Exploring the variations in ambient BTEX in urban Europe and its environmental health implications

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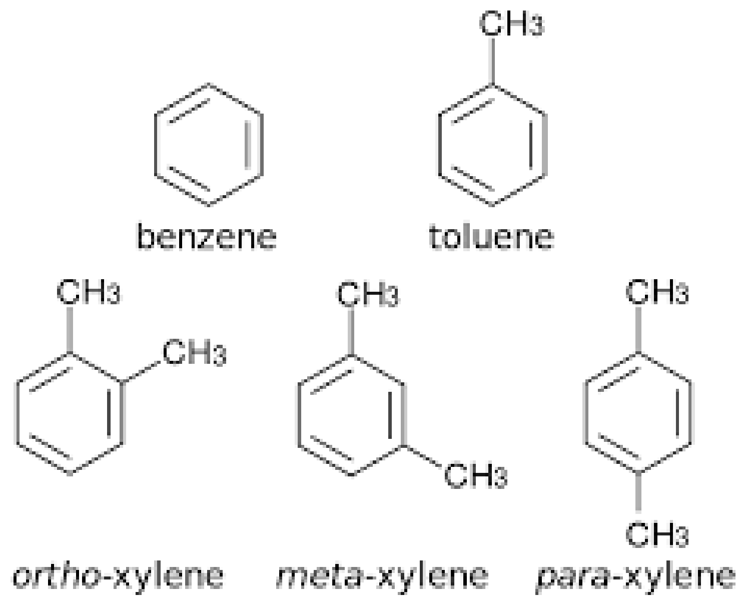
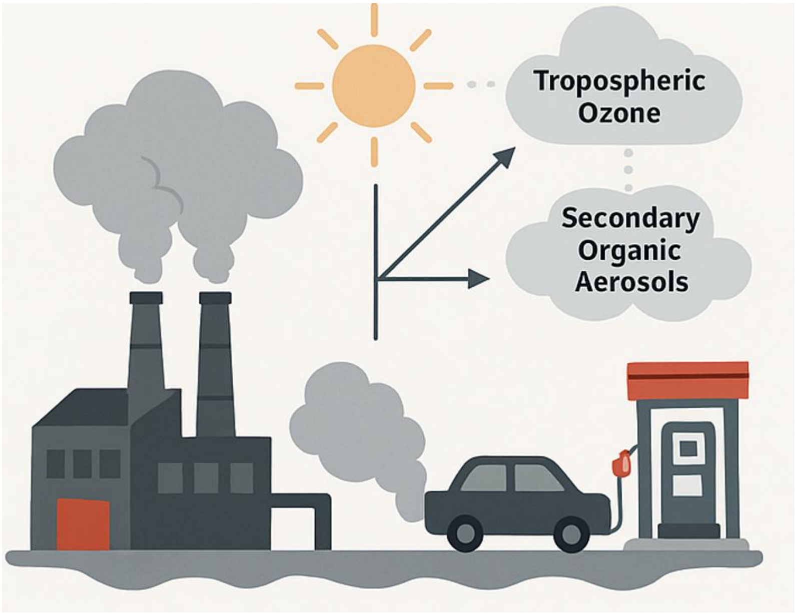
ACTRIS CIGAS DATA QA/QC

WORKSHOP 7-9 APRIL 2025

Overview of BTEX Compounds





- Benzene, toluene, ethylbenzene, xylenes (as **BTEX**)

