Information About Crumb-Rubber Infilled Synthetic Turf Athletic Fields

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Purpose

The installation of synthetic turf athletic fields by school districts, municipal governments, colleges & universities, and professional sports organizations has become widespread throughout the U.S. Several types of artificial turf fields use crumb rubber as an infill material deposited between blades of artificial grass attached to a backing material. This document will provide information about health and safety issues related to this type of synthetic turf field.

Background

The first well-publicized use of AstroTurf, a synthetic turf for athletic fields, was at the Houston Astrodome in 1966. This first generation of synthetic turf was essentially a short pile carpet with a foam backing. Since then, design changes have resulted in a greater variety of synthetic turf athletic fields. One type of synthetic turf is fabricated using synthetic fibers, manufactured to resemble natural grass, and a base material that stabilizes and cushions the playing surface. The fibers are typically made from nylon, polypropylene or polyethylene and are connected to a backing material. The base material, also called infill, consists of one or more granular materials that are worked in between the fibers during the installation process. Commonly used base materials are granulated crumb rubber produced from used tires, flexible plastic pellets, sand, and rubber-coated sand. A combination of sand and crumb rubber is sometimes used.

Crumb rubber is produced by grinding used tires. Steel and fiber tire components are removed during the process and the rubber pellets are sorted by size. Pellet sizes ranging from about one-sixteenth to one quarter inch in diameter are used on synthetic turf. Crumb rubber is typically applied at a rate of two to three pounds per square foot of field surface.

Health And Safety Considerations

Some potential health and safety considerations related to synthetic turf have generated public concern. These include:

- Heat stress
- Injury
- Infection
- Latex allergy
- Chemical exposure

Heat Stress

Synthetic turf fields absorb heat, resulting in surface temperatures that are much higher than the temperatures of the surrounding air. In June 2002 at Brigham Young University (BYU) in Utah, the average surface temperature on a synthetic turf field was reported to be 117°F while the average surface temperatures on natural turf and asphalt were 78°F and 110°F, respectively. A maximum surface temperature of 200°F on the BYU synthetic turf field was reported. A turf specialist at the University of Missouri reported measuring an air temperature of 138°F at "head-level" height on the university's synthetic turf field on a sunny 98°F day. The surface temperature of the field was reported to be 178°F. A study conducted at Penn State University measured surface temperatures on experimental plots of nine different types of infilled synthetic turf. Temperature measurements were made on three occasions. The average air temperatures reported were 79°, 78°, and 85°F. The corresponding average surface temperatures reported for the synthetic turf plots are 120°, 130° and 146°F. The highest surface temperatures typically occur when synthetic turf is in direct sunlight and the dark fibers, used to simulate grass, absorb solar radiation. Surface temperatures have been observed to drop rapidly when cloud cover is present.

Water can be applied to synthetic turf to reduce the surface temperatures on warm days. A study at BYU found that watering synthetic turf lowered the surface temperature from 174°F to 85°F, but the temperature rose to 120°F in five minutes and to 164°F in twenty minutes. A study conducted by Penn State University on experimental synthetic turf plots examined the effect of watering synthetic turf on surface temperature. Measurements were made on three occasions. For one monitoring period, surface temperatures ranging from about 130° to 160°F were lowered initially to about 75°F, but increased within 30 minutes to temperatures ranging from about 90° to 120°F, where they remained fairly stable for the three-hour monitoring period.

The surface temperatures reported on synthetic turf fields can get high enough to reach levels of discomfort and may contribute to heat stress among users of the fields. While watering synthetic turf may temporarily reduce surface temperatures, other factors are likely to influence its effectiveness. Studies were not found that examined the role of synthetic turf in contributing to heat stress or that compared the occurrence of heat stress among athletes playing on natural turf and synthetic turf.

Because of the potential for high temperatures on infilled synthetic turf fields, it is important that people who play or work on the fields be provided with adequate warnings regarding the potential for heat stress. People should also be advised to remain hydrated and to seek relief from the heat in shaded areas. The potential for high surface temperatures warrants consideration when making decisions about installing and using a synthetic turf field.

