California Office of Environmental Health Hazard Assessment

Draft Report on Synthetic Turf

28 April 2025

Submitted via: SyntheticTurf@oehha.ca.gov




Dr. Edwards:

Thank you for the opportunity to submit these comments on behalf of Safe Healthy Playing Fields, Inc (SHPFI).

SHFPI is an all-volunteer 501-c-3 non-profit. We are committed to educating communities, policy-makers and elected officials about the health, safety and financial realities of plastic fields versus grass fields and other synthetic surfaces for their parks and schools. Our constituency ranges from concerned individuals to community and civic organizations, legal, healthcare and science professionals, municipal leaders and state legislators.

While we appreciate that the COVID pandemic and changes in staffing created a significantly protracted timeline for this study, we do find significant areas of concern regarding “Synthetic Turf” study, including:

- The study only looked at used tire crumb, and did not include the fossil fuel-based petrochemical plastic blades, backing or underlayment pads.
- The literature review is grossly outdated, with the most recently reviewed article being published in 2014; does not qualify as “Recent Studies.”
- The Executive Summary alone cites two former OEHHA studies, two special interest groups (most recent 2020), two fact sheets (most recent 2018), one user guide, and only two peer reviewed research articles (most recent 2022).
- The rapid advancement in both technologies, methodologies and available research since the study began in 2015 makes this draft report obsolete.
- The lack of assessment, evaluation and inclusion of environmental impacts.
- The failure to evaluate risk based on chemical combinations and/or whole mixture assessment of chemicals.

- The failure to assess and evaluate the role of body temperature on the impact of dermal absorption, and on endocrine and cardiometabolic systems.
- The impact of microplastics released from the synthetic turf system on both human and environmental health.

As we find the 45 days to review and synthesize the over 2,000 pages in this report, information that took OEHHA over 10 years to compile, we will leave it to OEHHA to review the newer methodologies and techniques in the more current research we are providing.

The synthetic turf system:

The failure to address the multiple chemicals of concern in this plastic system is a major disservice to Californians and the nation, as others look to California for leadership in research, regulation and legislation.

Children, athletes and other vulnerable populations are exposed day in and day out, often for multiple hours per day, multiple days per week and from in utero through old age. Many of the chemicals in used tire crumb pose both human and environmental risk.

Consumers are increasingly aware of the myriad risks associated with chemicals in consumer products. They are seeking to protect themselves, their families, and the environment, and are also counting on the California EPA and legislators even more heavily, due to the recent change in Federal administration. Their voices have not become diminished since 2018,[1] but have only strengthen, not only in California, but globally in regards to used tire crumb, synthetic turf and all synthetic surfaces, the chemical leachate and microplastics from all of these wholly unnecessary products that only put humans and the environment at risk.

Whatever may, or may not, be poured on top of plastic grass carpet, it is merely window dressing and intended to distract attention from the toxic and carcinogenic components in the carpet, and the underlayment pad. You are, of course, well aware of the explosion in plant and mineral based infills on the market. Most of these are sourced outside of the United States in countries where there is heavy pesticide use, and where pesticide regulation is more absysmal than our own. In some instances, bacteria is used to accelerate the breakdown of fibers for processing. Often, these products are shipped across the world for additional processing, and then shipped again to outlet centers around the world…an unsustainable practice.

Environmental Impact:

> "*What at first seemed like a brilliant way to get rid of mountains of old tires has given new meaning to the old saying about what paves the road to hell*."[2]

The above statement, initially applied to the disastrous effects of rubberized asphalt, is even more relevant for used tire crumb infill and playground surfacing.

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[1] Watts, K (25 May 2018). *"Frustrated Families Call Out for Action From 3rd California Synthetic Turf Study."*
Public comment submission to OEHHA

[2] Anderson, P (21 Apr 1996).*"Where Rubber Meets the Road, It's a Mess."* Los Angeles Times.
https://www.latimes.com/archives/la-xpm-1996-04-21-mn-60932-story.html

By not considering the environmental impact of synthetic turf on the environment, the Office of Environmental Health Hazard Assessment (OEHHA) has failed in its mission to *"inform, support and guide regulatory and other actions."* Given the multiple shortcomings of this report, OEHHA has created a disservice, which is already being touted as having found that this toxic and carcinogenic material is safe to play on. This has left SHPFI questioning this apparent special interest report, contracted by CalRecyle,[3] another arm of CA EPA, that has a vested interest in promoting used tire crumb for use in sports fields, running tracks, playgrounds, and roadways, other construction projects and more, all of which ends up in our environment.[4]

Ignoring the widespread contamination from used tire crumb in our environment, from high altitude glaciers,[5] to oceans,[6] to food resources.[7,8]

Used tire crumb in the environment from playing fields, running tracks and playground surfaces has become ubiquitous. The omission of environmental consideration from the study is a very significant concern. Lost to air, water and soil from each playing field alone **per year from each playing field** alone:

- 1.5 to 5 tons of used tire crumb infill[9]
- 2,000 to 3,000 pounds of microplastic plastic blades[10]
- 439 pounds of microplastic carpet backing[11]

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[3] OEHHA study contracted by CalRecycle
[4] CalRecycle California Tire Derived Product Catalogue

[5] Jurkschat, L, Gill, AJ, Milner, R et al (13 Jan 2025). *"Using a citizen science approach to assess nano plastic pollution in remote high-altitude glaciers."* Sci Rep;(15), 1864. https://doi.org/10.1038/s41598-024-84210-9

[6] Halsband, C, Sorensen, L, Booth, AM, Herzke, D (23 Jul 2020). *"Car Tire Crumb Rubber: Does Leaching Produce a Toxic Chemical Cocktail in Coastal Marine Systems?"* Frontiers in Environmental Science;(8)125. https://www.frontiersin.org/articles/10.3389/fenvs.2020.00125/full

