

Evaluating Associations Between Polycyclic Aromatic Hydrocarbon and Heavy Metal Mixtures Across Air and Wipe Samples Among Firefighters

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Background

- Firefighters are exposed to **PAH and metal mixtures** through airborne contaminants and contamination deposited on gear and surfaces, which may persist after fire suppression.
- Exposure to certain PAHs and metals has been linked to **cancer, respiratory problems, and kidney or nervous system damage**.
- However, the relationships between airborne and deposited PAH–metal mixtures remain poorly understood. Evaluating both may provide a more complete picture of firefighters’ exposure.
- Study Objective:** Evaluate PAH–metal mixture associations in air samples, pre-/post-fire wipe samples, and across both exposure matrices.

Methods

- Model 1: Wipe mixture analysis — Longitudinal Canonical Correlation Analysis (LCCA)**
 - Examined how PAH and metal mixtures changed together from pre- to post-fire in gear wipe samples.
- Model 2: Air mixture analysis — Sparse Canonical Correlation Analysis (Sparse CCA)**
 - Identified key PAHs and metals contributing to the airborne mixture association.
- Model 3: Combined air + wipe analysis — Sparse CCA**
 - Examined PAH–metal mixture associations using air measurements together with pre-to-post changes in wipe samples.
- Follow-up Analysis**
 - Used Spearman correlation and linear regression to examine specific PAH–metal relationships among overlapping chemicals.

Takeaways / Recommendations

- Exposure does not necessarily end when the fire is out.** PAHs and metals can remain on turnout gear after fire suppression.
- What is in the air may be related to what settles on gear.** Our findings highlight the importance of examining both airborne and deposited contamination on turnout gear.
- Firefighters are exposed to chemical mixtures, not just individual pollutants.** Assessing these chemicals together provides a more complete picture of fireground exposure.
- Future research:** Investigate how these exposure mixtures relate to firefighters' long-term health.

