Responses to Interactive Comments

Journal: Atmospheric Chemistry and Physics

Manuscript ID: ACP-2025-596

Title: Toxic Dust Emission from Drought-Exposed Lakebeds – A New Air Pollution Threat from Dried Lakes

Our response is in blue and the modifications in the manuscript are in red.

We appreciate Referee #1's comments and suggestions to help improve the manuscript. We tried our best to address your comments and detailed responses and related changes are shown below.

Overall, the paper is well written, it is clear, and the work is interesting. I think small changes are needed to improve the paper.

Response: We thank Referee 1 for their valuable comments and suggestions. Below are the responses to each specific comment.

You need more discussion in the introduction section about the presence of heavy metals and PAHs in dust events in general, to show if the lake produces more, and how the emissions you found compare to these findings.

Response: Thank you for your comments. We have included additional details on the presence of heavy metals and PAHs in dust events in the introduction section.

Change in the manuscript:

Introduction

"In parallel, numerous studies have found that both polycyclic aromatic hydrocarbons (PAHs) and heavy metals are commonly present in atmospheric particulate matter during dust events (Mohammad Asgari et al., 2023; Bai et al., 2023; Wang et al., 2018; Onishi et al., 2015; Li et al., 2008). For example, long-term observations at the Kanazawa University Wajima Air

Monitoring Station in Japan recorded 54 Asian dust (AD) events between 2010 and 2021, where total suspended particles (TSP) increased significantly (up to 39.8 μg/m^3), yet PAH concentrations (∑9PAHs) remained relatively stable, ranging from 404 to 543 pg/m^3 depending on transport altitude (Bai et al., 2023). Similarly, in Abadan City, PAH concentrations reached 46.2–91.0 ng/m^3 under different dust conditions, with vehicular and petroleum emissions identified as the dominant sources (Mohammad Asgari et al., 2023). Studies in southern Italy reported PM_{10} concentrations exceeding 50 μg/m^3 during African dust intrusions, with crustal metals such as Al, Fe, and Mn reaching levels of 305, 289, and 6.7 ng/m^3 respectively, while trace metals like Pb, Zn, and Cd were primarily attributed to anthropogenic source (Buccolieri et al., 2006). Additionally, during AD events in East Asia, mean Pb, Cr, Mn, and Zn concentrations were found to be 44.4 ± 23.6, 10.2 ± 3.7, 72.8 ± 32.4, and 84.0 ± 40.0 ng/m^3 respectively—significantly higher than levels during non-dust periods (Onishi et al., 2015)."

Results and discussion

"This study shows that the dry lakebeds of Dongting and Poyang Lakes can emit dust with pollutant levels comparable to or even higher than those from major dust events. Modeled monthly PM_{10} concentrations reached 10.2 and 34.5 μg/m^3, with daily peaks up to 119.9 and 420.1 μg/m^3—exceeding many reported values for Asian and African dust. BaP concentrations from lakebed dust (0.010–0.014 ng/m^3) approached those observed during Asian dust events at background sites in Japan (0.133 ± 0.093 ng/m^3) (Bai et al., 2023). Heavy metals such as Cr reached 13–31 ng/m^3 daily, comparable to or higher than Asian dust levels (e.g., 10.2 ± 3.7 ng/m^3) (Onishi et al., 2015). These findings suggest that drought-exposed lakebeds are emerging dust sources with significant implications for air quality and health."

The map (Figure 1) should appear earlier to explain the sampling locations, as it was unclear to me until I got to the result part and saw that figure. Also, the usage of A, B, and C is weird. Can you give it a normal name?

Response: We appreciate the reviewer's suggestion. The clarity of the sampling site labels and the placement of the map were improved as follows:

First, in response to your comment, we have moved **Figure 1** from Line **371** to **157** in the manuscript to help readers understand the sampling layout before encountering the results. This adjustment should enhance the overall flow and contextual understanding of the study design.

Second, we agree that the original site labeling using A, B, and C (e.g., A1, B2, C3) was ambiguous and could be confusing. To address this, we have revised the naming scheme to use more descriptive and informative codes that reflect both the **lake** and the **hydrological zone** of each sampling site. The new naming format follows the structure:

Original Label	New Label	Description
A1	PY-D1	Poyang Lake – Dry Zone site 1
A2	PY-D2	Poyang Lake – Dry Zone site 2
A3	DT-D1	Dongting Lake – Dry Zone site 1
B1	PY-T1	Poyang Lake – Transitional Zone site 1
B2	PY-T2	Poyang Lake – Transitional Zone site 2
B3	DT-T1	Dongting Lake – Transitional Zone site 1
C1	PY-S1	Poyang Lake – Submerged Zone site 1
C2	PY-S2	Poyang Lake – Submerged Zone site 2
C3	DT-S1	Dongting Lake – Submerged Zone site 1

Last, this revised naming system helps clarify both the geographic origin and the environmental context of each sample. We have updated all labels accordingly in Figure 1, **figure captions**, **main text**, and **supplementary materials**, ensuring consistency throughout the manuscript.

