ABSTRACT

The efforts to monitor and forecast particulate matter (PM) concentrations have been attracting attention in recent years due to PM's impact on air quality and climate change. As part of these efforts, this study focused on analyzing the spatial and temporal variations of PM in Metro Manila, Philippines to identify the controls on its abundances and developing Feed-forward Back-propagation Artificial Neural Network (FFBP ANN) models to predict 3-hourly PM concentrations in the study area.

A year-round hourly data (2016/10/01 – 2017/09/30) of PM_{10} and $PM_{2.5}$ concentrations acquired by the Air Quality Monitoring System platform (AQMS, www.airtoday.ph) from four stations (Lung Center of the Philippines, LCP, Ayala Avenue, AYA, Edsa-Muñoz, MUN, and UST-España, UST) together with meteorological parameters were used. The highest (lowest) annual mean of PM_{10} and $PM_{2.5}$ concentrations were from AYA (LCP) with 31.05 ± 14.40 (mean $\pm$ 1) $\mu g/m^3$ and 19.15 ± 10.15 $\mu g/m^3$ (12.11 ± 9.32 $\mu g/m^3$ and 10.92 ± 8.66 $\mu g/m^3$), respectively. Diurnal variations and day-of-the-week patterns indicate the importance of traffic emissions as source of PM in the region; pronounced peaks during the morning and the evening rush hours (07:00 - 09:00 and 20:00 - 21:00) as well as higher PM concentrations during weekdays which peaked on Thursday and/or Friday and lower concentrations on weekend were observed. The seasonal variation confirms the importance of removal processes in controlling PM abundance though it was site specific since only LCP and EM stations reported relatively lower concentrations during wet season than dry season. The ratio between $PM_{2.5}$ and PM_{10} alongside with their dependence on temperature indicate that majority of observed $PM_{2.5}$ came from primary emissions which likely outweigh the signature of secondary formation via photochemical processes in the atmosphere. Based on the results, it is inferred that PM

concentrations recorded from four stations in Metro Manila are heavily controlled by traffic emissions and influenced by meteorological factors.

For each station, ANN models of feed-forward back-propagation approach were developed based on the results of the spatial and temporal analysis. Three hourly data of meteorological parameters, previous PM concentrations, and time-scale variables- hour of the day (HoD), day of the week (DoW), and month of the year (MoY) which served as traffic proxy were selected as network inputs. These were trained, validated, and tested using different number of hidden neurons and activation functions. Performance of the models were evaluated using five performance indicators, namely Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Bias Error (MBE), Coefficient of Determination (r^2), and Index of Agreement (IA).

The best network topologies (input neurons-hidden neurons-output neuron) for PM_{10} prediction at each station were 10-17-1 (LCP), 10-16-1 (AYA), 10-8-1 (MUN), and 10-8-1 (UST) while for $PM_{2.5}$, 10-9-1, 10-14-1, 10-8-1, and 10-11-1 with tangent sigmoid and pure linear combination of transfer functions. Except for AYA, ANN models for the rest of the three monitoring stations had good prediction results. These were compared to the commonly used Multiple Linear Regression (MLR) models. Consistently, for all AQMS stations for both PM_{10} and $PM_{2.5}$ prediction, ANN models outperformed the linear regression models, obtained 6% to 16% reduced RMSE and 8% to 17% MAE and had lower underestimation and overestimation of observed values. Prediction ability were also better as denoted by values of r^2 as high as 0.669 and IA (0.820-0.891). Therefore, FFBP ANN approach could be used to predict 3-hourly PM_{10} and $PM_{2.5}$concentrations in Metro Manila.