Health Risk-Oriented Source Apportionment of $PM_{2.5}$-Associated Trace Metals

Particulate matter ($PM_{2.5}$) comprises suspended particulates of diameter 2.5 μm or less in aerodynamic diameter in the atmosphere. Most emission sources of $PM_{2.5}$ are contributed from human activity, seriously impacting human health by direct inhalation. Xiangdong Li et al. investigated the $PM_{2.5}$-associated metals in two regions of high activity, YRD and PRD regions in China. The resulting carcinogenic risk that these elements posed was greater in YRD than in PRD. An increased contribution from the emissions of industrial activity was observed in the YRD region, but both traffic and non-traffic emissions from the burning of coal, waste and biomass were dominant sources of cancer and non-cancer risks posed by metals in both regions.

$PM_{2.5}$ is considered a health high-risk factor in the components of air pollutants, which can directly enter the respiratory system, leading to 4.2 million deaths per year. An air-quality index is currently used to define the air quality, which is predicted using the level of six atmospheric pollutants, including $PM_{2.5}$, PM_{10}, SO_2, NO_2, CO, and O_3. The $PM_{2.5}$ sampling period was from March 2016 to February 2017 in the Yangtze River Delta (YRD) and Pearl River Delta (PRD) regions. One 24-hour $PM_{2.5}$ sample was collected weekly in all locations of these YRD and PRD regions; monthly sampling was undertaken for Lishui in the YRD region. $PM_{2.5}$ was indicated to be associated with toxic trace metalloids and organics (*e.g.*, polycyclic aromatic hydrocarbons), significantly increasing health risks. The accumulated evidence indicates that transition metals in fine particles are closely associated with oxidative DNA damage despite their small mass relative to that of other components. $PM_{2.5}$ samples were analyzed, including organic carbon, elemental carbon (EC), water-soluble ions, total metalloids, and bio-accessible metalloids.

The health risks of inhalation of the sampling sites caused by $PM_{2.5}$-associated metal(loid)s were predicted on a basis of an annual average of bio-accessible concentrations of metallic elements Fe(III), Mn(II), V(V), Ni(II), Cr(III), As(V), Cu(II), Pb(II), Zn(II) and Cd(II), focusing on both the carcinogenic risks and non-carcinogenic risks for adult residents. Regarding the effect potency of various metals, the benchmark from the USA Environmental Protection Agency (USEPA), correlated with the use of the inhalation unit risk (IUR) and reference concentration (RfCi) of metals in their most toxic form is a common practice in risk assessments, shown in **Fig. 1(a)**. Arsenic shows great disparities in toxicity between various forms; inorganic As(V) was observed to be the predominant species, accounting for over 80% of the total arsenic content of airborne particles in urban areas. To explore the formation of molecular species and total arsenic ion (As(III) and As(V)) in a $PM_{2.5}$

