

Communication from Public

Name: Lisa Beebe

Date Submitted: 06/27/2024 12:19 PM

Council File No: 24-0602

Comments for Public Posting: Dear Mr. Blumenfield and Energy and Environment Committee Members, I am writing in support of LA City Agenda Item 2, Motion 24-0602 to transition away from future installations of synthetic grass / artificial turf citywide, and identify incentives and rebate programs to remove and replace synthetic turf / artificial grass, and encourage the transition to California friendly landscaping. Implementing artificial grass as a means to reduce water consumption would ultimately do more damage to our fragile natural environment. I would strongly prefer to see Los Angeles transition to landscaping with drought-tolerant native plants instead. Thank you, Lisa

Communication from Public

Name: Michael Wodkowski

Date Submitted: 06/27/2024 12:32 PM

Council File No: 24-0602

Comments for Public Posting: Dear Mr. Blumenfield and Energy and Environment Committee Members, We are writing in support of LA City Agenda Item 2, Motion 24-0602 to transition away from future installations of synthetic grass / artificial turf citywide, and identify incentives and rebate programs to remove and replace synthetic turf / artificial grass, and encourage the transition to California friendly landscaping; With the growing awareness of the climate crisis, cities and agencies are implementing artificial grass as a means to reduce water consumption. While initially it seems like a great way to save water, this solution is actually mired in unintended consequences including: killing microorganisms, wildlife habitats and biodiversity below every artificial turf installation emitting toxic leachate in runoff to nearby fields and storm drains creating heat islands as the heat is absorbed by these fields which is exacerbated by the fact that trees and other shade plants don't grow in artificial turf contributing to warming temperatures impacting the health of users increasing the cost of maintenance A study conducted at Brigham Young University found that "The surface temperature of the synthetic turf was 37° F higher than asphalt and 86.5° F hotter than natural turf." Artificial turf is a silent but significant contributor to our climate demise. Research indicates we need more real turf and have shown reduced global warming in countries where agriculture has intensified. We need to eliminate the use of artificial turf and institute its replacement immediately. We need to take every action possible to mitigate the negative effects of climate change. Please pass this motion.

Communication from Public

Name: Pat Saperstein
Date Submitted: 06/27/2024 12:34 PM
Council File No: 24-0602
Comments for Public Posting: I support a ban on artificial turf in Los Angeles. The last thing our city needs is to add large amounts of plastic to the environment, and it's not safe for children, pets and everyone else.

Communication from Public

Name: Dr. Tony Knight

Date Submitted: 06/27/2024 12:37 PM

Council File No: 24-0602

Comments for Public Posting: I urge the LA City Council to adopt Council File 24-0602 to transition away from artificial turf and toward drought-tolerant, native, nature-based landscaping. This motion is supported by various Los Angeles environmental organizations, including the Neighborhood Council Sustainability Alliance and the San Fernando Valley and Los Angeles Chapters of The Climate Reality Project. These organizations support a ban on new installations of artificial turf due to the various human health hazards, environmental contamination, and negative impacts on wildlife. Compared to natural turf, California native plants, and drought-tolerant grasses, artificial turf is NOT a safer playing surface, does NOT significantly reduce water usage, and is NOT a sound investment. As a result, these organizations strongly support installing natural grass fields and planting native California plants. Again, I urge you to follow the science related to artificial turf and encourage a swift transition away from artificial turf towards nature-based solutions.

Communication from Public

Name:

Date Submitted: 06/27/2024 12:41 PM

Council File No: 24-0602

Comments for Public Posting: Plastic Grass is a bad alternative for turf. It's unhealthy for the environment - provides no food for wild wildlife, is hot, and contains toxins which are detrimental to children's health. Additionally, it has been shown that artificial turf is actually more expensive to install and maintain than natural turf.
<https://www.youtube.com/watch?v=Uepmbvxc4GQ>

Communication from Public

Name: Vanessa

Date Submitted: 06/27/2024 12:51 PM

Council File No: 24-0602

Comments for Public Posting: I strongly support the move away from artificial turf. This is a small change that can have huge downstream effects on our local biodiversity and public health and safety.

Communication from Public

Name: Dennis Murphy

Date Submitted: 06/27/2024 12:57 PM

Council File No: 24-0602

Comments for Public Posting: Sustainable Silicon Valley strongly supports a reconsideration of the decisions leading up to the possible expenditure of millions of dollars on artificial turf fields and a moratorium on greenlighting these projects pending a deeper review. This decision path has been built upon faulty assumptions of the recent decade and represents a disservice to the community. The science may be inconvenient but is conclusive: we now know that synthetic turf is a clear health hazard with a high social cost, as the attached Santa Clara County Medical Association's Environmental Health AT Policy Recommendation exhaustively details. Plastic athletic fields are heat islands, breeding grounds of Staph (MRSA) infections and the cause of a significantly higher rate of knee, ankle and head injuries. There are serious clouds on the state horizon. Last legislative session Governor Newsom corrected an unfortunate 2014 drought restriction by signing SB 676, which excludes artificial turf definitionally as drought tolerant. He did veto AB 1423, which would have banned turf installation on PFAS grounds, but expressed a keen interest in uniformly implementing oversight. Lastly, SB 499, addressing school heat islands and mandating "cool" surface solutions, stalled in Assembly Appropriations but most likely will be taken up again. Industry marketing still maintains, against any evidence, that their petroleum-based plastic turf product is recyclable, requires "no" maintenance and uses "no" water. But the top layer, infill, backing, drainage and padding on an average synthetic field comprises some 220 tons(!) of single-use plastic destined for landfill or incineration, service advisories direct a fair amount of surface and sub-surface chemical treatment and water use for cleaning and cooling makes savings illusory. If the biggest decision factor is cost, synthetic turf fails here as well. Over the eight-ten-year life cycle of a plastic field, the district could install multiple natural turf fields. Xeriscaping makes sense in most all cases, but park land and athletic fields should be our special oasis and maintained appropriately.



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Policy Recommendation on the Use of Artificial Turf on Landscapes, Schools and Playing Fields

Santa Clara County Medical Association

June 10, 2024

Purpose: To educate and provide recommendations to physicians, officials, school administrators and teachers of the health risks and potential health and environmental hazards of artificial turf and synthetic grass on landscapes, schools, playgrounds and playing fields.

Recommendations: After careful consideration of the current scientific evidence of plastic and chemical contamination, sports injuries, urban heat effects, disposal, potential short and long-term health effects, as well as direct and indirect environmental costs, the SCCMA believes artificial turf is potentially harmful to both human and environmental health and is not a sustainable option when compared with natural grass. Taking a precautionary approach for the long-term protection of the children, the environment and public health, we recommend:

- 1) That artificial turf *not* be used on sports fields, playgrounds, landscaping, residential lawns or in schools, but instead that natural grass turf be used, a choice that will serve to benefit the health and safety of children, athletes and the environment, and
- 2) If artificial turf *is* in place, that at the end of its useful life it be replaced with natural grass and *not* artificial turf.

SCCMA Goals: The support of public health measures to prevent environmentally-related disease is a prime goal and objective of the Santa Clara County Medical Association (SCCMA). This especially applies to children who have greater lifetime exposures to- and accumulation of- toxins, and whose immune, cardiovascular, reproductive and neurologic systems are immature, increasing their vulnerability to acute and chronic diseases related to toxic exposures.

Introduction:

Rethinking Artificial Turf

Artificial turf was introduced into the sports world in 1965. Currently there are approximately 13,000 synthetic turf sport fields in the U.S. While in the past artificial turf initially seemed to be the better alternative due to reduced costs, reduced water usage and lower maintenance, newer information has come to light regarding the direct and indirect environmental and health impacts of synthetic grass, including a full life cycle analysis of costs. As more artificial turf fields are

installed, more long-term problems are being identified. Indeed, the environmental impacts of artificial turf components are now recognized as a global problem (Armada 2022). We think that artificial turf, based on available scientific studies, is not a sustainably safe alternative for landscaping, nor for use on sport fields, particularly for children. In addition, much progress has been made in developing state of the art drought resistant, water conserving grass fields that are sturdy, can be used year-round in California, and can be watered with non-potable recycled water. References follow.

Components of Artificial Turf

Artificial turf is a human-made surface of synthetic fibers, that was invented in the 1960's to look like and replace natural grass on sports fields and residential lawns. It consists of non-biodegradable plastic turf "blades" and a non-biodegradable backing. In the 1990's infill was added between the blades to soften the fields during play. Turf blades are composed of polyethylene, polypropylene or nylon.

The cushioning infill material is most often crumb rubber infill from crushed tires. Other materials have been used, such as silica from crushed quartz, synthetic rubber, polymer-coated sand, and other organic materials (cork and coconut fiber). However, these "eco-friendly" alternatives are typically coated with stabilizers and plasticizers for durability. The primary backing consists of woven or non-woven fabric made from high-strength polyester or polypropylene. The secondary backing is applied to permanently stabilize and secure the tufts of the artificial turf system. The most commonly used coating materials are latex and polyurethane.

Stated Benefits of Artificial Turf

The benefits widely promoted by the Synthetic Turf Council (STC) include less maintenance, less cost, no mowing, none-to-minimal water usage, no discoloration yearlong, no weeds, no allergies, no need for pesticides and durability, as the product withstands harsh weather conditions thus extending the sports season. We will look at some of these issues in the sections below.

Summary: Concerns about Artificial Turf

Chemical and Plastic Pollution

- Artificial turf and infill contain chemicals and heavy metals that are bio-accumulative, and thereby, harmful to humans and to the environment. These include polycyclic aromatic hydrocarbons (PAHs), phthalates, and perfluoroalkyl and polyfluoroalkyl "forever" substances (PFAS) (Ecology Center 2020; New Jersey State 2023; PEER 2024). Chemicals in artificial turf have a variety of biological effects and are known carcinogens, neurotoxicants, mutagens, and endocrine disruptors. Heavy metals such as arsenic, lead, chromium, zinc, antimony, and cadmium are also found in artificial turf components. (Armada 2022; Celeiro 2018; Llompарт M 2013; Zhang 2008; Winz 2023). Some of the incorporated metals are found above regulatory limits (Negev 2022).

- Crumb rubber from crushed used tires is often used as infill, (well as on playgrounds) and has a unique chemical risk profile for humans and the environment (Duque-Villaverde 2024; Frederico 2023; Mayer 2024; Murphy 2022).
- There is close and often repetitive contact of players with artificial turf surfaces and infill, especially for soccer and football players, with particles sticking to shoes and clothing
- There can be direct inhalation and ingestion or dermal uptake of chemicals from the plastic grass and infill (Celeiro 2021).
- There can be leaching of harmful chemicals and microplastics into groundwater, drinking water and soil, causing water contamination, as well as damage to the living soil and organisms beneath them (Celeiro 2021; Armada 2022; Cui 2022; Zhong 2022).
- Many of the chemicals can be volatilized, and thus inhaled, especially with high temperatures (Armada D 2022; Celeiro 2021, Llompert M 2013).
- Biocides and pesticides applied to artificial fields to kill bacteria, mold, viruses and weeds can cause skin sensitization and may pose risks to the health of workers, children, and surrounding ecosystems (Hahn 2010).
- Artificial turf contains microplastics which are considered contaminants of emerging concern as they do not biodegrade, but do bioaccumulate in the environment, thus creating harm at every stage of the plastic life cycle in their production, use, and disposal (Landrigan 2023).
- Microplastics are inflammatory and also found in humans in the blood, brain, lungs, liver, gut, testicular tissue, thrombi and placenta (Gaspar 2022; Leslie 2022; Ragusa 2021; Danopoulos 2022; Wu 2023; Garcia MA 2024; Garcia MM 2024; Saha 2024; Hu 2024). Polyethylene (used in artificial turf) has even been detected in atherosclerotic plaque in 58% of carotid artery specimens showing “visible, jagged-edged foreign particles” that could contribute to vascular inflammation (Marfella 2024).
- Artificial turf adds to the plastic pollution crisis (IUCN 2022).
- Artificial turf microplastics have been found in 50% of urban waterways tested in Spain and comprised 15% of plastic found in the water (deHaan 2023).
- Artificial turf components have been found to be toxic to earthworms (Pochron 2018), aquatic organisms (Kruger 2013) and chick embryos (Xu 2019).
- Artificial turf infill components can reduce sport grass growth (van Kleunen 2019).

Increased Surface Runoff

- Artificial turf is impervious and increases surface runoff that carries microplastics into storm water drains and local water bodies (de Haan 2023).

Increased Sports Injuries

- There is increased biomechanical stress on joints when playing on artificial turf fields versus natural grass, causing an increase in lower extremity sports injuries particularly in football and soccer (Gould 2023) and an increase in concussions because the artificial turf is laid over concrete or compacted earth (Mack 2019) with a resultant increased impact deceleration (Villanueva 2024).
- There is evidence of increased staphylococcus bacterial infections from turf abrasions

- Turf Toe injury is seen largely from artificial turf sports injury (Najefi 2018)

Athletic Preference for Natural Grass

- Athletes from high school to college to professional sports by far prefer to playing on natural grass (Owen 2016; Dumas 2023; NFLPA).
- National Football League (NFL) players prefer natural grass due to increased injuries from artificial turf (NFL Players Association).

Creation of Urban Heat Islands with Risk of Heat Injury

- Artificial turf can create harmful local heat islands with very high field surface temperatures which range from 40 - 60 degrees °F higher than natural grass - even with moderate air temperatures - causing poor athletic performance and heat related injury and illness, such as burns, heat stress, heat stroke and heat exhaustion, making the fields unusable (McFarlane 2015; Abraham 2019; Dujanovic 2017). In contrast natural grass fields rarely get above 100 degrees F.
- Cleats can get hot and have been known to melt on artificial turf (Litman 2015; Nazareth 2016).
- High synthetic field surface temperatures increase volatility and absorption of harmful chemicals from the synthetic turf (Armada D 2022; Llompart M 2013).
- A significant amount of water is used to manufacture, clean and cool synthetic sports fields (Alm 2016; Kanaan 2020).
- There is an expected rise in extreme heat events with a rise in heat-related illnesses and deaths in the next 20 years. Climate change will cause this to be more of an issue for athletes and children (California report “Indicators of Climate Change”).
- With rising temperatures artificial turf fields are expected to be increasingly hotter for longer periods, thereby reducing the number of days they can be used in warm or hot weather compared to natural grass.
- Children are physiologically more vulnerable to heat-related illness, due to their greater skin surface area in relation to their bodies, immature sweat glands and higher metabolic rates (Bytomski 2003; Antoniadis 2020; Malmquist 2021). Children can suffer a 24% longer *extreme danger* duration on artificial turf during sunny days than on natural grass (Liu and Kim).
- Parks with grass fields can be cooler than the surrounding urban environment by up to 7°C (Slater 2010).

Not Recyclable: Increasing Plastic Waste

- Artificial turf creates a significant waste problem at the end of its limited lifespan of 8-10 years, and it is difficult to recycle due to its complex plastic mixture. It often becomes landfill waste or is dumped on private land with persistent soil and water contamination leaching from the plastic, or is incinerated with accompanying adverse air quality impacts.

- California does not recycle artificial turf and it has to be sent out of state to an “advanced recycling” plant, however there is controversy over the true recyclability of artificial turf and its carbon cost. Only recently has one plant in Texas opened for recycling, and the results have not been measured. Many decades of artificial turf remain stocked in piles above ground in the U.S. and abroad.
- Industry advertising claims stating that artificial turf is recyclable has been challenged in a formal complaint (PEER 2022, York Daily Report 2019).
- A recent comprehensive report “The Fraud of Plastic Recycling” reveals that the plastic industry and the oil industry knew for decades that plastic was not truly recyclable (The Center for Climate Integrity 2024).
- Typical sports fields are about 80,000 square feet and contain about **40,000 pounds of “grass” turf** along with **240,000 to 720,000 pounds of infill** according to the Synthetic Turf Council.

Water Use

- Valley Water, headquartered in San Jose, notes that water conservation no longer includes artificial turf as they recognize that, “there are healthier and more ecologically sound alternatives”
- California Senate Bill 676, signed into law Oct 8, 2023 by Governor Newsom, specifies “that drought-tolerant landscaping does *not* include the installation of synthetic grass or artificial turf.”
- Water use on hot days is comparable for both natural grass and artificial turf that is cooled with water to allow playability (Kanaan 2020).
- Manufacture of *one* artificial turf field uses the same amount of water needed to maintain one natural grass field for *4 years* (Alm 2016).
- Recycled water may not be suitable for use on artificial turf due to high salt content which can break down artificial turf components (California Coastal Commission 2023). However, natural grass turf can withstand the salts in recycled water (Evanylo 2010; Hochmuth 2022)

Water Quality and Environmental Effects

- As artificial turf is used it degrades with wear and microplastic and chemicals leach into the soil, water and air on fields and in disposal sites (Wik 2009; Bessa 2018; Celeiro 2018 & 2021; de Haan 2023).
- Water contamination from artificial turf is recognized as a global problem with widespread pollutants in the aquatic environment. deHaan (2023) found artificial turf plastics were found in 50% of river samples and comprised 15% of all plastics in the water.
- Artificial turf is associated with a decline in diversity in soil and bird populations (Bernat-Ponce 2020; Sanches-Sotomayer 2022; Valeriani 2019).
- Integrated Pest Management Policies, Programs and Ordinances have been successfully implemented in many municipalities to reduce pesticide use on parks, landscapes and in agriculture (IPM EPA 2023; IPM San Francisco; IPM Santa Clara County; IPM Marin;

IPM-UC; IPM USDA). These programs protect biodiversity, reduce health risks and address long-term indirect consequences of toxic exposures.

Displacement of Green Space

- Artificial turf displaces natural green space, which is important to health, development and the well-being of children.
- California Extreme Heat Action Plan for California encourages natural plants and landscaping to strengthening community resilience.
- Artificial turf replaces natural grass, which provides soil organic carbon sequestration as well as oxygen.

Carbon Footprint

- Artificial turf is made of plastic that is derived from fossil fuels.
- Artificial turf produces greenhouse gas emissions during manufacturing and has been found to emit these gases as it degrades (Royer 2018).
- Natural grass sequesters carbon, especially when organic methods are used to maintain sports fields (Braun 2019; Cumming 2018; Hamido 2016; Kong 2014; Law 2017; Qian 2012; Zhang 2013).
- Turf farms used in industry can create a positive balance for carbon sequestration (Cummings 2018).

Cost is Less for Natural Grass Fields

- Using a Life Cycle Analysis which includes disposal, natural grass fields are less expensive in the long run (Daviscount 2017; University of Arkansas; TURI U of Mass Lowell).
- Cleanup costs for current disposal sites and environmental toxins are not taken into account in the total cost of artificial turf.

Benefits of Natural Grass

- Sequesters carbon
- Groundwater preservation and recharge by preventing runoff
- Restoration ecology, bioremediation and soil restoration
- Maintains healthy soil microbiome
- Water conservation
- Improves wellbeing
- Supports biodiversity in soil and the ecosystem

- Cooler microclimate

Examples of Natural Grass Playing Fields

Note: The Sports Field Management Association gives awards every year to well managed natural grass fields

- Marblehead, MA
- Springfield, MA
- Martha's Vineyard, MA
- Snapdragon Stadium in San Diego
- Woodland Middle School, Portola Valley
- Woodside Priory, Portola Valley

No Proof of Safety for Artificial Turf

- There is a significant data gap in understanding the safety of artificial fields. Gaps remain in understanding the chemicals, their toxicity and concerns about the dosages.
- Long-term human health impacts, such as cancer, remain uncertain with some evidence pointing to a higher risk (Tarafdar 2020).
- There are no studies indicating that artificial playing fields are safe
- In February 2016, the Federal Research Action Plan on Recycled Tire Crumb Used on Playing Fields and Playgrounds (FRAP) was announced. This multi-agency effort includes the U.S. Environmental Protection Agency (EPA), Centers for Disease Control and Prevention (CDC), and the U.S. Consumer Product Safety Commission (CPSC). The 2019 report released in 2024 discusses crumb rubber only.
- The Consumer Product Safety Commission recommends precautions to limit exposure to chemicals on artificial turf such as hand washing and limiting time on the playground on hot days. (CPSC)

Children are More Vulnerable

- It is well established that children are more vulnerable to toxic exposures due to their immature development that can be permanently disrupted (Carroquino 2012; Landrigan 2001, 2016, 2023; Endocrine Society).
- Children have a longer cumulative time of exposure.
- Children have close and repeated contact with turf surfaces.
- Children are more vulnerable to heat stress physiologically (Bytomski 2003; Antoniadou 2020; Malmquist 2021; Liu and Kim)
- The Mount Sinai Children's Environmental Health Center Position Statement on the use of Artificial Turf Surfaces in Nov 2023, "recommends against the installation of artificial turf playing surfaces and fields due to the uncertainties surrounding the safety of these

products and the potential for dangerous heat and chemical exposures.” (Mount Sinai 2023)

No Regulations on Artificial Turf for Children

- There are no federal safety regulations on artificial turf for children (Zucarro 2022)
- The European Union has banned the sale of products with intentionally added microplastics and products that release microplastics over time, including crumb rubber artificial turf infill (Zucarro 2024).
- Crumb rubber playgrounds and elementary school sports fields are not classified as a children’s product by the Consumer Product Safety Commission (PEER 2015)

Policies to Ban Artificial Turf or Components

The concerns for harmful plasticizers and microplastics in artificial turf, long-term effects on children’s health, as well as life cycle analyses have led to policies to ban artificial turf altogether as well as to ban specific toxic components (Millbrae, San Marino, Boston, Zucarro et al 2022). Millbrae, California, for example, recently passed an ordinance to ban artificial turf, including requiring natural grass replacements once artificial turf installations “begin to show visible signs of wear.” (Millbrae Ordinance 806, Chapter 8.65)

The law allows local governments to ban artificial turf due to well-documented health concerns. Unfortunately, the artificial turf industry does not have to prove safety of their products for humans or the environment in order to market their product. In fact, few studies on human health have been done. Murphy (2022) notes, “The only human epidemiology studies conducted related to artificial turf have been highly limited in design, focusing on cancer incidence.”

Background

1. Chemical Exposures and Contamination

Microplastics and Chemical Pollution: Plastics are now regarded “as a major threat to ecosystems worldwide” (de Haan 2023). Artificial turf is composed of plastic “blades of grass”, a plastic composite backing and cushioning infill. The synthetic green blades are typically made up of polyethylene and polypropylene, and due to its propensity to degrade with UV light, “stabilizers” are added to the mix in the manufacturing process to reduce breakdown. Tire crumb rubber is often used for infill due to cost. All of these components are derived from petroleum products. These components contain microplastics as well as chemicals acknowledged as being hazardous substances, such as polycyclic aromatic hydrocarbons (PAHs), bio-accumulative (“forever”) per- and polyfluoroalkyl substances (PFAS), phthalates, silica (silica crystal infill), polychlorinated biphenyls (PCBs), carbon black and metals such as lead, mercury, cadmium, chromium, cobalt, and arsenic. In addition, pesticides and biocides are used on

artificial fields to reduce bacteria, viruses and weeds, which could cause adverse reactions and skin sensitization.

A study by the United States Environmental Protection Agency (2019) noted, “a range of chemicals (metals and organic compounds) was found on fields,” but no biomonitoring studies on athletes has yet been done.

These chemicals can contaminate water supplies through runoff, as well as leach into groundwater and soil and persist in the environment (deHaan 2023). Children can be exposed via inhalation of off-gassing compounds, or ingestion of infill components. The crushed tire rubber infill adheres to skin, shoes and clothing, and then can enter cars and homes. Based upon the presence of known toxic substances in tire rubber and the lack of comprehensive safety studies the Children’s Environmental Health Center of the Icahn School of Medicine urged a moratorium on the use artificial turf generated from recycled rubber tires. The EPA states in their assessment that “the existing studies do not comprehensively evaluate the concerns about health risks from exposure to tire crumb.” (Marsili 2014). Artificial turf fields are installed on top of a bed of crushed rocks and a drainage system that typically feeds the runoff to storm sewers or surface waterways. As such, artificial turf contributes to the plastic waste crisis.

a. PFAS

High levels of PFAS have been found in artificial turf sold at Home Depot and Lowe’s by the Center for Environmental Health who sent a notice of Violation of the Safe Drinking Water Act on March 4, 2024 (CEH 2024). New health concerns have risen from the ubiquitous chemical group called perfluoroalkyl and polyfluoroalkyl substances (PFAS), which are a class of persistent and highly toxic chemicals with widespread contamination across the United States, and which have been to date found in all samples of artificial turf. PFAS are typically added for water and stain resistance for a myriad of commercial products from packaging to clothes, to food containers and also found in cleaning products and non-stick cookware. Manufacturers of artificial turf state it is used in processing to enhance smoothness and reduce friction during manufacturing.

PFAS in plastics are especially problematic because they are a category of chemicals that contain multiple fluorine atoms bonded to a chain of carbon atoms that makes them resistant to breakdown. This group of chemicals thus bioaccumulates in the food chain and has contaminated water supplies throughout the nation. PFAS are now found in breast milk, blood serum, urine, testicular tissue and placental blood. (ATSDR, Hall, Hu, Wu)

Human health risks include endocrine disruption, adverse effects on the liver and thyroid, as well as metabolic effects, developmental effects, neurotoxicity, and immunotoxicity, with evidence of reduction of effectiveness of childhood vaccinations (Grandjean 2017) as well as developmental harm.

The Mindaroo-Monaco Commission on Plastics and Human Health Report 2023

concludes: “It is now clear that current patterns of plastic production, use, and disposal are not sustainable and are responsible for significant harms to human health, the environment, and the economy as well as for deep societal injustices...The thousands of chemicals in plastics—monomers, additives, processing agents, and non-intentionally added substances—include amongst their number known human carcinogens, endocrine disruptors, neurotoxicants, and persistent organic pollutants. These chemicals are responsible for many of plastics’ known harms to human and planetary health. The chemicals leach out of plastics, enter the environment, cause pollution, and result in human exposure and disease. All efforts to reduce plastics’ hazards must address the hazards of plastic-associated chemicals...to protect human and planetary health, especially the health of vulnerable and at-risk populations, and put the world on track to end plastic pollution by 2040 this Commission supports urgent adoption by the world’s nations of a strong and comprehensive Global Plastics Treaty in accord with the mandate set forth in the March 2022 resolution of the United Nations Environment Assembly (UNEA)” Landrigan (2023).

The Mount Sinai Children’s Environmental Health Center Position Statement on the Use of Artificial Turf Surfaces Nov 2023, “recommends against the installation of artificial turf playing surfaces and fields due to the uncertainties surrounding the safety of these products and the potential for dangerous heat and chemical exposures.” They further state, “**To allow the installation of PFAS-containing surfaces would be extremely short-sighted as further restrictions and regulations on these chemicals are likely to come.**” Noting:

- Studies to assess the safety of artificial turf are ongoing and inconclusive.
- Questions remain about the safety of alternatives to crumb rubber.
- Undisclosed chemicals of concern are present in plastic grass blades and turf pads and matting.
- Chemical hazards escape from artificial turf surfaces to the environment
- Turf materials are transported home.

b. Infill

Infill is used to support synthetic fibers to prevent rippling of the blades, adds weight to the turf to keep it in place, acts as cushioning, assists drainage in high rains. Types of infill that are used include “crumb rubber” (crushed tires), Crystalline Silica sand, and newer alternatives such as coconut husk, walnut, wood and Zeolite.

Crumb Rubber Tire Infill

Crumb rubber from crushed used tires is used as cushioning infill on artificial turf. According the EPA 38 states ban pulverized scrap tires due to their hazardous components and tendency to catch fire, but in 2003 “markets for scrap tires were consuming 233 million, or 80.4%, of the 290 million annually generated scrap tires.” In 2016 the EPA found that 12.5% of all scrap tires were used in crumb rubber infill. (EPA

2016). Crumb rubber was considered an “environmental success story”, according to the Rubber Manufacturers Association (Rappleye 2024).

Crumb rubber, however, exposes humans and ecosystems to a plethora of hazardous chemicals due to the complex mixture of toxic chemicals used in manufacturing. **Celiero (2021)** found, “40 target compounds, including polycyclic aromatic hydrocarbons (PAHs), plasticizers, antioxidants and vulcanization agents were determined in 50 synthetic football pitches of diverse characteristics”. **Duque-Villaverde (2024)** found, “11 compounds of environmental and health concern, including antiozonants such as N-1,3-dimethylbutyl-N'-phenyl-p-phenylenediamine (6PPD) or N, N'-diphenyl-1,4-phenylenediamine (DPPD), and vulcanization and crosslinking agents, such as N-cyclohexylbenzothiazole-2-sulfenamide (CBS), 1,3-di-o-tolylguanidine (DTG) or hexamethoxymethylmelamine (HMMM) from tire rubber... **antiozonant 6PPD** [recently **linked to acute mortality in salmon**] is present at the highest concentrations up to 0.2 % in new synthetic fields. **Federico (2023)** found, “Trace elements such as Zn, Al, Fe, Cd, Cr, Ni, Hg, and Cu”, as well as a filler called carbon black composing up to 22-40%, or silica for wear resistance. **Lead** has been found in artificial turf as well (**Graca 2022**). A 2020 report by the Ecology Center in Maryland found high levels of lead [up to 30,292 ppm in one sample] in Maryland and Virginia playgrounds made from rubber shred. (**Ecology Center 2020**)

Tire industry workers are subjected to some 50 chemicals, many of which are toxic. Occupational studies of workers in the tire industry reveal an association with emphysema, leukemia, multiple myeloma, as well as cancers of the bladder, esophagus, larynx, liver, lung, pancreas, prostate and stomach. Most chronic diseases caused by occupational toxins don't appear until 10 or more years after first exposure. There are many studies on the toxicity of crumb rubber. (**Murphy 2022**)

Silica Infill

Crystalline silica from crushed quartz rock, also known as industrial sand, is a common alternative to crushed tire infill and contains 95% crystalline silicon dioxide. One manufacturer states: “Silica sand is one of the most ubiquitous forms of infill for the simple reason that it's inexpensive.” [<https://www.purchasegreen.com/blog/silica-sand-what-you-should-know/>] It is also considered a hazardous material. Silica dust has long been known to cause a chronic restrictive lung disease called silicosis and was first documented in 1700 in stone-cutters by Dr. Bernardino Ramazzini, considered the founder of occupational medicine. Symptoms of this progressive irreversible lung disease are persistent cough, shortness of breath and difficulty breathing which may occur years after the exposure as scarring and inflammation progress. Silicosis is the most prevalent chronic occupational lung disease in the world (Upadhyay 2024). Australia banned engineered stone because of silicosis risk that is increasingly found in workers who polish engineered countertops. (Nogrady 2023). A silicosis epidemic was recently noted in the Northeast San Fernando Valley stoneworkers (Norris 2024).

Silica Infill is Not Sand or “Just Dust”

Some people say that silica infill is just beach sand and therefore is safe. Indeed, beach sand is 80 to 95% silica, but is composed of larger particles that do not pose a risk of pulmonary disease. However, silica (silicon dioxide) exists in both crystalline and amorphous forms. A Yale Environmental Health and Safety report points out that beach sand is amorphous silica. Crystalline silica on the other hand is “at least 100 times smaller than ordinary sand found on beaches or playgrounds. It is generated when silica-containing materials are manipulated in such a way that a dust is created, [and] some fraction of that dust may include particles small enough to become respirable.”

The International Agency for Research on Cancer (IARC) Monographs Programme has classified crystalline silica as carcinogenic to humans, while amorphous silica was not classifiable as to its carcinogenicity in humans. The panel emphasized that crystalline silica in the form of quartz or cristobalite dust causes lung cancer in humans. [<https://acsjournals.onlinelibrary.wiley.com/doi/10.3322/caac.21214>]

The American Academy of Pediatrics (AAP) specifically recommends avoiding “Crushed crystalline silica (quartz)” in sandboxes or playgrounds. (American Academy of Pediatrics- Safety in the Sandbox). Some manufacturers state that the silica is contained inside a plastic or acrylic coating. This coating however may break down with use and pose yet more unknown and untested risks. Organic alternatives such as coconut husks or cork may have proprietary ingredients or coatings as well that stabilize the material but create regrettable substitutes with their own hazardous components. The alternative infill, Zeolite, can be toxic to the lungs with inhalation. (Sloan Kettering)

While new artificial infill and plastic technologies may make fields cooler or softer or bactericidal, we still do not know if they are safer. These alternatives may not have independent scientific studies to back their safety when inhaled, ingested or after they enter storm drains. A full toxic life cycle analysis is needed to fully inform a decision to place artificial turf.

Cancer is another concern for athletes and children playing on artificial turf and exposed to infill and a mix of synergistically harmful artificial turf chemicals. Although there are no studies to date associating an increased risk of cancer with artificial turf, questions remain unanswered regarding exposure to carcinogens on these fields.

2. Disposal of Plastic Waste and Recycling

Artificial turf creates an enormous plastic waste problem and recycling is problematic. Sports fields will last 8 to 10 years before disposal. As they are made of a complex mix of plastic and infill ingredients this produces an ongoing challenge at the end of their lifetime. There are over 15,000 artificial playing turfs in the US and about 1,500 are added yearly. The synthetic turf industry repurposes about one-twelfth of the 300 million auto tires that are withdrawn from use each year. An average soccer field of 80,000 square feet can use 27,000 crushed tires for infill at 4-15 pounds per square foot,

equivalent to 320,000-1 million pounds (160-500 tons) of infill along with 40,000 pounds(20 tons) of plastic (Claudio 2008).

Synthetic turf fields are typically under warranty for 8 years and have a lifespan of about 10 years. Thereafter the material must be disposed of and typically it is landfilled. While industry increasingly attempts to reuse or recycle their product, ultimately it is burned or chemically changed into substances that are potentially as harmful and disposed of somewhere later, adding to planetary pollution.

In general, these fields are never completely recycled and are increasingly dumped on unused private land (where owners are paid a rental fee), empty lots and sometimes illegally dumped where they continue to leach hazardous chemicals. Industry advertising claims that artificial turf is recyclable has been challenged in a formal complaint (PEER 2022, York Daily Report 2019). Even if the artificial turf can be recycled there is a substantial carbon footprint as well as economic cost to do so. Moreover, any increased recycling costs will be added on to the price paid by those purchasing artificial turf.

3. Sports Injuries

Injury prevention for athletes and children should be a fundamental objective as youth sports injuries can have not only short-term impacts but also more serious long-term impacts from orthopedic injuries. Many studies show an increased risk of lower extremity sports injuries from artificial turf in **high schools** (Paliobeis 2021;Voos 2019), **colleges** (Loughran 2019) and **professional sports** (Mack 2019;Calloway 2019; Robertson 2022; Gould 2023). It is concerning that Gould (2023) noted that studies showing a higher risk on natural grass were all funded by the artificial turf industry.

Biomechanical studies show there is increased frictional force at the shoe-surface interface with artificial turf compared to natural grass, thus likely explaining an increased incidence of injuries to the foot, ankle and knee. Furthermore, athletes' consistent perception is that natural grass is easier to play on and results in fewer injuries (Taylor 2012). Smeets (2012) concludes, "Torques on external rotational movements were significantly higher with blades [artificial turf]... High rotational torques between the shoe outsole and the sports surface has been correlated with torsional injuries of the lower limb and knee." Balazs (2015) notes this "is potentially relevant for the risk of anterior cruciate ligament (ACL) rupture, where noncontact mechanisms are frequent." Robertson (2022) performed the largest study of rugby player injury risk and surface type. They noted, "a significantly greater mean severity of hip/groin, and foot/toe injuries on artificial surfaces."

Turf toe is an injury initially coined by and most commonly seen on artificial turf. It typically occurs when an already hyperextended metacarpalphalangeal joint at the base of the toe has additional force placed on it from behind by another player contacting the heel or during play. If there is less "give" from the turf then a hyperextension injury occurs, resulting in anything from a minor sprain to a complete tear of the ligamentous complex

supporting the toe joint. (Najefi 2018) Turf toe is a rare but debilitating condition that requires accurate diagnosis and early definitive management to prevent a chronic condition.

Concussion and Playing Field Surface

Surveys of high school and collegiate trainers have shown more serious concussions occur when athletes play on artificial fields that have been built on a concrete foundation (Guskiewicz 2000; Naunheim 2002), or with firm gravel base. Natural grass absorbs physical impacts better. Villanueva (2024) tested this noting that “American football has the highest rate of concussions in United States high school sports. Within American football, impact against the playing surface is the second-most common mechanism of injury.” The authors measured impact deceleration between natural grass and synthetic turf high school football fields and “showed significantly greater impact deceleration on synthetic turf compared to the natural grass surfaces.”

Studies that confirm higher injury rates:

Gould (2022) in a review of 53 articles on sports injuries found a higher incidence of foot and ankle injuries on artificial turf, both old and new generation turf. He also revealed that, “Only a few articles in the literature reported a higher overall injury rate on natural grass compared with artificial turf, and all of these studies received financial support from the artificial turf industry.”

Paliobeis (2021) This study collected data from 26 high schools and found “Athletes were 58% more likely to sustain an injury on artificial turf. Football, soccer, and rugby athletes were at a significantly greater injury risk on artificial turf. Upper and lower extremity and torso injuries also occurred with higher incidence on artificial turf.”

Voos (2019) This review of the above 2019 study from Case Western Reserve University and the University Hospital Sports Medicine Institute analyzed data collected by 26 high school athletic trainers during the 2017-2018 athletic seasons. The authors found, “athletes were 58 percent more likely to sustain an injury during athletic activity on artificial turf. Injury rates were significantly higher for football, girls and boys soccer, and rugby athletes. Lower extremity, upper extremity, and torso injuries were also found to occur with a higher incidence on artificial turf.”

Mack (2019) examined injuries reported during the 2012-2016 regular season NFL games that were played on modern-generation surfaces. The study found that playing on synthetic turf “resulted in a 16% increase in lower extremity injuries per play than that on natural turf.” They concluded, “These results support the biomechanical mechanism hypothesized and add confidence to the conclusion that synthetic turf surfaces have a causal impact on lower extremity injury.”

Loughran (2019) looked at injury data from the National Collegiate Athletic Association American Football: 2004-2005 through 2013-2014 seasons and found a significantly higher rate of knee injuries on artificial turf, finding artificial turf a “risk factor”.

Calloway (2019) looked at injuries over 4 Major League Soccer seasons (2013-2016) and concluded “overall ankle injury, Achilles injury, and ankle fracture were found to have a statistically higher incidence on artificial turf...[and] elite-level athletes prefer to play on natural grass surfaces due to a perceived increase in injury rate, discomfort, and fatigability on artificial turf.”

Najefi (2018) describes “Turf Toe,” which is a “debilitating condition, particularly seen in American footballers after the introduction of harder, artificial ‘turf’ surfaces.” He noted that, “in a survey of 80 active professional American football players, 45% had suffered turf toe injuries in their professional careers, with 83% occurring on artificial turf (Rodeo).”

Sousa (2013) performed a one-season prospective study of amateur soccer players on artificial turf and found, “Injury incidence in amateur soccer players is higher during matches played on artificial turf than during training sessions.”

Meyer (2005) A 5-year prospective high school football study published in 2005 noted that during higher temperatures there were reported higher incidences of noncontact injuries, surface/epidermal injuries, and muscle-related trauma, reported on artificial fields.

4. Athlete Preference for Natural Grass Playing Fields

Ford and Monsanto Industries joined efforts to make the first artificial turf in 1964 called ChemGrass which was installed in the Houston Astrodome, when the grass died due to issues with the plastic covering of the dome. By the 1980’s athletes were complaining that the turf, then typically made with a base of concrete, was harder and caused more injuries. Indeed, there were more concussions seen on artificial turf fields (Guskiewicz 2000). Earlier turf studies noted, “A number of high-profile professional football players have suffered career-ending concussions.” (Naunheim 2002). Newer materials have been used with more infill placed on fields along with a compacted gravel base to address this issue. A poll by the National Football League in 1995 revealed that 95% of players believed that synthetic turf increased their risk of injuries (Claudio 2008). A recent National Football League Players Association (NFLPA) survey found similar results on newer artificial turf fields. (NFLPA 2020) As noted above, there is both anecdotal and scientific evidence of higher rates of injuries on artificial turf.

