Chemical characteristics, source apportionment, and health risk assessment of heavy metals in $PM_{2.5}$ in Bien Hoa city, southern Vietnam

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Content

1. Introduction

- **Air pollution** is one of the greatest scourges on in our era and its adverse impacts have posted a major concern to the environment and human health.
- **$PM_{2.5}$** can adsorb toxic materials (Fe, Cu, Mn, Cr, etc.) that damage human organs.
- Number of studies regarding to air pollution focus on the most populous cities **(e.g. Hanoi and Ho Chi Minh city)**.
- **Bien Hoa city (BHC)** is among the most populous cities nationwide, and a hotspot of major industrial establishments. Emission from BHC can disperse to the surrounding areas, and make contact with a much larger population.

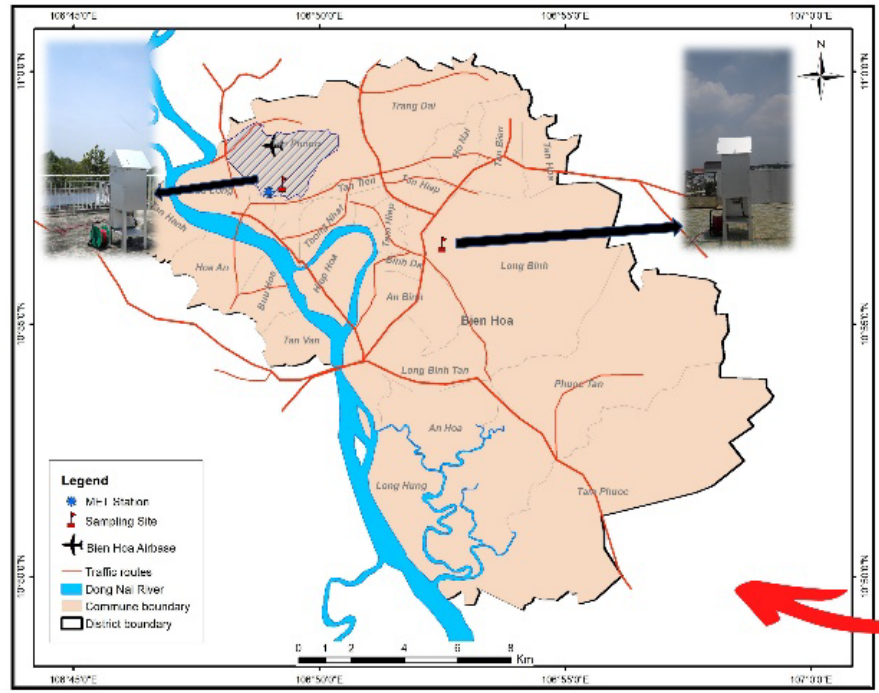
2. Materials and methods

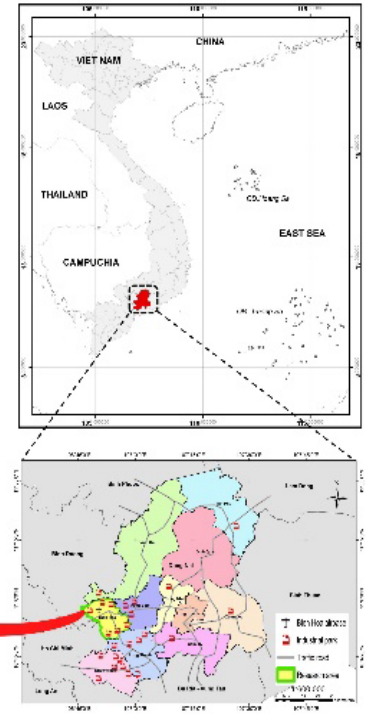
- Sampling and chemical analysis
- Enrichment factor (EF)
- Backward trajectories and concentration weighted trajectory
- Health risk assessment of soluble trace metals inhalation