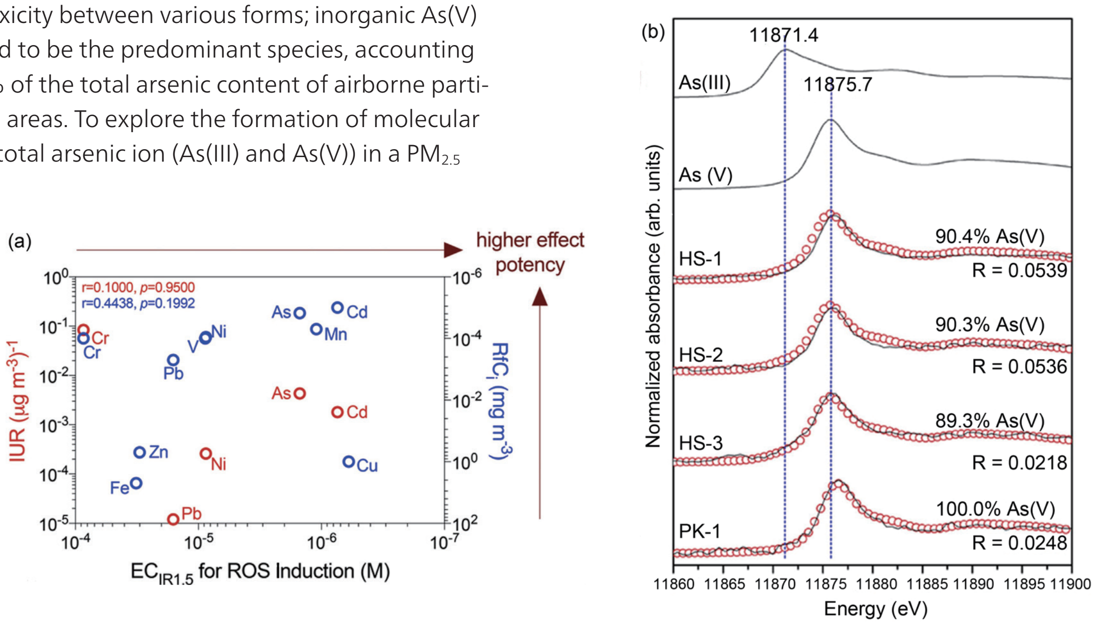

Fig. 1: Toxicity potency of metal ions about their speciation. (a) Correlation between effect concentration ($EC_{IR1.5}$) for reactive-oxygen-species (ROS) induction (M) of various metal ions and IUR $(mg/m^3)^{-1}$, as well as the reference concentration (mg/m^3) via inhalation (RfC_i) of various metals specified in the documents of USEPA (2018) and other national standards. The $EC_{IR1.5}$ data of the metal ions herein are based on particular kinds of speciation; (b) presents the dominant speciation of arsenic in three $PM_{2.5}$ samples with large concentrations of As(III) and As(V) in the semirural-industrial site (Heshan) in PRD and one in the suburban-industrial site (Pukou) in YRD, illustrated by XANES spectra (black solid line). The red dotted lines represent the LCF results. [Reproduced from Ref. 1]

particle sample, As K-edge (11,871.1 eV) X-ray- absorption near-edge structure (XANES) spectra of four selected $PM_{2.5}$ filter samples (*i.e.*, three from PRD and one from YRD regions) with a large concentration of As were acquired in fluorescence mode at **TLS 01C1**, coupled with $NaAsO_2$ and Na_2HAsO_4 as reference standards, shown in **Fig. 1(b)**.

Compared with the variations in $PM_{2.5}$ concentrations, the differences between inter-regional profiles of chemical compositions were more pronounced than those of intra-regional ones because of the diversities of industrial activity, shown in **Fig. 2.** A greater proportion of water-soluble ions relevant to secondary inorganic aerosols (NO_{3^-}, SO_4^{2-} and NH_{4^+}) was observed and a smaller proportion of carbonaceous materials (organic matter OM and EC) was indicated to contribute from combustion activities to the total identified components in YRD than in PRD.

