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Traffic-related $PM_{2.5}$ pollution in Hong Kong: source- and component-resolved health risks and cytotoxicity

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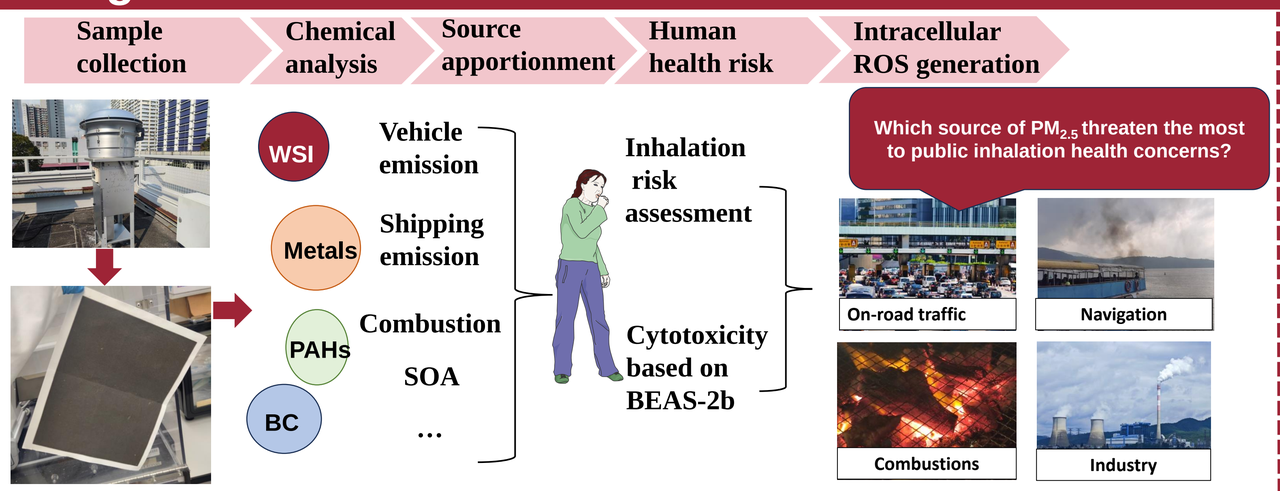
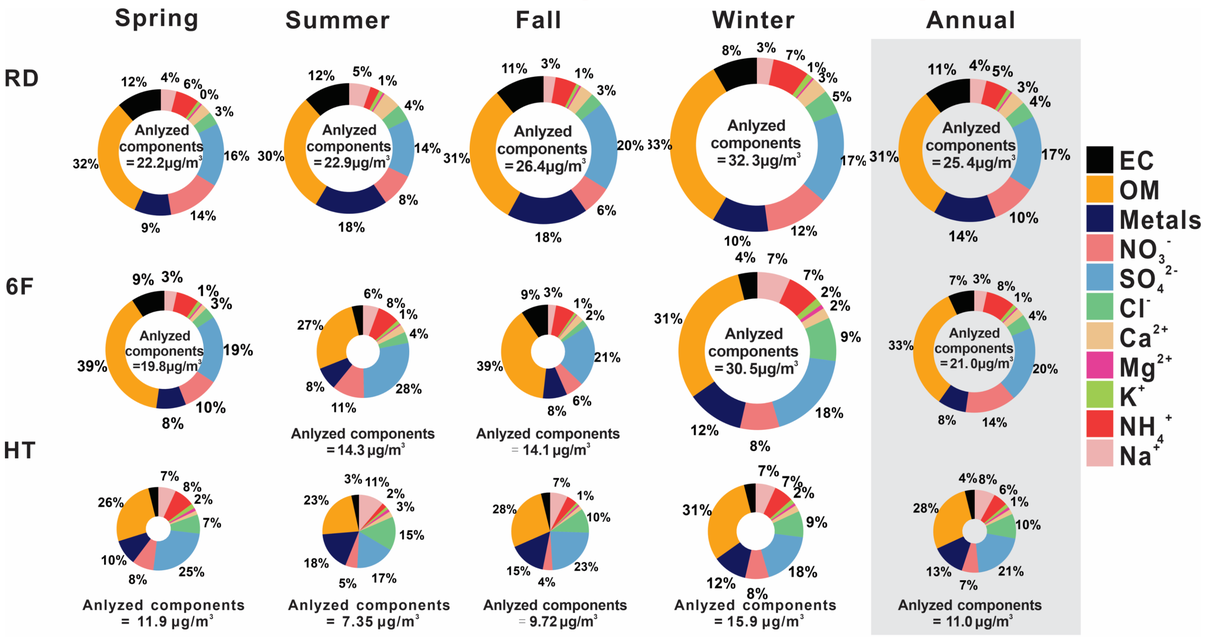
1. Figure abstract