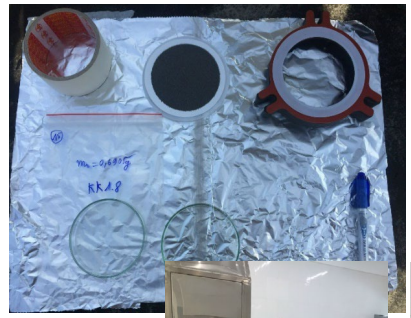
Sampling and chemical analysis

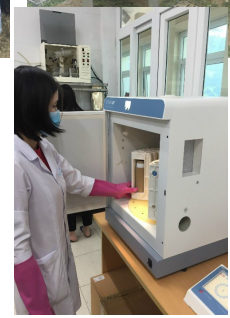
- **Sampling sites:**
  - Bien Hoa Airbase *(urban zone).*
  - Long Binh district *(industrial zone).*

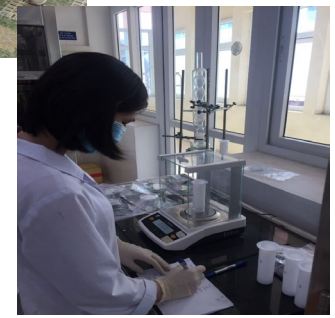
- **40 samples were collected:**
  - Rainy season ***vs.*** Dry season.
  - High volume air sampler *(E-1000DBLX).*
  - Quartz filter *(102 mm).*
  - Intake of 200 L/min.
  - h = 12 m above the ground.











Enrichment factor (EF)

$$EF = \frac{\left((\frac{C_i}{C_{ref}})Sample\right.}{\left((\frac{C_i}{C_{ref}})Crust\right.}$$

Where:

C_i : concentration of heavy metal i;

C_{ref} : concentration of reference metalic element;

$(C_i/C_{ref})_{sample}$: ratio within the sample

$(C_i/C_{ref})_{crust}$: ratio at the Earth's crust.

Backward trajectories and concentration weighted trajectory

Hybrid Single-Particle Lagrangian Integrated Trajectory model (HYSPLIT):

- Conducted via the SplitR package in R. 72-hour backward trajectory arrivals were calculated every 3 hours at an arrival height of 500 m.
- Concentration weighted trajectory (CWT) analysis was used to address potential sources of individual trace element.

Health risk assessment of soluble trace metals inhalation

$$EC_i = \frac{CA_i \times ET \times ED}{AT}$$

$$HQ_i = \frac{EC_i}{RfC_i \times 1000}$$

$$HI = \sum HQ_i$$

$$R_i = EC_i \times IUR_i$$

$$TCR = \sum R_i$$

Where:

EC_i : exposure concentration of the heavy metal i (µg/m^3),
CA_i : concentration of the heavy metal i in air media (µg/m^3),
ET : exposure time (estimate 8 h/day),
ED : exposure duration (40 years for adults * 365 days/year),
AT : averaging time (75 year lifetime x 365 days/year x 24 h/day) (75 years the average life expectancy of the Vietnam population in 2018