College and professional athletes prefer natural grass playing fields by far, due to reduced injuries and ease of play (Owens 2016; Dumas 2023; NFLPA). Players describe artificial turf as “sticky”. The NFLPA has taken a strong public stance against artificial

turf fields, advocating that "NFL clubs should proactively change all field surfaces to natural grass." (J.C. Tretter) The NFL Players Association tracks the league's official injury reports and has consistently found that natural grass fields provide a much lower risk for injuries when compared to artificial surfaces, both during practices and games. The NFLPA analysis shows that players have "a much higher rate of non-contact lower extremity injuries on turf compared to natural surfaces. Specifically, players have a 28% higher rate of non-contact lower extremity injuries when playing on artificial turf. Of those non-contact injuries, players have a 32% higher rate of non-contact knee injuries on turf and a staggering 69% higher rate of non-contact foot/ankle injuries on turf compared to grass." NFLPA President Tretter explained, "When you put so much force and so much torque in the ground, eventually something has to give. When you're on turf, it's going to be your joint."

5. Infections

Methicillin-resistant *Staphylococcus aureus* (MRSA) has been recognized as a significant skin infection in the athletic population, causing minor to serious infections. MRSA is responsible for 33% of infectious outbreaks reported among competitive high school and collegiate athletes. Bowers looked at three Division-I collegiate football programs and found that of the 491 collegiate football players, "33 (6.7%) were diagnosed with MRSA infections. Cutaneous manifestations included abscess (70%), cellulitis (16%), folliculitis, impetigo, and necrotizing fasciitis. Of the infections, 90% underwent surgical drainage, whereas 27% received intravenous antibiotics." The most common areas for infections were in the extremities: elbow, knee and forearm (Bowers 2008).

It is notable that high school football players have a 4-fold increase in MRSA infections than that of the general student-athlete population. While locker room surfaces can harbor MRSA, artificial turf can as well. An EPA study on artificial turf showed that 42% had at least one sample with *Staphylococcus aureus*. Of those, 70% had a least one positive sample for methicillin resistance.

The abrasive nature of synthetic turf along with sheltered MRSA in the turf and infill can make athletes and kids more vulnerable to "turf burn" and infection (Keller 2020). Synthetic turf requires bactericidal chemicals to reduce bacterial growth on fields and infections in players. These liquid turf cleaners can also be toxic and may pose risks to the health of workers, children, and surrounding ecosystems. Bactericides have been shown to act as skin sensitizers (Hahn 2010).

6. Localized Urban Heat Islands and Athlete Heat Stress

Artificial sports fields are known to absorb and retain heat from the sun thus creating significantly higher temperatures, at times 40 to 60 degrees higher than living grass, even

with moderate air temperatures. Studies at Penn State University's Center for Sports Surface Research compared surface temperatures of various synthetic turfs versus natural grass and found "that the maximum surface temperatures during hot, sunny conditions averaged from 140° F to 170°, noting that grass fields rarely get above 100° F due to the cooling effect of natural water evaporation from the living grass (NRPA). These studies have been replicated many times. The heat can be so intense it has been known to melt the plastic (DeSocio 2015).

Heat Injury- These higher temperatures on artificial turf sports fields can cause heat stroke, heat exhaustion, poor athletic performance and skin burns, making these fields potentially unusable under hotter weather conditions. Irrigating the fields with water reduces temperatures; however, the effect lasts for less than 20 minutes, according to research performed by Penn State Center for Sports Surface Research (Abraham 2019; Claudio 2008; NPRPA 2019).

The **Consumer Product Safety Commission** notes, "Most adults will suffer third-degree burns if exposed to 150° F water for two seconds. Burns will also occur with a six-second exposure to 140° F water or with a thirty second exposure to 130° F water. Even if the temperature is 120° F, a five-minute exposure could result in third-degree burns." **Note: A hot water heater is set to 120° F**, as above that burns can occur.

Heat stress on artificial turf vs natural grass was reviewed by Liu and Kim (2021). Heat waves and hot weather threaten human health when one is not exercising. Those playing sports or participating in strenuous exercise are at increased risk of heat-related illness. Artificial turf creates a higher temperature microclimate due to heat absorption from the sun. The authors note that **children have been identified as a heat vulnerable group** physiologically compared to adults due to "a higher surface area-to-mass ratio (Cheng, 2020), higher metabolic rate (Fabbri, 2013), higher skin temperature during exercise (Cheng, 2020), quicker rise in core temperature (Vanos, Herdt, Lochbaum, 2017), and lower sweat production (Gomes, Carneiro-Júnior, Marins, 2013). Psychologically, children have less experience coping with or realizing the signs of heat stress than adults (Cheng, 2020). Their findings show that children suffer a 24% longer *Extreme danger* duration on artificial turf on sunny days than natural grass (Liu and Kim 2021).

An urban heat island effect arises when natural land cover, vegetation and trees (greenscapes), which have natural evaporative cooling, are replaced with buildings, pavements and other surfaces, such as artificial turf, also called hardscape, that absorb heat from the sun. These artificial surfaces store heat and upon release can raise air temperatures in adjacent areas or even communities. Urban heat islands can be seen from space and differentiated from natural green landscapes. (ESA) Cities can have temperatures much higher than rural areas with vegetation. Even within cities there is significant variation depending on greenspace, parking lots, and housing density. Urban heat islands are being addressed now in cities such as New York, which has a "Cool neighborhoods NYC" program to plant trees and increase vegetation to cool the surrounding area. (Johnson 2022).

Studies Showing High Heat on Artificial Turf Fields

Brigham Young University: After an athlete suffered a heat burn from artificial turf in Utah, Brigham Young University performed a study on the artificial turf and found that the artificial turf temperature was 87 °F hotter than natural grass (Williams and Pulley 2002). A temperature recorded on an artificial turf was 200°F, well above that which would cause a skin burn. Buskirk (2002) measured temperatures for 24 days on artificial turf, natural grass and in air and recorded turf temperatures that were 50 °F higher than natural grass temperatures and reached 70 °F higher than the air temperatures.

Penn State University Center for Sports Surface: Studies at Penn State University's Center for Sports Surface Research compared surface temperatures of various synthetic turfs and found "that the maximum surface temperatures during hot, sunny conditions averaged from 140- 170° F, noting that grass fields rarely get above 100° F due to the cooling effect of natural water evaporation from the living grass. (NRPA)

University of Missouri: A University of Missouri comparative study showed **with artificial turf** there were both "elevated air temperatures (138 °F) and elevated turf temperatures (173 °F) – while **adjacent natural turf temperatures** were 105 °F and local air temperatures were 98 °F". (Abraham 2019)

University of Tennessee: This study by Thom et al (2014) looked at ten synthetic turf surfaces at the University of Tennessee Centre for Athletic Field Safety with different infills. They noted that maximum temperatures on artificial turf were 187 degrees Fahrenheit with ambient air temperatures of 98.7 degrees Fahrenheit. The authors noted, "Despite differences in infill ratios of crumb rubber to sand (0 kg m⁻² to up to 34.2 kg m⁻² of crumb rubber and sand), synthetic turf surface temperatures varied less than 6 C between the systems suggesting that synthetic turf infill does not affect surface temperature as much as fibers."

Local Heat Island from Artificial Turf at Moffett Park, Sunnyvale, California: Locally the Moffett Park Specific Plan of 2020 also mapped out the local heat island effect and it was evident on the artificial sports fields. **The Twin Creeks Sports Complex**, built in 1985, has 10 all-purpose synthetic turf fields which can be identified in the report as having a temperature in the hottest range (111-138 °F) versus the immediately surrounding area of 102-111°F. Average summer temperatures are "expected to increase in Santa Clara County by ~4°F by 2050 and up to more than 6°F by 2100 (Maizlish et al. 2017), while the number of extreme heat events will double by 2050 and triple by the end of the century." (MPSP, Cal-Adapt.)

Slater (2010) Noted in his study that parks can be cooler than the surrounding urban environment by up to 7°C and this extends up to 100 meters beyond a park borders.

Cooling Methods Used for Artificial turf

Cooling of artificial turf is accomplished through irrigating the field with water. The cooling effect lasts only about 20 minutes (Penn State Center for Sports Surface Research). In arid or semiarid climate zones the amount of water used to maintain artificial turf at temperatures similar to irrigated natural turf grass were comparable (Kanaan 2020). Attempts to alter turf materials to reduce surface temperatures significantly have not been shown to be successful to date. The turf is still significantly hotter. Games can be cancelled if temperatures are too high.

Heat Guidelines for Play on Artificial Turf

National Recreation and Park Association (NRPA) Heat Guidelines for Artificial Turf: For the safety of children public schools have developed heat guidelines for playing on synthetic sports fields due to the higher artificial turf temperatures even with moderate air temperatures. The National Recreation and Park Association (NRPA) 2019 notes that above 120 degrees burns can occur, as well as dehydration with heat stroke, heat exhaustion and poor athletic performance, making these fields potentially unusable under certain weather conditions.

The Montgomery County Public Schools developed the following heat guidelines that apply to and are posted at all its artificial turf fields:

- Anytime the outdoor temperature exceeds 80 degrees, coaches exercise caution in conducting activities on artificial turf fields.
- When outdoor temperatures exceed 90 degrees, coaches may hold one regular morning or evening practice (before noon or after 5 p.m.).
- When the heat index is between 91–104 degrees between the hours of noon and 5 p.m., school athletic activities are restricted on artificial turf fields to one hour, with water breaks every 20 minutes.

It is recommended that artificial turf fields be monitored for temperature and play times adjusted. As global temperatures rise with climate change the heat effects of artificial turf is an ever-increasing concern.

7. Children are More Vulnerable

Artificial turf contains hazardous chemicals and heavy metals. Children are especially vulnerable to all toxic exposures due to their immature biological systems. Scientific evidence (CDC, Landrigan 2001, 2016, 2023) notes that:

- “Children breathe more air, drink more water, and eat more food per pound of body weight than adults.
- Children are more likely to put their hands in their mouth.
- A child’s body may not be able to break down and eliminate harmful contaminants that enter their body.
- Rapid growth can be disrupted easily by toxic exposures

- “Health problems from an environmental exposure can take years to develop.”

On an artificial sport field children and athletes are routinely in close contact with dust and chemicals emitted from the surface of the fields, especially with soccer, football, field hockey and lacrosse, making them more readily inhaled, ingested, and in closer contact with the skin. Thus, it is reasonable to expect that these synthetic turf fields can pose an increased health risk to children. Precaution is thus imperative. (The full list of references is listed below under Children’s Vulnerability to Toxins)

Why Children are More Vulnerable:

- **Children’s ability to metabolize**, detoxify, and excrete chemicals is different from that of adults. Children are less able to detoxify and excrete toxic chemicals (Carroquino 2012).
- **Children undergo rapid growth** and development, and their development phases are perfectly scheduled to achieve complete functional development. If a developmental phase is disturbed at a given time, the correct pathway can be lost, thus causing developmental delay or arrest (brain development, reproductive development, immune development, etc) with permanent and irreversible dysfunction. (Carroquino 2012).
- **Environmental toxicants can harm germ cells** which affect an adult’s own fertility as well as the health of the offspring. (Carroquino 2012).
- **Chemicals can act as endocrine disruptors** that can block or enhance and endocrine effects and alter development at extremely low concentrations (Parts per trillion PPT -Lawson) and according to the OECD 2023, “They can trigger adverse effects at doses below the threshold values of traditional chemical analysis”. Disruption of thyroid hormone changes is especially problematic as this can indirectly alter critical pathways of neural development.
- **The immune system is not mature** up to the age of 7 or 8 (Simon 2015), and beyond that is constantly changing thus is susceptible to toxins causing autoimmune disease even in adulthood, i.e. lead, cadmium and mercury (Kharrazian 2021) and in the case of PFAS even causing reduced immune response to childhood vaccines (Grandjean 2017), as well as reproductive harm (Rickard 2022) and with fetal exposure it is strongly associated with congenital heart disease (Li 2024).
- **The brain and nervous system are not fully developed** until the age of about 26, with different stages of growth and vulnerability. Many chemicals pregnant women and children are exposed are neurotoxic and exposures can lead to neurobehavioral developmental abnormalities. (Grandjean and Landrigan 2014) Lead can cause direct damage to neurons with no safe level of exposure.
- **The reproductive system is complex** and can be disrupted by toxic exposures in utero or even after birth. Male reproduction is particularly susceptible as sperm is constantly maturing. (Lahimer 2023). Female ovaries are partially mature at birth and subject to toxins which can “age” the germ cells in ovaries throughout a lifetime and cause later infertility, also affecting the health of the offspring (Rickard 2022). The measure of cumulative toxic exposure is infertility. (Thomas)

- **Chemicals can act as direct neurotoxins** affecting brain development, i.e. lead causing damage to the hippocampus (memory center) and cerebellum and while nerve cells other than the brain can regenerate, brain cells have limited capacity for regeneration thus are more vulnerable to permanent damage. (Grandjean and Landrigan 2014)
- **Chemicals can also alter sections of DNA** without altering the base sequence i.e. epigenetic changes-and these alter the expression of genes throughout life-altering development and disease. (Ideta-Otsuka 2017)
- **Chemicals can have age dependent rates of absorption** and in one study, lead was absorbed 40-50 times more in younger animals (Sanders 2010)
- **Chemicals can also cause inflammation** of tissues in the body to create or enhance diseases in childhood throughout adulthood (Furman 2019)
- **Longer exposure from childhood-** “There is more time to develop chronic diseases triggered by early exposures...Many diseases, such as cancer and neurodegenerative diseases, are thought to arise through a series of stages that require years or even decades from initiation to actual manifestation of disease. Carcinogenic and toxic exposures, sustained early in life, including prenatal exposures, would then be more likely to lead to disease than similar exposures encountered later.” (Carroquino 2012)
- **Synergistic exposures to multiple chemicals** together can enhance toxicity and adverse health impacts (Gaynor 2022)

8. Cancer and Chemicals Still a Question

While there is no proof that artificial turf causes cancer, scientific evidence shows that many chemicals used on artificial turf and components are carcinogenic, can be endocrine disruptors and can be toxic to aquatic organisms. Murphy (2022) highlights this concern, noting a troubling lack of scientific data noting, “ The only human epidemiology studies conducted related to artificial turf have been highly limited in design.”

While there is an unfortunate lack of independent scientific data on the health impacts of artificial turf, Tarafdar (2020) studied risks of poured rubber surfaces versus classical soil playgrounds in Seoul and noted that the “cancer risk is approximately 10 times higher in poured rubber surfaced playgrounds than in uncovered soil playgrounds. Cancer rates in children and adolescents are rising (Siegel; CDC - Cancer in Children and Adolescents)

9. Environmental Impacts of Artificial Turf: Toxic inputs and Outputs, Water Contamination, Harm to Wildlife, Air Pollution, Carbon Footprint

The components of artificial turf are derived from fossil fuels, which have a number of troubling negative externalities: air pollution, water contamination, and CO2 emissions

contributing to global climate change as well as toxic pollution from short lived as well as “forever” chemicals and microplastics that use petroleum as the base. Adverse effects on soil organisms, birds and biodiversity have also been identified. The true costs of artificial turf have not been added in.

Alms (2016) gathered data for a life cycle analysis (LCA) of artificial turf using data from the Carnegie Mellon “Economic Input-Output Life Cycle Assessment” (EIO-LCA) to identify artificial turfs “unfiltered environmental toll”. She found that during the manufacturing process artificial turf:

- Released multiple air pollutants including carbon monoxide, CO₂, nitrogen oxide, sulfur oxide, PM 10, PM_{2.5} and volatile organic compounds.
- Produced about 143 metric tons of CO₂ released per field
- Used 4,985 kGal of water to produce one synthetic field, while about 1,290 kGal are needed to maintain a grass field per year.

Magnussen (2017) highlights the harmful substances from artificial turf that “may leach to water from infill of both new and recycled material.” The authors also identified increased energy use and greenhouse gas emissions from excavation and transportation of soil and rock materials, production and replacement of infills, maintenance with plowing, brushing and raking of the artificial turf field. Also noted was that the end-of-life emissions from disposal with incineration caused the highest energy use and emissions. They state, “One study found that natural grass was environmentally favorable to artificial turf, however the result was opposite if impacts were divided with the number of playing hours provided (Cheng et al., 2014)”. These facts, notwithstanding, are only estimates and do not take into account differences in playability on sunny days or increasing temperatures with climate change or extreme weather events. They also fail to take into account any health care costs for those injured or ill, or any costs for loss of habitat, degradation of the environment or cleanup costs.

Royer (2018) examined hydrocarbon gas emission from polyethylene, which is the most produced and discarded synthetic polymer globally, and the main plastic used in artificial turf blades. The authors found that as polyethylene ages it emits both methane and ethylene and this increases with time. The authors note that “plastics represent a heretofore unrecognized source of climate-relevant trace gases that are expected to increase as more plastic is produced and accumulated in the environment.” Royer noted in an interview, **“Synthetic turf has a lot more effect on the environment than anything else made of plastic.”**

Celeiro (2018 and 2021) looked at leaching of chemicals from sports fields and found multiple chemicals of environmental concern that were continuously entering the water, as well as chemicals identified in the air. The authors concluded, “The transfer of target chemicals into the runoff water poses a potential risk for the aquatic environment.”

Pochron (2018) found that aged crumb rubber and new crumb rubber posed similar toxic risks to earthworms, noting, “This study suggests an environmental cost associated with the current tire-recycling solution.”

Zhu X (2021) states, in his article, **The Plastic Cycle – An Unknown Branch of the Carbon Cycle**, “It is clear that plastic pollution has become a major environmental issue of our time. Due to the low degradation rates of plastic, almost every piece of plastic that is produced is still somewhere on this planet.” He suggests using the “terminology of biogeochemical cycles” to help scientists address this issue with sinks, reservoirs and fluxes to denote particles moving from one location to another. This would create the “plastic cycle” to better characterize the global nature of this problem.

Sanches-Sotomayer (2022) surveyed 21 parks with artificial grass and 24 parks with natural grass in 18 towns in autumn 2020 looking at differences in bird populations and biodiversity in artificial turf versus natural grass fields. The researchers found “The parks with natural grass always harbored higher gamma diversity, species richness and abundance... the trend of replacing natural by artificial grass in urban parks has harmful effects on urban bird communities and is a threat to bird conservation.” **Bernart-Ponce (2020)** found a similar loss of house sparrows where natural grass has been replaced with artificial turf.

A Report by the Center for Climate Integrity, “The Fraud of Plastic Recycling: How Big Oil and the plastics industry deceived the public for decades and caused the plastic waste crisis,” notes that industry knew for decades that most plastics cannot be recycled and that recycling plastic is neither technically nor economically viable. The report states, “Some types of “advanced recycling” may produce materials capable of being reprocessed into new plastic (plastic-to-plastic)—however, the majority of these processes produce waste or fuel (plastic- to-fuel), which do not qualify as recycling. As such, plastics cannot be meaningfully recycled through either method.”

SB 54- CA 2024-The Plastic Pollution Prevention and Packaging Producer Responsibility Act

The artificial turf industry states that at the end of life at about 10 years, artificial turf will be collected for “advanced recycling”. California bill SB 54 (2022) California mandates recycling of many single-use plastic items but excludes chemical recycling of plastic which means that making fuels from used plastic are excluded as a definition of recycling. Artificial turf thus does not necessarily qualify for recycling. (SB-54)

10. Water Quality and Contamination from Artificial Turf

Artificial turf plastics were found in 50% of river samples and comprised 15% of all plastics in the water. deHaan (2023) Artificial turf blades are typically composed of polyethylene and polypropylene plastic along with a multitude of other chemicals. With wear and tear and UV light this plastic breaks down into micro and macro-plastics. As artificial turf is an impervious substance, the surface water from the fields runs off into storm drains, streams, rivers and the ocean.

Researchers at the University of Barcelona in Spain in 2023 looked at 417 samples of river and surface waters including several waterways entering the ocean and found distinctive plastic from artificial turf in 50% of the water samples. They also found that “artificial turf fibers accounted for up to 15% of meso- and macro-plastic abundance.” deHaan (2023), **“The dark side of artificial greening: Plastic turfs as widespread pollutants of aquatic environments.”**

11. Environmental Benefits of Natural Grass

Benefits of Natural Grass

Water Conservation

Using drought resistant deeper rooted turfgrass, allowing for taller growth on turfgrass, using recycled water and following proper irrigation practices will lead to water conservation, as many fields are overwatered. Recycled water in some areas may contain too much salt to place on artificial turf, which will cause degradation, thus fresh water is needed to irrigate these artificial turf fields (Coastal Commission 2023). Recycled water can be used on natural grass turf, even though the water may have a higher salt concentration, as turfgrass is typically salt tolerant. “Turf grasses, most annuals, and deciduous trees are more tolerant of saline water” and do not accumulate high levels of salt because of frequent mowing. (UCANR)

Groundwater Preservation and Recharge

Dense above ground turfgrass biomass traps and holds water which reduces excess runoff and allows more water to infiltrate into the soil, enhancing groundwater recharge.

Healthy Soil

Organic turf fields which are designed to use few or no pesticides support healthy soil bacteria and earthworm populations, which contribute to “increased macropore space in the soil, resulting in higher soil water infiltration rates, higher water holding capacity, and improved soil structure.”

Restoration Ecology, Bioremediation and Soil restoration

Soil bacteria are also capable of breaking down organic pollutants in the environment, such as pesticides and other manmade pollutants. This concept is now being used in a process known as bioremediation as a less expensive and more effective option for cleaning up contaminated sites. (Alori 2022). Grass fields thus could help restore environmentally damaged areas, and at least prevent further land degradation and chemical pollution. Principles of restoration ecology can be used throughout the conversion of the Santa Clara County fairgrounds to reverse and repair some of the damage done to ecosystems and biodiversity. (Vaughn 2010)

Integrated Pest Management Programs (IPM) to Reduce Pesticide Use

There are many well established IPM programs in the US addressing pesticide use in parks, landscaping and agriculture. These are in cities, counties (Santa Clara County, San Francisco, Marin), universities (University of California, Massachusetts), as well as formulated by the US Department of Agriculture (USDA) and US EPA. All of these programs focus on alternatives to pesticides to reduce harm to the environment and human health. (See IPM in references)

Carbon Sequestration by Natural Grass

Studies have shown carbon sequestration could be higher or the same when one considers energy inputs for maintenance and highly managed fields. A study of turf growers in Australia showed a positive carbon sequestration among other benefits on turf farms.

Zirkle (2011) notes that “Lawns can be a net sink for atmospheric CO₂ under all three evaluated levels of management practices [low to high]” and factoring in mowing, irrigating, fertilizing, and using pesticides.

Tidaker (2017) notes for golf course management the amount of fertilizer, watering and mowing can affect the greenhouse gas emissions and should be addressed to reduce carbon footprint and increase carbon sequestration.

Cumming J (2018). Environmental Assessment of the Australian Turf Industry. The authors state, “The lifecycle assessment involved a review of five turf installation sites over one year. It showed that a well-maintained patch of turf is environmentally healthy, conserves natural ecosystems and will continue to sequester carbon dioxide from the atmosphere through the growth of soil organic matter... This study has also shown that all turf growers were able to provide a carbon positive product with net sequestered carbon dioxide averaging 1.6 kg of CO₂eq per square meter of turf produced... or 48,000 Tonne of CO₂eq per year.”

11. Environmentally Friendly Organically Managed Natural Turf Fields

Natural grass fields can provide a long-term, cost-effective, high-performance surface for athletic activities. Thoughtful management of natural grass organically improves the health of the soil and grass by supporting a rich microbial environment and promoting a strong root system that withstands wear. In addition, there is no need to put synthetic toxic pesticides or fertilizer on the fields. Water use may be reduced as well.

To reduce the risks of chemical exposure and to protect water quality some cities and schools have chosen to rehabilitate or rebuild natural grass turfs or replace artificial turfs with natural grass, learning how to maintain them organically, in a more ecological way with lower water inputs and with longer playability. These playing fields are living carbon sinks which contribute to biodiversity by their non-toxic nature and cooling effect that supports surrounding greenspaces, as well as living organisms such as bacteria, fungi, earthworms and birds. They also protect the health of humans and the environment.

Building an Organic Maintenance Program for Athletic Fields: Guidance from Experts and Experienced Communities. Toxics Use Reduction Institute, University of Massachusetts (TURI).

The key management elements used for increased performance and lower costs include:

- Aeration of the soil
- Proper irrigation and drainage
- Adjustments for mowing
- Soil testing for pH, moisture, nutrients and beneficial microorganisms
- The use of organic fertilizer
- Soil amendments

Examples of healthy safe natural grass turfs

Marblehead, MA: In 1998 the Marblehead Board of Health adopted a policy to reduce pesticides for the health and safety of children and families. Since 2002 all of Marblehead's playing fields have been managed organically, using integrated pest management (IPM) techniques. It was noted that in the past they have only closed the field for high rainfall, however, in 2018 "the fields were closed five times due to rain and twice due to extreme heat. Each was a one-day closure. The heat-related closures were the first that the town has experienced."

Start Date: 2002

Acres: 20 acres

Hours of Use: 1360 hours

Maintenance Cost: \$4,250 - \$4,500 per acre

Cancellations: 7 times

Springfield, MA. In 2014 Springfield received support through a grant to implement organic land care and grass turf management practices on municipal and school properties. The city started with six test pilot cases and grew to 12 organically managed sites by 2019, including multiuse or single use fields. One of the multiuse sports parks, Forest Park Baseball and Soccer Complex, which is open 7 days a week, tallied 3,300 hours per year of use. For strictly soccer use Treetop Park Full-Sized Soccer Field there was 1,051 hours per year of use.

Start date: 2014

Acres: 67 acres

Hours of use: 3,300 for multipurpose and 1,051 for soccer

Total Annual Maintenance Cost: \$98,080 for 12 fields

Cost per acre: \$1,460.

Martha's Vineyard, MA. In 2017, a group of Martha's Vineyard parents established The Field Fund, Inc to provide support to Martha's Vineyard schools and towns to improve their grass playing fields using organic practices. By September 2020 **The Field Fund** was supporting five athletic field complexes. Using organic practices, the schools and parks were able to meet all of their use needs, with only a few cancellations due to weather-related field conditions. In 2019 none of the 5 athletic fields were closed.

Start Date: 2017
Area: 5 sports and recreational fields
Total Annual Maintenance Cost: \$65,600
Cost per acre: \$7620.

Grass Sports Fields on Colleges and Universities

Snapdragon Stadium at San Diego State University was placed in 2022 and is popular with athletes and spectators.

Texas A&M. Ellis Field opened in 1994 and still has natural grass (Tifway Bermuda) .
<https://12thman.com/facilities/ellis-field/9>

University of Arkansas in 2019 replaced artificial turf with natural grass.

The Sports Field Management Association every year presents awards to the best natural grass sports fields that “exhibit excellent playability and safety and whose managers utilize innovative solutions, effectively use their budgets, and have implemented a comprehensive agronomic program. Five sport fields receive awards- baseball, football, softball, soccer, and sporting grounds. These are given to schools and parks, colleges and universities as well as professional fields throughout the United States. These awards promote natural grass sport fields for safety, quality and beauty. Prior winners were

- Jack Trice Stadium Iowa State University. Ames, IA
- Ryan Field. Northwestern University. Evanston, IL
- Folsom Field University of Colorado. Boulder, CO
- Ben Hill Griffin Stadium. University of Florida. Gainesville, FL
- Spartan Stadium. Michigan State University. East Lansing, MI
- Scott Stadium. University of Virginia. Charlottesville, VA
- Kyle Field. Texas A&M University. College Station, TX

12. Water Use of Artificial Turf Versus Natural Grass

Water is a limited and precious resource. One argument made to choose artificial turf over natural grass is the low water use compared to natural grass fields. A closer look at this shows that the differences are not as dramatic as claimed when a life cycle analysis is performed that includes manufacturing costs and irrigation for cooling. In in hotter, dryer climates where artificial turf is supposed to be most beneficial more water is used to cool

the field for players to extend use and reduce risks of heat related illness. Kanaan (2020) noted comparable water use for artificial turf and natural grass in hot climates in order to keep the temperature the same.

Alms (2016) looked at Carnegie Mellon 2015 data on lifecycle analysis of production and found that the amount of water used to manufacture artificial turf was 4,985 kGal of water to produce one synthetic field, while about 1,290 kGal are needed to maintain a grass field per year. Thus, the **manufacturing of artificial turf itself equaled 4 years of natural grass irrigation not counting watering in hot weather or surface cleaning.**

Kanaan et al (2020) performed a study at New Mexico State University to evaluate the amount of water required to maintain surface temperatures comparable to those of natural turfgrass areas. They noted that, “In arid and semiarid climate zones the surface temperature of the artificial turf fields can exceed 80°C[176 degrees Fahrenheit during the summer, requiring irrigation and drainage systems to keep them cool enough for use.... The model indicates that over a 24-hr period, **the amount of water (3.00 to 5.00 mm) required to maintain artificial turf at temperatures similar to irrigated natural turfgrass are comparable.**”

Artificial Turf is Not Drought Tolerant Landscaping

Regarding water use, the Santa Clara Valley Water District’s Landscape Rebate Program for water conservation no longer includes artificial turf as they recognize that, “there are healthier and more ecologically sound alternatives”. California Senate Bill 676, signed into law Oct 8, 2023 by Governor Newsom, specifies “that drought-tolerant landscaping does *not* include the installation of synthetic grass or artificial turf. [and]... drought-tolerant [natural] landscaping is a viable landscaping alternative that will further the goal of addressing long-term water conservation.”

Recycled Water Can Be Used on Natural Grass but Not on Artificial Turf

The California Coastal Commission in 2023 rejected an artificial turf baseball field at University of California Santa Barbara due to water quality impacts. They noted that **recycled water could not be used on the fields** due to its high salt content but recycled water could be used on hardy natural turfgrass.

13. Cost of Synthetic versus Natural Turf: Lifecycle Analysis

As cities and counties struggle with their limited budgets cost considerations become a central concern. Which is cheaper artificial turf or natural grass? While the narrative has been that artificial turf costs less, an analysis of the entire life cycle of artificial turf versus natural grass by Daviscount (2017) shows that using natural grass was cheaper in the long run. For grass fields there is initial equipment costs and it is noted that, maintenance decreases exponentially when additional fields are added. One full time skilled sports field

manager can maintain multiple fields. The disposal and replacement costs for a new field turf about every 8 to 10 years also need to be accounted for. Warranties for artificial turf are typically 8 years.

Identifying a complete lifecycle analysis for artificial turf versus natural grass is challenging due to variables and reviews seem to lack some of the direct or indirect costs, however, many articles provide some estimates. The additional costs for synthetic turf are described below and can be quite significant.

The Toxics Use Reduction Institute (TURI) performed a comprehensive cost analysis of artificial turf versus natural grass fields in 2015. They note that costs vary substantially depending on the type of field and the level of maintenance. They state, however, that “artificial turf fields have a higher life-cycle cost than natural grass fields. Once established, organic management of natural grass can be even more cost effective than conventional management of natural grass.” In addition, nonprofit groups such as The Field Fund have been created to help fund rebuilding or installing natural grass fields in schools and cities.

- **Installation costs** for an artificial turf field was about \$1,223,829. Infill costs varied from \$50,000 for crumb rubber to \$451,000 for “organic infill” .
- **Maintenance costs** varied widely for both with estimates from \$13,720-\$39,220 for synthetic turf to \$8,133-\$48,960 for a natural grass field.
 - **Maintenance of artificial turf systems** includes “fluffing, redistributing, and shock testing infill; periodic static control and disinfection of the materials; seam repairs and infill replacement; field line erasing and repainting; organic matter removal; and watering to lower temperatures on hot days.”
 - **Maintenance of natural grass** can include “irrigation, mowing, fertilizing, replacing sod, and other activities. A soil and grass health assessment of the field is needed to establish an appropriate maintenance program. Maintenance of a natural field may be minimized by substituting full field replacements and seam repairs with spot sod replacements

Daviscourt (2017) study noted, “The results of this case study support what has previously been estimated in the literature: synthetic fields cost more to install than natural turfgrass fields... The average cost of the life-cycle analysis for natural grass was \$821,000 and for synthetic infill was \$1,767,000.”

The initial cost for artificial turf is about \$1,350,000-\$2,000,000. Synthetic soccer turf fields last about 10 years as synthetic turf breaks down and becomes a safety, playability and aesthetic issue. It then needs replacement that costs \$350,000 to \$650,000 per artificial turf field, not counting any work needed on the base layer or drainage (Sports Venue Calculator). This is an added long-term cost for replacement added into the disposal costs. There are typically no replacement costs for natural grass.

The University of Arkansas came to the same conclusion noting increased maintenance costs of artificial turf. The costs for artificial fields included:

- **Installation Costs:** More extensive subgrade work for artificial fields

- Annual Maintenance: Additional infill, chemical disinfectants, sprays to reduce static cling and odors removal of organic matter, erasing and repainting temporary lines, irrigation because of unacceptably high temperatures on warm-sunny days.
- Replacement Costs of synthetic turf vs grass
- Disposal costs: Due to complex plastic components a special disposal fee is often needed.

Sports Field Manager Jerad Minnick, who has managed both natural and artificial playing fields collected data on costs. He states, “Existing turfgrass managers, provided with a few tools, can produce a low-cost, environmentally friendly field. In an age of needed job creation, committing money to maintain grass fields instead of building synthetic will create numerous new environmentally friendly jobs in the sports and park industry.” He also notes that for “grass fields, the cost numbers for maintenance decreases exponentially when additional fields are added.” Below is cost data for different quality of fields. Although this is from 2013 the initial costs for artificial turf as well as disposal fees have increased. Minnick notes there is debate about durability of artificial turf and highlights that artificial turf can fail. This was noted in a WTHR news report showing that some turf fields sold to schools and universities were wearing out more rapidly and had to be replaced. Warranties are typically for 8 years of use.

- Synthetic Professional: \$1,000,000
- Natural Grass Professional*: \$600,000
- Synthetic, Practice/ Tournament: \$850,000
- Natural Grass Practice/ Tournament*: \$350,000
- Natural Grass Youth Field*: \$150,000

Sports Venue Calculator (SVC) also showed that there is a range of costs for both, however, artificial turf is more expensive in terms of construction. Maintenance is generally in the same range to slightly more expensive for natural grass but this does not take into account disposal and replacement fees.

- Construction Costs Artificial Turf- \$700,000 - \$1,500,000
- Construction Costs Natural Grass Field- \$400,000 – \$820,000
- Maintenance Cost Artificial Turf per year \$6,000 - \$10,000
- Maintenance Cost Natural Grass Field per year- \$18,000-\$44,000

14. Year-Round Grass Playing Fields- The Grass is Always Greener

An argument made is that artificial turf withstands all weather and has more playing days. This may be true for winter sports at times, however, natural grass can be maintained with proper management in the winter (Neylan 2021). In hotter spring or even typical summer days artificial turf may be unusable. Artificial turfs must be constantly monitored if the outside air temperature is above 90 degrees and in sunny weather. In even moderate temperatures artificial fields can be unusable. This feature is not always calculated in field use data. Liu and Kim (2021) note the increased

vulnerability of children to heat related illness along with an increased risk of heat related illness on artificial turf. They found children suffer a 24% longer *Extreme danger* duration on artificial turf on sunny days than natural grass.

15. Mental Health and Wellbeing: Synthetic Turf Displaces Natural Green Space

Prior to 1970's all parks and sports fields were natural soft grass. Children and adults sat down on the grass, shared food and chatted. Small flowers often grew in the grass to create meadows. The use of synthetic fields displaces natural green spaces which are also important to the health, development and wellbeing of children. The tactile and sensory benefits of real grass are lost with artificial turf. Natural green spaces can reduce stress and improve wellbeing. (Zhang 2020) notes, "It is evident that time spent in, or exposure to, green space can improve positive mood and emotions, provide a retreat from daily hassles, and reduce the risk of psychological and physiological stress in adolescents. There is also evidence of lasting mental health benefits of green space exposure in childhood."

"Today's children largely grow up in synthetic, indoor environments. Now, with the growing popularity of synthetic turf fields, their experience with nature will be less than ever." (Claudio 2008) Athletes by far prefer playing on real grass (Owen 2016)

16. Policies to Ban Artificial Turf or Components

The concerns for harmful plasticizers and microplastics in artificial turf, long-term effects on children's health as well as life cycle analysis have led to policies to ban artificial turf altogether as well as ban specific toxic components. Zucarro (2022) reviewed policies on synthetic turf and wrote, "While nearly every country acknowledges the potential health risks posed by heavy metals, microplastics, PAHs, and PFAS chemicals, very few have actually implemented artificial turf and crumb rubber infill regulations and/or established adequate surveillance measures to protect those regularly exposed to the fields." Governments in the US and abroad are restricting the use of artificial fields with crumb rubber or certain hazardous plasticizers (EU and California) due to environmental bio-accumulation of toxic chemicals.

Montgomery County, Maryland banned the use of tire crumb on any newly constructed artificial turf fields due to health concerns in 2015.
[<https://moco360.media/2019/11/18/turf-war/3/>]

Westport, Connecticut banned crumb rubber in 2017 and passed an "Ordinance prohibiting the application of synthetic infill material on playing fields on town property," David Brown, a Westport resident with a doctorate in toxicology from Harvard University, formerly headed up a toxicology group at the state health department. He testified in favor of the synthetic infill ban and stated, "The primary problem with turf is

the off-gas from particles that contain toxic and carcinogenic chemicals. When people ingest the crumb rubber, the toxic chemicals are released in their body.”

In 2021 the European Union (EU) expanded the scope of restriction of the eight polycyclic aromatic hydrocarbons (PAHs) in infill material in synthetic turf use on playgrounds or sports fields.

Boston banned artificial turf in parks due to toxic ‘forever chemicals in 2022.

Holland is banning crumb rubber infill on artificial turf fields due to soil pollution under the turf.

Oak Bluffs Board of Health Banned Turf Fields. Martha’s Vineyard, Massachusetts. April 23, 2024. <https://vineyardgazette.com/news/2024/04/23/oak-bluffs-board-health-bans-turf-fields>

California SB 676 (2023) reverses in part AB 349 (2015) to prevent city or county bans on drought-tolerant landscaping and specifies that “drought-tolerant landscaping does not include the installation of synthetic grass or artificial turf.”

San Marino, California (2023) placed a temporary extended moratorium on Oct 27, 2023 banning the use of artificial turf or synthetic grass within the city (Ordinance No. O-23-1410.)

Millbrae, California (2023) banned artificial turf in 2023 in all areas of the city (Ord. 806, § 1).Chapter 8.65).

Sunnyvale, California in October 2023 rejected a proposal to place artificial turf athletic field in a park renovation.

Conclusion

There has been no proof of safety for artificial playing fields and there are many data gaps. Few studies exist on the health impacts of artificial turf, while numerous chemicals hazardous to human health and the environment are found in artificial turf and its leachate (Murphy 2022). There is growing evidence that significant environmental, as well as, health and safety risks outweigh the presumed benefits of artificial fields. It appears that natural grass is less expensive when a full life cycle analysis is performed. In addition, natural grass prevents storm water runoff of toxins and provides living carbon capture as well. Water use on artificial turf is not as low as stated with a full life cycle analysis. Considering that studies on the risks of long-term health have not been performed, along with absence of comprehensive data on the hazardous chemical components of artificial fields we recommend:

- 1) Not to place artificial turf on playing fields, and
- 2) Should artificial turf already be present, to replace this with natural grass

Children are increasingly exposed to many toxins in the environment. As physicians we advocate for reduction in toxic exposures to reduce individual harm, societal harm, and health care costs which are rising. A precautionary preventative health approach is recommended to avoid unintended consequences and unintended downstream costs.

References

Note: After Legislation and Reports other References are in alpha order as follows- Articles Scientific; Artificial Turf Components and Additives; Bans Artificial Turf; Cancer and Chemical Question; Chemical and Plastic Exposures and Contamination; Children's Vulnerability to Toxins; Climate Change; Costs; Disposal and Recycling; Environmental Benefits of Natural Grass; Environmental Impacts of Artificial Turf; Health and Safety; Heat Related Illness and Urban Heat Effect; Infections; Injuries – Sports (and athletic preferences); Laws and Policy; Lawsuits and Litigation; Letters; Mental Health and Greenscapes; Natural Grass Field Examples; News Articles; PFAS; Videos; Water Use; Water Quality and Contamination.