[7] Castan, S, Sherman, A, Peng, R et al (28 Dec 2023). *"Uptake, Metabolism, and Accumulation of Tire Wear Particle-Derived Compounds in Lettuce."* Environ Sci Technol.;57(1):168–178. https://pmc.ncbi.nlm.nih.gov/articles/PMC9835885/

[8] Masset, T, Ferrari, BJD, Dudefoi, W et al (31 Oct 2022). *"Bioaccessibility of Organic Compounds Associated with Tire Particles Using a Fish In Vitro Digestive Model: Solubilization Kinetics and Effects of Food Coingestion."* Environmental Science & Technology;(56), 22. https://pubs.acs.org/doi/10.1021/acs.est.2c04291

[9] Kimo International (2021) https://kimointernational.org/wp/wp-content/uploads/2018/11/KIMO_Resolution_18_01.pdf

[10] DTSC (27 Aug 2024). Presentation Slides

[11] Kole, PJ, Van Belleghem, F, Stoorvogel, JJ, et al (10 Dec 2023). *"Tire granulate on the loose: How much escapes turf? A systematic literature review."* Science of The Total Environment; (903)166221. https://doi.org/10.1016/j.scitotenv.2023.166221

Multiple studies on used tire crumb have confirmed chemicals of concern to both human health and the environment.[12,13,14,15,16] Korean researchers have found that children who play on crumb rubber surfaces are 10 times more likely to develop cancer than those who play on soil.[17]

When considering the loss of used tire crumbs from playing fields alone, the environmental impact alone is enormous.[18,19,20] In 2021, researchers found that synthetic turf fields in Toronto contribute the 2nd highest amount of crumb rubber microplastics to the environment with only litter contributing a higher amount.[21] Also reported in 2021, the San Francisco Estuary Institute

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[12] California Environmental Protection Agency (19 May 2019). *"Synthetic Turf Study."* Meeting of Scientific Advisory Panel. Office of Environmental Health Hazard Assessment.
https://oehha.ca.gov/media/downloads/crnr/may2019turfappendicespdf.pdf

[13] Perkins, AN, Inayat-Hussain, SH., Deziel, NC et al (Feb 2019). *"Evaluation of Potential Carcinogenicity of Organic Chemicals in Synthetic Turf Crumb Rubber."* Environ Res; 169:163-172.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6396308/#!po=78.3333

[14] Skoczyńska, E, Leonards, PEG, Llompart, M, de Boer, J (Aug 2021). *"Analysis of Recycled Rubber: Development of an Analytical Method and Determination of Polycyclic Aromatic Hydrocarbons and Heterocyclic Aromatic Compounds in Rubber Matrices."* Chemosphere. Vol. 276,130076
https://doi.org/10.1016/j.chemosphere.2021.130076

[15] Duque-Villaverde, A, Armada, D, Dagnac, T, Llompart, M (15 June 2024). *"Recycled tire rubber materials in the spotlight. Determination of hazardous and lethal substances."* Science of The Total Environment; (929), 172674.
https://www.sciencedirect.com/science/article/pii/S0048969724028213

[16] Armada, D, Llompart, M, Celeiro, M et al (15 March 2022). *"Global evaluation of the chemical hazard of recycled tire crumb rubber employed on worldwide synthetic turf football pitches."* Science of Total Environment; (812), 152542.
https://doi.org/10.1016/j.scitotenv.2021.152542

[17] Tarafdar, A, Oh, MJ, Nguyen-Phuong, Q et al (2020). *"Profiling and Potential Cancer Risk Assessment on Children Exposed to PAHs in Playground Dust/Soil: A Comparative Study on Poured Rubber Surfaced and Classical Soil Playgrounds in Seoul."* Environ Geochem Health 42, 1691–1704
https://doi.org/10.1007/s10653-019-00334-2

[18] Hann, S et al (2018). *"Investigating Options for Reducing Releases in the Aquatic Environment of Microplastics Emitted by (but not Intentionally Added in) Products."* Eunomia, United Kingdom.
https://www.eunomia.co.uk/case_study/measuring-impacts-of-microplastics/

[19] Kole, P, VanBelleghem, F, Stoorvogel, J et al (10 Dec 2023). *Tyre granulate on the loose; How much escapes the turf? A systematic literature review*. Science of The Total Environment; 903, 166221.
https://www.sciencedirect.com/science/article/pii/S0048969723048465

[20] Bø Sundan, SM, Michelsen, O, Nygaard Rasmussen, F et al (10 Apr 2025). *"Dynamic material flow analysis of microplastics lost from artificial turfs: A case study from Norway."* Science of The Total Environment;(973), 179159.
https://doi.org/10.1016/j.scitotenv.2025.179159

[21] Zhu, X, Hoffman, M, Rochman, C (1 Feb 2024). *A City-Wide Emissions Inventory of Plastic Pollution*. Environ. Sci. Technol; 58, 7, 3375–3385.
https://doi.org/10.1021/acs.est.3c04348

report submitted to the California Ocean Protection Council found that tire wear particles contributed 85% of microplastics in stormwater runoff across 12 test sites in the bay area. Playgrounds, rubber infill for synthetic turf and rubberized asphalt were all found to be contributing sources of tire particles in urban runoff.[22]

In 2023, research published by UCLA in conjunction with the Moore Institute for Plastic Pollution Research found playgrounds in parks release as much as five times greater microplastics from equipment and surfacing than other areas in parks.[23] This makes synthetic turf and rubber playground surfaces clearly major point sources of PFAS, additional chemicals of concern, and microplastic pollution that cannot go unaddressed.

The California Coastal Commission (CCC) conditioned a permit for University of California Santa Barbara's baseball stadium for natural grass only, citing microplastics, and that synthetic turf is not superior to natural grass and is not sustainable.[24] The initial plans called for used tire crumb, then changed doe to environmental concerns.

The CCC has also disallowed two used tire crumb (PIP) playgrounds in the coastal permit zone, again, due to microplastics and the impact of their chemical constituents on the environment and aquatic organisms.

