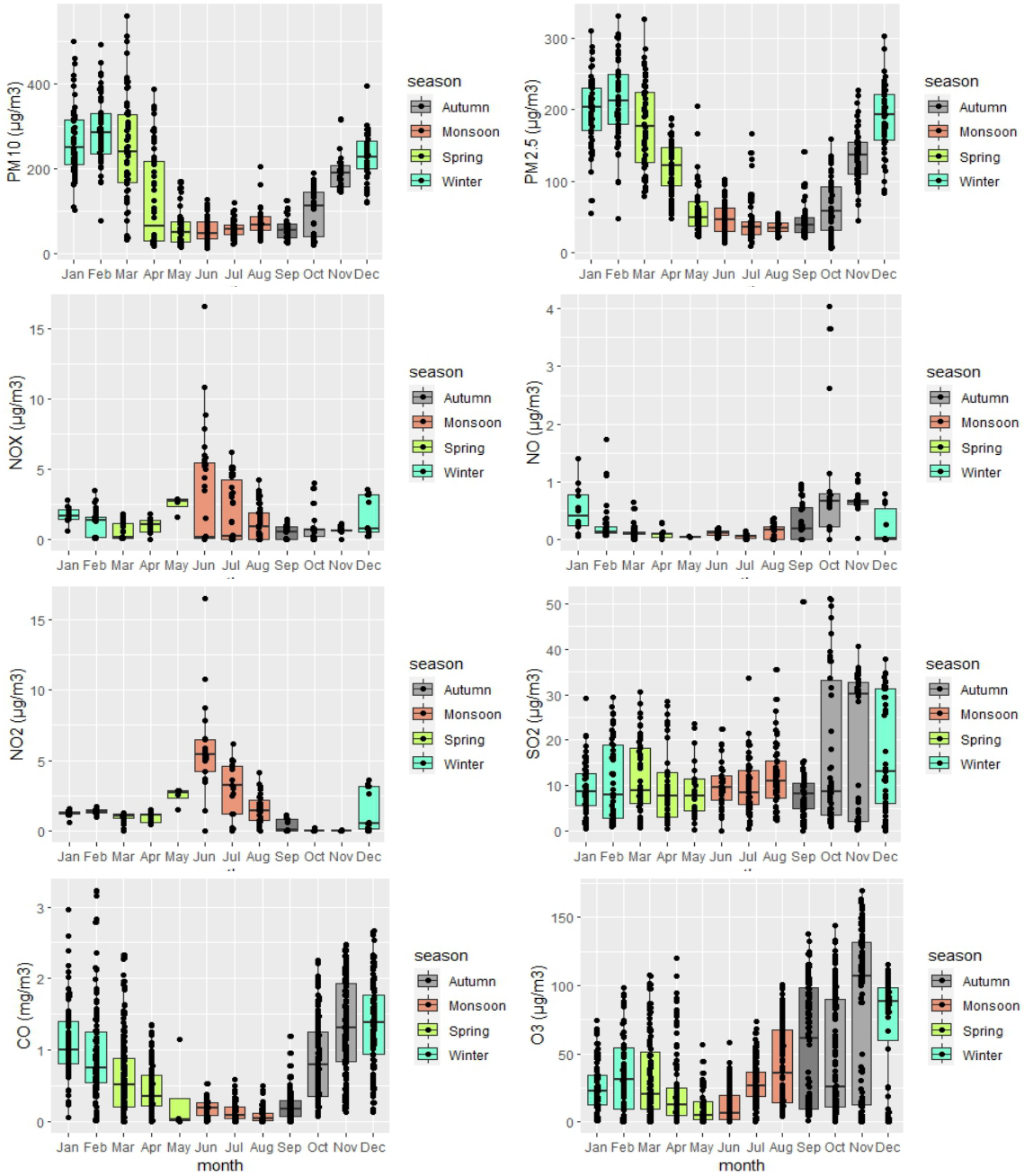


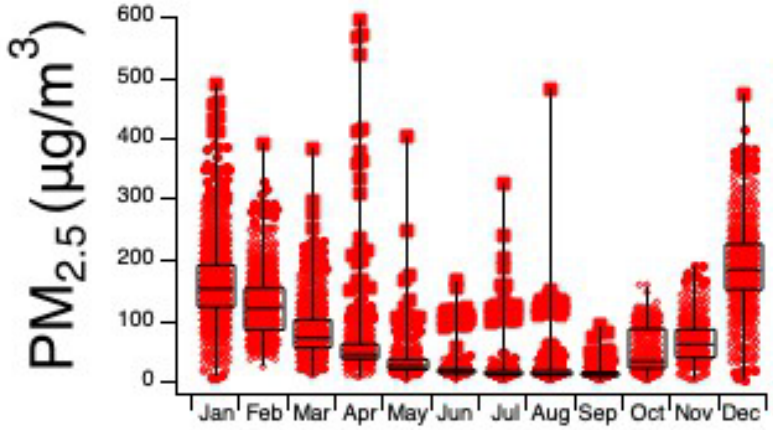

TIBET
UTTARAKHAND
UTTAR PRADESH
ew Delhi नई दिल्ली
ARUNACHAL PRADESH
Bhutan
ASSAM
NAGALAND
MEGHALAYA
MANIPUR
BIHAR
JHARKHAND
WEST BENGAL
India
Bangladesh
TRIPURA
MIZORAM
CHHATTISGARH
Nagpur नागपूर
Kolkata কলকাতা
Chiang Mai เทศบาล
LANGANA
yderabad హైదరాబాద్
Rangpur station
Dhaka station (Farmgate)
Rangpur
Grand Palace Hotel
Dhaka
ঢাকা
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus

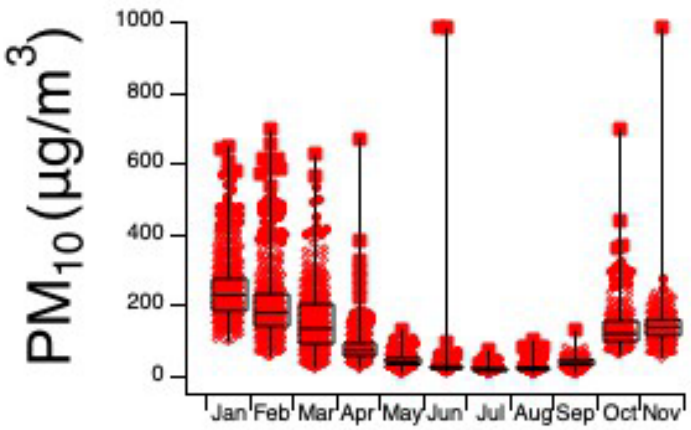
Dhaka (Urban Site)