Legislation, Policy, Position Statements

CA-SB-54 (2023) Solid waste: reporting, packaging, and plastic food service ware. (2021-2022) https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB54

CA-SB 54 (2023). Plastic Pollution Prevention and Packaging Producer Responsibility Act. Gov. Newsom signs law allowing local governments to ban artificial turf. Oct 28, 2023. <https://www.nbcsandiego.com/news/local/governor-newsom-signs-law-allowing-local-governments-to-ban-artificial-turf/3339853/>

CA-SB 676 (2023) Local ordinances and regulations: drought-tolerant landscaping. Signed into law Oct 8, 2023. <https://legiscan.com/CA/text/SB676/id/2844684>

CA-SB 676 (2023) - Senate Bill Policy Committee Analysis. <https://alcl.assembly.ca.gov/sites/alcl.assembly.ca.gov/files/SB%20676%20%28Allen%29.pdf>

CA-AB 349 (2015) (GONZALEZ). COMMON INTEREST DEVELOPMENTS: PROPERTY USE & MAINTENANCE. New protections for homeowners within HOAs installing artificial turf. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160AB349

CA- AB 1423 (2023) Product safety: PFAS: artificial turf or synthetic surfaces. 2023. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202320240AB1423

IPM- Santa Clara County IPM Ordinance- SCC Ordinance Code. Title B Regulations. Division B28 - INTEGRATED PEST MANAGEMENT AND PESTICIDE USE.
https://library.municode.com/ca/santa_clara_county/codes/code_of_ordinances?nodeId=TITBRE_DIVB28INPEMAPEUS

San Marino, California (2023) Urgency Interim Ordinance of the City Council of the City of San Marino Extending the Term of Ordinance No O-21-1385-U Establishing A Temporary Moratorium on the Installation of Artificial Turf and Synthetic Grass in the City of San Marino. (Ordinance No. O-23-1410.) Oct 27, 2023. <https://cms9files.revize.com/sanmarinoca/O-23-1410%20Extending%20the%20Term%20of%20Ordinance%20No%20O-21-1385-U,%20Establishing%20a%20Temporary%20Moratorium%20on%20the%20Installation%20of%20Artificial%20Turf%20and%20Synthetic%20Grass.pdf>

Millbrae, California. Prohibition of Artificial Turf. City of Millbrae Synthetic Grass and Artificial Turf Ordinance.” (Ord. 806, § 1).Chapter 8.65.
<https://www.codepublishing.com/CA/Millbrae/#!/Millbrae08/Millbrae0865.html#8.65>]
Or <https://www.ci.millbrae.ca.us/276/Prohibition-of-Artificial-Turf>

Mount Sinai Children’s Environmental Health Center: Position Statement on the Use of Artificial Turf Surfaces. Nov 30, 2023. <https://mountsinaiaexposomics.org/position-statement-on-the-use-of-artificial-turf-surfaces/>

Smith MN. **A Hazard-Based Framework for Identifying Safer Alternatives to Classes of Chemicals: A Case Study on Phthalates in Consumer Products.** Washington State Pollution Prevention Act. Environmental Health Perspectives. April 29, 2024.
<https://ehp.niehs.nih.gov/doi/10.1289/EHP13549>

Ulirsch GV et al. **Evaluating and Regulating Lead in Synthetic Turf.** Ulirsch GV et al. Envir Health Perspect. 2010 Oct; 118(10): 1345–1349.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2957910/>

Zucarro P et al. **The European Union Ban on Microplastics Includes Artificial Turf Crumb Rubber Infill: Other Nations Should Follow Suit.** Environ. Sci. Technol. 2024, 58, 6, 2591–2594. <https://pubs.acs.org/doi/10.1021/acs.est.4c00047>

California Coastal Commission. 2023. Memo W13.1a, dated November 30, 2023, Subject: Notice of Impending Development UCS-NOID-0002-23 (Baseball Stadium Turf) for Public Hearing and Commission Action at the December 13, 2022 <sic>, Commission Meeting.
<https://documents.coastal.ca.gov/reports/2023/12/W13.1a/W13.1a-12-2023-report.pdf>

Reports

California Coastal Commission. 2023. Memo W13.1a, dated November 30, 2023, Subject: Notice of Impending Development UCS-NOID-0002-23 (Baseball Stadium Turf) for Public Hearing and Commission Action at the December 13, 2022 <sic>, Commission Meeting. <https://documents.coastal.ca.gov/reports/2023/12/W13.1a/W13.1a-12-2023-report.pdf>

SCVWD. Water Conservation Fact Sheet. Landscape Rebate Program https://suwater.stanford.edu/sites/g/files/sbiybj19876/files/media/file/scvwd_artificialturf.pdf

SCVWD. Field, Pilot, and Laboratory Studies for the Assessment of Water Quality Impacts of Artificial Turf . Prepared For Santa Clara Valley Water District 5750 Almaden Expressway San Jose, CA 95118-3614. JUNE 2010.

<https://www.valleywater.org/sites/default/files/Water%20Use%20Impacts%20of%20Artificial%20Turf.pdf>

Articles-Scientific

AAP- American Academy of Pediatrics. **Safety in the Sandbox.** <https://www.healthychildren.org/English/safety-prevention/at-play/Pages/Safety-in-the-Sandbox.aspx>

Alm, Abigail (2016) **Is Synthetic Turf Really “Greener”?** A Lifecycle Analysis of Sports Fields Across the United States, Carthage College, Kenosha, Wisconsin. May 2016. <https://www.carthage.edu/academics/library/archives-special-collections/>

Abraham (2019) **Heat risks associated with synthetic athletic fields.** International Journal of Hyperthermia. 24 Apr 2019. <https://www.tandfonline.com/doi/full/10.1080/02656736.2019.1605096>

Adamson (2007) **Synthetic turf fields present unique dangers. Columbia (MO): University of Missouri- Columbia College of Agriculture, Food, and Natural Resources; 2007.** Available from: http://agebb.missouri.edu/news/ext/showall.asp?story_num=3521&iln=8.

Alori ET et al. **Bioremediation techniques as affected by limiting factors in soil environment.** *Front. Soil Sci.*, 04 August 2022. Sec. Soil Pollution & Remediation. Volume 2 – 2022. <https://www.frontiersin.org/articles/10.3389/fsoil.2022.937186/full>

Antoniades DG et al. **Thermal Environment of Urban Schoolyards: Current and Future Design with Respect to Children’s Thermal Comfort.** October 2020. *Atmosphere* 11(1144):1-26. https://www.researchgate.net/publication/345243319_Thermal_Environment_of_Urban_Schoolyards_Current_and_Future_Design_with_Respect_to_Children's_Thermal_Comfort

Armada D (2022) **Global evaluation of the chemical hazard of recycled tire crumb rubber employed on worldwide synthetic turf football pitches.** Science of The Total Environment. Vol 812, 15 March 2022, 152542.

<https://www.sciencedirect.com/science/article/pii/S0048969721076208?via%3Dihub>

Armada D (2022) **Green methodology based on active air sampling followed by solid phase microextraction and gas chromatography-tandem mass spectrometry analysis to determine hazardous substances in different environments related to tire rubber.** J Chromatogr A. 2022 Apr 12;1668:462911. <https://pubmed.ncbi.nlm.nih.gov/35248870/>

ATSDR. **Understanding PFAS Exposure and Your Body.**

Jan 18, 2024. <https://www.atsdr.cdc.gov/pfas/health-effects/PFAS-exposure-and-your-body.html>

Baker E. **New method spots unreported forever chemicals** 2023 October, Chemical & Engineering News. University of North Carolina, E.

<https://cen.acs.org/environment/New-method-spots-unreported-forever/101/i36>

Balazs GC et al. **Risk of Anterior Cruciate Ligament Injury in Athletes on Synthetic Playing Surfaces: A Systematic Review.** Am J Sports Med. 2015 Jul;43(7):1798-804.

<https://pubmed.ncbi.nlm.nih.gov/25164575/>

Barton K et al. **Cross-sectional associations between serum PFASs and inflammatory biomarkers in a population exposed to AFFF-contaminated drinking water.** Barton. Int J Hygiene and Environ Health. Vol 240. March 2022,.

<https://www.sciencedirect.com/science/article/abs/pii/S1438463921002200>

Beard JB et al. **The role of turfgrasses in environmental protection and their benefits to humans** (1994). J. Environ. Qual. 1994, 23 (3), 452–460.

<https://access.onlinelibrary.wiley.com/doi/abs/10.2134/jeq1994.00472425002300030007x>

Begier EM et al. **A high-morbidity outbreak of methicillin-resistant Staphylococcus aureus among players on a college football team, facilitated by cosmetic body shaving and turf burns.** Begier EM et al. Clin Infect Dis. 2004;39:1446-1453.

<https://pubmed.ncbi.nlm.nih.gov/15546080/>

Bell L et al. **CHEMICAL RECYCLING: A DANGEROUS DECEPTION WHY CHEMICAL RECYCLING WON'T SOLVE THE PLASTIC POLLUTION PROBLEM.** Beyond Plastic. October 2023.

https://static1.squarespace.com/static/5eda91260bbb7e7a4bf528d8/t/655791f76ad9bb07d10e1290/1700237880522/10-30-23_Chemical-Recycling-Report_web.pdf

Bernat-Ponce E et al. **Replacement of semi-natural cover with artificial substrates in urban parks causes a decline of house sparrows Passer domesticus in Mediterranean towns.**

Urban Ecosystems. Volume 23, pages 471–481, (2020) Feb 14, 2020.

<https://link.springer.com/article/10.1007/s11252-020-00940-4>

Bessa F et al. **Occurrence of microplastics in commercial fish from a natural estuarine environment.** Mar Pollut Bull. 2018 Mar;128:575-584.
<https://pubmed.ncbi.nlm.nih.gov/29571409/>

Blewitt M. AUSTRALIAN MICROPLASTIC ASSESSMENT PROJECT.
<https://www.ausmap.org/>

Bowers (2008) **Methicillin-resistant Staphylococcus aureus infections in collegiate football players.** Sci Sports Exerc. 2008 Aug;40(8):1362-7. <https://pubmed.ncbi.nlm.nih.gov/18614960/>

Brennan (2021) **Trends in the Regulation of Per- and Polyfluoroalkyl Substances (PFAS): A Scoping Review.** Brennan NM et al. Int J Environ Res Public Health. 2021 Oct; 18(20): 10900. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8536021/>

Buskirk (1971) **Microclimate over artificial turf.** Buskirk ER et al. J Health, Phys Educ Recreat. 1971;42:29–30. <https://www.tandfonline.com/doi/10.1080/00221473.1971.10617177>

Bytowski JR et al. **Heat illness in children.** Curr Sports Med Rep. 2003 Dec;2(6):320-4
<https://pubmed.ncbi.nlm.nih.gov/14583161/>

Calloway SP et al. **Injury Surveillance in Major League Soccer: A 4-Year Comparison of Injury on Natural Grass Versus Artificial Turf Field.** The American journal of sports medicine. 2019; 47(10), 2279–2286. <https://doi.org/10.1177/0363546519860522>

Carroquino MJ. **Environmental Toxicology: Children at Risk.** Carroquino MJ et al. Environmental Toxicology. 2012 Dec 4 : 239–291.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7121289/>

CDC. Lead in Soil.

<https://www.cdc.gov/nceh/lead/prevention/sources/soil.htm#:~:text=Risk%20from%20lead%20in%20artificial%20turf&text=As%20the%20turf%20ages%20and,lead%20the%20body%20will%20absorb.>

CEH. **Notice of Violation of the Safe Drinking Water Act and Toxic Enforcement Act.** March 4, 2024. <https://ceh.org/wp-content/uploads/2024/03/2024-03-04-Notice-PFOS-in-Turffx.pdf>

Celeiro (2021) **Evaluation of chemicals of environmental concern in crumb rubber and water leachates from several types of synthetic turf football pitches.** Chemosphere. 2021 May;270:128610. <https://pubmed.ncbi.nlm.nih.gov/33121811/>

Celeiro (2021). **Determination of priority and other hazardous substances in football fields of synthetic turf by gas chromatography-mass spectrometry: A health and environmental concern.** Chemosphere. 2018 Mar;195:201-211. <https://pubmed.ncbi.nlm.nih.gov/29268178/>

Claudio (2008) **Synthetic turf: health debate takes root.** Environ Health Perspect. 2008;116:A116–A122. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2265067/>

CDC.Children’s Environmental Health.

<https://www.cdc.gov/nceh/tracking/topics/ChildrensEnvironmentalHealth.htm#:~:text=Because%20they%20are%20small%20and,their%20hands%20in%20their%20mouth.>

CDC. Surveillance for Silicosis Deaths Among Persons Aged 15–44 Years — United States, 1999–2015

<https://www.cdc.gov/mmwr/volumes/66/wr/mm6628a2.htm>

CEH. Notice of Violation of the Safe Drinking Water Act and Toxic Enforcement Act.

March 4, 2024. <https://ceh.org/wp-content/uploads/2024/03/2024-03-04-Notice-PFOS-in-Turffx.pdf>

Cheng H et al. **Environmental and health impacts of artificial turf: a review.** Environ. Sci. Technol. 2014 Feb 18;48(4):2114–29. <https://pubmed.ncbi.nlm.nih.gov/24467230/>

Consumer Product Safety Commission (CPSC). Letter from CPSC regarding rubber products used by children but no listed as a “Children’s Product”. https://peer.org/wp-content/uploads/attachments/3_21_13_CPSC_childrens_product.pdf

CPHD. Health Advisory. To: Healthcare Providers and Local Health Departments-Global Epidemic Comes to California: Silicosis in Countertop Workers. 7/25/2023 State of California—Health and Human Services Agency, California Department of Public Health.

<https://www.cdph.ca.gov/Programs/OPA/Pages/CAHAN/Global-Epidemic-Comes-to-California-Silicosis-in-Countertop-Workers.aspx>

CPSC. Avoiding Tap Water Scalds. Consumer Product Safety Commission.

<https://www.cpsc.gov/s3fs-public/5098-Tap-Water-Scalds.pdf>

Cui W et al. **Adverse effects of microplastics on earthworms: A critical review.** Science of the Total Environment. Vol 850. 1 December 2022.

<https://www.sciencedirect.com/science/article/abs/pii/S0048969722051403>

Cumming J. **Environmental Assessment of the Australian Turf Industry.** July 20, 2018.

<https://www.horticulture.com.au/globalassets/hort-innovation/resource-assets/tu16000-benchmarking-report.pdf>

Danopoulos E et al. **A rapid review and meta-regression analyses of the toxicological impacts of microplastic exposure in human cells.** Journal of Hazardous Materials. Vol 427. 5 April 2022, 127861.

<https://www.sciencedirect.com/science/article/abs/pii/S0304389421028302?dgcid=author>

Daviscourt (2017) **A Life-Cycle Cost Analysis of Synthetic Infill and Natural Grass Systems.** International Turf Grass Society Research Journal.
<https://onlinelibrary.wiley.com/doi/full/10.2134/itsrj2016.10.0848>

DeSocio J. Five LAUSD high schools to replace 'melting' turf on fields. Sept 1, 2015. Fox 11.
<https://www.foxla.com/news/five-laUSD-high-schools-to-replace-melting-turf-on-fields>

de Haan et al. **The dark side of artificial greening: Plastic turfs as widespread pollutants of aquatic environments.** Environmental Pollution. October 2023, 12209.
<https://www.sciencedirect.com/science/article/pii/S0269749123010965?via%3Dihub>

Duque-Villaverde A et al. **Recycled tire rubber materials in the spotlight. Determination of hazardous and lethal substances.** Sci Total Environ. 2024 Jun 15:929:172674.
<https://pubmed.ncbi.nlm.nih.gov/38657808/>

EPA. **New Chemicals Program Review of Alternatives for PFOA and Related Chemicals.**
<https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/new-chemicals-program-review-alternatives-pfoa-and>

EPA. **Our Current Understanding of the Human Health and Environmental Risks of PFAS.** <https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas>

EPA. **U.S. Federal Research Action Plan (FRAP) on Recycled Tire Crumb Rubber Used on Synthetic Turf Playing Fields and Playgrounds.** https://www.epa.gov/sites/default/files/2019-08/documents/tc_public_webinar_-_august_6_2019.pdf

EPA. **Synthetic Turf Field Recycled Tire Crumb Rubber Research Under the Federal Research Action Plan . Final Report Part 1 –Tire Crumb Rubber Characterization.** Volume 1. July 2019. https://www.epa.gov/sites/default/files/2019-08/documents/synthetic_turf_field_recycled_tire_crumb_rubber_research_under_the_federal_research_action_plan_final_report_part_1_volume_1.pdf

EPA Scrap Tires. 2016. Wastes-Resource Conservation-Common Wastes and Materials. – Scarp Tires. Archives..
<https://archive.epa.gov/epawaste/conservation/materials/tires/web/html/basic.html#:~:text=38%20states%20ban%20whole%20tires,to%20be%20placed%20in%20landfills.>

Daviscourt (2017) **A Life-Cycle Cost Analysis of Synthetic Infill and Natural Grass Systems.** International Turf Grass Society Research Journal.
<https://onlinelibrary.wiley.com/doi/full/10.2134/itsrj2016.10.0848>

de Haan et al (2023) **The dark side of artificial greening: Plastic turfs as widespread pollutants of aquatic environments.** Environmental Pollution. October 2023, 12209.
<https://www.sciencedirect.com/science/article/pii/S0269749123010965?via%3Dihub>

Ecology Center (2020). **Analysis of Crumb Rubber Shed from Maryland and Virginia Playgrounds**. Sept 30, 2020.

<https://drive.google.com/file/d/1ouegpPJHIO6goZsU7U08Ddh0CVQnBeUt/view>

Ecology Center Memo on PFAS-free Synthetic Turf Standards and Testing. Nov 16, 2020.

<https://www.oakbluffsma.gov/DocumentCenter/View/5292/Ecology-Center-Jeff-Gearhart-email-Nov-16-2020>

Ekstrand (2006) **Risk of injury in elite football played on artificial turf versus natural grass: a prospective two-cohort study**. *ports Med*. 2006 Dec;40(12):975-80.

<https://pubmed.ncbi.nlm.nih.gov/16990444/>

Endocrine Society. **Endocrine Disrupting Chemicals**. <https://www.endocrine.org/topics/edc>

Evanylo (2010) **Reclaimed Water for Turfgrass Irrigation**. *Water* 2010, 2(3), 685-701.

<https://www.mdpi.com/2073-4441/2/3/685>

Foguth (2020) **Per- and Polyfluoroalkyl Substances (PFAS) Neurotoxicity in Sentinel and Non-Traditional Laboratory Model Systems: Potential Utility in Predicting Adverse Outcomes in Human Health**. Foguth R et al. *Toxics*. 2020 Jun; 8(2): 42.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7355795/>

Fort J (2022) **Environmental Consequences of Rubber Crumb Application: Soil and Water Pollution**. *Polymers (Basel)*. 2022 Apr; 14(7): 1416.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9003429/>

Frederico (2023) **Silent Contamination: The State of the Art, Knowledge Gaps, and a Preliminary Risk Assessment of Tire Particles in Urban Parks**. Frederico L et al

Toxics. 2023 May 9;11(5):445. <https://pubmed.ncbi.nlm.nih.gov/37235259/>

Garcia (2024) **Quantitation and identification of microplastics accumulation in human placental specimens using pyrolysis gas chromatography mass spectrometry**. Garcia MA et al. *Toxicol Sci*. 2024 Apr 29;199(1):81-88.

<https://pubmed.ncbi.nlm.nih.gov/38366932/>

Garcia (2024) **In Vivo Tissue Distribution of Polystyrene or Mixed Polymer Microspheres and Metabolomic Analysis after Oral Exposure in Mice**. Garcia MM et al. *Environmental Health Perspectives*. April 10, 2024.

<https://ehp.niehs.nih.gov/doi/10.1289/EHP13435>

Gaspar (2023) **Acute Exposure to Microplastics Induced Changes in Behavior and Inflammation in Young and Old Mice**. Gaspar L et al. *Int. J. Mol. Sci*. 2023, 24(15), 12308.

<https://www.mdpi.com/1422-0067/24/15/12308>

Goldstein BD (2001) **The Precautionary Principle Also Applies to Public Health Actions**. *Am J Pub health*. 2001 September; 91(9): 1358–1361.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1446778/>

Gomes (2021) **A review of potentially harmful chemicals in crumb rubber used in synthetic football pitches.** Gomes FO et al. J Hazard Mater. 2021 May 5:409:124998.
<https://pubmed.ncbi.nlm.nih.gov/33513533/>

Graca (2022) **Presence of metals and metalloids in crumb rubber used as infill of worldwide synthetic turf pitches: Exposure and risk assessment.** Graca CA et al. Chemosphere. Vol 299, July 2022, 134379. <https://www.sciencedirect.com/science/article/pii/S0045653522008724>

Grandjean(2017) **Estimated Exposures to Perfluorinated Compounds in Infancy Predict Attenuated Vaccine Antibody Concentrations at age 5-Years.** Grandjean P et al J Immunotoxicol. 2017 Dec. . <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6190594/>

Grandjean (2018) **Delayed discovery, dissemination, and decisions on intervention in environmental health: a case study on immunotoxicity of perfluorinated alkylate substances.** Environmental Health. Article number: 62 (2018)
<https://ehjournal.biomedcentral.com/articles/10.1186/s12940-018-0405-y>

Guskiewicz. (2000). **Epidemiology of concussion in collegiate and high school football players.** The American Journal of Sports Medicine, 28(5), 643-650.
<https://pubmed.ncbi.nlm.nih.gov/11032218/>

Hahn (2010) **Consumer exposure to biocides - identification of relevant sources and evaluation of possible health effects.** Environ Health. 9, Article number: 7 (2010)
<https://ehjournal.biomedcentral.com/articles/10.1186/1476-069X-9-7>

Hall (2022) **Concentrations of per- and polyfluoroalkyl substances (PFAS) in human placental tissues and associations with birth outcomes.** Hall SM et al. Chemosphere. 2022 Feb 7.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8923299/>

Harvard. **Microplastics Everywhere: The tiny particles are even in our bodies.** What might this mean for our health? Harvard. <https://magazine.hms.harvard.edu/articles/microplastics-everywhere>

Hausmann (2022) **New study casts doubt on safety of synthetic turf.** March 15, 2022.
<https://www.wvtf.org/news/2022-03-15/new-study-casts-doubt-on-safety-of-synthetic-turf>

Haug (2011) **Characterization of human exposure pathways to perfluorinated compounds — Comparing exposure estimates with biomarkers of exposure.** Haug LS et al (Dust) Environment International 2011; 37: 687–693. 2011.
<https://pubmed.ncbi.nlm.nih.gov/21334069/>

Hochmuth G et al. **MAXIMIZING THE BENEFITS OF RECLAIMED WATER FOR IRRIGATING THE LANDSCAPE AND PROTECTING THE ENVIRONMENT.** University of Florida Extension. <https://edis.ifas.ufl.edu/publication/SS587>

Hu (2024) **Microplastic presence in dog and human testis and its potential association with sperm count and weights of testis and epididymis.** Hu CJ et al. Toxicological Sciences, May 15, 2024. <https://academic.oup.com/toxsci/advance-article/doi/10.1093/toxsci/kfae060/7673133?login=false>

IARC. OCCUPATIONAL EXPOSURES IN THE RUBBER-MANUFACTURING INDUSTRY. <https://www.ncbi.nlm.nih.gov/books/NBK304412/>

IARC Monographs. **The IARC Monographs on the carcinogenicity of crystalline silica.** Guha N. Med Lav. 2011 Jul-Aug;102(4):310-20. <https://pubmed.ncbi.nlm.nih.gov/21834268/>

IPM- EPA-Integrated Pest Management (IPM) Principles. 2023. <https://www.epa.gov/safepestcontrol/integrated-pest-management-ipm-principles>

IPM- USDA Integrated Pest Management. <https://www.usda.gov/oce/pest/integrated-pest-management>

IPM- USDA. History of the Federal Integrated Pest Management Coordinating Committee. <https://www.usda.gov/sites/default/files/documents/20201110-FIPMCC-History.pdf>

IPM- Marin County Integrated Pest Management Ordinance. <https://www.marincounty.org/depts/ag/ipm>

IPM- Santa Clara County IPM. Office of Sustainability and Resiliency. <https://sustainability.santaclaracounty.gov/natural-environment/integrated-pest-management/program-implementation/management-tools/governing>

IPM- Santa Clara County IPM Ordinance- SCC Ordinance Code. Title B Regulations. Division B28 - INTEGRATED PEST MANAGEMENT AND PESTICIDE USE. https://library.municode.com/ca/santa_clara_county/codes/code_of_ordinances?nodeId=TITBRE_DIVB28INPEMAPEUS

IPM- San Francisco IPM. Parks and Rec. <https://sfrecpark.org/1400/Integrated-Pest-Management>

IPM- San Francisco Integrated Pest Management Ordinance.1996. https://codelibrary.amlegal.com/codes/san_francisco/latest/sf_environment/0-0-0-160

IPM- San Francisco Department of Environment. Pest Management for City Departments. <https://www.sfenvironment.org/pest-management-for-city-departments#list>

IPM- Santa Monica Unified School District Integrated Pest management Program. 2011. <https://www.smmusd.org/cms/lib/CA50000164/Centricity/Domain/299/IntegratedPestManagement.pdf>

IPM- National Pesticide Information Center. (NPIC) <http://npic.orst.edu/pest/agipm.html>

IPM- UC-IPM. UC California Statewide IPM Program. <https://ipm.ucanr.edu/what-is-ipm/#gsc.tab=0>

IPM- California's Pest Management Program. Frank Zalom. UC Davis.
<https://ipmworld.umn.edu/zalom-california-ipm>

IPM- IPM University of Massachusetts Amherst. Center for Agriculture, Food and the Environment. <https://ag.umass.edu/integrated-pest-management/about>

IPM- Landscape, Nursery and Urban Forestry Program. University of Massachusetts Amherst. Center for Agriculture, Food and the Environment... <https://ag.umass.edu/integrated-pest-management/ipm-by-commodity/landscape>

IPM- Advancing Alternatives: Successful least-toxic pest management programs in California's urban settings. Beyond Pesticides. 2000.
https://www.beyondpesticides.org/assets/media/documents/schools/schoolpolicies/links_statelaws/Reports/alternativesCPR.pdf

ITRC. 7 Human and Ecological Health Effects of select PFAS. Interstate Technology Regulatory Council. <https://pfas-1.itrcweb.org/7-human-and-ecological-health-effects-of-select-pfas/>

Jaradat (2020) **Methicillin Resistant Staphylococcus aureus and public fomites: a review.** Jaradat ZW et al. Glob Health. 2020 Dec;114(8):426-450.
<https://pubmed.ncbi.nlm.nih.gov/33115375/>

Kanaan(2020) . **Water Requirements for Cooling Artificial Turf.** Kanaan A et al. August 2020. Journal of Irrigation and Drainage Engineering 146(10)
https://www.researchgate.net/publication/343639132_Water_Requirements_for_Cooling_Artificial_Turf

Keller (2020) **The Fate of Methicillin-Resistant Staphylococcus aureus in a Synthetic Turf System.** Keller M et al. Sports Health. 2020 May-Jun; 12(3): 263–270.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7222665/>

Kim (2012) **Health Risk Assessment of Lead Ingestion Exposure by Particle Sizes in Crumb Rubber on Artificial Turf Considering Bioavailability.** Kim S et al. Environmental Health and Toxicology, Volume 27. January 2012
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278598/>

Kruger (2013) **New approach to the ecotoxicological risk assessment of artificial outdoor sporting grounds.** Kruger O et al. Environmental Pollution, Volume 175. April 2013.
<https://www.ncbi.nlm.nih.gov/pubmed/23337354>

Landrigan (2023) **The Minderoo-Monaco Commission on Plastics and Human Health.** Ann Glob Health. 2023 Mar 21;89(1):23. <https://pubmed.ncbi.nlm.nih.gov/36969097/>

Landrigan (2016) **Children's Environmental Health: A Brief History.** Landrigan PJ. Acad Pediatr. 2016 Jan-Feb;16(1):1-9. <https://pubmed.ncbi.nlm.nih.gov/26498257/>

Landrigan (2001) **CHILDREN'S ENVIRONMENTAL HEALTH: Lessons from the Past and Prospects for the Future.** Landrigan PJ. Pediatric Clinics of North America. Vol 48, Issue 5, 1 October 2001, Pages 1319-1330. <https://www.sciencedirect.com/science/article/abs/pii/S0031395505703771>

Lauria (2022) **Widespread Occurrence of Non-Extractable Fluorine in Artificial Turfs from Stockholm, Sweden.** Lauria MZ et al. Environmental Science & Technology Letters 2022. Aug 9;9(8):666-672. <https://pubs.acs.org/doi/10.1021/acs.estlett.2c00260>

Leslie (2022) **Discovery and quantification of plastic particle pollution in human blood.** Leslie HA et al. Environment International. Vol 163. May 2022. <https://www.sciencedirect.com/science/article/pii/S0160412022001258>

Liu and Kim (2021) **Playing on natural or artificial turf sports field? Assessing heat stress of children, young athletes, and adults in Hong Kong.** Liu Z and Kim CY. Sustainable Cities and Society. Vol 75. December 2021. <https://www.sciencedirect.com/science/article/abs/pii/S2210670721005473>

Liu (2022) **A toxicological profile of silica nanoparticles.** Liu and Sayes. Toxicology Research, Volume 11, Issue 4, August 2022. <https://academic.oup.com/toxres/article/11/4/565/6645393>

Llompart (2013) **Hazardous organic chemicals in rubber recycled tire playgrounds and pavers.** Llompart M et al. Chemosphere. 2013 Jan;90(2):423-31. <https://pubmed.ncbi.nlm.nih.gov/22921644/>

Loughran (2019) **Incidence of Knee Injuries on Artificial Turf Versus Natural Grass in National Collegiate Athletic Association American Football: 2004-2005 Through 2013-2014 Seasons.** Loughran GJ Et al. The American journal of sports medicine. 2019;47(6), 1294–1301. <https://doi.org/10.1177/0363546519833925>

Ma (2021) **Future-Proofing Capitalism: The Paradox of the Circular Economy for Plastics.** Ma A. Global Environmental Politics (2021) 21 (2): 121–142. <https://direct.mit.edu/glep/article/21/2/121/97367/Future-Proofing-Capitalism-The-Paradox-of-the>

Mack (2019) **Higher Rates of Lower Extremity Injury on Synthetic Turf Compared With Natural Turf Among National Football League Athletes: Epidemiologic Confirmation of a Biomechanical Hypothesis.** Am J Sports Med. 2019 Jan;47(1):189-196. <https://pubmed.ncbi.nlm.nih.gov/30452873/>

Magnusson (2017) **Analysis of energy use and emissions of greenhouse gases, metals and organic substances from construction materials used for artificial turf.** Magnusson S. Resources, Conservation and Recycling. Vol 122. July 2017, Pages 362-372
<https://www.sciencedirect.com/science/article/abs/pii/S0921344917300861>

Malmquist (2021) **Vulnerability and adaptation to heat waves in preschools: Experiences, impacts and responses by unit heads, educators and parents.** Malmquist A et al. Climate Risk Management.. Vol 31. 2021, 100271.
<https://www.sciencedirect.com/science/article/pii/S2212096320300619>

Marsili (2014) **Release of Polycyclic Aromatic Hydrocarbons and Heavy Metals from Rubber Crumb in Synthetic Turf Fields: Preliminary Hazard Assessment for Athletes.** Marsili L J Environ Anal Toxicol 2014, 5:2. <https://www.hilarispublisher.com/open-access/release-of-polycyclic-aromatic-hydrocarbons-and-heavy-metals-from-rubber-crumb-in-synthetic-turf-fields-2161-0525.1000265.pdf>

Massey (2020) **Artificial Turf Infill: A Comparative Assessment of Chemical Contents.** Massey R et al. Sage Journals. February 23, 2020.
<https://journals.sagepub.com/doi/full/10.1177/1048291120906206>

Mayer (2024) **Where the rubber meets the road: Emerging environmental impacts of tire wear particles and their chemical cocktails.** Mayer PM et al. Sci Total Environ. 2024 Jun 1;927:171153. <https://pubmed.ncbi.nlm.nih.gov/38460683/>

McNitt (2008) **Temperature amelioration of synthetic turf surfaces through irrigation.** McNitt AS et al. Acta Hort. 783:573-582. 2008.
<https://plantscience.psu.edu/research/centers/ssrc/documents/temperature-irrigation.pdf>

Menichini (2011) **Artificial-turf playing fields: contents of metals, PAHs, PCBs, PCDDs and PCDFs, inhalation exposure to PAHs and related preliminary risk assessment.** Menichini E et al. Sci Total Environ. 2011 Nov 1;409(23):4950-7.
<https://pubmed.ncbi.nlm.nih.gov/21907387/>

Meyers and Barnhill (2004) **Incidence, causes, and severity of high school football injuries on FieldTurf versus natural grass: a 5-year prospective study.** Meyers and Barnhill. American J Sports Med. 2004 Oct-Nov;32(7):1626-38.
<https://pubmed.ncbi.nlm.nih.gov/15494326/>

Mount Sinai Children's Environmental Health Center: Position Statement on the Use of Artificial Turf Surfaces. Nov 30, 2023. <https://mountsinaiaexposomics.org/position-statement-on-the-use-of-artificial-turf-surfaces/>

Murphy (2022) **Health impacts of artificial turf: Toxicity studies, challenges, and future directions.** Environ Pollution. <https://pubmed.ncbi.nlm.nih.gov/35948114/>

Najefi (2018) **Turf toe: A clinical update.** Najefi A et al. EFORT Open Review. 2018 Sep; 3(9): 501–506. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6174855/>

Naunheim (2002). **Does the use of artificial turf contribute to head injuries?** Journal of Trauma- Injury, Infection, and Critical Care, 53(4), 691-694. <https://pubmed.ncbi.nlm.nih.gov/12394868/>

Negev (2022) **Hazardous chemicals in outdoor and indoor surfaces: artificial turf and laminate flooring.** Negev M et al . J Expo Sci Environ Epidemiol. 2022 May;32(3):392-399. <https://pubmed.ncbi.nlm.nih.gov/34697408/>

Neves (2015) **Ingestion of microplastics by commercial fish off the Portuguese coast.** Neves D et al. Mar Pollut Bull. 2015 Dec 15;101(1):119 126. <https://pubmed.ncbi.nlm.nih.gov/26608506/>

New Jersey State Technical Memorandum on PFAS on Artificial Turf. Feb 8, 2023. <https://dep.nj.gov/wp-content/uploads/dsr/pfas-artificial-turf-memo-2023.pdf>

New York State (2018) Information About Crumb-Rubber Infilled Synthetic Turf Athletic Fields.

https://www.health.ny.gov/environmental/outdoors/synthetic_turf/crumb-rubber_infilled/fact_sheet.htm#:~:text=People%20playing%20on%20synthetic%20turf,particles%20suspended%20in%20the%20air.

Nogrady (2023) **Australia bans engineered stone because of silicosis risk.** Nogrady B. BMJ. 2023;383:p2954. <https://www.bmj.com/content/383/bmj.p2954>

Norris (2024) **A Silicosis Epidemic in the Northeast San Fernando Valley.** Norris SR. San Fernando Valley Sun. Feb 21, 2024. <https://sanfernandosun.com/2024/02/21/assemblywoman-luz-rivas-introduces-legislation-to-protect-stone-fabrication-workers/>

NRPA (2019) **Synthetic Sports Fields and the Heat Island Effect.** National Recreation and Park Association Guidelines. <https://www.nrpa.org/parks-recreation-magazine/2019/may/synthetic-sports-fields-and-the-heat-island-effect/>

Owen (2016) **Elite Players’ Perceptions of Football Playing Surfaces: A Mixed Effects Ordinal Logistic Regression Model of Players’ Perceptions.** Owen A et al. Institute of Science & Environment, University of Worcester, Worcester, UK. Journal of Applied Statistics on 02 May 2016. https://static1.squarespace.com/static/57fe8750d482e926d718f65a/t/593ed5d15016e1b82e820b5f/1497290197957/Elite_players_perceptions_of_football_playing_surfaces_-_an_ordinal_regression_model_IR.pdf

Paliobeis (2021) **Injury incidence is higher on artificial turf compared with natural grass in high school athletes: a retrospective cohort study.** Paliobeis A et al. Current Orthopedic

Practice. 32(4);355-360. July/August 2021. https://journals.lww.com/c-orthopaedicpractice/abstract/2021/07000/injury_incidence_is_higher_on_artificial_turf.6.aspx

Pavilonis (2014) **Bio-accessibility and Risk of Exposure to Metals and SVOCs in Artificial Turf Field Fill Materials and Fibers.** Pavilonis BT et al. Risk Analysis, Volume 34. January 2014. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4038666>

PEER (2019) **Toxic Forever Chemicals Infest Artificial Turf.: Processing aids that contaminate synthetic turf with PFAS may be in other plastic goods.** PEER. Oct 10, 2019. <https://peer.org/toxic-forever-chemicals-infest-artificial-turf/>

PEER (2024) **PFAS in Artificial Turf Coats Players' Skin Dermal Uptake Little Examined Exposure Pathway for Toxic PFAS.** PEER. March 12, 2024. <https://peer.org/pfas-in-artificial-turf-coats-players-skin/>

PEER (2024) **Test results for preliminary study PFOS on hands of soccer players and coaches on artificial turf vs grass.** PEER. March 6, 2024. https://peer.org/wp-content/uploads/2024/03/3_6_2024-Dermal-absorption-PFAS-AT.pdf

Penn State University (2022). **Survival of Staphylococcus Aureus on Synthetic Turf:** Staphylococcus aureus is a common bacterium, but is capable of causing diseases ranging from minor soft tissue infections and food poisoning to serious medical problems such as toxic shock syndrome. Penn State University. <https://extension.psu.edu/survival-of-staphylococcus-aureus-on-synthetic-turf>

Perkins (2019) **Evaluation of potential carcinogenicity of organic chemicals in synthetic turf crumb rubber.** Perkins AN et al. Environ. Res. 169, 163–172. February 2019. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6396308/>

Pfautsch (2020) **School Microclimates.** Pfautsch S et al. Western Sydney University. <https://researchdirect.westernsydney.edu.au/islandora/object/uws:57392>

Pochron (2018) **Exposure to aged crumb rubber reduces survival time during a stress test in earthworms (Eisenia fetida).** Pochron S et al. Environ Sci Pollut Res Int. 2018 Apr;25(12):11376-11383. <https://pubmed.ncbi.nlm.nih.gov/29423690/>

Ragusa (2021) **Plasticenta: First evidence of microplastics in human placenta.** Ragusa A et al. Environ Int. 2021. Jan;146:106274 <https://pubmed.ncbi.nlm.nih.gov/33395930/>

Robertson CM et al. **Influence of playing surface on match injury risk in men's professional rugby union in England (2013-2019).** Scand J Med Sci Sports. 2022 Nov;32(11):1615-1624. <https://pubmed.ncbi.nlm.nih.gov/36004455/>

Royer (2018) **Production of methane and ethylene from plastic in the environment.** Robertson CM et al. PLOS One. August 1, 2018.