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[22] Werbowski, LM, Gilbreath, AN, Munno, K et al (2021). *"Urban Stormwater Runoff: A Major Pathway for Anthropogenic Particles, Black Rubbery Fragments, and Other Types of Microplastics to Urban Receiving Waters."* ACS ES&T Water; *1* (6), 1420-1428.
https://pubs.acs.org/doi/full/10.1021/acsestwater.1c00017

[23] Koutnik, VS, Leonard, J, El Rassi, LA et al (1 Jan 2023). *"Children's playgrounds contain more microplastics than other areas in urban parks."* Science of The Total Environment; (854)158866.
https://doi.org/10.1016/j.scitotenv.2022.158866

[24] California Coastal Commission (13 Dec 2023). *"Notice of Impending Development UCS-NOID-0002-23 (Baseball Stadium Turf)."*
https://documents.coastal.ca.gov/reports/2023/12/W13.1a/W13.1a-12-2023-report.pdf

Add to that the used tire crumb lost from poured-in-place playground surfacing, and the harmful impact only continues to grow.[25,26,27] This is before considering the microplastics from the carpet blades being lost to soil, water and the ocean with their toxic payloads.[28,29,30,31,32,33]

Distinct from the plastic grass carpets themselves, known to contribute to climate change, used tire crumb is also a contributor.[34]

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[25] Tangaroa Blue (2021). *"Rubber Crumb Impact Report: Urgent change of tack needed for tired tyres. How a well-intentioned tyre recycling program risks becoming a micro-pollution disaster."* https://tangaroablue.org/wp-content/uploads/2024/11/Rubber-Crumb-Report_2021_TBF.pdf

[26] Koutnik, VS, Leonard, J, El Rassi, LA et al (1 Jan 2023). *"Children's playgrounds contain more microplastics than other areas in urban parks."* Science of The Total Environment; (854)158866. https://doi.org/10.1016/j.scitotenv.2022.158866

[27] Manoli, E, Fantidou, V, Kouras, A, Samara, C, (March 2025). Pre-print: *"Polycyclic Aromatic Hydrocarbons in settled dust of playgrounds in Thessaloniki, Greece: Concentration levels and implications for childhood cancer risk*. Environmental Research. https://doi.org/10.1016/j.envres.2025.121300

[28] Schultz, Madison. 2022. *"UC Davis Environmental Research Center fundamental at Lake Tahoe."* Sierra Sun. Accessed 26 Oct 2023. https://www.sierrasun.com/news/uc-davis-environmental-research-center-fundamental-at-lake-tahoe/

[29] Spencer, C (2023). *"Lake Tahoe has higher concentration of microplastics than ocean trash heap."* LA Times. https://www.latimes.com/california/story/2023-07-14/lake-tahoe-troubling-concentration-microplastics

[30] Personal email communication from research staff at Tahoe Environmental Research Center. Lake Tahoe Email

[31] De Haan, WP, Quintana, R, Vilas, C, Cózar, A et al (1 Oct 2023).*"The dark side of artificial greening: Plastic turfs as widespread pollutants of aquatic environments."* Environmental Pollution; 334, 122094. https://www.sciencedirect.com/science/article/pii/S0269749123010965?via%3Dihub

[32] Mylius, K (11 July 2024). "*Keep the Fake Plants and Turf Out of the Surf: A call to action to reduce the use of artificial grass and plants in our cities, preserving natural greenery and its benefits, and cleaning the Ocean."* SeaBin Foundation, Australia. https://seabinfoundation.org/keep-the-fake-plants-and-turf-out-of-the-surf/

[33] Awonaike, B, Lei, YD, Parajulee, A, Wania, F (1 Dec 2021). *"Phase partitioning, transport and sources of Benzotriazole Ultraviolet Stabilizers during a runoff event."* Water Research X; (13),100115 https://doi.org/10.1016/j.wroa.2021.100115

[34] Unnamed author (31 Jan 2025). *"Where the Rubber Meets the Road and Ends Up in Snow: The Hidden Effects of Tire Matter on Snowmelt and Mountain Ecosystems."* Geosciences and Environmental Change Science Center, United States Geological Survey. https://www.usgs.gov/centers/geosciences-and-environmental-change-science-center/science/where-rubber-meets-road-and

Notable chemical ommissions from the report:

Per- and Polyfluoroalkyl Substances (PFAS)

California Department of Toxic Substances Control is fully aware of PFAS in the synthetic sports carpets, and that 100% of all synthetic turf tested to date by independent, third party and academic laboratories using appropriate testing methods, technologies and reporting limits have revealed PFAS.[35,36] Two plant based infills that were tested were both found to contain per- and polyfluoroalkyl substances (PFAS), as were shock pads.[37,38,39]

PFAS is also used in tire manufacturing.[40,41,42,43,44,45] Despite being considered a major health crisis, and highly significant class of chemicals of concern globally, PFAS were not tested for in this study.

It should also be noted that NoMex and Kevlar used in tires also contain flame retardants, which can be dermally absorbed.[46]

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[35] Whitehead, H. D. (2023). *"Development of Analytical Methods for Highly Selective and Sensitive Analytical Analysis of Compounds Relevant to Human Health and the Environment."* Version 1. University of Notre Dame.
https://doi.org/10.7274/bg257d30j3m

[36] Pollard, L, Massey, R (Aug 2024). *"Per- and Poly-fluoroalkyl Substances (PFAS) in Artificial Turf: Academic, municipal, and other testing efforts."* Lowell Center for Sustainability, University of Massachusetts, Lowell.
https://www.uml.edu/docs/PFAS%20in%20Artificial%20Turf%20-%20Academic%20Municipal%20%26%20Other%20Tests%20Aug%202024_tcm18-386957.pdf

[37] FieldTurf Vertex with Schmidt shock pad and Safeshell (walnut) infill. June 2021 Installation.
https://nontoxicdovernh.files.wordpress.com/20219/09/pfas-testing-721-galbraith-cc-samples.pdf

[38] Seibert, KD, Canaan, IS (26 Feb 2021). Synthetic turf testing and analysis summary report, Martha's Vineyard Regional High School athletic fields project. Tetra Tech.
https://drive.google.com/file/d/1nT_Fi2Hdm0oVq4ZrqBbaEFMSktbKLFBQ/view?usp=drivesdk

[39] Green, L (12 Jan 2021). PFAS in Brockfill; from proposed synthetic field, Martha's Vineyard, MA.
https://www.mvcommission.org/sites/default/files/docs/Laura%20Green%20Health%20Risk%20Assessment_Brockfill%20and%20MV%20Soils_Jan%2012_2021.pdf

[40] Bridgestone/Firestone patent

[41] PFAS testing results (Nov 2022). Fibers from used tire crumb sample.