- key precursors for **tropospheric O_3** and **SOAs**

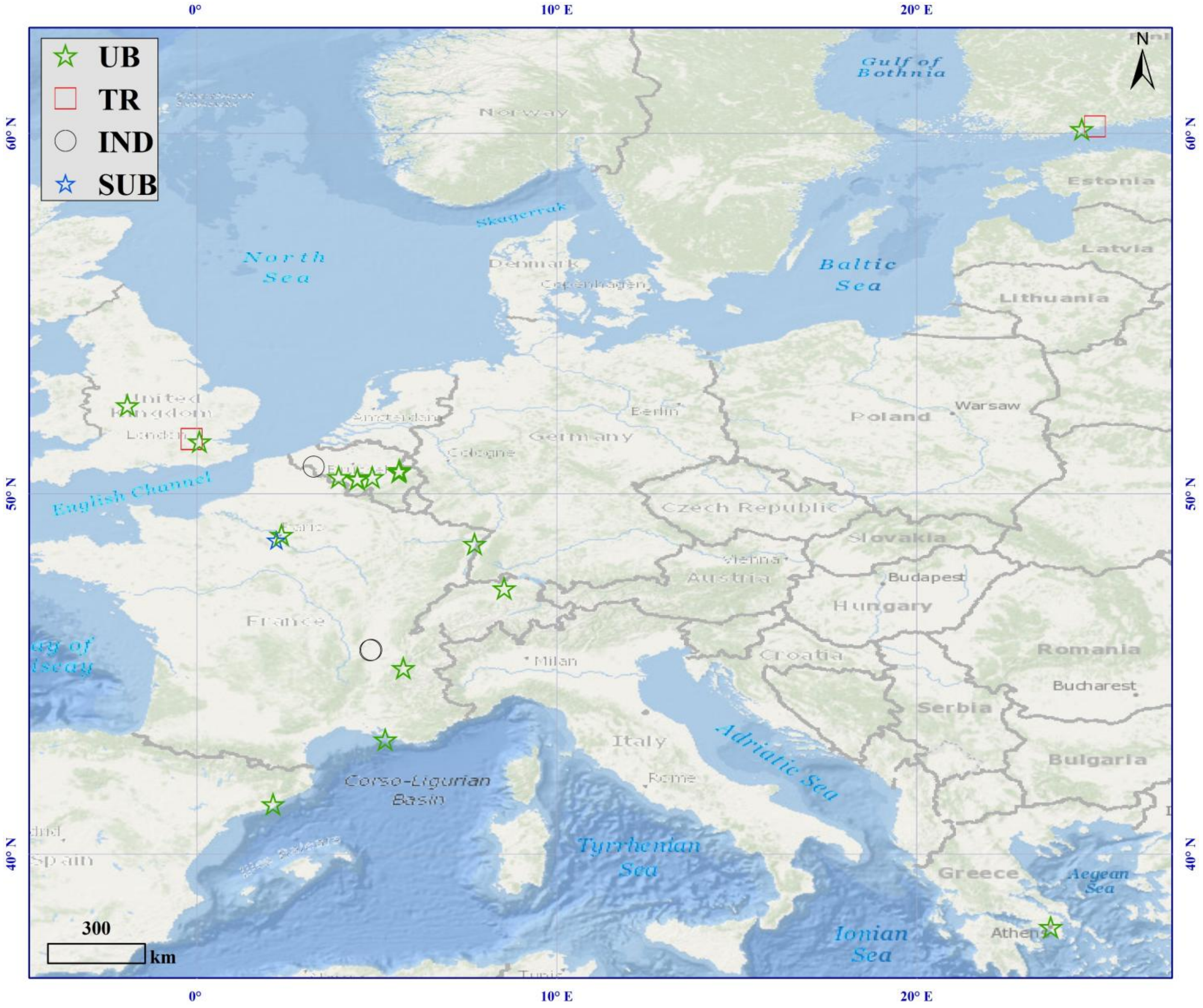
- **Impacts** on human health and the environment (Benzene is classified as a human carcinogen by the IARC)

Current Research Gaps and Objectives

- **Research Gap:** Limited comprehensive studies on BTEX concentrations and health impacts across European cities.

- **Study Objectives:** Analyze BTEX levels, identify sources, and assess health risks in different urban settings in Europe.

Monitoring Sites and Instrumentation



- 3 industrial (**IND**) sites,
- 2 traffic (**TR**) sites,
- 16 urban background (**UB**) sites
- 1 suburban background (**SUB**) site.

- Thermal Desorption Gas Chromatography with Flame Ionization Detectors (**TD-GC-FID/2FID**),
- Thermal Desorption Gas Chromatography-Mass Spectrometry (**TD-GC-MS**),
- Proton Transfer Reaction-Time of Flight-Mass Spectrometry (**PTR-TOF-MS**),
- **PTR-Quad-MS**
- passive samplers.

Data Treatment and Analysis

Data Quality Assessment

The data quality was assessed by two ACTRIS CiGas units based on established recommendations and guidelines. Outliers were identified and removed to ensure reliable results.

The use of mixing ratios (ppt) was preferred to reflect the non- normal distribution of BTEX data. Median mixing ratios and median absolute deviations were calculated to summarize the data.

