© 2024 IJNRD | Volume 9, Issue 8 August 2024| ISSN: 2456-4184 | IJNRD.ORG

IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

A Review On Ecological Hazards: Vehicle Tire Microplastics And Road Runoff

VIKAS KUMAR*, SANDEEP KUMAR TYAGI†, KULDEEP KUMAR ††, JITENDRA KUMAR MALIK†††, RAVINDRA SINGH PARMAR ††††

* Department of Chemistry, IIMT University, Meerut-250 001 (U.P.), India

† Department of Environment Chemistry, IIMT University, Meerut-250 001 (U.P.), India

†† Department of Agricultural Sciences, IIMT University, Meerut-250 001 (U.P.), India

†††Department of Agronomy, K D College, Simbhaoli, Hapur-245207 (U.P.), India

†††† Department of Chemistry, MIT, Meerut-250 004 (U.P.), India

Abstract:
As the world moves towards sustainable development, the impact of human activities (including transportation) on the environment has received increasing attention. One of the often overlooked consequences of vehicle traffic is the production of microplastic particles from vehicle tires and other road runoff pollutants. These particles, along with other pollutants, pose significant risks to aquatic and terrestrial ecosystems. This article explores the sources, distribution, and environmental impacts of vehicle tire microplastic particles and other contaminants in road runoff. It reviews current research findings, discusses potential ecological consequences, and proposes mitigation strategies to address this growing environmental problem.
Keywords: Sustainable development, Microplastic particles, Vehicle tires, Road runoff pollutants, Mitigation strategies

Introduction:
Microplastic pollution and road runoff pollutants pose major challenges to environmental health and pose risks to ecosystems and human well-being. This overview provides insight into the sources, characteristics, distribution and impacts of microplastic pollution and road runoff contaminants and highlights the urgent need for comprehensive mitigation strategies. Microplastics, defined as plastic particles less than 5 mm in size, have become a widespread environmental problem in recent years. They come from a variety of sources, including the degradation of larger plastic fragments, the wear and tear of synthetic textiles, and fragments of plastic products. However, one of the lesser-known sources of microplastics is the wear and tear of car tires. Car tire wear is a major cause of microplastic pollution, as the friction between the tire and the road gradually breaks down the rubber compound, releasing tiny particles into the environment. These microplastics then spread through wind, water and other mechanisms, eventually entering aquatic and terrestrial ecosystems. In addition to microplastics, road runoff also carries large amounts of pollutants, posing significant environmental risks [1-2]. As stormwater flows over roads, it collects a variety of

pollutants, including heavy metals, petroleum hydrocarbons, pesticides and road salt. These pollutants originate from vehicle emissions, industrial activities and degradation of road infrastructure. The composition of road runoff pollutants varies depending on factors such as traffic volume, pavement material, and land use patterns. Urban areas with high traffic density tend to have higher levels of pollutants in road runoff, posing greater risks to nearby water bodies and ecosystems. Once released into the environment, microplastics and road runoff pollutants can have widespread impacts on ecological health[3-4]. In aquatic ecosystems, microplastics are ingested by a variety of organisms, including fish, shellfish and waterfowl, leading to bioaccumulation and biomagnification in the food chain. Ingestion of microplastics can harm the health of aquatic species and ecosystems by causing physical harm, blockage in the digestive system, and leaching of toxic chemicals. In addition, road runoff pollutants such as heavy metals and petroleum hydrocarbons can degrade water quality, destroy aquatic habitats, and harm the health of aquatic life. Road runoff can also increase nutrient loads in water bodies, leading to eutrophication, algal blooms and hypoxic conditions, threatening aquatic biodiversity. On land, microplastics and road runoff pollutants can contaminate soil, adversely affecting soil quality, microbial communities and plant growth [4-6]. The accumulation of pollutants in soil also poses risks to terrestrial life and ecosystem function. In addition, airborne microplastics generated from transportation-related activities may be deposited in terrestrial habitats, further exacerbating environmental pollution. In addition to ecological impacts, microplastic pollution and road runoff pollutants also raise concerns for human health. Microplastics have been detected in a variety of foods, drinking water sources, and even the air we breathe, raising questions about their potential health effects on human consumers. Likewise, exposure to road runoff pollutants through contaminated water, soil, or air also poses risks to human health, particularly for individuals living close to roads or in urban areas. Addressing the challenges posed by microplastic pollution and road runoff contaminants requires a multifaceted approach. Efforts to reduce the production of microplastics from automobile tires may involve developing alternative tire materials, improving tire design, and implementing road maintenance measures aimed at minimizing tire wear. Additionally, strategies for managing road runoff pollution may include installing green infrastructure, implementing stormwater management measures, and taking pollution prevention measures [7-9]. Microplastic pollution and road runoff pollutants represent complex and interconnected environmental challenges with profound impacts on ecosystems and human well-being. By understanding the sources, characteristics, distribution and impacts of these pollutants, we can develop effective mitigation strategies to maintain environmental health and promote sustainable development. Collaboration among stakeholders, including policymakers, researchers, industry leaders and the public, is critical to solving these pressing environmental issues and creating a healthier, more resilient planet for future generations. Understanding the environmental risks of microplastic particles from automobile tires is crucial as they have significant ecological and health impacts. These particles can accumulate in soil, water and air, damaging ecosystems and posing risks to biodiversity[10]. They enter the food chain, bioaccumulate and biomagnify, threatening species at higher trophic levels. Microplastic pollution can contaminate soil and water, alter its quality and harm living organisms. There are also concerns that ingestion of contaminated food and water may lead to inflammation and oxidative stress, affecting human health. Due to their continued presence in the environment, regulatory measures are necessary to mitigate their impacts, such as tire design and composition standards and policies that promote alternative materials. Understanding these risks can help develop effective strategies to address this emerging environmental challenge and protect ecosystems and human well-being.