[42] PFAS in tire cord fabrics

[43] NoMex patent

[44] Kevlar patent

[45] Kevlar, NoMex flame retardant fabrics

[46] Abafe, OA, Harrad, S, Abdallah, MAE (Apr 2024). *"Assessment of human dermal absorption of flame retardant additives in polyethylene and polypropylene microplastics using 3D human skin equivalent models."* Environment International; (186), 108635.

Recent research has identified an age-related risk for cancer for children and adolescents who play on synthetic turf.[47] PFAS has been found to be dermally absorbed, as well.[48]

Of high significance, a study done by the Kassotis Lab, in conjunction with The Ecology Center (Ann Arbor, MI), "*In vitro endocrine and cardiometabolic toxicity associated with artificial turf materials"* published in the October 2024 edition of Environmental Toxicology and Pharmacology, demonstrates the cytotoxic effects of chemicals in synthetic turf to endocrine organs, and cardiac development and function. This study also demonstrates the importance of looking at combined chemical exposures associated with a given product.[49] No one is ever exposed to one chemical- certainly not with plastics and definitely not with synthetic turf.

6PPD/6PPDq

We acknowledge that the discovery of the antiozonant N-1,3-dimethylbutyl)-N-phenyl-p-phenylenediamine (6PPD) in used tire crumb was discovered after the 2015 start date of the current OEHHA study. It was found in the study, as reported in the 2019 draft report.[50]

In December 2020, researchers published findings on the antiozonant chemical, N-1,3-dimethylbutyl)-N-phenyl-p-phenylenediamine (6PPD) in used tire crumb converts to 6PPD-quinone (6PPDq), and has resulted in a 40-90% decline in the coho salmon population,[51] a federally designated endangered species that is also implicated in US treaties with several

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https://doi.org/10.1016/j.envint.2024.108635

[47] Mohammed, AMF, Saleh, IA, Abdel-Latif, NM (29 Mar 2023). *"Hazard assessment study on organic compounds and heavy metals."* Heliyon: (9), 4, e14928 https://doi.org/10.1016/j.heliyon.2023.e14928

[48] Ragnarsdóttir, O, Abdallah, MAE, Harrad, S (June 2024). *"Dermal bioavailability of perfluoroalkyl substances using in vitro 3D human skin equivalent models."* Environment International; (188), 108722. https://www.sciencedirect.com/science/article/pii/S0160412024003581#ak005

[49] Siegela, KR, Murraya, BR, Gearhart, J, Kassotis, CD (2024). *"In vitro endocrine and cardiometabolic toxicity associated with artificial turf materials."* Environmental Toxicology and Pharmacology; (111), 104562. https://doi.org/10.1016/j.etap.2024.104562

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[50] OEHHA (31 May 2019). Synthetic Turf Study: Synthetic Turf Scientific Advisory Panel Meeting; pg 3-14: 1,4-Benzenediamine, N-(1,3-dimethylbutyl)-N'-phenyl- https://oehha.ca.gov/media/downloads/crnr/may2019turfappendicespdf.pdf

[51] Tian, Zhenyu, Gonzalez, Melissa, Rideout, Craig A. Et al. 2022. "*6PPD-Quinone: Revised Toxicity Assessment and Quantification with a Commercial Standard."* Environ. Sci. Technol. Lett. 2022, 9, 2, 140–146. Updated toxicity assessment from original publication in 2019. https://pubs.acs.org/doi/10.1021/acs.estlett.1c00910#

Native American Tribes.[52,53] 6PPDq has been found to negatively impact other aquatic species, including rainbow and brook trout.[54]

On 15 July 2021, Representative Katie Porter, then chair of the US House of Representatives Natural Resources Committee, Sub-committee on Oversight and Investigations, held a hearing on toxic chemicals from car tires and playing surfaces.[55]

> *"Even if this harmful chemical was removed from tire production today, we will be dealing with the legacy of its use for the next 15 to 20 years."* Nisqually Tribe biologist, David Troutt.[56]

> *"6PPD is more toxic than Mercury, 27 times more toxic than Cyanide, 425 times more toxic than Arsenic and more toxic than DDT...we do know that all those same ingredients in the chemical reaction that kills salmon are in those playground and playing surfaces...What we need is research on the risks from 6PPD quinone and on the possible substitutes. We need to treat this with urgency befitting a danger to our children."* [8]

> *"…tire chemicals are also a concern for the effects of air pollution on human health. The smallest particles that wear from tires contribute to the particle pollution of air. These particles are inhaled when we breathe, and they release chemicals when they* *6PPD is more toxic than Mercury, 27 times more toxic than Cyanide, 425 times more toxic than Arsenic and more toxic than DDT...we do know that all those same ingredients in the chemical reaction that kills salmon are in those playground and playing surfaces...What we need is research on the risks from 6PPD quinone and on the possible substitutes. We need to treat this with urgency befitting a danger to our children."*
> The Honorable Katie Porter, Chair. Natural Resources Committee, Oversight and

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[52] NOAA fisheries: Coho salmon, https://www.fisheries.noaa.gov/species/coho-salmon

[53] Middleton Manning, R, Lusardi, R (13 July 2023). *"Removing Dams from the Klamath River is a Step Toward Justice for Native Americans."* Climate News, UC Davis. https://www.ucdavis.edu/climate/news/removing-dams-klamath-river-step-toward-justice-native-americans-northern-california

