

The Problems with Artificial Turf

by Jane Conrad

Summary

Artificial turf fields pose threats to player health, the environment, and community budgets.

Players on artificial turf face health risks which appear inherent to this product. 1) Artificial turf fields become dangerously hot, causing skin injury and heat exhaustion. Despite a decade of research, the industry has failed to make them cooler. 2) Joint injuries (including ACL tears) are more common on artificial turf because of the increased traction of this surface compared to natural grass. 3) Concussion has emerged as a risk on artificial turf, requiring ongoing expenditure and active field maintenance to mitigate. 4) Players on artificial turf are also exposed to toxic dust and gases as field components abrade and heat up. Especially at high temperatures, artificial turf emits volatile organic compounds including benzothiazole and n-hexadane. Particulate matter from artificial turf includes silica, carbon black, lead, arsenic, cadmium, chromium and other heavy metals. A study by an expert on children's exposure to lead suggests children on artificial turf fields are playing in a "significant particulate cloud."

Consumers may be unaware of these risks because agencies they trust to test product safety – the U.S. E.P.A. and the Consumer Product Safety Commission – instead acted between 2003 and 2015 as the marketing department of the industry they were supposed to regulate. The turf field boom was initially promoted by the EPA as a way of confronting a waste tire disposal crisis. By 2015, faced with a cancer cluster among soccer goalies, and under Congressional investigation, the agencies no longer claimed artificial turf is safe ("Safe to play on" means something to parents that I don't think we intended to convey"), but not before thousands of fields were installed across the country.

Artificial turf has many negative impacts on the environment. An artificial turf field creates a "heat island" hotter than asphalt, off-gasses VOC's, requires removal of organic soil and trees, requires regular treatment with chemicals, disperses 7000 lbs on average of microplastics annually into the environment, prevents groundwater recharge, contributes to flooding, contributes to global warming, and as each field wears out, requires disposal of 500,000 lbs of (mostly petroleum) waste every decade.

Artificial turf is ruinous to school or municipal budgets. An artificial turf field involves steep upfront costs upon installation (\$1 million and up); routine maintenance costs similar to or greater than the cost of maintaining a grass field (\$25,000/year and up); the not-uncommon risk of 'premature failure' of the field – leading to litigation, added expense and lost playing time; and the cost of disposal every ten years (\$200,000 and up), a cost which is guaranteed to rise.

I. Health issues

A. Heat injury

Since at least 2002, when Brigham Young University released its Synthetic Surface Heat Studies, we have known that artificial turf can attain temperatures that are dangerous to player health. On a June day in Utah with an average air temperature of 81.42 degrees F between 9 a.m. and 2 p.m., artificial turf fields attained temperatures of 156 degrees, while the maximum temperature of a grass field was 88.5. Since the amount of sunlight is the primary factor determining field temperature, “even in October the surface temperature reached 112.4 degrees F” (32.4 degrees hotter than ambient temperature).¹

Since then, the industry has searched for ways to make artificial turf cooler but to little avail. A 2011 test of 11 different combinations of plastic grass fibers and infill materials concluded

“As of right now, it is obvious that there is no ‘magic bullet’ available to dramatically lower the temperature of synthetic turf. Reductions of five or even ten degrees offer little comfort when temperatures can still exceed 150 degrees F.”²

The heat effects of artificial turf threaten player health in two ways. First, skin damage can result from direct contact with the playing surface. At 122 degrees, skin injury results in less than 10 minutes. 140 degrees can cause a third-degree burn in 5 seconds, and 160 degrees destroys human tissue on contact.³ The second type of hazard players face is heat exhaustion/heat stroke from playing on a torrid surface. The risk here is real but has proved hard to measure with precision. Tools such as the weather service’s Heat Index, which advises caution starting at air temperatures of 80 degrees, do not factor in the effect of playing on top of a heat source. Parents and coaches often have been unable to anticipate the danger to players:

“On Labor Day weekend in the D.C. area, with ambient temperatures of 82F, the field surface temperature hit 164F by noon on several fields used in a busy tournament for about 1000 children, both boys and girls, ages 8-15. Those levels are known to melt plastic cleats, require tubs of water on the sidelines to cool down shoes, and create heat-related injury including heat stroke, nausea, heat exhaustion and dehydration in children and all users. It is not unusual for children players to vomit, faint, and suffer dehydration from hot conditions on the fields.”⁴

Communities have tried to cope with the excessive heat of artificial turf in two main ways:

- Watering artificial turf. This costs money and labor. Brigham Young University noted that while watering an artificial field cooled it from 174F to 85F, after 5 minutes the temperature rebounded to 120F, and after 20 minutes had reached

164F. Monitoring the field and watering it “added many dollars to the maintenance budget.” Some fields with cork-based infill can be kept “only” 20 degrees hotter than grass, but they also require watering to achieve this.⁵

- Restricting field use, or closing fields. Burlington, Massachusetts specifies that for phys ed students, only a grass surface may be used when it is 85F with 60% humidity.⁶ (Maplewood in 2018 had approximately 69 days meeting these criteria, including 28 during the school year and 41 in July and August).⁷

B. Joint injury

Artificial turf has been sold as a safer playing surface for athletes, in contrast to the bumpiness of some natural fields. However, research now shows that artificial fields are associated with a greater incidence of mechanical injury to the joints (ACL tears, etc.) than natural fields.⁸ This is caused by the very feature – greater traction – afforded by artificial turf. Where natural grass tears under conditions of stress and torque, with an artificial turf “rug” it is the human body which gives way. Catastrophic injuries result when a player tries to quickly change direction, and gets a foot stuck in the web of unyielding plastic fibers.

Professional athletes do not like artificial fields. In their opinion, playing on turf increases risk of injury and shortens athletes’ careers.⁹ In recent years in every field sport, athletes have led campaigns to remove artificial turf and re-install grass fields. College football programs are turning away from artificial turf. In 2015 The U.S Women’s soccer team fought bitterly with FIFA for the right to play World Cup matches on grass, as the men’s teams do. Two years later they succeeded, and now “the team has not played a match on artificial turf, a surface many players disdain, since 2017.”¹⁰

C. Concussion risk

Users might expect artificial turf to offer a soft playing surface. However, experience has shown that as artificial turf fields age, the “infill” material (crumbs or pellets used to hold up the plastic grass) can become tightly packed together, forming a surface that is dangerously hard. Some sports leagues now mandate “GMAX” testing of turf hardness (\$750-\$1000) before competition in order to make sure players won’t be at heightened risk of concussion. The artificial turf industry recommends buying equipment or paying a contractor to regularly “fluff up” infill material. Fields using certain newer types of infill material known to become hard (TPE fields; also, fields that are mainly sand including “corkonut” fields) require in addition the installation of a “shock pad” (added cost in 2015 of \$130,000).¹¹

D. Toxic dust and gas exposure

We have known for a long time that artificial turf contains an array of harmful compounds. These materials, when exposed to sunlight, high temperatures, freezing and thawing, and abrasion by players' feet, break down and release various types of dust to which players are exposed.

Components of artificial turf fields

What are these materials? The main type of material in artificial fields, by volume, is the infill. The most common type of field installed in the U.S. (95% of all fields) uses 450,000 pounds of infill comprised of equal amounts of 1) silica sand and 2) crumb rubber made from shredded used tires (SBR). There are also fields using "alternative infills" now on the market (5% of existing fields). Many of these employ plastic-rubber polymers which are close relatives of SBR; all use equal or greater volumes of silica sand (see discussion below).

