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Microplastic pollution from tyre-wear: a review of source, emissions and risk

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Tyre-wear particles, which may account for a large proportion of microplastic pollution, are the focus of a recent review of studies on the environmental concentrations and impacts of non-exhaust vehicle emissions. The review finds that there is no data on the potential risk from ingestion via the food chain, and little information from either long-term monitoring, or on the particles' ecotoxicological effects.

Alongside vehicle exhaust, road traffic also produces pollution in the form of brake wear, road dust re-suspension and tyre-wear particles — the focus of this review. Recent risk assessment indicates that inhalation risk from tyre-wear particles is probably low. Most of these particles enter soil and water; however, there is little information on risk through food intake, for example. Meanwhile, monitoring of tyre-wear particle concentrations in the environment is hindered by a lack of common, reliable methodologies, reveals this recent review which assesses studies on tyre-wear particle emissions, discussing their concentrations in, and potential impacts on, the environment and human health.

About 1.3 million tons of tyre-wear particles are generated on Europe's roads each year. Approximately half of this is natural and synthetic rubber, making these particles a potential key source of synthetic polymer material released into the environment; the contribution of tyre-wear to total microplastic emissions is reported to be 50% in Denmark and Norway and about 30% in Germany, for instance.

When ingested by organisms, synthetic particles can have harmful effects, reducing food-intake ability or causing toxic impacts. Data on the effects of tyre-wear leachates on aquatic species show toxic effects connected with metals including zinc and organic compounds such as benzothiazoles. While differences in tyre composition, test design and species sensitivity may give rise to a wide range of toxicity data; studies report acute toxic-effect concentrations ranging from 25 to 100 000 milligrams (mg) of tyre-wear particles per litre of water. The reviewers also

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suggest that studies using crushed tyres, for example, do not reflect real-world conditions. Tyre particles are rarely found in their pure form in the environment and are instead found mixed with other particles — a mix termed "tyre- and road-wear particles" (TRWP).

TRWP roll and collect fine dust on the road, and include metal particles from sources such as brakes. Their size and average content varies; one study found 50 to 90 percentage by volume (vol %) rubber content, while another found 53% minerals and 23% polymers related to mass. Some particles may also be nanoparticles.

Toxicity of TRWP probably differs from laboratory test materials and future tests using TRWP collected in the environment, at concentrations found in surface waters, would be useful to confirm previous results, say the researchers. Data on toxicity in soil, meanwhile, is very scarce, with few studies showing ground tyre rubber in potting soil leading to growth reduction of some species.

Overall, less than 10% of TRWP emissions are airborne; and although this may contribute up to 11% of large particulate pollution in mass terms, the study reports that the health risk may be low, though this may not hold for all regions of the world, especially developing countries. Also, particularly vulnerable groups were not considered in this assessment. Further data is needed to confirm this conclusion. However, when assessing the relative health impacts of tyre particulate to other non-exhaust emissions (metals in brakes in particular) and to exhaust particles, the relevance of tyre particles appears to be several orders of magnitude lower.

The EU's TRWP emissions are estimated at 1.3 million tons/year or 2.6 kg per person, though cited estimates per person for individual countries are generally much lower, e.g. 0.7 to 1.7 kg per person for Germany, 0.6 kg per person in France and 0.5 kg/person in the Netherlands (after taking into account the fact that particles were largely trapped in pores in the road surface).

As tyre tread and TRWP have complex chemical compositions, zinc and vulcanisation chemicals (used in the process by which physical properties of rubber are altered) are often used as markers to detect TRWP in the environment. But several markers can also come from sources including de-icing salts, road barriers, antifreeze liquid and clutch linings, which have a similar function, and therefore composition, to brakes. Thermo-analytical methods, which involve heating samples and detecting degradation products, are more reliable, say the researchers.

Studies show highly variable TRWP concentrations in road runoff (5 to 92 milligram per gram (mg/g)), and roadside soils (0.1 to 160 mg/g dry weight). The highest concentrations were found in tunnel dust (maximum 204 mg/g) and sediments of a treatment basin for road runoff (up to 150 mg/g). Following rainfall, TRWP lands up to 1.5 metres adjacent to roads, where there is no man-made drainage. Air turbulence may also transport particles up to 6 metres from a road (this is particularly true of motorways, but less for urban roads).

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A study of roadside soils in Germany found a TRWP range from 0.4 to 158 mg/g of soil, but it must be noted the roads partly had zinc-coated safety barriers. Similar levels were found in the Seine river basin. The review suggests that data on TRWP degradation in soil is scarce — one study suggests a half-life of 16 months, but less for natural rubber — and that additives may hinder biodegradation.

TRWP enters sewage systems through roadside drainage. The Conference of European Directors of Roads (CEDR) states that, in accordance with the EU Water Framework Directive, polluted road runoff (e.g. from tunnels) must be cleaned before it is released to surface waters. Data for microplastics suggests that larger particles are trapped in sewage sludge, and that cleaning efficiency is over 90% for particles greater than 500 micrometers in waste-water treatment plants. One analysis of sludge in Berlin found TRWP concentrations of 150 mg/g in the soil retention filter of a road-runoff treatment system, reducing to 16 mg/g at the point of discharge. Where road runoff enters domestic sewage systems, however, part-treated water may be released after heavy rainfall.

Modelling studies on a few rivers indicate that most TRWP in surface waters is not transported into marine environments. But these results may not be accurate for other river basins and all hydrological conditions, say the researchers, who note that there are few studies on TRWP in marine sediments. Ingesting synthetic particles can harm organisms, and studies on aquatic species have found toxic effects, which are attributed to zinc, metals and organic compounds (e.g. phthalates and anti-oxidants[1]). However, the review posits that laboratory tests often do not reflect real-world conditions.

The researchers note that most of the reviewed monitoring studies test new analytical techniques, such as markers. They posit that repeated sampling over long periods is needed to investigate environmental concentrations of TRWP. Data suggests that large amounts are emitted each year, but with unknown ecotoxicological effects. The researchers call for more investigations with real-world samples and, based on the precautionary principle, mitigation measures including:

- addressing stormwater and runoff treatment systems;
- maintaining and designing roads considering particulate capture; and
- removing low durability tyres from the market, particularly for heavy-duty vehicles which are the largest source of tyre particulate.

The researchers add that traffic-related measures, such as use of lighter vehicles, will also reduce environmental impacts such as CO_2 and NO_x emissions, as well as noise[2].

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1. Z. Tian *et al.* 2020. A ubiquitous tire-rubber-derived chemical induces acute mortality in coho salmon. *Science*, 371: 6525, 185–189. Doi: 10.1126/science abd6951

2. Tyres are the main cause of road noise, which, EU-wide, causes 48 000 cases of ischaemic heart disease a year: see: https://www.eea.europa.eu/publications/environmental-noise-in-europe