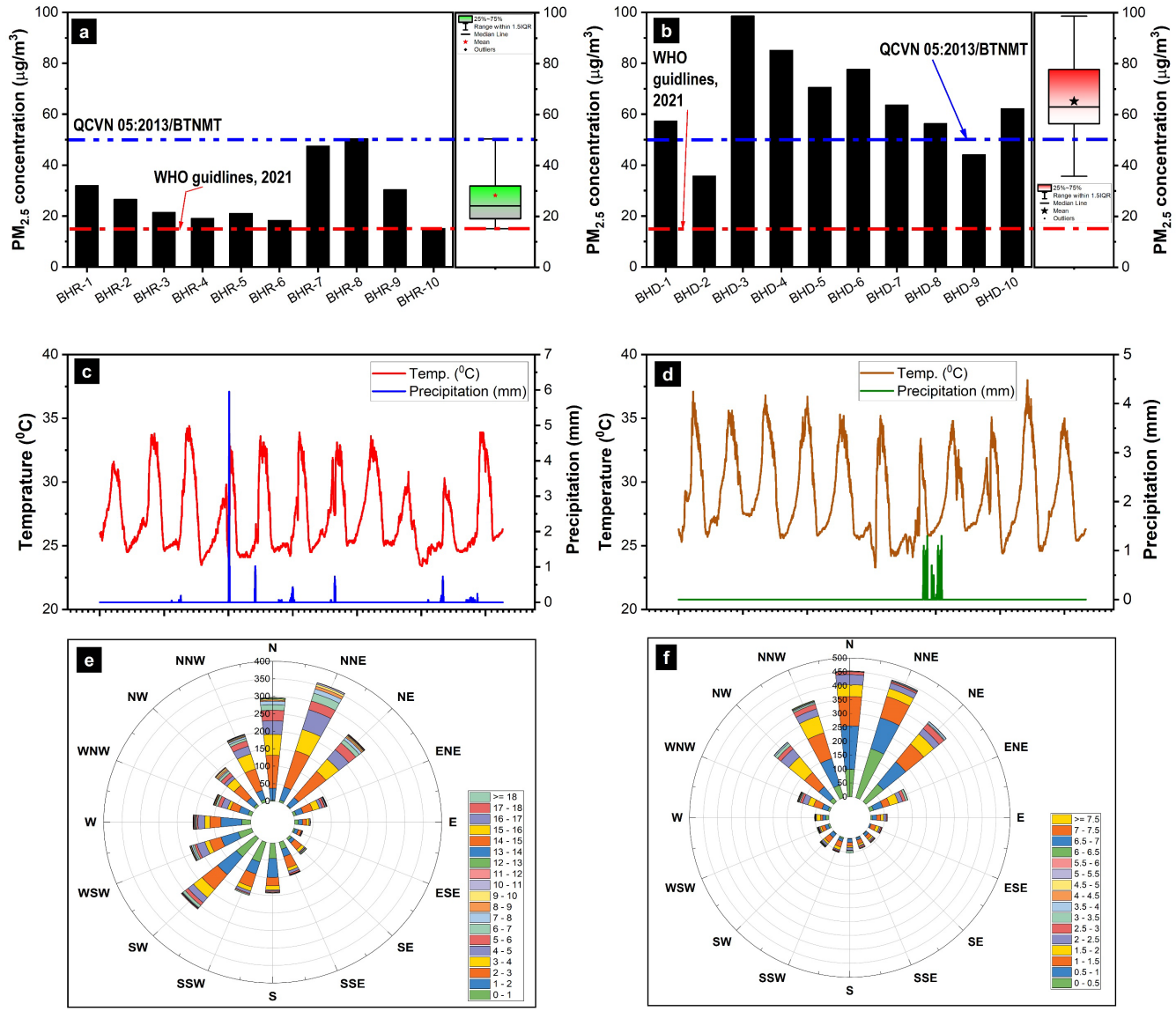
RfC_i : reference concentration for the element i - inhalation toxicity value (mg/m^3)
HQ_i : hazard quotient of element i (unitless)

IUR_i : inhalation unit risk of the carcinogenic element i (µg/m^3)
R_i : carcinogenic risk of the element i (unitless)

