Athletic Playing Fields and Artificial Turf: Considerations for Municipalities and Institutions

Municipalities, universities, schools and other institutions frequently need to make decisions about maintenance and installation of athletic playing fields. This may include choosing between natural grass and synthetic turf. Factors that may be considered include cost of installation and maintenance, number of days the field can be used, likelihood of player injuries, temperature of the playing environment, and athletes' exposure to chemicals.

The Massachusetts Toxics Use Reduction Institute (TURI) at UMass Lowell has worked with municipalities and other institutions to facilitate the adoption of turf management practices that are cost-effective and preferable for human health and the environment. This fact sheet introduces some of the considerations that are relevant to evaluating natural grass and artificial turf alternatives. TURI is also developing an alternatives assessment for sports turf, which will provide a detailed assessment of these factors.

Principles of toxics use reduction

TURI's work is based on the principles of toxics use reduction (TUR). The TUR approach focuses on identifying opportunities to reduce or eliminate the use of toxic chemicals as a means to protect human health and the environment. Projects to reduce the use of toxic chemicals often have additional benefits, such as lower life-cycle costs.

Children's environmental health

People of all ages benefit from a safe and healthy environment for work and play. However, special concerns exist for children. Children are uniquely vulnerable to the effects of toxic chemicals because their organ systems are developing rapidly and their detoxification mechanisms are immature. Children also breathe more air per unit of body weight than adults, and are likely to have more hand-to-mouth exposure to environmental contaminants than adults.[1] For these reasons, it is particularly important to make careful choices about children's exposures.

Artificial turf: chemicals in infill

Artificial turf is composed of several elements, including drainage materials, support and backing materials, synthetic fibers to imitate grass blades, and an infill that takes the place of soil. A number of concerns exist regarding chemicals in the artificial grass blades and infill. Here, we briefly review issues related to chemicals in infill. Toxic chemicals such as lead are also found in the artificial grass blades in some cases.[2]

Crumb rubber infill made from recycled tires. Crumb rubber made from recycled tires, also referred to as styrene butadiene rubber (SBR) infill, is currently the most widely used type of infill. This type of infill contains a large number of chemicals that are known to be hazardous to human health and the environment. These include polyaromatic hydrocarbons (PAHs); volatile organic compounds (VOCs); metals, such as lead and zinc; and other chemicals. Some of the chemicals found in crumb rubber are known to cause cancer.[3] Because of the large number of chemicals present in the infill, as well as the health effects of individual chemicals, crumb rubber made from recycled tires is the option that likely presents the most concerns related to chemical exposures.

Other synthetic materials. Other synthetic materials used to make artificial turf infill include EPDM rubber, thermoplastic elastomers (TPE), and Nike Grind (a proprietary rubber product made from recycled athletic shoes). These alternatives are sometimes marketed as safer alternatives. Relatively little information is available on the chemicals present in, or emitted from, these infills. Preliminary information suggests that these materials do contain some hazardous chemicals, but that they may generally pose less of a concern than crumb rubber made from recycled tires.[4] There is an urgent need for more information on these alternatives.

Mineral-based and plant-derived materials. Other materials used as infill can include sand, cork, and coconut hulls, among other materials. Again, these materials are likely to contain fewer hazardous chemicals than crumb rubber infill made from recycled tires, but the materials have not been well characterized or studied thoroughly.

Artificial turf and heat stress

In sunny, warm weather, artificial turf can become much hotter than natural grass, raising concerns related to heat stress for athletes playing on the fields.[5] Research indicates that all synthetic turf reaches higher temperatures than natural grass, regardless of the infill materials.[6]

- A report by the New York State Department of Environmental Conservation found that surface temperatures on a synthetic turf field were 35°F to 42°F higher than those on natural grass.[7]
- Another study found that the highest temperature measured on synthetic turf was 60.3°F greater than that observed on natural grass.[8]
- In another study, artificial turf fibers reached temperatures of 156°F under direct sunlight, while the crumb rubber infill reached 101°F.[9]
- Measurements taken by sports managers at Brigham Young University found that the surface temperature of synthetic turf was 37°F higher than asphalt and 86.5°F hotter than natural turf. The hottest surface temperature recorded during the study was 200°F on a 98°F day. Even in October, the surface temperature reached 112.4°F.[10]