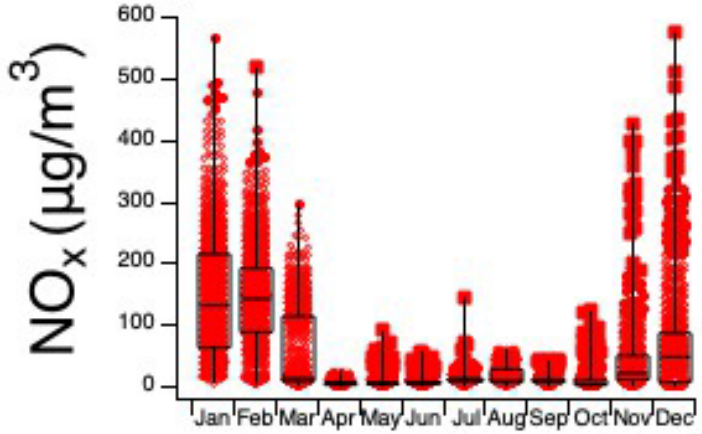


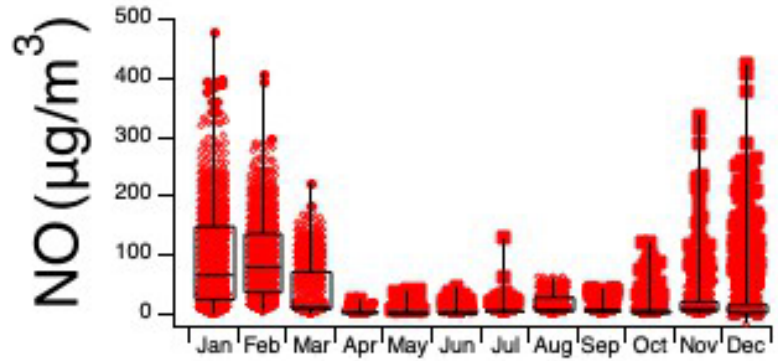
Rangpur (Remote Site)