3. Results and Discussion

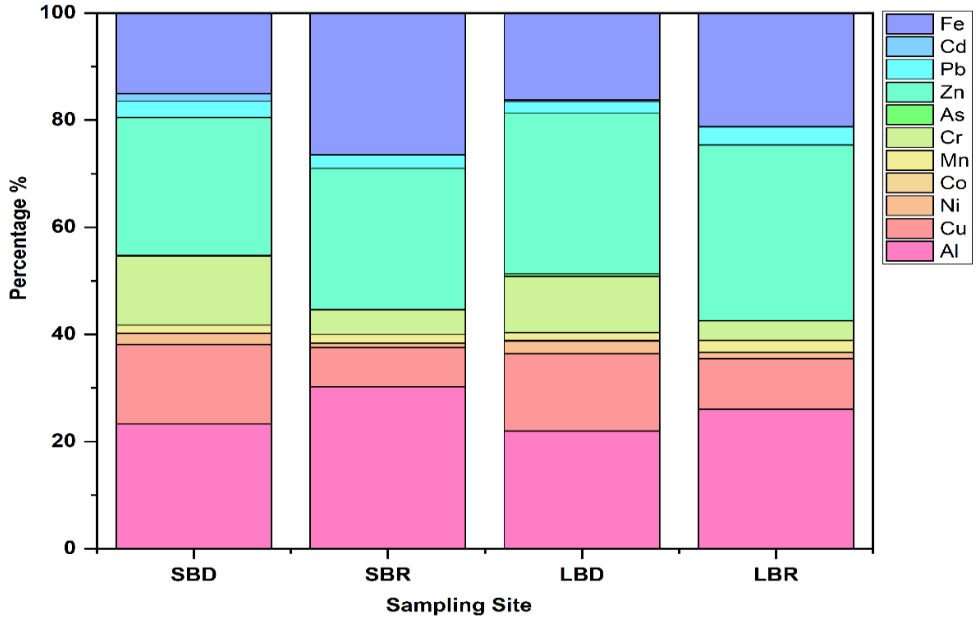
Air mass origins

- $PM_{2.5}$ conc. level (both sites/seasons) exceed the WHO guideline value **(15 µg/m³).**
- Only $PM_{2.5}$ conc. level in the dry season exceed the threshold of QCVN05:2013/BTNMT **(50 µg/m³).**

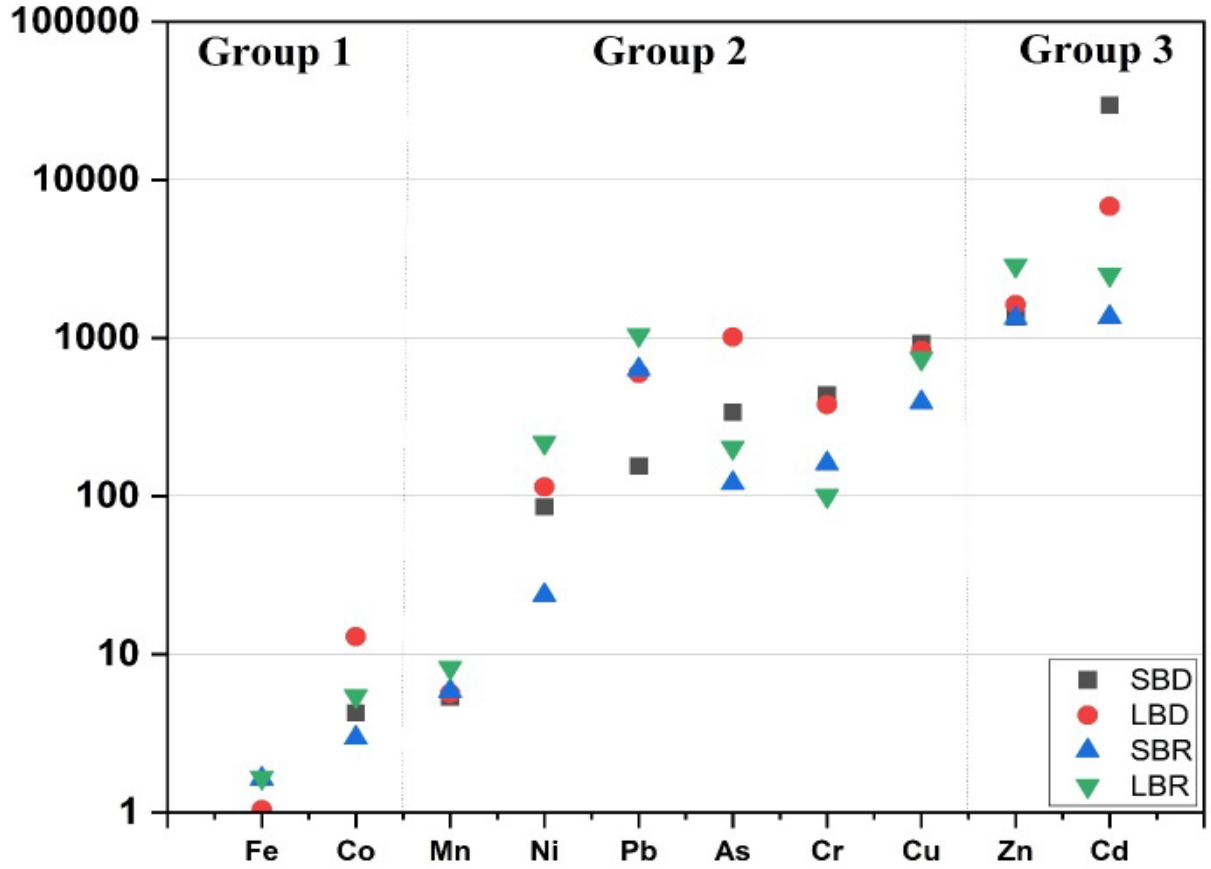


Heavy metals levels in $PM_{2.5}$

- **High (4% - 35%):** Fe, Zn, Cu, Al, and Cr.
- **Moderate (1% - 3%):** Ni, Mn, and Pb.
- **Low (< 1%):** As, Co, and Cd.



