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March 12, 2024

RE: Recommendation to use Natural Turf Grass on Santa Clara County Fairgrounds

Dear Santa Clara County Board of Supervisors,

We understand that there is a proposal to develop a public and private soccer field complex at the Santa Clara County Fairgrounds. In the draft proposal it is our understanding that 4 of the eight soccer playing fields will be open to the public, and will be composed of artificial turf. (Spotlight. Dec 6, 2023).

The SCCMA Environmental Health Committee has carefully examined this issue and strongly recommends that you do *not* place artificial turf, but rather require all soccer fields to be natural grass turf, to benefit the health and safety of children, athletes and the environment. Furthermore, we believe that this decision should apply to all sports fields, including those in schools. Several issues are considered in this recommendation, including chemical and plastic pollution of the environment, sports injuries and the urban heat island effect created from artificial turf hardscape. As more artificial turf fields are placed, more long-term problems are being identified. In addition, much progress has been made in developing state of the art drought resistant, water conserving grass fields that are sturdy and can be used year-round in California. Short and long-term financial costs, as well as direct and indirect health costs must be weighed in this decision.

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." The law allows local governments to ban artificial turf due to well documented health concerns. 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."

We think that artificial turf, based on scientific studies, is not a sustainable alternative on sports fields or landscaping, particularly for children and the environment. Others agree, as for example, the California Coastal Commission, which rejected an artificial turf baseball field at UCSB in 2023 due to water quality impacts. Millbrae 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)

Rethinking Artificial Turf

While in the past artificial turf 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, and importantly including a *full life cycle analysis*. Indeed, artificial turf is now recognized as a global problem (Armada 2022). All municipalities and schools need to investigate and rethink any placement or replacement of artificial turf.

1) **Full Lifecycle Analysis:** The cost of a natural field is less than synthetic fields in the long run when a full lifecycle analysis is performed, especially over 10 years when a sports field is at the end of its lifespan and has to be discarded. Daviscourt (2017) performed a full life cycle analysis comparing artificial turf versus natural turf over an 8-year period, and it revealed that the cost savings significantly favored natural turf grass. The University of Arkansas came to a similar conclusion when looking at maintenance costs that include mowing, cleaning, chemical applications, replacement costs, and water use. Also, the cost for maintenance decreases exponentially when additional fields are added. The additional costs for synthetic turf are described below and can be quite significant.

2) **Hazardous Chemicals:** Artificial turf contains hazardous chemicals and heavy metals as discussed below. 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

    Moreover, Dr. Landrigan states,"Health problems from an environmental exposure can take years to develop."
    On an artificial sport field children and athletes are routinely in 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.

3) **Sports Injuries:** There is also data showing increased risks of sports injuries on artificial turf, particularly in football and soccer, as well as an elevated presence of antibiotic resistant bacterial infections. While you can find studies that show less harm, why would you put children in harms way if there were any risk? (See more about this issue below)

4) **Local Heat Islands:** The creation of local heat islands are a well-known problem on artificial fields. Temperatures can be significantly higher even under normal weather conditions due to their solar absorption and lack of evaporative cooling that natural grass has. This poses risks of burns, heat stroke and heat exhaustion, as well as making the fields unusable in certain weather conditions. With climate change this will be more of an issue for athletes and children. Record or near record heat waves were seen in the Northern Hemisphere July 2023 (Masters and Henson, Yale). The California report "Indicators of Climate Change" expects this to continue, with a significant rise in extreme heat events along with heat-related illnesses and deaths in the next 20 years. In this scenario artificial turf fields are expected to be increasingly hotter for longer periods making them less usable for more days.

5) **Disposal:** Artificial turf creates an enormous waste problem. 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 about 13,000 artificial sports fields in the U.S. Typical sports fields are about 80,000 square feet and contain about 40,000 pounds of "grass" turf along with 240,000 ± 720,000 pounds of infill according to the Synthetic Turf Council. This complex mixture of compounds is *not* recyclable and is typically sent to landfills where they continue to leach chemicals. 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. Industry advertising claims that they are recyclable has been challenged in a formal complaint (PEER 2022, York Daily Report 2019).

A Deeper Dive

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 a plastic "blades of grass", 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. Typically tire crumb rubber is used for infill. 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 sand 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 biomonitoring studies on athletes have yet to be done.

These chemicals can contaminate water supplies through runoff, as well as leaching into groundwater and soil, persisting 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 then enters 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.

a. PFAS

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 resistance and stain resistance for a myriad of commercial products from packaging to clothes, to food containers and found in cleaning products, 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 which 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 and in placental blood (ATSDR, Hall).