Silica sand

The crystalline silica sand that is generally used in artificial turf infill contains silica dust. Silica dust, when inhaled, can cause cancer and silicosis (hardening of the lungs through inflammation and development of scar tissue). Tiny amounts are dangerous.¹² Silica is classified as a hazardous material by OSHA,¹³ and the American Academy of Pediatrics specifically recommends avoiding it on playgrounds. This is not beach sand, or river sand (which are in short supply worldwide).¹⁴ Standards exist for occupational exposure, but so far silica sand is unregulated in recreational settings.

SBR crumb rubber

The main components of SBR tire crumb are styrene and butadiene, both carcinogens, together with an array of vulcanizing agents, fillers (such as carbon black, which makes up 20-30% of each tire and is a carcinogen), plasticizers, fire retardants etc. SBR contains polynuclear aromatic hydrocarbons (PAHs), dioxins, furans, benzene, polychlorinated biphenyls (PCBs), and metals such as arsenic, cadmium, nickel, zinc, mercury, lead and chromium. Of the 96 chemicals found in a 2015 analysis of shredded tire material, at least 11 are carcinogens and 20 are classified as irritants. Because of their known toxicity, since 1990 many states have banned used tires from landfills.¹⁵

Preliminary studies have identified four main compounds volatilizing, or out-gassing, from tire crumbs. These include benzothiazole (a skin and eye irritant), 4-(t-octyl) phenol (irritant, destructive of mucous membranes), n-hexadane (a carcinogen), and butylated hydroxyanisole (a carcinogen, suspected endocrine toxicant, gastrointestinal toxicant, immunotoxicant and

neurotoxicant). Research established that, at temperatures easily achieved on artificial turf fields (140 degree field temperature, which can occur in bright sunlight at 80 degrees air temperature or less), these chemicals enter the vapor state and can be inhaled.¹⁶

Inadequate testing which does NOT prove safety

Despite knowing the hazardous materials used in artificial turf, over the past decades government and industry have failed to do the testing needed to assess the actual health risks to players on these surfaces. In 2017 the Environment & Human Health Institute released a devastating critique of 16 studies the artificial turf industry is “very fond of citing” and which they claim show fake turf is safe. In fact, these studies

- Show the presence of numerous heavy metals, chemicals and carcinogens in the samples tested;
- Show the extreme variability of fields, with lead levels (for example) in one field 500-1000 times that in another;
- Lack a design which would capture the volume of dust and gases, duration of exposure and multiple ways a player on the field might absorb these toxins, by breathing, ingestion, or getting it on the skin. Sample sizes are too small and the assumed duration of exposure is too brief. Further, no studies assess the effects of simultaneous exposure to multiple chemicals (for example, the consequence of inhaling an irritant as well as a carcinogen).¹⁷

A thoughtful study shows several reasons to worry

A well-designed study shows there is reason for concern. In 2009, Stuart Shalat, a research scientist at the New Jersey Department of Environmental Protection, had the crucial insight that the dust on a field is stirred up by players’ feet into their breathing zone. Testing using mobile monitors might better approximate the real-life conditions experienced by players. He collected air quality samples from instruments carried by a small robot he had invented, and a 12 year old boy, as they circulated over artificial turf fields for 1-2 hours. He found that these mobile monitors recorded levels of inhalable particulate matter and inhalable lead that were three times higher, on average, than levels simultaneously recorded on stationary monitors.¹⁸

Shalat was concerned. If the disturbance created by one 10 kg robot was sufficient to raise the inhalable lead concentration to a level half the EPA maximum, “how high could levels reach when two teams of players are actively engaged in a sporting event on such a field”? He considered it “highly likely that a significant particulate cloud can be created on the field and may persist in light wind conditions.”(p.9) Shalat expected a series of “follow on” studies would ensue. Yet to date no studies have built on his insights and methods. Why not?

We must consider that for many “stakeholders” in industry and government, this is “don’t want to know” information. Consider the resistance faced by Shalat in undertaking this research in the first place. Of the 50 New Jersey schools and municipalities he approached with an offer to be part of this free study, 45 declined. “The most common reason for not participating was the concern that if anything was uncovered it could lead to potential litigation. The next most common concern was that it might lead to the need to replace the field.”(p.5)

Dr. Shalat is an eminent scientist who developed test equipment and protocols to protect babies from lead exposure. His indignation rises off the pages of this scientific report:

“At present the economic disincentive for schools or communities to measure the presence or absence of lead contamination appears to exceed any public concern for children’s safety.” (p.9)

Federal agencies fail to test or regulate because of ties to industry

In the 1990’s, the U.S. Environmental Protection Agency faced the problem posed by growing mountains of used tires, as states increasingly banned tires from landfills. In search of solutions, in 2003 the EPA joined with rubber manufacturers and some environmental groups to form the Scrap Tire Workgroup. Somewhere along the line, the EPA lost sight of its essential role as a public agency and began using the power of the federal government to advance the interests of private industry. By 2007, a strategy outlined in the Workgroup’s marketing plan involved

...designating the EPA as the chief marketer to persistently promote the use of ground rubber while at the same time compiling and producing studies to respond to health and safety concerns over the material. Another strategy involved encouraging states to provide subsidies to cities and school districts that installed recycled tire material on playgrounds and athletic fields.¹⁹

In 2008 and 2009, the EPA and the Consumer Product Safety Commission (CPSC) put out two very limited studies which purported to address health concerns associated with artificial turf.²⁰ Although these studies were based on very small samples, methodologically flawed and limited in scope, the EPA claimed crumb rubber showed “no cause for immediate concern” and the CPSC declared artificial turf “Ok to install, ok to play on.” The artificial turf industry seized on these pronouncements to promote their products and reassure buyers. With the help of government subsidies, the industry grew rapidly – from 400 artificial turf fields in the U.S. in 2003 to 5500 in 2010 (and an estimated 12,000 today).²¹

Concerned scientists and others immediately assailed these two studies,²² which did not meet even the agencies’ own Information Quality Guidelines. From 2009 to 2013, Public Employees for Environmental Responsibility (PEER) and others repeatedly called on the agencies to either

do more and better research on the subject or else withdraw their endorsement of artificial turf. The agencies' response was to stonewall, or publicly claim to be planning research or considering enforcement actions when they were not.²³ Documents later obtained through a Freedom of Information Act lawsuit filed by PEER showed that during this period CPSC possessed "no independent information" to assess the health effects of synthetic turf – only information supplied by industry lobbyists. As the PEER director commented, "The agency appears to be captured by the industry it is supposed to regulate."²⁴

Public calls for scientific scrutiny increased in 2014 when Amy Griffin, a college soccer coach and former goalkeeper on the U.S. women's national team, identified a possible cancer cluster among her current and former students who had played on artificial turf. Of these, the majority were goalkeepers (the athletes in closest contact with the turf – those most likely to breathe, ingest and absorb it).²⁵ Called to testify before Congress (May 2015), the CPSC chairman suddenly developed "deep concerns" with the agency's 2008 "ok to install, ok to play on" press release. "Safe to play on means something to parents that I don't think we intended to convey, and I don't think we should have conveyed" he said, noting that "a political effort at the time" was behind that statement.²⁶ The EPA also quietly ceased endorsing crumb rubber products, withdrawing from the Scrap Tire Workgroup in 2014. A former EPA toxicologist commented:

"The EPA made a mistake in promoting this. This was a serious no-brainer. You take something with all kinds of hazardous materials and make it something kids play on? It seems like a dumb idea."²⁷

Under congressional directive, in August 2016 the U.S. Environmental Protection Agency, the Center for Disease Control and Prevention and the Agency for Toxic Substances and Disease Registry announced plans for a joint inquiry into "Recycled Tire Crumb Used on Playing Fields and Playgrounds." It is unknown whether this research will move forward under the Trump administration, or whether its design will be distorted by pressure from industry lobbyists. An interim report had one interesting finding: a widespread reluctance to participate in the study, with the main reason being concern about potential liability or the need to take action based on research outcomes²⁸. People do not seem to have a lot of confidence in the safety of these fields. It suggests some awareness of what has really happened here, that

"the tire crumb recycling industry, which appears 'green' in its efforts to sell millions of used tires in "repurposed" shredded form, in fact enables a direct transfer of the contamination burden of waste tires from landfills...to the play surfaces of 12,000 schools and sports centers," where ultimately local communities will pay the price.²⁹

Is “alternative infill” any safer?

