Policy brief on tyre wear particles

Major source of microplastics in the environment

Baltic Marine Environment Protection Commission

The problem

Tyre and road wear particles originate mainly from tyre rubber, but also from road markings and sometimes from polymer modified bitumen, which is used in the asphalt (Andersson-Sköld, 2020). Tyre wear particles have been identified as a major source of microplastics in the environment (Sundt et al. 2016, Eunomia & ICF 2018, Hann et al. 2018, Setälä & Suikkanen 2020). Among traffic microplastic particles, pure tyre wear particles exist in very low quantities in the environment, while most of the tyre wear particles are associated with road material (Grigoratos & Martini, 2014; Svensson & Andersson-Sköld 2021). Other traffic related sources of microplastics which are not related to tyre and road wear, such as crashed vehicles, littering and wear from certain brake pads, are not addressed in this policy brief.

Today, the knowledge on tyre and road wear particles is limited, in particular on the presence, pathways, exposure and effects on human health and the environment. Despite this, several facts are to be pointed out: emissions from tyre and road wear are very high; the particles are likely to be persistent in the environment; and particles themselves, the hazardous substances in the particles or sorbed on their surfaces, may cause negative impacts on organisms (Andersson-Sköld et al. 2020).

Road traffic is expected to increase, including the number of electric vehicles. Thus, at EU level, estimates suggest that passenger transport will increase by 42% by 2050, and freight transport by 60% (EC 2019). Passenger car fleet is also becoming bigger, heavier and more powerful (i.e. sport utility vehicles). For instance, sales of sport utility vehicles have doubled in the last 10 years and now account for about 40% of all new cars in the global market according to the International Energy Agency, IEA (IEA 2019).

Tyre and road wear particles may end up in the aquatic or terrestrial environments through many different pathways. These pathways include various transport and transformation processes influenced by different factors depending on local conditions making the overall picture very complex (Vogelsang et al. 2020). However, stormwater and air are known pathways for tyre and road wear particles ending up in the aquatic environment (Essel et al. 2015, Lassen et al. 2015, Eunomia 2016, Sundt et al. 2016, Verschoor et al. 2016, Boucher & Friot 2017, Kole et al. 2017).

Regulatory framework

There are not currently, to our knowledge, regulatory measures addressing the issue of tyre and road wear particles, including the minimum wear rate for tyres (Hann et al. 2018) nationally, regionally nor at EU level. However, several EU measures on microplastics from various sources are under development.

In 2019, upon request from the European Commission, the European Chemicals Agency (ECHA) proposed an EU restriction on intentionally added microplastics in products and the restriction is to be adopted in 2021 or 2022, if agreed by the European Commission and EU member states (ECHA, 2021). However, this restriction concerns only primary microplastics and EU has planned to tackle the issue of plastic pollution more widely addressing both intentional and unintentional sources of microplastics. In relation to this, EU launched in early 2022 a consultation for an upcoming EU proposal on measures to reduce microplastics that are unintentionally released into the environment, in which tyre wear is pointed out as one of the main sources. The consultation is focused on labelling, standardization, certification, and regulatory measures for the main sources of microplastics (EC 2022).

Finally, the EU's 'Sustainable and Smart Mobility Strategy' aiming at reducing transport related greenhouse gas (GHG) emissions by at least 90% by 2050 compared to 1990 is to be pointed out. However, a carbon neutral transportation system is to be considered in conjunction with other traffic related contamination, such as tyre and road wear particles.

Practical solutions to mitigate the problem

Due to the strong correlation between the number of kilometres travelled by road vehicles and the amount of tyre and road wear particles being generated, a reduction in the demand for transportation, more effective use of vehicles used for road transport, and a switch from travelling by car to walking, cycling and public transport, and from transport by trucks to transport on railroad and/or water will reduce the number of tyre and road wear particles generated (Johannesson & Lithner 2022).

The amounts of microplastics being emitted from tyre and road wear depend on vehicle type, asphalt type, speed, tyre type, driving style, etc. Thus, heavier and more powerful vehicles and vehicles with a faster acceleration capacity, like electric cars which can accelerate faster than many traditional cars, generate more tyre wear particles. Electric cars are today generally heavier than cars that run on liquid fuels or gas, due to the weight of the batteries. A lighter electric car with less engine power and slower acceleration is better from a microplastic, energy and resource perspective than a heavier electric car with a more powerful engine and faster acceleration. The same applies when comparing lighter and less powerful petrol or diesel cars with heavier and more powerful petrol and diesel cars, respectively. In general, smaller and lighter cars are more environmentally friendly than larger and heavier cars (Johannesson & Lithner 2022).

