Abstract

[Project Information]

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This study was carried out to estimate emissions of non-exhaust particles, with a particular focus on tyre wear particles (TWP). Various factors potentially related to TWP emissions were investigated through experimental approaches. The method targeted black carbon (BC) particles contained in TWP, enabling real-time measurement of their concentration from moving vehicles using a connected BC monitor. This approach allowed for the evaluation of emissions under a variety of dynamic driving conditions.

The test vehicles included a passenger car, a light-duty truck, and a medium-duty truck, and the test tyres consisted of 'comfort', 'eco', and 'studless' tyres. To express the relationship between vehicle behaviour and TWP emissions in terms of TWP emission factors (EF), the driving tests were divided into straight-line driving and turning manoeuvres. Finally, additional tests were conducted on public roads to gather additional data.

To estimate nationwide TWP emissions, a national vehicle activity database (DB) was developed by integrating road geometry with vehicle activity data across Japan. This DB contains the frequency distributions of tyre forces for each survey section (several kilometres in length) along major roads, as defined in the Japanese Road Traffic Census. For each section, average vehicle speed and second-by-second speed profiles—derived from real-world driving test cycles —were used to calculate longitudinal acceleration, as well as lateral forces resulting from road curvature. Tyre forces were computed using a quasi-steady-state vehicle model, which assumes an instantaneous balance of forces and moments acting

on the vehicle during motion. It also considers variations in load distribution among the tyres. The analysis incorporated two categories of vehicle size: passenger cars and trucks.

Using the TWP EF associated with tyre forces and the national vehicle activity DB, we estimated nationwide TWP emissions through an entirely different approach from the conventional method, which is based solely on vehicle mileage. As a result, the estimated emissions increased by a factor of 1.6 for passenger cars, 3.4 for trucks, and 2.7 overall compared to the conventional method. For trucks, the main reason for the higher emissions is the significantly larger TWP EF, but another contributing factor is the assumption that all rear wheels of freight vehicles serve as drive wheels. Nevertheless, this approach represents a significant innovation, and future efforts will focus on improving the estimation accuracy by addressing the remaining issues.

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