There are no guarantees, and plenty of reason to be suspicious. These “new” infills seem to be chemically similar rubber-plastic compounds and/or same old silica sand, sometimes with an added plastic coating, sometimes with a small amount (a top-dressing, really) of plant-based materials. None will be tested in the CDC-EPA-ATSDR study mentioned above, which is only looking at SBR crumb rubber. In addition, the industry promoting these fields has a history of deception and disregard for product characteristics hazardous to human health (see the 2016 expose of defective fields knowingly sold by FieldTurf, especially in New Jersey).³⁰

What “alternative infills” share is 1) a “green” name (Ecofill, Geofill, Ecogreen, Geopro, etc.), 2) an inflated price tag (\$150,000 - \$500,000 over the cost of a crumb rubber field, not including maintenance costs), and 3) the capacity, like SBR fields, to inevitably degrade into dust which can be breathed and absorbed by players, and 4) the fact that, like older field components, their actual impact on human health is totally untested under real-world conditions of use.

Types of alternate infill³¹

Plastic and rubber variations

- Thermoplastic Elastomers (TPE’s) Trade names: EcoGreen, Ecomax, BionPro, FutrFill – Extruded plastic pellets made from a rubber and plastic polymer. Wide variability in quality and chemical makeup. Advertised as free of lead and zinc; often composed of ethylene, butadiene and styrene (carcinogens).
- Ethylene Propylene Diene Monomer (EPDM Rubber) – Synthetic rubber polymer that can be new or recycled material (same zinc and chromium levels in each); similar in composition to crumb rubber; wide variability in quality and formulation.
- Nike Grind – Actual composition unknown; thought to be very similar to crumb rubber, with similar chemical exposures to carcinogens and neurotoxins; may contain heavy metals. According to an industry insider, “people should not be fooled by Nike’s strong brand or let it mask the fact that the grind is not from recycled shoes but rather is the ground up rubber from whatever is left over in the manufacturing process of sneakers in China – materials which have been found to contain high concentrations of aluminum, zinc, chromium and lead.”³²

Others

- Acrylic/Polymer Coated Sand. Trade names: Envirofill—Silica sand coated in acrylic or another polymer. Envirofill product warranty admits only 70% of silica will remain encapsulated inside the plastic coating.³³

- Plant-Derived Infills (PDI's), cork fields, "corkonut". Trade names: Greenplay Corkonut, Geofill – Include any combination of the following: coconut fiber, coconut husk, coconut peat, cork, rice husks, walnut shells etc.

It should be noted that 1) most of what comprises a PDI field is NOT plant material, and 2) these fields are expensive and high-maintenance. For example:

- a) All types of artificial turf fields employ silica sand as infill. While other infill systems are typically 50% sand, plant-based infill systems contain up to 85-90% silica sand.³⁴ As noted above, silica is a carcinogen.
- b) The "shock pad" recommended for cork and sand fields is made of SBR or other plastic compounds.
- c) The purity of some "natural" fields cannot be taken for granted. The Geofill patent allows the inclusion of 10-90% resilient particulate matter, including synthetic rubber or thermoplastic elastomers.³⁵
- d) Cork fields require installing an irrigation system, since the cork surface must be kept moist; it is also noted that cork may freeze hard in winter.³⁶
- e) Cork fields may require frequent replacement, presumably because natural materials decompose quickly.³⁷ This is expensive.
- f) If natural infill does not require frequent replacement, why not? What herbicides, fungicides, preservatives or plastic coatings have been added to them to increase their longevity? For example, some types of infill (e.g. Envirofill) are coated with an antibacterial called Microban – a trade name for triclosan, which is a pesticide banned for use in soaps because of its association with hormone disruption and antibiotic resistance.³⁸ Any such treatment has the clear potential to impact both human health and eventual options for disposal of this material.

II. Environmental Issues

The contrast between natural grass fields and artificial turf can be expressed in this way:

A natural grass field is a living, sustainable system, which with good cultural practices gets better and better over time.

A grass field contributes to the environment (and the playing environment) in multiple ways:

- A grassy surface is cool; on a hot day grass cools the surroundings by releasing small water droplets into the air.³⁹

- Through photosynthesis, grass produces oxygen for players to breathe.
- Healthy soil contains microorganisms which can neutralize pollutants (bird droppings, Gatorade etc.)
- An organic grass field provides a soft surface for players to land on, in part because of the earthworms which are continually aerating and fertilizing it. In the words of Paul Sachs, in Managing Healthy Sports Fields,

Earthworms' ability to aerate soil is powers of 10 better than any mechanical system. An acre of rich soil can be home to as many as 500,000 earthworms creating as much as 250 miles of tunnels per week. There is a linear relationship between the number of earthworms living in the soil and the amount and speed of water absorption into the soil.⁴⁰

- Because of this porosity (and because humus can hold 60x its weight in water), a healthy grass field can both absorb huge amounts of rainwater AND slowly release this moisture: a) upward through grass roots and leaves into the atmosphere where it lowers temperature and improves air quality and b) downward, filtering and purifying the rainwater and recharging groundwater.
- Grass fields sequester carbon. One frequently cited study found natural turf grass had sequestered carbon at an average rate of 1072 pounds per acre per year for many decades with no sign of diminishing (which equates to removing 3934 lbs of CO₂ from the atmosphere every year).⁴¹ Thus, a grass football field of 1.59 acres sequesters 1704 lbs of carbon (C) (removing 6255 lbs of CO₂) per year; a grass soccer field of 1.78 acres sequesters 1908 lbs C (7004 lbs CO₂) per year. Research by the Rodale Institute suggests that this rate of carbon sequestration can be increased by as much as 50% using a compost-based organic regime, but not by using synthetic chemical fertilizer, which can result in net loss of carbon stored in soil.⁴²

An artificial turf field is not a sustainable system; its playability declines over time until it must be replaced in 8-10 years. Therefore its impact on the environment must be considered both a) while it is being used as a playing surface and b) after removal, when it has been discarded.