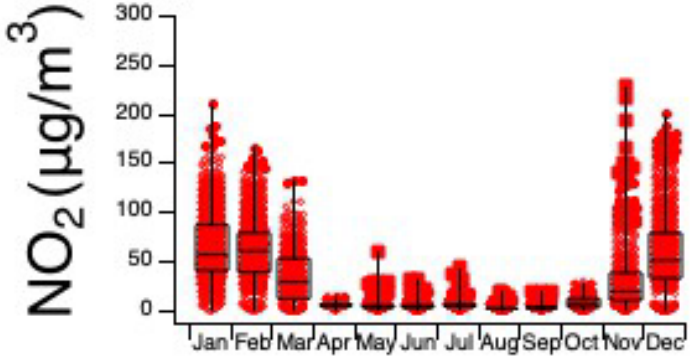


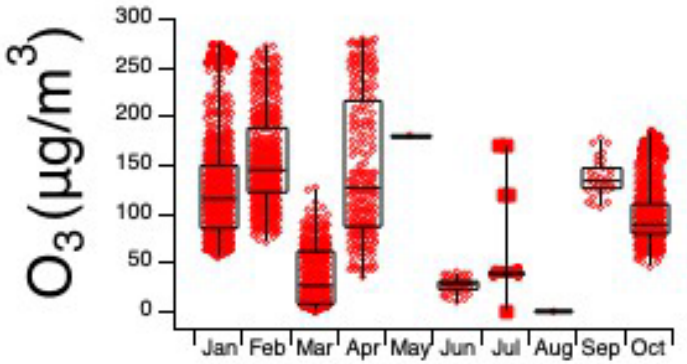


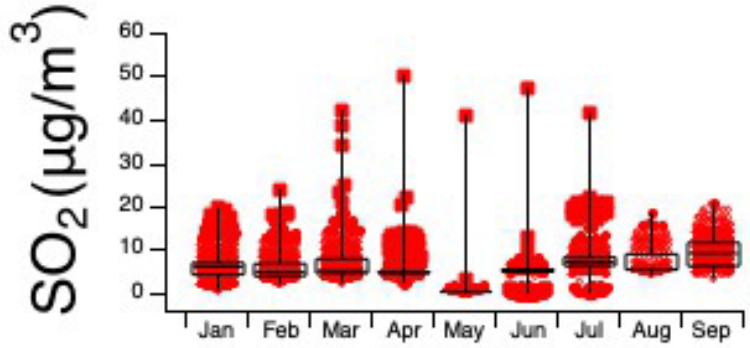


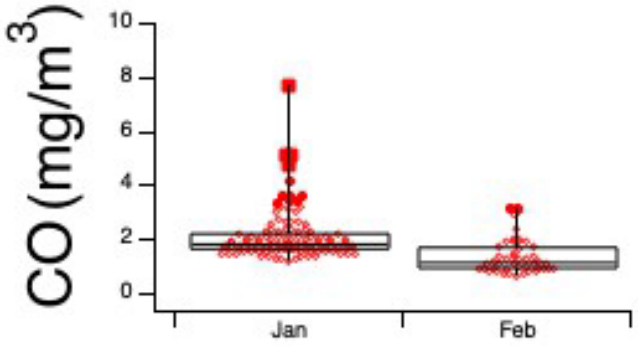






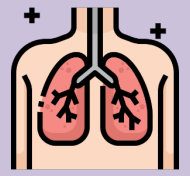


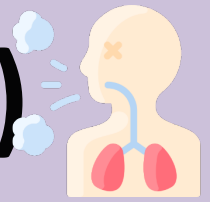




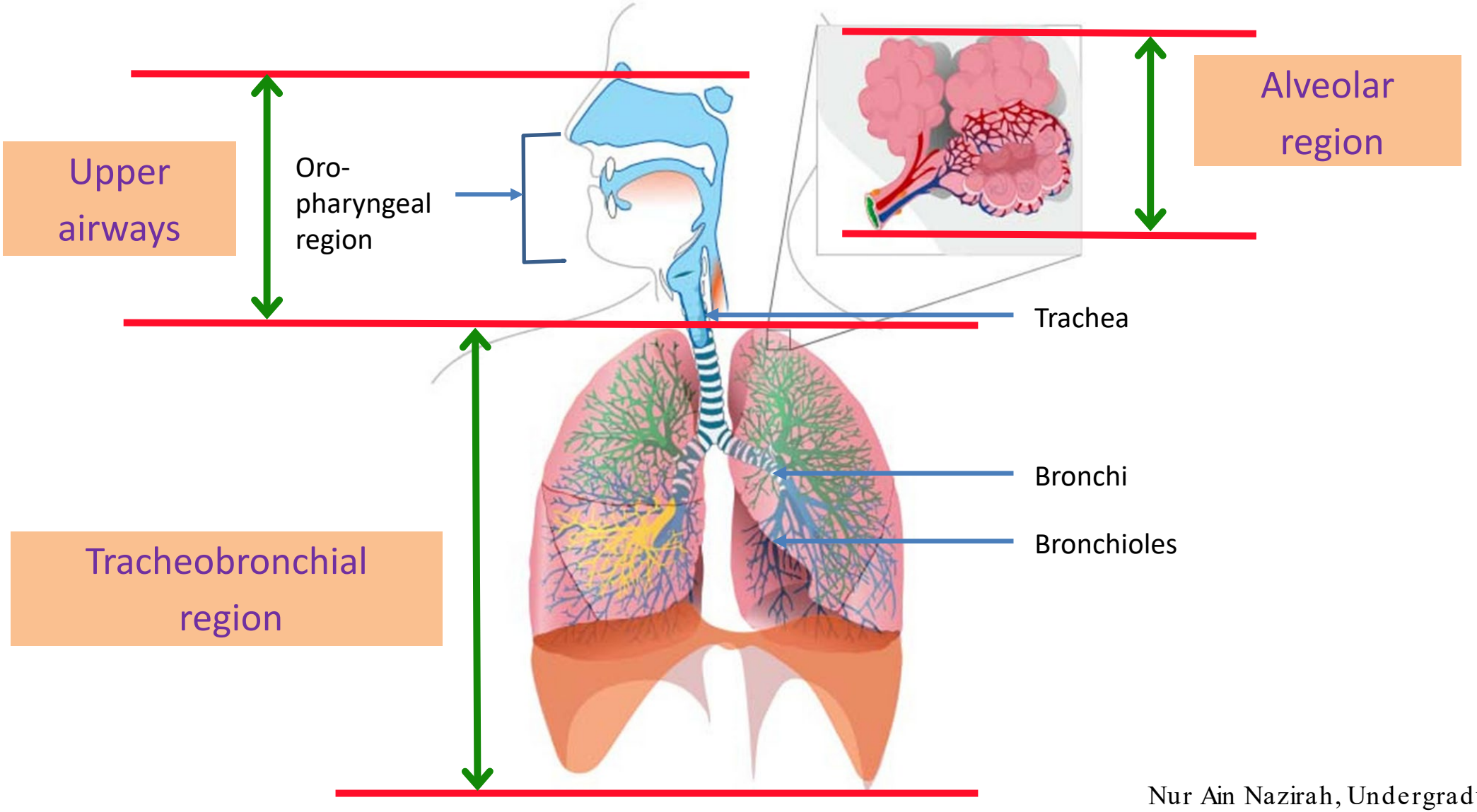
Barisal DOE Site (2020-2021)

SUB TOPIC 2: RESPIRATORY DEPOSITION DOSE (RDD)





RESPIRATORY DEPOSITION FLUX



Nur Ain Nazirah, Undergraduate student

RESPIRATORY DEPOSITION DOSE (RDD)

- Mass deposition of heavy metals in the respiratory system is determined using:

$$M_{dep} = PM \times V_m \times (DF)$$

- There are three deposition factors according to the airways of particles, which are upper airway (UA), tracheobronchial region (TB) and alveolar region (AL).

- Only one deposition factor value will be obtained for each airway using PM2.5.

- The deposition factor for each of the airway is determined using the following equations:

UPPER AIRWAY

$$DF_{UA} = IF \times \left(\frac{1}{1 + \exp(6.84 + 1.183 \ln d_p)} + \frac{1}{1 + \exp(0.924 - 1.885 \ln d_p)}\right)$$

where IF is the inhalable fraction, estimated by:

$$IF = 1 - 0.5\left(1 - \frac{1}{1 + 0.00076 d_p^{2.8}}\right)$$

TRACHEOBRONCHIAL REGION

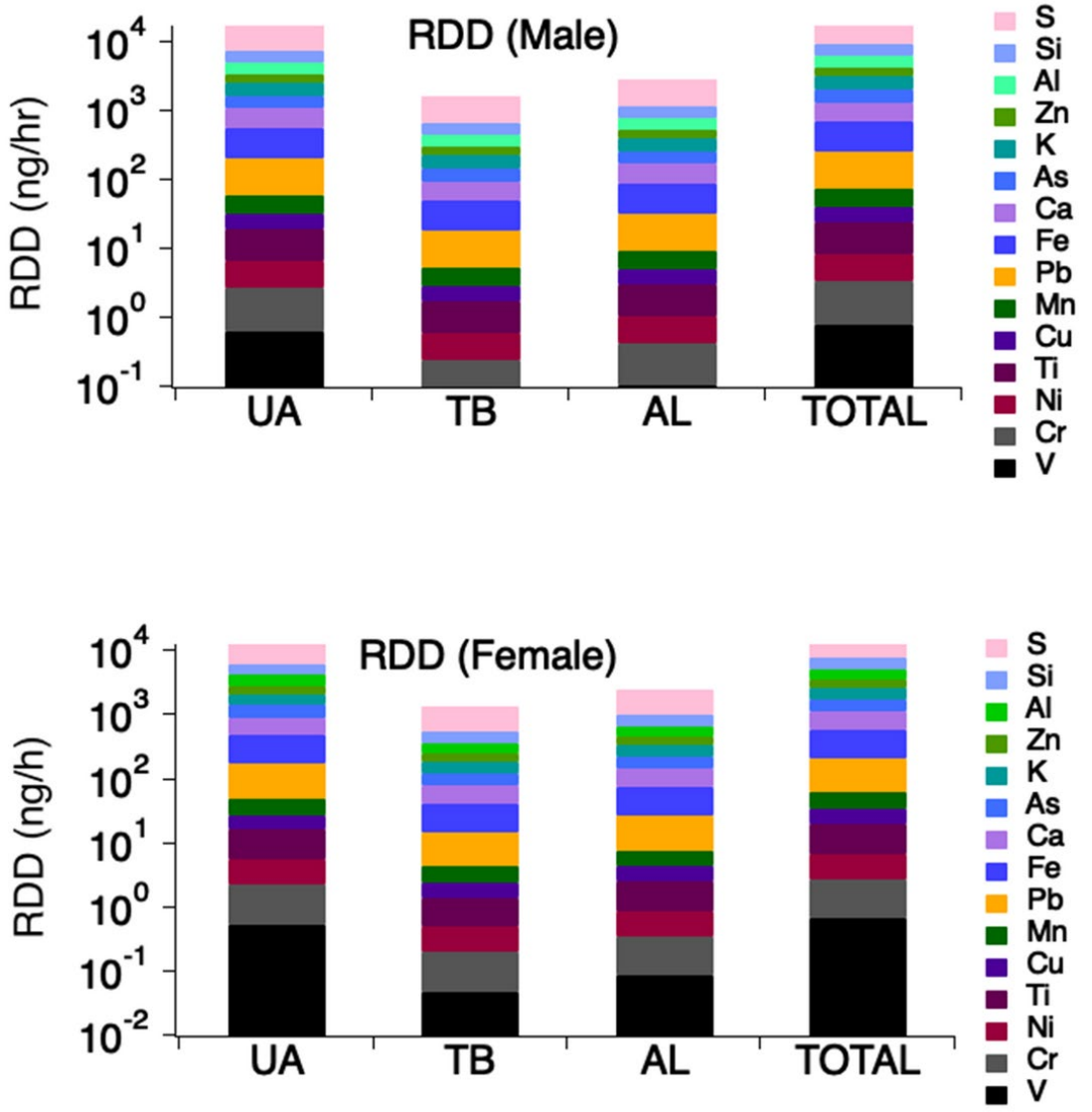
$$DF_{TB} = \left(\frac{0.00352}{d_p}\right)\left[\exp(-0.234(\ln d_p + 3.40)^2\right] + 63.9 \exp(-0.819(\ln d_p - 1.61)^2]$$

