Transport Research Institute
Part of Edinburgh Napier University

To:	Transport & Health Policy Makers, & Practitioners
From:	Professor Adrian Davis
Date:	23rd November 2021
Subject:	Essential Evidence 4 Scotland No.46 The contribution of brake wear to non-exhaust sources of traffic-related emissions

Top Line: As exhaust emissions control become stricter, non-exhaust source contributions and therefore brake wear to traffic-related emissions will become more significant and will raise the issue of regulation.

Traffic-related sources have been recognised as a significant contributor of particulate matter particularly within major cities. Exhaust and non-exhaust traffic-related sources are estimated to contribute almost equally to traffic-related PM10 emissions. Non-exhaust particles can be generated either from non-exhaust sources or pre-existing deposited roadside material and become resuspended due to traffic-induced turbulence. Non-exhaust processes have not yet been adequately studied. Questions regarding physicochemical characteristics, emission factors and adverse health effects of wear particles remain.

The most important abrasion processes which result in direct particulate matter (PM) emission are tyre, brake, clutch and road surface wear, with other potential sources being engine wear, abrasion of wheel bearings and corrosion of other vehicle components, street furniture and crash barriers. Besides direct traffic-related sources, non-exhaust PM exists due to resuspension of material already deposited on the road surface as a result of tyre shear, vehicle-generated turbulence, and the action of the wind. Road dust resuspension can be a significant contributor of PM especially in dryer climates.

In a Literature Review of the evidence of brake wear particle emissions researchers provided evidence of the contribution to total traffic-related emissions.[1] Brake wear has been recognised as one of the most important non-exhaust traffic-related source, with its relative contribution to non-exhaust traffic-related emissions ranging between 16 and 55 % and to total traffic-related PM10 emissions between 11 and 21 % (higher in urban areas). Two brake system configurations have been widely used in modern passenger vehicles: disc brakes, in which flat brake pads are forced against a rotating metal disc, and drum brakes, in which curved brake shoes are forced against the inner surface of a rotating cylinder. Modern passenger vehicles are usually equipped with disc front and rear brakes, while in the past, drum brakes were usually employed as rear brakes. Front brakes have to provide approximately 70 % of total braking power and therefore have to be replaced more frequently than rear ones. The majority of car braking systems consist of frictional pairs made of a disc, a pad and a calliper.

Approximately 50 % of total brake wear is emitted as airborne PM10. The rest may deposit on the road or nearby or maybe attracted by the vehicle. Brake wear contains particles from all fractions involved in the respiratory function. Additionally, some constituents of airborne brake wear particles have been recognised as dangerous or potentially dangerous for the human health.[2] Brake wear dust contains substantial amounts of metallic nanoparticles exhibiting toxicity for lung cells. However, there are no comprehensive studies linking brake wear particles with adverse effects on human health, while it is difficult to extrapolate animal and in vitro studies to humans. Despite the difficulties in measuring and characterising brake wear particles, an increasing number of researchers and experts have already raised a discussion on the need for regulating emissions from non-exhaust sources including brake wear.

[1] Grigoratos, T., Martini, G. 2015 Brake wear particle emissions: a review, *Environmental Science Pollution Research*, 22:2491–2504 DOI 10.1007/s11356-014-3696-8

[2] Puisney, C. et al, 2018 Brake wear (nano)particle characterization and toxicity on airway epithelial cells in vitro, *Environmental Science: Nano 5*: 1036 – 1044. DOI https://arxiv.org/ct?url=https%3A%2F%2Fdx.doi.org%2F10.1039%2FC7EN00825B&v=6783dd24