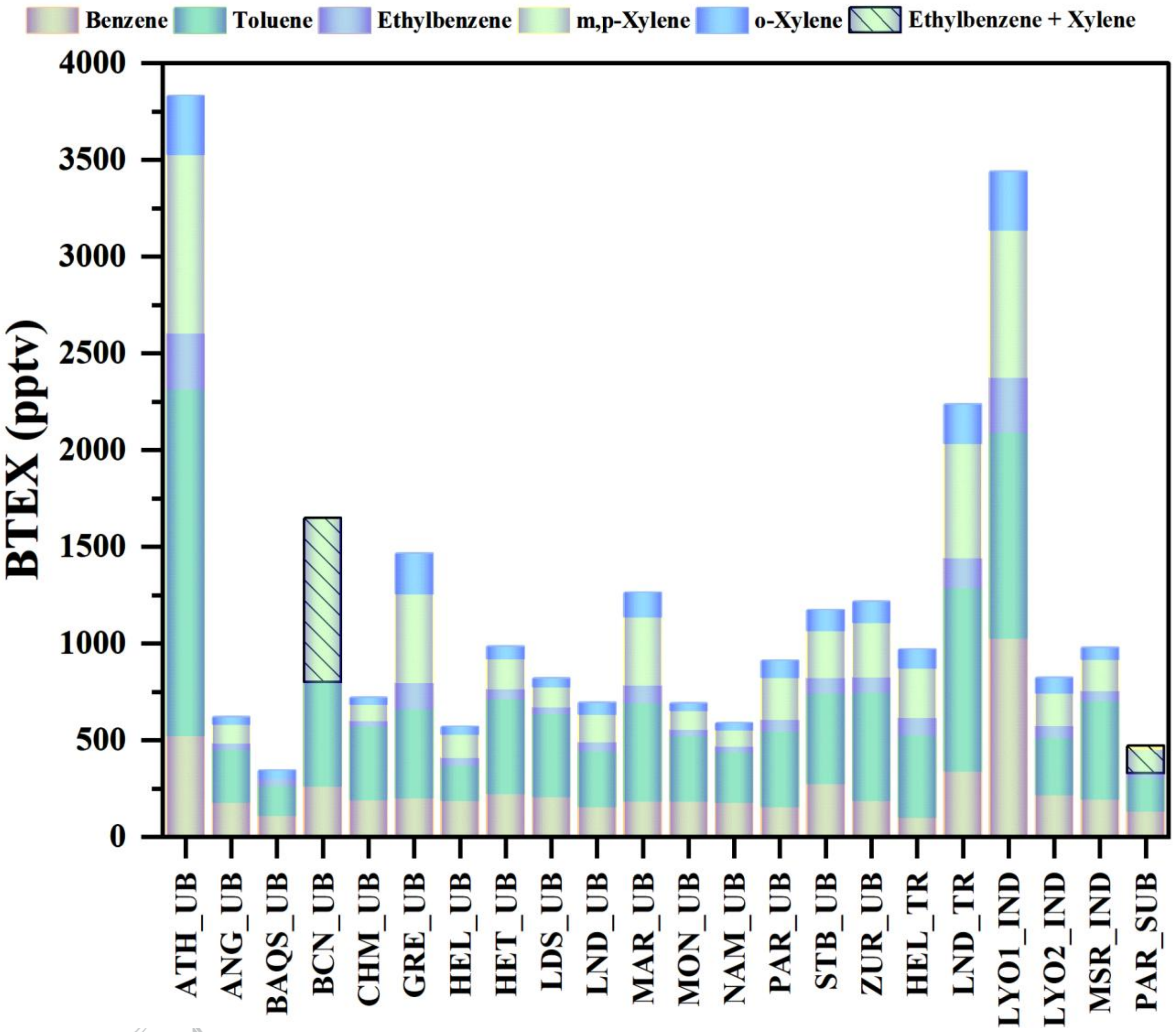
Statistical Methods

The Mann–Whitney U test and the Kruskal–Wallis test were employed to evaluate statistically significant differences in BTEX mixing ratios across different sites and seasons.

These non- parametric tests are robust for analyzing data that do not follow a normal distribution, ensuring accurate comparisons between various monitoring sites.

