A Monthly e Magazine
ISSN:2583-2212
February 2024 Vol.4(2), 757-762

Popular Article

Tire And Rubber Chemicals in Aquatic Systems and Their Management

Arun Konduri[1], Tao Kara[1], Swaraj Adakney[1], Amal CT[1], Vidya Shree Bharti[1]*
[1]Department of Aquatic Environment Management, ICAR-Central Institute of Fisheries Education, Mumbai-400061, India
https://doi.org/10.5281/zenodo.10702771

I. Introduction

The tire and rubber industry has been a cornerstone of modern transportation and infrastructure, providing the essential components for vehicles, machinery, and various consumer products. However, the widespread use of tires and rubber materials has brought about significant environmental challenges, particularly in aquatic systems. The demand for these materials has led to the proliferation of tire manufacturing plants and rubber processing facilities worldwide. Tire particles constitute a significant portion of microplastic pollution, releasing various chemical additives that have the potential to seep into water bodies and negatively impact aquatic organisms (Tallec *et al.*, 2022). The mechanical abrasion associated with road traffic unavoidably produces tire particles (TP). Each year, the global emissions of TP may amount to 2.9 million tons (Evangeliou et al., 2020). Tire particles come in a variety of sizes, spanning from just a few nanometers to particles exceeding 100 µm in size (Kole et al., 2017; Wagner et al., 2018). As the industry continues to expand, it becomes imperative to examine the environmental consequences of its operations, especially concerning aquatic ecosystems. Understanding the environmental impact of tire and rubber chemicals in aquatic systems is crucial for several reasons. First and foremost, aquatic ecosystems are vital to Earth's biodiversity, supporting many species and providing essential services such as water purification and nutrient cycling.

II. Transport of Tire and Rubber Chemicals in Aquatic Systems

A. Road Runoff and Pathways to Aquatic Systems

Surface Runoff: Rainwater interacts with road surfaces, carrying with its particles from tire wear,

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com

Published 25.02.2024

road dust, and residual chemicals. This runoff enters stormwater drains and flows into nearby water bodies, serving as a direct pathway for introducing tire and rubber chemicals into aquatic systems.

Leaching from Landfills: Improper disposal of tires in landfills can result in leaching of chemicals into the soil and, subsequently, groundwater. Over time, these contaminants may enter nearby rivers, lakes, or groundwater-fed ecosystems.

B. Atmospheric Deposition and Aerial Transport

Airborne Particles: Fine particles containing tire and rubber chemicals can become suspended in the air due to processes like mechanical wear and abrasion. These particles may settle onto water surfaces through atmospheric deposition, contaminating aquatic environments.

Long-Range Transport: Wind can carry airborne particles over considerable distances, leading to the deposition of tire and rubber chemicals in remote aquatic ecosystems. This long-range transport can result in contamination far from the original emission source.

C. Waterborne Transport and Dispersion

River Transport: Runoff from roads and urban areas enters rivers, facilitating the downstream transport of tire and rubber chemicals. The chemical mixed water can be transported over long distances, affecting multiple aquatic ecosystems along the way.

Sedimentation and Resuspension: Tire and rubber chemicals can bind to sediments in water bodies. This sedimentation process can lead to the accumulation of contaminants in the bottom sediments. However, resuspension events, such as storms or turbulence, may reintroduce these chemicals into the water column.

Bioavailability and Sorption: Their interactions with water and sediments influence the bioavailability of tire and rubber chemicals. Sorption processes, where chemicals attach to suspended particles or sediment surfaces, can affect their mobility and persistence in aquatic systems.

Table 1: Composition of the Tire and Rubber (Dodds *et al.*, 1983)

Components	**Weight Percent**
SBR	62.1
Carbon Black	31.0
Extender Oil	1.9
Zinc oxide	1.9

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published 25.02.2024

Stearic Acid	1.2
Sulfur	1.1
Accelerator	0.7

Figure 1: Constituents (%) of a typical passenger car tire (Sommer *et al*., 2018)

III. Environmental Impact of Tire and Rubber Chemicals

The widespread use of tires and rubber products has led to a notable environmental impact on aquatic ecosystems. Introducing tire and rubber chemicals into water bodies can have far-reaching consequences, affecting aquatic environments' physical and biological components.