When it comes to speed, Pohrt (2019) estimates that reducing the speed through a bend from 50 km/h to 30 km/h may reduce tyre wear by up to 13 per cent.

Asphalt and painted road markings are worn down by traffic, and the use of studded tyres by a significant proportion of vehicles, as well as maintenance tasks, such as snow clearing, accelerate the process (Svensson & Andersson-Sköld, 2021). Thus, in general, the presence of tyre and road wear particles in the environment can be reduced through preventive and removal methods. The most efficient way is through preventive methods influencing the factors that affect tyre and road wear (Sundt et al. 2016). These are related to proper use of tyres, driving behavior (eco-driving), and the characteristics of the tyres (more durable, in terms of tyre wear) as well as road surfaces (optimizing road surface to be smoother without affecting required traffic safety conditions). Removal methods are related to improved sewers, road cleaning, stormwater treatment and, for example, treatment of urban dust and snow (Winquist et al. 2021).

Preventive methods

Preventive measures to reduce tyre and road wear particles emissions include proper use of tyres, driving behavior and tyre characteristics (Table 1). An optimal tyre pressure is also to consider as well as the steering angles of the tyres, i.e. wheel alignment, which should be checked regularly, e.g. once a year (Firestone 2019).

Table 1. The questionnaire sent to PLC-6 project members in 2015.

Factor		Good practices	How to implement them
Proper use of tyres	Tyre pressure	Regular checking, varies also depending on the load	Education for drivers
	Wheel alignment	Regular checking once a year, occasionally more often if needed	Education for drivers, yearly inspections obligatory
Driving behaviour	Fast acceleration and heavy braking, high cornering speeds, high speed in general	Smoothly driving, tyre wear comparable to fuel consumption	Education for drivers, fuel consumption/tyre wear meter
Tyre characteristics	Summer tyres, non-studded winter tyres, studded tyres, all season tyres	Proper selection of tyres according to weather conditions and driving needs	Local guidelines for tyre selection, public awareness raising campaigns
	Tyre properties	Product development: chemical composition and pattern of the tyre tread	EU regulation for tyre wear, subsidies for eco-tyres (analogy with subsidies for electric vehicles)

Drivers can influence the tyre wear with their driving behavior. Sundt et al. (2016) estimated that by avoiding unnecessary rough driving there would be a potential to reduce the tyre wear particle generation by 10 %. An initiative for a tyre wear meter, "Ecometer", was proposed during the DEEP Microplastic Challenge 2019 (https://thinkcompany.fi/portfolio/microplastic/), an event organized as part of the FanpLESStic-sea project. The idea was to combine the tyre wear with driving-related factors in a similar manner than in a fuel consumption meter.

Currently, the EU tyre label regulation (EU 2020/740) focuses on three elements: fuel efficiency, wet grip and external rolling noise aiming at guiding both the manufacturers and customers towards more fuel-efficient, safe and quiet tyres; however, neither tyre wear nor chemical content of the tyres is included in this regulation (Johannesson & Lithner 2022). Despite the lack of regulation, there are forerunners among tyre manufactures who have identified the problem with traffic microplastics originating from tyre wear. Thus, one example could be a new eco-design which combines low rolling resistance with decreased tyre wear and fuel consumption. Test drives in Nordic countries and Russia shows 35% decreased tyre wear compared to previous model, which accounts to ca. 10,000 km depending on driving behavior (Tuulilasi 2020).

In Nordic conditions with seasonal variation, tyre characteristics vary also between winter and summer tyres. Thus, it is important to select the right tyres according to weather conditions. No winter tyres, not even non-studded ones, should be used during the summer – their performance is not appropriate for high temperature and their wear rate may be very high. For milder winter conditions, non-studded tyres are a better option than studded ones which may not be allowed under certain conditions.

In addition, measures that lead to a reduction in the number of vehicle-kilometres travelled can reduce the generation of tyre and road wear particles significantly. This includes those that make it more difficult for private and goods vehicles to use the roads, as well as those that promote alternative means of transportation or the avoidance of travel (OECD 2020).

Finally, from the life cycle perspective, the mismanagement of tyres into the environment may potentially lead to microplastics generation and leakage. Also, certain recycling options for end-of-life tyres (e.g. the use of tyre rubber granulate as infill in artificial sport turfs or as in moulded rubber granule surfaces, such as fall protections and multicourts present in playgrounds) constitute a further source of microplastics into the environment (OECD 2021, Olshammar et al. 2021). Therefore, measures are to be taken to support the prevention of rubber granulate leakage in the design and operation of artificial turf pitches. Examples of those include the installation of infrastructure which prevents the emission of rubber granulate particles (e.g. side paved areas around the pitch, cattle grids and brushing stations located near the pitch entrance, drainage and filtration systems for runoff) and the routine maintenance of the pitch (EuRIC, 2020, Eunomia & ICF 2018).