ALVEOLAR REGION

$$DF_{AL} = \left(\frac{0.0155}{d_p}\right)\left[\exp(-0.416(\ln d_p + 2.84)^2\right] + 19.11 \exp(-0.482(\ln d_p - 1.362)^2]$$

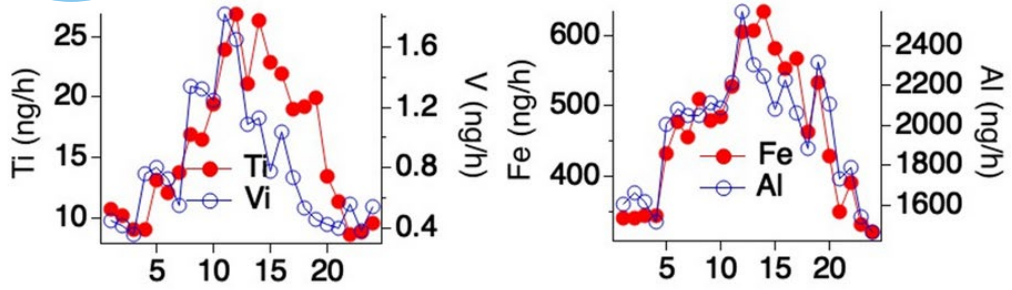
Farihah Sakinah, Undergraduate student

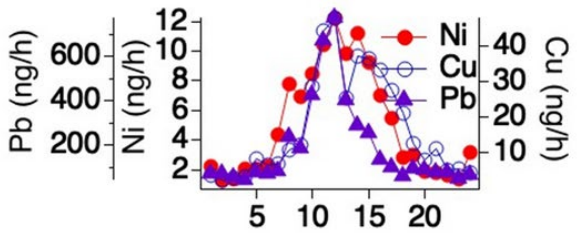
RESPIRATORY DEPOSITION DOSE (RDD)



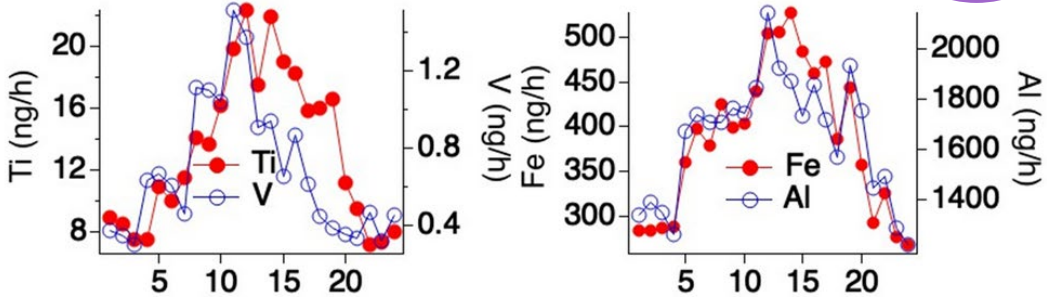
- The most toxic metals with public health concerns are As, Pb, Cd, Hg, and Cr.
- High deposition in UA is not very harmful because the mucus layer in UA will help to move the particles to the digestive system (Can-Terzi, Tecer & Sofuoglu, 2021).
- Male has higher RDD values than female. Males have a greater ventilation rate compared to females (Chalvatzaki et. al., 2018).
- Over 24 h, males inhale 0.578 mg of metals while female inhale 0.482 mg in Dhaka City.

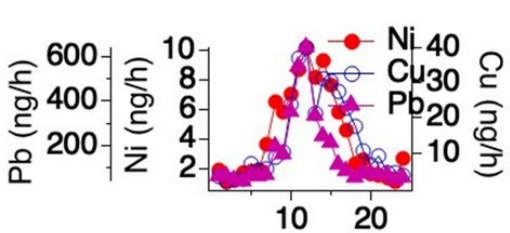
Diurnal total RDD of metals (Male)





Diurnal total RDD of metals (Female)