Results and Discussion

Status of BTEX Data Availability and Mixing Ratios

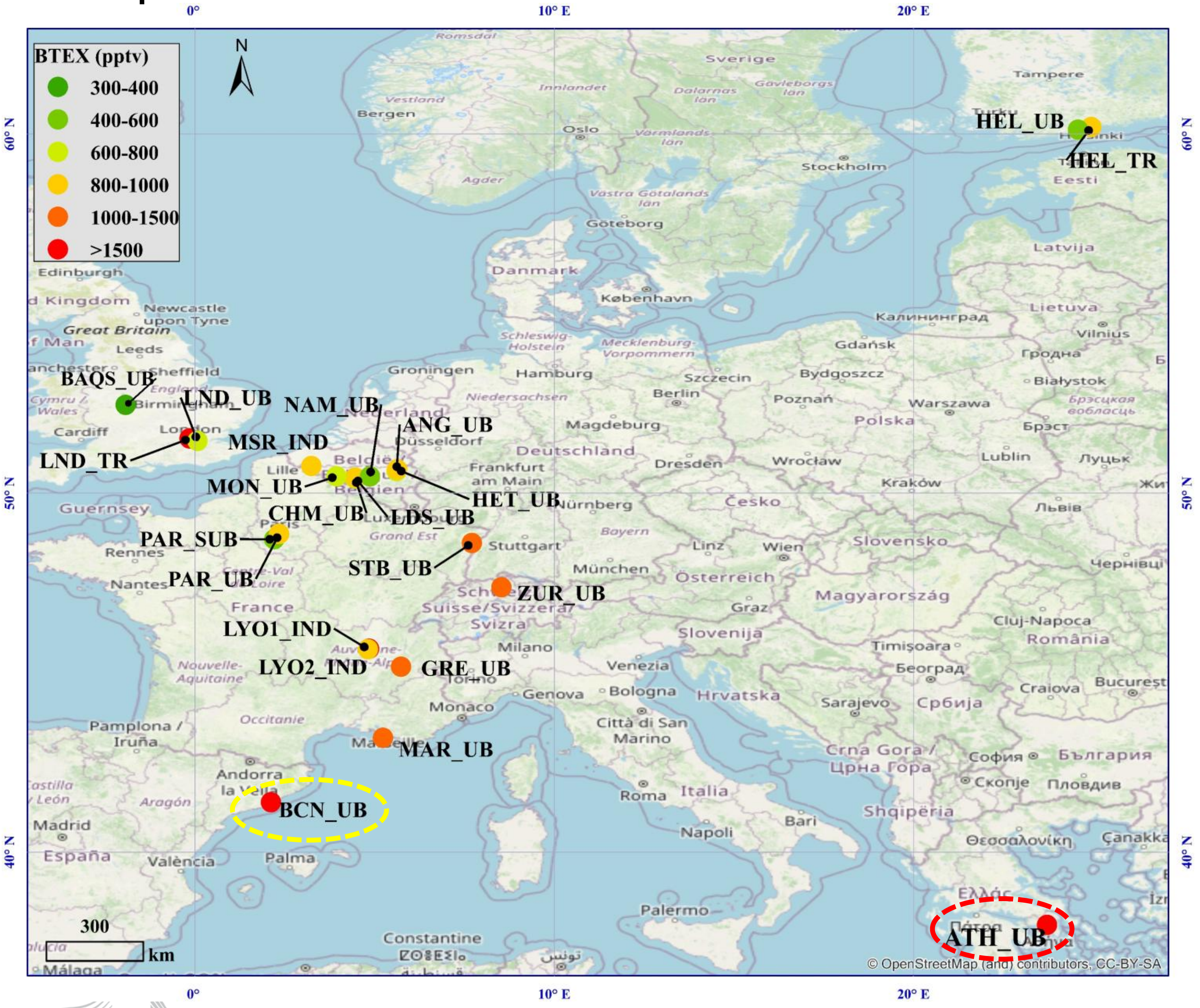


Relative Abundance of BTEX

- **toluene > benzene > m,p- xylene > o- xylene > ethylbenzene**

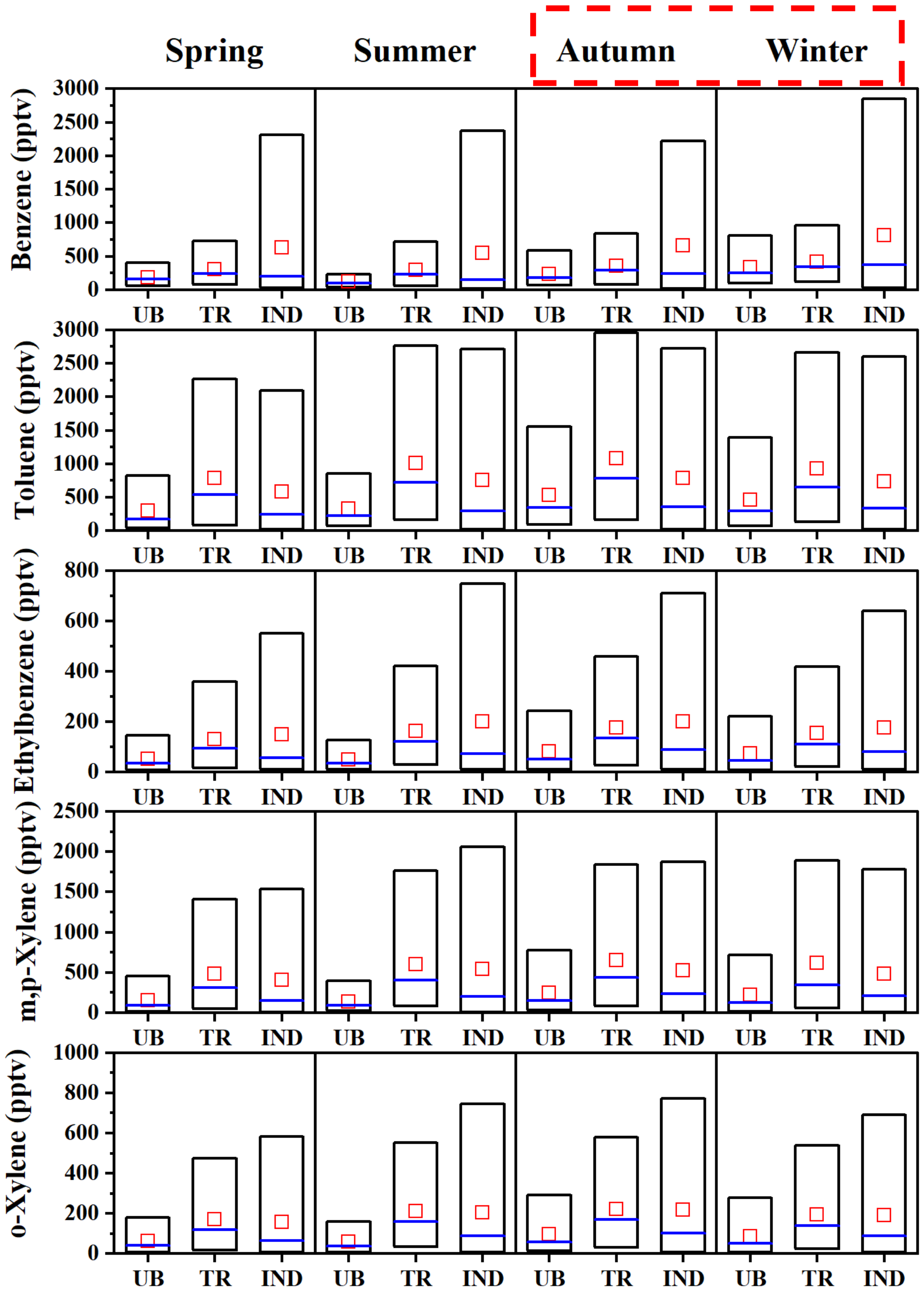
- toluene and benzene are the most prevalent BTEX compounds in urban environments, likely due to their significant contributions from traffic and industrial sources.

