News Article for RISUD Joint Research Fund

		Name	Department
1.	**Principal Investigator**:	Dr JIN Ling	CEE
3.	**Project Title:**	Air pollution-induced immune impair and respiratory pathogen colonization	

4. **Annual Progress/Achievement (*in layman's language, no more than two A4 pages, pls attach a few figures*)**

The annual progress report highlights the achievements and advancements made in line with the agreed objectives during the reporting period.

First, we established a comprehensive fractionation scheme to analyze the contributions of chemical and microbial components in $PM_{2.5}$ to immune responses. To resolve the long-standing question, we resolved a perquisite debate on whether the combined effect of these fractions could be explained by a concentration-addition (CA) model, where the effect of the mixture is the sum of the effects of its individual components. We investigated the joint effects of different fractions of $PM_{2.5}$ (particulate matter with a diameter of 2.5 micrometers or less) on IL-8 induction, which is a measure of inflammatory response. The fractions studied included water-soluble, polar, non-polar, and insoluble components. The proof was that the experimentally determined joint effect of the different $PM_{2.5}$ fractions mixed together could indeed be well explained by the CA model. This means that the addition of the effects of the individual fractions approximated the effect of the whole $PM_{2.5}$ sample. This finding was observed for both ambient PM samples and source-specific PM samples, indicating its generalizability. The study's results provide a solid foundation for quantitatively dissecting the contribution of individual toxic components and mixtures to $PM_{2.5}$ toxicities as follows.

We found that highly potent but low-concentration transformation products and natural microbial components contribute equally, if not more substantially, than anthropogenic and/or parent components. For ambient $PM_{2.5}$, the study compared two locations, a coastal background site (Hok Tsui on the southern tip of Hong Kong Island) and a roadside site (in vicinity of the Cross Harbour Tunnel), and analyzed the concentrations of endotoxin, which is a component associated with natural microbial sources. We found no significant difference in endotoxin concentrations between the two locations. However, the IL-8 induction, which is an indicator of inflammation, was significantly higher in the Roadside samples compared to the Hok Tsui samples. The contribution of endotoxin to IL-8 induction was higher in Hok Tsui (ranging from 0.5% to 11.6%) compared to Roadside (ranging from 0.2% to 1.6%), although the difference was not statistically significant. Interestingly, endotoxin accounted for less than 0.0001% of the $PM_{2.5}$ mass, which is nearly four orders of magnitude lower than its contribution to the IL-8 response. This suggests that even at low concentrations, endotoxin can have a substantial impact on the inflammatory response. For biomass combustion aerosol samples, we analyzed the toxicity of different extraction fractions, including methanol, water, and hexane extracts. They also investigated the influence of combustion temperature on the toxicity of particulate matter (PM) extracts. The toxicity demonstrated a temperature-dependent trend. As the combustion temperature increased from 400 °C to 600 °C, the toxicity of PM extracts significantly increased. However, as the combustion temperature further increased from 600 °C to 800 °C, the toxicity slightly decreased. The quantification of toxicity for identified compounds revealed that those derived from low-temperature combustion exhibited relatively low toxicity. However, there was a substantial increase in toxicity as the combustion temperature escalated to medium and high levels. Furthermore, the key components contributing to toxicity differed among PM samples generated at different temperatures. In the context of medium-temperature combustion, methoxy groups, acids, and amines emerged as the dominant toxicity contributors, surpassing even the highly toxic parent polycyclic aromatic hydrocarbons (PAHs). Notably, as the combustion temperature reached 800 ℃, parent PAHs became the primary toxicity contributors due to the conversion of precursors into parent PAHs.

Second, to assess the role of ambient air in transmitting antibiotic resistance and pathogens to human airway, we investigated the presence of inhalable antibiotic resistance genes (ARGs) in Asia's largest municipal waste treatment center. They studied a total of 84 air samples and analyzed the relationship between these inhalable ARGs and the resistomes present in the upper airway of on-site workers, consisting of 30 individuals. Over the course of the year-long study, both the air and airway resistomes exhibited resistances that were characteristic of the waste treatment center setting. Air, which demonstrated a high transmission network connectivity, was found to be predominantly associated with the resistome structure in the airways of the on-site workers. Importantly, the distribution of ARGs between the air and airway samples was non-random, with approximately 23% of the ARGs being specifically associated with both the air and airway samples. In terms of the transfer of ARGs, it was found that bacteriophages played a more significant role than plasmids in facilitating the cross-phylum transfer of ARGs. This facilitated the exchange of ARGs between the dominant microbial taxa present in both the air and airway samples. Furthermore, several closely related bacteria, such as *Corynebacterium*, *Pseudomonas*, and *Streptococcus species*, were identified in both the air samples and airway swabs, regardless of the seasons. This suggests a potential direct and long-lasting inhalation risk of ARG transmission from these bacteria.

Overall, significant progress has been made in understanding the complex relationship between air pollution, immune response, and respiratory infections. The research activities carried out during the reporting period have provided valuable insights and laid the foundation for further investigations. The project team has successfully built research collaborations and enhanced research capacity in the field of environmental health.