RR 683: Determining the ecological and air quality impacts of particulate matter from vehicle brake and tyre wear and road surface dust: Stage 1 - literature review and recommendations for developing new emission factors for New Zealand

Waka Kotahi research summary

October 2021

Determining the ecological and air quality impacts of particulate matter from vehicle brake and tyre wear and road surface dust: review and recommendations

Air- and water-borne emissions from road transport are significant pollutants from all vehicles. These emissions come not only from exhaust – they also come from particles emitted by tyres and brakes. Today, electric vehicles make up only 0.3% of the current fleet, but could increase up to about 50% of passenger vehicles by the 2040s. Therefore, non-exhaust emissions (NEEs) will also increase in importance relative to tailpipe emissions. This study gathered information on NEEs to assess and ultimately reduce their risks to humans and the environment.

Types of vehicle pollution

The major sources of particles from road transport in the air are:

- combustion engine exhaust
- particles from abrasion of brakes and tyres
- on-road particles that are lifted and resuspended by wind or passing traffic.

Particles from road transport found in stormwater are particles from the same sources listed above that have settled on the road surface and been washed off the road by rain.

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New data needs to reflect new vehicles

In this study, NIWA researchers provide updated information on NEEs from vehicles in New Zealand. Waka Kotahi estimates the environmental impact of traffic on air and water quality using estimates of emission factors (EFs) – the mass of a contaminant emitted by a vehicle for each kilometre it travels. The contaminants of interest for air are particles that are ≤2.5 µm ($PM_{2.5}$) and ≤10 µm (PM_{10}). These particles sizes can be breathed in by people, causing a possible health risk. The contaminants of interest for water quality are zinc (from tyre wear) and copper (from brake wear) and particles (called sediment) for water quality. These contaminants can affect ecosystem health of streams and rivers.

Emission factors (EFs) are used to characterise the amount of the contaminants above emitted by vehicles. Current EFs for NEEs are old and don't reflect ongoing modernisation of the vehicle fleet. To address this, Waka Kotahi proposed a two-stage programme:

- Stage 1: this desktop study – to identify and collate existing NEE data, determine the gaps in the data and recommend ways to address them
- Stage 2: a later project that is yet to be commissioned that acts on the recommendations from Stage 1.

Non-exhaust EFs can be estimated using two approaches.

- **'Emissions from vehicles'** measures the amount of each contaminant from vehicles or vehicle parts (ie brakes and tyres) directly under controlled experiments representing different types of vehicles (eg trucks and cars) and road surfaces, and vehicle speed and braking. The EFs are then used to calculate the amounts of each contaminant released along a section of road over a set period of time based on the numbers of each vehicle type, the type of road and driving conditions.
- **'Emissions to air and water'** measures the mass of contaminants in air, road dust and road runoff. It apportions the mass to brake, tyre and road wear based on the chemical and physical properties of the contaminant. Per-vehicle emissions are then estimated by dividing the contaminant mass by the traffic volume to give EFs that are representative of the road's type, traffic and driving conditions. These EFs can be used in the same way as above to estimate contaminant loads from other road sections.

Figure 3.1 Factors affecting the amount and composition of NEEs from vehicles

Emissions from vehicles

The researchers found that the wear rates reported for brakes, tyres and roads vary greatly between different studies due to differences in brake and tyre composition, driving conditions tested and the metrics reported. NEEs are generally greater from heavy, rather than light, vehicles. Other factors influencing NEEs include:

- driving conditions (eg road slope, traffic congestion)
- driver behaviour (eg speed, braking habits)
- climate.

For example, free-flowing high-speed traffic usually means lower brake emissions than slow, congested traffic, but greater amounts of road and tyre wear. Urban roads generally have higher emissions than rural roads due to the stop–start nature of urban driving. Emissions are also greater at bends and intersections due to braking.

The report also discusses the effects of changing technologies and legislation, such as the development and growth of EVs, and restrictions on copper used in brakes.

Emissions to air and water

NEEs from vehicles can be released to air, fall to the road surface as road dust, or be retained by the vehicle. Airborne particles can remain aloft, be transported away or deposited on the road surface. Surface dust can be resuspended by wind and traffic or washed off and transported in runoff during rainfall.

Gap analysis

The researchers found many gaps in understanding NEEs. This makes it hard to choose the most appropriate EFs for New Zealand use. The gaps include:

- a lack of current information on NEEs – most studies were published before 2005
- inadequate reporting of traffic flows and runoff volumes needed to calculate the mass of the contaminant released by vehicles
- whether NEE data from case-study locations can be used in other countries or regions
- a limited number of studies about impacts of new technologies and changes in fleet composition on NEEs
- no standard methods for determining EFs, and uncertain methods used and variability in the metrics reported

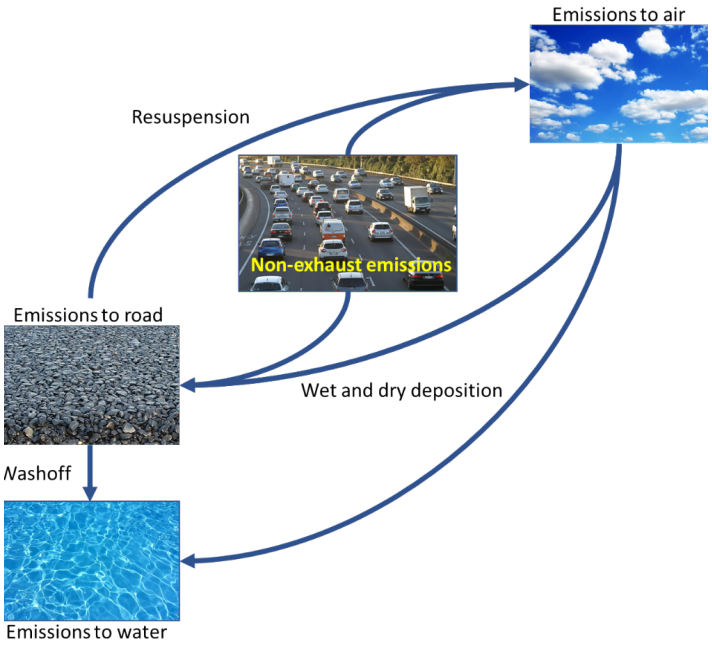

Figure 4.1 Schematic overview of the apportionment of NEEs to air and water

- variability in composition of brakes, tyres and roads investigated between studies
- difficulty linking NEEs to specific sources due to multiple sources of contaminants – not just those related to transport such as zinc from galvanised steel roofing
- being unable to separate old settled particles that have been lifted from the road surfaces from newly emitted particles, meaning possible double counting
- inconsistencies in estimated wear rates, and in air and water quality.

Recommendations for the next stage

The researchers recommend that Stage 2 of the research programme fill these gaps in two tranches.

Tranche 1 will undertake:

- a re-analysis of air quality data held by GNS Science to apportion airborne particles from traffic to vehicle types
- a sensitivity analysis of air and water quality models to get an understanding of how the choice of EF affects estimates of NEEs in air and water.

From there, Waka Kotahi may decide to retain the current EFs, or develop new monitoring and modelling to test a new set of EFs for New Zealand in Tranche 2.

RR 683 – Determining the ecological and air quality impacts of particulate matter from vehicle brake and tyre wear and road surface dust: Stage 1 - literature review and recommendations for developing new emission factors for New Zealand, Waka Kotahi NZ Transport Agency research report. Available at **www.nzta.govt.nz/resources/research/reports/683**