[54] Brinkmann, M, Montgomery, D, Selinger, S et al (2 Mar 2022). *"Acute Toxicity of the Tire Rubber-Derived Chemical 6PPD-quinone to Four Fishes of Commercial, Cultural, and Ecological Importance."* Environmental Science and Technology Letters. 9 (4): 333–338. https://pubs.acs.org/doi/10.1021/acs.estlett.2c00050

[55] Porter, K, Chair (15 Jul 2021). A congressional hearing*: "Are Toxic Chemicals fromTires and Playground Surfaces Killing Endangered Salmon?"* US House of Representatives Natural Resources Committee, Oversight and Investigations Subcommittee. 2021https://democrats-naturalresources.house.gov/hearings/are-toxic-chemicals-from-tires-and-playground-surfaces-killing-endangered-salmon

[56] Troutt, D (15 July 2021). Testimony before US House of Representatives Natural Resources Committee, Oversight and Investigations Subcommittee on 6PPDq impact on coho salmon. https://docs.house.gov/meetings/II/II15/20210715/112886/HHRG-117-II15-Bio-TrouttD-20210715.pdf

Investigations. 15 July 2021.[57]

Research from Hong Kong found daily intake doses of PPD-Qs in Hong Kong are:

> "*…estimated to be 1.08 ng/(kg·day), which exceeded the doses from their parent compounds [0.71 ng/(kg·day)] under the same exposure scenarios. The results indicated that ingestion of roadside soil dust was the main contributor to human exposure of PPDs and PPD-Qs. Dermal absorption represents the second highest exposure pathways, accounting for almost 15% intake rate of oral ingestion."*[58]

6PPD and 6PPDq have been confirmed in used tire crumb in playing fields and playgrounds.[59] It has been found in human urine, and is bioaccessible to humans.[60,61,62] Both 6PPD and 6PPD quinone have been found to be toxic to human liver cells.[63,64]

Research from 2024 indicates there is a need to further evaluate the potential impact of this chemical on male infertility.[65]

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[57] US House Natural Resources Committee (15 July 2021). *"Are Toxic Chemicals From Tires And Playground Surfaces Killing Endangered Salmon?"* Rep. Katie Porter, Chair. https://www.youtube.com/watch?v=IwVQV8MzlY0

[58] Cao, G, Wang, W, Zhang, J (5 Apr 2022). New Evidence of Rubber-Derived Quinones in Water, Air, and Soil. Environ Sci Technol; 56(7): 4142–4150. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8988306/

[59] Tian, Z (27 Jan 2022). *"Organic contaminants in tire and crumb rubber: 6PPD-quinone and beyond."* Slide deck from webinar presentation. Center for Environmental Health, Oakland, CA. https://www.healthandenvironment.org/assets/images/webinarimages/Tian%20Slides.pdf

[60] Armada, D, Martinez-Fernandez, A, Celeiro, M et al (20 Jan 2023). *"Assessment of the bioaccessibility of PAHs and other hazardous compounds present in recycled tire rubber employed in synthetic football fields."* Science of The Total Environment; (857) 2, 159485. https://www.sciencedirect.com/science/article/pii/S0048969721076208

[61] Mao, W, Jin, H, Guo, R et al (1 Mar 2024). *"Occurrence of p-phenylenediamine antioxidants in human urine."* Science of the Total Environment;(914), 170045. https://www.sciencedirect.com/science/article/abs/pii/S0048969724001797

[62] Deng, M, Ji, X, Peng, B, Fang, M (14 May 2024). *"In Vitro and In Vivo Biotransformation Profiling of 6PPD-Quinone toward Their Detection in Human Urine."* Environmental Science & Technology;(58), 21. https://pubs.acs.org/doi/10.1021/acs.est.4c01106

[63] Qi, Y, Qiu, A, Wei, X et al (2024). "*Effects of 6PPD-Quinone on Human Liver Cell Lines as Revealed with Cell Viability Assay and Metabolomics Analysis*" *Toxics* 12, no. 6: 389. https://doi.org/10.3390/toxics12060389

[64] Zhang, YY, Huang, JW, Liu, YH et5 al (15 Mar 2024). *" In vitro metabolism of the emerging contaminant 6PPD-quinone in human and rat liver microsomes: Kinetics, pathways, and mechanism."* Environ Pollut;(345), 123514. https://pubmed.ncbi.nlm.nih.gov/38346634/

[65] Yao, K, Kang, Q, Liu, W et al (15 May 2024). *"Chronic exposure to tire rubber-derived contaminant 6PPD-quinone impairs sperm quality and induces the damage of reproductive capacity in male mice."* J Hazard Mater;(470):134165.

Additional chemicals of concern:

Yale researchers (2019) identified a total of 306 chemicals in crumb rubber. Of these, 52 are classified as known carcinogens and another 6 are considered suspected or presumed carcinogenic by both the US EPA and the European Chemicals Agency (ECHA). An additional 197 are considered carcinogenic a priori.[66]

Carbon black:

We have been unable to verify that a risk assessment for carbon black was done, and find this omission alarming. A known carcinogen, carbon black constitutes 30 to 40% of tires by weight. Given the amount of time that children and student athletes play on used crumb rubber infilled synthetic turf and playground surfaces, the potential risk for disease and cancer is of no small consequence. This is particularly so for young children who are of shorter stature, have less control over musculature to break falls, have a larger head to body mass ratio, and due to developmental stages.[67] It should be noted that developmental stages extend through adolescence.