Sources and Distribution of vehicle's Tire Microplastic Particles:

The ubiquity of microplastics in the environment is of serious concern around the world. These tiny plastic particles are less than five millimeters in size and pose a threat to ecosystems and human health. While attention often focuses on larger sources such as plastic bottles and packaging, a new concern is the impact of car tires on microplastic pollution. One of the main sources of microplastics in car tires is wear. As tires roll on the road, friction causes them to gradually degrade, shedding tiny particles of rubber in the process. Known as tire wear particles (TWP), these particles contain various synthetic polymers used in tire manufacturing, such as styrene-butadiene rubber (SBR) and polybutadiene. In addition, TWP also contains additives such as plasticizers and antioxidants, which increase the overall microplastic content. In addition to tire degradation, the road itself also produces microplastics. When vehicles drive on asphalt and concrete roads, friction between the tires and the road causes wear, which results in the release of small plastic particles. The process not only helps disperse microplastics originating from tires, but also introduces other forms of microplastics present in road materials, such as asphalt binders and road marking paint. Microplastic particles released from car tires can enter the air and undergo atmospheric transport. These airborne particles are eventually deposited on a variety of surfaces, including soil, water and vegetation, through processes such as dry and wet deposition. Atmospheric deposition is an important pathway for the distribution of tire microplastics, leading to their ubiquity in terrestrial and aquatic environments[11-15].

Mechanisms of microplastic particle generation from vehicle's tire

Microplastic particles from vehicle tires are generated through complex interactions of mechanical, environmental, and operational factors. Abrasion and wear cause tire tread breakdown, releasing tire wear particles (TWPs), which contribute significantly to microplastic emissions. Interaction between tires and road surfaces, affected by factors like road material and driving conditions, amplifies microplastic release. Dynamic loading and stress on tires, influenced by speed and driving conditions, accelerate particle generation. Environmental factors such as temperature and UV exposure worsen this process. The size distribution of emitted particles varies, with larger fragments from abrasion and smaller ones from fragmentation. Understanding these mechanisms is vital for effective mitigation strategies against tire-derived microplastic pollution[16-19].

Pathways of Dispersion and Transport of Microplastic Particles in the Environment:

Microplastic particles, including those from car tires, are dispersed into the atmosphere through wear, fragmentation and resuspension. Driven by wind currents and atmospheric patterns, they travel great distances and colonize terrestrial and aquatic environments around the world. Urban areas, roads and agriculture promote their entry into rivers, lakes and oceans, where they accumulate or remain suspended in sediments. Microplastics circulate in sediment layers, affecting ecosystem integrity and the health of biota. In aquatic habitats, microplastics are ingested by organisms, causing clogging and uptake of contaminants, potentially affecting human health through biomagnification. Marine and terrestrial organisms inadvertently transfer microplastics throughout ecosystems, highlighting the interconnectedness of global microplastic diffusion[20-24].