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0200574&utm_medium=email&utm_source=GovDelivery#sec012

Saha (2024) **Effect of microplastics deposition on human lung airways: A review with computational benefits and challenges.** Saha SC et al. Heliyon. 2024 Jan 30; 10(2): e24355. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10826726/>

Sanches-Sotomayer (2022) **Artificial grass in parks as a potential new threat for urban bird communities.** Sanches-Sotomayer D et al. Bird Conservation International. Vol 33. July 26, 2022. Cambridge University Press. <https://www.cambridge.org/core/journals/bird-conservation-international/article/artificial-grass-in-parks-as-a-potential-new-threat-for-urban-bird-communities/55B131F50206D3DD485A57DE975C120C>

Siegel (2014) **Cancer incidence rates and trends among children and adolescents in the United States, 2001-2009.** Siegel DA. Pediatrics.. 2014 Oct;134(4):e945-55. <https://pubmed.ncbi.nlm.nih.gov/25201796/>

Selbes (2015) **Leaching of DOC [dissolved organic carbon], DN [dissolved nitrogen] and inorganic constituents from scrap tires.** Selbes M et al. Chemosphere, Volume 139. November 2015. <http://www.sciencedirect.com/science/article/pii/S004565351500082X>

Slater (2010) **The Cooling Ability of Urban Parks.** Slater GA. 2010. University of Guelph. <https://atrium.lib.uoguelph.ca/items/98ae9062-a51a-4ea8-86ae-fe6b3abe7e86>

Simpson (2021) **Artificial lawns exhibit increased runoff and decreased water retention compared to living lawns following controlled rainfall experiments.** Simpson TJ et al. Urban Forestry & Urban Greening, Volume 63, 2021, <https://www.sciencedirect.com/science/article/abs/pii/S1618866721002570>

Smeets (2012) **Torsional injuries of the lower limb: an analysis of the frictional torque between different types of football turf and the shoe outsole.** Smeets K et al. Br J Sports Med. 2012 Dec;46(15):1078-83. <https://pubmed.ncbi.nlm.nih.gov/22842236/>

Sousa (2013) **Injuries in amateur soccer players on artificial turf: a one-season prospective study.** Sousa P et al. Phys Ther Sport. 2013 Aug;14(3):146-51. <https://pubmed.ncbi.nlm.nih.gov/23072932/>

Sports Venue Calculator (SVC). How much does turf cost for a soccer field? <https://sportsvenuecalculator.com/knowledge/artificial-turf-field/how-much-does-a-turf-field-cost/>

STC. Synthetic Turf Council. <https://atxturf.com/whats-the-difference-between-slit-film-and-monofilament-synthetic-turf/>

STC. Synthetic Turf Council(STC)NEWSROOM: INDUSTRY NEWS -SYNTHETIC GRASS NEWS ARTICLE. July 23, 2021.

<https://www.syntheticurfCouncil.org/news/574409/Synthetic-Grass-News-Article--STC-FAQs.htm>

Steenland (2013) **Silica: A lung carcinogen**. American Cancer Society Journal. Steenland K. Dec 10, 2013. <https://acsjournals.onlinelibrary.wiley.com/doi/10.3322/caac.21214>

Sunderland (2019) **A review of the pathways of human exposure to poly- and perfluoroalkyl substances (PFASs) and present understanding of health effects**. Sunderland E.M. et al. J. Expo. Sci. Environ. Epidemiol. 2019;29:131–147. doi: 10.1038/s41370-018-0094-1. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6380916/>

Szilagyi (2020) **Perfluoroalkyl substances (PFAS) and their effects on the placenta, pregnancy and child development: A potential mechanistic role for placental peroxisome proliferator-activated receptors (PPARs)**. Szilagyi JT et al. Current Enviro Health Rep. Sept 2020. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7473499/>

Taylor (2012) **A review of synthetic playing surfaces, the shoe-surface interface, and lower extremity injuries in athletes**. Taylor SA et al. Phys Sports Med. 2012 Nov;40(4):66-72. <https://pubmed.ncbi.nlm.nih.gov/23306416/>

Tarafdar (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**. Tarafdar A et al. Environ Geochem Health 42, 1691–1704 (2020). <https://link.springer.com/article/10.1007/s10653-019-00334-2#citeas>

Thoms (2014) **Models for predicting surface temperatures on synthetic turf playing surfaces**. Thoms AW et al. Procedia Engineering 72 (2014) 895 – 900. <https://core.ac.uk/download/pdf/82104567.pdf>

Tidaker (2017) **Energy use and greenhouse gas emissions from turf management of two Swedish golf courses**. Tidaker P et al. Urban Forestry and Urban Greening. Vol 21. January 2017, Pages 80-87. <https://www.sciencedirect.com/science/article/pii/S1618866716302692>

Trowbridge (2023) **Extending Nontargeted Discovery of Environmental Chemical Exposures during Pregnancy and Their Association with Pregnancy Complications—A Cross-Sectional Study**. Trowbridge J et al. Environmental Health Perspectives. July 19, 2023. <https://ehp.niehs.nih.gov/doi/10.1289/ehp11546>

(TURI) Sports Turf Alternatives Assessment: Preliminary Results COST ANALYSIS. Massachusetts Toxics Use Reduction Institute September 2016. <https://www.turi.org/content/download/10395/173557/file/Cost%20Artificial%20Turf.%20September%202016.pdf>

(TURI) A Cost Comparison of Conventional (Chemical) Turf Management and Natural (Organic) Turf Management for School Athletic Fields. <https://www.nontoxiccommunities.com/uploads/1/2/3/8/123860248/turfcomparisonreport.pdf>

(TURI) Natural Grass Playing Field Case Study: Marblehead, MA: 20 Acres of Organically Managed Playing Fields. Toxics Use Reduction Institute (TURI).

<https://www.turi.org/content/download/12705/198916/file/Natural+Grass+Playing+Field+Case+Study+Marblehead+MA+revised.Nov2020.pdf>

(TURI) Natural Grass Playing Field Case Study: Springfield, MA: Organic Grass Fields Meet Athletes' Needs and Protect Connecticut River Watershed. Toxics Use Reduction Institute (TURI).

<https://www.turi.org/content/download/12156/190509/file/Natural+Grass+Playing+Field+Case+Study+Springfield+MA.+June+2019.pdf>

(TURI) Natural Grass Playing Field Case Study: Martha's Vineyard, MA: Improving the quality of grass playing fields with data collection and organic management. Toxics Use Reduction Institute (TURI).

<https://www.turi.org/content/download/13432/205432/file/Natural+Grass+Playing+Field+Case+Study+MV+MA.Dec2020.pdf>

(TURI) Building an Organic Maintenance Program for Athletic Fields: Guidance from Experts and Experienced Communities. Toxics Use Reduction Institute (TURI).

<https://www.turi.org/content/download/13543/206640/file/Factsheet.BuildinganOrganicMaintenanceProgramforAthleticFields.April2021.pdf>

(TURI) Sports Turf Alternatives Assessment: Preliminary Results COST ANALYSIS. Massachusetts Toxics Use Reduction Institute September 2016.

<https://www.turi.org/content/download/10395/173557/file/Cost%20Artificial%20Turf.%20September%202016.pdf>

Ulirsch (2010) **Evaluating and Regulating Lead in Synthetic Turf.** Ulirsch GV et al. *Envir Health Perspect.* 2010 Oct; 118(10): 1345–1349.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2957910/>

UMASS Lowell (2020). **Per- and Poly-fluoroalkyl Substances (PFAS) in Artificial Turf Carpet.** Toxics Use Reduction Institute. UMASS Lowell. Feb 2020.

<https://www.turi.org/content/download/12963/201149/file/TURI+fact+sheet+-+PFAS+in+artificial+turf.pdf>

Univ of Arkansas. **Synthetic Turf vs Artificial Grass Athletic Fields.** University of Arkansas.

<https://cms4files.revize.com/elkonv/Council%20Action%20Item%20II-G.pdf>

Upadhyay (2024) **Silica, crystalline.** Upadhyay P et al *Encyclopedia of Toxicology* (Fourth Edition) Vol 8. 2024, Pages 519-525.

<https://www.sciencedirect.com/science/article/abs/pii/B9780128243152007223>

USGS (2023) **Tap Water Study Detects PFAS Forever Chemicals Across the US.** USGS. July 5, 2023.

<https://www.usgs.gov/news/national-news-release/tap-water-study-detects-pfas-forever-chemicals-across-us>

Valeriani (2019) **Artificial-turf surfaces for sport and recreational activities: microbiota analysis and 16S sequencing signature of synthetic vs natural soccer fields.** Valeriani F et al. Heliyon 2019. [https://www.cell.com/heliyon/pdf/S2405-8440\(19\)35994-8.pdf](https://www.cell.com/heliyon/pdf/S2405-8440(19)35994-8.pdf).

van Kleunen (2019) **A microplastic used as infill material in artificial sport turfs reduces plant growth.** van Kleunen M et al. PLANTS, PEOPLE, PLANET. Oct 11, 2019. <https://nph.onlinelibrary.wiley.com/doi/10.1002/ppp3.10071>

van Rooij Joost (2010) **Hydroxypyrene in urine of football players after playing on artificial sports field with tire crumb infill.** van Rooij Joost and Jongeneelen Frans J. Int Arch Occup Environ Health (2010) 83:105–110. https://portal.ct.gov/-/media/Departments-and-Agencies/DPH/dph/environmental_health/Turf/ArtificialTurfVanRooij2010BioMpdf.pdf

Vaughn (2010) . **Restoration Ecology.** Vaughn, K. J. et al (2010). Nature Education Knowledge 3(10):66. <https://www.nature.com/scitable/knowledge/library/restoration-ecology-13339059/#:~:text=Ecological%20succession%20is%20the%20process,removing%20a%20source%20of%20disturbance.>

Villanueva (2024) **Impact Deceleration Differences on Natural Grass Versus Synthetic Turf High School Football Fields.** Villanueva N et al. Hawaii J Health Soc Well. 2024 Jan;83(1):4-9. <https://pubmed.ncbi.nlm.nih.gov/38223462/>

Voos (2019) **Artificial Turf Versus Natural Grass. Which is playing surface is safer for playing high school sports?** Voos JE. Innovations in Orthopedics. August 26, 2019. University Hospitals. <https://www.uhhospitals.org/for-clinicians/articles-and-news/articles/2019/08/artificial-turf-versus-natural-grass>

Wang (2022). **Carbon Sequestration in Turfgrass–Soil Systems.** Plants (Basel). 2022 Oct; 11(19): 2478. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9571228/>

Waninger (2011) **Community-associated methicillin-resistant Staphylococcus aureus on artificial turf substrates survival.** Med Sci Sports Exerc. 2011 May;43(5):779-84. <http://www.ncbi.nlm.nih.gov/pubmed/20962684>

Weingrill (2023) **Temporal trends in microplastic accumulation in placentas from pregnancies in Hawai‘i.** Weingrill RB et al. Environment International. Weingrill RB et al. Vol 180. October 2023, 108220. https://www.sciencedirect.com/science/article/pii/S0160412023004932?ssrnid=4502389&dgcid=SSRN_redirect_SD

Wik (2009) **Occurrence and effects of tire wear particles in the environment--a critical review and an initial risk assessment.** Wik A et al. Environ Pollut. 2009 Jan;157(1):1-11. <https://pubmed.ncbi.nlm.nih.gov/18990476/>

Winz (2023) **Assessing children's potential exposures to harmful metals in tire crumb rubber by accelerated photodegradation weathering.** Winz R et al. Sci Rep. 2023 Aug 24;13(1):13877. <https://pubmed.ncbi.nlm.nih.gov/37620365/>

Williams and Pulley (2002). **Synthetic surface heat studies.** Provo (UT): Brigham Young University; 2002. https://scholar.google.com/scholar_lookup?hl=en&volume=42&publication_year=1971&pages=29-30&journal=J+Health%2C+Phys+Educ+Recreat&author=ER+Buskirk&author=ER+McLaughlin&author=JL+Loomis&title=Microclimate+over+artificial+turf

Wu D (2023) **Pigment microparticles and microplastics found in human thrombi based on Raman spectral evidence** *Journal of Advanced Research*. Wu D et al. Vol 49. July 2023, Pages 141-150. <https://www.sciencedirect.com/science/article/pii/S2090123222002065?via%3Dihub>

Xu (2019) **Artificial turf infill associated with systematic toxicity in an amniote vertebrate.** Xu GE et al. Proc Natl Acad Sci U S A. 2019 Dec 10;116(50):25156-25161. <https://pubmed.ncbi.nlm.nih.gov/31767765/>

Yale. **Environmental Health and Safety. Silica.** <https://ehs.yale.edu/silica>

Yale e360. **Road Hazard: Evidence Mounts on Toxic Pollution from Tires.** Robbins J. Sept 19, 2023. <https://e360.yale.edu/features/tire-pollution-toxic-chemicals>

Zhang (2008) **Hazardous chemicals in synthetic turf materials and their bioaccessibility in digestive fluids.** Zhang JJ et al. J Expo Sci Environ Epidemiol. 2008 Nov;18(6):600-7. <https://pubmed.ncbi.nlm.nih.gov/18728695/>

Zhang (2020) **The Association between Green Space and Adolescents' Mental Well-Being: A Systematic Review.** Int J Environ Res Public Health. 2020 Sep; 17(18): 6640. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7557737/>

Zheng (2021) **Per- and Polyfluoroalkyl Substances (PFAS) in Breast Milk: Concerning Trends for Current-Use PFAS.** Zheng G et al Environ. Sci. Technol. 2021, 55, 11, 7510–7520. <https://pubs.acs.org/doi/10.1021/acs.est.0c06978>

Zeolite: Purported benefits and side effects. Sloan Kettering. <https://www.mskcc.org/cancer-care/integrative-medicine/herbs/zeolite>

Zhong (2022) **The effect of microplastics on earthworm-assisted sludge treatment wetlands.** *Journal of Cleaner Production*. Zhong H et al. Vol 331, Jan 10, 2022.
<https://www.sciencedirect.com/science/article/abs/pii/S095965262104110X>

Zirkle (2011). **Modeling carbon sequestration in home lawns.** Zirkle G et al. *HortScience* 46: 808– 814. (2011) <https://journals.ashs.org/hortsci/view/journals/hortsci/46/5/article-p808.xml>

Zucarro (2022) **Artificial turf and crumb rubber infill: An international policy review concerning the current state of regulations.** *Environ Chall (Amst)*. 2022 Dec; 9.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9838222/>

Zhu (2021) **The Plastic Cycle – An Unknown Branch of the Carbon Cycle.** Zhu X. *Front. Mar. Sci.*, 14 January 2021. Sec. Marine Pollution
<https://www.frontiersin.org/articles/10.3389/fmars.2020.609243/full>

PFAS Chemicals: EDCs Contaminating Our Water and Food Supply. Endocrine Society.
<https://www.endocrine.org/topics/edc/what-edcs-are/common-edcs/pfas#:~:text=PFAS%20chemicals%20can%20affect%20our,can%20cause%20adverse%20health%20effects.>

Artificial Turf Components and Additives

Lilse BD. **Materiality and Meaning: Synthetic Grass, Sport, and the Limits of Modern Progress.** *Material Matters*. University of Delaware.
<https://sites.udel.edu/mcses2012/papers/paper-i/>

A GUIDELINE TO RECYCLE, REUSE, REPURPOSE AND REMOVE SYNTHETIC TURF SYSTEMS. October 2017.
https://cdn.ymaws.com/www.syntheticurfCouncil.org/resource/resmgr/guidelines/STC_Guideline_for_Recycle_Re.pdf

Do you want to keep your artificial grass in optimal conditions? Add silica sand to it, learn why. June 30, 2022.
<https://diamondartificialgrass.com/blogs/news/do-you-want-to-keep-your-artificial-grass-in-optimal-conditions-add-silica-sand-to-it-learn-why>

Zeolite vs Silica. Premium Grass Blades. <https://premiumgrassblades.com/silica-or-zeolite-infill-materials/>

Silica Sand | What You Should Know. <https://www.purchasegreen.com/blog/silica-sand-what-you-should-know/>

TYPES OF INFILL FOR ARTIFICIAL GRASS. may 10, 2022.

<https://www.installartificial.com/how/artificial-grass-infill-types>

US Specialty Coatings- Synthetic Turf Disinfectants.

<https://usscproducts.com/field-marking-paints/synthetic-turf-disinfectants/c/6335>

ADVICE ON MAINTAINING THE INFILL ON YOUR SYNTHETIC FIELD.

2014.Sportsfield Management.

<https://sportsfieldmanagementonline.com/2014/07/18/advice-on-maintaining-the-infill-on-your-synthetic-field/4947/>

Infill: Why Infill for Artificial Grass? <https://www.purchasegreen.com/artificial-grass/product-info/supplies/infill/>

Composition of Artificial Turf Surfaces Key to Preventing High School Football Injuries, Says New Research. Field Turf Sports Company.

<https://fieldturf.com/en/articles/detail/composition-of-artificial-turf-surfaces-key-to-preventing-high-school-football-injuries-says-new-research/>

ADVICE ON MAINTAINING THE INFILL ON YOUR SYNTHETIC FIELD.

2014.Sportsfield Management.

<https://sportsfieldmanagementonline.com/2014/07/18/advice-on-maintaining-the-infill-on-your-synthetic-field/4947/>

Infill: Why Infill for Artificial Grass? <https://www.purchasegreen.com/artificial-grass/product-info/supplies/infill/>

MOTZ Infills. Envirofill manufacturers.

<https://themotzgroup.com/infills/>

Why We Recommend Envirofill Infill. <https://xgreensynthetic.com/envirofill/>

Matrix Turf. <http://www.matrix-turf.com/products/infills/geo-plus/>

All Turf Mats. <https://www.allturf mats.com/product-p/green-envirofill-12-20.htm>

WHAT'S THE DIFFERENCE BETWEEN SLIT FILM AND MONOFILAMENT SYNTHETIC TURF FIBERS? Oct 13, 2023. <https://atxturf.com/whats-the-difference-between-slit-film-and-monofilament-synthetic-turf/>

PROS AND CONS OF SAND INFILL FOR ARTIFICIAL TURF.

<https://xgreensynthetic.com/sand-infill>

USDA-CERTIFIED SACRAMENTO ARTIFICIAL GRASS.

<https://synlawnsacramento.com/usda-certified/>

Artificial Grass Regulations. Thinking about making the switch to an artificial grass? Learn more about the relevant CA regulations! <https://www.ergeon.com/blog/post/artificial-grass-regulations>

STC. Synthetic Turf Council. <https://atxturf.com/whats-the-difference-between-slit-film-and-monofilament-synthetic-turf/>

STC. Synthetic Turf Council (STC)NEWSROOM: INDUSTRY NEWS -SYNTHETIC GRASS NEWS ARTICLE. July 23, 2021.

<https://www.syntheticurfCouncil.org/news/574409/Synthetic-Grass-News-Article--STC-FAQs.htm>

IPEMA -International Play Equipment Manufacturers Association Certification Program. FACT SHEET: Overview of USDA's BioPreferred Program.

<https://www.usda.gov/media/press-releases/2016/02/18/fact-sheet-overview-usdas-biopREFERRED-program>

IPEMA Surfacing Certification Program. <https://ipema.org/wp-content/uploads/2024/04/2024-IPEMA-Surfacing-Certification-Program-Packet.pdf>

“IPEMA Certified” – What Does it Mean? <https://nofault.com/blog/ipema-certified-what-does-it-mean/>

ASTM Standards. <https://www.astm.org/>

ISO 14001 - Introduction to ISO 14001:2015.

<https://www.iso.org/files/live/sites/isoorg/files/store/en/PUB100371.pdf>

ISO 9001. Quality System Management Requirements.

<https://www.iso.org/standard/62085.html>

Bans Artificial Turf

Zucarro (2022) **Artificial turf and crumb rubber infill: An international policy review concerning the current state of regulations.** Environ Chall (Amst). 2022 Dec; 9.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9838222/>

Millbrae, California. Prohibition of Artificial Turf .City of Millbrae Synthetic Grass and Artificial Turf Ordinance.” (Ord. 806, § 1).Chapter 8.65.

<https://www.codepublishing.com/CA/Millbrae/#!/Millbrae08/Millbrae0865.html#8.65>]

Or [<https://www.ci.millbrae.ca.us/276/Prohibition-of-Artificial-Turf>]

Boston bans artificial turf in parks due to toxic ‘forever chemicals. The city joins a growing number across the US in limiting the use of artificial turf made with dangerous PFAS compounds. The Guardian. Sept 30, 2022.

<https://www.theguardian.com/environment/2022/sep/30/boston-bans-artificial-turf-toxic-forever-chemicals->

[pfas#:~:text=Testing%20of%20multiple%20artificial%20fields,in%20drinking%20water%20is%20safe.](https://www.theguardian.com/environment/2022/sep/30/boston-bans-artificial-turf-toxic-forever-chemicals-?text=Testing%20of%20multiple%20artificial%20fields,in%20drinking%20water%20is%20safe)

City of Boston Parks and Recreation. MALCOLM X PARK CONSTRUCTION UPDATE. New artificial Turf ban. August 26, 2022.

<https://www.boston.gov/sites/default/files/file/2022/08/Malcolm%20X%20Park%208-26-22.pdf>

California makes strides to ban toxic ‘forever chemicals’ in artificial turf. April, 2023.

<https://www.ewg.org/news-insights/news-release/2023/04/california-makes-strides-ban-toxic-forever-chemicals->

[artificial#:~:text=Artificial%20turf%20has%20been%20a,shown%20some%20turf%20contains%20PFAS.](https://www.ewg.org/news-insights/news-release/2023/04/california-makes-strides-ban-toxic-forever-chemicals-?text=Artificial%20turf%20has%20been%20a,shown%20some%20turf%20contains%20PFAS)

EU Restricts PAHs in Synthetic Turf Pitch Infill Materials and Other Sport Applications.

The EU has expanded the scope of restrictions on PAHs under entry 50 to Annex XVII of REACH. The new restrictions will become effective on August 10, 2022.

<https://www.sgs.com/en/news/2021/07/safeguards-10321-eu-restricts-pahs-in-synthetic-turf-pitch-infill-materials>

Holland banning crumb rubber on artificial turf. <https://www.wvtf.org/news/2022-03-15/new-study-casts-doubt-on-safety-of-synthetic-turf>

Brown Creates Nation's First Enforceable Lead Standards for Artificial Turf. August 14, 2009. <https://oag.ca.gov/news/press-releases/brown-creates-nations-first-enforceable-lead-standards-artificial-turf>

Once it was hailed as a drought fix — but now California’s moving to restrict synthetic turf over health concerns. Cal Matters. Oct 23, 2023.

<https://calmatters.org/environment/2023/10/california-synthetic-turf-pfas/>

More games or more grass fields? Turf wars play out across Massachusetts. May 10, 2022.

<https://www.wgbh.org/news/local-news/2022/05/10/more-games-or-more-grass-fields-turf-wars-play-out-across-massachusetts>

Sierra Club opposes artificial turf at Los Gatos schools. November 14, 2021. Mercury News. <https://www.mercurynews.com/2021/11/14/sierra-club-opposes-artificial-turf-at-los-gatos-schools/>

Los Gatos, Saratoga: High school district applying for drought rebates. July 22, 2015. Santa Cruz Sentinel. <https://www.santacruzsentinel.com/2015/07/22/los-gatos-saratoga-high-school-district-applying-for-drought-rebates/>

RTM proactively bans crumb rubber artificial turf. Dec 13, 2018. Connecticut Insider. <https://www.ctinsider.com/news/article/RTM-proactively-bans-crumb-rubber-artificial-turf-13464197.php>

ICAHN School of Medicine. Position Statement on the use of Recycled Tires in Artificial Turf Surfaces. Children’s Environmental Health Center. Department of Environmental Medicine and Public Health, Icahn School of Medicine at Mount Sinai . 2017. <https://icahn.mssm.edu/files/ISMMS/Assets/Departments/Environmental%20Medicine%20and%20Public%20Health/CEHC/CEHC%20Artificial%20Turf%20Position%20Statement%205.2017.pdf>

EPA. Federal Research Action Plan on Recycled Tire Crumb Used on Playing Fields. EPA. <https://www.epa.gov/chemical-research/federal-research-action-plan-recycled-tire-crumb-used-playing-fields>

Federal Research Action Plan on Recycled Tire Crumb Used on Playing Fields and Playgrounds. 2016. https://www.epa.gov/sites/default/files/2016-02/documents/federal_research_action_plan_tirecrumb_final_2.pdf

Gove plans crackdown on fake grass in new housing schemes. Dec 20, 2022. Architects Journal. <https://www.architectsjournal.co.uk/news/gove-plans-crackdown-on-fake-grass-in-new-housing-schemes>

The environmental impact of rubber infill near artificial turf field. 7/3/2018. <https://www.rivm.nl/publicaties/verkenning-milieueffecten-rubbergranulaat-bij-kunstgrasvelden>

Sunnyvale officials nix artificial turf on athletic field. Oct 27, 2023. San Jose Spotlight. <https://sanjosespotlight.com/sunnyvale-city-council-officials-nix-artificial-turf-on-athletic-fields-lakewood-park/>

Cancer and Chemicals Question

Brown K. Pediatric cancer is on the rise, with some types becoming more common. Dec 26, 2023. Northwell Health.

<https://www.northwell.edu/news/the-latest/pediatric-cancer-is-on-the-rise-with-some-types-becoming-more-common#:~:text=Some%20cancers%20are%20becoming%20more,the%20rise%20in%20pediatric%20cancers.>

Howie S. **Does playing soccer on artificial turf increase cancer risk, especially in kids?** Feb 8, 2024. NPR. KUOW. <https://www.kuow.org/stories/does-playing-soccer-on-artificial-turf-increase-cancer-risk-especially-in-kids>

CDC. Cancer in Children and Adolescents.

<https://www.cancer.gov/types/childhood-cancers/child-adolescent-cancers-fact-sheet>

Health Effects from Chemical Exposure. Missouri Department of health and Senior Services. <https://health.mo.gov/living/environment/hazsubstancesites/healtheffects.php#:~:text=The%20factors%20that%20affect%20their,a%20stage%20of%20rapid%20development.>

Llompart (2013) **Hazardous organic chemicals in rubber recycled tire playgrounds and pavers.** Llompart M et al. Chemosphere. 2013 Jan;90(2):423-31. <https://pubmed.ncbi.nlm.nih.gov/22921644/>

Perkins (2019) **Evaluation of potential carcinogenicity of organic chemicals in synthetic turf crumb rubber.** Perkins AN et al. Environ. Res. 169, 163–172. February 2019. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6396308/>

Siegel (2014) **Cancer incidence rates and trends among children and adolescents in the United States, 2001-2009.** Siegel DA. Pediatrics.. 2014 Oct;134(4):e945-55. <https://pubmed.ncbi.nlm.nih.gov/25201796/>

Tarafdar (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.** Tarafdar A et al. Environ Geochem Health 42, 1691–1704 (2020). <https://link.springer.com/article/10.1007/s10653-019-00334-2#citeas>

Artificial Turf: Cancers Among Players. Environment & Human Health, Inc. 2020.

<https://www.ehhi.org/turf-cancer-stats.php>

Did Artificial Turf Give More Than 200 Soccer Players Cancer?

Here's what the research says about turf safety. Feb 1, 2017.

<https://www.menshealth.com/health/a19538500/artificial-turf-cancer-risk/>

Turf Battle: New Study Finds No Increased Cancer Risk In Soccer Players. Jan 6, 2017.

CBS.

<https://www.cbsnews.com/colorado/news/turf-battle-new-study-finds-no-increased-cancer-risk-in-soccer-players/>

Synthetic Turf and Crumb Rubber Investigation of Reported Cancer Among Soccer Players in Washington State. <https://doh.wa.gov/community-and-environment/schools/environmental-health/synthetic-turf>

Report of cancer in soccer players using crumb-rubber fields led to investigation. Jan 21, 2017. <https://www.spokesman.com/stories/2017/jan/21/report-of-cancer-in-soccer-players-using-crumb-rub/>

Investigation of Reported Cancer among Soccer Players in Washington State. Washington State Department of Health. Revised April 2017. <https://doh.wa.gov/sites/default/files/legacy/Documents/Pubs/210-091.pdf?uid=64c0952cba096>

Urgent Need to Research Possible Link Between Artificial Turf Crumb Rubber and Cancer: Excerpt of speech by Amy Griffin, associate head coach at the University of Washington, recorded and produced by Melinda Tuhus. Between the Lines. Feb 20, 2019. <https://btionline.org/urgent-need-to-research-possible-link-between-artificial-turf-crumb-rubber-and-cancer/>

Chemical and Plastic Exposures and Contamination

Armada (2022) **Global evaluation of the chemical hazard of recycled tire crumb rubber employed on worldwide synthetic turf football pitches.** Armada D. Science of The Total Environment. Vol 812, 15 March 2022, 152542. <https://www.sciencedirect.com/science/article/pii/S0048969721076208?via%3Dihub>

Armada (2022) **Green methodology based on active air sampling followed by solid phase microextraction and gas chromatography-tandem mass spectrometry analysis to determine hazardous substances in different environments related to tire rubber.** Armada D. J Chromatogr A. 2022 Apr 12:1668:462911. <https://pubmed.ncbi.nlm.nih.gov/35248870/>

Baker E. **New method spots unreported forever chemicals** 2023 October, Chemical & Engineering News. University of North Carolina, E. <https://cen.acs.org/environment/New-method-spots-unreported-forever/101/i36>

Bessa F et al. **Occurrence of microplastics in commercial fish from a natural estuarine environment.** Mar Pollut Bull. 2018 Mar:128:575-584. <https://pubmed.ncbi.nlm.nih.gov/29571409/>

Brennan (2021) **Trends in the Regulation of Per- and Polyfluoroalkyl Substances (PFAS): A Scoping Review.** Brennan NM et al. Int J Environ Res Public Health. 2021 Oct; 18(20): 10900. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8536021/>

CDC. Lead in Soil.

<https://www.cdc.gov/nceh/lead/prevention/sources/soil.htm#:~:text=Risk%20from%20lead%20in%20artificial%20turf&text=As%20the%20turf%20ages%20and,lead%20the%20body%20will%20absorb.>

Celeiro (2021) **Evaluation of chemicals of environmental concern in crumb rubber and water leachates from several types of synthetic turf football pitches.** Celeiro M et al. Chemosphere. 2021 May;270:128610. <https://pubmed.ncbi.nlm.nih.gov/33121811/>

Celeiro M (2018) **Determination of priority and other hazardous substances in football fields of synthetic turf by gas chromatography-mass spectrometry: A health and environmental concern.** Celeiro M et al. Chemosphere. 2018 Mar;195:201-211. <https://pubmed.ncbi.nlm.nih.gov/29268178/>

CPHD. **Health Advisory. To: Healthcare Providers and Local Health Departments-Global Epidemic Comes to California: Silicosis in Countertop Workers.** 7/25/2023 State of California—Health and Human Services Agency, California Department of Public Health. <https://www.cdph.ca.gov/Programs/OPA/Pages/CAHAN/Global-Epidemic-Comes-to-California-Silicosis-in-Countertop-Workers.aspx>

Cui (2022) **Adverse effects of microplastics on earthworms: A critical review.** Cui W et al. Science of the Total Environment. Vol 850. 1 December 2022. <https://www.sciencedirect.com/science/article/abs/pii/S0048969722051403>

Danopoulos (2022) **A rapid review and meta-regression analyses of the toxicological impacts of microplastic exposure in human cells.** Danopoulos E et al. Journal of Hazardous Materials. Vol 427. April 2022, 127861. <https://www.sciencedirect.com/science/article/abs/pii/S0304389421028302?dgcid=author>

Duque-Villaverde (2024) **Recycled tire rubber materials in the spotlight. Determination of hazardous and lethal substances.** Duque-Villaverde A et al Sci Total Environ. 2024 Jun 15:929:172674. <https://pubmed.ncbi.nlm.nih.gov/38657808/>

Ecology Center (2020). **Analysis of Crumb Rubber Shed from Maryland and Virginia Playgrounds.** Sept 30, 2020. <https://drive.google.com/file/d/1ouegpPJHIO6goZsU7U08Ddh0CVQnBeUt/view>

Ecology Center **Memo on PFAS-free Synthetic Turf Standards and Testing.** Nov 16, 2020. <https://www.oakbluffsma.gov/DocumentCenter/View/5292/Ecology-Center-Jeff-Gearhart-email-Nov-16-2020>

EPA. **New Chemicals Program Review of Alternatives for PFOA and Related Chemicals.** <https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/new-chemicals-program-review-alternatives-pfoa-and>

EPA. **Our Current Understanding of the Human Health and Environmental Risks of PFAS.** <https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas>

EPA. **U.S. Federal Research Action Plan (FRAP) on Recycled Tire Crumb Rubber Used on Synthetic Turf Playing Fields and Playgrounds.** https://www.epa.gov/sites/default/files/2019-08/documents/tc_public_webinar_-_august_6_2019.pdf

EPA **Scrap Tires.** 2016. Wastes-Resource conservation-Common Wastes and Materials. – Scarp Tires. Archives.. <https://archive.epa.gov/epawaste/conserve/materials/tires/web/html/basic.html#:~:text=38%20states%20ban%20whole%20tires,to%20be%20placed%20in%20landfills.>

Foguth (2020). **Per- and Polyfluoroalkyl Substances (PFAS) Neurotoxicity in Sentinel and Non-Traditional Laboratory Model Systems: Potential Utility in Predicting Adverse Outcomes in Human Health.** Foguth R et al. *Toxics.* 2020 Jun; 8(2): 42. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7355795/>

Fort (2022) **Environmental Consequences of Rubber Crumb Application: Soil and Water Pollution.** Fort J et al. *Polymers (Basel).* 2022 Apr; 14(7): 1416. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9003429/>

Frederico (2023) **Silent Contamination: The State of the Art, Knowledge Gaps, and a Preliminary Risk Assessment of Tire Particles in Urban Parks.** Frederico L et al. *Toxics.* 2023 May 9;11(5):445. <https://pubmed.ncbi.nlm.nih.gov/37235259/>

Garcia (2024) **Quantitation and identification of microplastics accumulation in human placental specimens using pyrolysis gas chromatography mass spectrometry.** Garcia MA et al. *Toxicol Sci.* 2024 Apr 29;199(1):81-88. <https://pubmed.ncbi.nlm.nih.gov/38366932/>

Garcia (2024). **In Vivo Tissue Distribution of Polystyrene or Mixed Polymer Microspheres and Metabolomic Analysis after Oral Exposure in Mice.** *Environmental Health Perspectives.* April 10, 2024. <https://ehp.niehs.nih.gov/doi/10.1289/EHP13435>

Gaspar (2023) **Acute Exposure to Microplastics Induced Changes in Behavior and Inflammation in Young and Old Mice.** Gaspar L et al *Int. J. Mol. Sci.* 2023, 24(15), 12308. <https://www.mdpi.com/1422-0067/24/15/12308>

Gomes (2021) . **A review of potentially harmful chemicals in crumb rubber used in synthetic football pitches.** Gomes FO et al *J Hazard Mater.* 2021 May 5:409:124998. <https://pubmed.ncbi.nlm.nih.gov/33513533/>

Graca CA et al. **Presence of metals and metalloids in crumb rubber used as infill of worldwide synthetic turf pitches: Exposure and risk assessment.** *Chemosphere.* Vol 299, July 2022, 134379. <https://www.sciencedirect.com/science/article/pii/S0045653522008724>

Hall (2022) **Concentrations of per- and polyfluoroalkyl substances (PFAS) in human placental tissues and associations with birth outcomes.** Graca CA et al. . Chemosphere. 2022 Feb 7.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8923299/>

Hu (2024) **Microplastic presence in dog and human testis and its potential association with sperm count and weights of testis and epididymis.** Hu CJ et al. Toxicological Sciences, May 15, 2024. <https://academic.oup.com/toxsci/advance-article/doi/10.1093/toxsci/kfae060/7673133?login=false>

IARC Monographs. The IARC Monographs on the carcinogenicity of crystalline silica. Guha N. Med Lav. 2011 Jul-Aug;102(4):310-20. <https://pubmed.ncbi.nlm.nih.gov/21834268/>

IUCN. **The Plastic Pollution Crisis.** IUCN. International Union for Conservation of Nature and Natural Resources. July 2022. <https://www.iucn.org/our-union/iucn-world-conservation-congress>

ITRC. **7 Human and Ecological Health Effects of select PFAS.** Interstate Technology Regulatory Council. <https://pfas-1.itrcweb.org/7-human-and-ecological-health-effects-of-select-pfas/>

Kim (2012) **Health risk assessment of lead ingestion exposure by particle sizes in crumb rubber on artificial turf considering bioavailability.** Kim S et al. Environ Health Toxicol. 2012;27:e2012005. <https://pubmed.ncbi.nlm.nih.gov/22355803/>

Kruger (2013) **New approach to the ecotoxicological risk assessment of artificial outdoor sporting grounds.** Kruger O et al. Environmental Pollution, Volume 175. April 2013. <https://www.ncbi.nlm.nih.gov/pubmed/23337354>

Landrigan (2023) **The Minderoo-Monaco Commission on Plastics and Human Health.** Kruger O et al. Ann Glob Health. 2023 Mar 21;89(1):23. <https://pubmed.ncbi.nlm.nih.gov/36969097/>

Landrigan (2016) **Children's Environmental Health: A Brief History.** Landrigan PJ. Acad Pediatr. 2016 Jan-Feb;16(1):1-9. <https://pubmed.ncbi.nlm.nih.gov/26498257/>

Landrigan (2001) **CHILDREN'S ENVIRONMENTAL HEALTH: Lessons from the Past and Prospects for the Future.** Landrigan PJ. Pediatric Clinics of North America. Vol 48, Issue 5, 1 October 2001, Pages 1319-1330. <https://www.sciencedirect.com/science/article/abs/pii/S0031395505703771>

Lauria (2022) **Widespread Occurrence of Non-Extractable Fluorine in Artificial Turfs from Stockholm, Sweden.** Lauria MZ et al. Environmental Science & Technology Letters 2022. Aug 9;9(8):666-672. <https://pubs.acs.org/doi/10.1021/acs.estlett.2c00260>

Leslie (2022) **Discovery and quantification of plastic particle pollution in human blood.** Leslie HA et al. Environment International. Vol 163. May 2022.
<https://www.sciencedirect.com/science/article/pii/S0160412022001258>

Liu (2022) **Toxicological profile of silica nanoparticles.** Liu A. Toxicology Research, Volume 11, Issue 4, August 2022. <https://academic.oup.com/toxres/article/11/4/565/6645393>

Llompart (2013) **Hazardous organic chemicals in rubber recycled tire playgrounds and pavers.** Llompart M. Chemosphere. 2013 Jan;90(2):423-31.
<https://pubmed.ncbi.nlm.nih.gov/22921644/>

Ma (2021) **Future-Proofing Capitalism: The Paradox of the Circular Economy for Plastics.** Global Environmental Politics (2021) 21 (2): 121–142.
<https://direct.mit.edu/glep/article/21/2/121/97367/Future-Proofing-Capitalism-The-Paradox-of-the>

Magnusson (2017) **Analysis of energy use and emissions of greenhouse gases, metals and organic substances from construction materials used for artificial turf.** Resources, Conservation and Recycling. Vol 122. July 2017, Pages 362-372
<https://www.sciencedirect.com/science/article/abs/pii/S0921344917300861>

Marfella (2024) **Microplastics and Nanoplastics in Atheromas and Cardiovascular Events.** NEJM. March 6, 2024
<https://www.nejm.org/doi/full/10.1056/NEJMoa2309822>

Marsili (2014) **Release of Polycyclic Aromatic Hydrocarbons and Heavy Metals from Marsali (2014) Rubber Crumb in Synthetic Turf Fields: Preliminary Hazard Assessment for Athletes.** J Environ Anal Toxicol 2014, 5:2. <https://www.hilarispublisher.com/open-access/release-of-polycyclic-aromatic-hydrocarbons-and-heavy-metals-from-rubber-crumb-in-synthetic-turf-fields-2161-0525.1000265.pdf>

Menichini (2011). **Artificial-turf playing fields: contents of metals, PAHs, PCBs, PCDDs and PCDFs, inhalation exposure to PAHs and related preliminary risk assessment.** Menichini E et al. Sci Total Environ. 2011 Nov 1;409(23):4950-7.
<https://pubmed.ncbi.nlm.nih.gov/21907387/>

Murphy (2022). **Health impacts of artificial turf: Toxicity studies, challenges, and future directions.** Murphy M and Warner GR. Environmental Pollution. Vol 310.
<https://www.sciencedirect.com/science/article/abs/pii/S0269749122010557>

Negev (2022) **Hazardous chemicals in outdoor and indoor surfaces: artificial turf and laminate flooring.** J Expo Sci Environ Epidemiol. 2022 May;32(3):392-399.
<https://pubmed.ncbi.nlm.nih.gov/34697408/>

Neves (2015) . **Ingestion of microplastics by commercial fish off the Portuguese coast.** Neves D et al. Mar Pollut Bull. 2015 Dec 15;101(1):119-126.

<https://pubmed.ncbi.nlm.nih.gov/26608506/>

New Jersey State Technical Memorandum on PFAS on Artificial Turf. Feb 8, 2023.