Irrigation can lower field temperature for a short time. A study by Penn State's Center for Sports Surface Research found that frequent, heavy irrigation reduces temperatures on synthetic turf, but temperatures rebound quickly under sunny conditions.[11] Another study found that irrigation could lower temperatures by 10 to 20 degrees, for a period of at least 20 minutes.[12] Another found that irrigation lowered the surface temperature from 174°F to 85°F; however, the temperature rebounded to 164°F after 20 minutes.[13]

Heat-related illness can be a life-threatening emergency. Experts note that athletic coaches and other staff need to be educated about heat-related illness and understand how to prevent it, including cancelling sport activities when appropriate.[14]

Injuries

Injury rates can be affected by a variety of factors, including the type and condition of the playing surface as well as equipment used and type and level of sport. Studies show variable outcomes in the rates and types of injuries experienced by athletes playing on natural and on artificial turf.[15]

One particular concern is increased rates of turf burns (skin abrasions) associated with playing on artificial turf. For example, a study by the California Office of Environmental Health Hazard Assessment found a two- to three-fold increase in skin abrasions per player hour on artificial turf compared with natural grass turf.[16] These study authors noted that these abrasions are a risk factor for serious bacterial infections, although they did not assess rates of these infections among the players they studied.

Environmental concerns

Environmental concerns include loss of wildlife habitat and contaminated runoff into the environment. A study by the Connecticut Department of Environmental Protection identified concerns related to a number of chemicals in stormwater runoff from artificial turf fields. These include both metals and organic compounds. They noted high zinc concentrations in stormwater as a particular concern for aquatic organisms. They also noted the potential for leaching of high levels of copper, cadmium, barium, manganese and lead in some cases. The top concerns identified in the study were toxicity to aquatic life from zinc and from whole effluent toxicity (WET).[17] WET is a methodology for assessing the aquatic toxicity effects of an effluent stream as a whole.[18]

Current federal and state studies

A number of studies have examined the chemicals present in synthetic turf, with a particular focus on chemicals found in crumb rubber made from recycled tires. However, federal and state officials have identified a need for additional information. At the time of publication of this fact sheet, two key government studies are under way.

The California Office of Environmental Health Hazard Assessment (OEHHA), an office within the California Environmental Protection Agency, is conducting a three-year study of the potential health effects of exposure to synthetic turf as well as playground mats made from recycled waste tires. The project began in June 2015 and will be completed in June 2018. In the study, OEHHA will review the existing literature on chemicals in synthetic turf and playground mats; analyze samples of new and used synthetic turf and playground mats; develop exposure scenarios; and publish a risk assessment based on this information. OEHHA will also develop plans for a possible future study that would examine people's actual exposures through measurement of biological specimens or use of personal monitors.[19]

Three federal agencies have also recently begun a one-year assessment of potential health effects of exposure to synthetic turf. The agencies working on the study are the U.S. Environmental Protection Agency (EPA), the Consumer Product Safety Commission (CPSC), and the Agency for Toxic Substances and Disease Registry (ATSDR) within the Centers for Disease Control. Working with experts at OEHHA and elsewhere, the federal agencies will identify chemicals of concern found in crumb rubber made from recycled waste tires, as used in artificial turf fields and playgrounds; consider exposure scenarios; and identify areas for future study. The agencies will issue a draft status report by the end of 2016.[20] As background on the need for this study, the EPA website notes that, "Limited studies have not shown an elevated health risk from playing on fields with tire crumb, but the existing studies do not comprehensively evaluate the concerns about health risks from exposure to tire crumb."[21]

Natural grass

Natural grass fields can be the safest option for recreational space, by eliminating many of the concerns noted above. Natural grass can also reduce overall carbon footprint by capturing carbon dioxide. Grass fields may be maintained organically or with conventional or integrated pest management (IPM) practices. Organic turf management eliminates the use of toxic insecticides, herbicides and fungicides.

Organic management of recreational field space

Organic management of a recreational field space requires a site-specific plan to optimize soil health and minimize long-term costs. Over time, a well-maintained organic field is more robust to recreational use due to a stronger root system than that found in a conventionally managed grass field. Water needs also decrease over time. Key elements of organic management include the following steps.[22]

- **Field construction**: Construct field with appropriate drainage, layering, grass type, and other conditions to support healthy turf growth. Healthy, vigorously growing grass is better able to out-compete weed pressures, and healthy soil biomass helps to prevent many insect and disease issues.
- **Soil maintenance**: Add soil amendments as necessary to achieve the appropriate chemistry, texture and nutrients to support healthy turf growth. Elements include organic fertilizers, soil amendments, microbial inoculants, compost teas, microbial food sources, and topdressing as needed with high-quality finished compost.
- **Grass maintenance**: Turf health is maintained through specific cultural practices, including appropriate mowing, aeration, irrigation, and over-seeding. Trouble spots are addressed through composting and re-sodding where necessary.