Spatial variations



- Significant spatial variations in BTEX mixing ratios were observed across different European cities.
- **Athens** (Greece) had the highest median BTEX levels (2768 ± 4117 ppt), followed by **Barcelona** (Spain) with 622 ± 312 ppt.

Temporal Variations



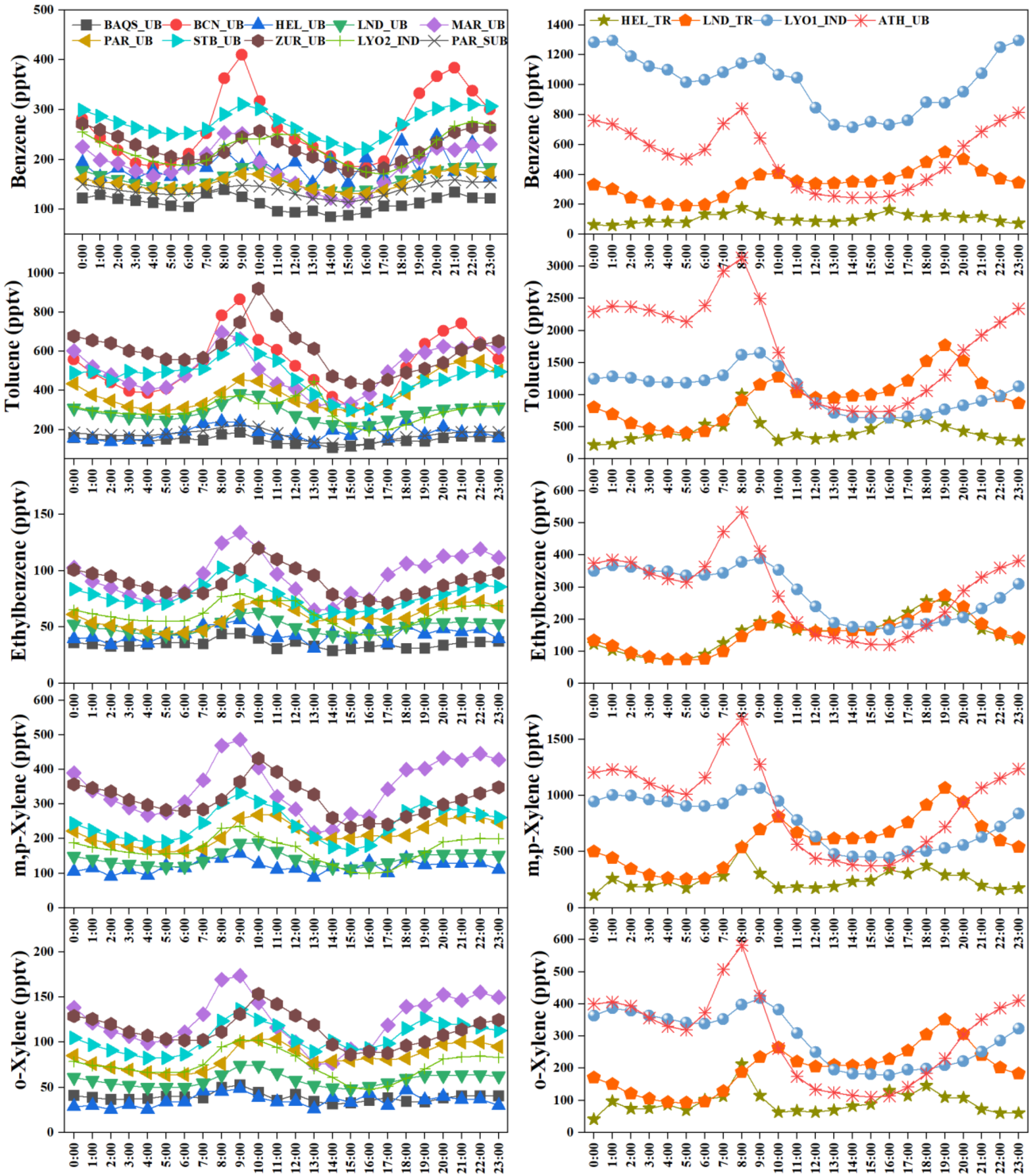
➢ **Seasonal Trends**

✓ Higher concentrations observed during autumn and winter compared to spring and summer

✓ Benzene concentrations at UB sites were similar across seasons, indicating mixed sources

✓ Toluene levels were highest in traffic and industrial areas during winter.

✓ Ethylbenzene and xylenes also showed seasonal differences, with higher concentrations in winter



➢ Diel Patterns

✓ Diel variations in BTEX mixing ratios revealed double peaks in some sites, coinciding with morning and evening rush hours.

