ABSTRACT

Air pollution from motor vehicles is one of the most serious and rapidly growing problems in various urban centre s of the world. From the population exposure point of view, the study of air quality in urban street canyons is of paramount importance since the highest pollution levels and considerably larger environmental impacts have often observed in these situations. To chalk out effective counter -measures for achieving sustainable street air quality, there is a need to analyze the air pollution dispersion phenomenon within the street canyon comprehensively.

Over the past two decades, significant progress has been made in understanding and modelling vehicular pollution dispersion phenomena under these urban environmental conditions by using Environmental Wind Tunnel (EWT) technique. In the EWT, the emission conditions, different meteorological situations, terrain and topographical features could be changed at will and useful data translatable to real -life situations might be obtained. These EWT studies carried out over the last ten years have greatly helped in determining the pollutant concentrations under various urban street canyon conditions as a function of building dimensions, upwind building configuration, wind direction concerning building configuration and roof geometry. These studies have further shown that the street canyon configuration, its aspect ratio, external wind speed and its direction and traffic produced turbulence are some of the important f actors influencing pollutant dispersion in urban areas.

In the present study, physical modelling of various street canyon configurations in the EWT facility at the Indian Institute of Technology (IIT) Delhi was carried out to study the Heterogeneous traffic -induced effects on pollutant dispersion in street canyon with a flyover. The traffic-induced turbulence, coupled with natural air motions , is an important factor

affecting the dispersion of exhaust emissions, especially under low wind conditions. Therefore, a systematic understanding of the traffic -induced effect on exhaust dispersion mechanisms in the close vicinity of the urban roadways/intersections/street canyons/freeways help in finding ways to mitigate vehicular pollution. Also, an attempt to investigate the effects of building patterns and approaching wind directions on the line source dispersion in the close vicinity of the urban intersection along with flyover was studied. The traffic -induced effects for variable traffic volume, speed and composition have also been investigated. And also, i n the present study, forecasting flow fields and concentration patterns in the near -field of a flyover have been investigated. Additionally, the evaluation of vertical spread parameters for various building patterns and approaching wind direction calculated.

A hybrid-model vehicle movement system for an urban intersection having two-way straight, radial peripheral traffic flows and elevated roads has been designed and fabricated in the EWT. The experiments have been carried out in the neutrally stratified atmospheric boundary layer, representing the urban terrain category. The tracer gas concentration has measured, online, at one hundred twenty locations by gas chromatography (FID type detector) at variable approaching wind directions, i.e., 0° , 30°, 60° and 90°and traffic volumes, i.e., no -traffic, lean traffic volume 1200 vehicles/ hr at a speed of 35 km/hr comprising of 10 vehicles/meter length in model and peak traffic volume of 5500 vehicles/hr at a speed of 15 km/hr in the field comprising of 38 vehicle s per meter length in wind tunnel tests. Heterogeneous traffic configuration simulated by taking 15 % two -wheelers, 15 % three-wheelers, 5 % buses and 60 % cars at a scale of 1: 100 to generate heterogeneous traffic conditions as seen in the Indian context.

The percentage reduction in normalized concentration (K) values was maximum for an urban road configuration consisting of flyover without buildings/and with downwind side buildings, the percentage decrease is 79 %. For two side building configurations with/and without flyover, the percentage decrease is 50 %. However, the reductions in K value s increased with the height of the building blocks and reached its maximum value of nearly 91 % at the top of the building blocks (z/ H = 0.96) for all traffic volumes. The study has indicated that under perpendicular and oblique wind directions, pollution distribution in the urban street canyon is affected by the central vortex , whereas, during parallel wind flow, the pollution gets dispersed due to channelling of the flow (Zajic D., 2011) Flow and turbulence in an urban canyon. J. Appl. Meteor. Climatol., 50, 203 –223. The effect of traffic produced turbulence reduced significantly with height (z/H). The effect of the vehicle-induced mixing found to be maximum at the pedestrian level, while at sampling locations close to the top edge, the effect of vehicle - induced mixing of pollution observed almost negligible.

The percentage reduction further increased when traffic and wind flow directions were opposite to each other. At the 'innermost corners' of the building blocks, facing the intersection, the percentage reductions in 'K' were more than at 'mid' sections of the building blocks, it may be due to the generation of the corner vortices.

The study has indicated that under perpendicular and oblique wind directions, pollution distribution in the urban street canyon is affected by the central vortex, whereas, during parallel wind flow, the pollution gets accumulated due to channeling of the flow. It is observed that while the increase in traffic increases the pollutant levels in the street canyon, the effect of increased pollution level, to a certain extent , is offset by the increased traffic produced turbulence (TPT) generated by these vehicles.