Change in the manuscript:

2.1 Sampling location

In October 2022, during an extreme drought event, a total of nine lakebed soil samples were collected from the top 5 cm of the soil profile at Poyang Lake and Dongting Lake to examine the concentrations of PAHs and heavy metals in exposed lakebed dust. The sampling sites were distributed across three types of hydrological zones: (1) areas typically not submerged throughout the year (PY-D1, PY-D2, and DT-D1); (2) transitional zones that alternate between wet and dry conditions (PY-T1, PY-T2, and DT-T1); and (3) areas usually submerged but exposed due to drought (PY-S1, PY-S2, and DT-S1). The sampling sites around Poyang Lake were all located within one kilometer of the lake surface. Details of the sampling locations are provided in Table 1 and shown in Fig. 1. All collected soil samples were air-dried, sieved through a 2 mm nylon mesh to remove debris, thoroughly homogenized, and stored at 4 °C in the dark prior to analysis.

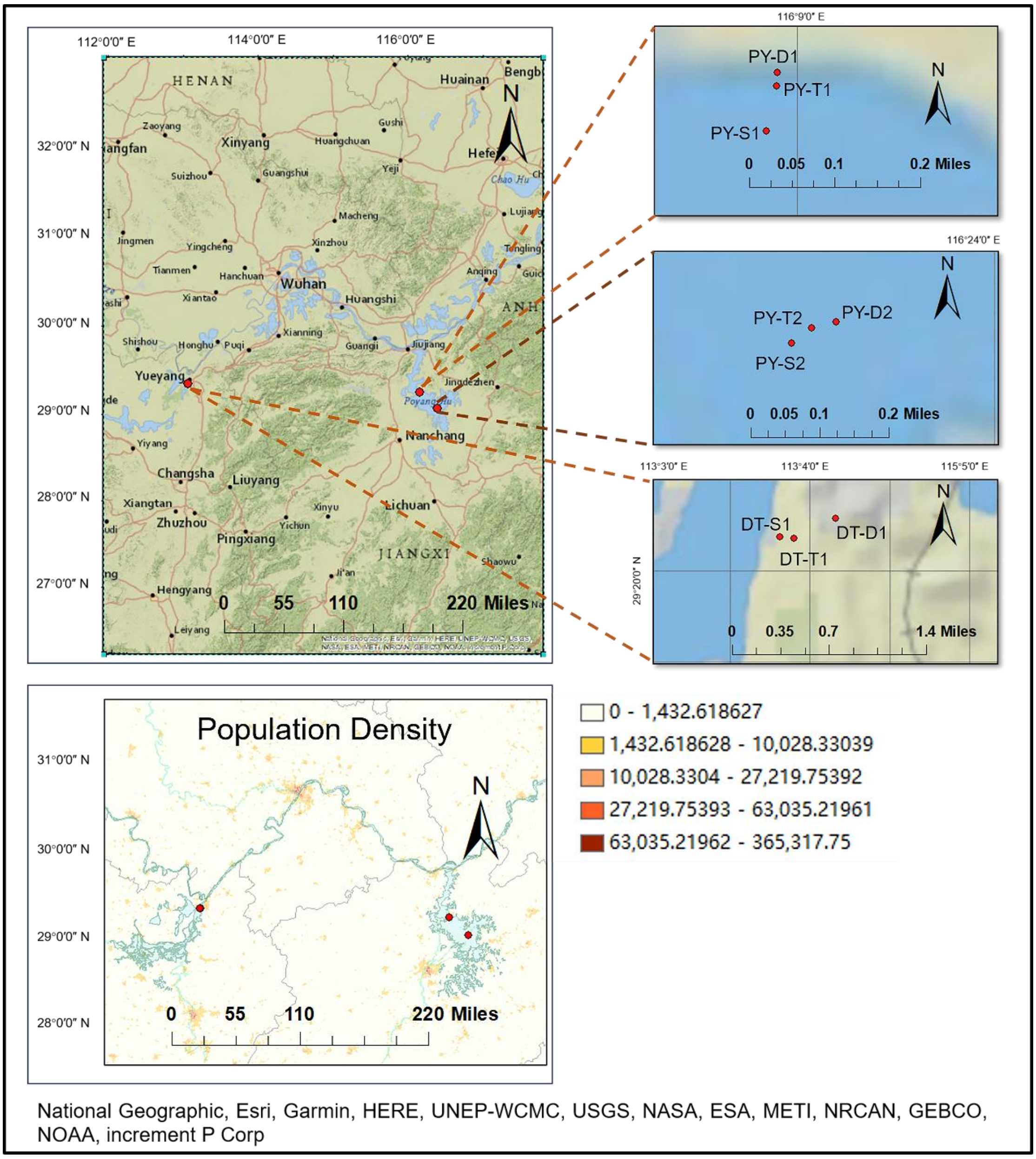


Figure 1. Sampling locations in Poyang Lake and Dongting Lake (marked as red dots). Sites PY-D1, PY-D2, and DT-D1 represent regions typically dry and exposed year-round. PY-T1, PY-T2, and DT-T1 are transitional zones that alternate between submerged and dry states. PY-S1, PY-S2, and DT-S1 are areas usually submerged but occasionally exposed due to extreme drought conditions. PY-D1, PY-T1, and PY-S1, along with PY-D2, PY-T2, and PY-S2, are located within Poyang Lake, while DT-D1, DT-T1, and DT-S1 correspond to Dongting Lake. A 2020 population density layer from WorldPop (1 km resolution) is overlaid, using a yellow-to-red color ramp to indicate increasing population density. The base map is sourced from National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, and increment P Corp, as provided in the ArcGIS software.