Injury

Many factors influence the rate of sports injuries, including the type of playing surface. The many kinds of synthetic turf surfaces and changes in the turf products over the years complicate the assessment of how the playing surface affects injury rates. Other risk factors have been implicated in injury rates among athletes, in addition to the type of playing surface. These risk factors include level of competition, skill level, age, shoe type, previous injury and rehabilitation, and a number of individual physical characteristics. Published studies were reviewed that compared injury rates (*e.g.,* rate of sprains, lacerations, fractures) among athletes when playing on infilled synthetic turf and natural turf fields. Although the ability of the studies to detect differences in injury rates was limited by the small number of injuries reported, studies that account for the amount of time spent on different types of playing surfaces concluded that there were no major differences in overall injury rates between natural and infilled synthetic turf. Although some studies found some differences in specific injury types, there was no consistent pattern across the studies.

The potential for head injuries from contact with the surfaces has been assessed by determining the ability of the surfaces to absorb impacts. Tests have shown that the force of impact on asphalt surfaces is much higher than the level generally accepted to be associated with serious head injury. The force of impact on many types of natural turf and all types of synthetic turf tested are below this level.

The abrasiveness of synthetic turf fibers may contribute to the injury risk among athletes, particularly for abrasions or "turf burns." The degree of abrasiveness appears to be dependent on the composition and shape of the turf fibers. A study conducted at Penn State University suggests that synthetic turf with nylon fibers, used in older synthetic turf fields, is more abrasive than synthetic turf with other fibers such as those made from polypropylene or polyethylene.

Infection Risk

There has been some concern that infections, including methicillin-resistant Staphylococcus aureus (MRSA), may be more common among users of synthetic turf fields than users of natural turf fields. Research has been conducted examining the ability of Staphylococcus aureus (S. aureus) to survive on synthetic turf infill and fibers. Considerable variability has been found in the survival time of S. aureus on different infill and fiber types when tested under laboratory conditions in the absence of direct sunlight and high temperatures. For indoor fields, which are not subjected to direct sunlight and high temperatures, S. aureus has been found to survive on both synthetic and natural turf for multiple days after being applied. The numbers of surviving bacteria decreased over time on both surface types. The application of commercially available antimicrobial treatments, detergents or cationic surfactants greatly reduced the survival rate of S. aureus on indoor synthetic turf fields. For outdoor fields, conditions of higher temperatures and sunlight were shown to be effective disinfectants and the bacterial survival rate was much lower than the rate for indoor fields. The survival rate of S. aureus on Kentucky bluegrass, which is often used for natural turf athletic fields in the northern United States, was found to be comparable to the survival rate on synthetic turf. A microbial survey of 20 outdoor synthetic turf fields and 2 natural turf fields did not find S. aureus on any of the playing surfaces. S. aureus was found in locker room samples collected from towels, blocking pads, weight equipment, a stretching table, as well as samples collected from the hands and faces of every player tested.

While injury studies have not consistently identified differences in abrasion and laceration risks between natural and infilled synthetic turf, some types of synthetic turf may result in more skin abrasions. Abraded skin is susceptible to infection through contact with infectious agents on surfaces. Although only a few research studies have been conducted, the available data do not suggest the widespread presence of infectious agents, such as MRSA, on synthetic turf fields. Also, the available information indicates that outdoor or indoor synthetic turf surfaces are no more likely to harbor infectious agents than other surfaces in those same environments. Disease outbreak investigations conducted in response to illnesses caused by a variety of infectious agents (e.g., MRSA, Campylobacter, meningococcus, echovirus, herpes simplex virus, hepatitis virus, coxsackie virus) have not identified playing fields, either natural or synthetic, as likely to increase the risk of transmitting infections.

Skin cuts and abrasions that may result from contact with athletic fields, including both natural and synthetic fields, are susceptible to infection. Athletes and others developing skin abrasions should clean the wounds, and seek prompt medical attention for proper wound care prior to returning to competition. To reduce the chances of transmitting infectious agents such as MRSA, athletes should avoid sharing towels (on and off the field), razors, soap and other personal-care materials with others, and should properly sanitize shared surfaces such as training equipment between uses.

Latex Allergy

Natural rubber contains substances called “latex allergens,” which can cause an allergic response in some people. About 6 percent of the general population is allergic to latex. Tire rubber contains latex allergens, although at much lower levels than in latex gloves and other consumer products. People playing on synthetic turf may be exposed to latex allergens through direct contact with the skin (dermal exposure) and inhalation of small rubber particles suspended in the air.