<https://dep.nj.gov/wp-content/uploads/dsr/pfas-artificial-turf-memo-2023.pdf>

New York State. **Information About Crumb-Rubber Infilled Synthetic Turf Athletic Fields.**

https://www.health.ny.gov/environmental/outdoors/synthetic_turf/crumb-rubber_infilled/fact_sheet.htm#:~:text=People%20playing%20on%20synthetic%20turf,particles%20suspended%20in%20the%20air.

Nogrady (2023) **Australia bans engineered stone because of silicosis risk.** Nogrady B

BMJ. 2023;383:p2954. <https://www.bmj.com/content/383/bmj.p2954>

Pavilonis (2014) **Bio-accessibility and Risk of Exposure to Metals and SVOCs in Artificial**

Turf Field Fill Materials and Fibers. Pavilonis BT et al. Risk Analysis, Volume 34. January 2014. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4038666>

Perkins (2019) **Evaluation of potential carcinogenicity of organic chemicals in synthetic turf crumb rubber.** Perkins AN et al. Environ. Res. 169, 163–172.

February 2019. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6396308/>

PEER. **Toxic Forever Chemicals Infest Artificial Turf.: Processing aids that contaminate synthetic turf with PFAS may be in other plastic goods.** PEER. Oct 10, 2019.

<https://peer.org/toxic-forever-chemicals-infest-artificial-turf/>

Saha (2024) **Effect of microplastics deposition on human lung airways: A review with computational benefits and challenges.** Saha SC et al. Heliyon. 2024 Jan 30; 10(2): e24355.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10826726/>

Silica Occupational Lung Disease. Science Direct.

<https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/occupational-lung-disease>

Silica. Yale. **Environmental Health and Safety. Silica.** <https://ehs.yale.edu/silica>

Silica: Status of Regulatory Efforts. Work Safely with Silica.

<https://www.silica-safe.org/regulations-and-requirements/status-of-regulatory-efforts/history>

Selbes (2015) **Leaching of DOC [dissolved organic carbon], DN [dissolved nitrogen] and inorganic constituents from scrap tires.** Selbes M et al. Chemosphere, Volume 139.

November 2015. <http://www.sciencedirect.com/science/article/pii/S004565351500082X>

Steenland (2013) **Silica: A lung carcinogen.** American Cancer Society Journal. Dec 10, 2013.

<https://acsjournals.onlinelibrary.wiley.com/doi/10.3322/caac.21214>

Tarafdar A et al. **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 (2020).
<https://link.springer.com/article/10.1007/s10653-019-00334-2#citeas>

Ulirsch (2010) **Evaluating and Regulating Lead in Synthetic Turf.** Ulirsch GV et al. Environ Health Perspect. 2010 Oct; 118(10): 1345–1349.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2957910/>

UMASS Lowell (2020). **Per- and Poly-fluoroalkyl Substances (PFAS) in Artificial Turf Carpet.** Toxics Use Reduction Institute. UMASS Lowell. Feb 2020.
<https://www.turi.org/content/download/12963/201149/file/TURI+fact+sheet+-+PFAS+in+artificial+turf.pdf>

Upadhyay (2024) **Silica, crystalline.** Upadhyay P et al. Encyclopedia of Toxicology (Fourth Edition) Vol 8. 2024, Pages 519-525.
<https://www.sciencedirect.com/science/article/abs/pii/B9780128243152007223>

USGS (2023) **Tap Water Study Detects PFAS Forever Chemicals Across the US.** USGS. July 5, 2023.
<https://www.usgs.gov/news/national-news-release/tap-water-study-detects-pfas-forever-chemicals-across-us>

Weingrill (2023). **Temporal trends in microplastic accumulation in placentas from pregnancies in Hawai‘i.** Environment International. Vol 180. October 2023, 108220.
https://www.sciencedirect.com/science/article/pii/S0160412023004932?ssrnid=4502389&dgcid=SSRN_redirect_SD

Wik (2009) **Occurrence and effects of tire wear particles in the environment--a critical review and an initial risk assessment.** Environ Pollut. 2009 Jan;157(1):1-11.
<https://pubmed.ncbi.nlm.nih.gov/18990476/>

Winz (2023) **Assessing children's potential exposures to harmful metals in tire crumb rubber by accelerated photodegradation weathering.** Sci Rep. 2023 Aug 24;13(1):13877.
<https://pubmed.ncbi.nlm.nih.gov/37620365/>

Wu (2023) **Pigment microparticles and microplastics found in human thrombi based on Raman spectral evidence** Journal of Advanced Research. Vol 49. July 2023, Pages 141-150.
<https://www.sciencedirect.com/science/article/pii/S2090123222002065?via%3Dihub>

Xu (2019) **Artificial turf infill associated with systematic toxicity in an amniote vertebrate.** Proc Natl Acad Sci U S A. 2019 Dec 10;116(50):25156-25161.
<https://pubmed.ncbi.nlm.nih.gov/31767765/>

Yale e360. **Road Hazard: Evidence Mounts on Toxic Pollution from Tires.** Robbins J. Sept 19, 2023. <https://e360.yale.edu/features/tire-pollution-toxic-chemicals>

Zhang (2008) **Hazardous chemicals in synthetic turf materials and their bioaccessibility in digestive fluids.** J Expo Sci Environ Epidemiol. 2008 Nov;18(6):600-7.
<https://pubmed.ncbi.nlm.nih.gov/18728695/>

Zhong (2022) **The effect of microplastics on earthworm-assisted sludge treatment wetlands.** **Journal of Cleaner Production.** Vol 331, Jan 10, 2022.
<https://www.sciencedirect.com/science/article/abs/pii/S095965262104110X>

Zhu (2021) **The Plastic Cycle – An Unknown Branch of the Carbon Cycle.** Front. Mar. Sci., 14 January 2021. Sec. Marine Pollution
<https://www.frontiersin.org/articles/10.3389/fmars.2020.609243/full>

IUCN. **The Plastic Pollution Crisis.** IUCN. International Union for Conservation of Nature and Natural Resources. July 2022. <https://www.iucn.org/our-union/iucn-world-conservation-congress>

What happens when sunlight breaks down plastics in the ocean? Potentially harmful chemical byproducts are left behind, research finds Dec 5, 2023.
Northeastern Global News (2023) .
<https://news.northeastern.edu/2023/12/05/ocean-plastic-breakdown-sunlight/>

PFAS Chemicals: EDCs Contaminating Our Water and Food Supply. Endocrine Society.
<https://www.endocrine.org/topics/edc/what-edcs-are/common-edcs/pfas#:~:text=PFAS%20chemicals%20can%20affect%20our,can%20cause%20adverse%20health%20effects.>

Artificial Turf Study Leachate and Storm Water Characteristics. Connecticut Department of Environmental Protection. July 2010. <https://portal.ct.gov/-/media/deep/artificialturf/departificialturfreportpdf.pdf>

Videos Plastic

What happens to plastic and polluting artificial turf? Netherlands Documentary. 2019.
<https://www.youtube.com/watch?v=Y5o3J7uy4Tk>

Plastic Wars. Video. NPR. <https://www.pbs.org/wgbh/frontline/documentary/plastic-wars/>?

Plastic People Documentary. 2024. <https://www.youtube.com/watch?v=WhOgnzuYkLM>

The Plastic Problem. A PBS NewsHour Documentary. 2020.
<https://www.youtube.com/watch?v=1RDc2opwg0I>

Children's Vulnerability to Toxins

Anderko (2020) **Exposures to per-and polyfluoroalkyl substances (PFAS): Potential risks to reproductive and children's health.** Anderko L et al. Current Problems in Pediatric and Adolescent Health Care.

[Volume 50, Issue 2](#), February 2020, 100760.

<https://www.sciencedirect.com/science/article/abs/pii/S1538544220300201>

Bennett (2018) **Inflammation-Nature's Way to Efficiently Respond to All Types of Challenges: Implications for Understanding and Managing "the Epidemic" of Chronic Diseases.** Bennett JM et al. Front Med (Lausanne). 2018 Nov 27:5:316.

<https://pubmed.ncbi.nlm.nih.gov/30538987/>

Bennett (2017) **'Multimorbidity' as the manifestation of network disturbances.** Bennett JM et al. J Eval Clin Pract. 2017 Feb;23(1):199-208. <https://pubmed.ncbi.nlm.nih.gov/27421249/>

Carroquinon (2012) **Environmental Toxicology: Children at Risk.** Carroquino MJ et al. Environmental Toxicology. 2012 Dec 4 : 239–291.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7121289/>

Endocrine Society. **Endocrine Disrupting Chemicals.** <https://www.endocrine.org/topics/edc>

Furman (2019) **Chronic inflammation in the etiology of disease across the life span.** Furman D et al. Nature Medicine. 05 December 2019. <https://www.nature.com/articles/s41591-019-0675-0>

Gaynor (2022) **Childhood exposures to environmental chemicals and neurodevelopmental outcomes in congenital heart disease.** PLoS ONE. 2022; 17(11): e0277611.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9671412/>

Grandjean (2006). **Developmental neurotoxicity of industrial chemicals.** Grandjean P, Landrigan PJ Lancet. 2006 Dec 16; 368(9553):2167-78.

<https://pubmed.ncbi.nlm.nih.gov/17174709/>

Grandjean P(2014). **Neurobehavioural effects of developmental toxicity.** Grandjean P, Landrigan PJ Lancet Neurol. 2014 Mar; 13(3):330-8.

[https://www.thelancet.com/journals/laneur/article/PIIS1474-4422\(13\)70278-3/fulltext](https://www.thelancet.com/journals/laneur/article/PIIS1474-4422(13)70278-3/fulltext)

Grandjean (2017). **Estimated Exposures to Perfluorinated Compounds in Infancy Predict Attenuated Vaccine Antibody Concentrations at Age 5-Years.** J Immunotoxicol. 2017 Dec;14(1): 188-195.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6190594/>

Ideta-Otsuka (2017) **Epigenetic toxicity of environmental chemicals upon exposure during development - Bisphenol A and valproic acid may have epigenetic effects.** Ideta-Otsuka M et al. Food and Chemical Toxicology. Vol 109. Part 1. Nov 2017. Pg 812-816.

<https://www.sciencedirect.com/science/article/pii/S0278691517305240#:~:text=Epigenetic%20toxicity%20is%20a%20phenomenon,to%20environmental%20factors%20including%20chemicals.>

Lahimer (2023) **Endocrine disrupting chemicals and male fertility: from physiological to molecular effects.** Lahimer M et al Front. Public Health, Vol 11, 10 October 2023 Sec. Environmental health and Exposome. <https://www.frontiersin.org/journals/public-health/articles/10.3389/fpubh.2023.1232646/full>

Landrigan (2011) **Children’s vulnerability to toxic chemicals: A challenge and opportunity to strengthen health and environmental policy.** Landrigan PJ, Goldman L. Health Affairs. 2011;30:842–850. <https://pubmed.ncbi.nlm.nih.gov/21543423/>

Larson (2009) **Endocrine Disruption.** Larson MC U.S. Department of Interior. Committee on Natural Resources. June 9, 2009. https://www.doi.gov/ocl/hearings/111/EndocrineDisruption_060909

Li S (2024) **Prenatal exposure to poly/perfluoroalkyl substances and risk for congenital heart disease in offspring.** Li S et al. Journal of Hazardous Materials. Volume 469. 5 May 2024, 134008. <https://www.sciencedirect.com/science/article/abs/pii/S0304389424005879>

Kharrazian (2021) **Exposure to Environmental Toxins and Autoimmune Conditions.** Kharrazian D . Integr Med (Encinitas) 2021 Apr; 20(2): 20–24. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8325494/>

Parke (1996) **Chemical-induced inflammation and inflammatory diseases.** Parke DV et al. Int J Occup Med Environ Health. 1996;9(3):211-7. <https://pubmed.ncbi.nlm.nih.gov/8972163/>

Mount Sinai Children’s Environmental Health Center: Position Statement on the Use of Artificial Turf Surfaces. Nov 30, 2023. <https://mountsinaiaexposomics.org/position-statement-on-the-use-of-artificial-turf-surfaces/>

Ragusa A et al. **Plasticenta: First evidence of microplastics in human placenta.** Environ Int. 2021 Jan;146:106274 <https://pubmed.ncbi.nlm.nih.gov/33395930/>

Rauh (2016) **Research Review: Environmental exposures, neurodevelopment and child mental health – new paradigms for the study of brain and behavioral effects.** Ragusa A et al. J Child Psychol Psychiatry. 2016 Jul; 57(7) : 775-793. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4914412>

Rickard (2022) **Per- and Poly-fluoroalkyl Substances (PFAS) and Female Reproductive Outcomes: PFAS Elimination, Endocrine-Mediated Effects, and Disease.** Rickard BP et al.

.Toxicology. 2022 Jan 15; 465.

<https://www.sciencedirect.com/science/article/pii/S0300483X2100353X?via%3Dihub>

Rodprasert (2023) **Environmental toxicants and male fertility**. Rodprasert W et al. Best Practice & Research Clinical Obstetrics and Gynaecology. Vol 86. February 2023, 102298.

<https://www.sciencedirect.com/science/article/pii/S1521693422001791>

Sanders (2010) **Neurotoxic Effects and Biomarkers of Lead Exposure: A Review**. Sanders T et al. Rev Environ Health. PMC 2010 Apr 22.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2858639/#:~:text=Within%20the%20brain%2C%20lead%2Dinduced,%2C%20Parkinson's%20disease%2C%20and%20schizophrenia.>

Siegel (2014) **Counts, incidence rates, and trends of pediatric cancer in the United States, 2003-2019**. Siegel DA et al. JNCI: Journal of the National Cancer Institute, Volume 115, Issue 11, November 2023, Pages 1337–1354.

<https://academic.oup.com/jnci/article/115/11/1337/7219716?login=false>

Simon (2015) **Evolution of the immune system in humans from infancy to old age**. Simon AK et al. Proc Biol Sci. 2015 Dec 22; 282(1821): 20143085.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4707740/>

Solmi(2022) **The environment is now known to be a powerful determinant of child health, Age at onset of mental disorders worldwide: large-scale meta-analysis of 192 epidemiological studies**. Solmi M et al . Molecular Psychiatry. Volume 27, pages 281–295 (2022). <https://www.nature.com/articles/s41380-021-01161-7>

Thomas RD. **Reproductive Toxicology**. Drinking Water and Health: Volume 6.

<https://www.ncbi.nlm.nih.gov/books/NBK219110/>

Tobe (2022) **Brain charts for the human lifespan**. Nature. April 6, 2022.

<https://www.nature.com/articles/s41586-022-04554-y>

Ugai (2022) **Is Early Onset Cancer a Global Epidemic? Current evidence and future implications**. Nature. Sept 6, 2022. <https://www.nature.com/articles/s41571-022-00672-8>

van Kleunen (2019) **A microplastic used as infill material in artificial sport turfs reduces plant growth**. PLANTS, PEOPLE, PLANET. Oct 11, 2019.

<https://nph.onlinelibrary.wiley.com/doi/10.1002/ppp3.10071>

Zhao (2023) **Global trends in incidence, death, burden and risk factors of early-onset cancer from 1990 to 2019**. BMJ Oncology. Vol 2 Issue 1. Sept 5, 2023.

<https://bmjoncology.bmj.com/content/2/1/e000049>

Children's Vulnerability to Heat

Antoniades (2020) **Thermal Environment of Urban Schoolyards: Current and Future Design with Respect to Children's Thermal Comfort**. Antoniades DG et al. October 2020. Atmosphere 11(1144):1-26.

https://www.researchgate.net/publication/345243319_Thermal_Environment_of_Urban_Schoolyards_Current_and_Future_Design_with_Respect_to_Children's_Thermal_Comfort

Bytowski (2003) **Heat illness in children**. Bytowski JR et al. Curr Sports Med Rep. 2003 Dec;2(6):320-4

<https://pubmed.ncbi.nlm.nih.gov/14583161/>

Liu and Kim (2021) **Playing on natural or artificial turf sports field? Assessing heat stress of children, young athletes, and adults in Hong Kong**. Liu Z and Kim CY. Sustainable Cities and Society. Vol 75. December 2021.

<https://www.sciencedirect.com/science/article/abs/pii/S2210670721005473>

Malmquist (2021) **Vulnerability and adaptation to heat waves in preschools: Experiences, impacts and responses by unit heads, educators and parents**. Malmquist A et al. Climate Risk Management. Vol 31. 2021, 100271.

<https://www.sciencedirect.com/science/article/pii/S2212096320300619>

Climate Change

Protecting Californians From Extreme Heat. A State Action Plan to Build Community Resilience. April 2022. <https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Climate-Resilience/2022-Final-Extreme-Heat-Action-Plan.pdf>

Preparing California for Extreme Heat: Guidance and Recommendations. Cal EPA and CDPH Heat Adaption Workgroup. 2013.

https://abag.ca.gov/sites/default/files/2013_cph_preparing_california_for_extreme_eat.pdf

Climate Resilience. Summary of Projected Climate Change Impacts on California.

<https://climateresilience.ca.gov/overview/impacts.html>

NASA Maps Key Heat Wave Differences in Southern California. Global Climate Change.

NASA. Aug 22, 2023. <https://climate.nasa.gov/news/3280/nasa-maps-key-heat-wave-differences-in-southern-california/#:~:text=Like%20much%20of%20the%20planet,with%20Florida%20or%20eastern%20Texas>

Masters and Henson. Yale. **The scorching summer of 2023 reaches ‘mind-blowing’ high temperatures.** Yale Climate Connections. July 17, 2023.

<https://yaleclimateconnections.org/2023/07/the-scorching-summer-of-2023-reaches-mind-blowing-high-temperatures/#:~:text=Astonishingly%2C%20Death%20Valley's%20Badwater%20Basin,climate%20history%2C%20according%20to%20a>

California Releases Extreme Heat Action Plan to Protect Communities from Rising Temperatures. Apr 28, 2022. <https://www.gov.ca.gov/2022/04/28/california-releases-extreme-heat-action-plan-to-protect-communities-from-rising-temperatures/>

Braun R et al. **Carbon Sequestration in Zoysiagrass Turf under Different Irrigation and Fertilization Management Regimes.** Agrosystems, Geoscience and the Environment. 21 March 2019. <https://access.onlinelibrary.wiley.com/doi/10.2134/age2018.12.0060>

Fargione GE et al. **Natural climate solutions for the United States.** Science Advances. Nov 14, 2018. <https://www.science.org/doi/10.1126/sciadv.aat1869>

Costs

Daviscourt (2017) **A Life-Cycle Cost Analysis of Synthetic Infill and Natural Grass Systems.** International Turf Grass Society Research Journal.

<https://onlinelibrary.wiley.com/doi/full/10.2134/itsrj2016.10.0848>

Univ of Arkansas. **Synthetic Turf vs Artificial Grass Athletic Fields.** University of Arkansas.

<https://cms4files.revize.com/elkonv/Council%20Action%20Item%20II-G.pdf>

Claudio (2008) **Synthetic turf: health debate takes root.** Environ Health

Perspect. 2008;116:A116–A122. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2265067/>

Sports Venue Calculator. **How much does turf cost for a soccer field?**

<https://sportsvenuecalculator.com/knowledge/artificial-turf-field/how-much-does-a-turf-field-cost/>

TURI. Sports Turf Alternatives Assessment: Preliminary Results COST ANALYSIS.

Massachusetts Toxics Use Reduction Institute September 2016.

<https://www.turi.org/content/download/10395/173557/file/Cost%20Artificial%20Turf.%20September%202016.pdf>

A Cost Comparison of Conventional (Chemical) Turf Management and Natural (Organic) Turf Management for School Athletic Fields.

<http://www.nontoxiccommunities.com/uploads/1/2/3/8/123860248/turfcomparisonreport.pdf>

Synthetic v. Grass: The Numbers. June 8, 2013. Jerad Minnick
sports field manager.

<https://jeradminnick.wordpress.com/2013/06/08/synthetic-v-grass-the-numbers/>

ARTIFICIAL VS. NATURAL TURF: COST COMPARISONS (CONSTRUCTION, MAINTENANCE, LABOR, REPLACEMENT). June 8, 2013.

<https://www.safehealthyplayingfields.org/grass-articles-resources-blog/2017/2/24/synthetic-v-grass-the-numbers>

Artificial Grass Regulations: Thinking about making the switch to an artificial grass? Learn more about the relevant CA regulations! January 2023.

<https://www.ergeon.com/blog/post/artificial-grass-regulations>

What is The Average Cost for An Artificial Turf Football Field. Turf Factory Direct.

<https://turffactorydirect.com/2021/02/08/the-average-cost-for-an-artificial-turf-football-field/>

How to Maintain a Natural Grass Field.

<https://heritageppg.com/blogs/pest-control-blog/how-to-maintain-a-natural-grass-field>

How Taxpayers Get Fooled On The Cost Of An Artificial Turf Field. Forbes. Sept 28, 201.

<https://www.forbes.com/sites/mikeozanian/2014/09/28/how-taxpayers-get-fooled-on-the-cost-of-an-artificial-turf-field/?sh=4c3045345db2>

Maintenance of natural grass fields. <https://www.safehealthyplayingfields.org/maintenance-grass-fields>

GRASS CAN MEET OUR NEEDS AT A LOWER COST THAN ARTIFICIAL TURF.

<https://www.safehealthyplayingfields.org/grass-articles-resources-blog/2016/10/19/grass-is-the-answer>

Sports Turf Alternatives Assessment: Preliminary Results COST ANALYSIS.

Massachusetts Toxics Use Reduction Institute September 2016.

<https://www.turi.org/content/download/10395/173557/file/Cost%20Artificial%20Turf.%20September%202016.pdf>

Building an Organic Maintenance Program for Athletic Fields: Guidance from Experts and Experienced Communities. Toxics Use Reduction Institute (TURI).

<https://www.turi.org/content/download/13543/206640/file/Factsheet.BuildinganOrganicMaintenanceProgramforAthleticFields.April2021.pdf>

The Field Fund: Responsibly Investing in Grass. <https://www.fieldfundinc.org/>

Pesticide Regulations in Massachusetts. <https://www.mass.gov/info-details/pesticide-regulations-in-massachusetts>

Protection of children and families from harmful pesticides. 333 CMR 14.00. Massachusetts. 2000. <https://www.mass.gov/regulations/333-CMR-1400-protection-of-children-and-families-from-harmful-pesticides>

A Cost Comparison of Conventional (Chemical) Turf Management and Natural (Organic) Turf Management for School Athletic Fields. 2010. Grassroots Environmental Education. <http://www.nontoxiccommunities.com/uploads/1/2/3/8/123860248/turfcomparisonreport.pdf>

The Average Cost for an Artificial Turf Football Field. Turf Factory Direct. <https://turfactorydirect.com/blog/the-average-cost-for-an-artificial-turf-football-field/>

LIFE CYCLE COST ANALYSIS: SYNTHETIC VS NATURAL TURF. Polyturf. https://cms1files.revize.com/denville/docs/Misc/Artificial_Turf_LifeCycle_Costs.pdf

Disposal and Recycling

Disposal

'Running out of room': How old turf fields raise potential environmental, health concerns
As fields are replaced, billions of pounds of rubber and synthetic fiber are piling up
because the U.S. has no plan for disposing of this product. York Daily Record. Nov 18, 2019
<https://www.ydr.com/in-depth/news/2019/11/18/old-artificial-turf-fields-pose-huge-waste-problem-environmental-concerns-across-nation/2314353001/>

What happens to plastic and polluting artificial turf? 2019. Documentary about the Netherlands problem with disposal of artificial turf fields.
<https://www.youtube.com/watch?v=Y5o3J7uy4Tk>

Used Artificial Turf Is Now Available In Sacramento California: Artificial Grass Recyclers Opens A New Store In Sacramento That Sells New And Used Artificial Turf.
<https://artificialgrassrecyclers.com/used-artificial-turf-is-now-available-in-sacramento-california/>

The Dangerous Pileup of Artificial Turf: Recycling scrap tires into synthetic turf was supposed to be an environmental win. The Atlantic. Dec 19, 2019.
<https://www.theatlantic.com/science/archive/2019/12/artificial-turf-fields-are-piling-no-recycling-fix/603874/>

Attorney General Bonta Announces Investigation into Fossil Fuel and Petrochemical Industries for Role in Causing Global Plastics Pollution Crisis. April 28, 2022. <https://oag.ca.gov/news/press-releases/attorney-general-bonta-announces-investigation-fossil-fuel-and-petrochemical>

Report slams taxpayer dollars sent to polluting plastic plants:

A watchdog called out subsidies for air-polluting plastic production, including facilities subject to Clean Air Act enforcement actions. 3/14/24.

<https://www.eenews.net/articles/report-slams-taxpayer-dollars-sent-to-polluting-plastic-plants/>

News Releases from Region 09 U.S. EPA requires two Los Angeles area plastics manufacturers to protect local waterways. <https://www.epa.gov/archive/epa/newsreleases/us-epa-requires-two-los-angeles-area-plastics-manufacturers-protect-local-waterways.html>

Recycling of Artificial Turf

Bell, L et al. **CHEMICAL RECYCLING: A DANGEROUS DECEPTION WHY CHEMICAL RECYCLING WON'T SOLVE THE PLASTIC POLLUTION PROBLEM.** Beyond Plastic. October 2023.

https://static1.squarespace.com/static/5eda91260bbb7e7a4bf528d8/t/655791f76ad9bb07d10e1290/1700237880522/10-30-23_Chemical-Recycling-Report_web.pdf

California Does Not Recycle Residential Fake Turf. Jan 18, 2023.

<https://www.prnewswire.com/news-releases/california-does-not-recycle-residential-fake-turf-301722141.html#:~:text=There%20are%20currently%20no%20state,for%20disposing%20of%20artificial%20grass.>

Advanced recycling is booming except in California. A new plastics law is to blame. Nov 2022. <https://calmatters.org/economy/2022/11/plastic-advanced-recycling-california-turf/>

The Fraud of Plastic Recycling: How Big Oil and the plastics industry deceived the public for decades and caused the plastic waste crisis. The Center for Climate Integrity. Feb 2024. <https://climateintegrity.org/uploads/media/Fraud-of-Plastic-Recycling-2024.pdf>

A GUIDELINE TO RECYCLE, REUSE, REPURPOSE AND REMOVE SYNTHETIC TURF SYSTEMS. October 2017.

https://cdn.ymaws.com/www.syntheticurfCouncil.org/resource/resmgr/guidelines/STC_Guideline_for_Recycle_Re.pdf

TenCate Grass launches synthetic turf recycling program.

The joint program with ExxonMobil and Cyclyx International will begin by processing 50 aged turf fields, mostly from California. Sept 20, 2022.

<https://www.recyclingtoday.com/news/tencate-grass-launches-synthetic-turf-recycling-program/>

Advanced recycling for plastics. Exxon Mobile. Baytown Texas May 6, 2024.

<https://corporate.exxonmobil.com/what-we-do/materials-for-modern-living/advanced-recycling-for-plastics>

US turf recycling plant hits a snag. Sportsfield info. April 2, 2023. <https://sportsfields.info/us-turf-recycling-plant-hits-a-snag/>

The chemical exec pushing advanced plastics recycling.

<https://www.politico.com/newsletters/the-long-game/2022/07/13/the-chemical-exec-pushing-advanced-plastics-recycling-00045400>

New program launched in U.S. to recycle artificial turf: Program aims to reclaim outdated turf. September 27, 2022. Turf and Rec. <https://www.turfandrec.com/new-program-launched-in-u-s-to-recycle-artificial-turf/>

Advanced recycling is booming except in California. A new plastics law is to blame. Nov 2022. <https://calmatters.org/economy/2022/11/plastic-advanced-recycling-california-turf/>

‘They lied’: plastics producers deceived public about recycling, report reveals. The Guardian. Feb 15, 2024. <https://www.theguardian.com/us-news/2024/feb/15/recycling-plastics-producers-report>

Environmental Benefits of Natural Grass

Alori ET et al. **Bioremediation techniques as affected by limiting factors in soil environment.** *Front. Soil Sci.*, 04 August 2022. Sec. Soil Pollution & Remediation. Volume 2 – 2022. <https://www.frontiersin.org/articles/10.3389/fsoil.2022.937186/full>

Beard, J. B.; Green, R. L. **The role of turfgrasses in environmental protection and their benefits to humans (1994).** *J. Environ. Qual.* 1994, 23 (3), 452–460. <https://access.onlinelibrary.wiley.com/doi/abs/10.2134/jeq1994.00472425002300030007x>

Boudh S et al. (2019) **Chapter 19 - Microbial resources mediated bioremediation of persistent organic pollutants.** *New and Future Developments in Microbial Biotechnology and Bioengineering Microbes in Soil, Crop and Environmental Sustainability.* 2019, Pages 283-294 <https://www.sciencedirect.com/science/article/abs/pii/B9780128182581000194>

Cumming J. **Environmental Assessment of the Australian Turf Industry.** July 20, 2018. <https://www.horticulture.com.au/globalassets/hort-innovation/resource-assets/tu16000-benchmarking-report.pdf>

Hanski I et al. **Environmental biodiversity, human microbiota, and allergy are interrelated.** PNAS May 22, 2012 109 (21) 8334-8339.
<https://www.pnas.org/doi/full/10.1073/pnas.1205624109>

Kowalewski A et al. **Best Management Practices for Construction of Sand Based, Natural Grass Athletic Fields.** 2015. Oregon State university.
<https://horticulture.oregonstate.edu/sites/agscid7/files/beaverturf/sports-turf/extension-bulletins/construction-of-sand-based-fields-%28pnw675%29.pdf>

Moore G.M. **Urban Trees: Worth More Than They Cost.** Burnley College, University of Melbourne. The 10th National Street Tree Symposium 2009.
<https://treenet.org/wp-content/uploads/2017/06/2009-urban-trees-worth-more-than-they-cost-dr-greg-moore.pdf>

Neylan J. **Winter management of natural turf sports fields.** Sporteng.
<https://blog.sporteng.com.au/winter-management-of-natural-turf-sportsfields>

Owen A. **Elite Players' Perceptions of Football Playing Surfaces: A Mixed Effects Ordinal Logistic Regression Model of Players' Perceptions.** Institute of Science & Environment, University of Worcester, Worcester, UK. Journal of Applied Statistics on 02 May 2016.
https://static1.squarespace.com/static/57fe8750d482e926d718f65a/t/593ed5d15016e1b82e820b5f/1497290197957/Elite_players_perceptions_of_football_playing_surfaces_-_an_ordinal_regression_model_IR.pdf

Petrovic A M et al. **The role of turfgrass management in the water quality of urban environments** Intl. Turfgrass Soc. Res. J. 10 55 69. 2005.
https://www.researchgate.net/profile/A-Petrovic-2/publication/267817326_The_Role_of_Turfgrass_Management_in_the_Water_Quality_of_Urban_Environment/links/5460af5f0cf27487b451dfad/The-Role-of-Turfgrass-Management-in-the-Water-Quality-of-Urban-Environment.pdf

Sahu R. **Research Report: Technical Assessment of the Carbon Sequestration Potential of Managed Turfgrass in the United States.**
<http://multivu.prnewswire.com/broadcast/33322/33322cr.pdf>

SEA (Sports Environment Alliance) (2020) **Future Proofing Community Sport & Recreation Facilities - A Roadmap for Climate Change Management for the Sport and Recreation Facilities Sector.** <https://www.sportsenvironmentalliance.org/resources/guide-to-future-proof-sport-recreation>

Slater GA. **The ability of urban parks to reduce air temperatures of surrounding neighbourhoods: A study of 4 Toronto parks.** University of Guelph. 2010.
<https://atrium.lib.uoguelph.ca/items/98ae9062-a51a-4ea8-86ae-fe6b3abe7e86>

UCANR. University of California Agriculture and Natural Resources. **Recycled Water Use in the Landscape.**

<https://ucanr.edu/sites/cetest/files/55089.pdf>

Vaughn, K. J. et al. **Restoration Ecology**. (2010). Nature Education Knowledge 3(10):66.
<https://www.nature.com/scitable/knowledge/library/restoration-ecology-13339059/#:~:text=Ecological%20succession%20is%20the%20process,removing%20a%20source%20of%20disturbance.>

Wang (2022). **Carbon Sequestration in Turfgrass–Soil Systems**. Plants (Basel). 2022 Oct; 11(19): 2478.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9571228/>

Zhang (2020) **The Association between Green Space and Adolescents’ Mental Well-Being: A Systematic Review**. Int J Environ Res Public Health. 2020 Sep; 17(18): 6640.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7557737/>

Sports Field Management Association. **NATURAL GRASS ATHLETIC FIELDS**.
<https://www.sportsfieldmanagement.org/natural-grass-athletic-fields/>

ENVIRONMENTAL BENEFITS OF NATURAL TURFGRASS

Sports Turf Managers Association. <https://www.stma.org/wp-content/uploads/2019/04/STMA-Infographic-Environmental-Benefits-Turfgrass-Long-2-STMA-logo.pdf>

What’s Growing On: The environmental benefits of turf grass. Dec 9, 2021.
<https://www.wcjb.com/2021/12/09/whats-growing-environmental-benefits-turf-grass/>

Oregon State University (OSU). Through thoughtful practices, lawns can be climate-friendly. Oregon State University. <https://extension.oregonstate.edu/gardening/lawn/through-thoughtful-practices-lawns-can-be-climate-friendly>

Snapdragon Stadium update: Word is that with Latitude 36 variety, the grass is always greener. San Diego Tribune. June 2, 2022.
<https://www.sandiegouniontribune.com/sports/aztecs/story/2022-06-02/snapdragon-stadium-update-grass-latitude-36-bermudagrass-american-sod-farms-san-diego-state-aztecs-sdsu-arizona>

Is Recycled Water Harmful To Turf And Landscape Plants? WATER RESOURCE CENTER. May 20, 2014. <https://www.usga.org/course-care/water-resource-center/our-experts-explain--water/is-recycled-water-harmful-to-turf-and-landscape-plants-.html#:~:text=On%20a%20positive%20note%2C%20the,to%20turfgrasses%20and%20landscape%20plants.>

Safer Grass Options for Athletic Fields. Green Building Alliance.
<https://gba.org/resources/green-healthy-schools-resources/safer-grass-options-for-athletic-fields/>

IPM- EPA-Integrated Pest Management (IPM) Principles. 2023.
<https://www.epa.gov/safepestcontrol/integrated-pest-management-ipm-principles>

IPM- USDA Integrated Pest Management. <https://www.usda.gov/oce/pest/integrated-pest-management>

IPM- USDA. History of the Federal Integrated Pest Management Coordinating Committee. <https://www.usda.gov/sites/default/files/documents/20201110-FIPMCC-History.pdf>

IPM- Marin County Integrated Pest Management Ordinance. <https://www.marincounty.org/depts/ag/ipm>

IPM- Santa Clara County IPM. Office of Sustainability and Resiliency. <https://sustainability.santaclaracounty.gov/natural-environment/integrated-pest-management/program-implementation/management-tools/governing>

IPM- Santa Clara County IPM Ordinance- SCC Ordinance Code. Title B Regulations. Division B28 - INTEGRATED PEST MANAGEMENT AND PESTICIDE USE. https://library.municode.com/ca/santa_clara_county/codes/code_of_ordinances?nodeId=TITBRE_DIVB28INPEMAPEUS

IPM- San Francisco IPM. Parks and Rec. <https://sfrecpark.org/1400/Integrated-Pest-Management>

IPM- San Francisco Integrated Pest Management Ordinance. 1996. https://codelibrary.amlegal.com/codes/san_francisco/latest/sf_environment/0-0-0-160

IPM- San Francisco Department of Environment. Pest Management for City Departments. <https://www.sfenvironment.org/pest-management-for-city-departments#list>

IPM- Santa Monica Unified School District Integrated Pest management Program. 2011. <https://www.smmusd.org/cms/lib/CA50000164/Centricity/Domain/299/IntegratedPestManagement.pdf>

IPM- National Pesticide Information Center. (NPIC) <http://npic.orst.edu/pest/agipm.html>

IPM- UC-IPM. UC California Statewide IPM Program. <https://ipm.ucanr.edu/what-is-ipm/#gsc.tab=0>

IPM- California's Pest Management Program. Frank Zalom. UC Davis. <https://ipmworld.umn.edu/zalom-california-ipm>

IPM- IPM University of Massachusetts Amherst. Center for Agriculture, Food and the Environment. <https://ag.umass.edu/integrated-pest-management/about>

IPM- Landscape, Nursery and Urban Forestry Program. University of Massachusetts Amherst. Center for Agriculture, Food and the Environment... <https://ag.umass.edu/integrated-pest-management/ipm-by-commodity/landscape>

IPM- Advancing Alternatives: Successful least-toxic pest management programs in California's urban settings. Beyond Pesticides. 2000.
https://www.beyondpesticides.org/assets/media/documents/schools/schoolpolicies/links_statelaws/Reports/alternativesCPR.pdf

Carbon Footprint

Braun R et al. **Carbon Sequestration in Zoysiagrass Turf under Different Irrigation and Fertilization Management Regimes.** Agrosystems, Geoscience and the Environment. 21 March 2019. <https://access.onlinelibrary.wiley.com/doi/10.2134/age2018.12.0060>

An environmental assessment of the Australian turf industry (TU16000). Hort Innovation. Feb 2020. <https://www.horticulture.com.au/growers/help-your-business-grow/research-reports-publications-fact-sheets-and-more/tu16000/>

Cumming J. **Environmental Assessment of the Australian Turf Industry.** July 20, 2018. <https://www.horticulture.com.au/globalassets/hort-innovation/resource-assets/tu16000-benchmarking-report.pdf>

Hamido S et al. **Carbon Sequestration under Warm Season Turfgrasses in Home Lawns.** *Journal of Geoscience and Environment Protection*, 4, 53-63. 2016. <https://www.scirp.org/journal/paperinformation?paperid=70666>

Kong L et al. **Carbon emission and sequestration of urban turfgrass systems in Hong Kong.** *Science of the Total Environment* 473-474 (2014) 13138. <https://www.sciencedirect.com/science/article/abs/pii/S0048969713014666?via%3Dihub>

Law QD et al. **Biogeochemical cycling of carbon and nitrogen in cool-season turfgrass systems.** *Urban Forestry and Urban Greening* 26: 158– 162. 2017. <https://www.sciencedirect.com/science/article/abs/pii/S1618866716302230?via%3Dihub>

Qian Y et al. **Carbon Dynamics and Sequestration in Urban Turfgrass Ecosystems.** *Carbon Sequestration in Urban Ecosystems.* Springer, Dordrecht. 2012. https://link.springer.com/chapter/10.1007/978-94-007-2366-5_8

United Nations Report. **Making Peace With Nature.** 2020. <https://www.unep.org/resources/making-peace-nature>

Zhang Y et al. **Simulation of Nitrous Oxide Emissions and Estimation of Global Warming Potential in Turfgrass Systems Using the DAYCENT Model.** J. Environ. Qual., 42: 1100-1108. July 1, 2013. <https://access.onlinelibrary.wiley.com/doi/full/10.2134/jeq2012.0486>

Examples of Well-Maintained Organic Natural Grass Turf Fields (See also **Natural Grass Turf Examples** below for more examples of grass turfs)

Natural Grass Playing Field Case Study: Marblehead, MA: 20 Acres of Organically Managed Playing Fields. Toxics Use Reduction Institute (TURI).
<https://www.turi.org/content/download/12705/198916/file/Natural+Grass+Playing+Field+Case+Study+Marblehead+MA+revised.Nov2020.pdf>

Natural Grass Playing Field Case Study: Springfield, MA: Organic Grass Fields Meet Athletes' Needs and Protect Connecticut River Watershed. Toxics Use Reduction Institute (TURI).
<https://www.turi.org/content/download/12156/190509/file/Natural+Grass+Playing+Field+Case+Study+Springfield+MA.+June+2019.pdf>

Natural Grass Playing Field Case Study: Martha's Vineyard, MA: Improving the quality of grass playing fields with data collection and organic management. Toxics Use Reduction Institute (TURI).
<https://www.turi.org/content/download/13432/205432/file/Natural+Grass+Playing+Field+Case+Study+MV+MA.Dec2020.pdf>

Environmental Impacts of Artificial Turf

Alm, Abigail. (2016) **Is Synthetic Turf Really “Greener”?** A Lifecycle Analysis of Sports Fields Across the United States, Carthage College, Kenosha, Wisconsin. (May 2016).
<https://www.carthage.edu/academics/library/archives-special-collections/>

Bernat-Ponce E et al. **Replacement of semi-natural cover with artificial substrates in urban parks causes a decline of house sparrows *Passer domesticus* in Mediterranean towns.** Urban Ecosystems. Volume 23, pages 471–481, (2020) Feb 14, 2020.
<https://link.springer.com/article/10.1007/s11252-020-00940-4>

Braun R et al. **Carbon Sequestration in Zoysiagrass Turf under Different Irrigation and Fertilization Management Regimes.** Agrosystems, Geoscience and the Environment. 21 March 2019. <https://access.onlinelibrary.wiley.com/doi/10.2134/age2018.12.0060>

de Haan et al. **The dark side of artificial greening: Plastic turfs as widespread pollutants of aquatic environments.** Environmental Pollution. October 2023, 12209.
<https://www.sciencedirect.com/science/article/pii/S0269749123010965?via%3Dihub>

Li R. **Tracking Microplastics from Artificial Football Fields to Stormwater Systems.** Stockholm University. Department of Geography. Dissertation. <https://su.diva-portal.org/smash/record.jsf?pid=diva2%3A1330304&dswid=1072>

Kukflsz B. **The degree of flammability for an artificial grass surface system.** Volume 45, 2018 . VI International Conference of Science and Technology INFRAEKO 2018 Modern Cities. Infrastructure and Environment. https://www.e3s-conferences.org/articles/e3sconf/abs/2018/20/e3sconf_infraeko2018_00038/e3sconf_infraeko2018_00038.html

Kruger O et al. **New approach to the ecotoxicological risk assessment of artificial outdoor sporting grounds.** Environmental Pollution, Volume 175. April 2013.
<https://www.ncbi.nlm.nih.gov/pubmed/23337354>

Ma A. **Future-Proofing Capitalism: The Paradox of the Circular Economy for Plastics.** Global Environmental Politics (2021) 21 (2): 121–142.
<https://direct.mit.edu/glep/article/21/2/121/97367/Future-Proofing-Capitalism-The-Paradox-of-the>

Magnusson S. **Analysis of energy use and emissions of greenhouse gases, metals and organic substances from construction materials used for artificial turf.** Resources, Conservation and Recycling. Vol 122. July 2017, Pages 362-372
<https://www.sciencedirect.com/science/article/abs/pii/S0921344917300861>

Massey R et al. **Artificial Turf Infill: A Comparative Assessment of Chemical Contents.** Sage Journals. February 23, 20.
<https://journals.sagepub.com/doi/full/10.1177/1048291120906206>

Pochron S et al. (2018) **Exposure to aged crumb rubber reduces survival time during a stress test in earthworms (*Eisenia fetida*).** viron Sci Pollut Res Int. 2018 Apr;25(12):11376-11383. <https://pubmed.ncbi.nlm.nih.gov/29423690/>

Royer SJ et al. **Production of methane and ethylene from plastic in the environment.** PLOS One. August 1, 2018.
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0200574&utm_medium=email&utm_source=GovDelivery#sec012

Sanches-Sotomayer D et al. **Artificial grass in parks as a potential new threat for urban bird communities.** Bird Conservation International. Vol 33. July 26, 2022. Cambridge University Press. <https://www.cambridge.org/core/journals/bird-conservation-international/article/artificial-grass-in-parks-as-a-potential-new-threat-for-urban-bird-communities/55B131F50206D3DD485A57DE975C120C>

Simpson TJ et al. **Artificial lawns exhibit increased runoff and decreased water retention compared to living lawns following controlled rainfall experiments.** Urban Forestry & Urban Greening, Volume 63, 2021,

<https://www.sciencedirect.com/science/article/abs/pii/S1618866721002570>

Tidaker P et al. **Energy use and greenhouse gas emissions from turf management of two Swedish golf courses.** Urban Forestry and Urban Greening. Vol 21. January 2017, Pages 80-87.

