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Mitigation of Indoor Human Exposure to Traffic-Related Fine Particulate Matter ($PM_{2.5}$)

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Abstract : Motor vehicles emit a number of air pollutants, among which fine particulate matter ($PM_{2.5}$) is of major concern in cities with high population density due to its negative impacts on air quality and human health. Typically, people spend more than 80% of their time indoors. Consequently, human exposure to traffic-related $PM_{2.5}$ in indoor environments has received considerable attention. Most of the public residential buildings in tropical countries are designed for natural ventilation where indoor air quality tends to be strongly affected by the migration of air pollutants of outdoor origin. However, most of the previously reported traffic-related $PM_{2.5}$ exposure assessment studies relied on ambient $PM_{2.5}$ concentrations and thus, the health impact of traffic-related $PM_{2.5}$ on occupants in naturally ventilated buildings remains largely unknown. Therefore, a systematic field study was conducted to assess indoor human exposure to traffic-related $PM_{2.5}$ with and without mitigation measures in a typical naturally ventilated residential apartment situated near a road carrying a large volume of traffic. Three $PM_{2.5}$ exposure scenarios were simulated in this study, i.e., Case 1: keeping all windows open with a ceiling fan on as per the usual practice, Case 2: keeping all windows fully closed as a mitigation measure, and Case 3: keeping all windows fully closed with the operation of a portable indoor air cleaner as an additional mitigation measure. The indoor to outdoor (I/O) ratios for $PM_{2.5}$ mass concentrations were assessed and the effectiveness of using the indoor air cleaner was quantified. Additionally, potential human health risk based on the bioavailable fraction of toxic trace elements was also estimated for the three cases in order to identify a suitable mitigation measure for reducing $PM_{2.5}$ exposure indoors. Traffic-related $PM_{2.5}$ levels indoors exceeded the air quality guidelines (12 $\mu g/m^3$) in Case 1, i.e., under natural ventilation conditions due to advective flow of outdoor air into the indoor environment. However, while using the indoor air cleaner, a significant reduction ($p < 0.05$) in the $PM_{2.5}$ exposure levels was noticed indoors. Specifically, the effectiveness of the air cleaner in terms of reducing indoor $PM_{2.5}$ exposure was estimated to be about 74%. Moreover, potential human health risk assessment also indicated a substantial reduction in potential health risk while using the air cleaner. This is the first study of its kind that evaluated the indoor human exposure to traffic-related $PM_{2.5}$ and identified a suitable exposure mitigation measure that can be implemented in densely populated cities to realize health benefits.

Keywords : fine particulate matter, indoor air cleaner, potential human health risk, vehicular emissions
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