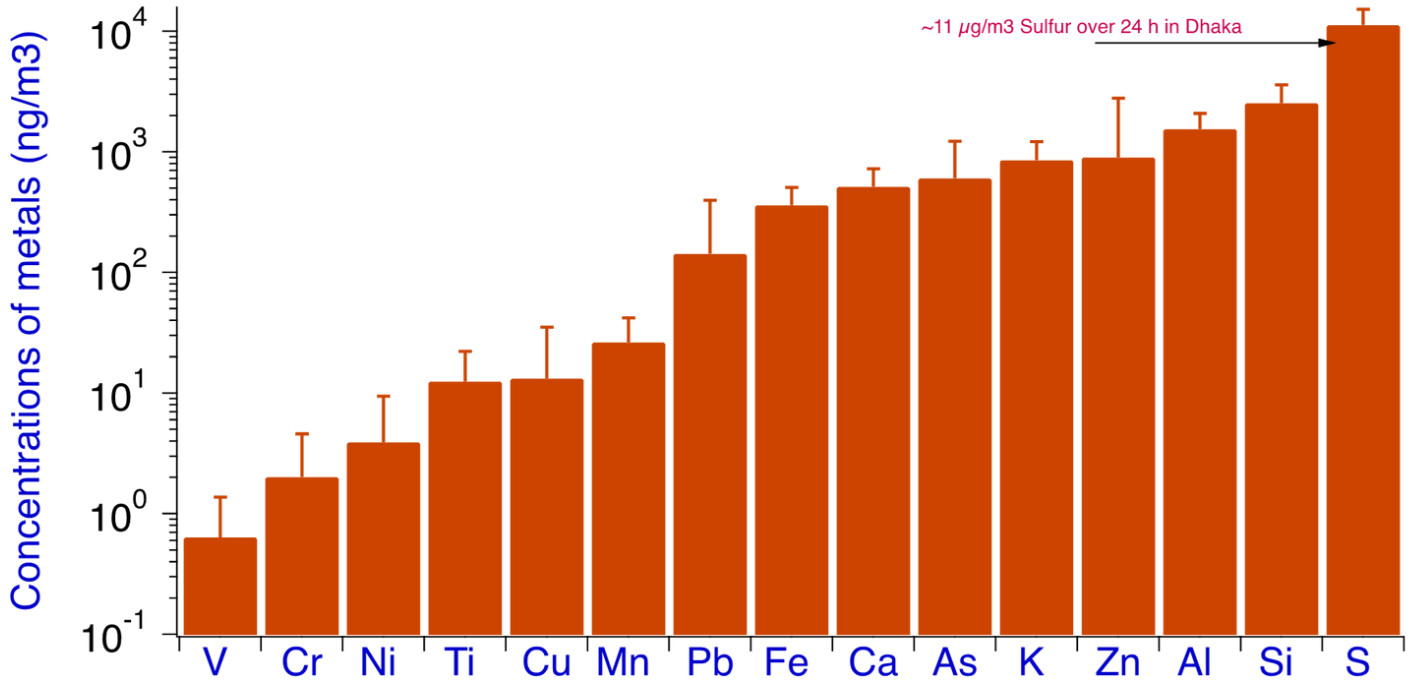


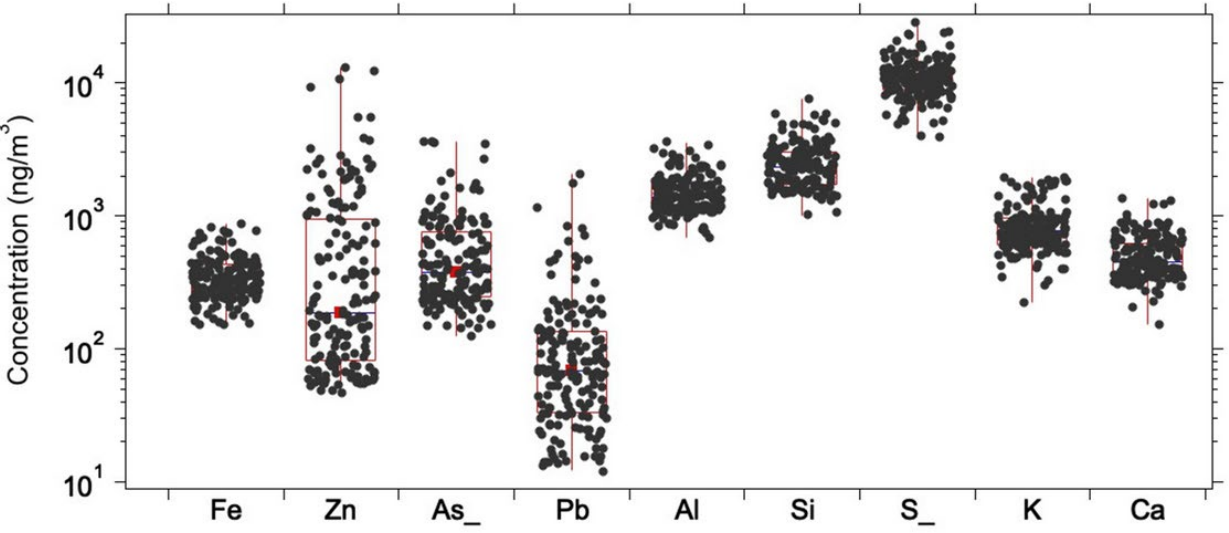


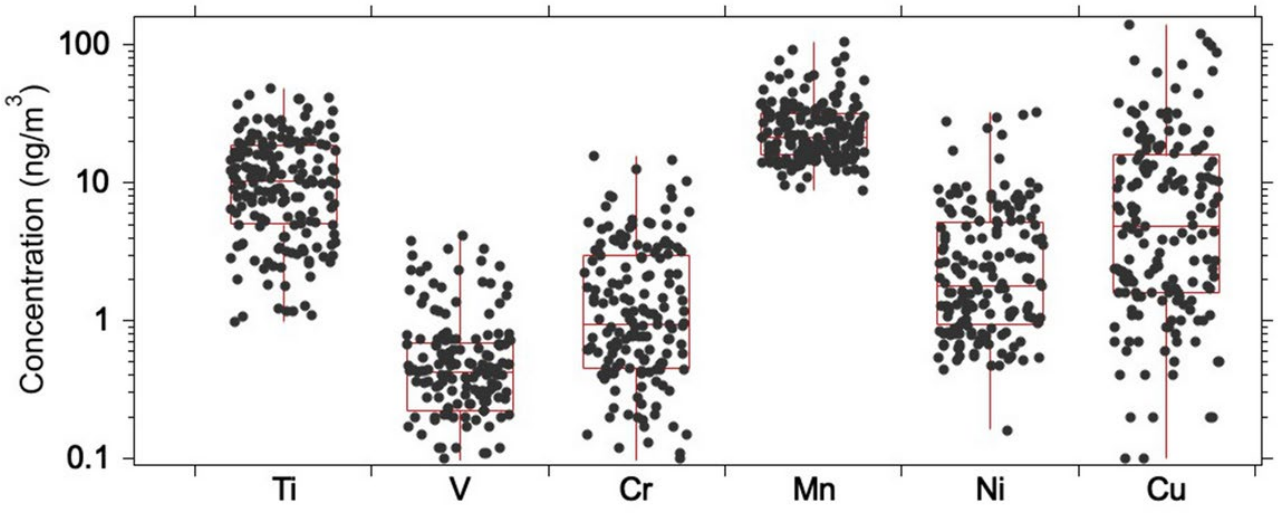
Compositions of $PM_{2.5}$ from an urban site in Dhaka (real-time)

Compositions pose huge health concerns:

