Reviewer 2:

This paper investigates emitted microplastics aerosols from five sources in northwest China. The authors present a comprehensive characterization of the sources and plasticizer profiles. An eco-health risk assessment was conducted, providing key details like daily exposure risks. These findings are especially valuable for informing risk-mitigation policies and protecting individuals who are often close to sources like those in rural households which burn plastics, agricultural workers or incineration plant workers. This paper merits publication in ACP after some minor revisions.

Response:

We sincerely appreciate the time and effort you have dedicated to reviewing our manuscript. We also thank you for your meticulous attention to detail, which has helped us improve the clarity and accuracy of the manuscript. We have carefully addressed each suggestion and implemented the necessary revisions. Below are our detailed responses to your comments:

General comments

The authors must be aware of using past and present tense. Many places are inconsistent with using the correct tense.

Response:

Thank you for your suggestion. We have conducted a systematic review of verb tenses throughout the manuscript. Specifically, we have used the past tense throughout the sections on experimental methods and results to accurately reflect completed actions. In the discussion section, we have employed the present tense to describe current interpretations and implications of the findings.

1. Line 19: Add "i.e.," in front of phthalates

Response:

Suggestion taken.

2. Add a comma after (AF).

Response:

Suggestion taken.

3. Replace the verb "features".

Response:

This point has been revised as follows.

"PB exhibits high proportions of poly(methyl methacrylate) (PMMA) and 2-hydroxy benzothiazole (HOBT), with PMMA being more abundant in coarse particles (PM_{coarse})."

4. Line 36: Spell out ROS to keep consistency.

Response:

Suggestion taken.

5. Line 43: in a range of "five millimeters to one micrometer"

Response:

Suggestion taken.

6. Line 53: It is recommended to change “results” to “result” because the subject is plural.

Response:

Suggestion taken.

7. Line 59: Define PMs.

Response:

The definition of PMs has been added.

“Evangeliou et al. (2020) have estimated that annual total global tire wear particle emissions were 2907 kt y^{-1}, with 29 and 288 kt y^{-1} for $PM_{2.5}$ (particulate matter with aerodynamic diameters ≤ 2.5 μm) and PM_{10} (≤ 10 μm), respectively.”

Reference:

Evangeliou, N., Grythe, H., Klimont, Z., Heyes, C., Eckhardt, S., Lopez-Aparicio, S., and Stohl, A.: Atmospheric transport is a major pathway of microplastics to remote regions, Nat. Commun., 11, 10.1038/s41467-020-17201-9, 2020.

8. Line 77: rephrase the words in the presentation.

Response:

The statement has been rewritten as below.

“Airborne MPs can easily enter the human body directly via respiratory system respiration compared to other environmental exposure pathways, posing a direct and serious health concern (Liao et al., 2021; Luo and Guo, 2025).”

Reference:

Liao, Z., Ji, X., Ma, Y., Lv, B., Huang, W., Zhu, X., Fang, M., Wang, Q., Wang, X., Dahlgren, R., and Shang, X.: Airborne microplastics in indoor and outdoor environments of a coastal city in Eastern China, J. Hazard. Mater., 417, 10.1016/j.jhazmat.2021.126007, 2021.

Luo, R. C. and Guo, K.: The hidden threat of microplastics in the bloodstream, The Innovation Life, 3, 10.59717/j.xinn-life.2025.100130, 2025.

9. Line 81-83: The sentence must be advanced.

Response:

We have advanced the sentence. The revised paragraph is as follows.

“Recent studies suggest that these inhaled pollutants can promote reactive oxygen species (ROS) generation (Wang et al., 2024). Oxidative potential is a metric reflecting the ability of inhaled pollutants to produce ROS, serving as a critical indicator of PM toxicity (Jiang et al., 2019; Bates et al., 2019; Luo et al., 2024). The ROS overproduction acts as a central driver of oxidative stress, which can damage biomolecules and disrupt cellular functions (Bates et al., 2019; Jiang et al., 2019). Previous studies have demonstrated that metals and organic compounds can affect the oxidative potential of PMs (Luo et al., 2023; Ghanem et al., 2021).”

Reference:

Wang, L. J., Pei, W. L., Li, J. C., Feng, Y. M., Gao, X. S., Jiang, P., Wu, Q., and Li, L.:

Microplastics induced apoptosis in macrophages by promoting ROS generation and altering metabolic profiles, Ecotox. Environ. Safe., 271, 11, 10.1016/j.ecoenv.2024.115970, 2024.

