

Performance Enhancement of a Regulatory Model using, Background Concentration and Simulated Meteorological Inputs

Air pollution poses a significant urban challenge in both developed and developing countries due to rapid urbanization, industrialization, and the increasing vehicular population. In regions like Delhi, where dense monitoring networks are economically challenging, dispersion modeling serves as a critical tool for estimating pollutant concentrations and informing regulatory policies. This study focuses on enhancing the performance of the AERMOD dispersion model by integrating high-resolution emission inventories and background concentration estimates.

A fine-resolution emission inventory for the Delhi National Capital Territory (NCT) for the year 2019–2020 was developed with a spatial resolution of $1\text{ km} \times 1\text{ km}$, accounting for key emission sources such as industries, transport, households, restaurants, municipal solid waste burning, and aircraft. The inventory was validated using AERMOD, and model performance was evaluated using standard statistical metrics.

To address underestimation of pollutants due to unaccounted emissions, background concentrations were estimated using statistical techniques, including meteorological filtering, spectral analysis, and the Kolmogorov-Zurbenko (KZ) filter. These values were validated using data from the COVID-19 lockdown and compared with simulations from the WRF-Chem model, which also assessed the impact of long-range pollutant transport on particulate concentration during severe pollution events across seasons.

In the final analysis, AERMOD model performance was evaluated under different scenarios—using the emission inventory, integrating background concentrations, and meteorological inputs obtained from both observational stations and the WRF model. Results showed that AERMOD underpredicted particulate matter and overpredicted gaseous pollutants in its default setup. Incorporating background concentrations improved model accuracy, particularly during the summer and monsoon seasons. The WRF-AERMOD coupling yielded better performance during winter months, highlighting the importance of meteorological fidelity.

Keywords: Air Quality Modelling, Emission Inventory, Background Concentration, WRF-Chem, AERMOD.