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https://pubmed.ncbi.nlm.nih.gov/38574660/

[66] Perkins, AN, Inayat-Hussain, SH., Deziel, NC et al (Feb 2019). *"Evaluation of Potential Carcinogenicity of Organic Chemicals in Synthetic Turf Crumb Rubber."* Environ Res; 169:163-172. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6396308/#!po=78.3333

[67] Niranjan, R, Thacker, AK (30 Jun 2017). *"The Toxicological Mechanisms of Environmental Soot (Black Carbon) and Carbon Black: Focus on Oxidative Stress and Inflammatory Pathways."* Front Immunol;(30),8, 763. https://pmc.ncbi.nlm.nih.gov/articles/PMC5492873/

- Benzothiazole (BT)
- 2- Mercapto- benzothiazole (MBT)
- 1,3-Diphenylguanidine (DPG)
- Cadmium
- Benzene
- Formaldehyde
- Copper
- Mercury
- Hexamethoxymethylmelamine (HMMM)
- Short (SCCP) and long chain (LCCP) chlorinated paraffins

Zinc:

A threat to aquatic organisms, zinc and other metals are known to leach from used tire crumb.[5,68]

A big wake up call came in 2019 when Canadian researchers were studying the effects of crumb rubber leachate on chicken embryos. Zinc was the most abundant metal ion leached from the tire crumb, followed by Cu. Amniote vertebrate were used to determine the impacts of crumb rubber on higher vertebrates, including humans, as birds and mammals "show little interspecific variation and amniotes undergo no genome duplications." Findings include mild to severe malformations, reduced growth including of the midbrain, the cardiovascular system, and gene, thyroid and other endocrine response pathways.[69]

Zinc in motor vehicle tires is a proposed priority for California Department of Toxic Substances Control.[70]

Lead (Pb):

Lead and other heavy metals are found in used tire crumb and in playground surfacing.[71] In PIP surfacing, which is heterogeneous, lead levels can vary widely, including hot-spots with significantly higher lead readings from one area to another. Used tire crumb is known to have leachable lead. Lead from used tire crumb has been shown to have both non-cancerous and cancerous [72]

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[68] Xie, L, Zhu, K, Jiang, W et al (Dec 2022). *"Toxic effects and primary source of the aged micro-sized artificial turf fragments and rubber particles: Comparative studies on laboratory photoaging and actual field sampling."* Environment International;(170), 107663. https://www.sciencedirect.com/science/article/pii/S0160412022005906#b0025

[69] Xu, EG, Lin, N, Cheong, RS, et al (10 Dec 2019). *"Artificial turf infill associated with systematic toxicity in an amniote vertebrate."* Proceedings of the National Academy of Sciences of the United States of America (PNAS). https://www.pnas.org/content/116/50/25156?__cf_chl_jschl_tk__=pmd_ebee69f85747577a16db016011dd9d106a583981-1627359919-0-gqNtZGzNAeKjcnBszQgO

[70] https://dtsc.ca.gov/scp/motor_vehicle_tires_containing_zinc/

[71] Gearhart, J (2021). Letter to Deputy Mayor of Education, Washington, DC: *"Report on lead in pour in place (PIP) rubber playground at Janney Elementary School."* The Ecology Center, Ann Arbor, MI https://drive.google.com/file/d/1UfMzsVQ0EZKquGlnUKBgkspohIod9D-H/view?usp=drivesdk

[72] Graça, CAL, Rocha, F, Gomes, FO et al (23 Mar 2022). *"Presence of metals and metalloids in crumb rubber used as infill of worldwide synthetic turf pitches: Exposure and risk assessment."* Chemosphere;(299), 134379. https://pubmed.ncbi.nlm.nih.gov/35339520/

There is recent research on the age of crumb rubber and leaching of heavy metals. [73]

Numerous experts worldwide have stated there is no safe level of lead exposure:

> *"EPA and the Centers for Disease Control and Prevention (CDC) agree that there is no known safe level of lead in a child's blood. Taking action to reduce these exposures can improve outcomes. Lead is harmful to health, especially for children."* US EPA
>
> *"There is no level of exposure to lead that is known to be without harmful effects. Lead exposure is preventable."* World Health Organization
>
> "*There is no safe level of lead exposure in children, with lasting decreases in cognition documented in children with blood levels as low as 5 micrograms per deciliter of lead in blood."* American Academy of Pediatrics
>
> *"It is also likely that when many more athletes are active on a field (e.g., 22 in a football game), the "cloud" of particulates that is generated may result in an elevated exposure relative to the particulates mobilized by a single occupant."* Drs. Stuart L Shalat and Alan Stern
>
> "*…data provide sufficient evidence to eliminate childhood lead exposure by banning all nonessential uses of lead and further reducing the allowable levels of lead in air emissions, house dust, soil, water, and consumer products."*
> Pediatrician and researcher on lead, children's health and environment, Dr. Bruce Lanphear
>
> *"No safe blood lead level in children has been identified. Children are especially at risk from lead because of their small size and developing brains. Lead exposure can affect nearly every system in the body. Even low levels of lead in blood have been shown to negatively affect a child's intelligence, ability to pay attention, and academic achievement. Removing all sources of lead exposure is important before a child is harmed."* Centers for Disease Control (CDC).

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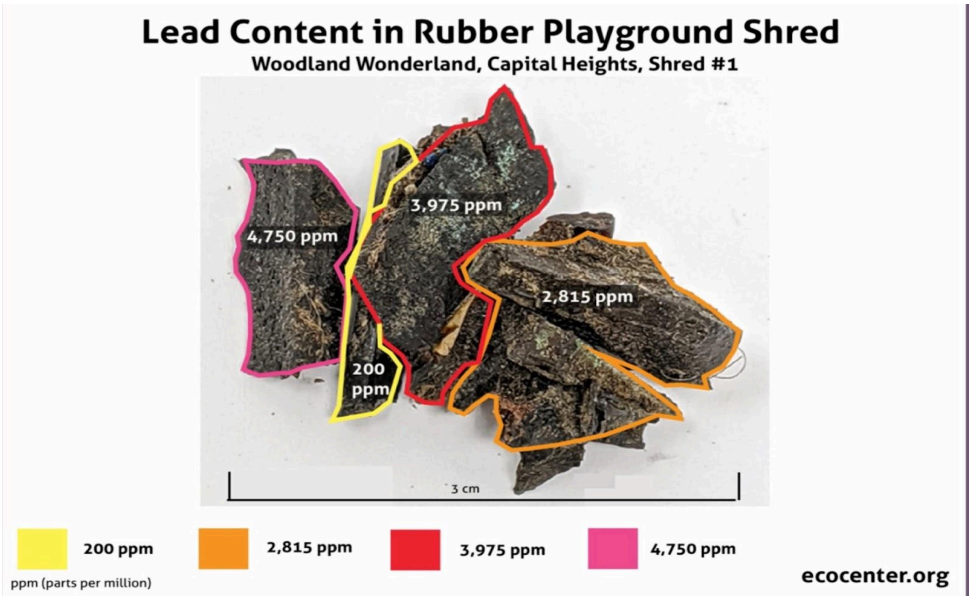
[73] Winz, R, Yu, LL, Sung, LP et al (1 Jan 2023). *"Assessing children's potential exposures to harmful metals in tire crumb rubber by accelerated photodegradation weathering."* Nature. https://www.nature.com/articles/s41598-023-38574-z.pdf