✓ For instance, sites like Athens, Barcelona, and London exhibited pronounced morning and evening peaks, highlighting the significant influence of traffic emissions on BTEX concentrations.

✓ The diel patterns also varied depending on the site type and local meteorological conditions.

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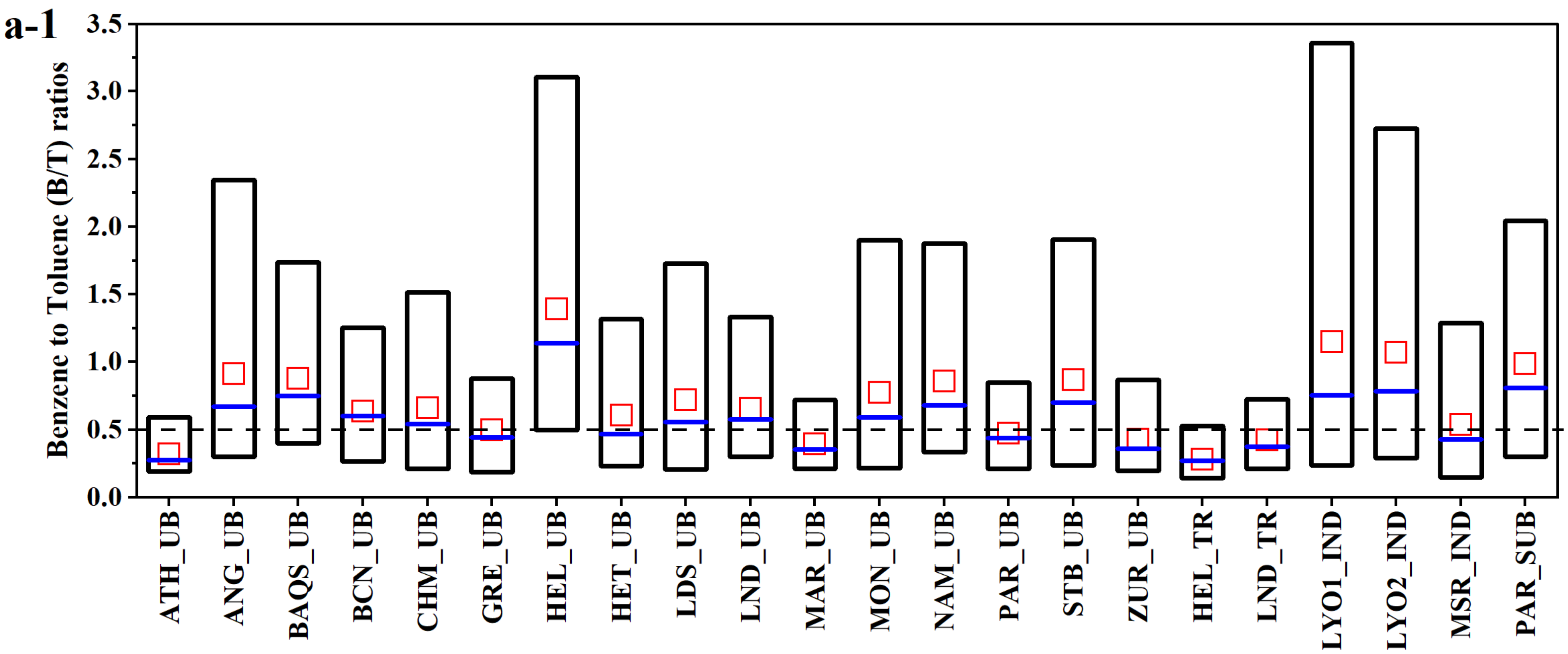
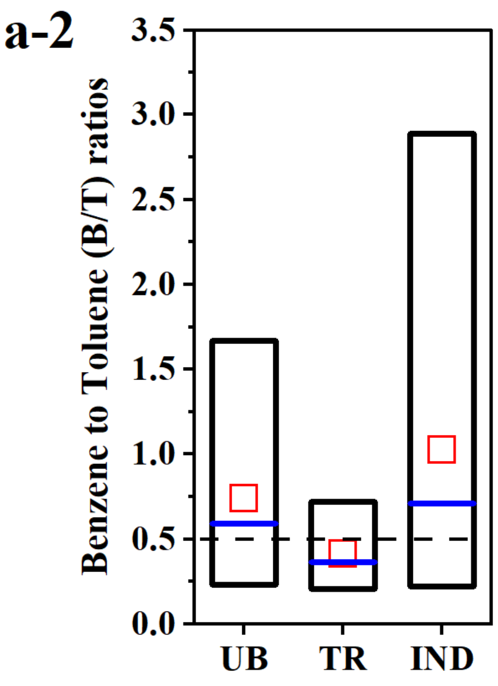
Specific Ratios of BTEX

