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Advanced Prediction of PM10 Trends Using ANN-NARX Under CMIP6 Climate Change Scenarios

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ABSTRACT

Introduction: As climate change continues to reshape our environment, accurately forecasting air quality becomes essential for developing effective public health and environmental strategies. This study investigates changes in particulate matter (PM10) concentrations under the Shared Socioeconomic Pathways of the Climate Model Intercomparison Project Phase 6 (CMIP6).
Methods and Materials: Historical climatic data (1998-2014) were collected to establish baseline conditions, and vital climatic variables—maximum and minimum temperatures, precipitation, and radiation—were gathered between 2013 and 2022 from the Iran Meteorological Organization. The Long Ashton Research Station Weather Generator (LARS-WG 6.0) software was used to perform statistical downscaling, generating high-resolution time series datasets from the historical climatic data. The MIROC6 atmospheric circulation models simulated future climate scenarios using three Shared Socioeconomic Pathways (SSPs) from the sixth IPCC Assessment Report (AR6): optimistic (SSP1-2.6), intermediate (SSP2-4.5), and pessimistic (SSP3-7.0). Monthly PM10 concentrations were obtained from MODIS satellite images. An Artificial Neural Network Nonlinear Autoregressive with Exogenous Input (ANN-NARX) model was developed using the collected climatic variables as predictors, and this model was used to estimate PM10 concentrations for the period 2023-2042 under each SSP scenario.
Results: In various SSP scenarios, PM10 levels were assessed between 2023 and 2042. An increase in PM10 was observed across all scenarios, particularly during the hotter months of summer and spring over the next 20 years. The SSP2-4.5 scenario showed minimal change, maintaining levels close to historical data. In contrast, SSP3-7.0 exhibited significant increases in PM10, especially during the warmer months of summer and spring. Sensitivity analysis identified radiation and maximum temperature as critical factors influencing PM10 predictions, with sensitivity plots showing a notable increase in MSE when these factors were removed. The ANN-NARX model demonstrated satisfactory performance across the training, validation, and testing sets, with RMSE values ranging from 0.15 to 0.30, MAE values from 0.10 to 0.35, and MSE values from 0.01 to 0.1, and R values from 0.91 to 0.92.
Conclusion and Discussion: The study concluded that PM10 concentrations in Ahvaz were significantly influenced by radiation and maximum temperature. The anticipated temperature increases under various SSP scenarios suggest a potential decline in future air quality, with expected rises in PM10 levels. These findings underscore the urgent need for effective air quality management and climate adaptation strategies in Ahvaz.

Keywords: Climate, Particulate matter, Temperature