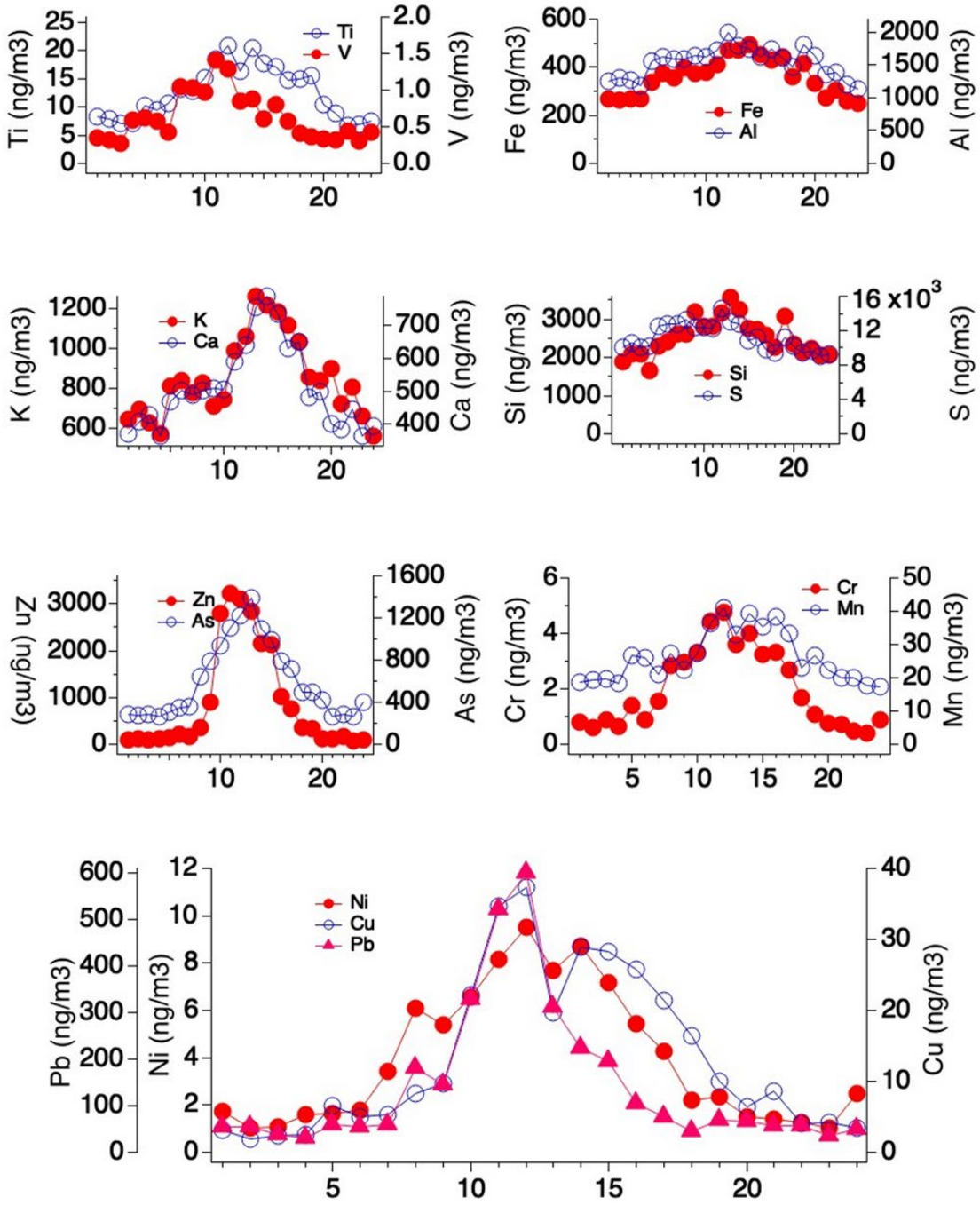
- Cr 2.01 (0.02 - 15.83) ng/m3
- As 603.21 (124.5 - 3615.9) ng/m3
- Pb 143.18 (12 - 2060) ng/m3
- S 11258.95 (3875.8 - 28428.5) ng/m3







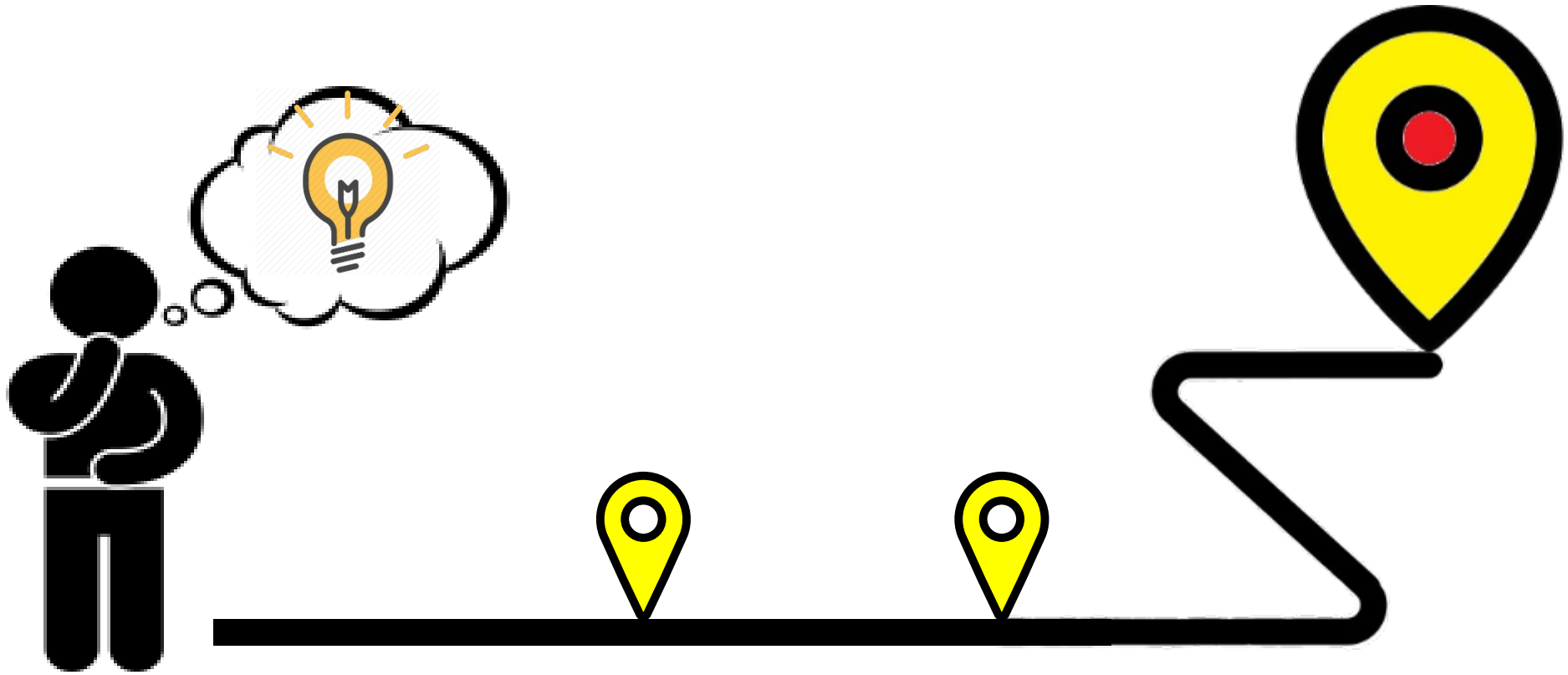
Diurnal changes of the metals in $PM_{2.5}$



- Metals from Earth-Crust show relatively flat distribution
- Metals from anthropogenic origin peak in the middle of the day
- Changes in short interval indicate the emission from local sources
- Local meteorology also play important role to change the level of metals

