ABSTRACT

Globally, vehicular emissions are recognized as the main source of air pollution in urban areas. The trend of urbanization has led to a surge in private vehicle ownership, particularly in metropolitan cities such as Delhi, India, resulting in significant growth of the automobile sector. Additionally, Delhi has experienced a considerable influx of people migrating from neighbouring states in the past decade, leading to higher demand for transportation facilities. The growing number of vehicles has a direct impact on air pollution by causing higher fuel consumption and increased traffic congestion. The activity of vehicles on congested roads, including sudden acceleration and deceleration, significantly affects emissions. As a result, precise estimation of vehicular emissions is critical in developing systematic pollution mitigation strategies.

In the present study, the analysis of emission measurement has focused on a heavy traffic road junction of Delhi city, which includes a mid-block signalized intersection. In the past, many modelling studies have used the average speed of vehicle for entire road segments that resulted in underestimation of emission. The relationship between vehicle operating characteristics, inter- and intra-vehicle fleet variability, driving behaviour, and traffic conditions have been investigated by developing an integrated modelling framework called VMIMD (VISSIM-MOVES Integration Model for Delhi city). The modelling framework serves as an interface between the VISSIM (traffic flow simulation) and MOVES (emission) models, allowing for the generation of operating condition-based emission factors (EFs) by considering VSP (vehicle specific power) and speed as an intermediate parameter.

The analysis of results shows a strong correlation between time spent in each operating condition (idling, cruising, and braking) and emission generation. Heavy traffic hours have the highest

percentage of distribution in braking/deceleration mode which reduces the speed of vehicles and increases power demand. As a result, the emission changes very rapidly as vehicles shift from cruising mode to braking mode. The study has found that HCVs and Buses are more sensitive to variations in speed than other types of vehicles, despite being a smaller proportion of the total traffic fleet. The impact of heavy traffic congestion on emission has also been found by analysing diurnal variation of EFs for HC, CO, NO_X and $PM_{2.5}$ pollutants. All pollutants show the highest emission level from 0900 to 1100 hrs., which is the peak hour of traffic. The study also compares VMIMD generated EFs, and ARAI developed EFs and found a significant difference between emissions especially during peak hours. The ARAI developed EFs fail to consider the impact of real-world driving conditions. Further, the effect of fuel type on emission has also been evaluated in the study. The contributions of HC and CO pollutants are mainly from petrol-fuelled vehicles; while NO_X and $PM_{2.5}$ are primarily contributed by diesel-fuelled vehicles. Additionally, CNG vehicles have also been found to contribute substantially to the levels of HC, CO, and NO_X emissions.

Further, the dispersion analysis of pollutants has been performed by using Gaussian based dispersion model, AERMOD. During winter months, the pollutants concentrations are found to be higher than summer months; besides, daytime, and night-time concentrations analysis have also been carried out. Temperature and wind speed have a positive impact on pollutant dispersion, while high relative humidity results in poor mixing and an increase in pollutant concentrations. Although, the maximum concentrations are observed at roadside near the source and most of the time the concentrations of pollutants are observed above the permissible limits. Moreover, the overall performance of integrated modelling approach has been evaluated by validating monitored (CPCB website) and predicted concentrations (using AERMOD) of pollutants using statistical

descriptors such as d, FB, NMSE, MG and VG. The statistical descriptors generally indicate satisfactory performance for both the summer and winter seasons.