Removal technologies

Existing methods for the removal of microplastic-containing road runoff particles are usually based on sedimentation, especially for larger and higher density particles. Filtration and adsorption are also important mechanisms especially for finer particles (Vogelsang et al. 2020, Andersson-Sköld et al. 2020). Urban and highway stormwater runoff are direct pathways for land based solid particles including microplastics and other traffic-borne particles into freshwaters. The traditional management practice for stormwater in urban areas has been to channel it in underground stormwater networks to the nearest waterbody without any treatment.

Stormwater management methods for separate sewer systems include roadside gully pots and various nature-based solutions (Vogelsang et al. 2020). Nature-based solutions, so-called sustainable drainage systems in urban areas include infiltration chamber systems and dry swales (Vogelsang et al. 2020). Stormwater ponds and wetlands can be an effective way to separate microplastics. High separation efficiencies of 90–100 percent for microplastic particles larger than 20 µm have been demonstrated (Jönsson 2016). However, data on the efficiency of these stormwater treatment methods for removal of tyre associated microplastic particles is lacking. However, there are novel results on microplastic removal efficiency from stormwater runoff using a concrete-based filtration system with two comparative fine filtration media (sand and biochar, Pankkonen 2020).

In urban areas with a combined sewer system, stormwater runoffs end up in local wastewater treatment plants (WWTPs), which can, according to many recent studies, remove up to 99% of the microplastics in the influent during the primary and secondary treatment processes (Simon et al. 2018, Sun et al. 2019). However, no data on the removal efficiency of WWTPs for road traffic associated microplastics has yet been published (Vogelsang et al. 2020).

Street cleaning is also used to reduce the amounts of dust and pollutants in urban air. Street sweeping has been shown to collect considerable amounts of tyre and bitumen microplastic particles. Therefore e.g. weekly street sweeping might prevent transport of these microplastics via stormwater out in the environment (Järlskog et al. 2020), particularly if plastic brushes are not used, and provided that sweep sand and water from sweeping are managed appropriately (Johannesson & Lithner 2022).

There is currently scarce data on the amounts of microplastics from tyre and road wear present in cleared snow from roads (Pikkarainen 2017) and the risks they may pose when large volumes of snow are deposited on land, or when exemptions are made, depending on national regulations, to allow snow to be dumped in water (Johannesson & Lithner 2022). This may be due to the difficulties of analysing tyre wear emissions in environmental samples (water, soil, sediment). Therefore, further research and development on harmonization of sampling, sample preparation and analytical methods for tyre and road wear particles is needed to better evaluate and understand the problems associated to tyre and road wear particles.

Key messages

From the analysis of the tyre and road wear particle problematic contained in this policy brief, the following messages could be extracted:

Prioritize measures that prevent or reduce the formation of tyre and road wear particles over measures that stop or decrease their spread to the environment, since, in general, they are more cost-effective. Simple preventive methods are related to the use of tyres (regular checking of tyre pressure and wheel alignment), driving behavior (avoiding fast acceleration, high speed and heavy braking), and tyre characteristics (non-studded instead of studded tyres, tyres with better wear resistance).

In addition to decreasing microplastics emissions from tyre wear, these measures provide other benefits such as improved air quality in cities and safety in traffic and decreased noise pollution, fuel consumption and greenhouse gas emissions.

Promote the use of train, bus, cycling and walking instead of private vehicles by i.a. improving the required infrastructure, providing bicycle-sharing systems, municipal carpools.

Disincentive the use of private vehicles by introducing environmental zones, banning cars on certain roads or during certain times, reducing the number of car parking spaces, introducing taxes on road vehicles.

Discourage purchases of heavy, powerful and high-torque petrol, diesel, or hybrid cars versus light weight fully electric cars.

Provide positive and negative incentives for "eco-tyres" to improve the technology development and market penetration of tyres, which wear less and contain less hazardous compounds.

Develop tyre labels that include a standardized wear rate marking and chemical content.

Raise awareness through a more comprehensive education for drivers and campaigns on the traffic microplastic issue in general. In addition to guiding the drivers towards more economic driving, they would also lengthen the lifetime of tyres and decrease the tyre wear.

