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Assessment of Source Areas and Prediction of Particulate Matter using Neural Networks over Heritage and Steel Cities of India

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Identification of sources that contribute for escalation of particulate matter (PM) and prediction of the concentrations play a prominent role in the assessment of air quality and implementation of mitigation measures to provide a healthier environment to various living entities. Receptor-based source apportionment techniques help to identify the local and transboundary sources of pollution over the considered study areas. In the present study, Respirable suspended particulate matter (RSPM, also called PM2.5) and suspended particulate matter (SPM, also called PM10) concentrations over two Indian cities: a non-industrial site, Agra (popularly known as heritage city of India) for a study period of 2011-2015 and an industrial site, Rourkela (popularly known as steel city of India) for a study period of 2009-2013 are considered. The seasonal averages of RSPM and SPM concentrations over Agra and Rourkela were found to be always crossing the thresholds specified by the Central Pollution Control Board (CPCB), Govt. of India, thereby depicting a disastrous effect not only to the residents of these cities but also to the monuments like Tajmahal (one of the Seven Wonders of the World situated in Agra).
Keeping this in view, we have employed source apportionment technique i.e. weighted concentration weighted trajectory function (WCWT) to investigate local and regional sources that are accountable for the augmentation of PM concentrations in various seasons. We have calculated two days (48 h) back trajectories by using HYSPLIT model for performing WCWT. The results of WCWT over Agra reveal the fact that PM pollution is transboundary with sources of emission existing in the north-west direction. New-Delhi, the capital of India was found to be influencing Agra in the north-west direction by transporting higher loads of PM. For Rourkela, WCWT identified both local and regional sources. Rourkela steel plant, cement factory, coal-based Talcher power plant are identified as major sources for augmentation of PM over Rourkela.
Prediction of PM over these study areas is vital to circumvent the disastrous consequences of air pollution. Hence in the present study artificial neural networks (ANN) modelling is employed to predict RSPM and SPM in advance for the considered study periods. Four ANN models: multi-layer perceptron neural network (MLPNN), recurrent neural network (RNN), wavelet-based multi-layer perceptron neural network (WMLPNN) and wavelet-based recurrent neural network (WRNN) are considered to predict seasonal PM concentrations. Meteorological parameters and RSPM and SPM concentrations for the study period 2011-2015 for Agra and 2009-2013 for Rourkela are considered to perform prediction. WMLPNN performed well among the considered models by depicting an acceptable correlation between the predicted and observed concentration of PM for Agra in pre-monsoon, monsoon and winter seasons and MLPNN in post-monsoon season during the study period. Whereas, for Rourkela, WMLPNN was found to be the best architecture to predict the future values of PM. The correlation coefficient ranged from 0.7-0.93 in different seasons for Agra using WMLPNN and MLPNN techniques whereas 0.7 to 0.98 for Rourkela using WMLPNN.