A. Water Pollution

Chemical Contamination: Tire and rubber chemicals, including plasticizers, antioxidants, and vulcanizing agents, can leach into water bodies, leading to chemical contamination. This pollution threatens the overall water quality and the organisms inhabiting these environments. Some of tire rubber's chemical additives are toxic to aquatic animals (Capolupo et al., 2020, Halle et al., 2020). The introduction of tire and rubber chemicals can alter water's pH and chemical composition, affecting the aquatic biota that are sensitive to changes in these parameters.

Toxicity to Aquatic Life: Some tire and rubber chemicals can potentially exhibit toxic effects on aquatic life. This includes detrimental impacts on fish, invertebrates, and other organisms, disrupting their behaviour, growth, and reproduction. The growth and development of freshwater invertebrates are negatively impacted by the presence of polyester fibre and rubber particles from

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published 25.02.2024

automobile tires, both in short-term and long-term exposure scenarios (Schell et al., 2022). Leachate from tires has been found to cause harmful impacts on the survival, reproductive system, and developmental processes of *Mytilus galloprovincialis* (Capolupo et al., 2020), *Crassostrea gigas* (Tallec et al., 2022), *Pimephales promelas* (Kolomijeca et al., 2020)) under experimental conditions.

B. Bioaccumulation

Uptake by Aquatic Organisms: Tire and rubber chemicals released into water can be absorbed by aquatic organisms through various exposure pathways. This includes direct uptake from water, ingestion of contaminated sediments, and consumption of contaminated prey. N-(1,3-Dimethylbutyl)-N′-phenyl-p-phenylenediamine (6-PPD) serves as a commonly employed antioxidant in tire rubber, and it has been identified to infiltrate aquatic ecosystems through road runoff. The resultant transformation product, 6-PPD quinone, has been linked to severe acute toxicity in certain fish species, such as coho salmon (Grasse et al., 2023).

Bioaccumulation in Food Chains: Once introduced into aquatic ecosystems, tire and rubber chemicals may bioaccumulate in the tissues of organisms over time. This bioaccumulation can result in higher concentrations of chemicals in predators at the top of the food chain, leading to potential ecological imbalances. Rubber particles and the chemicals released from worn-out tire particles can lead to elevated mortality rates among aquatic species, including trout and frogs (Halle et al., 2020).

IV. Management Strategies for Tire and Rubber Chemicals

Addressing the environmental impact of tire and rubber chemicals in aquatic systems requires a multifaceted approach that combines regulatory measures, industry practices, and public awareness. Effective management strategies aim to reduce the release of contaminants, mitigate their impact, and promote sustainable practices within the tire and rubber industry.

A. Regulatory Measures and Policies

Emission Standards: Implement and enforce strict emission standards for tire manufacturing plants and rubber processing facilities. These standards should focus on limiting the release of key chemicals into the air and water, addressing both direct discharges and atmospheric deposition.

Stormwater Management: Develop and enforce regulations for stormwater management to prevent road runoff from transporting tire and rubber chemicals into aquatic ecosystems. This includes the installation of effective stormwater treatment systems and the implementation of best

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com

Published 25.02.2024

management practices.

Chemical Use Restrictions: Implement restrictions on using certain chemicals that pose environmental risks in tire manufacturing. This may include substituting hazardous compounds with safer alternatives and promoting the adoption of eco-friendly manufacturing processes.

B. Sustainable Tire and Rubber Manufacturing Practices

Green Chemistry Initiatives: Encourage the tire and rubber industry to adopt green chemistry principles, focusing on developing environmentally friendly processes and materials. This includes the use of alternative additives and sustainable sources of raw materials.