Consider traffic related contamination such as tyre and road wear particles together with a carbon neutral transportation system towards a sustainable transport system.

Further research to develop both environmentally friendly and cost-effective microplastic removal methods related to traffic microplastics, as well as on effective preventive measures.

Further development and harmonization of sampling, sample preparation and analytical methods for tyre and road wear particles to better evaluate and understand the problem.

References

Andersson-Sköld, Y., Johannesson, M., Gustafsson, M., Järlskog, I., Lithner, D., Polukarova, M. & Strömvall, A.-M. 2020. Microplastics from tyre and road wear - A literature review. Swedish National Road and Transport Research Institute (VTI), VTI rapport 1028A. http://vti.diva-portal.org/smash/get/diva2:1430623/FULLTEXT02.pdf

Boucher, J. & Friot D. 2017. Primary Microplastics in the Oceans: A Global Evaluation of Sources. Gland, Switzerland: IUCN. 43pp.

ECHA 2021. Microplastics. https://echa.europa.eu/hot-topics/microplastics (accessed 21 March 2022)

EC 2022. European Commission. https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12823-Microplastics-pollution-measures-to-reduce-its-impact-on-the-environment/public-consultation_en (accessed 21 March 2022).

EC 2019. European Commission. Transport in the European Union. Current Trends and Issues. March 2019. https://www.amt-autoridade.pt/media/1934/2019-transport-in-the-eu-current-trends-and-issues.pdf (accessed 21 March 2022)

Essel, R., Engel, L., Carus, M. & Ahrens, R. 2015. Sources of microplastics relevant to marine protection in Germany. Federal Environment Agency of Germany. https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/texte_64_2015_sources_of_microplastics_relevant_to_marine_protection_1.pdf

Eunomia 2016. Study to support the development of measures to combat a range of marine litter sources, Report for European Commission DG Environment. https://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/MSFD%20Measures%20to%20Combat%20Marine%20Litter.pdf

Eunomia & ICF 2018. Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products. Final report for DG Environment of the European Commission. https://www.eunomia.co.uk/reports-tools/investigating-options-for-reducing-releases-in-the-aquatic-environment-of-microplastics-emitted-by-products/

EuRIC 2020. Implementation of best practices in synthetic turfs to avoid the release of microplastics from rubber granulate into the environment, European Recycling Industries' Confederation, https://www.euric-aisbl.eu/position-papers/item/350-implementation-of-best-practices-in-synthetic-turfs-to-avoid-the-release-of-microplastics-from-rubber-granulate-into-the-environment.

Firestone 2019. Do I Need an Alignment with New Tyres? https://www.firestonecompleteautocare.com/blog/alignment/do-i-need-an-alignment-with-new-tires/ (accessed 21 March 2022).

Grigoratos, T. & Martini, G. 2014. Non-exhaust traffic related emissions. Brake and tyre wear PM. JRC Science and policy reports, European Union 2014. https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/non-exhaust-traffic-related-emissions-brake-and-tyre-wear-pm

Hann, S., Sherrington, C., Jamieson, O., Hickman, M., Kershaw, P., Bapasola, A. & Cole, G. 2018. Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products. Final report for DG Environment of the European Commission. https://www.eunomia.co.uk/reports-tools/investigating-options-for-reducing-releases-in-the-aquatic-environment-of-microplastics-emitted-by-products/

IEA 2019. World Energy Outlook 2019, International Energy Agency, Paris. https://www.iea.org/reports/world-energy-outlook-2019

Johannesson, M., Lithner, D. 2022. Potential policy instruments and measures against microplastics from tyre and road wear: Mapping and prioritisation. Swedish National Road and Transport Research Institute (VTI). http://vti.diva-portal.org/smash/get/diva2:1641512/FULLTEXT01.pdf

Jönsson, R. 2016. Mikroplast i dagvatten och spillvatten - Avskiljning i dagvattendammar och anlagda våtmarker (Master Thesis). The Department of Earth Science, Uppsala University.

Kole, P.J., Löhr, A.J., Van Belleghem, F.G.A.J. & Ragas, A.M.J. 2017. Wear and Tear of Tyres: A Stealthy Source of Microplastics in the Environment. Int. J. Environ. Res. Public Health 2017, 14, 1265. https://doi.org/10.3390/ijerph14101265

Lassen, C., Foss Hansen, S., Magnusson, K., Norén, F., Bloch Hartmann, N. I., Jensen, P. R., Nielsen, T.G. & Brinch, A. 2015. Microplastics - Occurrence, effects and sources of releases to the environment in Denmark, Environmental project No. 1793. The Danish Environmental Protection Agency. https://www2.mst.dk/Udgiv/publications/2015/10/978-87-93352-80-3.pdf

OECD 2021. Policies to Reduce Microplastics Pollution in Water: Focus on Textiles and Tyres, OECD Publishing, Paris. https://doi.org/10.1787/7ec7e5ef-en.