SUB TOPIC 3: CHEMOMETRIC APPLICATION IN AIR POLLUTION

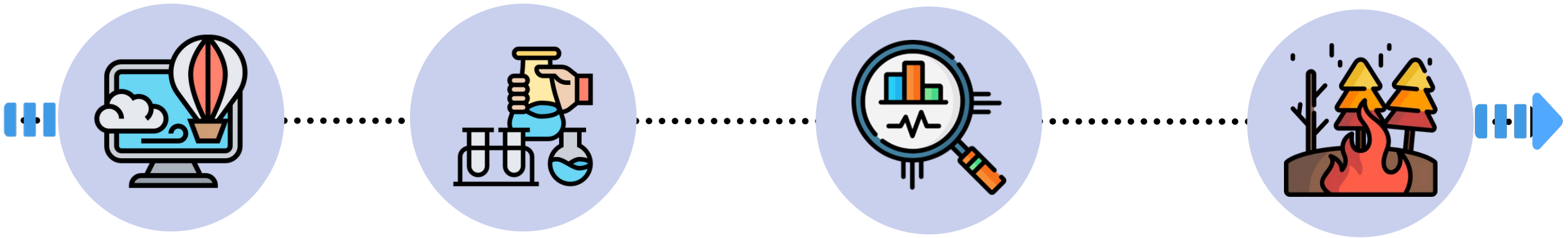
RECEPTOR MODELLING / CHEMOMETRIC APPROACH IN MITIGATION OF AIR POLLUTION



CHEMOMETRICS

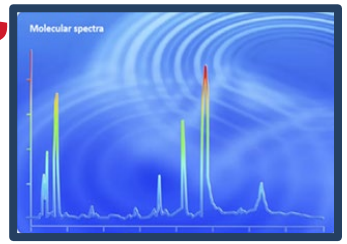
WHAT IS IT?

HOW DOES IT WORK?



Air quality monitoring

Chemical analysis



Pattern recognition

- Multivariate Receptor Modelling

Source identification

- Wild fires
- Vehicle emissions

LINK TO EXPLORE CHEMOMETRIC MODELS

1. **Traditional Mass Closure Model**

2. **Principal Component Analysis/Absolute Principal Component Analysis (PCA/APCS)**

3. **Positive Matrix Factorization (PMF) Model for environmental data analysis**

   https://www.epa.gov/air-research/positive-matrix-factorization
   environmental-data-analyses

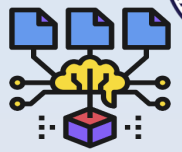
4. **Unmix 6.0 Model for environmental data analyses**

   https://www.epa.gov/air-research/unmix-60-model-environmental-data-analyses

5. **Chemical Mass Balance (CMB) Model**

   https://www3.epa.gov/scram001/receptorcmb.ht

Source Apportionment / Chemometric Models



Traditional Methods

- Enrichment Factor (EF)
- Elemental/Diagnostic Ratio or tracer analysis
- Cluster Analysis
- Mass Closure Models
  - JR Stedman (1998)
  - Harrison et al. (2000)
  - Khan et al. (2016)

Receptor Models

- PCA/MLR
- PCA/APCS
- PMF
- CMB
- Unmix

Receptor-Hysplit Coupling

- Concentration Weighted Trajectory (CWT)
- Potential Source Contribution Function (PSCF)

OUR WORK AND APPLICATION OF CHEMOMETRIC AIR POLLUTION

AGU PUBLICATIONS

JGR

Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE

10.1002/2016JD025894

Comprehensive assessment of $PM_{2.5}$ physicochemical properties during the Southeast Asia dry season (southwest monsoon)

Key Points:
- Physical driving factors govern the concentration of $PM_{2.5}$
- Morning and evening rush hours coincide with enhanced levels of CO and NO_2
- EC is associated with biomass burning, while OC is mainly due to secondary sources

Supporting Information:
- Supporting Information S1

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Citation:
Khan, M. F., et al. (2016), Comprehensive assessment of $PM_{2.5}$ physicochemical

Md Firoz Khan[1], Nor Azura Sulong[2], Mohd Talib Latif[2,3], Mohd Shahrul Mohd Nadzir[1,2], Norhaniza Amil[4], Dini Fajrina Mohd Hussain[2], Vernon Lee[2], Puteri Nurafidah Hosaini[2], Suhana Shaharom[2], Nur Amira Yasmin Mohd Yusoff[2], Hossain Mohammed Syedul Hoque[2], Jing Xiang Chung[2], Mazrura Sahani[5], Norhayati Mohd Tahir[6,7], Liew Juneng[2], Khairul Nizam Abdul Maulud[8,9], Sharifah Mastura Syed Abdullah[10,11], Yusuke Fujii[12], Susumu Tohno[13], and Akira Mizohata[14]

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CHEMOMETRIC MODEL: PMF

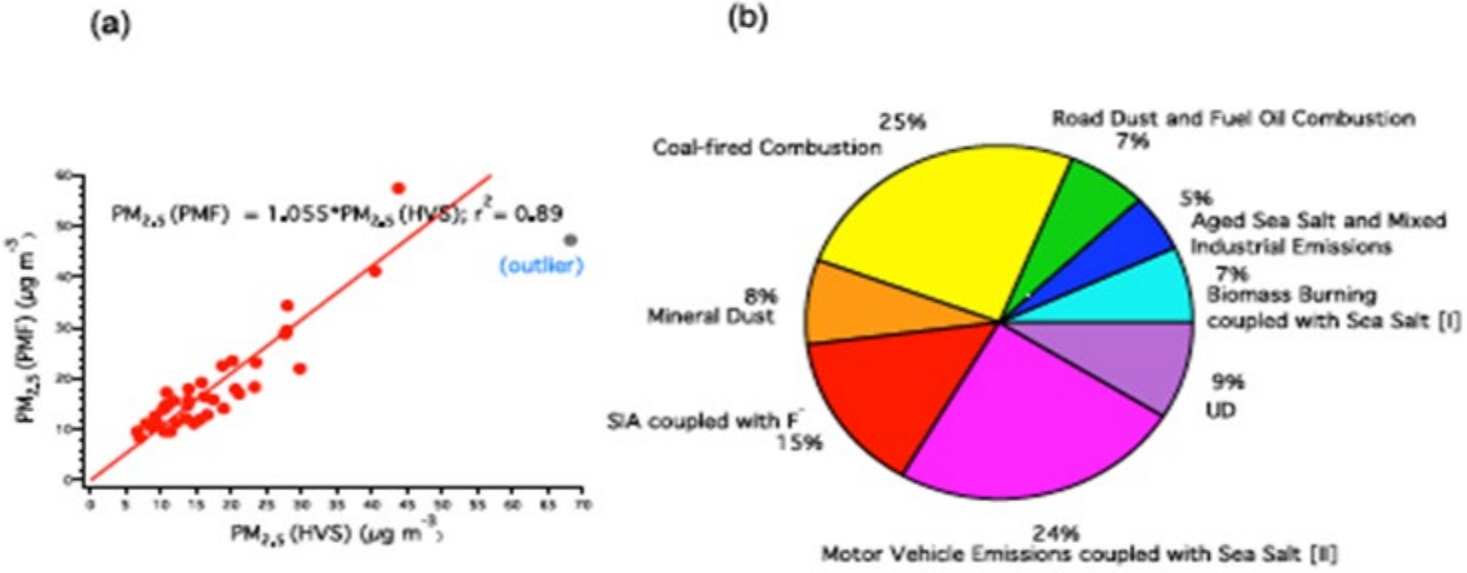
- PMF, a robust model has been comprehensively applied to explore the southeast Asian seasonal plume.
- Reported the emission sources of $PM_{2.5}$ using metals, ions, carbon fractions, & PNC.
- Air mass plume during the moderate HAZE has been exclusively described using PMF.
- PSCF statistical function has been coupled with Factors derived from PMF to add info about source regions.

