Wear and Tear of Tyres in the Global Environment: Size Distribution, Emission, Pathways and Health Effects

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1. Introduction

In this document we show that wear and tear from tyres significantly contributes to the flow of (micro) plastics into the environment. Our study compiles the fragmented knowledge on tyre wear and tear characteristics, amounts of particles emitted, pathways in the environment, and the possible effects on humans.

2. Materials and methods

We performed a literature study which covered four aspects of tyre wear and tear: (1) particle size distribution, (2) amount of tyre emitted as wear and tear from road contact, (3) spreading into the environment, and (4) effects of the particles on human health. Apart from these issues we provide some thoughts on mitigation. Literature on particle size is fragmented. Studies focus on just a part of the total size range and depend on the technical specifications of the equipment and analytical techniques used. Notwithstanding these restraints, we provide a general view on particle size distribution by combining data from different studies. The amount entering the environment was estimated in two ways. One uses emission factors per vehicle-km multiplied by the total mileage; the other uses the number of tyres multiplied by the weight loss during use. Tyres in Europe must be collected after use and processed by the manufacturer or importer. Therefore, almost all used tyres will be handed in and, hence, the numbers are known. To predict the global number of tyre wear and tear released into the environment, we retrieved figures on mileage and tyres used for a substantial number of countries. When estimating the spreading of tyre wear and tear in the environment, we considered PM entering the air and the run off from roads entering sewers and surface waters. In most studies on microplastics, tyre wear and tear is not dealt with separately and we therefore use data on microplastics as an indicator to describe the possible pathways of tyre wear and tear. To provide an overview of knowledge on the health effects from tyre wear and tear we looked at two intake routes: by air in the human respiratory system and by food in the digestion system.

3. Results and discussion

3.1. Size of Wear and Tear

Literature data show a considerable variation in the size distribution of tyre wear and tear particles,covering the range from 10 nm to several 100 µm; 10 nm being the lower threshold. The smaller size ranges of wear and tear correspond to the size of carbon black that is added to the tyres during the production process, having particle sizes from 1 to 30 nm.

3.2. Estimates on the Amount of Wear and Tear from Tyres

We managed to gather data covering half the world's inhabitants (Table 1). The emission per capita is in the same order of magnitude for all countries, i.e., between 0.23 and 1.9 kg/year, but 4.7 kg/year for the USA. If the mileage of the 1,054 million vehicles in Table 1 is considered representative for all the world's 1,776 million vehicles, the world total amount of emitted tyre wear and tear is 1,776 / 1,054 × 3,477.583 tonnes/year = 5,859,760 tonnes/year. On a global population of 7,323 million people, the amount of emitted tyre dust per person equals 5,860 million kg / 7,323 million people = 0.80 kg/year.

3.3. Pathways into the Environment

In the Netherlands an estimated 12% of the tyre wear and tear released from the road is contributing to PM matter in air. To sewers 15% is released and to surface waters 6%. The contribution of tyre wear and tear to the global loading of the ocean with plastics has been estimated to be in the range of 5–10%.

	Number of Capita	Number of Cars	Total Emission (tonnes/y)	Emission/Capita/year (kg)
Denmark	5,593,785	2,911,147	6721	1.2
Norway	5,265,158	3,671,885	7884	1.5
The Netherlands	17,016,967	9,612,273	8834	0.52
Sweden	9,880,604	5,755,952	13,238	1.3
Australia	22,992,654	17,180,596	20,000	0.87
Italy	62,007,540	51,269,218	50,000	0.81
United Kingdom	64,430,428	35,582,650	63,000	0.98
France	67,364,357	42,792,103	75,291	1.2
Germany	80,722,792	52,391,000	125,188	1.6
Japan	126,702,133	76,763,402	239,762	1.9
India	1,266,883,598	159,490,578	292,674	0.23
Brazil	205,823,665	81,600,729	294,011	1.4
China	1,373,541,278	250,138,212	756,240	0.55
USA	323,995,528	265,043,362	1,524,740	4.7
Sum :	3,632,220,487	1,054,203,107	3,477,583	Average: 0.96

Table 1: The amount of wear and tear of car tyres per country per capita per year

3.4. Health effects

Tyre wear and tear has been estimated to contribute 3–7% to PM2.5 and the toxic potential of PM2.5 has been well established. Using PM2.5 as an exposure metric, the WHO recently estimated that outdoor air pollution was responsible for 4.2 million deaths globally in 2016 from which 77,550 in the USA, 5,320 in the Netherlands and 1,028 in Finland [2]. It is yet unkown how much tyre wear and tear contributes to this death toll, but if it contirubutes relative to its weight fraction, it would be reponsible for 130,000-300,000 annual deaths globally, from which 2,330–5,430 in the USA, 160-370 in the Netherlands and 30–70 in Finland.

3.5. Mitigation

Tyre wear and tear will remain in the environment for a long time. The degradation half-life of tyre wear and tear in soil is estimated at 490 days; in sediment it is considered to be one order of magnitude less, 4900 days [3]. Currently there is no alternative material for tyres; but the precautionary principle urges for mitigation. Waste water treatment plants should become more efficient, tyres more wear resistant and more roads should be made from open asphalt concrete capturing wear and tear. A major contribution could be expected from self-driving cars which can be programmed to reduce wear and tear by quiet acceleration, taking bends slowly and anticipation to traffic circumstances. Policy should steer this development.

4. Conclusions

We demonstrated the per capita emission of micronized tire rubber to the environment ranging from 0.23 to 4.7 kg/year, with a global average of 0.80 kg/year. Emissions and pathways depend on local factors like road type and sewage systems. The relative contribution of tyre wear and tear to the total global amount of plastics ending up in our oceans is estimated to be 5–10%. Tyre wear and tear is estimated to contribute 3–7% to PM2.5. The WHO estimated 4.2 million deaths globally from outdoor PM in 2016. This suggests a potential 130.000 - 300.000 annual deaths from tyre wear and tear. The wear and tear also enters our food chain, but further research is needed to assess human health risks. Micronized tire rubber should be considered as part of the microplastic family. For primary microplastics as a product, alternatives can be used as shown in cosmetics. However, for tyre wear and tear no practical alternatives are known. Mitigation should therefore focus on emission reduction, i.e. the development of wear resistant tyres, self-driving cars (less wear), open asphalt concrete roads (capturing wear and tear) and improving sewers and waste water treatment plant efficiency. It is concluded here that tyre wear and tear is a stealthy source of microplastics in our environment, which can only be addressed effectively if awareness increases, knowledge gaps on quantities and effects are being closed, and creative technical solutions are being sought. This requires a global effort from all stakeholders; consumers, regulators, industry and researchers alike.

5. References

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