An artificial turf field negatively affects the environment in various ways:

- Artificial turf raises ambient temperatures, contributing to the “heat island” effect. Heat studies of Manhattan and the Bronx conducted by Dr. Stuart Gaffin of the Earth Institute at Columbia University found that sports turf surfaces were “among the

hottest possible for urban areas, rivaling dark roofs and fresh asphalt. Typical early afternoon surface temperatures during the summer were in the 140-160 degree F range⁴³

- The increased heat and loss of soil nutrients typically doom nearby vegetation (such as the trees encircling Ritzer Field), which in turn makes it hotter. Sometimes trees are cut down so their roots or leaves won't "harm" the artificial turf.⁴⁴ The Synthetic Turf Council states "Leafy trees should not be located next to a field."⁴⁵
- Artificial fields do not contribute oxygen, but "off-gas."⁴⁶
- Artificial fields cannot neutralize pollutants, so these fester if not cleaned off.⁴⁷
- The fields are flammable.⁴⁸
- The crumbs of infill continually migrate off the edges of the field into the surrounding environment. The volume of material contributing to microplastic pollution in this way is significant. According to Andrew McNitt, director of the Center for Sports Science at Penn State, "between 6000 and 7000 pounds of crumb rubber can come out of a field each year." Turf crumbs contain substances that are harmful to plants and highly toxic to aquatic life.⁴⁹
- The drainage capacities of artificial turf are often touted. However, these systems fail with some frequency (see the many photos of flooded fields on Synturf.org, 'Water damage'). Cork, in particular, has a "propensity to plug/affect drainage."⁵⁰
- Even when artificial turf drainage systems work as advertised, this is not necessarily a positive benefit for the surrounding environment.

"The artificial field uses an engineered sub-surface filtration system, of a scale that will locally lower the water table and deprive the soil of both water and sunlight. As the health of the living soil beneath the field diminishes, it can no longer retain water. Ken Sorvig, a researcher at the University of New Mexico, says, "When you remove the vegetation from an area so completely, you're actually contributing, in the long run, to drought."⁵¹

Unlike natural grass fields which can function as a reservoir, turf fields have no absorptive capacity – they just let all the water through at once. In a downpour, this can overwhelm the local storm water system and lead to flooding.⁵² According to the Synthetic Turf Council:

"A synthetic turf surface acts just like an impervious surface...The huge volumes of water collected by synthetic sports field drainage systems can very rarely be fed into a municipality's storm water system without some kind of flow control mechanisms and water detention structures, (such as) ponds, or else below

ground, close to or even under the playing surface , in closed tanks or stone filled trenches.”⁵³

- Artificial turf contributes to global warming. One study estimated the amount of greenhouse gases emitted during the life cycle of a football-sized synthetic field at 72.6 tons, requiring the planting of 1861 trees in order to achieve 10-year carbon neutrality.⁵⁴ However, this appears a serious underestimation of the true carbon cost of extracting, manufacturing, shipping and disposing of what is essentially a 500,000 pound petroleum product. Incineration alone (an end-of-life, “waste to energy” disposal option) generates 113 tons of CO₂ per field.⁵⁵

III. Unending financial and environmental burden

The true cost of an artificial turf field must be assessed in terms of 1) initial cost of installation, 2) recurring costs of required maintenance, 3) possible unforeseen costs arising from “premature failure” of field components, and 4) the cost of disposal.

Initial cost

The price tag for a single field hovers around the \$1,000,000 mark, with upcharges for alternative infill types, shock pads and irrigation systems. Site preparation and installation of the drainage system are a significant part of the overall cost. More difficult sites with significant slope (artificial turf fields must have less than 1% slope), a high water table such as is found at the foot of a steep hill, or required underground water detention structures, will inflate these costs. The field is expected to last 10 years before requiring replacement, but standard warranties only cover eight years.

Recurrent/Maintenance costs

Artificial turf fields have been marketed as low maintenance, but this has not proven to be the case. In addition, failure to perform (and maintain records documenting) regular field maintenance voids the product warranty.

The Synthetic Turf Council, in “Guidelines for Maintenance of Infilled Synthetic Turf Sports Fields” (p. 5-8) assumes the following operations can be performed in-house:⁵⁶

- “A maintenance person should walk the field daily, removing all waste items and airborne contaminants such as leaves and other debris. If allowed to remain on

the surface for any length of time, they will migrate into the system, inhibiting drainage and causing infill compaction.”

- Grooming the surface: “Regular brushing is an important function that must not be overlooked or neglected. Brushing helps to maintain uniform infill levels, keeps the grass fibers upright, removes debris and improves the field’s appearance.” This operation requires special synthetic fiber brushes of recommended stiffness, mounted on an approved type of tractor with particular tires suited for driving on artificial turf. The surface should be brushed in a regular pattern, but in different directions on different days, and using the correct brush height settings. Frequency depends on intensity of field use; Boston College grooms its field every two weeks.⁵⁷ Since grooming should be done year-round, as long as the field is in use, labor and equipment needs are thus about the same as required for mowing natural grass.

The Synthetic Turf Council recommends other types of annual and semi-annual maintenance for artificial turf. Some of these again mirror natural grass upkeep, including

- Decompaction, twice yearly (like deep core aeration for natural grass)⁵⁸
- Adding infill (like top-dressing with compost and other soil amendments). Replacing the 7000 pounds of infill lost annually costs at least \$7000 (\$1/lb applied, 2005⁵⁹ prices).
- Spray treatment with herbicides, pesticides, antifungal agents etc. (not part of an organic regime)

Artificial turf upkeep also requires operations that are **never** necessary with grass, such as seam repair of the plastic rug (reported as \$30 to \$70 per linear foot in 2005). This requires the services of an outside contractor, and can be a significant budget item, for example costing \$8000 in 2005 on a three-year-old field.⁶⁰

Watering artificial turf, a common practice, also adds significant expense. Cork infill requires frequent watering (presumably because otherwise it would blow away?). The required level of dampness can be achieved by using 12,000 gallons per field every three days, according to the supplier.⁶¹ Artificial turf is also watered to settle the infill after grooming, to reduce severe static electricity, and to “keep the dust levels down.”⁶²

Very often, artificial turf is watered in order to lower field temperature to a level where play can occur. Since field temperatures rebound quickly after watering, managers must often water between games, or even during halftime. A turf-grass specialist remarked that the amount of water needed to cool down the turf “is actually higher than what we would need on a healthy Bermuda grass lawn to irrigate on a hot summer day.”⁶³

What is the total annual cost of maintaining an artificial turf field? More recent estimates are needed, but a field manager at Michigan State University provided a detailed accounting of the cost in 2005 of maintaining a three-year-old indoor field: a total of \$22,760; including \$6,220 for supplies (mainly infill replacement), \$3500 for equipment, \$8000 for outside contractor repair, and labor costs of \$5040 (280 hours at \$18/hour, benefits not included).⁶⁴ Notice that this figure does not include costs that would be incurred on an outdoor field, such as decompaction (\$3500 twice yearly, 2006 cost), watering (Gale Associates allots \$15,000 for cork irrigation), and the labor and equipment costs of leaf removal. It is easy to see that the total maintenance cost in 2019 of an outdoor artificial turf field could be in the \$40,000 – 50,000 range.

Unforeseen costs

A key difference between artificial turf and natural grass fields is the risk of “premature failure” of the field, which results in significant additional expense as well as the loss of playing time.