Jiang, H. H., Ahmed, C. M. S., Canchola, A., Chen, J. Y., and Lin, Y. H.: Use of dithiothreitol assay to evaluate the oxidative potential of atmospheric aerosols, Atmosphere, 10, 21, 10.3390/atmos10100571, 2019.

Bates, J. T., Fang, T., Verma, V., Zeng, L. H., Weber, R. J., Tolbert, P. E., Abrams, J. Y., Sarnat, S. E., Klein, M., Mulholland, J. A., and Russell, A. G.: Review of acellular assays of ambient particulate matter oxidative potential: Methods and relationships with composition, sources, and health effects, Environ. Sci. Technol., 53, 4003-4019, 10.1021/acs.est.8b03430, 2019.

Luo, L., Guo, S., Shen, D., Shentu, J., Lu, L., Qi, S., Zhu, M., and Long, Y.: Characteristics and release potential of microplastics in municipal solid waste incineration bottom ash, Chemosphere, 364, 143163, 10.1016/j.chemosphere.2024.143163, 2024.

Luo, Y., Zeng, Y. L., Xu, H. M., Li, D., Zhang, T., Lei, Y. L., Huang, S. S., and Shen, Z. X.: Connecting oxidative potential with organic carbon molecule composition and source-specific apportionment in PM2.5 in Xi'an, China, Atmospheric Environment, 306, 9, 10.1016/j.atmosenv.2023.119808, 2023.

Ghanem, M., Perdrix, E., Alleman, L. Y., Rousset, D., and Coddeville, P.: Phosphate Buffer Solubility and Oxidative Potential of Single Metals or Multielement Particles of Welding Fumes, Atmosphere, 12, 23, 10.3390/atmos12010030, 2021.

10. Line 84: Add “Most of the” at the start of the sentences.

Response:

Suggestion taken.

11. Line 91: Remove “primary”

Response:

Suggestion taken.

12. The First and Second paragraphs must be combined with a reasonable logic. It should start with the sample collection place and time.

Response:

Thank you for your valuable suggestion. We have restructured these paragraphs to improve logical flow by beginning with the spatiotemporal context of sample collection (location and time), then introducing the sampling methodology, and finally presenting the analytical approach. The revised paragraph starts as follows.

“During January and February 2024, $PM_{2.5}$ and PM_{10} samples were collected simultaneously from five distinct sources in three key cities of the Guanzhong Plain: Xi’an, Tongchuan, and Xianyang (Figure S1). The selected sources included Plastic Burning (PB), Fruit-bag Burning (FB), Road Traffic (RT), Agricultural Film (AF), and Livestock Breeding (LB).”

13. Line 102: The term of “PB burned plastics” is not an appropriate term.

Response:

It has been revised as follows.

“It should be noted that the types of plastics used for Plastic Burning source incineration

including plastic bags, bottles, disposable tableware, foam boxes, and other plastic daily necessities."

14. Table 1: The format of the table must be advanced. The alignment of the first line in each block must be on the top.

Response:

Suggestion taken. The revised Table 1 is as follows:

Table 1 Basic sampling information of target emission sources

Emission source	Sampling duration (h)	Sampling height	Sample No.	Sampling location
Plastic burning (PB)	2.0	3-4 m above the ground	5	Open space, about 1 m downwind of chimney of rural household stove in rural Xianyang
Fruit bag burning (FB)	2.0	3-4 m above the ground	5	
Road Traffic (RT)	13.6-14.1	3 m above the ground	5	Open space, flyovers on traffic arteries in downtown Xi'an
Agricultural film (AF)	24	1.5 m above the ground	5	Open space, about 2 m away from the greenhouse in farmland in rural Tongchuan
Livestock breeding (LB)	2.5-3.5	1.5 m above the ground	5	About 1 m from the feed trough in a cow shed of approximately 8 m^2 in rural Tongchuan

15. Line 122" A missing space for 'at -20°C'.

Response:

Suggestion taken.