Consider moving some of the figs from the supplement section to the main section, as some of them are important for the understanding of the paper.

Response: We appreciate the reviewer's suggestion regarding the organization of figures between the main text and the supplementary information. we have moved additional figures from the supplementary information into the main manuscript, increasing the number of figures in the article from **4** to **7**.

1. As suggested, we have moved the map (now revised as Fig. 1) to the beginning of the materials and methods section to aid readers in understanding the sampling design. A population density layer has also been added (bottom left panel) to highlight the spatial relationship between sampling sites and nearby human populations. This adjustment improves the spatial context and addresses the concern about figure timing and clarity.

2. The **individual PAH concentration figures** (original supplementary Figure S6) from the Supplementary information have been **merged with total PAH concentrations** (original Figure 1) to create a more informative Figure 2, which is now included in the main text.

3. In addition, **Figure S15** and **Figure S14**—which are important for interpreting the health risks from toxic substances of lakebed dust emissions—have been **moved to the main text as Figures 5 and 6**, respectively.

These modifications aim to improve readability and ensure that all key visual data are easily accessible within the main text.

Change in the manuscript:

2.1 Sampling location

In October 2022, during an extreme drought event, a total of nine lakebed soil samples were collected from the top 5 cm of the soil profile at Poyang Lake and Dongting Lake to examine the concentrations of PAHs and heavy metals in exposed lakebed dust. The sampling sites were distributed across three types of hydrological zones: (1) areas typically not submerged throughout the year (PY-D1, PY-D2, and DT-D1); (2) transitional zones that alternate between wet and dry conditions (PY-T1, PY-T2, and DT-T1); and (3) areas usually submerged but exposed due to drought (PY-S1, PY-S2, and DT-S1). The sampling sites around Poyang Lake were all located within one kilometer of the lake surface. Details of the sampling locations are provided in Table 1 and shown in Fig. 1. All collected soil samples were air-dried, sieved through a 2 mm nylon mesh to remove debris, thoroughly homogenized, and stored at 4 °C in the dark prior to analysis.