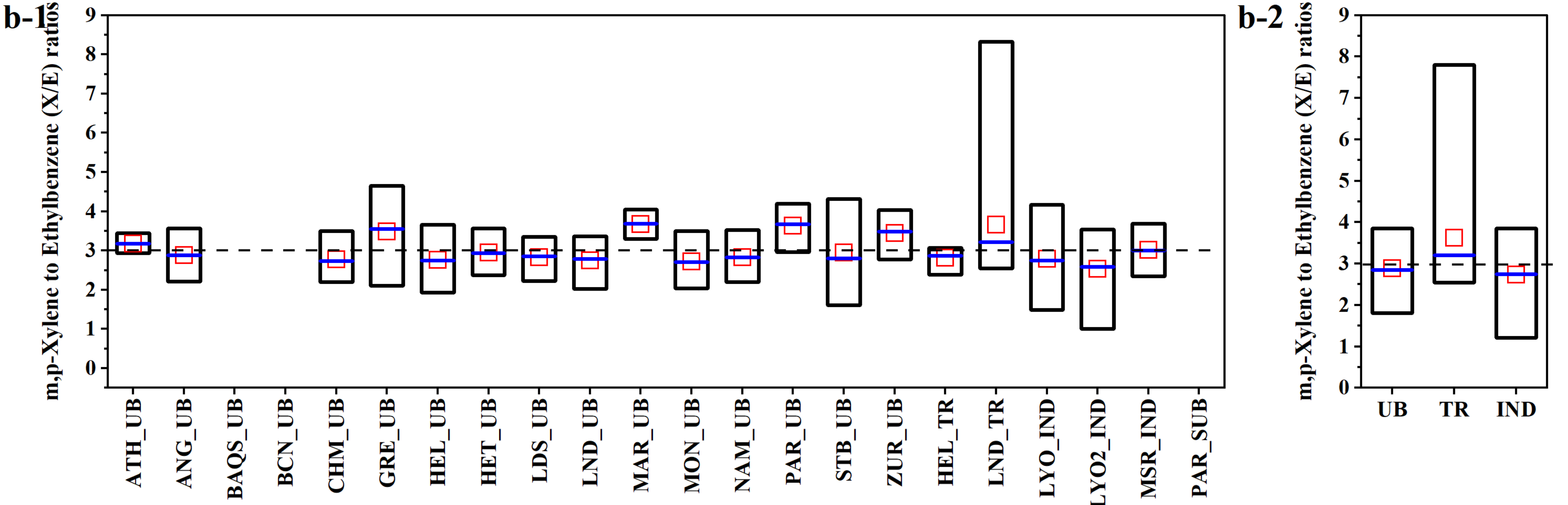
Benzene to Toluene (B/T)





- The B/T ratio ranged from 0.29 ± 0.11 to 1.35 ± 0.95 across monitoring sites
- Industrial sites had higher B/T ratios due to the different atmospheric lifetimes of benzene and toluene

Specific Ratios of BTEX m,p-Xylene to Ethylbenzene (X/E)

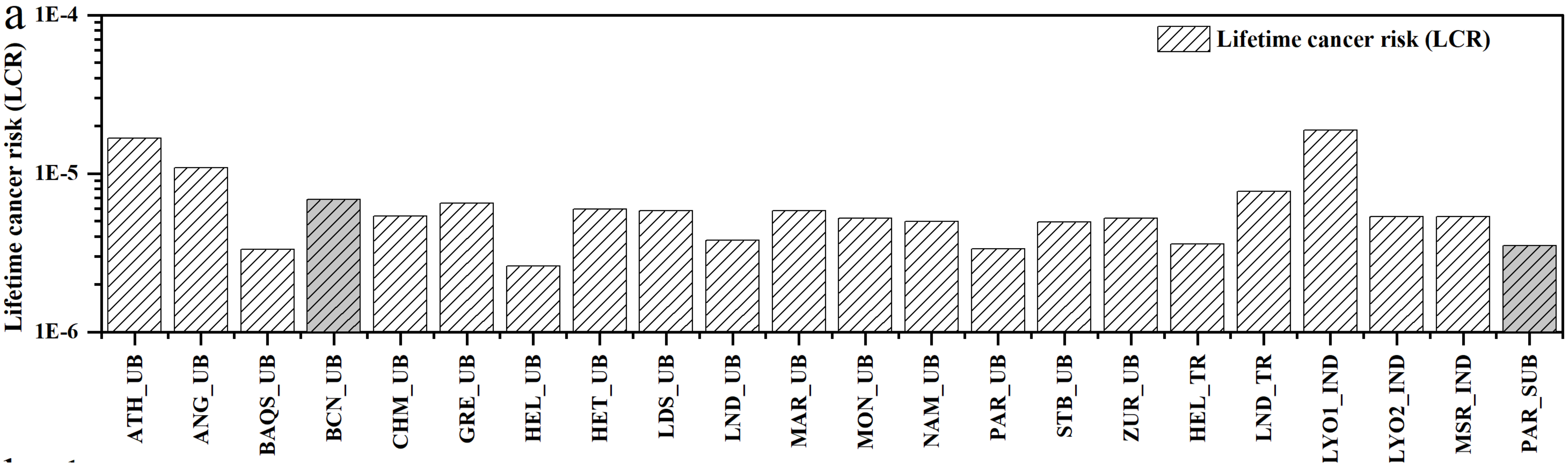


- The X/E ratio ranged from 1.75 ± 0.91 to 3.68 ± 0.30, indicating that pollutants at the monitoring sites are primarily emitted from local sources.