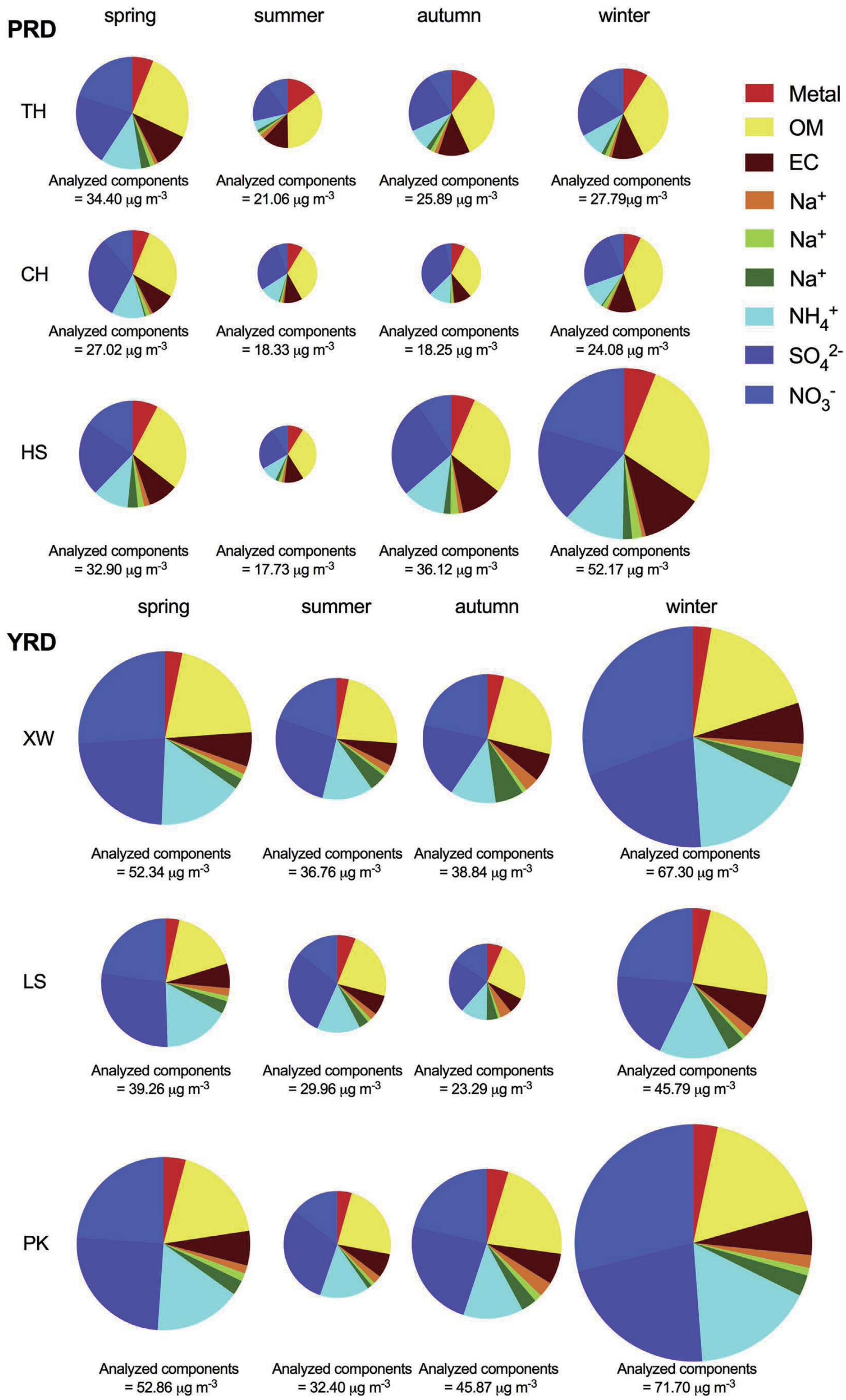

Fig. 2: Quarterly variations in major chemical components analyzed in $PM_{2.5}$ in PRD and YRD regions of China. [Reproduced from Ref. 1]

This investigation profiled regional $PM_{2.5}$ pollution, variations in $PM_{2.5}$ associated metals, and other chemical species based on the regional development in YRD (east China) and PRD (south China) regions, and also highlighted the importance of associating bioaccessibility and speciation of metal ions with $PM_{2.5}$ to assess the health risks of residents in those regions. Xiangdong Li (Chinese Academy of Sciences, China) and coworkers considered promoting the low-risk living environment and emission reduction in a supplement to the current mass-concentration-based framework. (Reported by Yao-Chang Lee)

This report features the work of Xiangdong Li and his collaborators published in Environ. Pollut. ***262****, 114655 (2020).*

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- XANES
- Environmental Science

Reference

1. J. Xie, L. Jin, J. Cui, X. Luo, J. Li, G. Zhang, X. Li, Environ. Pollut. **262**, 114655 (2020).