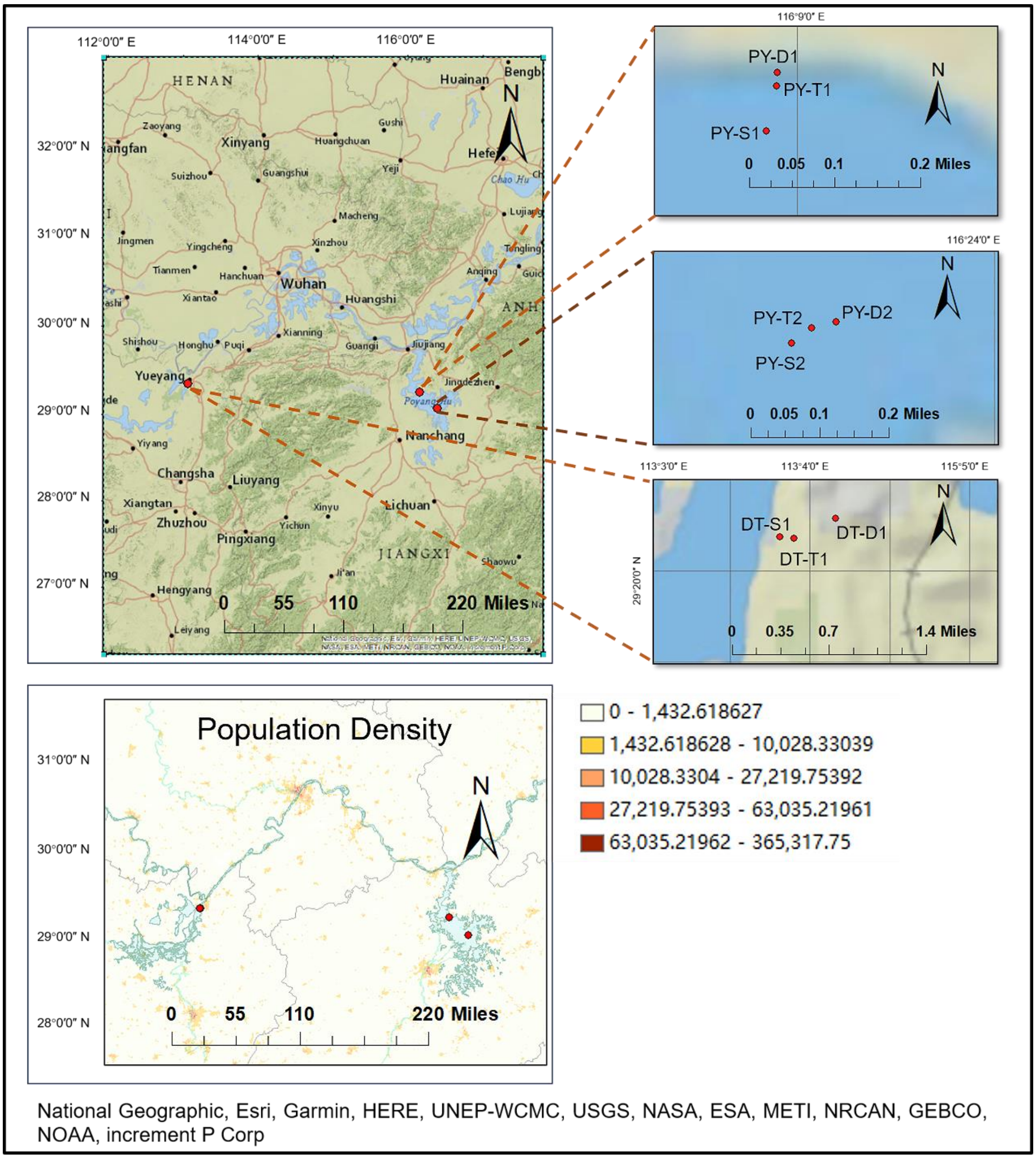


Figure 1. Sampling locations in Poyang Lake and Dongting Lake (marked as red dots). Sites PY-D1, PY-D2, and DT-D1 represent regions typically dry and exposed year-round. PY-T1, PY-T2, and DT-T1 are transitional zones that alternate between submerged and dry states. PY-S1, PY-S2, and DT-S1 are areas usually submerged but occasionally exposed due to extreme drought conditions. PY-D1, PY-T1, and PY-S1, along with PY-D2, PY-T2, and PY-S2, are located within Poyang Lake, while DT-D1, DT-T1, and DT-S1 correspond to Dongting Lake. A 2020 population density layer from WorldPop (1 km resolution) is overlaid, using a yellow-to-red color ramp to indicate increasing population density. The base map is sourced from National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI,

NRCAN, GEBCO, NOAA, and increment P Corp, as provided in the ArcGIS software.

"Among the compounds, NAP, FLU, and PHE dominated across most samples, while BaP, a carcinogenic PAH, was also consistently present. Compared to Poyang Lake sites (Fig. 2d and Fig. 2e), Dongting Lake samples (Fig. 2f) showed higher overall PAH levels and a greater proportion of high-molecular-weight species, particularly in fine particles."