Polycyclic aromatic hydrocarbons (PAHs):

Research released in 2019 used 20 passively deployed silicone wristbands and Low Density Polyethylene (LDPE) samplers and crumb rubber from 10 synthetic turf sites over 47 days in 2016. The samplers detected 25 chemicals not previously reported in synthetic turf (some with known human effects), 44 PAHs and 7 OPAHs (oxygenated PAHs). Twelve of the detected PAHs had not previously been reported in synthetic turf, including many alkyl-naphthalenes, which may be more toxic than parent PAHs. A new indoor synthetic field, had the highest PAH concentrations, at 20- and 13-fold greater than at outdoor fields, respectively. One PAH not previously reported was benzo[c]fluorene, with an estimated carcinogenic potency 20 times greater than benzo[a]pyrene (USEPA 2010). Benzo[c]fluorene was detected in all LDPE samplers at all sites.[74] The use of participant worn samplers is more likely to provide more accurate depiction of exposures than using stationary equipment staged behind goal posts.

Researchers in the Netherlands discovered 46 new PAHs found in crumb rubber.

> *"It has recently been discovered that the rubber granulates in artificial turf contain even more harmful and carcinogenic substances than had previously been assumed. Furthermore, several of these substances are even more prone to leaking than the substances in rubber granulate that had already been identified as being harmful. This information was revealed by a new doctoral study conducted by chemist Ewa Skoczynska from Vrije Universiteit Amsterdam (VU). According to her supervisor,* Jacob de Boer, a professor of environmental chemistry and toxicology*, these findings mean that the current standards for rubber granulate should be much stricter. The professor expects that sports fields containing rubber granulate will eventually become a thing of*

[74] Donald, CE, Scott, RP, Wilson, G et al (7 Mar 2019). *"Artificial turf: chemical flux and development of silicone wristband partitioning coefficients."* Air Quality, Atmosphere & Health (2019) 12:597–61. https://link.springer.com/content/pdf/10.1007/s11869-019-00680-1.pdf

the past. "I am pretty sure of this. You do not want to run this kind of risk and these types of sports fields are not even necessary."[75]

Multiple studies have shown PAHs in crumb rubber.[76] Research released in 2023 has shown the bioaccessibility of most of the 16 US EPA PAHs and 8 ECHA (European Chemicals Agency) PAHs in used tire crumb.[77] The European Union placed a 20 mg/kg summed limit on 8 PAHs that went into effect 10 Aug 2022. The chemicals included are: BaP, DBAhA, BeP, BaA, CHR, BbFA, BjFA and BkFA.[78]
Newly released research from Greece found that dust from used tire crumb playgrounds top coated with EPDM showed a six fold increase in exposure to petroleum based PAHs in dust that extended beyond the playground surface and onto surrounding concrete areas.[79]

We are long past the time of denying PAHs are unsafe.[80,81,82]

Phthalates:

Published in 2022, research on 91 used tire crumb samples taken from soccer fields in 17 countries on four continents confirmed the presence of multiple toxic and carcinogenic chemicals:

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[75] Skoczyńska, E, Leonards, PEG, Llompart, M, de Boer, J (Aug 2021). *"Analysis of Recycled Rubber: Development of an Analytical Method and Determination of Polycyclic Aromatic Hydrocarbons and Heterocyclic Aromatic Compounds in Rubber Matrices."* Chemosphere. Vol. 276,130076
https://doi.org/10.1016/j.chemosphere.2021.130076

[76]

[77] Armada, D, Martinez-Fernandez, A, Celeiro, M et al (20 Jan 2023). *"Assessment of the bioaccessibility of PAHs and other hazardous compounds present in recycled tire rubber employed in synthetic football fields."* Science of The Total Environment; (857) 2, 159485.
https://www.sciencedirect.com/science/article/pii/S0048969721076208

[78] https://echa.europa.eu/hot-topics/granules-mulches-on-pitches-playgrounds

[79] Manoli, E, Fantidou, V, Kouras, A, Samara, C, (March 2025). Pre-print: *"Polycyclic Aromatic Hydrocarbons in settled dust of playgrounds in Thessaloniki, Greece: Concentration levels and implications for childhood cancer risk*. Environmental Research.
https://doi.org/10.1016/j.envres.2025.121300

[80] Duque-Villaverde, A, Armada, D, Dagnac, T, Llompart, M (15 June 2024). *"Recycled tire rubber materials in the spotlight. Determination of hazardous and lethal substances."* Science of The Total Environment; (929), 172674.
https://www.sciencedirect.com/science/article/pii/S0048969724028213

[81] Armada, D, Llompart, M, Celeiro, M et al (15 March 2022). *"Global evaluation of the chemical hazard of recycled tire crumb rubber employed on worldwide synthetic turf football pitches."* Science of Total Environment; (812), 152542.
https://doi.org/10.1016/j.scitotenv.2021.152542