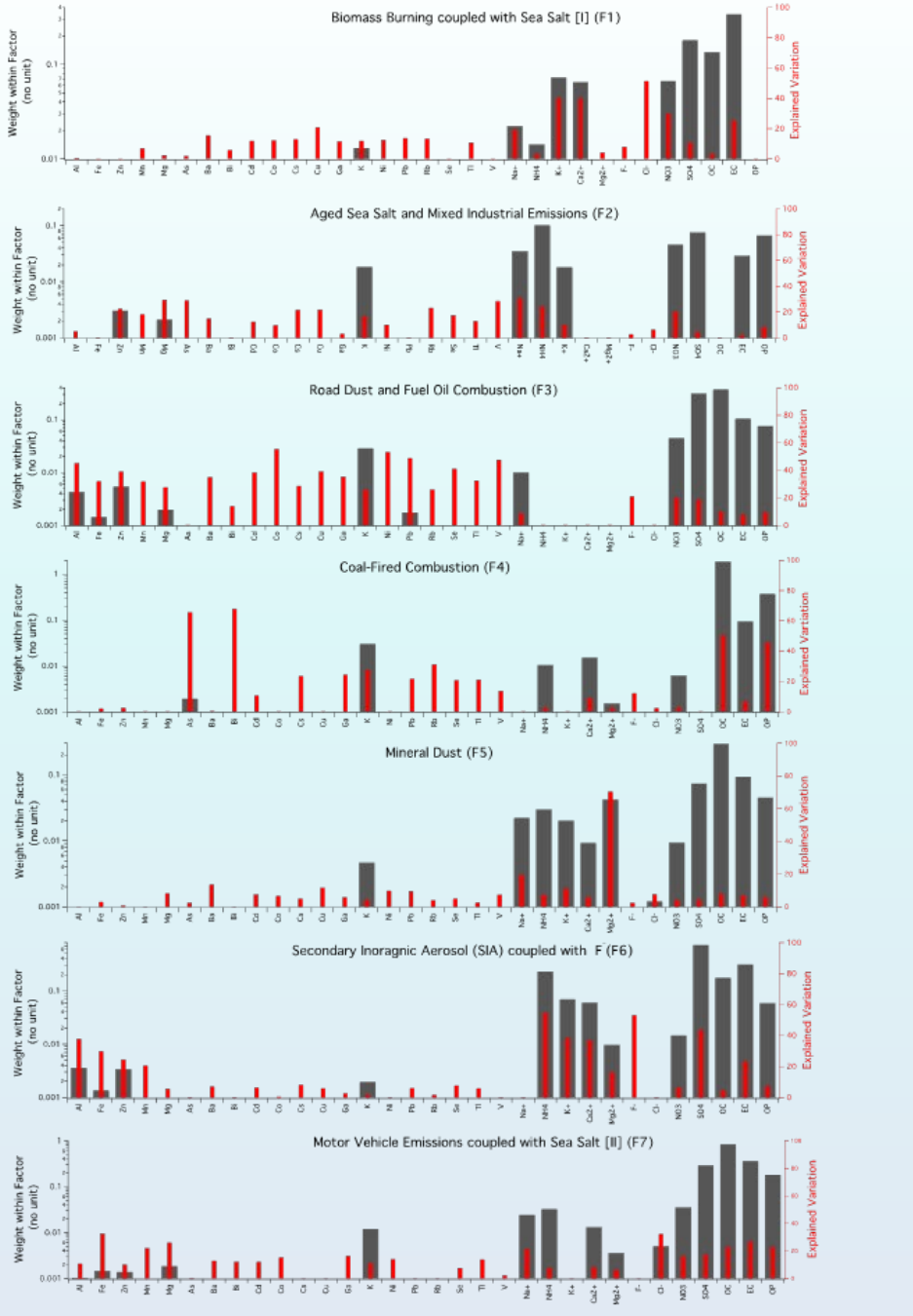
OUR WORK AND APPLICATION OF CHEMOMETRIC AIR POLLUTION

CHEMOMETRIC MODEL: PMF

PMF helps to know the contributing sources during MODERATE HAZE:

- Coal burning
- Motor vehicle
- Secondary inorganic
- Biomass burning, etc

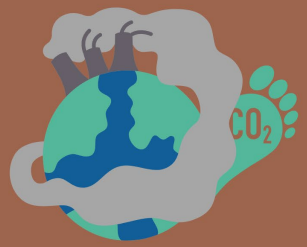




Proposed Mitigation Strategies for air pollution in Bangladesh

by Aerosol Lab, NSU

Regional agreements and political commitments for mitigating the local air pollution



Increase awareness on air pollution for health protection

Apply 3R's – Reuse, Reduce and Recycle to Municipal's Solid Waste

Urgent Call for Phasing out the Old fleets

Practice carpooling and reduce number of car trips

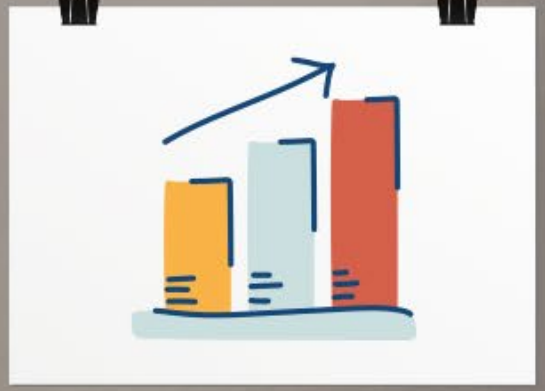
Use public transport

In Singapore

Carbon-Tax

P S I
Hourly Pollutant Standard Index

C E M S
Continuous Emissions Monitoring System



In Ireland

Renewable Electricity
80% Conversion within 2030

Reduce Food Waste
by 50% by 2030

Organic Land
Increase to 350,000 hectares

*** Followed the EU Policies for Cleaner Eurpoe ***

In Canada

Zero Emission
Transit Fund

A Q H I
Forecasting Twice a Day

Air Quality Alert
at immediate risk from air pollution

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- Farihah Sakinah, UM
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- Prof. Aftab Ali Sheikh, Chairman, BCSIR
- Dr. Nurul Huda Shakil, DU
- Naharin, DU
- Tonmay, DU
- Shangha Mitra, NSU
- Sanjida, NSU
- Maisha, NSU
- Afia, NSU
- AEROSOL Lab, NSU

thank you!

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