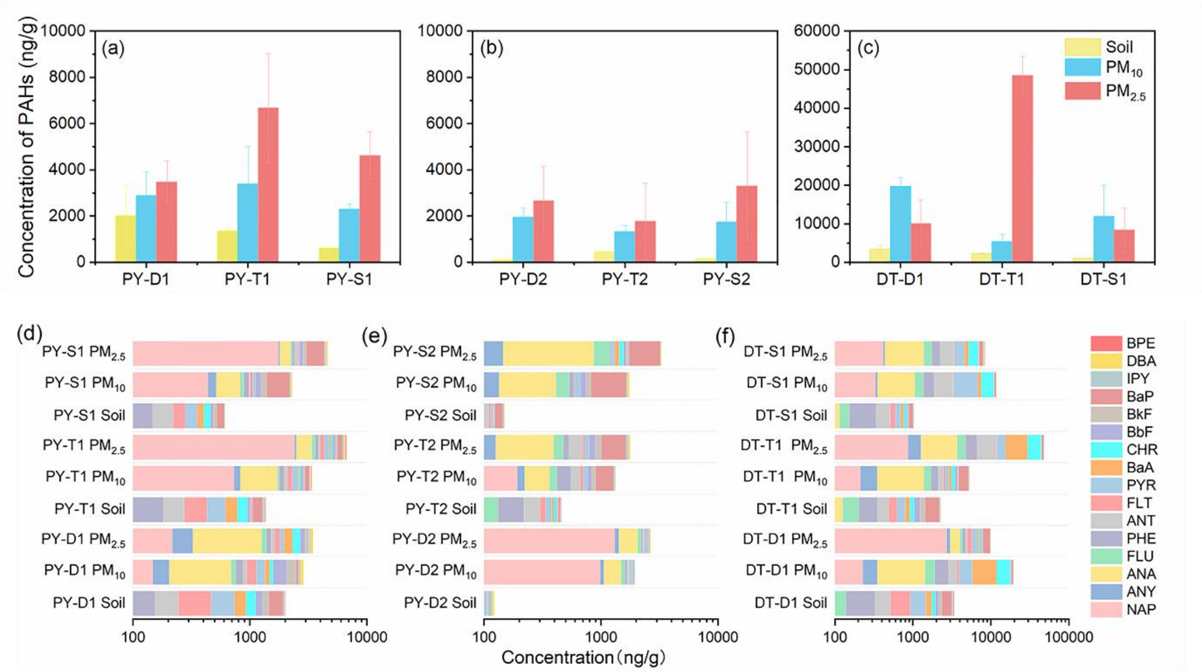


Figure 2. Concentrations and compositional profiles of PAHs in parent lakebed soils and associated dust aerosols from Poyang Lake (PY) and Dongting Lake (DT). (a)–(c) present total PAH concentrations (ng/g) in soils, dust-PM_{10}, and dust-$PM_{2.5}$ samples across different hydrological zones: dry (D), transitional (T), and submerged (S) for Poyang Lake (PY-D1, PY-T1, PY-S1; PY-D2, PY-T2, PY-S2) and Dongting Lake (DT-D1, DT-T1, DT-S1). (d)–(f) shows the compositional distribution of 16 priority PAHs in soil and dust aerosol samples from the same zones.

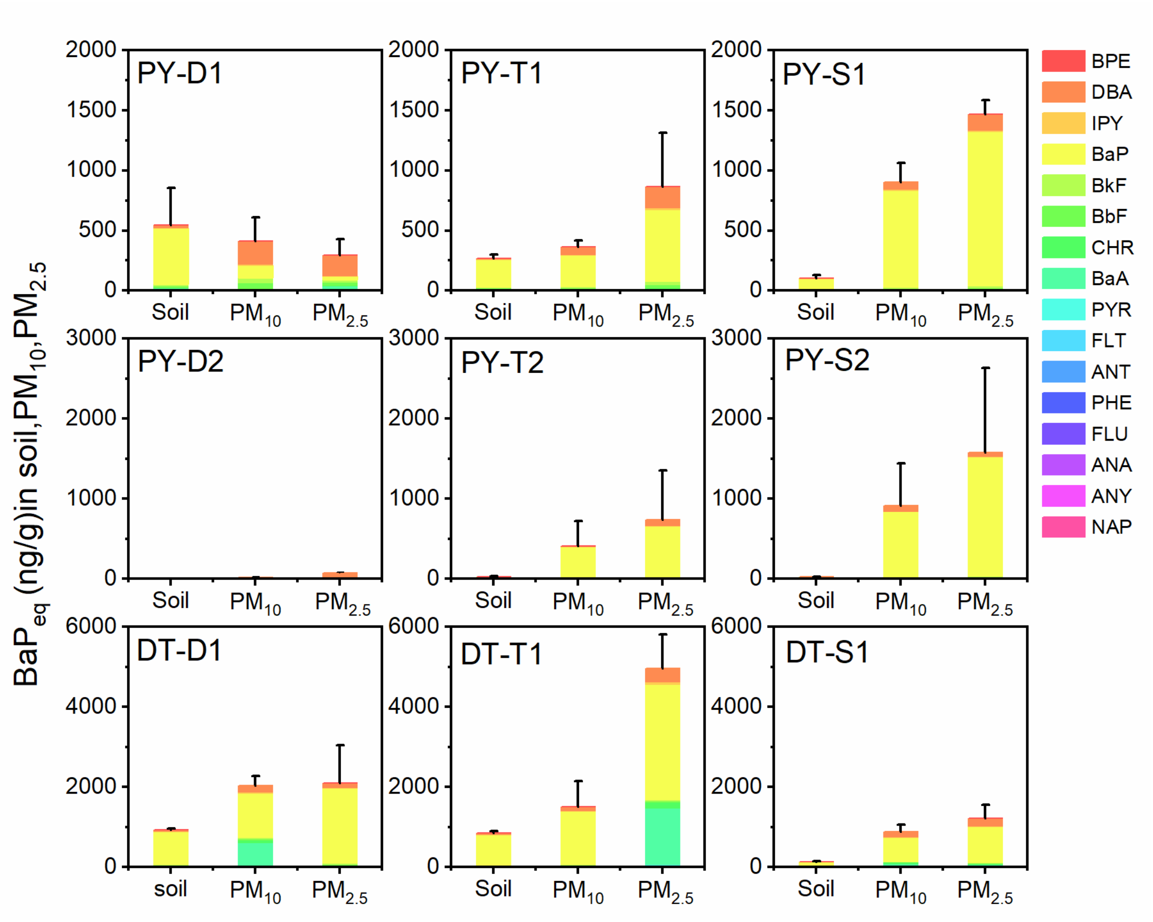


Figure 5. Comparison of BaP-equivalent concentrations of PAHs (BaPeq) in soil, dust-PM_{10} and dust-$PM_{2.5}$ samples at nine sampling sites in Poyang Lake (PY-D1, PY-T1, PY-S1, PY-D2, PY-T2, PY-S2) and Dongting Lake (DT-D1, DT-T1, DT-S1). The stacked bars show the contributions of individual PAH compounds to the total BaPeq at each site. BaPeq was calculated using toxic equivalency factors (TEFs) obtained from the U.S. EPA.