16. Figure 1: It is recommended that the error bars should be thickened to increase the clarity.

Response:

Suggestion taken. The modified Figure 1 is as follows:

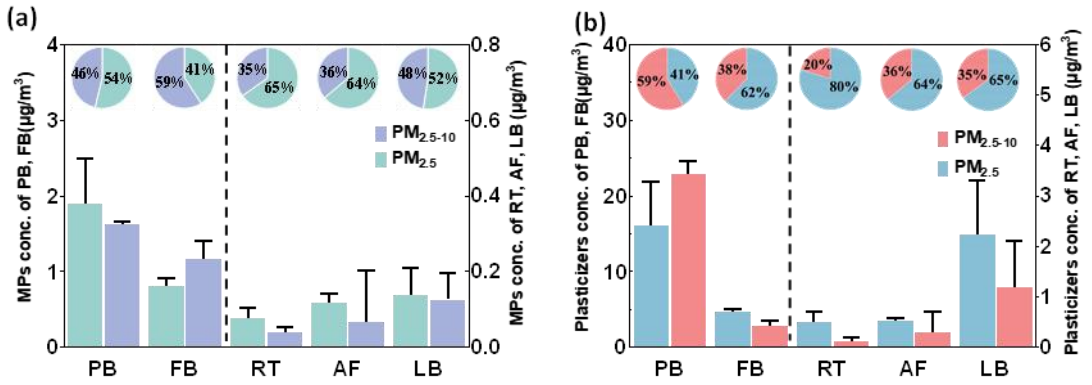

Figure 1 Average concentrations of MPs (a) and plasticizers (b) in $PM_{2.5}$ and $PM_{2.5-10}$ from five

sources (PB: Plastic Burning, FB: Fruit-bag Burning, RT: Road Traffic, AF: Agricultural Film, LB: Livestock Breeding).

Section 2.2.

17. Line 147: More advanced information on the procedures of the GC/MS analysis must be shown (i.e. capillary column used, and MSD setting), not just referring to a reference.

Response:

We sincerely appreciate your suggestion. As requested, we have now provided the detailed GC/MS analytical procedures, including capillary column, MSD settings, and other relevant parameters, in Supplementary Information (Appendix 2). The specific information is as follows:

*"**Appendix 2** Analysis of plasticizers*

Phthalates were quantified using in-injection port-thermal desorption/mass spectrometry (TD-GC/MS) method. Aliquots of the filters (1.578 cm^2) were cut into small pieces, spiked with ISs (Chrysene-d12, 96%, LGC Standard Limited, United States), and inserted into thermal tubes (78 mm long, 4 mm I.D., 6.35 mm O.D., Agilent Technology, USA) for analyses. The sample tube was directly loaded into a GC injection port (GC7890, Agilent Technology), at an initial temperature of 50°C. The temperature of injector was then ramped to 275°C for desorption in a splitless mode, while the GC oven temperature was kept at 30°C. The desorbed analytes were refocused at the column head. After the injector temperature reaches the set point, the oven program starts. The analytes were speared by an DB-5ms capillary column (30 m × 0.25 mm i.d. × 0.25 μm film thickness; J&W Scientific). The carrier gas was ultra-high purity (99.9999%) He at a constant flow of 1.0 cm^3 min-1. The MSD (5975, Agilent Technology) was full scanned from 50 to 550 amu under electron impact ionization (EI) at a voltage of 70 eV and an ion source temperature of 230°C. Identification was achieved by characteristic ion and retention times of the chromatographic peaks with those of authentic standards.

To quantify benzothiazole and its derivatives, each of 1.578 cm^2 of the filter sample was cut and spiked with an internal standard (IS) of benzothiazole-d4 (benzothiazole=d4, 95%, LGC Standard Limited, United States). The filter is transferred into a test tube, and 10 mL of a mixture of ultrapure deionized water (18 M-Ohm) and methanol (HPLC grade, Fisher Chemical, USA) (5:3, v:v) was added. The sample was extracted in an ultrasonic water bath at room temperature for 60 min. The combined extracts were concentrated and then diluted to with ultrapure deionized water containing 0.2% v/v formic acid (~pH 2.5). The diluted extract was purified using an Oasis HLB Flangeless Vac Cartridge (3cc, 60 mg sorbent per cartridge, 30 μm particle size; Waters, USA). The target analytes were eluted with 5 mL of methanol and the eluents were evaporated to 1 mL under a gentle nitrogen stream prior to analysis. The separation of target analytes was performed using an ultra-performance liquid chromatography (UPLC; ACQUITY, Waters), and both identification and quantification were accomplished using a triple quadrupole mass spectrometer (ESI-MS/MS; Xevo TQ-S, Waters). An ACQUITY UPLC BEH SHIELD RP 18 column (100 mm ×3 mm × 1.7 mm) was serially connected to a Vanguard column (BEH C18, 5 mm × 2.1 mm × 1.7 mm). The mobile phase comprises 100% methanol (A) and ultrapure deionized water acidified with 0.1% (v/v) formic acid (B) at a flow rate of 450 mL min^{-1}. A gradient elution program was applied for the separation. The tandem MS system was operated in the positive ion multiple reaction monitoring mode. Identification was achieved by characteristic ion and retention times of the chromatographic peaks with those of authentic standards."

