Sports turf alternatives assessment: Research update and discussion

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Overview

- Artificial turf: What we know so far
  - Overview
  - Heat
  - Injuries
  - Costs
  - Chemicals in infills
- Lessons learned, challenges, & areas needing additional research
- TURI resources

Note: This is work in progress

- Information provided in these slides is drawn from work in progress; these slides are not for citation. For completed work that can be cited and distributed, see TURI's website: http://www.turi.org/Our_Work/Home_Community/Artificial_Turf
- We are working to develop an alternatives assessment that is appropriate for the level of information available to us. It is not quantitative and, at this point, does not include rankings or an over-all comparison.

Artificial turf – quick overview

- Used increasingly in the US and abroad
- Increasing concern about health & environmental effects, especially of tire crumb
- Increasing interest in alternative infills
  - Alternative infills may address some, but certainly not all, of the concerns that have been raised about tire crumb;
  - There continue to be important information gaps.

Heat

- All artificial turf gets hotter than natural grass
  - 35° F to 42° F hotter than grass (NYDEC, 2009)
  - 156° F under direct sunlight (Milone & MacBroom 2008)
  - 200° F on a 98° F day (Williams & Pulley 2004)
- Heating most pronounced in the artificial grass fibers
- Choice of infill type *may* lead to some variation in the amount of excess heat
- Frequent, heavy irrigation can help to control heat
- Concerns: blisters; burns; heat-related illness
  - Education for coaches, other decision-makers

Injuries

- Mixed evidence on many types of injuries. Sample studies:
  - Similar rate over all, but different types of injuries (Dragoo & Braun 2010)
  - Possible decrease in incidence of the most serious injuries (Meyers & Barnhill 2004)
  - More head & neck injuries for men, fewer ankle sprains for women (Fuller et al. 2007)
- Higher incidence of skin abrasions
  - Need for vigilance re: skin infections

Costs

- In nearly all scenarios, the life-cycle cost of synthetic turf is higher than that of natural grass for an equivalent area.

Table 12: Sample Life Cycle Cost Estimate (65,625 square foot field)				
	Natural		Synthetic (replacements in years 8 & 16)	
	Low	High	Low	High
Installation*	$39,000	$328,000	$295,000	$673,000
Annual Maintenance*	$4,000	$14,000	$4,000	$4,000
Annual Labor (hrs)*	250	750	300	300
Annual labor cost	$5,000	$15,000	$6,000	$6,000
Resodding (yrs 6, 11, 16)	$25,000	$45,000	$0	$0
Disposal & resurfacing & transport & landfill*	$0	$0	$557,000	$642,000
Net Present Value	$197,000	$753,000	$1,189,000	$1,676,000

*Source: SportsTurf Managers Association. [no date.] A Guide to Synthetic and Natural Turfgrass for Sports Fields. 3rd edition. Lawrence, KS: STMA. Assumptions: Hourly rate $20; interest rate 3%, disposal/resurfacing occurs in years 8 & 16; natural grass resodding in years 6, 11 and 16; conversion factor used to calculate annualized cost from NPV 0.0796. In the scenarios used here, at year 16 the field is in equally good condition as in year 1.

Infills

Synthetic	Tire crumb
	EPDM
	TPE
	Waste athletic shoe materials
Mineral- or plant-based	Sand
	Cork
	Coconut hulls & fibers
Combinations	Acrylic-coated sand

Infills:
Useful concepts & background information

Multiple materials in each category

Additives

- Cross-linking agents, accelerators, stabilizers, plasticizers, fillers, antimicrobials

Other useful terminology

- Thermosets vs. thermoplastics
- Curing/crosslinking/vulcanization

Infills - Regulatory standards cited

- Proposition 65
- European Standard EN 71-3 – Safety of Toys Part 3: Migration of certain elements
  - 19 metals
    - Notes: metals only; toy standard only; 3 possible performance levels (I. dry/brittle/powder; II. liquid/sticky; III. **scraped-off**)
- ASTM voluntary standard
    - Metals; ingestion
- Misc. environmental standards
  - Various soil lead/zinc standards; leaching standards for landfills; German standard for artificial turf

Tire crumb

- EPA: just over 350 chemicals or chemical categories discussed in existing literature on tire crumb
- Presence and amount of a given chemical can vary depending on the sample.