There have been hundreds of reports of premature failure of artificial turf fields. A common reason for failure has been the disintegration of plastic grass fibers that make up the turf rug. In at least 167 fields sold by Field Turf between 2005 and 2012, the grass fiber failed within 3-4 years of installation, requiring replacement (often after significant delay and litigation.)⁶⁵ Other reasons for failure have included extensive seam ripping⁶⁶ and disintegration of the underlying shock pad,⁶⁷ development of pot holes under the field,⁶⁸ subsidence of the stone base,⁶⁹ and failure of the drainage system, resulting in flooding of the field, loss of infill, and damage and displacement of the artificial turf rug.⁷⁰

These types of failure can require extensive diagnosis by experts, excavation, replacement of pipes and often of the whole field. Even though the field is under warranty, repair costs may not be covered if recommended maintenance has not been performed or if documentation is lacking. This is so even though the turf industry itself appears to see the eventual failure of drainage systems as inevitable:

“(U)ltimately, whether it is the result of insufficient maintenance practices or simply the age of the artificial turf itself, the likelihood is that water will eventually fail to drain away completely.”⁷¹

This potential for premature, catastrophic failure sets the stage for local communities to lose control of their budgets. This is different from what can happen on a natural grass field. If a grass field floods, the worst that happens is you wait a few days for the field to dry out. Perhaps you add another round of deep core aeration to improve infiltration. If a pothole appears on the field, you repair it with a few shovelfuls of soil and some grass seed.

Local communities are capable of repairing their own grass fields with relatively little added expense and disruption. What they are less able to do is withstand the big expenses of premature failure of artificial turf, or of prolonged litigation while parents clamor for fields to re-open, and turf companies deny responsibility for the field's failure but offer a "deal" on the installation of a new one.⁷²

How often do artificial turf fields fail prematurely? This is what Mike Ozanian of Glen Rock, New Jersey, a writer for Forbes, inquired of a Field Turf representative. The company said it could not reply because of ongoing litigation and industry competition concerns. Yet communities need this information.

“The simple truth of the matter is that unless (one) knows the premature failure rate of artificial turf installed each year, (one) cannot possibly know if artificial turf is more durable than real grass. Nor can one assert that artificial turf is less expensive than real grass.”⁷³

Disposal costs

A huge volume of mostly plastic waste

Having an artificial turf field means that every decade or less, there will be 500,000 pounds of waste material to dispose of somehow. First, there is the 50,000 pound plastic grass carpet and the geotextile that supports it, which are made of a variety of plastics and nylons. Then there are the 450,000 pounds of infill, which could include tire crumb rubber, other plastics, silica sand, “corkonut”, or some combination.⁷⁴ (Though some corkonut purveyors assert that their product can be sprinkled around gardens, this is not true if they have been treated with biocides). Increasingly there is also the ‘shock pad,’ another plastic product.

Field removal in 2008 cost around \$2. per square foot (this amounted to \$115,200 for a football field; \$172,800 for a soccer field). Then there is the cost of transporting the dismantled field to its destination. Most artificial turf goes into landfill, with landfill fees of \$60,000 or more per field.⁷⁵ Some amount is incinerated to produce electricity or steam, a process which is estimated to generate 113 tons of CO₂ per field.⁷⁶

The recycling myth

What about recycling? Vendors claim that artificial turf can be recycled as part of their sales pitch. In theory this might be true, but in practice it's not happening – and seems unlikely to happen. According to the Synthetic Turf Council:

“Unfortunately, converting synthetic turf to a recyclable material that is useable cannot be done at the point of removal. Material must be shipped to different processing locations. The cost of shipping is one of the biggest challenges associated with synthetic turf reclamation.”⁷⁷

I’ll say. Only four vendors of “recycling services” for artificial turf are listed on the STC website – two in Atlanta, one in Canada and one in Denmark (the only one in Europe). Why aren’t there more recyclers of turf fields? The answer seems to be, it’s not profitable. The materials used in artificial turf are dirt cheap but expensive to separate. Any potential buyer of such recycled products can instead just buy the original raw materials (old tires, sneakers etc.) more cheaply.⁷⁸

The current “system” of disposal in New Jersey seems to rely on landfill operators looking the other way, or removal companies “storing” discarded materials indefinitely, often in unsafe locations where they contribute to pollution.⁷⁹ How long can this last? Surely, not long. The volume of discarded artificial turf fields is set to explode. Fields are now being discarded at a rate of 1000/year, a pace which is expected to continue. When we are no longer able to “benefit” from the current system which allows us to treat toxic waste like household refuse, we and other communities may have to pay the really, really high disposal fees that might make recyclers appear (though they still may not.)

In any case, the people who sell us these fields are unconcerned with this issue. The big profits in the artificial turf industry are realized in the initial sale and installation of “new” turf fields – by the time disposal is a crisis they will be long gone.

Summary: the false claims of artificial turf companies

With huge profits to be made, and a raw material that was essentially free, the artificial turf industry has made a series of claims to sell its product. These claims have all been debunked:

- 1) “Artificial turf poses no risk to children’s health.”

Instead, there is clear risk of heat injury, joint damage, and possibly concussion, as well as respiratory exposure to VOC’s such as benzothiazole and field dust toxins including silica, carbon black, lead and other heavy metals.

2) “Artificial turf is ‘green’.”

There is no sense in which a 500,000 pound petroleum product, which as an impermeable surface prevents groundwater discharge, off-gasses VOC’s, disperses 7000 pounds of microplastics annually into the environment, acts as a heat island and eliminates a grassy field with mature trees can be considered “green.”

3) “Artificial turf is less expensive than natural grass.”

In fact, artificial turf is vastly MORE expensive. No grass field approaches the 10-year lifecycle cost of a \$1,000,000 field, plus \$25,000-40,000 annual maintenance, plus \$250,000 end-of-life disposal cost.

4) “Artificial turf requires less labor than natural grass.”

As discussed, artificial turf requires regular maintenance in order to keep the field playable and to uphold conditions of the warranty.

5) “Artificial turf allows more playing hours.”

In fact, heat makes the fields unavailable for months at a time. Fields will still not be playable in driving rain, or when covered with snow or ice (since removal is forbidden because of the high risk of damaging the field). Many activities that are allowed on natural grass (such as playing in flat-soled shoes) are forbidden on artificial turf. When turf fields do fail, they are apt to be closed much longer than grass fields, because repair is more complex and beyond the expertise of school or municipal employees.

Artificial turf fields were promoted in the context of a ‘pro-business,’ ‘pro-petroleum’ political/economic environment, in which the urgency of solving the waste tire crisis outweighed the responsibility to protect the environment and children’s health.

There is reason to hope this will not continue to be the case, and that communities will conclude sooner rather than later that “taking something with all kinds of hazardous materials in it and making it something kids play on” is indeed a dumb idea.

When communities finally realize something is dumb (like underground oil tanks), there is often a rush for the exits.

Let’s not be the last ones off the field.

The Problems with Artificial Turf

References

¹ C. Frank Williams and Gilbert E. Pulley, Synthetic surface heat studies. Brigham Young University, 2002. Excerpted at Synturf.org 'Heat effects' #2 "The Utah Study."

² Penn State Center for Sports Surface Research , Sports Turf, (June 6, 2011) "Is there any way to cool synthetic turf?" Cited in Synturf.org 'Heat effects' #49 "A duh! moment for the artificial turf industry."

³<https://www.reference.com/health/temperature-human-skin-burn-82a1af6b1322b289>

"At what temperature does human skin burn?"; see also Synturf.org 'Health & safety' #131 "Rockwood Files"

⁴ Safe Healthy Playing Fields (May 2, 2016) "Comments on ASTDR 2016-0002-0003 Federal Research Action Plan on Recycled Tire Crumbs Used in Playing Fields and Playgrounds," p. 51.

⁵ Williams and Pulley, op. cit.; ISA Sport USA "Turf and infill temperature evaluation" (June 30, 2012)

⁶ Synturf.org 'Heat effects' #65 Burlington, Massachusetts, (Sept 1, 2017) "City issues heat policy guidelines for use of artificial turf fields by students"

⁷ National Oceanic & Atmospheric Administration, Record of climatological observations, Newark Liberty International Airport, April-October 2018.