OECD 2020. Non-exhaust particulate emissions from road transport, an ignored environmental policy challenge. OECD Publishing, Paris. https://doi.org/10.1787/4a4dc6ca-en

Olshammar, M., Graae, L., Robijn, A. (IVL) & Nilsson, F. (KTH). 2021. Microplastic from cast rubber granulate and granulate-free artificial grass surfaces. ISBN 978-91-620-7021-2. https://www.naturvardsverket.se/globalassets/media/publikationer-pdf/7000/978-91-620-7021-2.pdf

Pankkonen, O. 2020. Urban stormwater microplastics – Characteristics and removal using a developed filtration system. Master Thesis. https://core.ac.uk/download/pdf/323363067.pdf

Pikkarainen, K. 2017. Pure as snow? Snow as a route for microplastics and other waste from urban areas to sea. Master's thesis. https://helda.helsinki.fi/bitstream/handle/10138/299030/Pro%20gradu_Pikkarainen.pdf?sequence=2&isAllowed=y

Pohrt, R. 2019. Tire wear particle hot spots – review of influencing factors. Facta universitatis, Mechanical Engeneering, 17, 17–27. https://doi.org/10.22190/FUME190104013P.

Regulation (EU) 2020/740 of the European Parliament and of the Council of 25 May 2020 on the labelling of tyres with respect to fuel efficiency and other parameters, amending Regulation (EU) 2017/1369 and repealing Regulation (EC) No 1222/2009 (Text with EEA relevance).

Setälä, O. & Suikkanen, S. 2020. Suomen merialueen roskaantumisen lähteet. Suomen Ympäristökeskuksen raportteja 9/2020. https://helda.helsinki.fi/handle/10138/313542

Simon, M., van Alst, N. & Vollertsen, J. 2018. Quantification of microplastic mass and removal rates at wastewater treatment plants applying Focal Plane Array (FPA)-based Fourier Transform Infrared (FT-IR) imaging, Water Research 142: 1-9.

Sun, J., Dai, X., Wang, Q., van Loosdrecht, M.C.M., Ni, B.-J. 2019. Microplastics in wastewater treatment plants: Detection, occurrence and removal, Water Research 152: 21-37.

Sundt, P., Syversen, F., Skogesal, O., & Schulze, P.-E. 2016. Primary microplastic-pollution: Measures and reduction potentials in Norway. Norwegian Environment Agency (Miljødirektoratet). https://www.miljodirektoratet.no/globalassets/publikasjoner/M545/M545.pdf

Svensson, N. & Andersson-Sköld, Y. 2021. Dispersion and fate models for microplastics from tyre and road wear - State of the art and opportunities. Swedish National Road and Transport Research Institute (VTI). http://vti.diva-portal.org/smash/get/diva2:1616069/FULLTEXT01.pdf

Tuulilasi 2020. Vihreämpää autoilua pohjoisen teille: Uusi Nokian Hakka Green 3 -kesärengas. https://www.apu.fi/artikkelit/vihreampaa-autoilua-pohjoisen-teille-uusi-nokian-hakkagreen-3-kesarengas (accessed 24th February 2021).

Verschoor, A., de Poorter, L., Dröge, R., Kuenen, J., de Valk E. 2016. Emission of microplastics and potential mitigation measures - Abrasive cleaning agents, paints and tyre wear. Report for the National Institute for Public Health and the Environment (the Netherlands). https://www.rivm.nl/bibliotheek/rapporten/2016-0026.pdf

Vogelsang, C., Lusher, A. L., Dadkhah, M. E., Sundvor, I., Umar, M., Ranneklev, S. B., Eidsvoll, D., Meland, S. 2020. Microplastics in road dust – characteristics, pathways and measures. Norwegian Environment Agency (Miljødirektoratet). Norwegian Institute for Water Research (NIVA). https://www.miljodirektoratet.no/globalassets/publikasjoner/M959/M959.pdf

Winquist, E., Vahvaselkä, M., Vuola, M., Sainio, P. 2021. Traffic microplastic – solutions to mitigate the problem: FanpLESStic-sea project report. Natural resources and bioeconomy studies 56/2021. Natural Resources Institute Finland. http://urn.fi/URN:ISBN:978-952-380-255-1.