Characterization of Atmospheric $PM_{2.5}$ in Southern Taiwan

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Fine particulate matter ($PM_{2.5}$) has been identified as one of the major air pollutants in urban areas, which is responsible for the adverse effects on public health (Chang *et al.*, 2013, Diaz, 2008). In this study, the characteristics of $PM_{2.5}$ were studied for Chiayi City, which has a high population density and is surrounded by agricultural area. The mass concentration, water-soluble ionic component, trace metal component, carbon component and modeling the contribution source for $PM_{2.5}$ were evaluated. The Taiwan Emission Data System 8.1 (TEDS 8.1) was utilized as the input data to Model-3/CMAQ for modeling seasonal $PM_{2.5}$ contributions from stationary, mobile, and area sources.

In the spring, the $PM_{2.5}$ concentrations were 33-61 $\mu g/m^3$. The $PM_{2.5}/PM_{10}$ ratios were 45.9-58.0%, which is characteristic of a typical urban area. The main wind directions were NW and N, leading to the relatively higher $PM_{2.5}$ levels around the east of Chiayi City. There was particulate accumulation in valley or near-mountain locations. The mass concentrations of $PM_{2.5}$ were mainly composed of 58.7% water soluble ions, 14.4% carbonates, and 5.1% metals. The ion contents in $PM_{2.5}$ were majorly composed of NO_3^- (22.4%), SO_4^{2-} (16.8%), and NH_4^+ (14.3%). In average, the OC (10.1%) mass content was higher the EC (4.9%).

In the summer, the $PM_{2.5}$ concentrations ranged from 9 to 22 $\mu g/m^3$. The range of $PM_{2.5}/PM_{10}$ ratios was 33.3-42.9%, which is significantly lower than other seasons. This could be as a result of the inhibition of primary particles and secondary gaseous precursors by temporal precipitation. Generally, the mass concentrations of $PM_{2.5}$ were mainly composed of 39.1% water soluble ions, 18.0% carbonates, and 13.0% metals. The ion contents were majorly composed of SO_4^{2-} (21.8%), NH_4^+ (8.8%), and NO_3^- (7.2%). The average OC (10.6%) mass content was higher the EC (7.4%).

In the autumn, The $PM_{2.5}/PM_{10}$ ratios were 34.9-59.1%. For autumn, mass concentrations of $PM_{2.5}$ were mainly composed of 54.2% water soluble ions, 10.2% carbonates, and 7.5% metals. The ion contents were majorly composed of SO_4^{2-} (21.9%), NO_3^- (16.6%), and NH_4^+ (11.0%). The average OC (6.4%) mass content was higher the EC (3.8%).

In winter, the $PM_{2.5}$ concentrations were 29-69 $\mu g/m^3$. The $PM_{2.5}/PM_{10}$ ratios were 52.9-67.9%, reporting the higher fine particle level with more potential harmful effects than other seasons. The mass concentrations of $PM_{2.5}$ were mainly composed of 59.2% water soluble ions, 13.7% carbonates, and 4.6% metals. Similar to other seasons, the major ions were SO_4^{2-} (20.7%), NO_3^- (17.5%), and NH_4^+ (12.6%). Similarly, the average OC (9.5%) mass content was higher the EC (3.9%).

The results of CMB model revealed the main contribution for locally atmospheric $PM_{2.5}$ to be as follows. Spring: secondary nitrate (20.13%), traffic source (15.45%), secondary sulfate (12.29%), re-suspending soil particle (10.80%), petrochemical industry (7.46%), agricultural open burning (5.96%), metallurgical industry (4.92%), cement industry (4.25%) and sea salt (2.71%). Summer: secondary sulfate (18.98%), secondary nitrate (13.73%), re-suspending soil particle (12.36%), traffic source (11.42%), petrochemical industry (10.87%), sea salt (10.46%), cement industry (4.08%), and metallurgical industry (3.92%). Autumn: secondary sulfate (18.22%), secondary nitrate (17.12%), traffic source (15.59%), petrochemical industry (9.08%), re-suspending soil particle (8.10%), agricultural open burning (7.79%), sea salt (7.43%), cement industry (5.19%), and metallurgical industry (3.80%). Winter: traffic source (21.56%), secondary nitrate (18.09%), secondary sulfate (12.98%), agricultural open burning (9.89%), petrochemical industry (9.23%), re-suspending soil particle (8.32%), sea salt (5.36%), metallurgical industry (3.92%), and cement industry (3.20%).

The results of this study provide useful information for air quality control in such a densely populated and agricultural city.

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