Enrichment factor

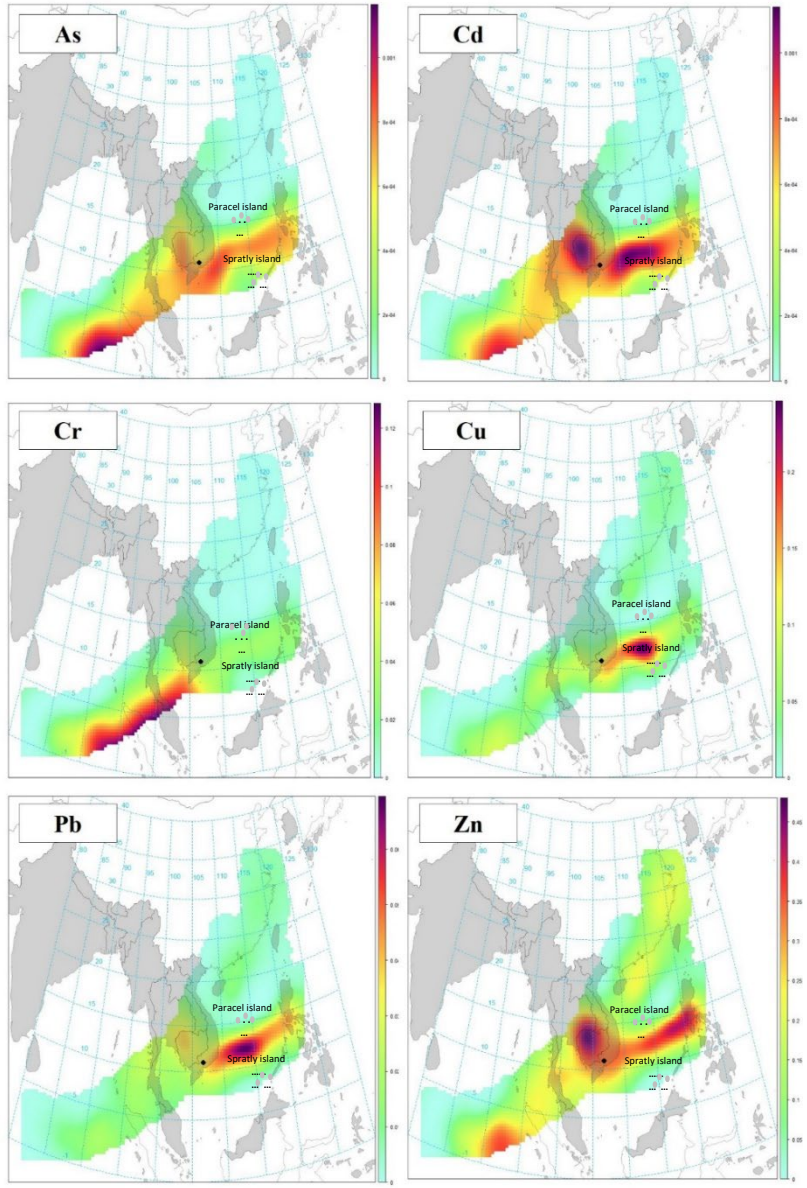


HYSPLIT model

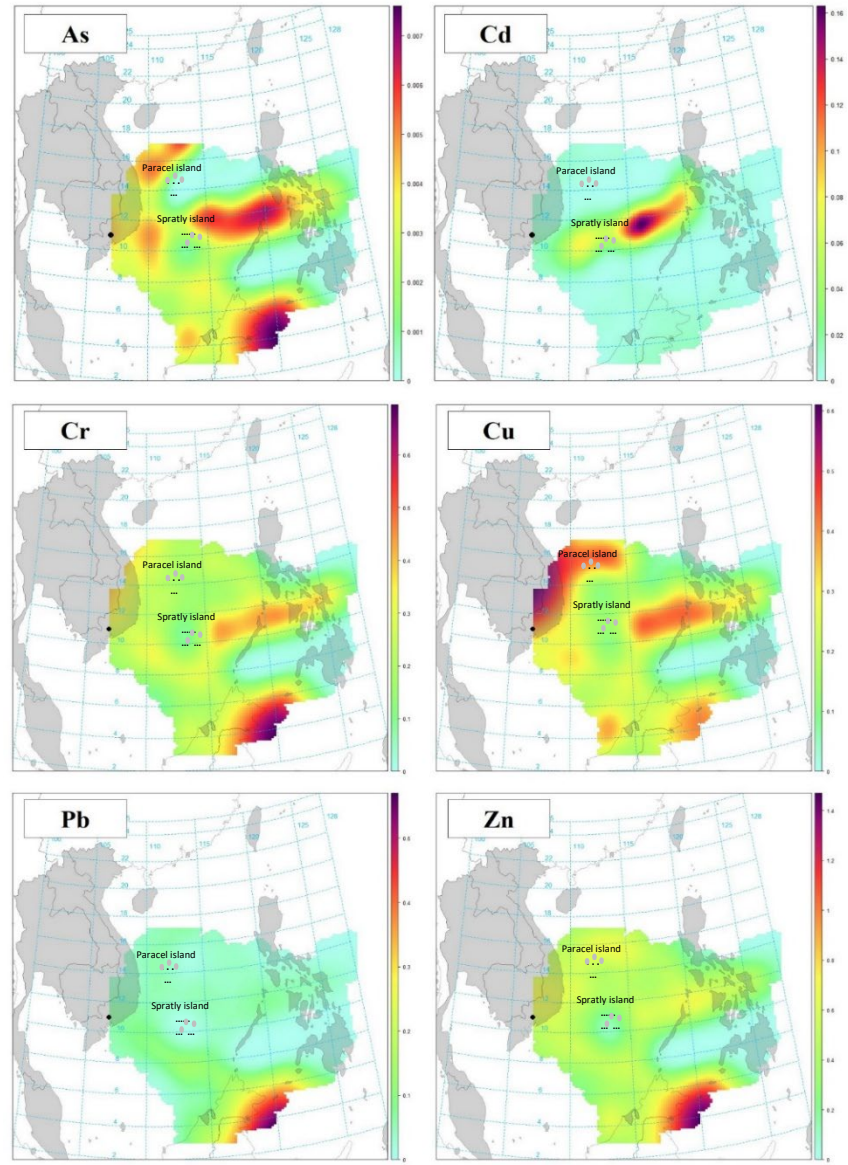
Main sources:

- transportation,
- industry,
- dioxin treatment activities ?.

(a) rainy season



(b) dry season



Health risk exposure of $PM_{2.5}$ soluble metals

- Health risk assessment focuses on the six classified carcinogenic agents (As, Cd, Cr, Pb, Co, and Ni).
- HI values remain under 1 for all samples, except for SBD → low risks of resulting in chronic adverse health impacts.
- TCR values all greatly exceed the recommended threshold at 10^{-6}, ranging between $10^{-4} \leq TCR \leq 10^{-3}$

Location	SB		LB	
Sample	SBD	SBR	LBD	LBR
HI	**1.384 ± 1.976**	0.182 ± 0.058	0.962 ± 0.638	0.150 ± 0.062
TCR	7.2E-04 ± 3.1E - 04	1.5E-04 ± 7.1E-05	7.9E-04 ± 5.6E-04	1.0E-04 ± 6.6E-05

4. Conclusion

- The concentration and potential emission source of eleven heavy metals in $PM_{2.5}$ in BHC are studied (As, Pb, Mn, Fe, Cd, Cr, Zn, Co, Al, Cu, and Ni) + 8 ions.

- Three groups: **high concentration** at over 4% (Fe, Zn, Cu, Al, Cr), **moderate** 1% - 3% (Ni, Mn, Pb), and **low** <1% (As, Co, Cd).

- EF of Pb, As, Cr, Cu, Zn and Cd at above 100.

- **As for the potenial cancer risk**, samples at both locations and seasons yeild TCR values ranging between $10^{-4} \leq TCR \leq 10^{-3}$

- Results of HYSPLIT model suggest that there are emission contribution originated from other countries within the Southeast Asia region.

Thank you!

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