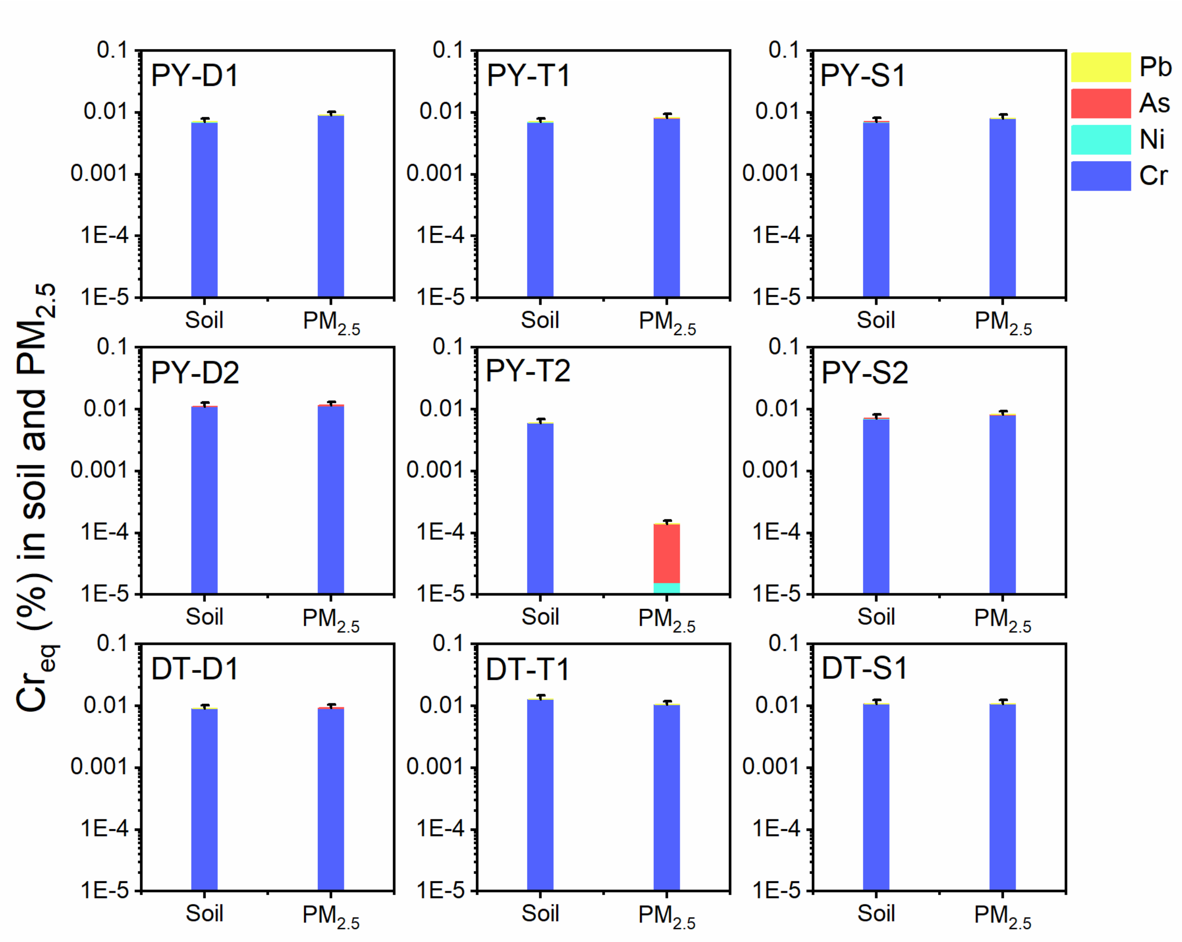


Figure 6. Comparison of Cr_{eq} (%) values of four toxic metals (Pb, As, Ni, and Cr) in natural soil and dust-PM_{10} samples at nine sampling sites in Poyang Lake (PY-D1, PY-T1, PY-S1, PY-D2, PY-T2, PY-S2) and Dongting Lake (DT-D1, DT-T1, DT-S1). Cr_{eq} values were calculated based on toxic equivalent factors (TEFs), and the stacked bars represent the relative contribution of each metal to the total Cr_{eq}.

You have several figs that seem too small, like Fig 2, or I couldn't see the numbers of some of the figures in the supplements, as Fig S5, the yellow color is not showing, and the size of the figures was very hard to examine, even when I used a magnification of 200

Response: We sincerely thank the reviewer for the valuable feedback regarding figures readability. We acknowledge that some of the figures—such as the original Fig. 2 (renumbered as Fig. 3) and the original Fig. S5—were too small or lacked sufficient color contrast (e.g., the yellow in Fig. S5). In response, we have increased the resolution and size of these figures in both the main text and supplementary materials. Specifically, all axis labels and numerical values have been enlarged, and the color schemes have been adjusted to ensure visibility against a white background. The revised versions should now be clearly legible, even when printed or viewed at standard magnification.