Composition and Characteristics of Road Runoff Pollutants:

Road runoff, or stormwater runoff, collects pollutants from roads and adjacent areas and flows into water bodies such as rivers and lakes. Sediments, including soil particles and debris, increase turbidity and carry heavy metals, nutrients and hydrocarbons, harming aquatic life and human health. Heavy metals originate from vehicle emissions and eroded road surfaces, accumulating in sediments and organisms. Nutrients in chemical fertilizers can cause eutrophication, while hydrocarbons in vehicle exhaust and road materials pose toxicity risks. Road salt and de-icing chemicals used in winter can increase chloride levels and damage freshwater ecosystems. Microplastic particles from tires and road debris persist in water, posing ingestion risks to aquatic life and enhancing contaminant impacts [25-29].

Environmental Impacts:

Microplastic particles often enter the aquatic environment through road runoff, damaging aquatic ecosystems through ingestion, chemical contamination and ecological damage. They are ingested by a variety of organisms, causing internal injuries and facilitating the transfer of toxic chemicals, leading to bioaccumulation and biomagnification. Microplastics alter ecosystem structure by changing sediment composition and serving as a substrate for invasive species[30-32]. Combined with other pollutants such as heavy metals and hydrocarbons, they exacerbate stress on aquatic life, impair physiological functions and lead to eutrophication. Comprehensive strategies are needed to reduce pollutant inputs, improve stormwater management, enhance ecosystem resilience to microplastic pollution, and protect aquatic biodiversity and ecosystem services.

Implications for terrestrial habitats and wildlife.

Microplastic pollution from road runoff affects terrestrial habitats and wildlife through uptake and ecological damage. Microplastics may be ingested by wildlife, causing internal injuries and facilitating the transfer of contaminants. Microplastics alter soil properties, nutrient cycling and plant growth, and serve as carriers for the transport of contaminants within ecosystems. They disrupt predator-prey dynamics and affect invertebrate populations, which in turn affects ecosystem function. Coordinated efforts to reduce sources of microplastics and improve stormwater management are critical to protecting terrestrial biodiversity and ecosystem integrity[33-34].

Human Health Concerns:

The ingestion of microplastics and contaminated runoff poses multiple risks to human health, wildlife and ecosystems due to their persistence and interaction with biological systems[35]. In humans, ingestion raises concerns about exposure to harmful chemicals, which can lead to inflammation and disruption of hormonal signaling. Wildlife may suffer physical damage and bioaccumulation of contaminants, affecting growth and reproduction[36]. Microplastics disrupt ecosystem dynamics, alter soil properties and nutrient cycling, leading to ecological imbalance and habitat degradation. Comprehensive strategies are needed to reduce sources of microplastic pollution and improve stormwater management to safeguard human health, biodiversity and ecosystem integrity.

Health effects of exposure to road runoff pollutants.

Exposure to pollutants in road runoff poses multiple health risks to humans due to the presence of complex mixtures of pollutants. Heavy metals from vehicle emissions and road wear can cause neurological disease, cardiovascular disease and developmental problems, especially in vulnerable groups[37]. Hydrocarbons in vehicle exhaust and fuel leaks can cause respiratory problems, cancer and chronic disease with long-term exposure. Nutrients in road runoff can contribute to waterborne diseases and eutrophication, while microplastic particles can carry harmful chemicals and pathogens, causing gastrointestinal irritation and immune disruption. Comprehensive strategies are needed to minimize pollutant inputs, improve stormwater management, and increase public awareness to protect human health and promote environmental sustainability[38-39].

Mitigation and Management Strategies:

Addressing the issue of tire microplastic release requires innovative engineering solutions to minimize wear while maintaining performance and safety standards[40-41]. Strategies include optimizing tire design and materials, employing precise manufacturing techniques, and implementing maintenance practices to reduce localized wear. Developing alternative materials such as natural rubber and exploring advanced manufacturing technologies offer environmentally friendly options. Additionally, innovative recycling methods, such as closed-loop processes and pyrolysis, can minimize microplastic waste in end-of-life tires [42]. A multifaceted approach throughout the tire lifecycle promotes sustainable mobility and minimizes environmental impact.

Conclusion:

In summary, as the need for sustainable development continues to grow, so does our understanding of the environmental consequences of human activities, particularly vehicular traffic. One of the less discussed but pressing issues is microplastic particles produced by car tires and other pollutants in road runoff. These particles, along with various pollutants, pose significant risks to aquatic and terrestrial ecosystems. Through a thorough review of its sources, distribution and environmental impact, this article reveals the seriousness of the situation. By reviewing current findings and discussing potential ecological impacts, it highlights the urgency of addressing this emerging environmental issue. Going forward, concerted efforts are needed to implement effective mitigation strategies, protect ecosystems and promote sustainable practices in transportation and road management. Only through collaborative action and informed decision-making can we mitigate the adverse impacts of microplastic particles from vehicle tires and road runoff pollutants, ensuring a healthier environment for current and future generations.