A study conducted for the California Environmental Protection Agency tested samples of tire rubber on the skin of guinea pigs. None of the animals developed any rashes or allergic reactions from contact with the rubber.

Whether crumb rubber can cause an allergic response in people is not known. Reports of latex allergy associated with contact with crumb rubber or synthetic turf fields were not found.

Chemical Exposure

Exposure to a chemical requires contact with it. Contact with a chemical occurs in three ways: swallowing it (ingestion exposure), breathing it (inhalation exposure), or having it come in direct contact with the skin or eyes (dermal/ocular exposure). For each of these types of contact ("exposure routes") exposure only occurs if the contact with the chemical results in the chemical being absorbed into the body. Not all chemicals are readily absorbed by all routes. For complex substances containing many chemicals such as crumb rubber, the ability of a chemical to be released from the substance is an important factor in determining how much is absorbed, and therefore how much exposure actually occurs to the specific chemical.

The potential for harmful effects from exposure to a chemical depends on the amount of the chemical a person contacts, how the chemical enters the body (i.e., the route (ingestion, inhalation, or dermal/ocular) and how well it's absorbed by that route), how often contact occurs, the toxic properties of the chemical, and many other individual factors such as age, gender, general health, genetic differences, exposure to other chemicals, and lifestyle choices.

Tires are manufactured from natural and synthetic rubbers along with numerous chemical additives, including zinc, sulfur, carbon black, and oils that contain polyaromatic hydrocarbons (PAHs), volatile organic chemicals (VOCs) and semi-volatile organic chemicals (SVOCs). Because crumb rubber is manufactured from used tires, it is expected to contain the same chemicals as tire rubber.

A number of studies exploring the chemical-exposure potential of crumb rubber have involved extracting chemicals using strong acids or organic solvents under high temperature conditions. While the results of such studies provide information about the total amount of individual chemicals contained in crumb rubber, the extraction conditions are not representative of conditions in the environment or the human body. These types of studies do not accurately quantify exposure potential and, therefore, cannot be used to accurately estimate potential health risk.

The potential for ingestion exposure to the chemicals in crumb rubber by children playing on synthetic turf has been evaluated in several studies where crumb rubber was extracted under conditions designed to mimic the human digestive tract. This type of study provides a more realistic estimate of exposure potential for chemicals contained within the crumb rubber material by simulating what chemicals in the crumb rubber are likely to be released (and therefore would be available to be absorbed). None of these simulated absorption studies indicated that ingestion of crumb-rubber by children would pose a significant health risk. A controlled study that fed crumb rubber to laboratory rats for 14 days and incorporated crumb rubber into their bedding material found no signs of adverse health effects resulting from the exposures.

Crumb rubber contains zinc, and studies consistently find that zinc readily leaches from crumb rubber in greater quantities than any other substance. The concentrations of zinc leached from crumb rubber have been found to not represent a human health risk.

Several studies have assessed potential health risks resulting from inhalation exposures to chemicals contained in synthetic turf fields. Health agencies in New York State, New York City, and the State of Connecticut collected air samples on synthetic and natural turf fields during use. The air samples were analyzed for VOCs, SVOCs, and airborne particulate matter. The studies concluded that inhalation exposures resulting from playing on synthetic turf fields were insignificant, and not different from inhalation exposures on natural turf fields. The Connecticut study found that air samples collected from an indoor synthetic turf field had higher concentrations than the outdoor fields. The authors noted that other potential sources of VOCs and SVOCs were present, and that the facility did not have its exhaust system operating on the day samples were collected. The authors concluded that, based on their findings, exposure levels for indoor synthetic turf fields represented only a marginal health risk, but ventilation of indoor fields was recommended. Several earlier European studies had similar findings. An Italian study found that inhalation exposures resulting from playing on synthetic turf are negligible, and that exposures associated with motor vehicle emissions in the areas near the fields during the same time period were about ten times higher. Two studies that measured a metabolite of PAHs in the urine of soccer players after playing on synthetic turf found no measurable uptake of PAHs resulted from playing on the field.