Changes in manuscript:

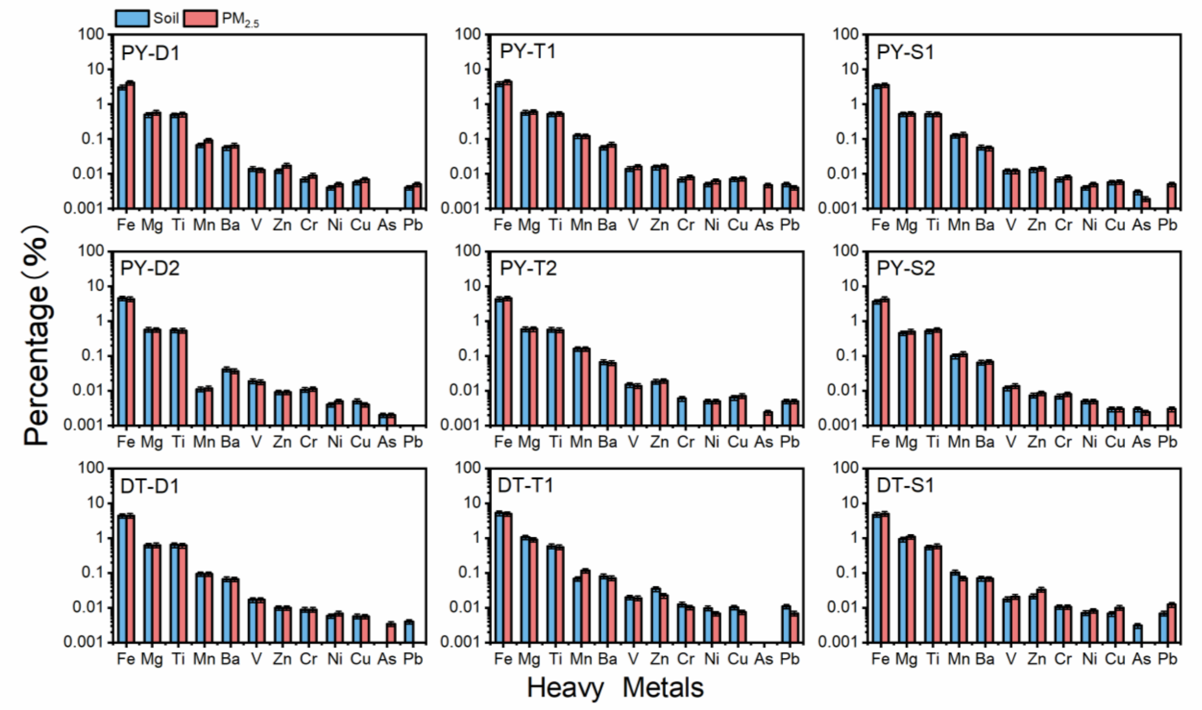
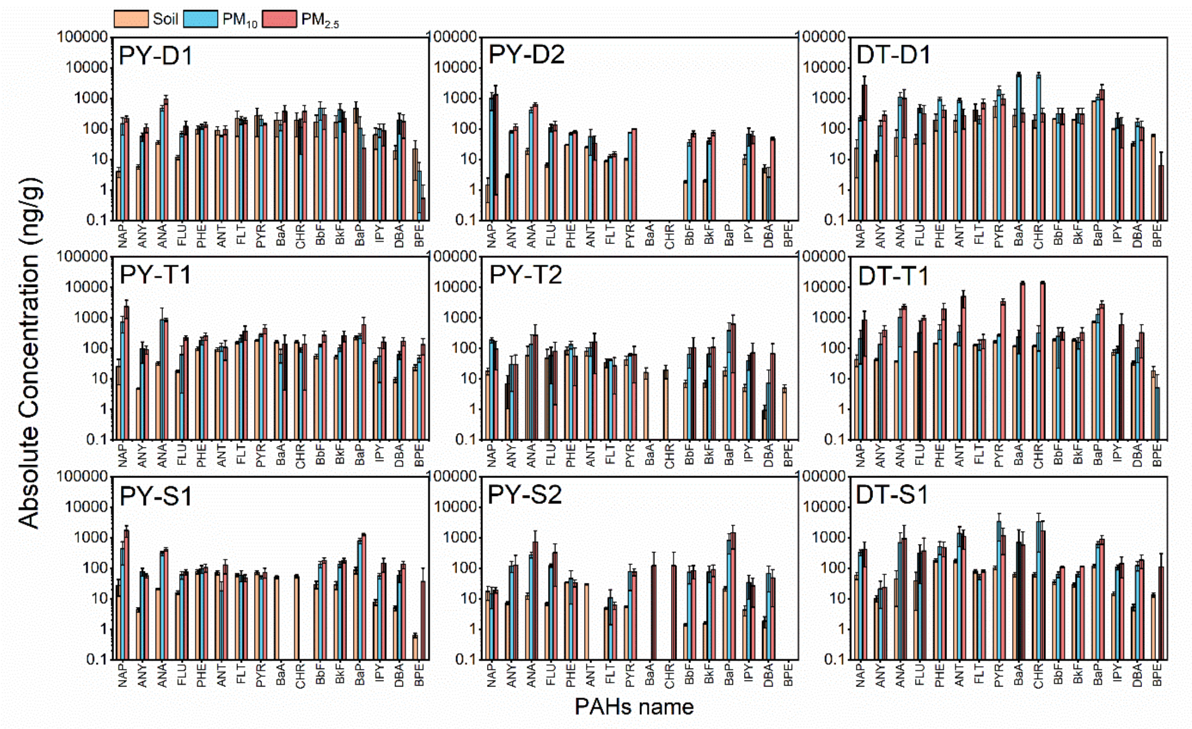