[82] Sibeko, MA, Adeniji, AO, Okoh, OO et al (9 Sep 2020). *"Trends in the management of waste tyres and recent experimental approaches in the analysis of polycyclic aromatic hydrocarbons (PAHs) from rubber crumbs*." Environ Sci Pollut Res;(27), 43553–43568
https://pubmed.ncbi.nlm.nih.gov/32902752/

> *"…including the eight ECHA (European Chemicals Agency) PAHs considered as carcinogenic, and anthracene (ANC), pyrene (PYR) and benzo[ghi]perylene (B[ghi]P), catalogued as substances of very high concern (SVHC). Endocrine disruptors such as some plasticizers (mainly phthalates), and other compounds like benzothiazole (BTZ) and 2-mercaptobenzothiazole (MBTZ)."*[47]

Phthalates are used extensively in the manufacturing of plastics. They have endocrine disrupting[83] as well as neurotoxic effects.[84] As plasticizers, they are used in plastic toys, playground equipment, "natural rubber" and tire manufacturing.[85] Use of phthalate-containing products is choosing to risk impairment of children's I.Q.s, their brains and their overall health. Phthalates are both endocrine disrupting chemicals (like PFAS) and neurotoxins.

> *"Ortho-phthalates are diesters of phthalic acid and are the predominate type of phthalate used in commerce. (For simplicity, we will refer to them as phthalates.) They are high-production-volume chemicals used most often as a plasticizer in polyvinyl chloride (PVC) and other plastics.* Phthalates *are used in numerous consumer products, including food production materials and packaging; medical supplies and coatings of medicines; flooring, wall coverings, and other home materials; and cosmetics and other personal care products. Approximately 4.9 million metric tons are produced annually worldwide. The highest-production phthalates are di-2-ethylhexyl phthalate (DEHP), diisononyl phthalate (DiNP), butylbenzyl phthalate (BBzP), dibutyl phthalates (DBPs), and diethyl phthalate (DEP)."*[49]

Additional areas of concern:

> *"OEHHA adopted the following age groups to represent the individuals in these categories: third trimester fetus in pregnant women, newborns to children under age 2…"*

Notably absent, is exposure in first and second trimesters of pregnancy when organogenesis is most susceptible to environmental insult.[86] Pregnant individuals do not refrain from attending events on synthetic turf until the third trimester of pregnancy.

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[83] Wang, Y, Qian, H, (18 May 2021). *"Phthalates and Their Impacts on Human Health."* Healthcare (Basel); 9(5), 603.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8157593/

[84] Engel, SM, Patisaul, HB, Brody, C (Apr 2021). "*Neurotoxicity of Ortho-Phthalates: Recommendations for Critical Policy Reforms to Protect Brain Development in Children."* Am J Public Health. 2021;111(4): 687–695.
https://doi.org/10.2105/AJPH.2020.306014

[85] Johannessen, C, Liggio, C, Zhang, X et al (Sep 2022), *"Composition and transformation chemistry of tire-wear derived organic chemicals and implications for air pollution."*
Atmospheric Pollution Research; 13(9), 101533
https://www.sciencedirect.com/science/article/pii/S1309104222002148

[86] American College of Obstetrics and Gynecology; Fetal development.
https://www.acog.org/womens-health/faqs/how-your-fetus-grows-during-pregnancy

Running on the field may stir up particles into the air and cause athletes, who have elevated breathing rates, to inhale increased amount of chemical vapor and particulates."

Body temperatures of athletes were not assessed. Nor was specific gravity of urine before and after play, which would indicate hydration levels. Hydration status and Increased body temperature associated with exercise impact dermal absorption. The increased temperature of plastic playing fields, and increasing frequency of higher ambient air temperatures increase increases body temperatures, risk of dehydration, and therefore dermal absorption.[41,87] The higher skin surface area to body weight ratio in children is also a factor that must be considered in dermal absorption.[88]

New information on the health impacts of inhalation and ingestion of tire crumb only increases concern over use of this material on playing fields and playgrounds.[89]

We question whether risk based on individual chemicals, then totaling the scores, as well as using synthetic sweat and gastrointestinal fluids rather than using human skin cells and whole mixture toxic assessment was the best tactic. While this may have saved money, it certainly did not save time…and therefore undoubtedly cost taxpayers significantly more than the allotted $3,000,000 for the study.

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[87] Kilo, S, Wick, J, Vijayan, SM et al (Oct 2020). *"Impact of physiologically relevant temperatures on dermal absorption of active substances - an ex-vivo study in human skin."* Toxicology in Vitro;(68),104954. https://www.sciencedirect.com/science/article/abs/pii/S088723332030504X

[88] Yun, YE, Calderon-Nieva, D, Hamadeh, A, Edginton, AN (12 Jan 2022). *"Development and Evaluation of an In Silico Dermal Absorption Model Relevant for Children."* Pharmaceutics; 14(1):172. https://pmc.ncbi.nlm.nih.gov/articles/PMC8780349/

[89] Huang, Q, Wand, J, Wang, U (4 Dec 2023). *"Emerging Health Risks of Crumb Rubber: Inhalation of Environmentally Persistent Free Radicals via Saliva During Artificial Turf Activities."* Ecotoxicoloy and Public Health. https://pubs.acs.org/doi/10.1021/acs.est.3c03278

Given the outdated literature review, lack of a comprehensive database on chemicals in tires,[90] availability of standards for many chemicals, outdated technologies and reliance on outdated risk assessment procedures, and failure to address the vast environmental impacts, we do not find that this study meets criteria for a declaration of “safe to use.” SHPFI urges you to employ the precautionary principle.

Respectfully submitted,

Diana Conway, President
Dianne Woelke MSN, Board Member
Safe Healthy Playing Fields, Inc.
https://www.safehealthyplayingfields.org
SHPFI is an all-volunteer nonprofit 501-c-3

[90] Rødland, E, Lin, Y (2 Jun 2023). *“Actions Are Needed to Deal with the High Uncertainties in Tire Wear Particle Analyses.”* Environmental Science & Technology;(57), 22.
https://www.nature.com/articles/s41598-022-10691-1