References:

1. Ashrafy, A., Liza, A. A., Islam, M. N., Billah, M. M., Arafat, S. T., Rahman, M. M., & Rahman, S. M. (2023). Microplastics Pollution: A brief review of its source and abundance in different aquatic ecosystems. *Journal of Hazardous Materials Advances*, *9*, 100215. https://doi.org/10.1016/j.hazadv.2022.100215
2. Periyasamy, A. P., & Tehrani-Bagha, A. R. (2022). A review on microplastic emission from textile materials and its reduction techniques. *Polymer Degradation and Stability*, *199*, 109901. https://doi.org/10.1016/j.polymdegradstab.2022.109901
3. Müller, A., Österlund, H., Maršálek, J., & Viklander, M. (2020). The pollution conveyed by urban runoff: A review of sources. *Science of the Total Environment*, *709*, 136125. https://doi.org/10.1016/j.scitotenv.2019.136125
4. Masoner, J. R., Kolpin, D. W., Cozzarelli, I. M., Barber, L. B., Burden, D. S., Foreman, W. T., Forshay, K. J., Furlong, E. T., Groves, J., Hladik, M. L., Hopton, M. E., Jaeschke, J. B., Keefe, S. H., Krabbenhoft, D. P., Lowrance, R., Romanok, K. M., Rus, D. L., Selbig, W. R., Williams, B., & Bradley, P. M. (2019). Urban stormwater: an overlooked pathway of extensive mixed contaminants to surface and groundwaters in the United States. *Environmental Science & Technology*, *53*(17), 10070–10081. https://doi.org/10.1021/acs.est.9b02867
5. Agbekpornu, P., & Kevudo, I. (2023). The risks of microplastic pollution in the aquatic ecosystem. In *IntechOpen eBooks*. https://doi.org/10.5772/intechopen.108717
6. Yu, R., & Singh, S. (2023). Microplastic pollution: Threats and impacts on global marine ecosystems. *Sustainability*, *15*(17), 13252. https://doi.org/10.3390/su151713252
7. *Microplastics from textiles: towards a circular economy for textiles in Europe*. (n.d.). European Environment Agency. https://www.eea.europa.eu/publications/microplastics-from-textiles-towards-a
8. Ghosh, S., Sinha, J. K., Ghosh, S. K., Vashisth, K., Han, S., & Bhaskar, R. (2023). Microplastics as an emerging threat to the global environment and human health. *Sustainability*, *15*(14), 10821. https://doi.org/10.3390/su151410821
9. Kumar, R., Verma, A., Shome, A., Sinha, R., Sinha, S., Jha, P. K., Kumar, R., Kumar, P., Shubham, Das, S., Sharma, P., & Prasad, P. V. V. (2021). Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions. *Sustainability*, *13*(17), 9963. https://doi.org/10.3390/su13179963
10. Ashrafy, A., Liza, A. A., Islam, M. N., Billah, M. M., Arafat, S. T., Rahman, M. M., & Rahman, S. M. (2023b). Microplastics Pollution: A brief review of its source and abundance in different aquatic ecosystems. *Journal of Hazardous Materials Advances*, *9*, 100215. https://doi.org/10.1016/j.hazadv.2022.100215
11. Qiu, R., Song, Y., Zhang, X., Xie, B., & He, D. (2020). Microplastics in urban environments: sources, pathways, and distribution. In *˜The æhandbook of environmental chemistry* (pp. 41–61). https://doi.org/10.1007/698_2020_447
12. An, L., Liu, Q., Deng, Y., Wu, W., Gao, Y., & Wei, L. (2020). Sources of microplastic in the environment. In *˜The æhandbook of environmental chemistry* (pp. 143–159). https://doi.org/10.1007/698_2020_449
13. Luo, Z., Zhou, X., Su, Y., Wang, H., Yu, R., Zhou, S., Xu, E. G., & Xing, B. (2021). Environmental occurrence, fate, impact, and potential solution of tire microplastics: Similarities and differences with tire wear particles. *Science of the Total Environment*, *795*, 148902. https://doi.org/10.1016/j.scitotenv.2021.148902
14. Goßmann, I., Halbach, M., & Scholz-Böttcher, B. M. (2021). Car and truck tire wear particles in complex environmental samples – A quantitative comparison with "traditional" microplastic polymer mass loads. *Science of the Total Environment*, *773*, 145667. https://doi.org/10.1016/j.scitotenv.2021.145667