It is important to note that organic turf management requires proper training. Conventional turf management may follow a similar protocol each year; organic turf managers make adjustments based on changing conditions.

Installation and maintenance costs: Comparing artificial turf with natural grass

In analyzing the costs of artificial vs. natural grass systems, it is important to consider full life-cycle costs, including installation, maintenance, and disposal/replacement. Artificial turf systems of all types require a significant financial investment at each stage of the product life cycle. In general, the full life cycle cost of an artificial turf field is higher than the cost of a natural grass field.

Cost information is available through university entities, turf managers' associations, and personal communications with professional grounds managers. Information is also available on the relative costs of conventional vs. organic management of natural grass.

Installation. According to the Sports Turf Managers Association (STMA), the cost of installing an artificial turf system may range from $4.50 to $10.25 per square foot. For a football field with a play area of 360x160 feet plus a 15-foot extension on each dimension (65,625 square feet), this yields an installation cost ranging from about $295,000 to about $673,000. These are costs for field installation only, and full project costs may be higher. Costs for a larger field would also be higher.

In one site-specific example, information provided by the town of Natick, Massachusetts shows that the full project budget for the installation in 2015 of a new artificial turf field (117,810 square feet), along with associated landscaping, access and site furnishings, totaled $1.2 million.[23]

For natural grass, installation of a new field may not be necessary. For communities that do choose to install a new field, costs can range from $1.25 to $5.00 per square foot, depending on the type of field selected. For the dimensions noted above, this would yield an installation cost ranging from about $82,000 to about $328,000.[24]

Maintenance. Maintenance of artificial turf systems can include fluffing, redistributing and shock testing infill; periodic disinfection of the materials; seam repairs and infill replacement; and watering to lower temperatures on hot days. Maintenance of natural grass can include watering, mowing, fertilizing, replacing sod, and other activities. In both cases, specialized equipment is needed. Communities shifting from natural grass to artificial turf may need to purchase new equipment for this purpose. According to STMA, maintenance of an artificial turf field may cost about $4,000/year in materials plus 300 hours of labor, while maintenance of a natural grass field may cost $4,000 to $14,000 per year for materials plus 250 to 750 hours of labor.[25]

Fifteen acres of playing fields in Marblehead, MA are managed organically. Annual maintenance costs are $2,400–$3,000 per 2-acre playing field, not including mowing costs. Mowing costs for a 2-acre field were estimated in 2010 to be $10,000 annually. Thus, total maintenance costs per 2-acre field are $12,400 to $13,000 annually.[26]

Natural grass maintenance: Conventional vs. organic costs. Organic turf maintenance can be cost-competitive with conventional management of natural grass. One study found that once established, an organic turf management program can cost 25% less than a conventional turf management program.[27]

Disposal/replacement. Artificial turf also requires disposal at the end of its useful life. STMA estimates costs of $6.50 to $7.80 per square foot for disposal and resurfacing.[28] Those estimates yield $426,563–$511,875 for a 65,625 square foot field and $552,500–$663,000 for an 85,000 square foot field.

Annualized costs. In 2008, a Missouri University Extension study calculated annualized costs for a 16-year scenario. The calculation included the capital cost of installation; annual maintenance; sod replacement costing $25,000 every four years for the natural fields; and surface replacement of the synthetic fields after eight years. Based on this calculation, a natural grass soil-based field is the most cost effective, followed by a natural grass sand-cap field, as shown in the table below.[29] Another study, conducted by an Australian government agency, found that the 25-year and 50-year life cycle costs for synthetic turf are about 2.5 times as large as those for natural grass.[30]

Table 1: Comparison of annualized costs	
Field type	**16-year annualized costs**
Natural soil-based field	$33,522
Sand-cap grass field	$49,318
Basic synthetic field	$65,849
Premium synthetic field	$109,013
Source: Brad Fresenburg, "More Answers to Questions about Synthetic Fields – Safety and Cost Comparison." University of Missouri.	

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