Some types of synthetic turf fibers contain elevated levels of lead (*e.g.*, in the range of about 2,000 to 9,000 parts per million). Degradation of these fibers can form a dust that presents a potential source of lead exposure to users of the fields. The Centers for Disease Control and Prevention and the Agency for Toxic Substances and Disease Registry addressed the potential for lead exposures from synthetic turf fibers in a June 2008 Health Advisory (http://www.cdc.gov/nceh/lead/artificialturf.htm). Newer synthetic turf products are available that do not contain elevated lead levels.

In 2014, a women's soccer coach at the University of Washington compiled a list of players she knew of who were diagnosed with cancer, raising concerns about the possibility that playing soccer on artificial turf fields might increase the risk of developing cancer. In response, public health officials at the Washington State Department of Health and researchers from the University of Washington School of Public Health investigated the cases on the coaches list but did not find this to be an unusual rate of occurrence for residents of similar age in Washington State. Based on their investigation, Washington State Department of Health determined in 2017 that no further public health response was warranted at that time. A 2018 California study found no association at the county level between artificial turf field density and lymphoma incidence in adolescents and young adults. In addition, while it is well established that crumb rubber contains PAH carcinogens, multiple lines of evidence as described above indicate that they are not readily released or absorbed during athletics on these fields. Thus, a number of assessments reviewed here (see Chemical Exposures) have concluded that cancer and non-cancer risks are low.

Uncertainties

A number of studies have been conducted in the US and other countries that are quite consistent in their conclusions regarding the low potential for chemical exposure from crumb-rubber artificial turf fields. However, some uncertainty remains due to study limitations such as the small number of fields tested under a limited range of environmental conditions, limited information about effects of direct ingestion and direct contact with crumb rubber, and limited sources and ages of crumb rubber tested. New studies underway in California, and at the federal level by NTP, and USEPA/CDC/CPSC should help address these limitations and lessen uncertainty further.

Other Considerations

Several other factors may need to be considered when installing and using synthetic turf.

Costs

Costs for any given installation will depend on many site-specific factors, both for synthetic and natural turf fields. However, in general for a given set of site conditions, installation of synthetic turf tends to be more expensive than installation of natural turf, while synthetic turf fields have a longer average lifetime, have lower maintenance costs, and can be used without the rest periods required for natural turf.

Alternative Types of Infill

Manufacturers have developed several alternative materials to crumb rubber infill, including: manufactured materials such as ethylene propylene diene terpolymer and thermoplastic elastomer; Nike Grind made from recycled athletic shoes; and mineral-based and plant-derived materials such as sand, cork, and coconut hulls. Any alternative infill materials would need to be subjected to the same rigorous physical and chemical testing that crumb rubber has undergone to determine if they are preferable substitutes for crumb rubber for use as infill material. Thermoplastic elastomer, for example, has been found to release greater amounts of PAHs in water and air than does crumb rubber.

Summary of Information for Crumb-Rubber Infilled Synthetic Turf Athletic Fields

Health Concern	Finding
Heat stress	Surface temperatures on crumb-rubber infilled synthetic turf fields can reach levels of discomfort and may contribute to heat stress. This warrants consideration when making decisions about installing and using a synthetic turf field. While watering synthetic turf may briefly reduce surface temperatures, a number of factors may influence its effectiveness. People using these fields should be advised to remain hydrated and to seek relief from the heat in shaded areas.
Injury	Overall, studies have found no consistent differences in injury rates between natural and crumb-rubber infilled synthetic turf.
Infection	Skin cuts and abrasions that may result from contact with athletic fields (natural and synthetic turf) are susceptible to infection. Athletes and others developing skin abrasions should clean the wounds and seek prompt medical attention. Athletes should avoid sharing equipment, razors, towels, soap and other objects with others, because these items can spread germs.
Latex allergy	NYSDOH is not aware of cases of latex allergy resulting from contact with crumb rubber or synthetic turf fields.
Chemical exposures	Results from numerous studies suggest that the potential for chemical exposures from crumb rubber in synthetic turf is low; further studies by the federal government and California are underway to fill data gaps and decrease uncertainties.
Cancer	Analyses in California and Washington State have not found support for cancer associations with artificial turf field use; various exposure and risk assessments do not support a cancer risk.

Where Can I Get More Information?

Please email us, call us at (518) 402-7800, or mail your request to:

Center for Environmental Health
Bureau of Toxic Substance Assessment
Empire State Plaza-Corning Tower, Room 1743
Albany, New York 12237

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