<https://www.sciencedirect.com/science/article/pii/S1618866716302692>

Valeriani F et al. **Artificial-turf surfaces for sport and recreational activities: microbiota analysis and 16S sequencing signature of synthetic vs natural soccer fields.** Heliyon 2019.

[https://www.cell.com/heliyon/pdf/S2405-8440\(19\)35994-8.pdf](https://www.cell.com/heliyon/pdf/S2405-8440(19)35994-8.pdf).

van Kleunen M et al. **A microplastic used as infill material in artificial sport turfs reduces plant growth.** PLANTS, PEOPLE, PLANET. Oct 11, 2019.

<https://nph.onlinelibrary.wiley.com/doi/10.1002/ppp3.10071>

Wik A et al. **Occurrence and effects of tire wear particles in the environment--a critical review and an initial risk assessment.** Environ Pollut. 2009 Jan;157(1):1-11.

<https://pubmed.ncbi.nlm.nih.gov/18990476/>

Zirkle G et al. **Modeling carbon sequestration in home lawns.** HortScience 46: 808– 814.

(2011) <https://journals.ashs.org/hortsci/view/journals/hortsci/46/5/article-p808.xml>

Zhu X. **The Plastic Cycle – An Unknown Branch of the Carbon Cycle.** Front. Mar. Sci., 14 January 2021. Sec. Marine Pollution

<https://www.frontiersin.org/articles/10.3389/fmars.2020.609243/full>

Why are artificial lawns bad for the environment? University of Plymouth. UK.

<https://www.plymouth.ac.uk/discover/why-are-artificial-lawns-bad-for-the-environment#:~:text=Why%20is%20artificial%20grass%20harmful,soil%20dwellers%20such%20as%20worms.>

ENVIRONMENTAL BENEFITS OF NATURAL TURFGRASS

Sports Turf Managers Association. <https://www.stma.org/wp-content/uploads/2019/04/STMA-Infographic-Environmental-Benefits-Turfgrass-Long-2-STMA-logo.pdf>

Connecticut EPA. Artificial Turf Study Leachate and Stormwater Characteristics.

Connecticut Department of Environmental Protection July 2010

<https://portal.ct.gov/-/media/deep/artificialturf/departificialturfreportpdf.pdf>

SCVWD. Field, Pilot, and Laboratory Studies for the Assessment of Water Quality Impacts of Artificial Turf . Prepared For Santa Clara Valley Water District 5750 Almaden Expressway San Jose, CA 95118-3614. JUNE 2010.

<https://www.valleywater.org/sites/default/files/Water%20Use%20Impacts%20of%20Artificial%20Turf.pdf>

Report slams taxpayer dollars sent to polluting plastic plants:

A watchdog called out subsidies for air-polluting plastic production, including facilities subject to Clean Air Act enforcement actions. 3/14/24.

<https://www.eenews.net/articles/report-slams-taxpayer-dollars-sent-to-polluting-plastic-plants/>

News Releases from Region 09 U.S. EPA requires two Los Angeles area plastics manufacturers to protect local waterways. <https://www.epa.gov/archive/epa/newsreleases/us-epa-requires-two-los-angeles-area-plastics-manufacturers-protect-local-waterways.html>

The Future's Not in Plastics: Why plastics demand won't rescue the oil sector. The oil and petrochemical industries are betting their future growth prospects on demand for plastics. Carbon Tracker. 2020. <https://carbontracker.org/reports/the-futures-not-in-plastics/>

Diaz S et al. **Pervasive human-driven decline of life on Earth points to the need for transformative change.** Science. Dec 13, 2019.

<https://www.science.org/doi/10.1126/science.aax3100>

Hardin G. **The Tragedy of the Commons: The population problem has no technical solution; it requires a fundamental extension in morality.** Science Vol 162. No 3859. Dec 13, 1968. <https://www.science.org/doi/10.1126/science.162.3859.1243>

Eykelbosh A. **Artificial turf: The contributions and limits of toxicology in decision-making.** Environmental Health Review. Vol 62. No 4. 2019. <https://pubs.ciphi.ca/doi/full/10.5864/d2019-026>

Water Quality Impacts and Pollution of Artificial Turf

Bessa F et al. **Occurrence of microplastics in commercial fish from a natural estuarine environment.** Mar Pollut Bull. 2018 Mar;128:575-584.

<https://pubmed.ncbi.nlm.nih.gov/29571409/>

CEH. **Notice of Violation of the Safe Drinking Water Act and Toxic Enforcement Act.** March 4, 2024. <https://ceh.org/wp-content/uploads/2024/03/2024-03-04-Notice-PFOS-in-Turffx.pdf>

Celeiro (2021) **Evaluation of chemicals of environmental concern in crumb rubber and water leachates from several types of synthetic turf football pitches.** Chemosphere. 2021 May;270:128610. <https://pubmed.ncbi.nlm.nih.gov/33121811/>

Celeiro M et al (2018) **Determination of priority and other hazardous substances in football fields of synthetic turf by gas chromatography-mass spectrometry: A health and**

environmental concern. Chemosphere. 2018 Mar;195:201-211.
<https://pubmed.ncbi.nlm.nih.gov/29268178/>

Chiba R et al. **Ingestion of rubber tips of artificial turf fields by goldfish.** Sci Rep. 2023 Jan 24;13(1):1344. <https://pubmed.ncbi.nlm.nih.gov/36693897/>

de Haan et al. **The dark side of artificial greening: Plastic turfs as widespread pollutants of aquatic environments.** Environmental Pollution. October 2023, 12209.
<https://www.sciencedirect.com/science/article/pii/S0269749123010965?via%3Dihub>

Kruger O et al. (2013) **New approach to the ecotoxicological risk assessment of artificial outdoor sporting grounds.** Environmental Pollution, Volume 175. April 2013.
<https://www.ncbi.nlm.nih.gov/pubmed/23337354>

Neves D et al. **Ingestion of microplastics by commercial fish off the Portuguese coast.** Neves D et al. Mar Pollut Bull. 2015 Dec 15;101(1):119 126.
<https://pubmed.ncbi.nlm.nih.gov/26608506/>

Petrovic A M et al. **The role of turfgrass management in the water quality of urban environments** Intl. Turfgrass Soc. Res. J. 10 55 69. 2005.
https://www.researchgate.net/profile/A-Petrovic-2/publication/267817326_The_Role_of_Turfgrass_Management_in_the_Water_Quality_of_Urban_Environment/links/5460af5f0cf27487b451dfad/The-Role-of-Turfgrass-Management-in-the-Water-Quality-of-Urban-Environment.pdf

SCVWD. **Field, Pilot, and Laboratory Studies for the Assessment of Water Quality Impacts of Artificial Turf.** Prepared for Santa Clara Valley Water District 5750 Almaden Expressway San Jose, CA 95118-3614. JUNE 2010.
<https://www.valleywater.org/sites/default/files/Water%20Use%20Impacts%20of%20Artificial%20Turf.pdf>

Simpson TJ et al. **Artificial lawns exhibit increased runoff and decreased water retention compared to living lawns following controlled rainfall experiments.** Urban Forestry & Urban Greening, Volume 63, 2021,
<https://www.sciencedirect.com/science/article/abs/pii/S1618866721002570>

Plastic on the pitch: Artificial turf leads to marine pollution. Sept 22, 2023. Sustainability Times.
<https://www.sustainability-times.com/clean-cities/plastic-on-the-pitch-artificial-turf-leads-to-marine-pollution/>

California Coastal Commission. 2023. Memo W13.1a, dated November 30, 2023, Subject: Notice of Impending Development UCS-NOID-0002-23 (Baseball Stadium Turf) for Public Hearing and Commission Action at the December 13, 2022 <sic>, Commission Meeting.
<https://documents.coastal.ca.gov/reports/2023/12/W13.1a/W13.1a-12-2023-report.pdf>

Health Effects & Safety

Adamson (2007) **Synthetic turf fields present unique dangers**. Columbia (MO): University of Missouri- Columbia College of Agriculture, Food, and Natural Resources; 2007. Available from: http://agebb.missouri.edu/news/ext/showall.asp?story_num=3521&iln=8.

Claudio (2008) **Synthetic turf: health debate takes root**. Environ Health Perspect. 2008;116:A116–A122. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2265067/>

Cheng H et al. **Environmental and Health Impacts of Artificial Turf: A Review**. Environ. Sci. Technol. 2014, 48, 2114-2129. <https://pubs.acs.org/doi/abs/10.1021/es4044193>.

Danopoulos E et al. **A rapid review and meta-regression analyses of the toxicological impacts of microplastic exposure in human cells**. Journal of Hazardous Materials. Vol 427. 5 April 2022, 127861. <https://www.sciencedirect.com/science/article/abs/pii/S0304389421028302?dgcid=author>

EPA. **Our Current Understanding of the Human Health and Environmental Risks of PFAS**. <https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas>

EPA. **U.S. Federal Research Action Plan (FRAP) on Recycled Tire Crumb Rubber Used on Synthetic Turf Playing Fields and Playgrounds**. https://www.epa.gov/sites/default/files/2019-08/documents/tc_public_webinar_-_august_6_2019.pdf

Goldstein BD (2001) **The Precautionary Principle Also Applies to Public Health Actions**. Am J Pub health. 2001 September; 91(9): 1358–1361. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1446778/>

Gomes FO et al. **A review of potentially harmful chemicals in crumb rubber used in synthetic football pitches**. J Hazard Mater. 2021 May 5:409:124998. <https://pubmed.ncbi.nlm.nih.gov/33513533/>

Grandjean P et al. **Estimated Exposures to Perflourinated Compounds in Infancy Predict Attenuated Vaccine Antibody Concentrations at age 5-Years**. J Immunotoxicol. 2017 Dec. . <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6190594/>

Grandjean P. **Delayed discovery, dissemination, and decisions on intervention in environmental health: a case study on immunotoxicity of perfluorinated alkylate substances**. Environmental Health. Article number: 62 (2018) <https://ehjournal.biomedcentral.com/articles/10.1186/s12940-018-0405-y>

Hahn (2010) **Consumer exposure to biocides - identification of relevant sources and evaluation of possible health effects.** Environ Health. 9, Article number: 7 (2010)
<https://ehjournal.biomedcentral.com/articles/10.1186/1476-069X-9-7>

Hall SM et al. **Concentrations of per- and polyfluoroalkyl substances (PFAS) in human placental tissues and associations with birth outcomes.** Chemosphere. 2022 Feb 7.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8923299/>

Hausmann S. **New study casts doubt on safety of synthetic turf.** March 15, 2022.
<https://www.wvtf.org/news/2022-03-15/new-study-casts-doubt-on-safety-of-synthetic-turf>

IARC. **OCCUPATIONAL EXPOSURES IN THE RUBBER-MANUFACTURING INDUSTRY.** <https://www.ncbi.nlm.nih.gov/books/NBK304412/>

ITRC. **7 Human and Ecological Health Effects of select PFAS. Interstate Technology Regulatory Council.** <https://pfas-1.itrcweb.org/7-human-and-ecological-health-effects-of-select-pfas/>

Janes C et al. **A review of the potential risks associated with chemicals present in poured-in-place rubber surfacing.** Environmental Health Review. 22 March 2018.
<https://pubs.ciphi.ca/doi/full/10.5864/d2018-001>

Kim S et al. (2012) **Health Risk Assessment of Lead Ingestion Exposure by Particle Sizes in Crumb Rubber on Artificial Turf Considering Bioavailability.** Environmental Health and Toxicology, Volume 27. January 2012
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278598/>

Liu Z and Kim CY. **Playing on natural or artificial turf sports field? Assessing heat stress of children, young athletes, and adults in Hong Kong.** Sustainable Cities and Society. Vol 75. December 2021. <https://www.sciencedirect.com/science/article/abs/pii/S2210670721005473>
Liu A **toxicological profile of silica nanoparticles.** Toxicology Research, Volume 11, Issue 4, August 2022. <https://academic.oup.com/toxres/article/11/4/565/6645393>

Mount Sinai Children's Environmental Health Center: **Position Statement on the Use of Artificial Turf Surfaces.** Nov 30, 2023. <https://mountsinaiaxposomics.org/position-statement-on-the-use-of-artificial-turf-surfaces/>

Sunduk K et al. **Health Risk Assessment of Lead Ingestion Exposure by Particle Sizes in Crumb Rubber on Artificial Turf Considering Bioavailability.** Environ Health Toxicol. 2012; 27. <https://pubmed.ncbi.nlm.nih.gov/22355803/>

Trowbridge (2023) **Extending Nontargeted Discovery of Environmental Chemical Exposures during Pregnancy and Their Association with Pregnancy Complications—A Cross-Sectional Study.** Trowbridge J et al. Environmental Health Perspectives. July 19, 2023.
<https://ehp.niehs.nih.gov/doi/10.1289/ehp11546>

van Rooij Joost **Hydroxypyrene in urine of football players after playing on artificial sports field with tire crumb infill.** van Rooij Joost and Jongeneelen Frans J. Int Arch Occup Environ Health (2010) 83:105–110. https://portal.ct.gov/-/media/Departments-and-Agencies/DPH/dph/environmental_health/Turf/ArtificialTurfVanRooij2010BioMpdf.pdf

Artificial turf pitches – an assessment of the health risks for football players. Prepared by: Norwegian Institute of Public Health and the Radium Hospital Oslo, January 2006 . https://www.iss-sportsurfacescience.org/downloads/documents/74WA3X7E22_FHIEngelsk.pdf

Health Impact Assessment of the Use of Artificial Turf in Toronto. April 2015. Toronto Public Health. https://www.toronto.ca/wp-content/uploads/2017/11/9180-HIA_on_Artificial_Turf_Summary_Report_Final_2015-04-01.pdf

Lung Cancer Center. Tire and Rubber Industry Rates of Occupational Disease. <https://www.lungcancercenter.com/who-lung-cancer-affects/tire-rubber-industry/>

‘Unintended consequences’: The rubber industry’s toxic legacy in Akron. March 5, 2021. Public Integrity. <https://publicintegrity.org/health/unintended-consequences-rubber-industry-toxic-legacy-in-akron/>

Safety Testing

CPSC Staff Finds Synthetic Turf Fields OK to Install, OK to Play On. July 30, 2008. <https://www.cpsc.gov/Newsroom/News-Releases/2008/CPSC-Staff-Finds-Synthetic-Turf-Fields-OK-to-Install-OK-to-Play-On>

Consumer Product Safety Commission (CPSC). Letter from CPSC regarding rubber products used by children but no listed as a “Children’s Product”. https://peer.org/wp-content/uploads/attachments/3_21_13_CPSC_childrens_product.pdf

PEER. 2015. **U.S. Product Safety Commission Stumbles on Artificial Turf.** Feb 19, 2015. <https://peer.org/u-s-product-safety-commission-stumbles-on-artificial-turf/>

Status of CPSC’s Review of Playgrounds with Crumb Rubber. Federal Research Action Plan . U.S. Product Safety Commission. 2019. <https://www.cpsc.gov/Safety-Education/Safety-Education-Centers/Crumb-Rubber-Safety-Information-Center>

New study casts doubt on safety of synthetic turf. March 15, 2022. WVTF. <https://www.wvtf.org/news/2022-03-15/new-study-casts-doubt-on-safety-of-synthetic-turf>

EPA. Federal Research on Recycled Tire Crumb Used on Playing Fields and Playgrounds. April 2024. <https://www.epa.gov/chemical-research/federal-research-recycled-tire-crumb-used-playing-fields-and-playgrounds>

Federal Research Action Plan on the Use of Tire Crumbs in Playing Fields and Playgrounds (FRAP). Tire Crumb Exposure Characterization Report (Volumes 1 and 2). April 2024. <https://www.epa.gov/chemical-research/tire-crumb-exposure-characterization-report-volumes-1-and-2>

Silica

AAP- American Academy of Pediatrics. **Safety in the Sandbox.** <https://www.healthychildren.org/English/safety-prevention/at-play/Pages/Safety-in-the-Sandbox.aspx>

OSHA. Silica, Crystalline Hazards. Occupational Health and Safety Administration. U.S. Department of Labor. <https://www.osha.gov/silica-crystalline/health-effects>

CDC. Health Risks of Silica Exposure and Medical Monitoring. The National Institute for Occupational Health. <https://www.cdc.gov/niosh/topics/silica/risks.html>

Yale. Environmental Health and Safety. Silica. <https://ehs.yale.edu/silica>

Heat Related Illness and Urban Heat Islands

Abraham (2019) **Heat risks associated with synthetic athletic fields.** Abraham J. International Journal of Hyperthermia. 24 Apr 2019. <https://www.tandfonline.com/doi/full/10.1080/02656736.2019.1605096>

Buskirk (1971) **Microclimate over artificial turf.** Buskirk ER et al. J Health, Phys Educ Recreat. 1971;42:29–30. <https://www.tandfonline.com/doi/10.1080/00221473.1971.10617177>

Claudio (2008) **Synthetic turf: health debate takes root.** Environ Health Perspect. 2008;116:A116–A122. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2265067/>

Jim CY et al. **Intense summer heat fluxes in artificial turf harm people and environment.** Landscape and Urban Planning, Volume 157, pp. 561-576. 2017. <https://www.sciencedirect.com/science/article/abs/pii/S0169204616301992?via%3Dihub>

Liu Z and Kim CY. **Playing on natural or artificial turf sports field? Assessing heat stress of children, young athletes, and adults in Hong Kong.** Sustainable Cities and Society. Vol 75. December 2021. <https://www.sciencedirect.com/science/article/abs/pii/S2210670721005473>

Madden AL et al. **Cool School Initiative.** Western Sydney University. 2018. <https://researchdirect.westernsydney.edu.au/islandora/object/uws%3A47915>

Litman L. **It's so hot in Texas, turf is melting cleats.** Aug 11, 2015. USA Today. <https://ftw.usatoday.com/2015/08/its-so-hot-in-texas-turf-is-melting-cleats>

Nazareth E. **Blazing heat burning shoe soles on Toronto's turf fields**
Researcher found one artificial field had a surface temperature of 95 C. CBC News. Aug 10, 2016. <https://www.cbc.ca/news/canada/toronto/summer-heat-turf-1.3714351>

NRPA (2019) **Synthetic Sports Fields and the Heat Island Effect.** National Recreation and Park Association Guidelines. <https://www.nrpa.org/parks-recreation-magazine/2019/may/synthetic-sports-fields-and-the-heat-island-effect/>

Pennsylvania State University Center for Sports Surface Research. Synthetic Turf Heat Evaluation-Progress Report. January 2012. <https://plantscience.psu.edu/research/centers/ssrc/documents/heat-progress-report.pdf>

Pfautsch S et al. **School Microclimates.** Western Sydney University. <https://researchdirect.westernsydney.edu.au/islandora/object/uws:57392>

Slater GA. **The Cooling Ability of Urban Parks.** 2010. University of Guelph. <https://atrium.lib.uoguelph.ca/items/98ae9062-a51a-4ea8-86ae-fe6b3abe7e86>

Thoms AW et al. **Models for predicting surface temperatures on synthetic turf playing surfaces.** Procedia Engineering 72 (2014) 895 – 900. <https://core.ac.uk/download/pdf/82104567.pdf>

Williams and Pulley (2002). **Synthetic surface heat studies.** Provo (UT): Brigham Young University; 2002. https://scholar.google.com/scholar_lookup?hl=en&volume=42&publication_year=1971&pages=29-30&journal=J+Health%2C+Phys+Educ+Recreat&author=ER+Buskirk&author=ER+McLaughlin&author=JL+Loomis&title=Microclimate+over+artificial+turf

University of Arkansas. Synthetic Turf vs Artificial Grass Athletic Fields. University of Arkansas. Photos of different temperatures measured. <https://cms4files.revize.com/elkonv/Council%20Action%20Item%20II-G.pdf>

Mum's random experiment shows fake turf can be dangerous for kids and pets. Jan 5, 2019. <https://www.kidspot.com.au/health/family-health/safety/mums-random-experiment-shows-fake-turf-can-be-dangerous-for-kids-and-pets/news-story/a347bb4ca90e13af7eb2098ddf451a33>

Johnson DP. **Satellites zoom in on cities' hottest neighborhoods to help combat the urban heat island effect.** June 27, 2022. <https://www.space.com/satellites-zoom-into-hottest-cities>

(ESA) Sensing city night heat from space. European Space Agency.
https://www.esa.int/Applications/Observing_the_Earth/Sensing_city_night_heat_from_space

MPSP. Moffett Park Specific Plan Urban Ecology. Technical Report. San Francisco Estuary Institute. April 2020. Urban heat Effects. Page 16.
https://www.sfei.org/sites/default/files/biblio_files/MPSP_Ecology_20_04.pdf

Cal- Adapt
<https://cal-adapt.org/tools/>

Impact of heat on grass and artificial turf fields | VERIFY
Some local schools have canceled or moved games and practices because of the heat this week. The type of field students play on could influence that decision. Sept 6, 2023.
<https://www.wusa9.com/article/news/verify/verify-impact-heat-grass-artificial-turf-fields/65-f2fbb611-109a-4673-9b2f-7468bea55c70>

Infections

Begier (2004) **A high-morbidity outbreak of methicillin-resistant Staphylococcus aureus among players on a college football team, facilitated by cosmetic body shaving and turf burns.** Begier EM et al. Clin Infect Dis. 2004;39:1446-1453.
<https://pubmed.ncbi.nlm.nih.gov/15546080/>

Bowers (2008) **Methicillin-resistant Staphylococcus aureus infections in collegiate football players.** Sci Sports Exerc. 2008 Aug;40(8):1362-7. <https://pubmed.ncbi.nlm.nih.gov/18614960/>

Jaradat (2020) **Methicillin Resistant Staphylococcus aureus and public fomites: a review.** Jaradat ZW et al. Glob Health. 2020 Dec;114(8):426-450.
<https://pubmed.ncbi.nlm.nih.gov/33115375/>

Keller (2020) **The Fate of Methicillin-Resistant Staphylococcus aureus in a Synthetic Turf System.** Keller M et al. Sports Health. 2020 May-Jun; 12(3): 263–270.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7222665/>

Penn State University. **Survival of Staphylococcus Aureus on Synthetic Turf:** Staphylococcus aureus is a common bacterium, but is capable of causing diseases ranging from minor soft tissue infections and food poisoning to serious medical problems such as toxic shock syndrome. Penn State University. <https://extension.psu.edu/survival-of-staphylococcus-aureus-on-synthetic-turf>

Penn State University Extension. **Survival of Staphylococcus aureus on Synthetic Turf.** <http://plantscience.psu.edu/research/centers/turf/extension/factsheets/staphylococcus>

Waninger (2011) **Community-associated methicillin-resistant Staphylococcus aureus on artificial turf substrates survival.** Med Sci Sports Exerc. 2011 May;43(5):779-84.
<http://www.ncbi.nlm.nih.gov/pubmed/20962684>

Injuries - Sports

Balazs GC et al. **Risk of Anterior Cruciate Ligament Injury in Athletes on Synthetic Playing Surfaces: A Systematic Review.** Am J Sports Med. 2015 Jul;43(7):1798-804.
<https://pubmed.ncbi.nlm.nih.gov/25164575/>

Calloway SP et al. **Injury Surveillance in Major League Soccer: A 4-Year Comparison of Injury on Natural Grass Versus Artificial Turf Field.** The American journal of sports medicine. 2019; 47(10), 2279–2286. <https://doi.org/10.1177/0363546519860522>

Ekstrand J et al. **Risk of injury in elite football played on artificial turf versus natural grass: a prospective two-cohort study.** Sports Med. 2006 Dec;40(12):975-80.
<https://pubmed.ncbi.nlm.nih.gov/16990444/>

Gould HP et al. **Lower Extremity Injury Rates on Artificial Turf and Natural Grass Playing Surfaces: A Systematic Review.** *Foot Ankle Orthop.* 2022 Jan; 7(1).
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8794856/>

Guskiewicz. (2000). **Epidemiology of concussion in collegiate and high school football players.** The American Journal of Sports Medicine, 28(5), 643-650.
<https://pubmed.ncbi.nlm.nih.gov/11032218/>

Loughran GJ Et al. **Incidence of Knee Injuries on Artificial Turf Versus Natural Grass in National Collegiate Athletic Association American Football: 2004-2005 Through 2013-2014 Seasons.** The American journal of sports medicine. 2019;47(6), 1294–1301.
<https://doi.org/10.1177/0363546519833925>

Mack (2019) **Higher Rates of Lower Extremity Injury on Synthetic Turf Compared With Natural Turf Among National Football League Athletes: Epidemiologic Confirmation of a Biomechanical Hypothesis.** Am J Sports Med. 2019 Jan;47(1):189-196.
<https://pubmed.ncbi.nlm.nih.gov/30452873/>

McNitt AS et al. **Temperature amelioration of synthetic turf surfaces through irrigation.** Acta Hort. 783:573-582. 2008.
<https://plantscience.psu.edu/research/centers/ssrc/documents/temperature-irrigation.pdf>

Meyers and Barnhill (2004) **Incidence, causes, and severity of high school football injuries on FieldTurf versus natural grass: a 5-year prospective study.** Meyers and Barnhill. American J Sports Med. 2004 Oct-Nov;32(7):1626-38.

<https://pubmed.ncbi.nlm.nih.gov/15494326/>

Najefi A et al. **Turf toe: A clinical update.** Najefi A et al. EFORT Open Review. 2018 Sep; 3(9): 501–506. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6174855/>

Naunheim R et al. **Does the use of artificial turf contribute to head injuries?** Journal of Trauma- Injury, Infection, and Critical Care, 53(4), 691-694. (2002).
<https://pubmed.ncbi.nlm.nih.gov/12394868/>

Paliobeis A et al. **Injury incidence is higher on artificial turf compared with natural grass in high school athletes: a retrospective cohort study.** Current Orthopedic Practice. 32(4);355-360. July/August 2021. https://journals.lww.com/c-orthopaedicpractice/abstract/2021/07000/injury_incidence_is_higher_on_artificial_turf.6.aspx

Robertson CM et al. **Influence of playing surface on match injury risk in men's professional rugby union in England (2013-2019).** Scand J Med Sci Sports. 2022 Nov;32(11):1615-1624.
<https://pubmed.ncbi.nlm.nih.gov/36004455/>

Smeets K et al. **Torsional injuries of the lower limb: an analysis of the frictional torque between different types of football turf and the shoe outsole.** Br J Sports Med. 2012 Dec;46(15):1078-83. <https://pubmed.ncbi.nlm.nih.gov/22842236/>

Sousa P et al. **Injuries in amateur soccer players on artificial turf: a one-season prospective study.** Phys Ther Sport. 2013 Aug;14(3):146-51. <https://pubmed.ncbi.nlm.nih.gov/23072932/>

Taylor SA et al. **A review of synthetic playing surfaces, the shoe-surface interface, and lower extremity injuries in athletes.** Phys Sportsmed. 2012 Nov;40(4):66-72.
<https://pubmed.ncbi.nlm.nih.gov/23306416/>

Villanueva N et al. **Impact Deceleration Differences on Natural Grass Versus Synthetic Turf High School Football Fields.** Hawaii J Health Soc Well. 2024 Jan;83(1):4-9.
<https://pubmed.ncbi.nlm.nih.gov/38223462/>

Voos JE. **Artificial Turf Versus Natural Grass. Which is playing surface is safer for playing high school sports?** Innovations in Orthopedics. August 26, 2019. University Hospitals.
<https://www.uhhospitals.org/for-clinicians/articles-and-news/articles/2019/08/artificial-turf-versus-natural-grass>

Turf Toe. Cedars Sinai. <https://www.cedars-sinai.org/health-library/diseases-and-conditions/t/turf-toe.html#:~:text=This%20causes%20severe%20soreness%2C%20swelling,less%20shock%2Dabsorbent%20than%20grass.>

Athlete Preferences

(NFLPA 2020) Only Natural Grass Can Level The NFL's Playing Field. J.C. Tretter. Sept 2020. <https://nflpa.com/posts/only-natural-grass-can-level-the-nfls-playing-field>

Dumas T. Why high school football players prefer the grass fields over artificial playing surfaces. Sept 26, 2023. The Metro West Daily News. <https://sports.yahoo.com/just-move-better-grass-why-080417170.html>

Owen A. Elite players' perceptions of football playing surfaces: a mixed effects ordinal logistic regression model of players' perceptions. Loughborough University Institutional Repository. Journal of Applied Statistics. 02 May 2016, https://static1.squarespace.com/static/57fe8750d482e926d718f65a/t/593ed5d15016e1b82e820b5f/1497290197957/Elite_players_perceptions_of_football_playing_surfaces_-_an_ordinal_regression_model_IR.pdf

Laguano Rodrigo. NFL Teams Should Consider Changing to Grass Fields for Safety of Their Players. Oberlin Review. March 12, 2024. <https://oberlinreview.org/30765/sports/nfl-teams-should-consider-changing-to-grass-fields-for-safety-of-their-players/>

Joint NFL/NFLPA committee finds similar injury rates on grass and turf fields in 2023. NBC Sports. Feb 2, 2024. Josh Alper. <https://www.nbcsports.com/nfl/profootballtalk/rumor-mill/news/joint-nfl-nflpa-committee-finds-similar-injury-rates-on-grass-and-turf-fields-in-2023>

NFLPA: New Injury Data Shows Grass is Significantly Safer Than Turf. April 20, 2023. Kevin Seifert. https://www.espn.com/nfl/story/_/id/36243906/nflpa-new-injury-data-shows-grass-significantly-safer-turf

NFLPA: Why the NFL's Approach to Field Surfaces Is Uneven. JC Tretter. 4/19/23 <https://nflpa.com/posts/nfl-approach-field-surface-uneven>

NFLPA: NFL Player Health & Safety Lies Beneath the Surface. JC Tretter. 11/12/22 <https://nflpa.com/posts/nfl-player-health-safety-lies-beneath-the-surface>

Laws and Policy

SB-47 Environmental health: artificial turf. Hill. Proposed 2015. https://leginfo.legislature.ca.gov/faces/billCompareClient.xhtml?bill_id=201520160SB47&show_amends=false

SB-676 Local ordinances and regulations: drought-tolerant landscaping. 2023. CA Senator Ben Allen. District 24. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202320240SB676

“This bill would instead prohibit a city, including a charter city, county, or city and county from enacting or enforcing any ordinance or regulation that prohibits the installation of drought-tolerant landscaping using living plant material on residential property. The bill would specify that drought-tolerant landscaping does not include the installation of synthetic grass or artificial turf.”

FDA, Industry Actions End Sales of PFAS Used in US Food Packaging. The following is attributed to Jim Jones, Deputy Commissioner for Human Foods. Feb 28, 2024. .

<https://www.fda.gov/news-events/press-announcements/fda-industry-actions-end-sales-pfas-used-us-food-packaging>

Lawsuits & Legal Actions

Complaint of Deceptive and Unfair Advertising of Artificial Turf. PEER.

https://peer.org/wp-content/uploads/2022/03/3_7_22-Filed-FTC-Complaint-2.28.22.pdf

Electron Hydro to pay \$1 million Clean Water Act penalty for 2020 artificial turf, tire crumb discharge into Puyallup River. <https://www.epa.gov/newsreleases/electron-hydro-pay-1-million-clean-water-act-penalty-2020-artificial-turf-tire-crumb>

CEH. Notice of Violation of the Safe Drinking Water Act and Toxic Enforcement Act.

March 4, 2024. <https://ceh.org/wp-content/uploads/2024/03/2024-03-04-Notice-PFOS-in-Turffx.pdf>

Five LAUSD high schools to replace 'melting' turf on fields. Sept 1, 2015.

<https://www.foxla.com/news/five-laUSD-high-schools-to-replace-melting-turf-on-fields>

Neshannock School District sues FieldTurf over defective artificial turf fields. June 2017.

Pennsylvania Record. <https://penncor.com/stories/511123895-neshannock-school-district-sues-fieldturf-over-defective-artificial-turf-fields>

NESHANNOCK TOWNSHIP SCHOOL DISTRICT vs FIELDTURF USA, INC., 3/23/17. UNITED STATES DISTRICT COURT WESTERN DISTRICT OF PENNSYLVANIA PITTSBURGH DIVISION. class action complaint against FieldTurf USA, Inc., FieldTurf Inc., and FieldTurf Tarkett SAS.

https://media.nj.com/ledgerupdates_impact/other/2017/03/25/Neshannock%20Complaint.pdf

FIELDTURF TRYING TO FIX DEFECTIVE FIELDS WITH THOUSANDS OF GALLONS OF LATEX GLUE. 5/16/16. <https://www.safehealthyplayingfields.org/cost-articles-blog/2017/9/7/fieldturf-fixing-revolution-fields-with-thousands-of-gallons-of-latex-glue>

California Coastal Commission. 2023. Memo W13.1a, dated November 30, 2023, Subject: Notice of Impending Development UCS-NOID-0002-23 (Baseball Stadium Turf) for Public

Hearing and Commission Action at the December 13, 2022 <sic>, Commission Meeting.
<https://documents.coastal.ca.gov/reports/2023/12/W13.1a/W13.1a-12-2023-report.pdf>

Artificial turf problems prompt lawsuits and early replacements. Dec 12, 2018.
<https://www.wthr.com/article/news/investigations/13-investigates/artificial-turf-problems-prompt-lawsuits-and-early-replacements/531-e5b96258-c7fc-4e0c-aad3-9f68d8626262>

COURTS GIVE FINAL APPROVAL FOR 3M SETTLEMENT TO ADDRESS PFAS IN DRINKING WATER. Association of State Drinking Water Administrators. April 1, 2024.
<https://www.asdwa.org/2024/04/01/courts-give-final-approval-for-3m-settlement-to-address-pfas-in-drinking-water/>

"On March 29, the U.S. District Court in Charleston, South Carolina, gave the [final approval](#) for chemical manufacturer 3M's \$10.3 to \$12.5 billion settlement agreement with U.S. public water suppliers (PWS) to address PFAS contamination in drinking water.

JUDGE APPROVES SETTLEMENT REQUIRING DUPONT, CHEMOURS, AND CORTEVA TO PAY \$1.1 BILLION IN PFAS CONTAMINATION SUIT Association of State Drinking Water Administrators. Feb 16, 2024. <https://www.asdwa.org/2024/02/16/judge-approves-settlement-requiring-dupont-chemours-and-corteva-to-pay-1-1-billion-in-pfas-contamination-suit/>

"The United States District Court for the District of South Carolina has [approved a settlement](#) requiring chemical manufacturers DuPont, Chemours, and Corteva (both spin-offs of DuPont) to pay \$1.185 billion to settle liability claims from public water systems....The public water systems included in the settlement serve the vast majority of the U.S. population."

Letters

Letter to Board of Education of Montgomery County on Artificial Turf Fields and Playgrounds
Diana Zuckerman, PhD, National Center for Health Research, April 23, 2018.
<http://stopcancerfund.org/policy/letter-to-board-of-education-of-montgomery-county-on-synthetic-playgrounds/>

National Center for Health Research. NCHR Letter to the DC City Council on Artificial Turf.
Diana Zuckerman, PhD, National Center for Health Research, October 26, 2017
<https://www.center4research.org/nchr-letter-dc-city-council-artificial-turf/>

Letter to Montgomery School District, Maryland. Artificial Turf. Kathleen Michels, PhD. Feb 10, 2020.
[https://www.boarddocs.com/mabe/mcpsmd/Board.nsf/files/BLNL8N555755/\\$file/Kathleen%20Michels.pdf](https://www.boarddocs.com/mabe/mcpsmd/Board.nsf/files/BLNL8N555755/$file/Kathleen%20Michels.pdf)

Mental Health and Greenscapes

Chiang HL et al. **Physical Fitness and Risk of Mental Disorders in Children and Adolescents.** JAMA. April 29, 2024.

https://jamanetwork.com/journals/jamapediatrics/fullarticle/2818132?guestAccessKey=979d790c-d9c4-4c8c-b56c-7ed603e7f753&utm_source=silverchair&utm_medium=email&utm_campaign=article_alert-jamapediatrics&utm_term=mostread&utm_content=olf-widget_05062024&adv=000518800647

Essterli MC et al. **Association of Team Sports Participation With Long-term Mental Health Outcomes Among Individuals Exposed to Adverse Childhood Experiences.** Essterli MC et al. JAMA Pediatr. 2019;173(7):681-688.

