UNIVERSITY OF THE PHILIPPINES

Master of Science in Environmental Science

Karen S. Yañgo

The influence of chemical composition on the hygroscopic properties of particulate matter ($PM_{2.5}$) collected in Metro Manila, Philippines

Thesis Adviser:
MYLENE G. CAYETANO, Ph.D.
Institute of Environmental Science and Meteorology
University of the Philippines - Diliman

Thesis Co-adviser:
JINSANG JUNG, Ph.D.
Korea Research Institute of Standards and Science
Daejeon, South Korea

Thesis Reader:
GERRY BAGTASA, Ph.D.
Institute of Environmental Science and Meteorology
University of the Philippines - Diliman

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ABSTRACT

Aerosol hygroscopicity or the ability of suspended particles to absorb and release water from and to the atmosphere, has been known to have direct impact on atmospheric visibility, cloud formation and aerosol radiative forcing. This study involved the determination of hygroscopic growth of water-soluble components of $PM_{2.5}$ and investigated the correlation with aerosol chemistry.

Samples were collected in roadside of Katipunan Avenue, Quezon City, defined as Quezon City road side (QCRS) in this study. Growth factors were measured using the humidified tandem differential mobility analyzer (HTDMA) with an initial particle diameter of 100 nm which were then exposed at increasing relative humidity (5 – 90 %). The measured growth factor at 85 % RH ranged from 1.23 to 1.37 (mean: 1.28 $\pm$ 0.05) and at 90 % RH, growth ranged from 1.33 to 1.58 (mean: 1.42 $\pm$ 0.07) which were, expectedly, lower than sea water (2.1) and pure NaCl (2.42). Hygroscopicity parameter (kappa) which relates particle growth to cloud condensation nuclei (CCN) activity was measured 0.17 to 0.37 at 90 % RH (mean: 0.24 $\pm$ 0.05). Kappa was within the characteristic range of a multi-component atmospheric PM ($0.1 < \kappa < 0.9$). About 65.22 % of the samples were less-hygroscopic while 34.78 % were more-hygroscopic. Results were compared with Quezon City urban background site sample (QCUBS) where mean g(85 %) was measured as 1.28 $\pm$ 0.04 and mean kappa was computed as 0.23 $\pm$ 0.05 at 90 %. Comparison of means showed no significant difference at α=0.05.

To assess the link between aerosol hygroscopicity and chemistry, correlation analyses were performed between growth factors and (a) ion concentrations, (b) mass fractions and (c) reconstructed salt concentrations. Results showed moderate correlations of the former with [Cl^-] (0.65), Cl^- mass fraction (0.54), and NaCl, (0.64), respectively.

Cl^-/Na^+ molar ratio ranged from 0.04 to 0.60 with mean of 0.27 $\pm$ 0.03 was way lower than Cl^-/Na^+ of seawater (1.18). NaCl possibly underwent acid displacement process that have depleted available chlorine which consequently reduced Cl^-/Na^+ molar ratio and particle growth. The decline in g(85 %) due to chloride depletion was further supported with the moderate positive correlation between g(85 %) and Cl^-/SO_4^{2-} (0.50). NaCl reacted with H_2SO_4 during transport converting some NaCl into less-hygroscopic salt, Na_2SO_4. Moderate positive correlation was also found between g(85

%) and $Cl^-/WSOC$ (0.65) which implied further growth suppression by WSOC. For both correlations, two fractions of hygroscopicity were observed: more-hygroscopic fraction where particles have high g(85 %) and high Cl^-/SO_4^{2-} [Cl^-/WSOC] ratios and the less-hygroscopic fraction where particles have low g(85 %) and low Cl^-/SO_4^{2-} [Cl^-/WSOC] ratios. It can be concluded that hygroscopic growth of particles was mainly affected by Cl^- concentration but atmospheric processes that led to chloride depletion as well as presence of WSOC suppressed the growth of particles.

Growth factors obtained in this study can provide useful information to accurately model climate simulations and improve estimates on visibility degradation and aerosol radiative forcing as most models and calculations generally simplify hygroscopic properties of particles to unity and do not account for the effect of relative humidity.