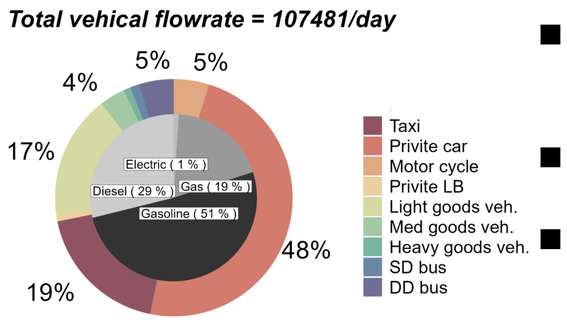
2. Chemical analysis

2.1 Seasonal variation of major chemical composition

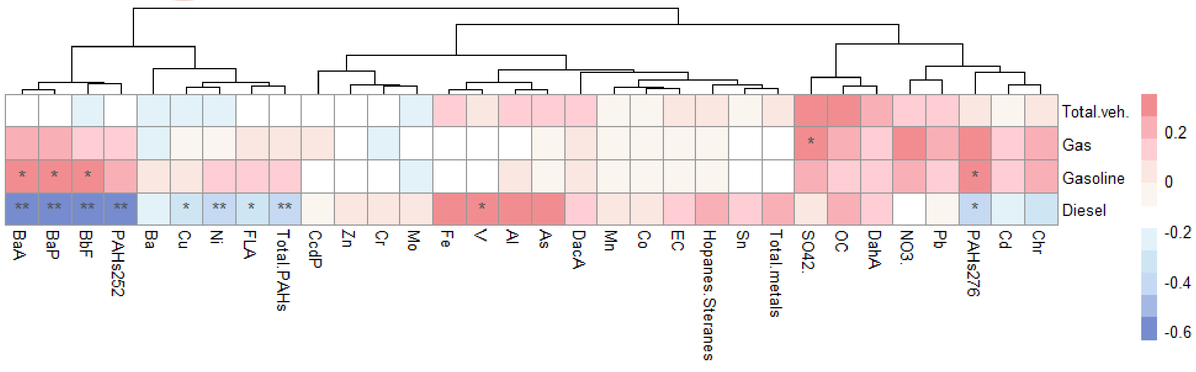


- Significant seasonal trend in total mass concentration: **Winter> Summer**
- Highest trace metals and elemental carbon (EC) contents in roadside samples.
- Secondary nitrate and sulfate contributed more to urban $PM_{2.5}$.

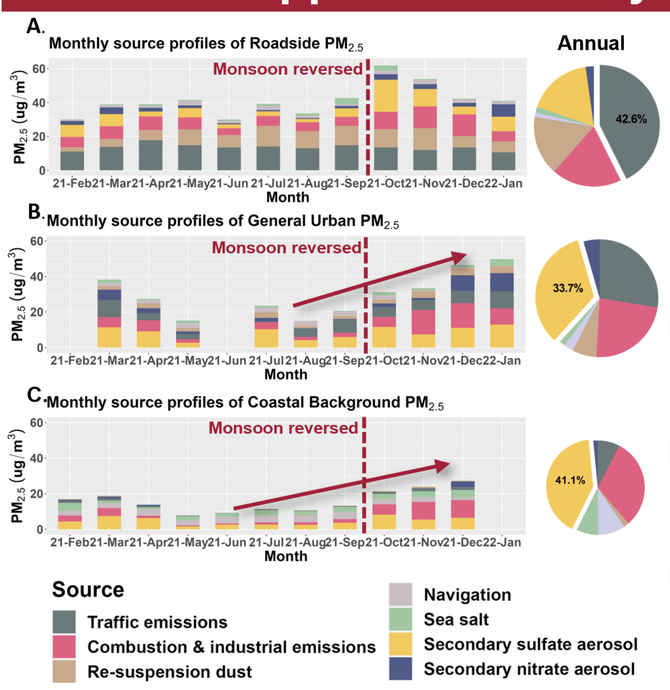
2.2 Correlation analysis of vehicular characteristic with key toxic components in $PM_{2.5}$