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).

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, made up of crushed used tires, exposes humans and ecosystems to a plethora of hazardous chemicals. 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 and 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.

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)

Silica Infill is Not Sand or "Just Dust"
Some say silica infill is just beach sand and is thus safe. Beach sand is 80 to 95% silica, however sand is composed of larger particles that do not pose a risk of pulmonary disease. 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 — 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 remarked 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 specifically recommends avoiding "Crushed crystalline silica (quartz)" in sandboxes or playgrounds. 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 to artificial turf, many questions remain about exposure to carcinogens on these fields.

2. Water 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 macroplastics. 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 macroplastic abundance." deHaan (2023), **"The dark side of artificial greening: Plastic turfs as widespread pollutants of aquatic environments**."

3. Plastic Waste

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 to 1 million pounds of infill along with 40,000 pounds of plastic (Claudio 2008). Synthetic turf fields have a lifespan of about a decade. Thereafter the material must be disposed of and typically it is landfilled. Increasingly industry is attempting to reuse or recycle their product but ultimately it is burned or chemically changed into substances that are potentially as harmful and are disposed of somewhere later, adding to planetary pollution.

4. 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. High school, college and professional athletes prefer natural grass playing fields by far, due to reduced injuries and ease of play (NFLPA, Owens, Dumas 2023). Players describe artificial turf as "sticky"

The National Football League Players Association (NFLPA) has taken a strong public stance against artificial turf fields, advocating that "NFL clubs should proactively change all field surfaces to natural grass." It's president, J.C. Tretter, cited the league's official injury reports from 2012-2018 to state his case that natural grass fields provide a much lower risk for injuries, when compared to artificial surfaces, 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." Tretter noted, "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."

Studies that confirm this:

Paliobeis (2021) this published 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 which 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 the now common injury called "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.

Other surveys of high school and collegiate trainers have shown more serious concussions when athletes play on artificial fields that have been built on a concrete foundation (Guskiewicz; Naunheim). Natural grass better absorbs physical impacts.

5. 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 first installed in the 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 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 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 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.

6. 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 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).

7. Localized Urban Heat Islands

Artificial sports fields absorb and retain heat from the sun thus create significantly higher temperatures, at times 40 to 60 degrees higher than living grass, even with moderate air temperatures. This creates significant heat risk to athletes and children using the fields.

This 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 urban heat islands can be seen from space and differentiated from natural green landscapes. 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).

Penn State Center for Sports Surface Research: 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; NPRA 2019).

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° 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)

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)

Attempts to alter turf materials to reduce surface temperatures have not been successful to date. Games can be cancelled if temperatures are too high.

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. In Santa Clara County 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.)

National Recreation and Park Association (NRPA) Guidelines for Artificial Turf: Public schools have developed heat guidelines for playing on synthetic sports fields. 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.

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

One 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.

9. Cost of Synthetic versus Natural Turf

Cities and counties are all struggling with their budget. 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 confirmed that using natural grass was cheaper in the long run (Daviscourt 2017). This 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 which 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.

Maintenance of natural grass field is more than artificial turf per year, but not by much, and much of the calculation industry notes is for initial investment in equipment (tractors, mowers, trimmers and seeders). Artificial turf needs maintenance as well with cleaning, painting, replacing infill.
Turfgrass manager Jerad Minnick 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 & park industry." He also notes that for "grass fields, the cost numbers for maintenance decreases exponentially when additional fields are added."

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.

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

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)

11. 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.

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.”

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

12. Environmental Benefits of Natural Grass

Turfgrass is a living organism and thus can provide many environmental benefits (Sports Field Management Association). It cools the surrounding areas including homes and can help control soil erosion and run off. Carbon sequestration is another benefit. It is estimated that net carbon sequestration rates in urban lawns are between 200 and 1,800 lbs of carbon per acre per year. Research modeling of carbon sequestration by lawns indicates "lawns in the United States alone can sequester between 12.5 million and 95 million tons of atmospheric carbon dioxide per year. That's equivalent to the annual emissions of between 2.4 million and 18 million typical passenger vehicles."

Sports fields compared to lawns or parks are not a net carbon sink, however, due to higher maintenance and operations. The University of Oregon has been researching this and recommends several management practices for irrigation, fertilization, and mowing which can help transform sports fields into a neutral or carbon sink while also maintaining healthy turf.

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 s are overwatered. Recycled water in some areas may contain too much salt to place on artificial turf thus fresh water is needed to irrigate these 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 for 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 aboveground 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 County fairgrounds to reverse and repair some of the damage done to ecosystems and biodiversity. (Vaughn 2010)

There are examples of natural grass stadiums that have been maintained with newer turf options such as Snapdragon Stadium in San Diego.