18. More detailed QC/QA procedures must be given for all analyses.

Response:

Thank you for your suggestion. The details of QC/QA procedures have already been documented in Section 2.3 of the Methods and as follows.

"Quality assurance/Quality control (QA/QC)

The flow rates of all samplers were calibrated using a mass flowmeter (Model 4140, TSI, Shoreview, MN, USA) before and after each sampling cycle. All quartz filters used in this study were preheated at 800°C for 3 h to remove any potential contaminants and then cooled before use. To minimize experimental error, sampling was conducted in duplicate for each particle size of each source. For the chemical measurements, one in every 10 samples was reanalyzed for quantity assurance purposes, and the SD errors of replicate trials were within 10% for the pyrolysis analyses. Calibration curves were established using reference standards. The linearities of the standard calibration curves were > 0.987. The standard deviations of the pyrolyzed standard were within 94.1% to 98.3%. Background contamination (Table S3) was monitored by processing operational blanks (unexposed filters) simultaneously with field samples."

19. Section 2.5

Consider renaming it as "Data Analysis and Statistical Method.

Response:

Suggestion taken.

20. Line 216: The data must be tabulated instead of shown in a figure. The values are more appropriate to demonstrate the actual circumstances.

Response:

Thank you for your valuable suggestion. We have added Table S2 in the Supporting Information (SI) file.

21. The values and percentages must be presented in the form of mean plus standard deviation. Check out all these in all sections.

Response:

Thank you for your valuable comments. We have revised all values to the format of mean ± standard deviation throughout the text.

22. The uses of PM10 and PMcoarse are confusing Standardize to use one term.

Response:

Sorry for the confusion. We have standardized our terminology by replacing "PM_{coarse}" with "$PM_{2.5-10}$" (particulate matter with aerodynamic diameters between 2.5 and 10 μm). When characterizing microplastics and plasticizers, we specifically use "fine particles ($PM_{2.5}$)" and "coarse particles ($PM_{2.5-10}$)" to clearly differentiate and compare their characteristics across different size fractions.

However, we need to retain "PM_{10}" in the sections of the source profiles and health risk assessments of MPs and plasticizers. For the source profile and health risk assessment sections, we primarily use "PM_{10}" because it represents the total inhalable particulate matter that is most

relevant for exposure assessment and it allows direct comparison with other studies.

23. Line 230: The verb “crushed” is inappropriate.

Response:

This point has been revised as follows.

“One possible explanation for this is that plastic waste can be fragmented into MPs during the process of combustion.”

24. Line 274: What is the meaning of “greenhouses” here?

Response:

Thank you for your question. In original Line 274, the term "greenhouses" refers to controlled agricultural environments, plastic film structures covering crops, which are used to regulate climatic conditions. In this study, AF (agricultural film) primarily refers to greenhouse coverings, which are generally made of transparent polyethylene and are typically less than 8 μm thick (Wang et al., 2018; Li et al., 2022). The compositions of MPs in AF may be influenced by wear/degradation of plastic film and other plastic equipment in greenhouses. The original lines 272-274 suggest that the high PS content in AF could stem from PS-based materials (e.g., lamp-chimneys, electrical devices) commonly used in greenhouse facilities.

To avoid ambiguity, we revised the original sentence (Lines 272-274) as follows:

"Agricultural facilities made of PS (e.g., lamp-chimneys, electrical devices) in greenhouses may influence the MPs composition of Agricultural Film source (Qi et al., 2023)."

Reference:

Qi, R., Tang, Y., Jones, D. L., He, W., and Yan, C.: Occurrence and characteristics of microplastics in soils from greenhouse and open-field cultivation using plastic mulch film, Sci. Total Environ., 905, 10.1016/j.scitotenv.2023.166935, 2023.