<https://jamanetwork.com/journals/jamapediatrics/fullarticle/2734743>

Roslund MI et al. **Biodiversity intervention enhances immune regulation and health-associated commensal microbiota among daycare children.** Science. SCIENCE ADVANCES

14 Oct 2020, Vol 6, Issue 42. <https://www.science.org/doi/10.1126/sciadv.aba2578>

Environmental benefits of healthy lawns. <https://extension.umn.edu/lawn-care/environmental-benefits-lawns#turfgrass-improves-water-quality-637160>

Parks for a Sustainable Future. Beyond Pesticides.

<https://www.beyondpesticides.org/resources/power-organic-parks-program>

Natural Grass Field Examples

Woodland Middle School Annual Report 2021-2022. Portola Valley, CA. New field in 2021 with help from their school Fund a Need. Pg 13.

<https://resources.finalsite.net/images/v1664202824/woodland/l5d3utjxqovbievwvutp/WoodlandAnnualReport2021-22Web.pdf>

Woodside Priory. Portola Valley, CA has a multi-purpose grass field.

<https://www.prioryca.org/support/building-ingenuity/our-present>

Manteca Unified School District. East Union High School Unveils Renovated Dino Cunial Stadium. <https://www.mantecausd.net/post-details/~board/district-news/post/east-union-high-school-unveils-renovated-dino-cunial-stadium>

Upgraded East Union High stadium will be ready to use in time for last two home football games. Manteca/Ripon Bulletin. Aug 30, 2023. <https://www.mantecabulletin.com/news/local-news/upgraded-east-union-high-stadium-will-be-ready-use-time-last-two-home-football-games/>

Krasovic T. **SDSU's new stadium gets 'A' grades for at least two features.** Aug 29, 2022. San Diego Tribune. <https://www.sandiegouniontribune.com/sports/aztecs/story/2022-08-29/snapdragon-stadium-grass-field-san-diego-state-aztecs-football>

(TURI). **A Cost Comparison of Conventional (Chemical) Turf Management and Natural (Organic) Turf Management for School Athletic Fields.** <http://www.nontoxiccommunities.com/uploads/1/2/3/8/123860248/turfcomparisonreport.pdf>

(TURI). **Natural Grass Playing Field Case Study: Marblehead, MA: 20 Acres of Organically Managed Playing Fields.** Toxics Use Reduction Institute (TURI). <https://www.turi.org/content/download/12705/198916/file/Natural+Grass+Playing+Field+Case+Study+Marblehead+MA+revised.Nov2020.pdf>

(TURI). **Natural Grass Playing Field Case Study: Springfield, MA: Organic Grass Fields Meet Athletes' Needs and Protect Connecticut River Watershed.** Toxics Use Reduction Institute (TURI). <https://www.turi.org/content/download/12156/190509/file/Natural+Grass+Playing+Field+Case+Study+Springfield+MA.+June+2019.pdf>

(TURI). **Natural Grass Playing Field Case Study: Martha's Vineyard, MA: Improving the quality of grass playing fields with data collection and organic management.** Toxics Use Reduction Institute (TURI). <https://www.turi.org/content/download/13432/205432/file/Natural+Grass+Playing+Field+Case+Study+MV+MA.Dec2020.pdf>

(TURI). **Building an Organic Maintenance Program for Athletic Fields: Guidance from Experts and Experienced Communities.** Toxics Use Reduction Institute (TURI). <https://www.turi.org/content/download/13543/206640/file/Factsheet.BuildinganOrganicMaintenanceProgramforAthleticFields.April2021.pdf>

(TURI). **Sports Turf Alternatives Assessment: Preliminary Results COST ANALYSIS.** Massachusetts Toxics Use Reduction Institute September 2016. <https://www.turi.org/content/download/10395/173557/file/Cost%20Artificial%20Turf.%20September%202016.pdf>

Protection of children and families from harmful pesticides. 333 CMR 14.00. Massachusetts. 2000. <https://www.mass.gov/regulations/333-CMR-1400-protection-of-children-and-families-from-harmful-pesticides>

The Field Fund: Responsibly Investing in Grass. <https://www.fieldfundinc.org/>

The 9 Best College Football Fields With Good Ol' Grass. John Egan. March 11, 2017. <https://www.lawnstarter.com/blog/environment/best-natural-turf-college-football-stadiums/>

Sports Field Management Association. FIELD OF THE YEAR. 2024. <https://www.sportsfieldmanagement.org/foy-awards/>

Texas A&M. Ellis Field opened in 1994 and still has natural grass (Tifway Bermuda) . <https://12thman.com/facilities/ellis-field/9>

The science underneath Kyle Field. Oct 9, 2023. <https://www.kbtx.com/2023/10/09/science-underneath-kyle-field/>

A natural look: Insiders detail Razorbacks' switch back to grass.

July 21, 2019. Whole Hog Sports. <https://www.wholehogsports.com/news/2019/jul/21/natural-look-insiders-detail-razorbacks-switch-bac/>

UA: Grass replacement not needed as expected. June 30, 2022. Northwest Arkansas. Democrat Gazette. <https://www.nwaonline.com/news/2022/jun/30/ua-grass-replacement-not-needed-as-expected/>

Costly upkeep, less-than-ideal weather lead most college football stadiums to use artificial turf. Spectrum News 1. Milwaukee. Oct 29, 2023. <https://spectrumnews1.com/wi/milwaukee/news/2023/10/09/college-football-stadiums--artificial-turf--nfl>

UNIVERSITY of ARKANSAS Turfgrass Field Day. Agriculture Research and Extension Center Horticulture Field Lab Fayetteville, AR Tuesday, August 1, 2023. <https://horticulture.uark.edu/research-extension/turf/turf-education/2023-field-day-book-FINAL.pdf>

News Articles

Deal struck for soccer fields at Santa Clara County Fairgrounds. The Spotlight. Dec 6, 2023. <https://sanjosespotlight.com/deal-struck-for-san-jose-earthquakes-soccer-fields-at-santa-clara-county-fairgrounds/>

Dujanovic D. **Artificial turf temperatures too hot for young athletes? KSL investigates.** July 17, 2017. KSL. <https://www.ksl.com/article/45066889/artificial-turf-temperatures-too-hot-for-young-athletes-ksl-investigates>

DeSocio J. **Five LAUSD high schools to replace 'melting' turf on fields.** Sept 1, 2015. Fox 11. <https://www.foxla.com/news/five-laUSD-high-schools-to-replace-melting-turf-on-fields>

Dulik, Brian. **NFLPA asking teams to change all fields to natural grass.** AP News. September 20, 2020. <https://apnews.com/article/nfl-football-archive-9b34d4402f2f82ae60708605f65aa560>

ESPN. **NFL Field Surface Intel: Grass vs turf, owners, problems.** Oct 11, 2023. https://www.espn.com/nfl/story/_/id/38565107/nfl-stadium-surfaces-strategies-challenges-faqs

Litman L. **It's so hot in Texas, turf is melting cleats.** Aug 11, 2015. USA Today. <https://ftw.usatoday.com/2015/08/its-so-hot-in-texas-turf-is-melting-cleats>

Nazareth E. **Blazing heat burning shoe soles on Toronto's turf fields
Researcher found one artificial field had a surface temperature of 95 C.** CBC News. Aug 10, 2016. <https://www.cbc.ca/news/canada/toronto/summer-heat-turf-1.3714351>

Turf War: Artificial turf is replacing natural grass at many schools and parks in Montgomery County. But is it safe? Nov 18, 2019. <https://moco360.media/2019/11/18/turf-war/3/>

The Case Against Artificial Turf. Just an Awful Toll. Artificial turf is murder on football players; It causes more breaks, bruises, tears, and strains than SOD does. John Underwood, sportswriter and author. Sports Illustrated. August 12, 1985. <https://vault.si.com/vault/1985/08/12/just-an-awful-toll>

False Artificial Turf Recycling Claims Ripped: FTC Enforcement Urged to End Deceptive Turf Industry Greenwashing. PEER March 7, 2022. <https://peer.org/false-artificial-turf-recycling-claims-ripped/>

Artificial Turf – A Plague on the Earth. PEER Nov 23, 2023. <https://peer.org/commentary-artificial-turf-a-plague-on-the-earth/>

Planned turf field at IC to contain toxic chemicals. Feb 8, 2024. <https://theithacan.org/46374/sports/fronts/artificial-turf-raises-environmental-concerns/>

City Shuts Field Over Lead Concern. New York Times. Sewell Chan. Dec 24, 2008. <https://archive.nytimes.com/cityroom.blogs.nytimes.com/2008/12/24/city-shuts-playground-over-lead-concern/>

FIELDTURF TRYING TO FIX DEFECTIVE FIELDS WITH THOUSANDS OF GALLONS OF LATEX GLUE. 5/16/16. <https://www.safehealthyplayingfields.org/cost-articles-blog/2017/9/7/fieldturf-fixing-revolution-fields-with-thousands-of-gallons-of-latex-glue>

The Latest FieldTurf Issue Is Nothing 1,000 Gallons of Glue Won't Fix: The turf company that has had problems throughout San Diego and the country has another sticky situation on its hands, and has turned to dumping loads of glue on weak fields to make them stronger. April 13, 2017. <https://voiceofsandiego.org/2017/04/13/latest-fieldturf-issue-nothing-1000-gallons-glue-wont-fix/>

5 Takeaways From Our FieldTurf Investigation. Nov 18, 2016. Voice of San Diego.

https://voiceofsandiego.org/2016/11/18/5-takeaways-fieldturf-investigation/?_gl=1%2A11z7je7%2A_ga%2ANTk2MjQyNTM0LjE3MTMyNzQ1NjE.%2A_ga_XZHKKHWNYS%2AMTcxMzI3NDU2MC4xLjAuMTcxMzI3NDU2MC42MC4wLjM2MDYwNDIwMA..%2A_ga_59H3Q0N7SX%2AMTcxMzI3NDU2MS4xLjAuMTcxMzI3NDU2MS4wLjAuMA..&_ga=2.69625945.838068225.1713274561-596242534.1713274561

Part 1 Across the County, Taxpayer-Funded Turf Fields Are Falling Apart After Just a Few Years. Ashley McGlone. Nov 14, 2016. https://voiceofsandiego.org/2016/11/14/across-county-taxpayer-funded-turf-fields-falling-apart-just-years/?_gl=1%2Alpf0az%2A_ga%2ANTk2MjQyNTM0LjE3MTMyNzQ1NjE.%2A_ga_XZHKKHWNYS%2AMTcxMzI3NDU2MC4xLjEuMTcxMzI3NDYzNC42MC4wLjM2MDYwNDIwMA..%2A_ga_59H3Q0N7SX%2AMTcxMzI3NDU2MS4xLjEuMTcxMzI3NDYzNC4wLjAuMA..&_ga=2.36183273.838068225.1713274561-596242534.1713274561

https://voiceofsandiego.org/2016/11/14/across-county-taxpayer-funded-turf-fields-falling-apart-just-years/?_gl=1%2Alpf0az%2A_ga%2ANTk2MjQyNTM0LjE3MTMyNzQ1NjE.%2A_ga_XZHKKHWNYS%2AMTcxMzI3NDU2MC4xLjEuMTcxMzI3NDYzNC42MC4wLjM2MDYwNDIwMA..%2A_ga_59H3Q0N7SX%2AMTcxMzI3NDU2MS4xLjEuMTcxMzI3NDYzNC4wLjAuMA..&_ga=2.36183273.838068225.1713274561-596242534.1713274561

Part 2 The Consummate Salesman. Ashley McGlone. November 15, 2016. The Voice of San Diego. https://voiceofsandiego.org/2016/11/15/the-consummate-salesman/?_gl=1%2Ah70z0a%2A_ga%2ANTk2MjQyNTM0LjE3MTMyNzQ1NjE.%2A_ga_XZHKKHWNYS%2AMTcxMzI3NDU2MC4xLjEuMTcxMzI3NTAyNi41OS4wLjM2MDYwNDIwMA..%2A_ga_59H3Q0N7SX%2AMTcxMzI3NDU2MS4xLjEuMTcxMzI3NTAyNi4wLjAuMA..&_ga=2.92753876.838068225.1713274561-596242534.1713274561

https://voiceofsandiego.org/2016/11/15/the-consummate-salesman/?_gl=1%2Ah70z0a%2A_ga%2ANTk2MjQyNTM0LjE3MTMyNzQ1NjE.%2A_ga_XZHKKHWNYS%2AMTcxMzI3NDU2MC4xLjEuMTcxMzI3NTAyNi41OS4wLjM2MDYwNDIwMA..%2A_ga_59H3Q0N7SX%2AMTcxMzI3NDU2MS4xLjEuMTcxMzI3NTAyNi4wLjAuMA..&_ga=2.92753876.838068225.1713274561-596242534.1713274561

Part 3 Despite Failures, San Diego Unified Just Can't Quit FieldTurf. Ashley McGlone. November 16, 2016. Voice of San Diego. https://voiceofsandiego.org/2016/11/16/despite-failures-san-diego-unified-just-cant-quit-fieldturf/?_gl=1%2A7ons1i%2A_ga%2ANTk2MjQyNTM0LjE3MTMyNzQ1NjE.%2A_ga_XZHKKHWNYS%2AMTcxMzI3NDU2MC4xLjEuMTcxMzI3NTI4MS41OS4wLjM2MDYwNDIwMA..%2A_ga_59H3Q0N7SX%2AMTcxMzI3NDU2MS4xLjEuMTcxMzI3NTI4MS4wLjAuMA..&_ga=2.36710249.838068225.1713274561-596242534.1713274561

https://voiceofsandiego.org/2016/11/16/despite-failures-san-diego-unified-just-cant-quit-fieldturf/?_gl=1%2A7ons1i%2A_ga%2ANTk2MjQyNTM0LjE3MTMyNzQ1NjE.%2A_ga_XZHKKHWNYS%2AMTcxMzI3NDU2MC4xLjEuMTcxMzI3NTI4MS41OS4wLjM2MDYwNDIwMA..%2A_ga_59H3Q0N7SX%2AMTcxMzI3NDU2MS4xLjEuMTcxMzI3NTI4MS4wLjAuMA..&_ga=2.36710249.838068225.1713274561-596242534.1713274561

Part 4. How a Turf Company With High Prices and a Defective Product Cornered the SD Market. Ashley McGlone. Nov 17, 2016. Voice of San Diego.

https://voiceofsandiego.org/2016/11/17/turf-company-high-prices-defective-product-cornered-sd-market/?_gl=1%2Azlz0ja%2A_ga%2ANTk2MjQyNTM0LjE3MTMyNzQ1NjE.%2A_ga_XZHKKHWNYS%2AMTcxMzI3NDU2MC4xLjEuMTcxMzI3NTU2MC42MC4wLjM2MDYwNDIwMA..%2A_ga_59H3Q0N7SX%2AMTcxMzI3NDU2MS4xLjEuMTcxMzI3NTU2MC4wLjAuMA..&_ga=2.63522662.838068225.1713274561-596242534.1713274561

Artificial Turf Market - Forecast (2020-2025).

https://www.researchandmarkets.com/reports/5566652/artificial-turf-market-forecast-2020-2025?utm_source=GNOM&utm_medium=PressRelease&utm_code=dzsfvp&utm_campaign=1688807+-+The+Worldwide+Artificial+Turf+Industry+is+Expected+to+Reach+%247+Billion+by+2025+&utm_exec=jamu273prd

PFAS

ATSDR. Understanding PFAS Exposure and Your Body.

Jan 18, 2024. <https://www.atsdr.cdc.gov/pfas/health-effects/PFAS-exposure-and-your-body.html>

Barton K et al. **Cross-sectional associations between serum PFASs and inflammatory biomarkers in a population exposed to AFFF-contaminated drinking water.** Barton. Int J Hygiene and Environ Health. Vol 240. March 2022,.

<https://www.sciencedirect.com/science/article/abs/pii/S1438463921002200>

Ecology Center Memo on PFAS-free Synthetic Turf Standards and Testing. Nov 16, 2020.

<https://www.oakbluffsma.gov/DocumentCenter/View/5292/Ecology-Center-Jeff-Gearhart-email-Nov-16-2020>

EPA. Our Current Understanding of the Human Health and Environmental Risks of PFAS. EPA. <https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas>

Grandjean (2018). **Delayed discovery, dissemination, and decisions on intervention in environmental health: a case study on immunotoxicity of perfluorinated alkylate substances.** Environmental Health. Article number: 62 (2018)

<https://ehjournal.biomedcentral.com/articles/10.1186/s12940-018-0405-y>

Grandjean (2017) **Estimated Exposures to Perfluorinated Compounds in Infancy Predict Attenuated Vaccine Antibody Concentrations at Age 5-Years.** Grandjean P et al. J Immunotoxicity. Dec 2017. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6190594/>

Haug (2011) **Characterization of human exposure pathways to perfluorinated compounds — Comparing exposure estimates with biomarkers of exposure.** Haug LS et al. (Dust) Environment International 2011; 37: 687–693. 2011.

<https://pubmed.ncbi.nlm.nih.gov/21334069/>

Lauria (2022) **Widespread Occurrence of Non-Extractable Fluorine in Artificial Turfs from Stockholm, Sweden.** Lauria MZ et al. Environmental Science & Technology Letters 2022. Aug 9;9(8):666-672. <https://pubs.acs.org/doi/10.1021/acs.estlett.2c00260>

Marsili (2014) **Release of polycyclic aromatic hydrocarbons and heavy metals from rubber crumb in synthetic turf fields: preliminary assessment for athletes.** Marsili L et al., January 2014 J. Environ. Anal. Toxicol 5 (2). <https://www.hilarispublisher.com/open-access/release-of-polycyclic-aromatic-hydrocarbons-and-heavy-metals-from-rubber-crumb-in-synthetic-turf-fields-2161-0525.1000265.pdf>

New Jersey State Technical Memorandum on PFAS on Artificial Turf. Feb 8, 2023.
<https://dep.nj.gov/wp-content/uploads/dsr/pfas-artificial-turf-memo-2023.pdf>

PEER (2019) Toxic Forever Chemicals Infest Artificial Turf.: Processing aids that contaminate synthetic turf with PFAS may be in other plastic goods. PEER. Oct 10, 2019.
<https://peer.org/toxic-forever-chemicals-infest-artificial-turf/>

PEER (2024) PFAS in Artificial Turf Coats Players' Skin Dermal Uptake Little Examined Exposure Pathway for Toxic PFAS. PEER. March 12, 2024. <https://peer.org/pfas-in-artificial-turf-coats-players-skin/>

PEER (2024) Test results for preliminary study PFOS on hands of soccer players and coaches on artificial turf vs grass. PEER. March 6, 2024. https://peer.org/wp-content/uploads/2024/03/3_6_2024-Dermal-absorption-PFAS-AT.pdf

Sunderland E.M. et al. **A review of the pathways of human exposure to poly- and perfluoroalkyl substances (PFASs) and present understanding of health effects.** J. Expo. Sci. Environ. Epidemiol. 2019;29:131–147. doi: 10.1038/s41370-018-0094-1. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6380916/>

Szilagyi (2020) **Perfluoroalkyl substances (PFAS) and their effects on the placenta, pregnancy and child development: A potential mechanistic role for placental peroxisome proliferator-activated receptors (PPARs).** Sunderland E.M. et al. Current Enviro Health Rep. Sept 2020. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7473499/>

UMASS Lowell (2020). **Per- and Poly-fluoroalkyl Substances (PFAS) in Artificial Turf Carpet.** Toxics Use Reduction Institute. UMASS Lowell. Feb 2020.
<https://www.turi.org/content/download/12963/201149/file/TURI+fact+sheet+-+PFAS+in+artificial+turf.pdf>

USGS. Tap Water Study Detects PFAS Forever Chemicals Across the US. USGS. July 5, 2023.
<https://www.usgs.gov/news/national-news-release/tap-water-study-detects-pfas-forever-chemicals-across-us>

Zheng (2021) **Per- and Polyfluoroalkyl Substances (PFAS) in Breast Milk: Concerning Trends for Current-Use PFAS.** Environ. Sci. Technol. 2021, 55, 11, 7510–7520.
<https://pubs.acs.org/doi/10.1021/acs.est.0c06978>

Zucarro (2022) **Artificial turf and crumb rubber infill: An international policy review concerning the current state of regulations.** Environ Chall (Amst). 2022 Dec; 9.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9838222/>

EWG. New Studies Show PFAS in Artificial Grass Blades and Backing. Environmental Working Group. 2019. <https://www.ewg.org/news-insights/news/new-studies-show-pfas-artificial-grass-blades-and-backing>

Toxic Forever Chemicals Infest Artificial Turf.: Processing aids that contaminate synthetic turf with PFAS may be in other plastic goods. PEER. Oct 10, 2019. <https://peer.org/toxic-forever-chemicals-infest-artificial-turf/>

What are the health effects of PFAS? Agency for Toxic Substances and Disease Registry. <https://www.atsdr.cdc.gov/pfas/health-effects/index.html>

How “forever chemicals” might impair the immune system. April 8, 2021. <https://www.pnas.org/doi/full/10.1073/pnas.2105018118>

‘Our community has been deceived’: Turf wars mount over PFAS

By E.A. Crunden, Ariel Wittenberg | 08/03/2022. <https://www.eenews.net/articles/our-community-has-been-deceived-turf-wars-mount-over-pfas/>

PFAS in Artificial Turf Coats Players’ Skin

Dermal Uptake Little Examined Exposure Pathway for Toxic PFAS. PEER. March 12, 2024. <https://peer.org/pfas-in-artificial-turf-coats-players-skin/>

Test results for preliminary study PFOS on hands of soccer players and coaches on artificial turf vs grass. PEER. 2023. https://peer.org/wp-content/uploads/2024/03/3_6_2024-Dermal-absorption-PFAS-AT.pdf

Videos

What happens to plastic and polluting artificial turf? 2019. Documentary about the Netherlands problem with disposal of artificial turf fields. <https://www.youtube.com/watch?v=Y5o3J7uy4Tk>

Plastic Wars. Video. NPR. <https://www.pbs.org/wgbh/frontline/documentary/plastic-wars/>

Plastic People. Documentary. White Pines Production. Scientists investigate the threat of microplastics in human bodies. Journalist visits labs and undergoes testing to find plastic in home, food and body. <https://plasticpeopledoc.com>

The Plastic Problem. A PBS NewsHour Documentary. 2020. <https://www.youtube.com/watch?v=1RDc2opwg0I>

Environmental Health Impacts of Synthetic Turf and Safer Alternatives. 2022. Rachel Massey and Lindsay Pollard. <https://www.youtube.com/watch?v=mel-tIUQImY&t=11s>

Water Use

Alm, Abigail (2016) **Is Synthetic Turf Really “Greener”? A Lifecycle Analysis of Sports Fields Across the United States**, Carthage College, Kenosha, Wisconsin. May 2016.
<https://www.carthage.edu/academics/library/archives-special-collections/>

Evanylo G et al. **Reclaimed Water for Turfgrass Irrigation**. *Water* 2010, 2(3), 685-701.
<https://www.mdpi.com/2073-4441/2/3/685>

Hochmuth G et al. **MAXIMIZING THE BENEFITS OF RECLAIMED WATER FOR IRRIGATING THE LANDSCAPE AND PROTECTING THE ENVIRONMENT**. University of Florida Extension. April 2022. <https://edis.ifas.ufl.edu/publication/SS587>

Kanaan A et al. **Water Requirements for Cooling Artificial Turf**. August 2020
Journal of Irrigation and Drainage Engineering 146(10)
https://www.researchgate.net/publication/343639132_Water_Requirements_for_Cooling_Artificial_Turf

McNitt AS et al. **Temperature amelioration of synthetic turf surfaces through irrigation**. *Acta Hort.* 783:573-582. 2008.
<https://plantscience.psu.edu/research/centers/ssrc/documents/temperature-irrigation.pdf>

Moore G.M. **Urban Trees: Worth More Than They Cost**. Burnley College, University of Melbourne. The 10th National Street Tree Symposium 2009.
<https://treenet.org/wp-content/uploads/2017/06/2009-urban-trees-worth-more-than-they-cost-dreg-moore.pdf>

Water Quality and Contamination (same as in Environmental Impacts above)

Bessa F et al. **Occurrence of microplastics in commercial fish from a natural estuarine environment**. *Mar Pollut Bull.* 2018 Mar:128:575-584.
<https://pubmed.ncbi.nlm.nih.gov/29571409/>

CEH. **Notice of Violation of the Safe Drinking Water Act and Toxic Enforcement Act**. March 4, 2024. <https://ceh.org/wp-content/uploads/2024/03/2024-03-04-Notice-PFOS-in-Turffx.pdf>

Celeiro (2021) **Evaluation of chemicals of environmental concern in crumb rubber and water leachates from several types of synthetic turf football pitches.** Chemosphere. 2021 May;270:128610. <https://pubmed.ncbi.nlm.nih.gov/33121811/>

Celeiro (2018) **Determination of priority and other hazardous substances in football fields of synthetic turf by gas chromatography-mass spectrometry: A health and environmental concern.** Celeiro M et al. Chemosphere. 2018 Mar;195:201-211. <https://pubmed.ncbi.nlm.nih.gov/29268178/>

Chiba R et al. **Ingestion of rubber tips of artificial turf fields by goldfish.** Sci Rep. 2023 Jan 24;13(1):1344. <https://pubmed.ncbi.nlm.nih.gov/36693897/>

de Haan et al. **The dark side of artificial greening: Plastic turfs as widespread pollutants of aquatic environments.** Environmental Pollution. October 2023, 12209. <https://www.sciencedirect.com/science/article/pii/S0269749123010965?via%3Dihub>

Kruger O et al. (2013) **New approach to the ecotoxicological risk assessment of artificial outdoor sporting grounds.** Environmental Pollution, Volume 175. April 2013. <https://www.ncbi.nlm.nih.gov/pubmed/23337354>

Neves D et al. **Ingestion of microplastics by commercial fish off the Portuguese coast.** Neves D et al. Mar Pollut Bull. 2015 Dec 15;101(1):119-126. <https://pubmed.ncbi.nlm.nih.gov/26608506/>

OECD. Endocrine Disrupting Chemicals in Freshwater: Monitoring and Regulating Water Quality. 2023. The Organization for Economic Co-operation and Development (OECD) <https://www.oecd.org/environment/resources/policy-highlights-endocrine-disrupting-chemicals-in-freshwater.pdf>

SCVWD. **Field, Pilot, and Laboratory Studies for the Assessment of Water Quality Impacts of Artificial Turf.** Prepared for Santa Clara Valley Water District 5750 Almaden Expressway San Jose, CA 95118-3614. JUNE 2010. <https://www.valleywater.org/sites/default/files/Water%20Use%20Impacts%20of%20Artificial%20Turf.pdf>

Plastic on the pitch: Artificial turf leads to marine pollution. Sept 22, 2023. Sustainability Times. <https://www.sustainability-times.com/clean-cities/plastic-on-the-pitch-artificial-turf-leads-to-marine-pollution/>

California Coastal Commission. 2023. Memo W13.1a, dated November 30, 2023, Subject: Notice of Impending Development UCS-NOID-0002-23 (Baseball Stadium Turf) for Public Hearing and Commission Action at the December 13, 2022 <sic>, Commission Meeting. <https://documents.coastal.ca.gov/reports/2023/12/W13.1a/W13.1a-12-2023-report.pdf>

Communication from Public

Name:

Date Submitted: 06/27/2024 01:04 PM

Council File No: 24-0602

Comments for Public Posting: CF 24-0602 Please see attached PDF requesting a ban on all new and replacement artificial turf. Thank you.

Dear Finance Committee Members,

There are *many* issues of concern with artificial turf, any one of them alone giving ample reason to choose real turf instead. But the one issue I want to focus on primarily here is PFAS.

The PFAS situation as a whole is extremely complicated but when it comes to artificial turf it's not complicated at all. The artificial turf blades are manufactured with PFAS, simple. (PFAS is required for the extrusion machinery to stop the plastic gunging up.)¹ On top of that, other artificial turf field components are also testing positive for PFAS. **The only way to keep these PFAS (and microplastics) in artificial turf systems from entering our environment and our children and to avoid any subsequent astronomical investigation, remediation and litigation costs is to not install artificial turf in the first place.** For this reason a total ban is necessary. Please stop any further new installations or replacements of any artificial turf.

The following broadly addresses some of the main issues with PFAS.

What Are PFAS?

PFAS (per- and polyfluoroalkyl substances) are sometimes referred to as “forever chemicals” because of their persistence in the environment.² Some may take more than 1,000 years to break down.³ Many PFAS are Persistent Bioaccumulative Toxic substances (PBTs) meaning they persist in the environment and they bioaccumulate in the human body and other living beings⁴. So every time artificial turf is installed or replaced, the level of PFAS in the environment increases along with human exposure. PFAS are known to be detrimental to human health and some of those detrimental health effects according to the EPA are:⁵⁶

- Reproductive effects such as decreased fertility or increased high blood pressure in pregnant women.
- Developmental effects or delays in children, including low birth weight, accelerated puberty, bone variations, or behavioral changes.

¹ <https://www.newmoa.org/wp-content/uploads/2023/02/PFAS-in-Artificial-Turf.pdf>

² <https://www.turi.org/content/download/12963/201149/file/TURI+fact+sheet+-+PFAS+in+artificial+turf.pdf>

³ <https://magazine.nd.edu/stories/having-coffee-with-graham-peaslee/>

⁴ <https://www.theguardian.com/environment/article/2024/jun/22/toxic-pfas-chemicals-testes>

⁵ <https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas>

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<https://www.ewg.org/news-insights/news/2024/04/what-do-new-federal-pfas-drinking-water-standards-mean>

- Increased risk of some cancers, including prostate, kidney, and testicular cancers^{7 8}.
- Reduced ability of the body's immune system to fight infections, including reduced vaccine response.
- Interference with the body's natural hormones.
- Increased cholesterol levels and/or risk of obesity.

With regard to male fertility specifically, a meta-analysis of over 40,000 men from 1973 to 2011 (covering North America, Europe, Australia, NZ) noted a lowering of sperm count by 59%.⁹ Staying on that trajectory, half the men in these Western countries would be infertile by 2045. That's half of today's male youth population. One of the factors tied to this decline in sperm count is exposure to certain chemicals common in plastic including PFAS compounds.¹⁰ A more recent analysis incorporating another 7 years of data lowered the sperm count even further to 62.3%^{11 12} A statistic like this should be reason enough to at least think very carefully about what we are *unnecessarily* exposing our children to.

Unfortunately the general public are very much unaware of what PFAS are, what the potential health risks associated with them are or that PFAS are in artificial turf systems. The EPA recently uploaded a *very* basic PFAS explainer as part of their effort to educate the public.¹³ But it seems lacking. The Explainer states that “*Very little* of the PFAS in water can get into your body through your skin”. What is this definition of “very little”? Very little amounts over a long period is exactly the pathway for chronic toxins which PFAS are.¹⁴

Children More Vulnerable to Toxins

7

<https://cancer.illinois.edu/new-study-shows-forever-chemicals-linked-to-testicular-cancer-tumor-growth/#:~:text=New%20Study%20Shows%20Forever%20Chemicals%20Linked%20to%20Testicular%20Cancer%20Tumor%20Growth.-Apr%2024%2C%202024&text=A%20new%20paper%20published%20by.of%20esticular%20germ%20cell%20tumors.>

⁸ <https://www.mdpi.com/2305-6304/12/4/232>

9

<https://pubmed.ncbi.nlm.nih.gov/28981654/#:~:text=Wider%20implications%3A%20This%20comprehensive%20meta.Europe%2C%20Australia%20and%20New%20Zealand.>

10

https://www.epw.senate.gov/public/_cache/files/e/a/ea0ad70-3006-409e-ae2e-1e45ac629da0/02FACAE8F235E3FF7AA2E3C45043C2DD.12-15-2022-myers-testimony.pdf?fbclid=IwZXh0bgNhZW0CMTEAAR386gee0xb-Ko3WuolcYqp8hgJmWdButAnOpP9PdvZv5cm6i6a6KFpooSM_aem_ZmFrZWR1bW15MTZieXRlcw

¹¹ <https://academic.oup.com/humupd/article/29/2/157/6824414?login=false>

12

https://nypost.com/2022/11/15/sperm-counts-worldwide-have-plunged-62-in-under-50-years-study/?fbclid=IwZXh0bgNhZW0CMTEAAR0XEgEZt_egEzyqZLtFF4w_Y3101GT2Yf24odP_7EmanjObzj1ffOn9MQA_aem_AUorSHp6s6u_10DIFPH3WV08aXxcfUg7eoYSdOISe68LQPNcIkEkhM_-eFV5vTu1KwjaZCsijwMDZHuySYvdgVaR

¹³ <https://www.epa.gov/system/files/documents/2023-10/final-virtual-pfas-explainer-508.pdf>

¹⁴ <https://magazine.nd.edu/stories/having-coffee-with-graham-peaslee/>

Children are more susceptible to environmental pollution exposures than adults because of their size (they are closer to the ground) and play habits (hand to mouth) and the length of time they spend playing. And, because of their developing systems, children and youth are uniquely vulnerable to the effects of that exposure.¹⁵ Children also breathe more air, drink more water, and eat more food per kilogram of body weight than adults. This results in greater exposures per kilogram of body weight to any contaminants in the air, water, or food compared with adults.¹⁶ Vulnerability to chemicals persists through the teen years as the reproductive and nervous systems continue to develop beyond the first two decades of life. Lastly, children have more future years of life over which chronic diseases linked to the chemicals in artificial turf develop.¹⁷ Environmental pollution damage caused to children can be subtle, devastating and/or permanent, and the latency period for certain effects can be decades. It's not yet known if a mixture of chemicals could be additive or synergistic, multiplying each other's potential effects on children.

The routes of exposure for chemical absorption on an artificial turf field are ingestion, inhalation, ophthalmic absorption and dermal absorption. A recent study highlighted how PFAS on childrens' hands increased after playing on an artificial turf field.^{18 19} This study was very small but should be cause for concern and act as a catalyst for much bigger studies.

Dr Graham Peaslee on PFAS - "it's all toxic"

The extent and urgency of the PFAS problem is emphasized by Dr Graham Peaslee, Concurrent Professor of Chemistry & Biochemistry at University of Notre Dame and leading researcher of PFAS in consumer products, who describes PFAS as all "bioaccumulative" and all "persistent," and "as much as we can study, it's all toxic ... so there's no such thing as a good PFAS at this point." Dr Peaslee also said PFAS are "probably" the largest pollution problem facing the U.S. He said the cost associated with cleaning up pollutants like asbestos and dioxin are likely to "pale in comparison." Let's consider that cost a little more. It's not just the financial cost to actually clean up the water, soil and air contamination. There will be medical costs which likely will lead to litigation costs. Ethen Ostroff Law is just

¹⁵

https://www.atsdr.cdc.gov/csem/pediatric-environmental-health/why_children.html#:~:text=Increased%20vulnerability%20results%20from%20children's.especially%20susceptible%20to%20toxic%20insults.

¹⁶

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6982419/#:~:text=Infants%20and%20children%20are%20at.their%20boundless%20curiosity%20and%20oral>

¹⁷

<https://www.tapinto.net/towns/scotch-plains-slash-fanwood/articles/the-children-s-environmental-health-center-of-the-icahn-school-of-medicine-at-mount-sinai-strongly-discourages-the-installation-of-artificial-turf>

¹⁸ https://peer.org/wp-content/uploads/2024/03/3_6_2024-Dermal-absorption-PFAS-AT.pdf

¹⁹ <https://www.theguardian.com/environment/2024/mar/15/athletes-higher-pfas-levels-artificial-turf>

one law firm that is waiting in the wings ready to jump on that litigation band wagon.²⁰ All those costs stem from one thing, the human health cost. The potential “costs” of PFAS pollution from artificial turf are immeasurable.

Another point Dr Peaslee makes is that PFAS are not acute toxins. They are chronic toxins, meaning that the effects of them are from long term exposures.²¹ This means that the effects on children playing on artificial turf for years on end may not be realized for some time after (years or even decades).

According to the EPA there are now almost 15,000 PFAS.²² This number is increasing rapidly as more are discovered. (Consider that in 2020 the EPA had identified 12,039 PFAS). Along with a rise in identified PFAS, health concerns are also rising as more PFAS are studied and toxicities are realized.²³

PFAS Strategic Roadmap: EPA’s Commitments to Action (2021-2024)²⁴

The EPA recognises PFAS are huge problem and states in their roadmap : "Every level of government - federal, Tribal, state, and local - needs to exercise increased and sustained leadership to accelerate progress to clean up PFAS contamination, **prevent new contamination**, and make game-changing breakthroughs in the scientific understanding of PFAS". The Earthquakes are in partnership with the local government hence it should be your combined duty to lead the way in this respect. Let’s not forget that any PFAS are in the environment as a result of adults’ creation. It is our responsibility, as adults, to essentially turn off the tap and clean up this catastrophic mess, not contribute to it more.

The EPA’s PFAS Strategic Roadmap goes on to stipulate that textile manufacturing and landfills are two of the six leading contributors to PFAS discharges. Artificial turf *is* a textile and the great majority of it *is* landfilled at the end of its useful “life”.²⁵

As part of the Roadmap, on February 8, 2024, the EPA proposed adding nine PFAS (PFOA, PFOS, PFBS, GenX, PFNA, PFHxS, PFDA, PFHxA, PFBA) as **hazardous constituents** under the Resource Conservation and Recovery Act (RCRA). “To be listed as a hazardous constituent under RCRA, scientific studies must show that the chemical has toxic, carcinogenic, mutagenic, or teratogenic effects on humans or other life forms. EPA

²⁰

<https://ethenostrofflaw.com/artificial-turf-cancer-lawsuit/#:~:text=The%20artificial%20turf%20cancer%20lawsuit,a%20potential%20link%20to%20cancer>

²¹ <https://magazine.nd.edu/stories/having-coffee-with-graham-peaslee/>

²² <https://www.niehs.nih.gov/health/topics/agents/pfc>

²³ <https://factor.niehs.nih.gov/2020/8/papers/pfas>

²⁴ https://www.epa.gov/system/files/documents/2021-10/pfas-roadmap_final-508.pdf

²⁵ <https://peer.org/artificial-turfs-big-lie-old-fields-not-recycled/>

evaluated toxicity and epidemiology data for these chemicals and determined that these nine PFAS compounds meet the criteria for listing as a RCRA hazardous constituent.”²⁶

Furthermore, on April 10, 2024 the EPA finalized legally enforceable National Primary Drinking Water Regulations for the following PFAS, PFOA, PFOS, PFHxS, PFNA, HFO-DA (GenX) and PFBS (all of which have been found in various artificial turf components) by setting Maximum Contaminant Levels.²⁷

In summary, the new enforceable PFAS MCLs and MCLGs are as follows:

PFAS	MCL Goal	MCL	Health Based Water Concentration (HBWC)
PFOS	Zero	4.0 ppt	-
PFOA	Zero	4.0 ppt	-
GenX (HFPO-DA)	10 ppt	10 ppt	10 ppt
PFNA	10 ppt	10 ppt	10 ppt
PFHxS	10 ppt	10 ppt	10 ppt
PFBS	-	-	2,000 ppt
Mixtures Containing Two or More of Gen X, PFNA, PFHxS, and PFBS	Hazard Index of 1	Hazard Index of 1	-

28

To give parts per trillion some context:

- 4 parts per trillion is equivalent to 0.000004 parts per million
- Texas has 7 trillion square feet. 4 parts per trillion would therefore equal 28 square feet in the entire state of Texas.²⁹
- 4 parts per trillion is the equivalent of four drops of water in 20 olympic sized swimming pools.³⁰

²⁶<https://www.epa.gov/hw/proposal-list-nine-and-polyfluoroalkyl-compounds-resource-conservation-and-recovery-act>

²⁷ https://www.epa.gov/system/files/documents/2024-04/pfas-npdwr_fact-sheet_general_4.9.24v1.pdf

²⁸ <https://www.lathropgpm.com/newsroom-alerts-72747.html>

²⁹

<https://www.ewg.org/news-insights/news/2024/04/what-do-new-federal-pfas-drinking-water-standards-mean>

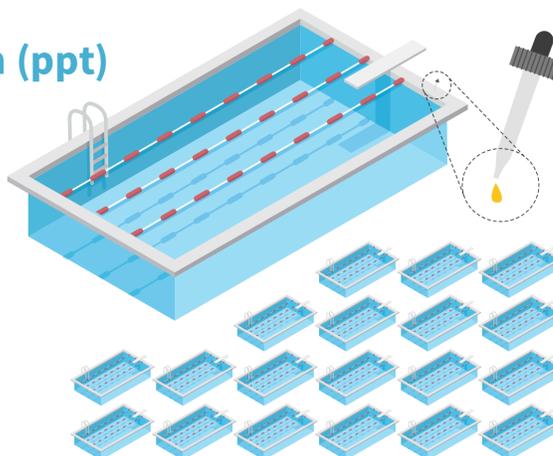
³⁰

<https://www.michigan.gov/-/media/Project/Websites/PFAS-Response/Images/PPT-Swimming-Pool.pdf?rev=5104c6f80cc74cf79fcb5e2add3c9088>

1 part per trillion (ppt)

IS EQUIVALENT TO A
SINGLE DROP OF
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20 olympic-sized
swimming pools



Also in April, the EPA designated PFOA and PFOS as hazardous substances under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).³¹ (If you've never heard of PFOA, then the Docu-movie "Dark Waters", which follows the true story of lawyer Rob Bilott taking on Dupont, may help with some understanding of the toxicity of this PFAS and industry deception.)