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 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, prevents storm water runoff of toxins and provides living carbon capture as well. 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 exposed to increasing 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. We recommend a precautionary approach for the long-term protection of the environment and public health.

Thank you for your consideration,

Dr. Gloria Wu
SCCMA President

References

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

Legislation and Policy

Senate Bill No. 54 (2022) . Plastic Pollution Prevention and Packaging Producer Responsibility Act, https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB54

CA-SB 54, 2023. 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-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 Product safety: PFAS: artificial turf or synthetic surfaces. 2023. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202320240AB1423

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]

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 References

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

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. Accessed March 2019. [Google Scholar]

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

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

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 Hygeine and Environ Health. Vol 240. March 2022,.
https://www.sciencedirect.com/science/article/abs/pii/S1438463921002200

Begier (2004) **A high-morbidity outbreak of methicillin-resistant Staphylococcus aureusamong 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/

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

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

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/

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.

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

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

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. **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]

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/

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/

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

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

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/

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/

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 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/

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 PJ **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 PJ**. 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

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

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/

Marsili L (2014) **Release of Polycyclic Aromatic Hydrocarbons and Heavy Metals from 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/

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/

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

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 (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/

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.

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 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

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/

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

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

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/

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

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

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

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 P et al. **Silica, crystalline.** 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

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

Voos JE (2019) **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

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 RB et al. **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

Weingrill RB et al. **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

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

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

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

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 G et al. **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

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

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/

Articles News & Other

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/

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

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/

Artificial Turf Components, Additives and Recycling

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.syntheticturfcouncil.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/

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.allturfmats.com/product-p/green-envirofill-12-20.htm]

PROS AND CONS OF SAND INFILL FOR ARTIFICIAL TURF. https://xgreensynthetic.com/sand-infill

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.

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.

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

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

Benefits of Natural Grass

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

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

ENVIRONMENTAL BENEFITS OF NATURAL TURFGRASS
Sports Turf Managers Association. https://www.stma.org/wp-content/uploads/2019/04/STMA-Infographc-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

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/

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

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

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

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.

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

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

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.

UCANR. University of California Agriculture and Natural Resources. **Recycled Water Use in the Landscape.** https://ucanr.edu/sites/cetest/files/55089.pdf

Cancer Question

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://btlonline.org/urgent-need-to-research-possible-link-between-artificial-turf-crumb-rubber-and-cancer/

Chemical and Plastic Exposures and Contamination

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

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

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/

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/

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

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/

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/

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/

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/

Landrigan PJ et al. (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 PJ (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 PJ. (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

Marsili L et al. **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

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.

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. **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/

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

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 P et al. **Silica, crystalline.** 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 RB et al. **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

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

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/

Climate Change

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

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-turf-cost-for-a-soccer-field/#:~:text=Artificial%20turf%20soccer%20fields%20cost,additional%20equipment%20equipment%20or%20operations

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

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/

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.

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/

Environmental and Water Quality Issues

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

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-Infographc-Environmental-Benefits-Turfgrass-Long-2-STMA-logo.pd

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

Health Effects

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. Accessed March 2019. [Google Scholar]

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

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

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/

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 A **toxicological profile of silica nanoparticles.** Toxicology Research, Volume 11, Issue 4, August 2022. https://academic.oup.com/toxres/article/11/4/565/6645393

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

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/

Silica

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 Islands

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

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/

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/

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/

Infections

Begier (2004) **A high-morbidity outbreak of methicillin-resistant Staphylococcus aureusamong 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

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 (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/

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/

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 (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/

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

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/

Voos JE (2019) **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 2023. **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 et al**. Elite players' perceptions of football playing surfaces: a mixed e□ects ordinal logistic regression model of players' perceptions**. Loughborough University Institutional Repository. 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

LLaguano Rodrigo**. NFL Teams Should Consider Changing to Grass Fields for Safety of Their Players.** Oberln Review. March 12, 2024. https://oberlinreview.org/30765/sports/nfl-teams-should-consider-changing-to-grass-fields-for-safety-of-their-players/

Legal

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

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 Hygeine and Environ Health. Vol 240. March 2022,. https://www.sciencedirect.com/science/article/abs/pii/S1438463921002200

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 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

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

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

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

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 JT et al. **Perfluoroalkyl substances (PFAS) and their effects on the placenta, pregnancy and child development: A potential mechanistic role for placental peroxisome proliferator-activated receptors (PPARs).** 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 G et al. **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 P et al (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/