15. Knight, L. J., Parker-Jurd, F. N., Al-Sid-Cheikh, M., & Thompson, R. C. (2020). Tyre wear particles: an abundant yet widely unreported microplastic? *Environmental Science and Pollution Research International*, *27*(15), 18345–18354. https://doi.org/10.1007/s11356-020-08187-4
16. Sommer, F., Dietze, V., Baum, A., Sauer, J., Gilge, S., Garra, P., & Gieré, R. (2018). Tire abrasion as a major source of microplastics in the environment. *Aerosol and Air Quality Research*, *18*(8), 2014–2028. https://doi.org/10.4209/aaqr.2018.03.0099
17. Prenner, S., Allesch, A., Staudner, M., Rexeis, M., Schwingshackl, M., Huber-Humer, M., & Part, F. (2021). Static modelling of the material flows of micro- and nanoplastic particles caused by the use of vehicle tyres. *Environmental Pollution*, *290*, 118102. https://doi.org/10.1016/j.envpol.2021.118102
18. Vogelsang, C., Lusher, A., Dadkhah, M. E., Sundvor, I., Umar, M., Ranneklev, S. B., Eidsvoll, D., & Meland, S. (2019). *Microplastics in road dust – characteristics, pathways and measures*. https://toi.brage.unit.no/toi-xmlui/handle/11250/2670146
19. Selonen, S., Dolar, A., Kokalj, A. J., Sackey, L. N. A., Skalar, T., Fernandes, V. C., Rede, D., Delerue-Matos, C., Hurley, R., Nizzetto, L., & Van Gestel, C. A. (2021). Exploring the impacts of microplastics and associated chemicals in the terrestrial environment – Exposure of soil invertebrates to tire particles. *Environmental Research*, *201*, 111495. https://doi.org/10.1016/j.envres.2021.111495
20. He, B., Smith, M., Egodawatta, P., Ayoko, G. A., & Rintoul, L. (2021). Dispersal and transport of microplastics in river sediments. *Environmental Pollution*, *279*, 116884. https://doi.org/10.1016/j.envpol.2021.116884
21. Alfonso, M. B., Arias, A. H., Ronda, A. C., & Piccolo, M. C. (2021). Continental microplastics: Presence, features, and environmental transport pathways. *Science of the Total Environment*, *799*, 149447. https://doi.org/10.1016/j.scitotenv.2021.149447
22. Horton, A. A., & Dixon, S. (2017). Microplastics: An introduction to environmental transport processes. *WIREs. Water*, *5*(2). https://doi.org/10.1002/wat2.1268
23. Li, Y., Zhang, H., & Tang, C. (2020). A review of possible pathways of marine microplastics transport in the ocean. *Anthropocene Coasts*, *3*(1), 6–13. https://doi.org/10.1139/anc-2018-0030
24. Lu, X., Wang, X., Liu, X., & Singh, V. P. (2023). Dispersal and transport of microplastic particles under different flow conditions in riverine ecosystem. *Journal of Hazardous Materials*, *442*, 130033. https://doi.org/10.1016/j.jhazmat.2022.130033
25. Krein, A., & Schorer, M. (2000). Road runoff pollution by polycyclic aromatic hydrocarbons and its contribution to river sediments. *Water Research*, *34*(16), 4110–4115. https://doi.org/10.1016/s0043-1354(00)00156-1
26. Zuo, X., Fu, D., He, L., & Singh, R. P. (2011). Distribution characteristics of pollutants and their mutual influence in highway runoff. *Clean*, *39*(10), 956–963. https://doi.org/10.1002/clen.201000422
27. Helmreich, B., Hilliges, R., Schriewer, A., & Horn, H. (2010). Runoff pollutants of a highly trafficked urban road – Correlation analysis and seasonal influences. *Chemosphere*, *80*(9), 991–997. https://doi.org/10.1016/j.chemosphere.2010.05.037
28. Hilliges, R., Endres, M., Tiffert, A., Brenner, E. F., & Marks, T. (2016). Characterization of road runoff with regard to seasonal variations, particle size distribution and the correlation of fine particles and pollutants. *Water Science & Technology*, *75*(5), 1169–1176. https://doi.org/10.2166/wst.2016.576
29. Kayhanian, M., Fruchtman, B. D., Gulliver, J. S., Montanaro, C., Ranieri, E., & Wuertz, S. (2012). Review of highway runoff characteristics: Comparative analysis and universal implications. *Water Research*, *46*(20), 6609–6624. https://doi.org/10.1016/j.watres.2012.07.026
30. Ali, N., Khan, M. H., Ali, M. A., Sidra, Ahmad, S., Khan, A., Nabi, G., Ali, F., Bououdina, M., & Kyzas, G. Z. (2024). Insight into microplastics in the aquatic ecosystem: Properties, sources, threats

and mitigation strategies. *Science of the Total Environment*, *913*, 169489. https://doi.org/10.1016/j.scitotenv.2023.169489

