Source Apportionment of Atmospheric $PM_{2.5}$ at a Coastal City in Southern Taiwan

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Abstract

Fine particulate matters ($PM_{2.5}$) has been identified as one of the major air pollutants in urban areas, which are responsible for the adverse effects on public health and the deterioration of visibility. Its air quality standards were promulgated world widely, while becomes a new challenge for Taiwan environment issue. In Taiwan, the most of major cities are located close to the ocean for the transportation demand of economic development, when Tainan is the most representative coastal city in southern Taiwan. The population density goes up to 14,000 people km^{-2} in the coastal region, which is similar to those of Tokyo and New York. Additionally, there are over 9,000 factories around the city. Nevertheless, the open burning is another potential emission source, since a wide agricultural region is located at the north. On the other hand, the monsoon winds come from the North and South and bring the pollution from South East Asia and China via long range transport. Consequently, the complicated $PM_{2.5}$ source apportionment is interesting and helpful for further proposing local atmospheric control strategies.

In this study, the atmospheric levels and characteristics of $PM_{2.5}$ were evaluated by measuring the mass concentration and compositions, including water-soluble ions, carbonates (EC and OC), and metals, at Xinying and Tainan cite for three seasons during 2013. The former cite site was located at more rural area at northern Tainan, and the other one was at urban center at south, which were both only 15 kilometers far from coastline. Their relative locations might also indicate the pollutant transports by seasonal winds. Additionally, a Chemical Mass Balance (CMB) receptor model was used to identify possible sources of $PM_{2.5}$ and their contributions.

The current $PM_{2.5}$ levels in Tainan in spring and winter (41-49 μg m^{-3}) were substantially high. The most dominant anions were sulfate and nitrate, while the cations were dominated by ammonium. These three ions accounted for over 70% mass of total ionic composition. These results are similar to those obtained by Yin *et al*. (2012) and Souza *et al*. (2014) whereby SO_4^{2-}, NO_3^- and NH_4^+, were the dominants ions in $PM_{2.5}$ during a major haze even in Yong'an China. Furthermore, the secondary inorganic ions NH_4^+ NO_3^- and SO_4^{2-} were the dominant species in $PM_{2.5}$ recently in Beijing, China by Wang *et al*. (2015). According to *I* and *J* values, determined by Seinfeld et al. (1998), the case, $J < 1$ and $I > 2$, indicated that the NH_4^+ was enough to neutralize the SO_4^{2-}, but could not capture all the NO_3^-. Therefore, the excess NO_3^-could couple with the other cation, such as Na^+, Mg^{2+}, and Ca^{2+}. Thus, controlling NOx might be better than SOx to reduce secondary $PM_{2.5}$ level. For carbon contents, the EC/OC ratio was relatively higher in summer than in other seasons at Tainan site, which might be resulted from the stronger photosynthesis and humidity leaded to formation of the secondary aerosol in summer. Additionally, the atmospheric boundary layer was lower in winter and cause the inhibit the diffusion of primary EC, leading to a much lower EC/OC in urban area with multiple emission sources. The above phenomenon could not found in Xinying site, which has less population and primary EC emissions. Furthermore, information on OC and EC is useful for understanding the light scattering capacity of the aerosol and the visibility of the atmosphere (Souza *et al*., 2014).

According to the results CMB modeling, the main contributions on $PM_{2.5}$ were $(NH_4)_2SO_4$ and NH_4NO_3, which are secondary PM, and traffic, which is primary aerosol. The sulfate and nitrate in $PM_{2.5}$ were mostly emitted from the stationary sources and diesel vehicles. Crustal elements, which could be considered as the background components were varied between different sampling sites. Notably, the traffic contribution was 32~50% in the high pollution season, especially at the urban area. Seasonal variations were evident whereby open burning, secondary OC and suspended dust were highest contributors of $PM_{2.5}$ in summer.

Consequently, to improve $PM_{2.5}$ of Tainan City, the priority control pollutantsare primary $PM_{2.5}$ (open burning, construction sites and road dust by vehicles), NOx (diesel vehicle emissions), and SOx (fuels).

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