A HYBRID MODEL FOR PREDICTION OF CARBON MONOXIDE FROM VEHICULAR EXHAUSTS IN URBAN ENVIRONMENTS

by

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Dedicated

to

my mother and lather,

Sau. Shanti & Shri. Bhaurao

यत् सांख्यैः प्राप्यते स्थानं तद् योगैर् अपि
गम्यते ।
एकं सांख्यं च योगं च यः पश्यति स पश्यति
॥५॥

yat sankhyaih prapyate sthanam
tad yogalr apt gamyate
ekam sankhyam ca yogam ca
yah paśyati sa paśyati

One who knows that the position reached by means of analytical study can also be attained by devotional service, and who therefore sees analytical study and devotional service to be on the same level, sees things as they are.

BHAGAVAD-GlTA¨ (V- 5)

CERTIFICATE

This is to certify that the thesis entitled **"A Hybrid Model for Prediction of Carbon Monoxide from Vehicular Exhausts in Urban Environments"** being submitted by Mr. **Sharad Gokhale,** has been prepared under my supervision in conformity with the rules and regulations of the **Indian Institute of Technology, Delhi.** I further certify that the thesis has attained a standard required for the award of a degree of **Doctor of Philosophy** of the institute. This work, or any part thereof, has not been submitted elsewhere for the award of any other degree or diploma.

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ABSTRACT

Air pollution is a growing problem because of the increasing urban population, causing high densities of motor vehicle traffic, and expanding commercial and industrial activities. A major problem related to air pollution is the urban transport and its interaction with the city. The motor vehicles produce different emissions under different conditions of speed-deceleration, acceleration and idle. The road junctions, the traffic intersections and the signalized roadways in an urban area are more prone to the severe vehicular pollution. Vehicles spend longer time at these 'spots' and generate more pollutants in association with the local meteorology, leading to the higher ambient concentrations (extremes). The vehicular sources, therefore, pose a main threat to the urban air quality. Against this background, it becomes quite important to predict the air pollution caused by the vehicular sources in the urban areas. Therefore, air quality models play an effective role in the efficient management of air pollution (Khare and Sharma, 2002).

Several conventional deterministic-based models exist to evaluate and predict the pollutant dispersion in urban areas but majority of them are 'causal' in nature and fail to predict the 'extreme' concentrations. The statistical distribution models, on the other hand, are 'non-causal' and are based on the historical data. Therefore, they overcome the above limitation of the deterministic models and predict the 'extreme' concentrations. However, the environmental damages are caused by both *extremes* as well as by the sustained *average* concentration of pollutants. Hence, the model should predict not only 'extreme' ranges but also the 'middle' ranges of pollutant concentrations, i.e. the entire range.

Hybrid modelling is one of the techniques that estimates/predicts the 'entire range' of the distribution of pollutant concentrations by combining the deterministic based models with suitable statistical distribution models. The present research, aims at developing a hybrid model for the carbon monoxide (CO)[1] predictions at one of the traffic intersections, Income Tax Office (ITO), in the Delhi city, where the traffic is heterogeneous[2] in nature and meteorology is 'tropical'.

The three years (1 January 1997-31 December 1999) CO concentration and meteorological (wind speed, direction, stability classes) data are acquired for the model development, verification and validation. The hybrid model combines the general finite line source model (GFLSM) as its deterministic, and log logistic distribution (LLD) model, as its statistical components. The hybrid (GFLSM-LLD) model is then applied at the ITO intersection. The results show that the hybrid model predictions match with that of the observed CO concentration data within the 5 to 99 percentile range. The performance of the model has been evaluated using the statistical descriptors, i.e. index of agreement (d), fractional bias (FB) and the normalized mean square error (NMSE). The value of 'd' is, 0.6, for the GFLSM and 0.98 for the hybrid model, at the ITO intersection. The FB (-0.008) and NMSE (0.81), indicate good model performance with the slight over prediction and small scatter between the observed and predicted data. The hybrid model is further verified for different meteorology and emission scenarios for the years 1997 and 1998, at the ITO intersection. The predictions match the observed CO concentrations, satisfactorily, giving the 'd' values as 0.76 and 0.74, for the verification test case-I and -II, corresponding to the years 1997 and 1998, respectively. The model is further validated at Sirifort roadway. The validation results show that the model predicts CO

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[1] CO has been used as an *indicator* in the vehicular exhaust emission modelling studies *(Hick/nan and Colwill, 1982)*. It is non-reactive, i.e. conservative pollutant, therefore the modeling scenario is optimized to avoid the complexity of chemical parameterization of the domain.

[2] It consists of light vehicles, heavy vehicles, three- wheelers (auto rickshaws) and two- wheelers (scooters, motorcycles, etc).

concentrations fairly well (d = 0.91) in 10 to 95 percentiles range. The regulatory compliance is also developed to estimate the probability of exceedance of hourly CO concentration beyond the National Ambient Air Quality Standards (NAAQS).

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