As you can see, the EPA is taking this matter extremely seriously. However, it admitted in the Strategic Roadmap that regulatory efforts do not extend to the other approximately 600 PFAS currently in commerce in the US which gives cause for concern, especially given that scientists are stating the more study that is done, the more harm that is found.³²

Given that there are around 15,000 PFAS, it would take hundreds, if not thousands, of years to assess risk for all of them which is why an international group of scientists said PFAS are so similar that they should be treated and regulated as a single chemical class, instead of individually, a proposal that could increase the efficiency and effectiveness of efforts to reduce the chemicals' harm to human health and the environment.³³ An example of the cost of not doing this is when PFOA was replaced with GenX (another PFAS) which has proved to be at least as bad, if not worse, than PFOA.³⁴ We cannot simply replace one PFAS with another unstudied PFAS with unknown risks. The fact that PFAS can change is also reason to treat and regulate PFAS as a group.

³¹ <https://www.epa.gov/pfas/key-epa-actions-address-pfas>

³² <https://factor.niehs.nih.gov/2020/8/papers/pfas>

³³ <https://factor.niehs.nih.gov/2020/8/papers/pfas>

³⁴

<https://ncnewsline.com/2021/10/26/epa-genx-far-more-toxic-that-originally-thought-could-prompt-nc-to-significantly-reduce-health-advisory-goal/#:~:text=Chemours%20and%20the%20chemical%20industry,many%20other%20types%20of%20PFAS.>

California Proposition 65³⁵

The negative effects of a few PFAS have only been proven relatively recently. The PFAS on the CA Prop 65 list (last updated December 2023) are:

Specific PFAS	Type of toxicity	Date listed
● PFOA (Perfluorooctanoic acid)	developmental -	November 10, 2017
● PFOS (Perfluorooctane sulfonate)	developmental -	November 10, 2017
● PFOS (Perfluorooctane sulfonic acid) and its salts and degradation precursors	cancer -	December 24, 2021
● PFNA (Perfluorononanoic acid) and its salts	male reproductive-	December 31, 2021
● PFOA(Perfluorooctanoic acid)	cancer -	February 25, 2022

These PFAS have already been found in various artificial turf components. In fact, on May 10, 2024, the Center for Environmental Health (CEH) served Home Depot and Lowes a 60 day notice for violating CA Proposition 65 regarding PFOS in several of their artificial turf products.³⁶

More PFAS will inevitably be added. What happens when these PFAS are added and any artificial turf fields in the Fairgrounds are found to contain those PFAS? You “may” get a free pass legally for any fields that are already installed, but does that give you a free pass with our children’s health? Or, will the Fairgrounds be like some schools were in New Jersey in 2012, when extremely unsafe levels of lead were found in artificial turf fields. At that time only 5 of 50 schools allowed their fields to even be tested for lead.³⁷ 45 refused. Basically, it seemed school funds took priority over children’s health. We can’t have this happening again with any type of PFAS (and remember, there are thousands) or any other chemical for that matter.

Synergistic Effects

When PFAS themselves are combined or mixed with microplastics, lead and any other chemicals found in artificial turf systems there are added human health concerns due to the potential synergistic effects of toxins when they are mixed together. Any effects can be exacerbated by years of cumulative exposures. (Recall Dr Peaslee states PFAS are chronic toxins.) The Environment & Human Health Inc. (EHHI) states in a report that: “Chemicals can sometimes act together to cause cancer, even when low-level exposures to individual chemicals might not be cancer causing, or carcinogenic.” This finding was the result of an international task force of 170 cancer scientists known as the Halifax Project.³⁸ So, even if individual chemicals are below required limits or are even deemed negligible in artificial turf,

³⁵ <https://oehha.ca.gov/media/downloads/proposition-65//p65chemicalslist.pdf>

³⁶ <https://oag.ca.gov/system/files/prop65/notices/2024-01833.pdf>

³⁷ <https://peer.org/lead-limits-needed-on-tire-crumb-playgrounds/>

³⁸ <https://www.ehhi.org/newturf-release.php>

what happens when different “acceptable” and/or “negligible” chemical amounts are put together? This has yet to be studied and until it is, artificial turf cannot be deemed safe. Add to this the fact that developing children are also much more vulnerable to any of these potential chemical interactions and toxic effects and there is even greater cause for concern. The synergistic effect of exposure to multiple PFAS and other chemicals will likely take years or even decades to be realized. We can’t allow another “lead”, “asbestos” or “smoking” scenario at the expense of our children’s health.

PFAS in Artificial Turf

PVDF HFP (a PFAS) has been named as the PFAS used in the manufacturing of artificial turf.³⁹ It’s also worth noting that Dr Peaslee has stated that in order to make PVDF HFP other PFAS are used.⁴⁰ PVDF HFP, and any other PFAS present, has the potential to leach off the artificial field components for the rest of the field’s useful and unuseful life, exposing the environment and players to their toxicity even if in the most minute amounts (more on minute amounts later). As the situation stands right now, the only way to guarantee no health risk or environmental pollution risk from artificial turf is to not install it. It’s really that simple. PFAS are a huge environmental concern and by extension a human health concern.

Kevin mentioned that the EPA doesn’t deem the PFAS (PVDF HFP) used in the manufacturing process as a PFAS. I have never heard this and I have found no verification of this. What I have heard some say is that PVDF HFP is not a PFAS of “concern”. But, as with many PFAS, PVDF HFP is perhaps not a PFAS of concern *yet*, because research is scant. The grave issues with certain PFAS have only come to light in recent years and it seems the more scientists learn the more complicated and concerning it gets. Relating this specifically to artificial turf, there is suspicion that PVDF HFP, under certain conditions, may break down to form PFOS (a very toxic PFAS).⁴¹ In fact one PVDF-HFP Safety Data Sheet dated 09/14/21 states PVDF HFP is stable **at room temperature**. (Even cork infilled fields easily reach 170F nevermind tire crumb rubber or other polymer based infills). The SDS also stated “to the best of our knowledge the chemical, physical and toxicological properties have not been thoroughly investigated”. *There was also no ecological information.*⁴²

The artificial turf industry then claims that PVDF HFP is not a PFAS of concern since it is used in the likes of cardiac stents. Is a continually degrading 80,000 square feet artificial turf field system with an approximately 40,000 lb plastic carpet⁴³ laced in PVDF HFP smothering soil and leaching into the ground and storm water and the greater environment the equivalent of extremely small life saving stents that are contained in a person’s body? This is beyond comparing apples to oranges.

³⁹ <https://oakbluffsma.gov/DocumentCenter/View/7715/Kyla-Bennett--Dec-29-2021>

⁴⁰ <https://oakbluffsma.gov/DocumentCenter/View/7715/Kyla-Bennett--Dec-29-2021>

⁴¹ <https://www.eenews.net/articles/our-community-has-been-deceived-turf-wars-mount-over-pfas/>

⁴² <https://nontoxicdovernh.wordpress.com/2021/12/11/artificial-turf-producers-admit-using-pfas/>

⁴³ <https://peer.org/artificial-turfs-big-lie-old-fields-not-recycled/>

However, PVDF HFP is not the only PFAS of concern when it comes to artificial turf. To date, a list compiled by Safe Healthy Playing Fields Inc, with information obtained from public records, has found the following PFAS present in various artificial turf components and plant based infill:

- D2-N-EtFOSAA
- D3-EtFOSA
- D9-EtFOSE
- 6:2 FTS
- 6:2 FTSA
- 7:3 FTCA
- 8:2 FTOH
- 12C2-4:2 FTS
- 13C2-6:2 FTS
- 13C2-8:2 FTS
- GenX
- D3-MeFOSA
- D3-N-MeFOSAA
- D7-N-MeFOSE
- MTP
- PFBA
- PFBS
- PFDA
- PFHpA
- PFHxA
- PFHxS
- PFNA
- PFOA
- PFOS
- PFPeA
- PFPrA
- PFTTrDA
- PMPA
- PPF acid
- PTFE
- PVDF
- R-EVE

The PFAS that are in artificial turf systems are leaching off these fields for their entire existence from manufacture, throughout use to site of disposal. If you question whether this is an issue on the field, consider that a typical warranty specifies that 50% blade loss over the warranty period (generally 8 years) is acceptable. Where do those PFAS laced micro and nano plastic blade pieces go? Given the sheer size of sports fields (around 2 acres), that is a lot of disintegrating microplastics and PFAS that end up in the environment somewhere and potentially in our children.

PFAS Concentrations and Artificial Turf

One field is said to contain between .454 to 17 kgs of PFAS.⁴⁴

Dr Graham Peaslee in a recent webinar provided a “back of the envelope” estimate (his expertise means it’s a fairly educated estimate). Taking into account the EPA regulatory limit of 4ng/kg for PFOA and PFOS, just 12 mg of PFAS leached from one soccer field per year is enough to pollute 800,000 gallons of run-off.^{45 46} This sounds innocuous BUT consider that one teaspoon is about 5,000 mgs. Then re-consider that just 12 mgs of PFAS can contaminate 800,000 gallons of water. Then consider that PVDF HFP (used in artificial turf blade manufacturing) is suspected of changing to form the very toxic PFOS.

PFAS research is ongoing, but while it’s ongoing, we should not be using our kids as guinea pigs. The same young, impressionable eyes that can absorb toxins are also watching us.

⁴⁴

<https://beyondpesticides.org/dailynewsblog/2024/03/synthetic-turf-fields-forever-chemicals-and-the-safer-alternative-organic-grass/>

⁴⁵ <https://www.youtube.com/watch?v=i8xlCA9M8hl>

⁴⁶ <https://bruceshermanforanc.org/>

We are under their microscope. So we've got to set a good example for them and care for their short and long term health as well as that of their environment. We've got to do whatever it takes to make that happen. As adults we have a duty of care to do so.

Artificial Turf Industry “PFAS Free” Claims

Be weary of artificial turf manufacturers stating their product has no PFAS which they often do. No artificial turf carpet independently tested has been found to have no PFAS. As a consumer we expect no PFAS to mean there are no PFAS in the products at all. But here's what is often behind industries' supposed no PFAS claims:

- Testing for only a hand full of PFAS (even though testing is available for around 80 now)⁴⁷
- Using tests appropriate for water and not solids
- Not testing for Total Organic Fluorine (which indicates if any of the other thousands of PFAS are present without being able to identify which specific PFAS they are).
- Not testing to high enough concentrations (parts per million rather than parts per trillion)
- Not performing the Synthetic Precipitation Leaching Procedure to more accurately assess the release of PFAS overtime as the product degrades (as it would on the field with exposure to the elements, aging, abrasion etc.)
- Claiming there are no intentionally added PFAS even though PFAS are intentionally added to the manufacturing process and come in direct contact with the product
- Using CA Proposition 65 compliance (even though this only accounts for 3 PFAS to date)
- Claiming the chemical (PVDF HFP) used in artificial turf is not a PFAS according to the EPA (A new one on me but stated by Kevin in our meeting as per his information source.)

If a manufacturer states they can *now* make a PFAS free artificial turf carpet (an admission in itself that PFAS is used) like Tencate did this year, ask the manufacturer to provide extensive, independent testing to substantiate this claim. Ask them to be transparent about their definition of PFAS free. And then get all the other proposed components that will be married into the artificial turf system tested bearing in mind that various infills and shockpads have also been proven to contain multiple PFAS.

Why does the above matter? Because only a handful of PFAS have been studied and right now the *great* majority of PFAS (thousands upon thousands) can not even be individually identified as no testing method has been developed for them yet. These thousands of PFAS are unknown quantities. Even many of the 80 or so that can now be identified through testing haven't been extensively studied, Given that the PFAS that have been studied so far

⁴⁷

<https://www.eurofinsus.com/environment-testing/resources/webinars/pfas-forensic-tools-tof-top-assay-and-non-target-analysis-part-4/>

have been found to be detrimental in some way or another this should be reason enough to not be putting *any* PFAS in our playing fields. Especially when these are unnecessary playing surfaces due to the fact that there is a viable natural alternative, that being real turf.

On the Subject of Chemicals

Artificial turf proponents often hone in on the chemicals used on turf such as pesticides and fertilizers. What they fail to mention is that for a properly managed field these concerns can be avoided. What they further fail to address is that artificial turf itself IS chemicals. It's hundreds if not thousands of chemicals when you take into account the different components that make up an artificial turf field. In reality there are around 16,000 plastic chemicals of which 4,200 are deemed hazardous of which 3,600 are unregulated.⁴⁸ Add to that, all the chemicals that can typically be used to maintain these fields. Anything from cleaners, solvents, anti-statics, biocides, pesticides, fungicides (yes these are required at times) etc. Many of these chemicals are likely stored in fluorinated plastic containers which leach PFAS into the liquid contents providing a further pathway for more PFAS to pass through these fields into the groundwater and greater environment. Even if every component of artificial turf truly contained zero PFAS, it is still fundamentally a *petrochemical* plastic polluting product.

“Background Levels”

If you hear someone referring to “background levels” of PFAS as justification for artificial turf that is not just flawed, it's dangerous. “Background level” *implies* that any PFAS that are already in the environment are there naturally. They are not. PFAS were not naturally occurring. They were created by man and therefore wherever they have ended up is as a result of that creation. Any more PFAS that are added to a location is only going to increase this so-called “background” level of PFAS.

PFAS and Microplastics are Everywhere?

Artificial turf proponents argue that PFAS are everywhere. If artificial turfs are not yet in the Fairgrounds then PFAS and microplastics are not necessarily everywhere *yet*. Sports fields, playgrounds, school fields, are some of the few surfaces that children are exposed to that should not, and need not, be smothered in petrochemical plastics or PFAS. And it's perhaps the most important in that it's where the young developing children exert themselves with strenuous exercise and play. Providing sports fields is admirable and desperately needed, but these surfaces should also be safe and healthy, otherwise it defeats the purpose. We need to keep those surfaces real turf.

Are PFAS in many things? Absolutely. But the world is only just waking up to the PFAS issues and it's coming down to essential uses and non-essential uses. Artificial turf is a non-essential, unnecessary product. Also, many other large corporations acknowledged the issues with PFAS some time ago and have either already phased out PFAS or are being

⁴⁸ https://www.cnn.com/2024/03/14/health/toxic-unregulated-chemicals-report-wellness?cid=ios_app

proactive and removing PFAS from their products. Starbucks, McDonalds,⁴⁹ Yum Brands, Lululemon, LL Bean, Patagonia, etc.

Infills

The great majority of fields still have tire crumb rubber infill. These are tires that are too hazardous to go into landfill and yet it's OK to grind them up and put thousands upon thousands of pounds into each sports field for children to play on. (Roughly 400,000 lbs for each regulation size soccer field). As these artificial fields degrade, children are literally playing on tire crumb and tire dust. Manufacturers have been trying to come up with alternative infills but at the end of the day there is no "good" infill. All infills either have environmental, maintenance, financial, practical or health and safety issues. Infills, including natural infills like BrockFILL, are also testing positive for PFAS.

It is mind boggling to think how much money, time and resources have been invested in developing infills and carpets in trying to make plastic turf do what turf does easily. Plastic will never be real turf. Imagine if all those resources had simply been poured into real turf playing fields for kids.

BrockFILL

Since BrockFILL, a plant sourced infill and perhaps one of the least bad of the infill choices, was mentioned as a potential infill option in the meeting, I've attached a maintenance guide for this product. To achieve a comparably playable high use field, the guide indicates the amount of maintenance required will likely be similar to a turf field and notice the requirement for rinsing the field, suggesting you should also be looking at installing irrigation even if the fields are artificial turf. Brock also state there is less migration of the infill when it is hydrated.⁵⁰ The point is, why not just go with real turf.

With regard to PFAS in BrockFILL, a February 2021 report found several PFAS in BrockFILL along with indiscernible organic fluorine compounds.⁵¹ This report went on to state that if the artificial turf field was subject to specific oxidizing conditions, precursor PFAS compounds may be present that could transform into other PFAS compounds (suggesting other PFAS compounds which cannot yet be identified may occur). The report continually states "no significant risks from PFAS can be identified based on *available data and regulatory standards*", and it concludes with this final sentence. "*However, the understanding of PFAS detection and risk are limited for the vast majority of PFAS compounds, and certainty in such as assessment is not possible at this time.*" As a parent

⁴⁹

<https://toxicfreefuture.org/mind-the-store/retailers-committing-to-phase-out-pfas-as-a-class-in-food-packaging-and-products/>

⁵⁰ <https://www.brockusa.com/athletes-matter-brockfill/>

⁵¹

<https://www.npsk.org/cms/lib/MA01907678/Centricity/Domain/1356/Tetra%20Tech%20Report%20MVRHS.pdf>

and consumer this brings me little comfort knowing how much progress there has been in the discovery and research of PFAS since the report was released and the negative health and environmental effects that have been exposed as a result. Recall the EPA imposed stringent PFAS limits in drinking water just this April.⁵² Again, the point is why not just go with real turf.

If, after realizing there is no “good” infill, you decide to default to the more economical option of tire crumb rubber, consider the following: Recent studies have indicated that “the risk of cancer associated with children who play over recycled tire rubber surfaces is 10 times higher than in uncovered surfaces”.⁵³ And perhaps also consider Amy Griffin’s List.

Amy Griffin’s List⁵⁴

In 2009, soccer coach Amy Griffin (now Associate Head Coach at Washington University) began compiling a list of young soccer players she knew who played on tire crumb fields and developed cancer. The graphs below breakdown these almost 300 cases into cancer type, sport played, years of play and position played. Amy doesn’t claim this list is scientific. In fact, Amy herself is astounded that nothing more scientific has been done yet.⁵⁵ One would think this list would be reason enough for extensive research to begin and for extreme caution and precautionary measures to be taken in the meantime.

In 2017, when Amy’s list was at 53 players, the Washington State Department of Health (WSDH) released a 90 page report “debunking” this list . That WSDH report misleadingly assumed Amy Griffin’s list represented *all* sports players with cancer that had played on tire crumb. The WSDH did not consult the cancer registry or the Washington youth soccer registry to build a bigger more scientific picture, and it did not distinguish between elite and recreational soccer players who have very different amounts of time on the field. Essentially, The Washington State Department of Health’s report debunking Amy Griffin’s List was itself denounced by leading epidemiologists.⁵⁶

⁵² https://www.epa.gov/system/files/documents/2024-04/pfas-npdwr_fact-sheet_general_4.9.24v1.pdf

⁵³ <https://www.sciencedirect.com/science/article/pii/S0048969722065846?via%3Dihub>

⁵⁴

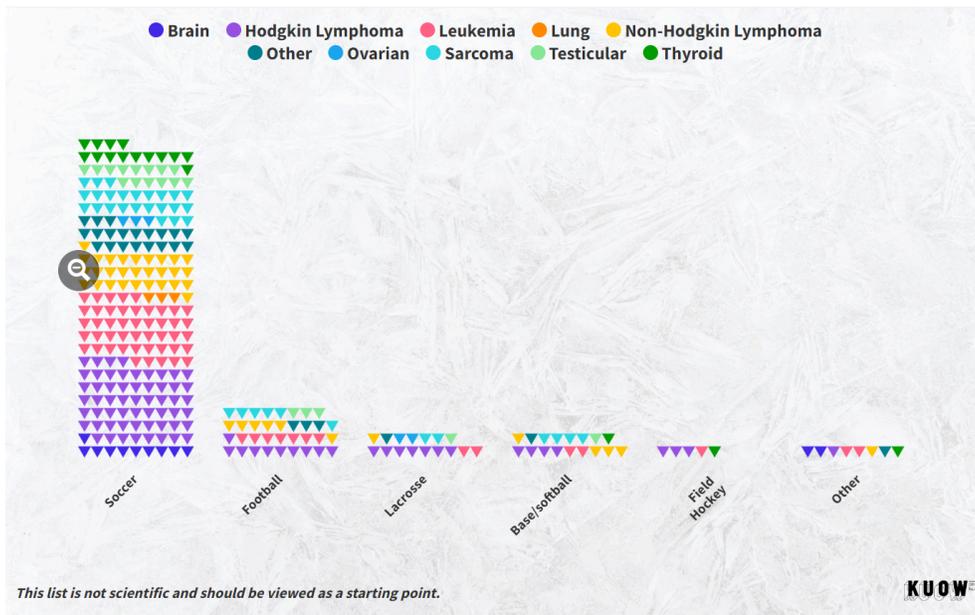
<https://www.kuow.org/stories/does-playing-soccer-on-artificial-turf-increase-cancer-risk-especially-in-kids>

⁵⁵ <https://zerowasteithaca.org/artificial-turf/>

⁵⁶ <https://zerowasteithaca.org/artificial-turf/>

← → Players were asked what **primary sport(s)** they played on crumb rubber turf.

2 of 4



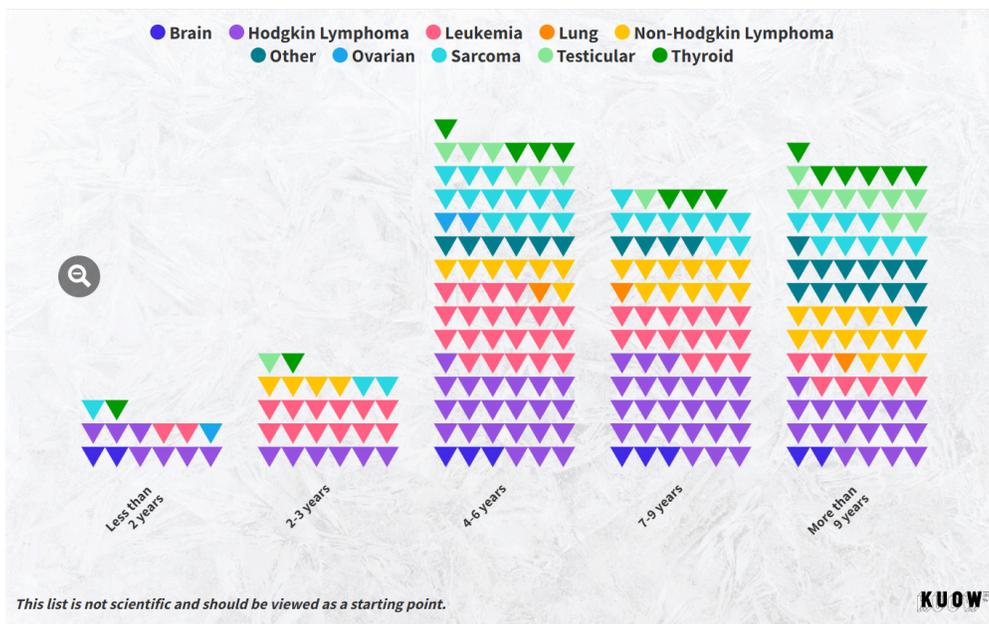
This list is not scientific and should be viewed as a starting point.

KUOW

A Flourish data visualization

← → Players were asked to estimate **how many years** they played on crumb rubber turf.

3 of 4



This list is not scientific and should be viewed as a starting point.

KUOW

A Flourish data visualization

Another assumption that has been made with Amy Griffin's List is the potential cancer and tire crumb association. What if it's not just the tire crumb? What if PFAS (or other microplastics) are contributing? The amount of resources it would take to establish this either way is phenomenal and not likely to happen any time soon. A lead, smoking or asbestos scenario is more likely, which means it will be too late. In the meantime, our kids should not be playing on these fields and essentially being guinea pigs.

Can Consumers Trust the Artificial Turf Industry?

- The artificial turf industry is a multibillion dollar industry driven by profit and growth.
- The industry has tried to hi-jack the term "turf" to represent its fake product leaving consumers confused.⁵⁷ This is where the greenwashing begins. Transparency was left behind when they ditched the original brand name "ChemGrass" (short for chemical grass) which was a product of ChemStrands a subsidiary of Monsanto (yes, *that* Monsanto).⁵⁸ It's not hard to figure out why they rebranded but a change of name does not change the fact that the product is indeed *chemical grass*.
- FieldTurf, a major leader in artificial turf products, have sold defective products in the past but, more concerningly, continued to sell these products knowing they were defective.⁵⁹⁶⁰
- The artificial turf industry misleads communities with PFAS free claims.⁶¹ Eg. testing for only 30 without testing for the presence of others,⁶² testing to low detection limits or not assessing how the components will leach PFAS over time with degradation.
- The artificial turf industry will argue there are no "intentionally added" PFAS in their products even though they know PFAS are intentionally added to the manufacturing process and will remain in the end product.
- The artificial turf industry is, at present, self-regulating. So, every time we simply take them at their word, they, and their products, are left unchecked. (Products that our kids are exposed to day after day, year after year.)

⁵⁷

https://www.google.com/search?q=turf+definition&oq=turf+definition++&gs_lcrp=EgZjaHJvbWUyCggAEEUYFhgeGDkyCAgBFEUYJxg7MggIAhBFGCcYOzIHCAMQABiABDIHCAQQABiABDIHCAUQABiABDIGCAYQRRg8MgYIBxBFGEHSAQg0NTI5ajBqNKgCALACAQ&sourceid=chrome&ie=UTF-8

⁵⁸ <https://www.sciencehistory.org/stories/magazine/turf-wars/>

⁵⁹

<https://www.nj.com/middlesex/2023/08/nj-federal-judge-oks-class-action-suit-against-top-field-turf-company.html#:~:text=%E2%80%9CFrom%20the%20moment%20FieldTurf%20began.undercut%20by%20its%20own%20testing.>

⁶⁰

<https://www.nbcwashington.com/news/local/turf-company-knowingly-sold-defective-unsafe-product-lawsuit-says/176687/>

⁶¹

<https://nontoxicdovernh.wordpress.com/2022/06/16/multiple-pfas-found-in-portsmouths-pfas-free-synthetic-turf-field/#:~:text=After%20the%20field%20was%20installed.their%20consultants%20rejected%20the%20evidence>

⁶²

<https://hopnews.com/where-did-the-pfas-in-hopkintons-water-come-from/#:~:text=%E2%80%9COur%20community%20has%20been%20deceived.was%20%E2%80%9Cpfas%20free.%E2%80%9D>

- Because the artificial turf industry is not regulated they can essentially hide ingredients under "confidential business information". (Which has left independent scientists and researchers having to waste consumer money, time and resources reverse discovering PFAS in artificial turf.)
- The artificial turf industry has fought regulation. The Synthetic Turf Council (STC) fought to have artificial turf removed from the CA Department of Toxic Substances Control's 2021-23 Priority Product Work Plan for the CA DTSC's independent study and potential regulation. The STC did not succeed, and artificial turf is currently being analyzed by the CA DTSC which is likely to lead to regulation. Will fields currently installed meet future regulations and be safe for our children and their environment?
- The consultant that the STC hired to help fight this study and regulation by the CA DTSC is the same consultant brought in by the artificial turf industry (Verde Design) to school district board meetings to allay any fears of artificial turf safety. Conflict of interest?
- The artificial turf industry denied PFAS were used in their products for the longest time⁶³ even when independent testing proved PFAS were in the plastic carpets as reported on October 8, 2019 by Dr Kyla Bennett (Director of Science Policy - Public Employees for Environmental Responsibility (PEER) and previously employed at Environmental Protection Agency (EPA)).⁶⁴ Eventually the industry had to admit PFAS were used as an extrusion aid in the blade manufacturing process. (More on that later.)
- Documents from 3M (a PFAS manufacturer) recommend up to *1,000 parts per million* of such PFAS compounds to aid in the type of processing which is used for the artificial turf blades.⁶⁵ (that's 1,000,000,000 parts per trillion)
- The artificial turf industry fought California Assembly Bill 1423, which would have limited PFAS in artificial turf systems and protected our children. The bill passed through legislature but was vetoed by Governor Newsom in 2023, not because he didn't agree with it but because it didn't incorporate regulatory oversight. So the matter was passed to the CA Department of TOXIC Substances Control since they are already studying artificial turf with a mind to regulation. Whether through another Bill or the CA DTSC, regulations are coming. What if products don't meet these regulations? Regulations may give presently installed fields an "out" but does that change the fact that you may potentially have fields that are deemed unsafe for our children?
- Even the artificial turf PFAS limit of 20 parts per million (ppm) proposed in AB1423 is high and equates to 20,000,000 parts per trillion (ppt). For some PFAS, harm can

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<https://www.cityofportsmouth.com/sites/default/files/2020-03/MET%20PFAS%20Statement%20Fieldturf.pdf>

⁶⁴ <https://peer.org/toxic-forever-chemicals-infest-artificial-turf/>

⁶⁵ <https://www.eenews.net/articles/our-community-has-been-deceived-turf-wars-mount-over-pfas/>

occur with as little as 4 ppt (0.000004 ppm) which is the amount that the EPA is now enforcing for PFOA and PFOS in drinking water.

- An artificial turf industry lobbyist (speaking on behalf of the Synthetic Turf Council), in attempting to increase the AB1423 proposed PFAS limits for artificial turf to 100 ppm, referred to “environmental” PFAS in the same way that the industry refers to “background” PFAS as a way to mislead the government members and downplay the PFAS content of artificial turf products.
- Not only was the lobbyist pushing for higher concentrations of PFAS in AB1423 but he was also trying to push the starting dates out, stating there was not time for the industry to find suitable PFAS replacements. Firstly, they’ve had decades to be proactive about this and secondly, that was an admission of the very PFAS content and levels that they had denied for so long.
- To defend their own use of PFAS the artificial turf industry argues that PFAS are in many things. This is not justification to pollute unnecessarily. The broader PFAS issue has only recently come to light and the hammer is coming down on all polluters. (And lawsuits are stacking up in all directions.)
- Industry falsely claims the products are recycled. There is no evidence artificial turf is truly recycled at scale. Some is repurposed but the great majority is landfilled or burnt (burning is not recycling and creates air pollution). So every installed field will release PFAS and plastic pollution throughout its hundreds of years of unuseful existence as well.
- Even if artificial turf was recycled, this would be recycling and potentially increasing the load of any PFAS content in the products that result from each subsequent round of manufacturing.
- An artificial turf consultant stated that the PFAS they use in manufacturing, PVDF-HFP, is harmless and stable but there is suspicion that PVDF-HFP may change into a harmful PFAS (PFOS) with UV exposure. And we know from the Safety Data Sheet it is only stable at room temperature.⁶⁶
- A letter from FieldTurf dated October 25, 2019, promised the Portsmouth City Council that their products were “free of PFAS, PFOS and fluorine”. But, AFTER installation, it was discovered they were not. Why did FieldTurf mislead consumers and claim PFAS free when FieldTurf knew full well what consumers meant by PFAS free and they knew PFAS was used in the manufacturing process?
- On November 8, 2021, whilst one artificial turf industry hired consultant was telling the Los Gatos Union School District Board and community the PFAS issue was “not real, it’s not an issue” another on the east coast was finally admitting for the first time (maybe accidentally?) that PFAS were used in the blade manufacturing process.
- Is it a coincidence then that, after the November 8, 2021 disclosure by Dr Green, the German manufacturer released Safety Data Sheets in December 2021 confirming PVDF-HFP was used in manufacturing.⁶⁷ These SDS’s were actually dated

⁶⁶ <https://nontoxicdovernh.wordpress.com/2021/12/11/artificial-turf-producers-admit-using-pfas/>

⁶⁷ <https://nontoxicdovernh.wordpress.com/2021/12/11/artificial-turf-producers-admit-using-pfas/>

08/21/2018 and 05/28/19 (originally 07/16/18 for the latter), ie. well before the manufacturers eventual admission.

- The artificial turf industry greenwashes their own products while hinging on, and exaggerating natural grass issues of the past. Whilst artificial turf has developed over time, so have real turf types, management practices and technologies. The difference is that developments in artificial turf usually means even more chemicals.
- Once the artificial turf industry gets a foot in the door it's nearly impossible to get it out. Consumers get trapped into replacements every 8 to 10 years at prices dictated by industry. When trying to convert back to turf, the industry will emphasize the cost, the amount of trucks required to remove everything, and the effort required to remediate the soil. All those trucks and work are required in reverse to install artificial turf in the first place and yet this is never emphasized when industry is promoting their own product. Why not just avoid all the truck loads and effort, avert worry and litigation risks and leave the soil with real turf?

Synthetic Turf Council (STC) and the value of the Federal Research Action Plan (FRAP) report on Tire Crumb Rubber

This year in April, the EPA released Part 2 of a Federal Research Action Plan (FRAP) report studying Recycled Tire Crumb Rubber Exposure Characterisation. The Synthetic Turf Council (STC) jumped on this report claiming it verified that artificial turf was safe. Melanie Taylor, President and CEO of the STC, stated "We thank the EPA for the dedication and time that went into this report and are pleased to see it reaffirms what other research has shown: synthetic turf and its system components are safe," Any uninformed consumer could easily believe this, but it's simply not true. Here are just a few points about Part 1 and Part 2 of the report:

- Both parts were a study of tire crumb rubber only (NO other components or infills)
- Part 1, (just the Tire Crumb Rubber Characterization part) released in July 2019, only studied tire crumb rubber to F140 degrees. (Wholly insufficient given artificial fields with tire crumb rubber easily reach F180 degrees an average day and F200 and over on a hot day.)
- Part 1 did not take into account that children have higher exposures and are uniquely vulnerable to even low levels of toxins
- The study itself stated: *"What is this report and what is it not... Part 1 provides tire crumb rubber characterization research results that provide greater insight into potential human exposure to chemicals present in the material. Neither Part 1 nor Part 2 of this study, separately or combined, will constitute a human health risk assessment of playing on synthetic turf fields with tire crumb rubber. The results of the research described in the final versions of both Part 1 and Part 2 of this study can inform future risk assessments."*
- What Dr Kyla Bennett, PEER had to say about Part 1,

“Unfortunately, this report is just the latest example of EPA abdicating its public health responsibilities.”⁶⁸

- Part 2, the Exposure Characterization, only studied a few chemicals
- Part 2 only had a very small subject pool (which I believe did not include small children).
- Jeff Gearhart of the Ecology Center stated Part 2 of the study basically admits to not doing what it set out to do. Deep within Part 2 of the study it states:
 "the data was not adequate to support exposure modeling approaches"
 "there was limited or no data for some of the important parameters needed to estimate exposure for athletes using synthetic fields with tire crumb rubber"
 "there are a large number of chemicals substances associated with tire crumb rubber infill that have not been included in exposure assessments. Lack of certainty and identification of many of these chemicals and lack of measurements inhibit a more complete cumulative exposure assessment"
- **NO PFAS were analyzed in either Part 1 or Part 2 of the study.** (The FRAP study itself was requested by the Obama administration in 2016 which was before PFAS were discovered in artificial turf by Jeff Gearhart and Dr Kyla Bennett in 2019. Part 1 was also released before the PFAS discovery.)

Unfortunately, what seems to be consistently overlooked by artificial turf proponents and decision makers are all the environmental and health benefits that well maintained (ideally organically managed) real turf fields provide. Properly maintained real turf:

- **Provides equitable access to healthy fields for 1000's of athletes**
- **Naturally cools environment by evapotranspiration**
- **Produces oxygen and improves air quality**
- **Reduces pollution by sequestering carbon**
- **Cleans air by trapping dust/dirt/pollen**
- **Reduces glare and light reflection**
- **Absorbs sound**
- **Filters stormwater**
- **Reduces flooding**
- **Breaks down organic chemicals**
- **Breaks down organic matter reducing thatch**
- **Stabilizes soil and reduces erosion with root system**
- **Facilitates biodiversity over and under ground**
- **Reduces risk of heat, non-contact, and concussion injuries**
- **Promotes wellness - calms the mind, reduces stress induced muscle tension**
- **Builds an understanding and appreciation of nature**

⁶⁸ <https://peer.org/epa-fumbles-artificial-turf-science/>

- **Does not leach microplastics or PFAS to the environment**

Dan Sawyer, CEO of Brock, the manufacturer of BrockFILL has stated “all athletes prefer natural grass” and “natural turf will always outperform, on a pretty significant level, the safety values that you get, when you compare it to synthetic turf,”⁶⁹ AstroTurf, an artificial turf industry leader, also recognizes that real turf is the gold standard.⁷⁰ But these statements are generally meant in the context of injury and performance. What is being forgotten about is the gold standard in environmental and human health as listed above. Our kids’ health deserves this holistic gold standard.

In contrast, artificial turf pollutes water,⁷¹ soil, air, humans and wildlife for its entire existence from manufacture through use to disposal site. The more artificial turf claims it can do, the more chemicals it has. This is why, when artificial turf is being considered, it is of paramount importance to ensure that the entire artificial turf system (including the carpet blades, backing, infill, base/pad, field paint etc.) is tested correctly and comprehensively to prove no PFAS are present in order to ensure our children and their environment will not be exposed to PFAS unnecessarily both now and into the future. The health of the environment and human health are intrinsically and inextricably, This fact is inescapable. And when it’s realized that there is no PFAS free artificial turf, turf should be the only choice.

Mitigation? (Our kids are the filters!)

Various mitigation measures have been proposed over the years including filters but to date there is no viable way to deal with PFAS contamination from artificial turf. But one filter the industry has overlooked is our children. Not only are our children’s minds sponges but so are their bodies. They absorb everything through their lungs, digestive tract, skin and eyes. Our kids are also uniquely vulnerable to these chemical exposures. Installing artificial turf is intentionally making our children potential vectors for and victims of this toxic pollution.

Going forward, before even considering any artificial turf fields, please earnestly investigate the feasibility of real turf fields taking into account ALL of the “costs”. And if you are still hell-bent on installing artificial turf, please allow time to request the most comprehensive, independent PFAS testing on all proposed artificial turf components (carpet, backing, shockpad, infill, etc.) to ensure they are truly 100% PFAS free (in the true definition) and also use 100% organic plant sourced infills to reduce the petrochemical load of the field.

Does Artificial Turf “save” water?

If you hear artificial turf saves water, does it? Plastic turf won’t die without water but consider this:

⁶⁹ https://www.youtube.com/watch?v=zpm0w_qTUVU&t=77s (15:47) (5:13)

⁷⁰ <https://astroturf.com/astroturf-the-story-behind-the-product-that-revolutionized-sports-surfaces/>

⁷¹ <https://calmatters.org/environment/2023/10/california-synthetic-turf-pfas/>

- Responsibly managed artificial sports fields should have irrigation installed for safer play (cleaning, cooling, reducing friction) and to extend life of the field.
- In heat (and Santa Clara is hot) a comparably playable artificial field requires more water than a natural turf field.
- The amount of water used just to produce a regular sized soccer field is estimated to be \$7.5 million gallons.
- Plastic turf requires potable water
- Any water in the manufacture, use, final disposal place (generally landfill) of plastic turf gets contaminated with microplastics and PFAS.

Does this bigger picture suggest a water “saving”? No. And this is exactly why there should be no new or replacement installations of artificial turf. We must protect our water, soil and air in order to protect our children and future generations.

The presence of PFAS in artificial turf systems is only one chemical issue. The whole system itself is still a petrochemical plastic product with the potential to cause a whole array of environmental and human health issues. We can't forget the thousands of unregulated plastic chemicals and the fact that the artificial turf industry is allowed to hide ingredients as “confidential business information”. So, PFAS, though a massive concern on their own, are not the only concern with artificial turf. Our children shouldn't be filters for all these contaminants. Any future worry and consequences stemming from the use of artificial turf can be averted by simply choosing properly maintained (ideally organically), drought tolerant, turf fields.

Kind regards,