Results & Key Findings

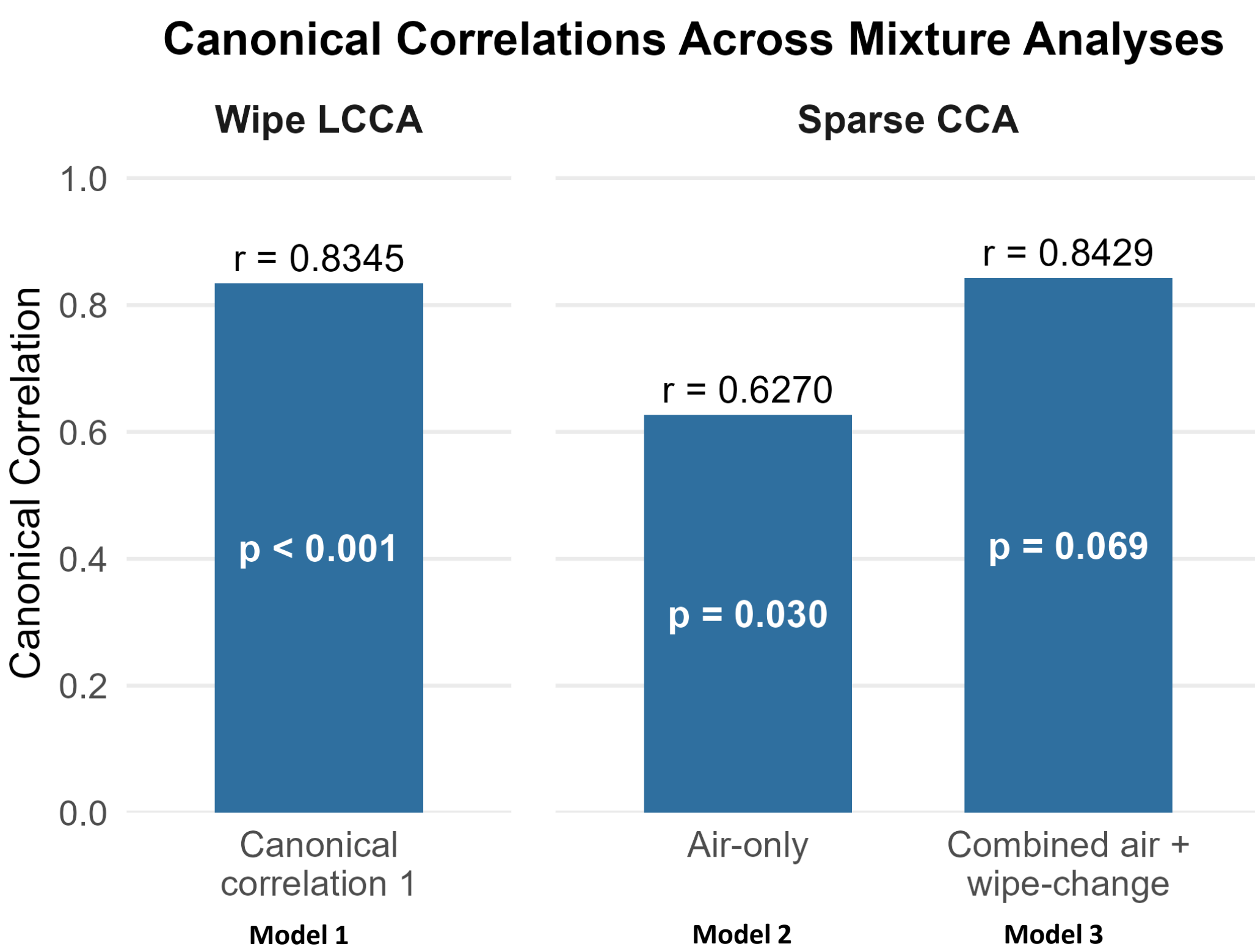


Figure 1. Are PAH and metal mixtures related?

- PAH and metal mixtures showed significant associations in both gear wipes ($r = 0.835$, $p < 0.001$) and air samples ($r = 0.627$, $p = 0.030$).
- Combining air measurements with changes in wipe contamination showed a high correlation ($r = 0.843$), although it was not statistically significant ($p = 0.069$).

Figure 3. Which chemicals are repeatedly identified?

- Several chemicals were selected by both models within each sample type:
 - Air: Naphthalene, acenaphthene, 1-methyl-naphthalene, Cu, Sr, and Ba.
 - Wipe: Acenaphthene, Te, Y, and La.
- These chemicals were consistently identified as contributors to the mixture patterns.