⁸ Synturf.org, "Health & Safety" #31 Hospital for Special Surgery (New York City, Oct. 11, 2009) Study: "Artificial turf surface produced most strain on ACL;"

#60 "Injuries on artificial turf fields," a study of NFL players presented at the 2010 meeting of the American Orthopaedic Association. One finding: "Playing on FieldTurf was associated with an 88% greater risk of ACL injury"

#69 "Stanford study says football knee injuries more likely on artificial turf"

#78 "Not for the squeamish!" (video footage showing no-contact injuries occurring during football, soccer games)

#128 Montreal, Canada (Oct. 2016), "How turf soccer fields are causing devastating injuries to unsuspecting athletes"

#129 The Netherlands Times (Sept. 20, 2016) "More sports injuries occur on artificial turf than on grass. Period"

#151 Orthopedic surgeon Dr. John-Paul Rue (Feb. 2018), "Playing on synthetic turf is associated with 'an increased risk of injury, particularly to the ACL.' "

#7 (April 15, 2008) "Is artificial turf especially cruel to female athletes?"

⁹ See, in general, articles filed under Synturf heading 'Players' Views' and 'Health & Safety'

#51 "Major survey: pro soccer players link artificial turf to higher risk of injury"

#60 "Former University of Alabama running back rejoices over conversion to natural grass at Ole Miss's Vaught-Hemingway stadium" (June 3, 2016)

#61 Foxboro, Mass. (Nov. 25, 2016) "New England Patriots Tom Brady wants natural grass"

#67 "Texas Rangers baseball players hate playing on artificial turf"

#100 "Faster aging curve among baseball players playing on artificial turf"

¹⁰ Synturf #106 "FIFA 2015 Women's World Cup sheds light on the unforgiving nature of artificial turf"

Rachel Maddow (June 9, 2015) "U.S. Women's soccer objections force end to FIFA use of artificial turf fields" <http://www.msnbc.com/rachel-maddow-show/watch/us-womens-soccer-puts-end-to-fifa-turf-use-460951619836>

Andrew Das, "Claiming bias, female players sue U.S. soccer," The New York Times (March 9, 2019) p. 16.

¹¹ Synturf.org, 'Health & Safety' #144(Aug 1, 2017) "More about the relationship between playing on artificial turf and concussion"

"The Synthetic Turf Council, an industry trade group, recommends 165 as its GMAX limit. By comparison, a well-maintained natural grass field typically ranges from 80 to 140 on the GMAX scale."

#61 (May 6, 2011) “Laguna Beach, California: Football mom calls out town officials for negligence and indifference.”

#114 (Oct 29, 2015) “Columbus, Ohio: Lack of artificial turf maintenance endangers athletes’ health and safety.”

“Investigators asked 68 central Ohio school districts whether they had turf and what their latest GMAX field test results are. Some area schools, including almost all the area’s private schools, would not disclose what their ratings are. Athletes and their parents have no way of knowing.”

#118 (Dec. 31, 2015) “Synthetic turf and concussion – a year’s end review”

“One in 7 high school sports concussions is caused by surface impacts, and one in 4 concussions in youth soccer and football.”

Gale Associates, Inc. (2015) “Alternative infills for synthetic turf” Available at: <https://www.galeassociates.org/wp-content/uploads/2015/03/Alternative-Infills-for-Synthetic-Turf.pdf>

An information sheet, provided by a turf consultant, shows which types of infill require a shock pad: silica sand fields (polymer-coated or not); cork or coconut husk or similar, and thermoplastic elastomer (TPE). Cost of shock pad listed as \$130,000. (2015 price)

¹²See articles and discussion under Synturf.org heading ‘Silica’

#4 “How dangerous is silica in artificial turf fields?”

“Breathing only a tiny amount of silica dust per day – enough, roughly, to cover Franklin Delano Roosevelt’s nose on a dime – can put a worker at risk for myriad health problems, according to Michael Breitenstein of the National Institute for Occupational Safety and Health.”

¹³Federal Register, Occupational Safety and health Administration (March 26, 2016)
“Occupational exposure to respirable crystalline silica”

¹⁴Smithsonian (Sept. 8, 2017) “The world is running out of sand,”
<https://www.smithsonianmag.com/science/world-facing-global-sand-crisis-1809648>

This article shows how mining sand from rivers and beaches devastates ecosystems.

Business Insider (June 11, 2018) “The world is running out of sand – and there’s a black market for it now”

<https://www.scmp.com/week-asia/society/.../world-running-out> “Most analysts expect a spike in sand prices.”

¹⁵ See Synturf.org articles and discussion under heading ‘Crumb rubber’

Synturf.org, ‘Fact Sheets’ #15 “Two basic documents to begin the conversation”

Environment & Human Health, Inc. (2015) “Artificial turf: chemical analysis”

¹⁶ Synturf.org ‘Wrap-up articles’ #2 “The Westport brief: citizens question safety of rubber crumb in artificial turf (Sept 28, 2007). See section entitled “The EHHI report on the CAES study” (Connecticut Agricultural Experiment Station)

¹⁷ David Brown, Director of Public Health Toxicology for Environment & Human Health Institute, Synthetic turf: industry’s claims versus the science: a careful analysis of studies that industries use to justify safety claims (Nov. 2017)

¹⁸ Stuart Shalat, Sc.D., New Jersey Department of Environmental Protection, “An evaluation of potential exposures to lead and other metals as the result of aerosolized particulate matter from artificial turf playing fields: Final Report” (July 14, 2011)

<http://www.nj.gov/dep/dsr/publications/artificial-turf-report.pdf>

“Research has shown that even limited activity on carpeted surfaces can result in multiple orders of magnitude of increases in respirable/inhalable particulate matter. It is therefore desirable to sample in a non-static fashion for any potential particulate matter that is released from the surface.” (p.2)

¹⁹ San Francisco Chronicle (Feb. 21, 2015), Melody Gutierrez, “Critics say EPA played dual role in recycled tire controversy.” Excerpted in Synturf.org ‘EPA’ #19.

²⁰Consumer Product Safety Commission, Analysis and assessment of synthetic turf grass blades. (July 2008); Environmental Protection Agency, Scoping-level field monitoring study of synthetic turf fields and playgrounds. (2009)

²¹Synturf.org 'Maintenance/replacement' #64 "Financial impact on sellers and insurers of premature deterioration of artificial turf fields under warranty"

²²See the critique of CPSC methodology and assumptions by David Brown of EHHI in Synturf.org 'CPSC' #3 "CPSC says 'Turf industry should get out the lead, but turf fields are okay to play on' (August 3, 2008)

²³Synturf.org 'EPA':

#10 (June 7, 2009) "PEER: EPA endorsed use of crumb rubber in playing fields without analyzing its potential toxicity;"

#13 (Sept 14, 2009) "PEER says EPA punts on risks to children from playground tire crumb;

#14 (Oct 13, 2009) "EPA is dragging its feet on testing artificial turf fields;"

PEER (March 21, 2013) "Demand for Correction under the Information Quality Act: 2009 Study Regarding Synthetic Fields and Playgrounds"

²⁴Synturf.org 'CPSC' #10, "Public Employees for Environmental Responsibility (PEER): (Synthetic) Turf Lobbyists Cultivate Consumer Product Safety Commission" (April 28, 2015)

According to PEER executive director Jeff Ruch, documents obtained via the Freedom of Information Act "depict a consumer watchdog which has learned to play dead too well. While industry gets unfettered access, consumer complaints about excess lead get the run-around before they are forgotten altogether."