Wang, Y., Zhu, H. K., and Kannan, K.: A Review of Biomonitoring of Phthalate Exposures, Toxics, 7, 28, 10.3390/toxics7020021, 2019.

Wang, L., Zhang, B., & Tian, G. Q. (2018). Research on government intervention in agricultural plastic film using and recycling in Chinese. Issues in Agricultural Economy, 08, 137–144.

25. Line 281-284: The presentation could not be fully understood.

Response:

We apologize for the confusion in the presentation. The text has been revised for clarity as follows:

“The percentages of BTs and BPA among the three detected plasticizer types were below 2%. The highest concentrations of PAEs, BTs, and BPA still appear in PB among five sources.”

26. Line 286: Relative: is an inappropriate word used here.

Response:

It has been revised as follows.

“Compared to other sources, Road Traffic source demonstrated a higher concentration of BTs.”

27. Line 297: Is it should be shown in a new Sub-Section? Please verify that.

Response:

We do agree with the reviewer's comment. We have moved the content ("Compositions and distributions of PAEs", "Compositions and distributions of BTs") to a new Sub-Section.

28. Figure 5 should use legends in the figure to clarify all symbols rather than explanation in the captions ("sections marked in red")

Response:

Thank you for your comment. We have revised Figure 5 to incorporate legends within the figure. The revised Figure 5 is as follows.

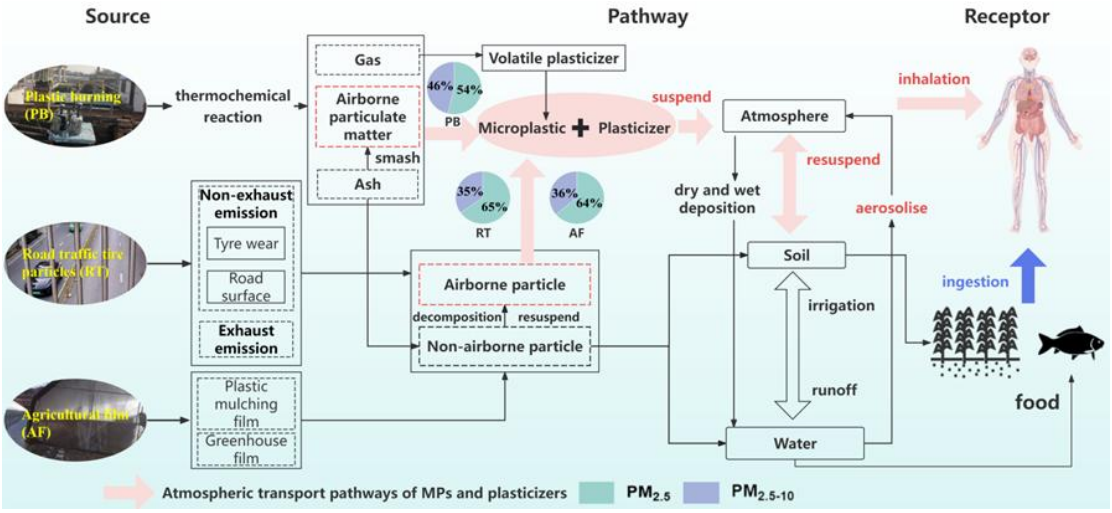

Figure 5 Source-Pathway-Receptor model associated with three different MP and plasticizer sources.

29. The DTT included in this study was reported in volume-base. What is the reason for choosing this DTT to describe the toxicity of PMs?

Response:

We adopted the volume-based DTT assay in this study to maintain consistency with the volume-based quantification of MPs and plasticizers in $PM_{2.5}$ and PM_{10} (quantified as mass per cubic meter of air). This approach facilitates a clearer interpretation of the relationship between the concentrations of MPs/plasticizers and the oxidative potential of PMs per unit volume of air (m^3).

30. The future research directions must be advanced. For example, it is recommended to consider coupling the multiple ecological health assessment methods mentioned in this study, measure the weights of different methods, and provide comprehensive evaluation indices.

Response:

Thank you for your valuable suggestion. We have revised the relevant sentence in the manuscript to incorporate the integration of multiple ecological health assessment methods.

"Future studies should expand the range of assessed MPs and plasticizers and integrating multiple ecological health assessment methods to further refine the health risk assessment system and deepen the understanding of the environmental and health hazards of MPs."