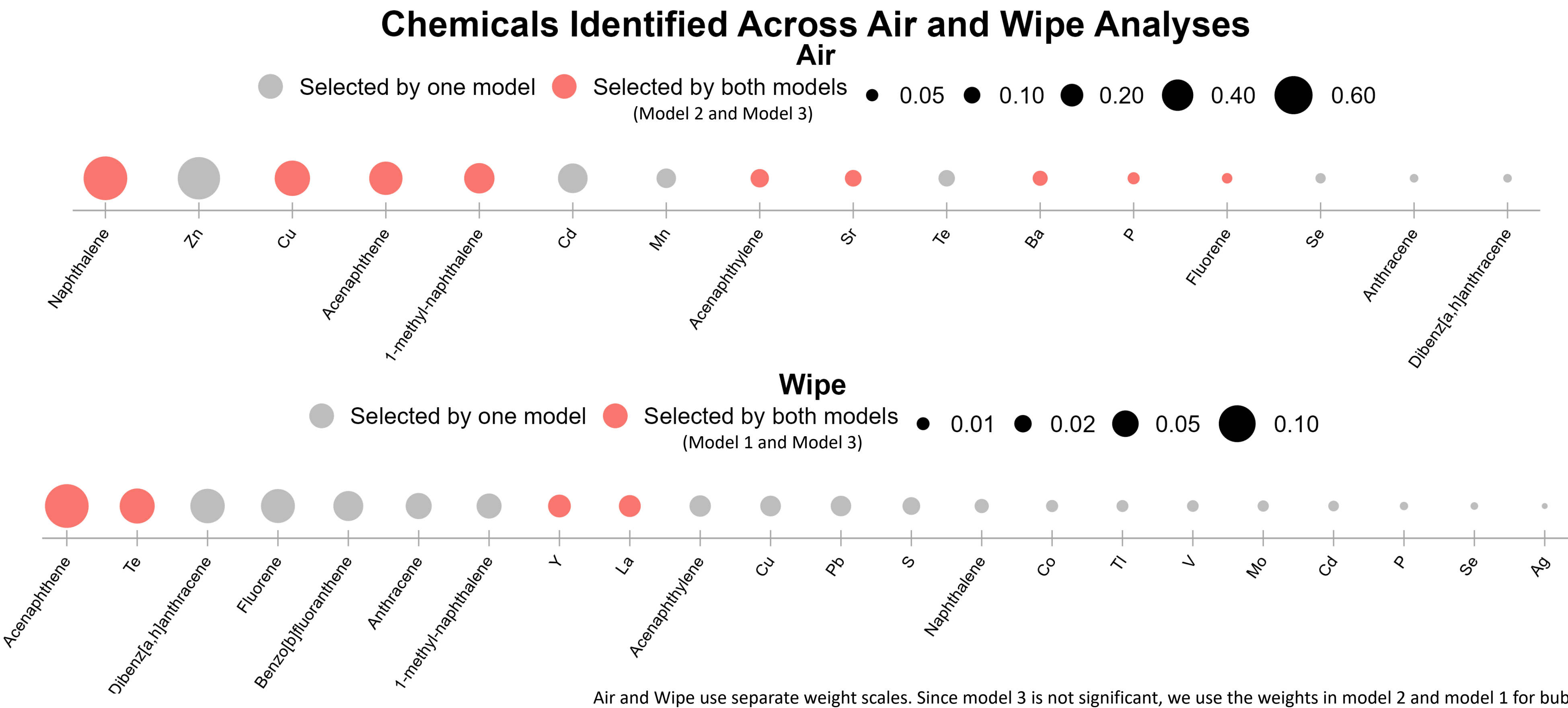


Figure 2. Which chemicals contribute to changes in gear contamination?

- Acenaphthene, dibenz[a,h]anthracene, and fluorene were the leading PAH contributors to the shared pre-to-post wipe pattern.
- Te, Y, and La were the leading metal contributors.