Thomas Frank, USA Today (March 16, 2015) "Feds promote artificial turf as safe despite health concerns."

²⁵Synturf.org 'Health & Safety' #146, "Amy's list summary, Sept. 2017"

As of Sept. 2017, Amy Griffith's list had grown to 248 athletes (average age 20-21) with cancer (lymphoma, leukemia, sarcoma, testicular, thyroid, brain, ovarian and lung). Of these 248, 62% (155) have blood cancers (lymphoma and leukemia, which are believed

to be influenced by environmental exposure). Of the 196 soccer players with cancer, 115 (59%) are goalkeepers.

²⁶ Lynne Peeples, Huffington Post (June 9, 2015) “Artificial grass may save water, but does it endanger people?”

Synturf.org ‘CPSC’ #9 “Chairman of the Consumer Product Safety Commission has deep concerns with the (2008) press release that said synthetic turf fields OK to install, OK to play on.”

²⁷ Suzanne Wuerthele, toxicologist for 23 years at EPA, quoted in Synturf.org ‘EPA’ #19 “US EPA no longer promotes the use of recycled tires on artificial turf fields and playgrounds.”

²⁸ Center for Disease Control and Prevention (CDC), U.S. Environmental Protection Agency (USEPA), Agency for Toxic Substances and Disease Registry (ATSDR). Federal research action plan on recycled tire crumb used on playing fields and playgrounds. Status report. December 2016, p. 136-8.

²⁹ Safe Healthy Playing Fields, in “Comments on ASTDR 2016-0002-0003 Federal Research Action Plan on Recycled Tire Crumbs Used in Playing Fields and Playgrounds,” (May 2, 2016) p.78.

³⁰ Synturf.org ‘Process’ #82, “NJ Advance Media’s report lays bare FieldTurf’s marketing and sale of a defective product” A report by Christopher Baxter and Matthew Stanmyre, “100-Yard Deception” (Dec 4, 2016) <http://fieldturf.nj.com>

³¹ Delaware Riverkeeper Network, “Alternative infills for artificial turf fact sheet” www.delawareriverkeeper.org

³² Synturf.org, ‘Alternative infills’ #12 “On Nike Grind and other alternative infills.”

³³ Diana M. Zuckerman, PhD, President, National Center for Health Research (August 28, 2017), “Letter from NCHR about dangerous playgrounds and athletic fields to the mayor and city council of Washington, D.C.”

³⁴ Gale Associates Inc. (2015) “Alternative infills for synthetic turf.” Available at <https://www.galeassociates.org/wp-content/uploads/2015/03/Alternate-Infills-for-Synthetic-Turf.pdf>

³⁵ Synturf.org, ‘Alternative infills’ #16 “Buyer beware! Rubber and other unsuspected ingredients in some plant-derived infills

³⁶ Gale Associates Inc. (2015)

³⁷ Gale Associates Inc. (2015); Synturf.org, ‘Alternative infills’ #15, Long Beach, Cal. (June 16, 2015) “Health concerns prompt Parks and Recreation to recommend organic infill.” Geofill, a corkonut infill, is described as having a 2-3 year lifespan.

³⁸ Zuckerman, op. cit.

³⁹ Synturf.org ‘Heat effects’ #17 “Why grass is cooler than turf” (April 2008)

“Synthetic turf fields run 60 degrees hotter than grass fields on sunny afternoons, easily reaching temperatures of 140 degrees F or more. How do plants manage to avoid reaching such high temperatures? The answer is evaporation of soil moisture through their leaves. Plants are nature’s ‘geniuses’ when it comes to evaporating water to stay cool in the sunlight.”

⁴⁰ Paul Sachs, Managing Healthy Sports Fields: a guide to using organic materials for low-maintenance and chemical-free playing fields. Hoboken, John Wiley & Sons, 2004, p.129-30.

⁴¹ Y. Qian and R.F. Follett, “Assessing soil carbon sequestration in turfgrass systems using long-term soil testing data” *Agron J* 94: 930-935. (2002)

Ranajit Sahu, Technical assessment of the carbon sequestration potential of managed turfgrass in the United States (2008), excerpted in Synturf.org ‘Carbon footprint’ #2 “Natural grass to the rescue!”

G. Zirkle, R. Lal and B. Augustin, “Modeling carbon sequestration in home lawns” *Hort Science* 46 (5) 808-814. (2011)

⁴²P. Hepperly, D. Lotter, C. Ziegler Ulsh, R. Seidel and C. Reider, "Compost, manure and synthetic fertilizer influence crop yields, soil properties, nitrate leaching and crop nutrient content" *Compost Science & Utilization*, Vol 17 no 2, 117-126. (2009)

The Rodale Institute found:

"Compost treatments supported both high yields and increased soil C and N (nitrogen) content, while synthetic chemical fertilizer and raw manure produced only high yields but did little or nothing to improve soil nutrient content.

The compost treatments also required no liming over the trial, while chemical fertilization acidified the soil, making lime applications necessary...Liming increases the atmospheric C impact of chemical fertilizer systems because the breakdown of acids in the soil liberates carbon dioxide from the calcium carbonate being applied."

⁴³ Synturf.org 'Heat effect' #4 "The New York City Study" (2006).

⁴⁴ Synturf.org. 'Carbon footprint' #4, Duncan, British Columbia, Canada: "One more act of cruelty against nature – making way for synthetic turf fields;"

⁴⁵ Synthetic Turf Council, "Guidelines for maintenance of infilled synthetic turf sports fields" (January 2013)

⁴⁶ Icahn School of Medicine at Mount Sinai, Children's Environmental Health Center, "Artificial turf: a health-based consumer guide" (May 2017)

This consumer guide advises that there is potential exposure concern from off-gassing of inhalable volatile organic compounds (VOC's and PAH's) including benzothiazole, hexane, toluene, formaldehyde and others. These include respiratory irritants, asthma triggers, neurotoxicants and some known human carcinogens.

⁴⁷ Synturf.org#5, Newton, Mass., (Feb. 16, 2008)"What do vomit, spit, sweat and other human and animal discharge, and mold and bacterial growth look like in the fibers of artificial turf? Wonder no more!"

⁴⁸ See Synturf.org articles under 'Vandalism'

⁴⁹See Synturf.org articles under 'Migration' for the problem of infill spreading off the field and into the environment; in particular

#34 Andrew McNitt, director of the Center for Sports Science at Penn State says
"between 6000 and 7000 lbs of crumb rubber can come out of a field each year."

#4, 'Crumb rubber microplastics,' "The myth of rubberized landscapes." Rubber leachate from car tires can kill entire aquatic communities of algae, zooplankton, snails and fish. Plant species have been known to accumulate abnormally high levels of zinc, sometimes to the point of death.

See also <http://www.kimointernational.org/feature/microplastic-pollution-from-artificial-grass-a-field-guide/>

⁵⁰See Synturf.org 'Water damage' for articles and photos of flooded fields

Synturf.org 'Migration' # Montclair Local (Aug. 15, 2018) "Heavy rains wash away crumb rubber off three town fields"

⁵¹Leigh Davis, "Care and feeding of your new artificial grass" Highland Park Mirror (June 18, 2009) <http://www.highlandparkmirror.com/hpmfts2.html>

⁵²Synturf.org 'Heat effect' #4 "The New York City Study"

Larry Wroblewski, "Athletic field blamed for flooding woes," on MetroWNY.com, (Oct. 6, 2011) http://www.metrony.com/news/974-Athletic_field_blamed_for_flooding_woes.html

⁵³Synthetic Turf Council, "Guidelines for synthetic turf base systems" (February 2017)

⁵⁴ Synturf.org 'Carbon footprint' #1 "Estimating the required global warming offsets to achieve a carbon neutral synthetic turf field installation." A study by the Athena Institute, Merrickville, Ontario.