31. Huerta Lwanga, E., Gertsen, H., Gooren, H., Peters, P., Salánki, T., van der Ploeg, M., et al. (2016). Microplastics in the terrestrial ecosystem: Implications for Lumbricus terrestris (Oligochaeta, Lumbricidae). Environmental Science & Technology, 50(5), 2685-2691.
32. Nizzetto, L., Futter, M.N., and Langaas, S. (2016). Are agricultural soils dumps for microplastics of urban origin? Environmental Science & Technology, 50(20), 10777-10779.
33. Horton, A.A., Walton, A., Spurgeon, D.J., Lahive, E., and Svendsen, C. (2017). Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities. Science of the Total Environment, 586, 127-141.
34. de Souza Machado, A.A., Kloas, W., Zarfl, C., Hempel, S., Rillig, M.C., and Fischer, D. (2018). Microplastics as an emerging threat to terrestrial ecosystems. Global Change Biology, 24(4), 1405-1416.
35. Huang, W., Song, B., Liang, J., Niu, Q., Zeng, G., Shen, M., Deng, J., Luo, Y., Wen, X., & Zhang, Y. (2021). Microplastics and associated contaminants in the aquatic environment: A review on their ecotoxicological effects, trophic transfer, and potential impacts to human health. *Journal of Hazardous Materials*, *405*, 124187. https://doi.org/10.1016/j.jhazmat.2020.124187
36. Chaukura, N., Kefeni, K. K., Chikurunhe, I., Nyambiya, I., Gwenzi, W., Moyo, W., Nkambule, T. T., Mamba, B. B., & Abulude, F. O. (2021). Microplastics in the Aquatic Environment—The occurrence, sources, ecological impacts, fate, and remediation challenges. *Pollutants*, *1*(2), 95–118. https://doi.org/10.3390/pollutants1020009
37. Xiang, Y., Jiang, L., Zhou, Y., Luo, Z., Zhi, D., Yang, J., & Lam, S. S. (2022). Microplastics and environmental pollutants: Key interaction and toxicology in aquatic and soil environments. *Journal of Hazardous Materials*, *422*, 126843. https://doi.org/10.1016/j.jhazmat.2021.126843
38. De Zwart, D., Adams, W., Burgos, M. G., Hollender, J., Junghans, M., Merrington, G., Muir, D. C. G., Parkerton, T. F., De Schamphelaere, K. A., Whale, G., & Williams, R. J. (2018). Aquatic exposures of chemical mixtures in urban environments: Approaches to impact assessment. *Environmental Toxicology and Chemistry*, *37*(3), 703–714. https://doi.org/10.1002/etc.3975
39. Tamis, J., Koelmans, A. A., Dröge, R., Kaag, N., Keur, M., Tromp, P., & Jongbloed, R. (2021). Environmental risks of car tire microplastic particles and other road runoff pollutants. *Microplastics and Nanoplastics*, *1*(1). https://doi.org/10.1186/s43591-021-00008-w
40. Kole, P. J., Löhr, A., Van Belleghem, F., & Ragas, A. (2017). Wear and tear of tyres: a stealthy source of microplastics in the environment. *International Journal of Environmental Research and Public Health/International Journal of Environmental Research and Public Health*, *14*(10), 1265. https://doi.org/10.3390/ijerph14101265
41. Verschoor, A., De Poorter, L., Dröge, R., Kuenen, J., De Valk, E., RIVM, & TNO. (2016). Emission of microplastics and potential mitigation measures. In *RIVM Report 2016-0026* (pp. 2–73). National Institute for Public Health and the Environment. https://rivm.openrepository.com/bitstream/handle/10029/617930/2016-0026.pdf
42. Andersson-Sköld, Y., Johannesson, M., Gustafsson, M., Järlskog, I., Lithner, D., Polukarova, M., & Strömvall, A. (2020). *Microplastics from tyre and road wear : a literature review*. DIVA. https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1430623&dswid=-8677