Tire crumb infill – Chemicals (EPA)

Category	Examples
Metals	Aluminum, arsenic, barium, cadmium, chromium, copper, lead, nickel, zinc
VOCs	Benzene, benzothiazole, hexane, naphthalene, styrene, toluene, xylenes
PAHs	Anthracene, benz(a)anthracene, fluoranthene, naphthalene, phenanthrene, pyrene
Phthalates	Benzylbutyl phthalate, di(2-ethylhexyl)adipate, di(2-ethylhexyl)phthalate [DEHP, a.k.a. bis(2-ethylhexyl)phthalate]
Other (e.g. rubber curatives)	4-tert-(octyl)-phenol, butylated hydroxytoluene

Tire crumb: lead and zinc data (examples)

Study	Lead	Zinc	Notes
Bocca et al. 2009	12 to 46 mg/kg	118 to 19,375 mg/kg (median 10,229)	"concentration range for each metal was wide with respect to the different samples analyzed"
Simcox et al. 2010	<68.9 to 271 µg/g [equivalent to mg/kg]		Lead concentrations are below the level considered by EPA to present a "'soil lead hazard' in play areas" (400 µg/g).
Marsili et al. 2015	10.76 to 38.99 mg/kg	3,474 to 13,202 mg/kg	9 AT fields in Italy

Tire Crumb, cont'd

- VOCs
  - Some studies highlight benzothiazole as a concern
- PAHs
  - Release of chemicals from tire crumb "represents a major contribution to the total daily intake of PAHs by different routes" (Marsili et al. 2015)
- Phthalates
  - DEP, DEHP, DINP, others (various studies)
- PCBs & other POPs
  - PCBs above Italian standard for "soils to be reclaimed for use as 'green areas'" (Menichini et al. 2011)

EPDM

- Specialty elastomer
- Can be mixed with high levels of additives & oils (can be as high as a 50-50 mix); often mixed with carbon black

EPDM

- Norwegian Building Institute (NBI), 2004
  - Compared tire crumb with EPDM
  - Found lower levels of hazardous substances in EPDM, except for chromium & zinc
    - More chromium
    - Similar levels of zinc
    - Both chromium & zinc above “sensitive land use” standards
    - *Lower* levels of PAHs, phthalates, phenols
    - *Lower* level of lead
    - No PCBs

Table 4: Comparison: Recycled Rubber Granulate vs. EPDM infill (NBI 2004)			
		Recycled rubber granulate (n=3)	EPDM (n=1)
PAHs	Total PAHs	Yes (16 PAHs detected; total PAHs 51 to 76 mg/kg)	Yes (5 PAHs detected; total PAHs 1 mg/kg)
Phthalates	Phthalates – over all	Yes	Yes (lower)
	Dimethylphthalate (DMP)	No*	Yes (3.4 mg/kg)
	Diethylphthalate (DEP)	No*	Yes (1.5 mg/kg)
	Dibutylphthalate (DBP)	Yes (2.6 to 3.9 mg/kg)	Yes (1.6 mg/kg)
	Benzylbutylphthalate (BBP)	Yes (1.3 to 2.8)	No*
	Diethylhexylphthalate (DEHP)	Yes (21 to 29 mg/kg)	Yes (3.9 mg/kg)
	Di-n-octylphthalate (DOP)	No*	Yes (3.2 mg/kg)
	Diisononylphthalate (DINP)	Yes (57 to 78 mg/kg)	No data
	Diisodecylphthalate	No*	No data
Phenols	Phenols – over all	Yes	Yes (lower)
	4-t-octylphenol	Yes (19,600 to 33,700 µg/kg)	Yes (49.8 µg /kg)
	Iso-nonylphenol	Yes (9120 to 21,600 µg /kg)	Yes (1120 µg /kg)
VOCs (offgassing test)		Yes (12 detected)	Yes (4 detected, all at lower levels than the recycled rubber granulate)

TPE

- Thermoplastic elastomer
- Can melt; not vulcanized/cured.
- Composed of two materials: one material that is “hard at room temperature and fluid when heated,” and one that is “soft and rubber-like at room temperature.”
- Broad category – describes multiple materials

TPE

- Advantages appear to include:
  - Lower VOC levels than tire crumb
  - No vulcanization compounds *expected*

TPE

- Norwegian Pollution Control Study (Dye et al., 2006)
  - Compared two tire crumb fields with one TPE field (all indoor)
    - Airborne dust:
      - $PM_{2.5}$ lower for TPE
      - Vulcanization compounds, preservative compounds, and carbon black all present at tire crumb fields, absent at TPE field
        - » But note this will depend on the specific TPE formulation

TPE – Dye et al., cont'd

- Air
  - TVOCs: very high to high at tire crumb fields (exceeding recommended levels); slightly elevated at TPE field
  - PAHs: present at all fields, but lower at TPE field
- Other selected chemicals (dust and/or air):
  - benzothiazole, toluene – present but lower at TPE field
- Conclusions
  - TPE preferable to tire crumb based on the chemicals examined in the study;
  - however, the authors were not able to make a broad recommendation about TPE infill because they did not know what other chemicals it contained.