⁵⁵ Synturf.org 'Disposal' #8 Montgomery County, Maryland: "Disposal issues follow removal of Richard Montgomery high school field material," (Aug 7, 2018)

This article includes a graphic illustration of "Lifecycle Options of Synthetic Turf" presented by Turf Reclamation Solutions.

⁵⁶Synthetic Turf Council, "Guidelines for maintenance of infilled synthetic turf sports fields" (January 2013), p. 5-8.

⁵⁷Synturf.org 'Maintenance/replacement' #6 "Boston College interview" (May-June 2006)

⁵⁸Synthetic Turf Council, "Guidelines for maintenance," p. 8.

⁵⁹Synturf.org, 'Maintenance/replacement' #5 "Fouty's perspective" (Annual maintenance figures from Michigan State University athletic turf manager)

⁶⁰Fouty, *ibid.*

⁶¹ISA Sport USA for Limonta, *op cit.*

⁶²Boston College interview, *op cit.*

⁶³Kyle Hanson, "Special report: is artificial turf cheaper to maintain?" ABC 7 KVIA News, (August 8, 2018) Quote is from New Mexico State University professor Bernd Leinauer, turf-grass extension specialist for the State of New Mexico.

<https://www.kvia.com/special-reports/more-water-needed-to-keep-artificial-turf-cool-study-says/779081355>

⁶⁴Fouty, *op cit.*

⁶⁵New Jersey Advance Media, *op cit.*

⁶⁶ See, under Synturf.org, 'Maintenance/replacement' :

#23 Brookfield, Connecticut, "Brookfield High School turf unplayable after a couple of years"

#31 Midland, Texas "Turf bursts at the seams, needs replacement after five years"

#54 New York, NY "Soccer referees boycott two turf fields due to dangerous conditions"

#112 Clifton, NJ "Another case of premature deterioration of artificial turf fields," NorthJersey.com, (April 22, 2017)

⁶⁷Zoe Roos "One year old Guilford High School synthetic turf field has to be replaced," The Courier, (Dec. 31, 2018)

<https://www.zip06.com/news/20181231/entire-high-school-turf-field-to-be-replaced>

"The synthetic turf carpet was coming apart at the seams and sections of padding had come apart."

Synturf.org, 'Maintenance/replacement' #113 Burnett, Texas "Defective artificial turf field needs replacing just two years after installation" (May 24, 2017)

⁶⁸Synturf.org, 'Maintenance/replacement':

#57 Carlisle, Pennsylvania "Sink hole in 1-year-old artificial turf field deep-sixes soccer match" (May 4, 2010)

#35 Liverpool, New York "The bubbling turf field is still closed" (December 3, 2010)

#22 Liverpool, New York "Team has no home field" (July 25, 2008)

"Acting director of athletics Mark Potter said erosion in a crushed stone layer under the turf has created soft spots – or potholes – along with bumps. He likened the experience (of playing on this surface) to walking down stairs, only to miss the last step."

#19 Cedar Hill, Texas "Repairs to stadium's turf drainage system may cost district \$850,000"

⁶⁹Synturf.org, 'Maintenance/replacement'

#25 Brookfield, Connecticut "High school turf field is in dire need of repairs after just two years"

⁷⁰ See Synturf.org, 'Water damage':

#6 Philipsburg, NJ "Standing water on 30% of 2-year turf mars soccer game" (Sept 2008)

#11 East Greenwich, RI "Artificial turf field floods after one-half inch of rain" (July 2009)

#15 Ridgewood, NJ "Flood closes down artificial turf field" (April 2011)

#17 Bernards Township, NJ "Water polo, anyone" (June 2013)

#18 East Huntingdon, PA "Rains pleat the artificial turf field" (Sept 2013)

After two inches of rain fell, the water "burrowed under the playing surface. The surface then buckled up, ripped apart and washed away."

#20 "Float that carpet, wash away the infill" (Oct 2016)

In Spring Lake Park, Minnesota, after a heavy rain “The football/soccer field was under at least half a foot of water, with a large air bubble pushing the turf up in a long bump that ran down the middle of the playing surface....(T)he AD figures that the field drainage system couldn’t keep up with the heavy rain....and with the pumps pushing back against the deluge, air was forced underneath the turf, causing the huge bubbles to form.”

⁷¹Nick Harris, Technical Surfaces Ltd., “Artificial pitch maintenance – who, how, when and why” Pitchcare Magazine, Issue 40, (Dec 2011-Jan 2012)

⁷²Synturf.org, ‘Maintenance/replacement’

#117 Southern California – “Premature aging and failing artificial turf fields are costing taxpayers millions in addition to the expensive upfront installation cost” (June 19, 2018)

“Each customer with a high school football field, soccer field or other synthetic turf surface has been forced to decide whether to accept a standard replacement (of the same, failing turf) from FieldTurf for free, pay extra for an upgraded surface, or sue the company.” FieldTurf said it would replace failing fields free of charge “only if it used the same fibers from the same company it had used three years earlier; an upgrade would cost \$175,000 per field.”

#95 Charlestown, West Virginia “Another case of premature aging” (February 20, 2014)

“FieldTurf has only offered to provide a discount on installing a new field, rather than replace the failing turf...We’ll end up suing them. They’re not going to honor (the warranty).”

#85 Beaverton, Oregon “Failing artificial turf fields, faulty record-keeping as to use and maintenance, useless warranty = taxpayers’ nightmare!”

“According to a news report in The Oregonian (April 6, 2012) “Beaverton School District plans to spend as much as \$850,000 to replace the artificial turf at Westview and Southridge high schools after the 6-year-old fields failed prematurely. Although the district signed a limited warranty with the installer, faulty record-keeping on the district’s part complicated negotiations for a new field.” When the school district negotiated with FieldTurf to replace the field, “they discovered the district had not followed the requirements of the warranty.

The warranty signed by the district required the staff to keep track of the hours of field use as well as the frequency and type of maintenance. The warranty also limited the field use to football and soccer, but the schools use them for lacrosse, baseball, band, cheerleading and PE (physical education) classes. It also restricted repetitive or high-intensity training on the same part of the field, such as around goals.”

⁷³Mike Ozanian, “Failure rates of artificial turf fields unknown by public,” Forbes (Nov 2, 2014).

Mike Ozanian, “Buyer’s remorse surfacing over artificial turf fields” Forbes (Oct 27, 2014).

⁷⁴Montgomery County, Maryland, “Disposal issues” op. cit.

⁷⁵Synthetic Turf Council, “Removal, recovery, reuse and recycling of synthetic turf and its system components” (Revised July 2015)

⁷⁶Montgomery County, Maryland, “Disposal issues, op. cit.

⁷⁷Synthetic Turf Council, “Removal, recovery” op. cit. p. 2.

⁷⁸Synturf.org ‘Disposal’ #5, “Current theory and practice of dealing with used artificial turf fields.”

⁷⁹Synturf.org ‘Disposal’ #2 Middletown, New Jersey (Oct. 2, 2008) “Town plans to dispose of old turf in garbage.” According to Board of Education attorney Paxton, “Our original plan was to roll it up and do whatever.”