Figure 3. Comparison of heavy metal percentage between lakebed soil and generative dust-$PM_{2.5}$. PY-D1, PY-T1, PY-S1, PY-D2, PY-T2 and PY-S2 were obtained in Poyang Lake, and DT-D1, DT-T1 and DT-S1 were obtained in Dong ting Lake. PY-D1, PY-D2, and DT-D1 are regions typically dry and exposed year-round. PY-T1, PY-T2, and DT-T1 are transitional zones that fluctuate between submerged and dry states. PY-S1, PY-S2, and DT-S1 are areas usually underwater but sometimes exposed due to extreme drought.



Supplementary Figure S5. Comparison of the absolute concentrations of heavy metals between natural soil samples and dust aerosols. PY-D1, PY-T1, PY-S1, PY-D2, PY-T2 and PY-S2 were obtained in Poyang Lake, and DT-D1, DT-T1 and DT-S1 were obtained in Dong ting Lake. PY-D1, PY-D2, and DT-D1 are regions typically dry and exposed year-round. PY-T1, PY-T2, and DT-T1 are transitional zones that fluctuate between submerged and dry states. PY-S1, PY-S2, and DT-S1 are areas usually underwater but sometimes exposed due to extreme drought. The whiskers on the bars represent the standard deviations of triplicates.

Specific comments

Line 68, Owen Lake is not the primary dust source in the US.

Response: We thank the reviewer for pointing this out. We agree that the original statement was too strong and may have overstated the role of Owens Lake. We have revised the sentence to read.

Changes in manuscript:

"Owens Lake in California, which supplied drinking water to Los Angeles since 1913 and originally covered 280 km², was completely drained by 1926 (Reheis, 1997) and has since become one of the most well-documented point sources of dust emissions in the continental U.S. (Gill and Gillette, 1991)."

Line 151 misplacement of () in citation

Response: We thank the reviewer for pointing out the citation formatting issue. We have corrected it. The citation now follows proper academic formatting conventions.

Changes in manuscript:

"The shaker was optimally set to operate at 500 cycles/min (Lafon et al., 2014), with an airflow rate of 8 L/min, controlled by a mass flow controller (MFC, Sevenstar, Beijing Sevenstar Flow Co., LTD)."

Lines 444-454: Is there any level of exposure for these metals that you could add to how, if the values were above these thresholds

Response: Thank you for your thoughtful comment. According to Eq. 5 and 7, the level of short-term exposure (EC_{ST}) is equivalent to the contaminant concentration, while the level of chronic exposure (EC_C) represents the time-weighted concentration. The concentrations of all species are presented in Fig. S13 and S14.

Results indicated that only Mn (short-term) and Cr (chronic) exceeded the health risk thresholds. The EC_{ST} of Mn has shown in Fig. S13. Given that the spatial distribution patterns of EC_C and concentrations (Fig. S14) are identical, the EC_C of Cr are not presented.

We have clarified this comparison with health-based thresholds in the Results and discussion section to better reflect the public health implications of lakebed dust exposure.

Line 473 is missing a space between s15 and to present

Response: Thank you for catching this formatting oversight. We have added the missing space in the revised manuscript.

Table S5 seems like a mistake, or unclear, most heavy metals do not have values.

Response: Thank you for your helpful comment. We agree that **Table S5** was unclear in its original form, particularly because TEF values were only listed for a subset of the metals. To address this issue, we have revised Table S5 and now clearly indicate that **only the metals with available TEF values from the U.S. EPA were assigned values**, while others were marked as "/" to avoid confusion. We also added a note below the table stating: "Only metals with available TEFs from the U.S. EPA database are listed with values; others are marked as '/' to indicate that no TEF has been established."

Changes in manuscript:

Heavy metals	TEF
Fe	/
Mg	/
Mn	/
Ba	/
Ti	/
V	/
Cu	/
Zn	/
Cr	1
Ni	3.1×10^{-3}
As	5.12×10^{-2}
Pb	1.43×10^{-4}

Note: Only metals with available toxicity equivalency factors (TEFs) from the U.S. EPA are listed with values; "/" indicates that no TEF value is currently available.

We thank Referee 1 again for the comments and suggestions!

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