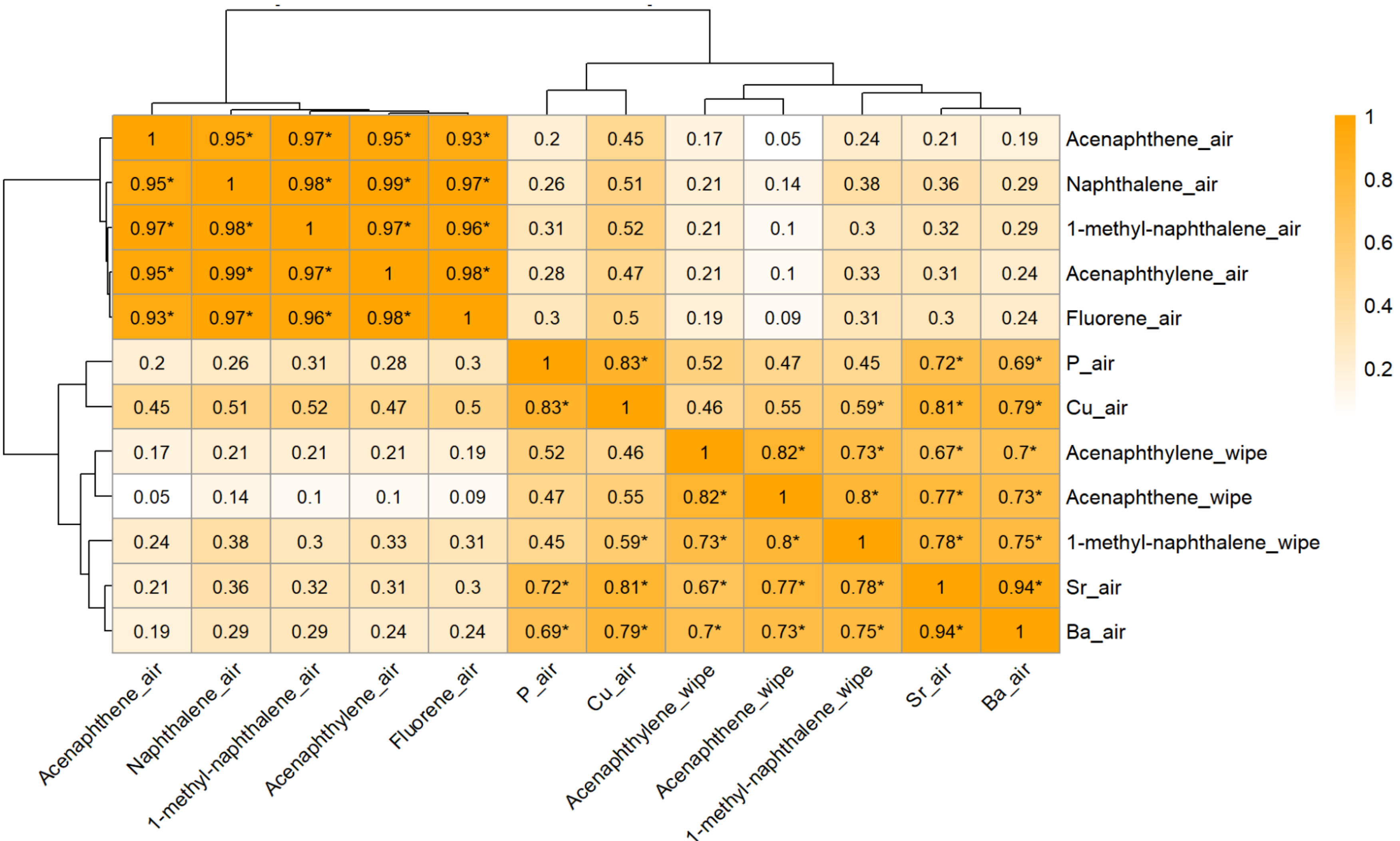
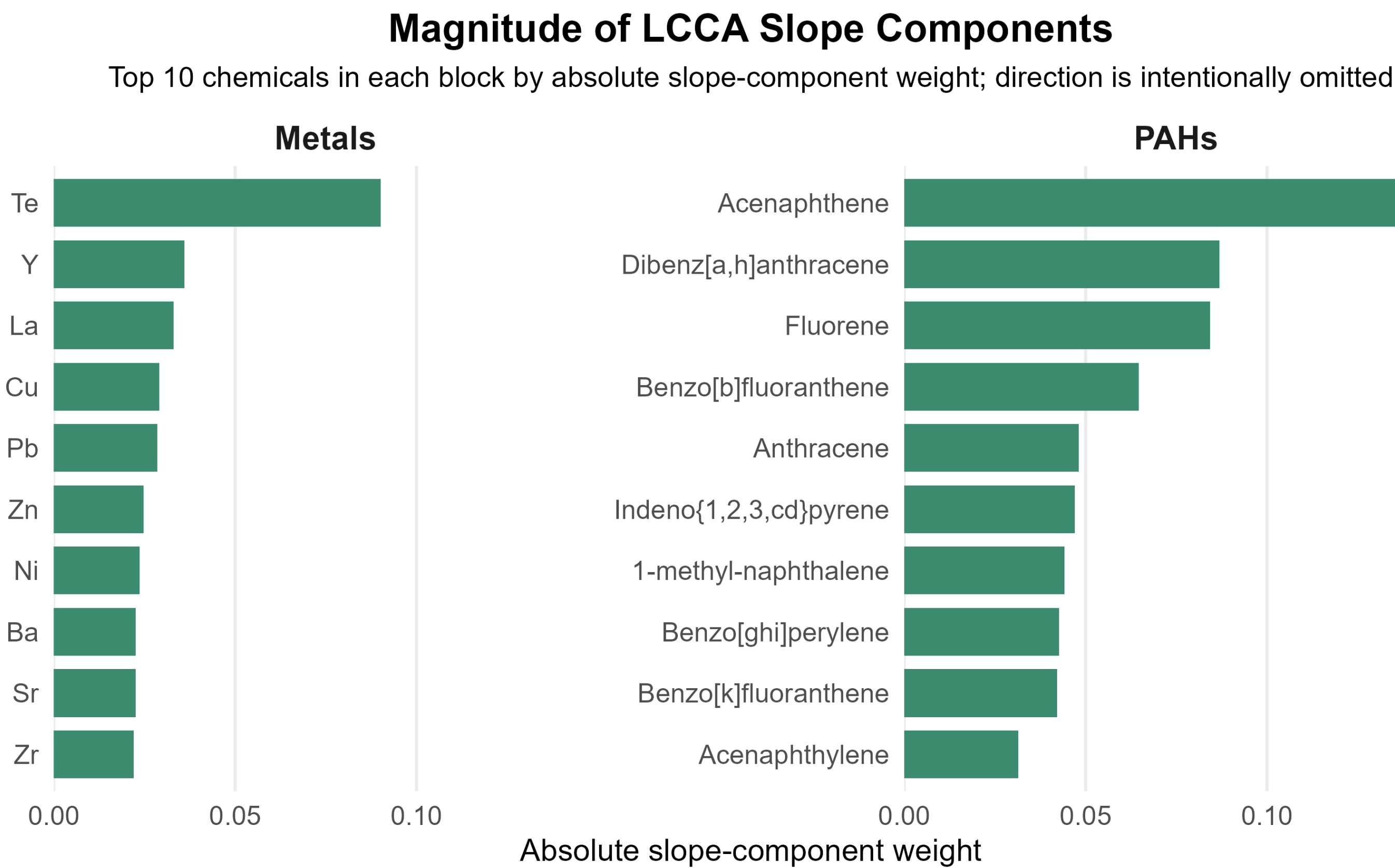


Figure 4. Which specific airborne metals are associated with PAHs deposited on gear?

Correlation

- The five airborne PAHs were strongly correlated with one another ($r = 0.93$ – 0.99).
- Airborne Sr and Ba were positively correlated with deposited 1-methyl-naphthalene, acenaphthylene, and acenaphthene ($r = 0.67$ – 0.78).

Linear Regression

- When both metals were included in the same model, deposited acenaphthene was positively associated with airborne Sr ($\beta = 0.606$, $p = 0.005$) and negatively associated with airborne Ba ($\beta = -0.495$, $p = 0.035$), after adjusting for each other.

Acknowledgement

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