- Gasoline & diesel are still major energy (80%) of the total vehicular flow of cross-harbor in 2021.
- High-molecular-weight PAHs may be associated with gasoline vehicle emissions.
- Trace metals, especially V, Fe, and As may be associated with diesel vehicle emissions.



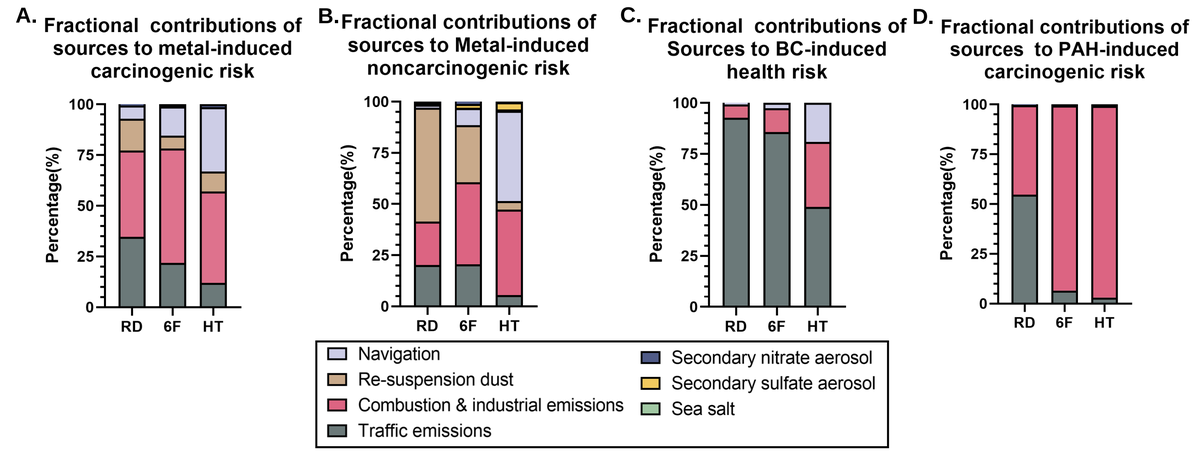
3. Source apportionment by PMF model



Site	1st trace metals contributor	1st PAHs contributor	1st OC contributor
Roadside	Traffic emissions (38.7%)	Traffic emissions (57.6%)	Traffic emissions (54.7%)
Urban	Combustions (39.0%)	Combustions (52.3%)	Combustions (44.2%)
Background	Combustions (49.3%)	Combustions (82.5%)	Combustions (60.3%)

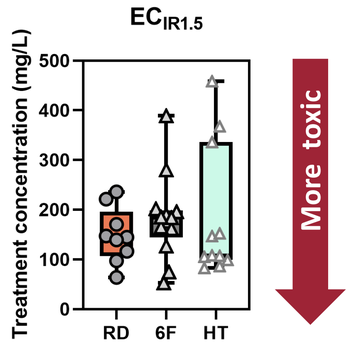
- EPA PMF 5.0. (Factors = 7, runs = 100)
  Tracers: OCEC, metals, ions, NPOCs
- **Stationary variation→ local source** (e.g., Traffic emissions, Re-suspension dust, Navigation, and Sea salt.)
- **Significant variation→ regional source** (e.g., Combustion & industrial emissions, SSA, SNA)