Recycling Programs: Promote and incentivize tire recycling programs to reduce the volume of waste tires and prevent the environmental release of tire and rubber chemicals. Recycled rubber can be used in various applications in footwear, plastics, coatings, carpets, tires, etc. and reducing the demand for new materials and minimizing environmental impact.

Life Cycle Assessment: Conduct comprehensive life cycle assessments of tires to identify environmental hotspots and opportunities for improvement. This holistic approach considers the environmental impact of tires, from raw material extraction to end-of-life disposal.

V. Conclusion

Tire and rubber chemicals in aquatic systems demand urgent attention; effective management strategies, including stronger regulations, technological advancements, and public awareness, are crucial for mitigating environmental impact. Collaboration among industries, government, and the public is essential to promote responsible practices and ensure the long-term health of aquatic ecosystems.

References

Capolupo, M., Sørensen, L., Jayasena, K.D.R., Booth, A.M. and Fabbri, E., 2020. Chemical composition and ecotoxicity of plastic and car tire rubber leachates to aquatic organisms. Water research, 169, p.115270.

Dodds, J., Domenico, W.F., Evans, D.R., Fish, L.W., Lassahn, P.L. and Toth, W.J., 1983. Scrap tires: a resource and technology evaluation of tire pyrolysis and other selected alternate technologies (No. EGG-2241). EG and G Idaho, Inc., Idaho Falls (USA).

Evangeliou, N., Grythe, H., Klimont, Z., Heyes, C., Eckhardt, S., Lopez-Aparicio, S. and Stohl, A., 2020. Atmospheric transport is a major pathway of microplastics to remote regions. Nature communications, 11(1), p.3381.

Grasse, N., Seiwert, B., Massei, R., Scholz, S., Fu, Q. and Reemtsma, T., 2023. Uptake and Biotransformation of the Tire Rubber-derived Contaminants 6-PPD and 6-PPD Quinone in the Zebrafish Embryo (Danio rerio). Environmental Science & Technology, 57(41), pp.15598-15607.

Halle, L.L., Palmqvist, A., Kampmann, K. and Khan, F.R., 2020. Ecotoxicology of micronized tire rubber: Past, present and future considerations. Science of the Total Environment, 706, p.135694.

Kole, P.J., Löhr, A.J., Van Belleghem, F.G. and Ragas, A.M., 2017. Wear and tear of tyres: a stealthy source of microplastics in the environment. International journal of environmental research and public health, 14(10), p.1265.

Kolomijeca, A., Parrott, J., Khan, H., Shires, K., Clarence, S., Sullivan, C., Chibwe, L., Sinton, D. and Rochman, C.M., 2020. Increased temperature and turbulence alter the effects of leachates from tire particles on fathead minnow (Pimephales promelas). Environmental science & technology, 54(3), pp.1750-1759.

Schell, T., Martinez-Perez, S., Dafouz, R., Hurley, R., Vighi, M. and Rico, A., 2022. Effects of polyester fibers and car tire particles on freshwater invertebrates. Environmental Toxicology and Chemistry, 41(6), pp.1555-1567.

Sommer, F., Dietze, V., Baum, A., Sauer, J., Gilge, S., Maschowski, C. and Gieré, R., 2018. Tire abrasion as a major source of microplastics in the environment. Aerosol and air quality research, 18(8), pp.2014-2028.

Tallec, K., Gabriele, M., Paul-Pont, I., Alunno-Bruscia, M. and Huvet, A., 2022. Tire rubber chemicals reduce juvenile oyster (Crassostrea gigas) filtration and respiration under experimental conditions. Marine Pollution Bulletin, 181, p.113936.

Wagner, S., Hüffer, T., Klöckner, P., Wehrhahn, M., Hofmann, T. and Reemtsma, T., 2018. Tire wear particles in the aquatic environment-a review on generation, analysis, occurrence, fate and effects. Water research, 139, pp.83-100.

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com

Published 25.02.2024