Waste athletic shoe materials

- Variety of synthetic rubbers; may also include natural rubber
- Shoe manufacturers' Restricted Substance List (RSL) may give insight

Waste athletic shoe materials

- Like other products, may contain vulcanizing agents, antioxidants, colorants, stabilizers, plasticizers.
- Allergic reactions to additives used in shoe rubber
  - Literature on shoe-related dermatitis
    - Chemicals used in vulcanization process are implicated in some studies
      - E.g. mercaptobenzothiazole (MBT), a rubber accelerator

Acrylic-coated sand

- Sample product
  - Sand
  - Proprietary acrylic
  - Antimicrobial
  - Pigment

Antimicrobials

- Triclosan: GreenScreen® Benchmark 1 ("Avoid: Chemical of High Concern")
  - PBT concerns
  - Acute & systemic human toxicity
  - Very high ecotoxicity
  - Chronic aquatic toxicity

Plant-based infill

- EN71-3 testing
  - Detected aluminum, barium, boron, chromium, copper, manganese, nickel, strontium, and zinc. Least stringent standard is met for all of these metals. Most stringent standard may be met as well (undetermined for hexavalent chromium).
- Unanswered questions
  - Hazards from respirable fibers?
  - Allergens/sensitizers?
- Additional layers (pad and underlayment) should also be researched

Plant-based infill

- Cork
  - Cork workers can develop respiratory disease through cork dust exposure (suberosis). Fungi that colonize cork seem to play a role.
- Coconut
  - Allergies are rare
- Zeolite

Natural grass

- Safer alternative
  - Opt for organically managed grass whenever possible

Lessons learned, questions, next steps

- No artificial turf option is clearly benign;
- Alternatives are likely to be safer than tire crumb;
- Municipalities and others are asking for input on how to select among alternatives;
- The task is complicated by lack of full information on material composition.
- Concerns that exist regardless of infill type include:
  - Implications for wildlife
  - Stray particles in environment
  - Heat hazards
  - Loss of green space
  - Cost
- Role of other market factors

- Multiple metrics to consider
  - Numerous chemicals, information gaps
    - Infill
      - *Next step – more testing?*
    - Synthetic “grass” blades
    - Pad/underlayment
    - Disinfection/cleaning chemicals
  - Many other factors, including performance, durability
- Issues for municipalities
  - Discussions re: playing time
  - Subsidies
- Alternatives assessment – questions re: scope & approach

TURI Resources

Artificial Turf

Sports Turf

When municipalities, universities, schools and other institutions consider what type of athletic playing fields to install, they need to decide between natural grass, artificial turf with crumb rubber infill and artificial turf with other forms of infill.

TURI created a fact sheet that describes considerations such as performance, safety, cost and the potential environmental and health impacts. Read the Fact Sheet.

TURI Sports Turf Alternatives Assessment: Preliminary Results

TURI has received requests for information about artificial turf fields as an alternative to natural grass fields. In response, we have developed an alternatives assessment for sports turf. Preliminary sections of the assessment are being published when completed. Documents available are:

- Introduction
- Cost Analysis
- Physical and Biological Hazards

Artificial Turf Overview

Artificial Turf

Alternatives Assessment

Introduction

Cost Analysis

Physical and Biological Hazards

Infills Overview

Infills Recycled Tires

Natural Grass Organic Athletic Field in Springfield

http://www.turi.org/Our_Work/Home_Community/Artificial_Turf

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Artificial Turf

Resources to help communities decide whether to install artificial turf on municipal and school fields.

Last Updated: May 3, 2017 | URL: http://guides.turi.org/artificialturf | Print Guide | RSS Updates

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Introduction

A number of studies indicate a basis for concern about toxic chemicals in artificial turf and crumb rubber. Below is a brief compilation of recent publications on the topic. This page includes resources from government agencies, health care providers, nonprofit organizations, and peer reviewed journal articles. For more information about artificial turf and safer alternatives, also see TURI's Artificial Turf webpage.

Resources from federal agencies

December 2016 Status Report: Federal Research Action Plan on Recycled Tire Crumb, US EPA, (updated December 30, 2016).

Tire Crumb and Synthetic Turf Field Literature and Report List as of Nov. 2015, US EPA, (updated November 10, 2016).

Federal Research on Recycled Tire Crumbs Used on Playing Fields, US EPA, (updated May 3, 2016).

Artificial turf. Centers for Disease Control and Prevention: web resource (updated October 2013).

A Scoping-Level Field Monitoring Study of Synthetic Turf Fields and Playgrounds, US EPA, November 2009.

CPSC Staff Analysis and Assessment of Synthetic Turf "Grass Blades", July 2008.

CPSC staff finds synthetic turf fields OK to install, OK to play on, U.S. Consumer Product Safety Commission, July 30, 2008.

Resources from state agencies

http://guides.turi.org/artificialturf

Thank you

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