

This study presents a one-year measurement of PM_{2.5} and water-soluble inorganic ions at a semi-arid background site in northwestern China. This study aims to characterize the seasonal variability of aerosol levels and composition, aerosol acidity, and its driving factors. The dataset is potentially valuable as observations in this region are relatively less abundant compared with other more extensively studied areas in China such as North China Plain. However, the manuscript in its current form is difficult to follow and interpret. The method descriptions lack key information, making it hard to assess the robustness of the conclusions. There are also obvious errors and unclear expressions throughout the manuscript. My specific comments are listed below.

Section 3.1: The measurements show interesting features, including relatively lower PM_{2.5} levels possibly due to distance from urban cores, nitrate-dominated composition compared to sulfate, and high calcium concentrations in spring. These could have important implications for aerosol acidity and may differ from conditions in other urban or sulfate-dominated regions. This aspect could be emphasized more clearly. At the same time, some analyses seem less relevant to aerosol pH and do not add much context, thus could be reduced. For example, the discussion related to the cation/anion balance and the comparison between observed and predicted NH₄⁺. It is not sufficient to use ion balance alone to infer aerosol acidity, as mentioned in Lines 312–314. The imbalance is more likely influenced by unmeasured species such as CO₃²⁻, HCO₃⁻, organics, rather than H⁺. The discussion related to “predicted NH₄⁺” is also unclear. What is the “predicted NH₄⁺” and why predicting NH₄⁺? The ammonia-sulfate ratio is also only indirectly related to aerosol acidity, and this analysis does not seem to provide additional information.

Section 2.4: The description of the multiple linear regression model lacks important details, which makes the results difficult to interpret. Even with a citation, a brief summary is needed to provide basic information, such as how the predicting variables are selected and how the significant tests are performed. Besides, the author should provide more information about the training data instead of only listing a reference. Does the training dataset represent the conditions at this site? If it is from an urban core, are the concentrations much higher than here? How long does the training dataset span? Does it sufficiently cover all seasons? How many data points are used? In Figure 4, the predicted NHR shows some bias compared with observations. How does this bias affect the pH calculation? Also, is the predicted NH₃ level within the range of the training data? If not, is it valid to extrapolate to this site? In Table S2, some t values are very low (close to 0). Are these variables really useful in predicting NHR? What are the corresponding p-values? Without a clearer description of the training data and validation, the use of predicted NH₃ hence the pH estimates are not convincing. In addition, to help validate the pH results at this site, it would be helpful to compare NH₃-NH₄⁺ partitioning from ISORROPIA output with that used as the input (calculated by measured NH₄⁺ and estimated NH₃).

Section 2.5: The sensitivity tests and quantitative analysis both lack necessary details, even though references are provided. For the sensitivity analysis, the “relative standard deviation” mentioned in the abstract and in Line 489 appears abruptly. What does it represent, and what is the purpose of this analysis?

The quantitative decomposition of pH contributions seems to use a different method, but the description is unclear. The text mentions change from “scenario 1 to scenario 2,” but what are these scenarios? This makes Figure 7 difficult to interpret. In spring, the sum of contributions from all components does not match the overall pH change shown by the markers, which seems inconsistent with the method description in Section 2.5. Both the sensitivity analysis and the contribution decomposition aim to explain the drivers of aerosol acidity. Why are both methods needed, and what is the connection between them? At present, they read like two separate analyses presented in parallel, with some repetition and even conflicting interpretations. For example, in the sensitivity test, higher temperature reduces ALWC and increases acidity (Lines 524–525), whereas in the quantitative analysis, temperature is said to enhance aerosol acidity in winter and spring but not in summer and autumn.

Other comments:

Line 22-25: Without context, it is unclear what the percentages represent.

Line 28: Similarly, without any context, the mentioning of relative standard deviation is unclear.

Line 33-34: What is the link between aerosol acidity driving factors and PM_{2.5} control strategies? The current discussion does not provide any context for this statement.

Line 115: The word “distinct” is vague. The two examples given here are not uncommon.

Line 128-130: What is the connection between aerosol acidity analysis and precise ammonia reduction? The current discussion did not provide any context.

Line 135: “Guangdong Plain” should be “Guanzhong Plain”

Lines 195-196: The method of NH₃ estimation should be clearly described in method section instead of referring to discussion section.

Lines 289-290: What is the “NH₄ vertex”?

Lines 288-293: The logic here is unclear.

Lines 330-331: What does the “signifies NH₄⁺ excess post-reaction” mean?

Lines 334-343: This reads like background information and could be shortened.

Lines 346-350: What is meant by “unstable outcome”?

Lines 422 What are “acidic products”

Lines 446-447 What does “acidification processes” refer to?

Lines 449-451: What is “heightened hydrogen ion activity”?

Lines 470-472: Why are low NH_x cases less accurate? NH₃ is from multi linear regression, while NH₄⁺ is from measurements.

Lines 488-491 The discussion related to relative standard deviation is abrupt without any context.

Lines 536-539: This seems like method description but is not clearly explained earlier.

Lines 540-541: Concentration of what?

Lines 541-543: This sentence is unclear. What does “weaken basic buffer capacity” mean? How does it disrupt equilibrium?

Lines 549-550. How do RH and calcium play similar roles?

Lines 552 What are the “synergistic effects”?

Figure 1: Although a colorbar is provided, the current colormap is misleading. The brown color could be interpreted as high elevation.

Figure 2: In the bottom panel, why are there negative PM_{2.5} values? Why is the y-axis set from -200 to 300?

Figure 3: What do the four panels represent? Are they different seasons?

Figure 5: Error bars should be added. It is also unclear why -200 to 200 is used as the ALWC range.

Figure 6: The line representing H⁺ is thin and difficult to see.

Figure 7: The figure is difficult to interpret due to limited method description. What is included in “others”? The sum of delta pH contributions from different components does not seem to match the overall pH value, especially for Spring.

Table 1. The caption seems to be copied from Table 2. Besides, while most variables are from measurements, NHR and NH₃ seem to be derived from the multiple linear regression model. This should be clearly stated in the caption.

SI: It would be helpful to provide a separate reference list. For example, Wu et al., 2018 cited in table S4 does not match any citations in the main text.

Table S5: There are only two polluted days in summer thus no calculation of standard deviation. This should be clearly noted in the caption. Does these two days show similar or clearly distinct results? This limited data availability should also be clearly noted in the related discussion.

Figure S5. The figure shows delta ALWC, but the caption still refers to delta pH.