- The consistent X/E ratios around 3 at most sites suggest that direct emissions from local sources dominate.

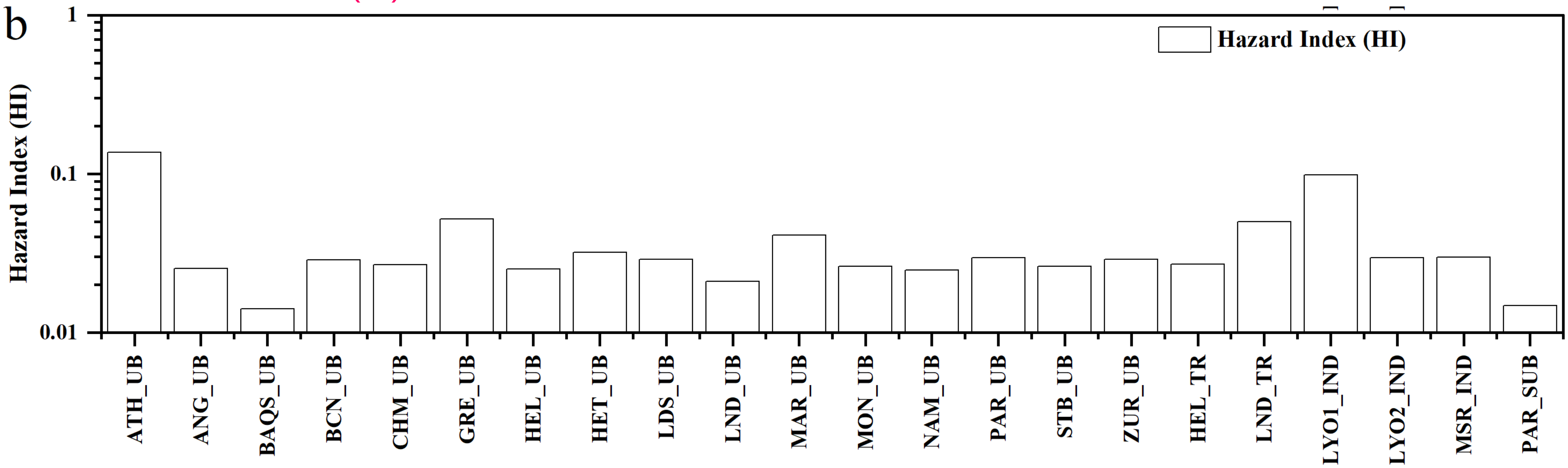
- Slight seasonal variations were observed, with higher X/E ratios in winter due to stable atmospheric conditions and lower in summer due to increased photochemical reactions.

Health Risk Assessment of BTEX Lifetime Cancer Risk (LCR)



- The LCR values associated with benzene and ethylbenzene exposure ranged from 2.6 × 10^- 6 to 1.9 × 10^- 5. These values are below the definite risk threshold (10^- 4) but exceed the permissible risk level (10^- 6), indicating a moderate cancer risk.
- The highest LCR values were observed in traffic and industrial environments, highlighting the need for stricter emission controls and monitoring in these areas.

Hazard Index (HI)



- The HI values for BTEX compounds were generally below the threshold limit value (1), suggesting a low non-carcinogenic risk from outdoor exposure.
- However, elevated HI values were noted at some sites, such as Lyon and London, due to higher concentrations of benzene.
- Long- term exposure to BTEX, even within these safe limits, can still have adverse health effects. Therefore, continuous monitoring and regulatory measures are essential to mitigate potential health risks.

Summary of Key Findings

Major Sources and Variations

The study identified traffic and industrial activities as the primary sources of BTEX pollution in urban Europe.

Significant seasonal and diel variations in BTEX mixing ratios were observed, influenced by changes in emission sources, photochemical reactions, and meteorological conditions.

The B/T and X/E ratios provided valuable insights into the spatial and temporal variations of BTEX sources, highlighting the dominance of local emissions and the influence of photochemical processes.

Health Risk Implications

The health risk assessment indicated a moderate lifetime cancer risk from benzene and ethylbenzene exposure, with LCR values exceeding the permissible risk level.

The HI values suggested a generally low non- carcinogenic risk, but elevated concentrations at some sites warrant further investigation.

The findings emphasize the need for continued monitoring and regulation of BTEX emissions to protect public health and improve air quality in urban areas.

Recommendations for Future Research

➢ Standardized Monitoring and Data Analysis

Establishing a standardized observation platform across all monitoring sites is crucial for consistent data collection and reliable risk assessments. This would enable better- informed decision- making for public health interventions and air quality management strategies.

Future studies should focus on quantifying the individual contributions of different sources (e.g., traffic, industry, biomass burning) to BTEX emissions and evaluating the effectiveness of current air quality regulations in reducing exposure.

Thanks for your attention!!!!

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