RC1:

The manuscript entitled " Exploring the variations in ambient BTEX in urban Europe and its environmental health implications" aimed to offer essential insights into BTEX pollution in European urban environments. However, No more new idea and deep insights about the pollution characteristics, as well as the environmental risk of BTEX pollution were put forth in the manuscript. In my opinion, the current manuscript can't be recommended for publication in Atmospheric Chemistry and Physics.

Response: Thank you for your valuable feedback on our manuscript entitled "Exploring the variations in ambient BTEX in urban Europe and its environmental health implications." We appreciate your insights and the opportunity to clarify and expand upon the contributions of our research.

Addressing Concerns Regarding Novelty and Insights

(1) Identification of Pollution Sources: Our study elucidates the distinct sources of BTEX pollution in urban environments by analyzing the mixing ratios across various site types (urban background, traffic, and industrial). The finding that traffic and industrial activities are significant contributors to BTEX pollution not only confirms existing knowledge but also adds specific spatial and temporal data, enhancing the understanding of urban pollution dynamics in Europe.

(2) Spatiotemporal Analysis: We conducted a comprehensive spatiotemporal analysis of BTEX levels across 22 European urban monitoring sites over several years (2017-2022). This provides a robust dataset that highlights not only the variability of BTEX concentrations in different urban settings but also identifies trends over time, reflecting the effectiveness of air quality regulations in some regions. Our results offer a unique perspective on how BTEX pollution levels are changing, which has implications for policy-making and public health strategies.

(3) Seasonal and Diel Variations: Our investigation into seasonal and diel variations in BTEX mixing ratios reveals important insights into how atmospheric conditions and human activities influence pollutant concentrations. This level of detail enhances the understanding of BTEX pollution's temporal dynamics, which has not been extensively studied in the context of European cities at this large scale.

(4) Environmental and Health Implications: While the manuscript outlines the characteristics of BTEX pollution, it also emphasizes the environmental and health risks associated with these compounds, particularly their role in contributing to air quality issues and potential health impacts. Additionally, we expanded the current risk assessment to include non-cancer risks associated with benzene and its derivatives. We argue that understanding these pollution characteristics is essential for evaluating public health risks and formulating effective mitigation strategies.

(5) Future Research Directions: We propose several avenues for future research, including the investigation of BTEX emissions from specific sources (e.g., residential heating, solvent use, industrial processes) and the long-term health effects of chronic exposure to BTEX in urban populations. This highlights the need for continued research in this area and underscores the relevance of our findings.

In summary, we believe that our manuscript contributes with important insights into the variations in BTEX pollution across urban Europe and its environmental health implications. We appreciate your suggestion for a deeper exploration of the pollution characteristics, and we will take this

opportunity to revise the manuscript to better articulate these insights and their implications.

Specific comments:

1. The first is that the method is not innovative (only analyzing spatio-temporal changes, characteristic ratios, and health risks).

Response: Thank you for your valuable comment. We acknowledge the reviewer's concern regarding the lack of methodological innovation in our analysis. While the methods employed—spatio-temporal changes, characteristic ratios, and health risk assessments—are established techniques, they provide a comprehensive framework for understanding BTEX pollution dynamics in urban Europe. Our aim was to synthesize existing knowledge and present a thorough analysis of BTEX pollution characteristics across diverse urban environments. By focusing on European urban areas, we contribute to the existing literature by contextualizing these methods within a specific geographical framework and highlighting trends and variations that may inform future studies and policies.

2. The second is that the conclusion is also not innovative (the main source is not quantitative, many of which are the results of previous research).

Response: We appreciate your feedback regarding the perceived lack of innovation in our conclusions. We have revised the conclusion to emphasize the quantitative insights gained from our analysis and how they contribute to the existing body of knowledge on BTEX pollution. Specifically, we have clarified that, while we recognize transportation and industrial activities as significant contributors to BTEX pollution, our current data do not allow us to separately quantify their individual contributions. Additionally, we emphasize that the primary aim of our study was to assess the health impact based on quantified indicators, as indicated in the title, rather than to conduct a detailed source apportionment analysis of BTEX. Our approach focuses on providing a comprehensive assessment of the health risks associated with BTEX exposure, while acknowledging the limitations in quantitatively distinguishing the contributions from various sources.

The revised text can be found in the conclusion section (Lines 490-492):

"While we recognize that transportation and industrial activities are key contributors to BTEX pollution, our current data do not allow us to quantify their individual contributions."