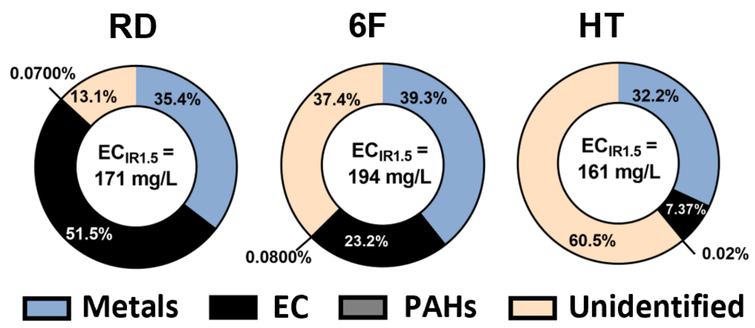
4. Source-resolved health risk assessment



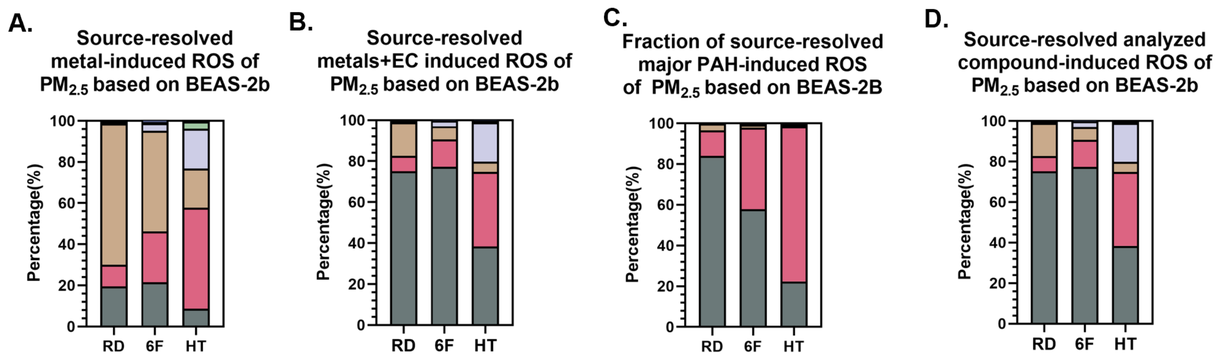
Site	1st metal-induced CR contributor	1st metal-induced NCR contributor	1st BC-induced CR contributor	1st PAH-induced CR contributor
Roadside	Combustions (42.6%)	Re-suspension dust (55.6%)	Traffic emissions (92.6%)	Traffic emissions (54.7%)
Urban	Combustions (56.5%)	Combustions (40.1%)	Traffic emissions (85.7%)	Combustions (93.0%)
Background	Combustions (45.1%)	Navigation (44.0%)	Traffic emissions (48.9%)	Combustions (96.2%)

5. Source-resolved cytotoxicity





- **Trace metals** are the dominating contributors to HK $PM_{2.5}$ –induced cytotoxicity, with an output of 20~45% in urban samples, and up to 40~80% in roadside samples, followed by **EC and PAHs**.



Site	1st metal-induced intracellular ROS	1st PAHs-induced intracellular ROS	1st contributor for intracellular ROS induced by Metals+EC+PAHs
Roadside	Re-suspension dust (68.6%)	Traffic emissions (83.9%)	Traffic emissions (75.1%)
Urban	Re-suspension dust (48.8%)	Traffic emissions (57.7%)	Traffic emissions (77.3%)
Background	Combustions (49.0%)	Combustions (76.2%)	Combustions (36.4%)

- Combining all analyzed components, **traffic emissions** emerged as the predominant source of intracellular ROS induced by $PM_{2.5}$ in Hong Kong, in which importance should be attached to **non-exhaust emissions**.

6. Conclusions

- This investigation **first** linked source profiles with component-specific cytotoxicity of $PM_{2.5}$, putting forward the **source-resolved cytotoxicity** assessment.
- The **local fresh sources were more dominant** in the ROS induction, comparing with the regional sources under long-term transport.
- Our health risks assessment identified **traffic-related sources** as the primary contributors to health risks and intracellular ROS caused by **trace metals, EC** in urban areas.
- Attention should also be paid to non-exhaust traffic-related emissions. Fe, Zn, Mn, and Cu, which are typically linked to friction and road dust, contribute the major part to the non-carcinogenic risk and cell ROS induction.
- Our study firstly estimated the **EC-specific contribution** in intracellular ROS, which draws further attention to the toxicity induced by the insoluble fractions in $PM_{2.5}$.

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