We hope this revision addresses your concerns and strengthens the manuscript's contribution to the understanding of BTEX pollution.

3. Thirdly, the results were relatively arbitrary and did not take into account the influence of various factors on the external field. For example, in the section of Line 182-187, it is not very appropriate to conclude that transportation and industrial activities are the main sources of BTEX pollutants in the study area based solely on the different concentrations of different types of pollutants, as the meteorological conditions in these locations may vary greatly.

Response: We appreciate the reviewer's comments regarding the need to account for various factors that can influence BTEX concentrations and sources. We acknowledge that meteorological conditions and other external factors play a significant role in determining BTEX levels and should not be overlooked. In our manuscript (line 196-211), we initially provided a preliminary analysis based on available data to identify potential sources. To strengthen our conclusions, we applied a commonly used method to determine urban enhancement ratios (ER) (Salameh et al., 2019, https://doi.org/10.1016/j.aeaoa.2018.100003), estimating the slopes of least-square linear regressions between each TEX compound and benzene. By using ER, we reduce the sensitivity of

the analysis to background conditions, dilution, and air-mass mixing compared to using absolute concentrations (Salameh et al., 2019).

Our results show spatial differences in the ER values for TEX/B, with the highest ratios observed at TR sites, followed by UB sites, and the lowest at IND sites. Specifically, the slopes were 2.09±0.05 for T/B, 0.37±0.01 for E/B, 1.21±0.03 for m,p-X/B, and 0.48±0.01 for o-X/B at TR sites, 1.57±0.02 for T/B, 0.23±0.00 for E/B, 0.71±0.01 for m,p-X/B, and 0.27±0.00 for o-X/B at UB sites, and 0.37±0.01 for T/B, 0.13±0.00 for E/B, 0.29±0.01 for m,p-X/B, and 0.13±0.00 for o-X/B at IND sites. A similar trend was observed in the seasonal variations, with ER values generally following the order TR > UB > IND. Notably, for UB and TR sites, the ER for TEX/B was higher in summer, while for IND sites, the ER was lowest during summer (Table S1). These findings suggest that the additional evaporative sources, potentially related to traffic or solvent usage, particularly at urban background sites, may contribute to the observed seasonal and spatial variations.

Additionally, our study examined diurnal variations, which showed that meteorological and photochemical processes (e.g., daytime vs. nighttime conditions) also influence BTEX levels, supporting the complex interplay of various factors impacting the pollutant concentrations.

Table S1. *Urban enhancement ratios (ER) of different types (urban background, UB; traffic, TR; industrial site, IND) in different seasons.*

Seasons	Types	Toluene vs. Benzene	Ethylbenzene vs. Benzene	m,p-Xylene vs. Benzene	o-Xylene vs. Benzene
Spring	UB	1.69 ± 0.05	0.23 ± 0.01	0.67 ± 0.05	0.3 ± 0.02
Spring	TR	2.19 ± 0.09	0.36 ± 0.01	1.13 ± 0.05	0.45 ± 0.02
Spring	IND	0.46 ± 0.02	0.13 ± 0.01	0.30 ± 0.01	0.13 ± 0.01
Summer	UB	2.64 ± 0.06	0.32 ± 0.01	1.02 ± 0.05	0.37 ± 0.02
Summer	TR	3.28 ± 0.20	0.55 ± 0.02	1.82 ± 0.07	0.69 ± 0.03
Summer	IND	0.30 ± 0.01	0.10 ± 0.01	0.21 ± 0.01	0.09 ± 0.01
Autumn	UB	1.70 ± 0.04	0.20 ± 0.01	0.60 ± 0.01	0.25 ± 0.01
Autumn	TR	2.54 ± 0.06	0.49 ± 0.02	1.65 ± 0.06	0.65 ± 0.02
Autumn	IND	0.42 ± 0.03	0.24 ± 0.01	0.49 ± 0.02	0.23 ± 0.01
Winter	UB	1.76 ± 0.03	0.29 ± 0.01	0.88 ± 0.02	0.32 ± 0.01
Winter	TR	1.98 ± 0.05	0.33 ± 0.01	1.04 ± 0.05	0.42 ± 0.02
Winter	IND	0.38 ± 0.02	0.10 ± 0.01	0.27 ± 0.01	0.12 ± 0.01