Sports turf alternatives assessment: Research update and discussion

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Massachusetts Toxics Use Reduction Institute
IC2 Webinar – May 25, 2017
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• Information provided in these slides is drawn from work in progress; these slides are not for citation or distribution. For completed work that can be cited and distributed, see TURI’s website.

• We are working to develop an alternatives assessment that’s 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)

<table>
<thead>
<tr>
<th></th>
<th>Natural Low</th>
<th>Natural High</th>
<th>Synthetic Low (replacements in years 8 &amp; 16)</th>
<th>Synthetic High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation*</td>
<td>$39,000</td>
<td>$328,000</td>
<td>$295,000</td>
<td>$673,000</td>
</tr>
<tr>
<td>Annual Maintenance*</td>
<td>$4,000</td>
<td>$14,000</td>
<td>$4,000</td>
<td>$4,000</td>
</tr>
<tr>
<td>Annual Labor (hrs)*</td>
<td>250</td>
<td>750</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Annual labor cost</td>
<td>$5,000</td>
<td>$15,000</td>
<td>$6,000</td>
<td>$6,000</td>
</tr>
<tr>
<td>Resodding (yrs 6, 11, 16)</td>
<td>$25,000</td>
<td>$45,000</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Disposal &amp; resurfacing &amp; transport &amp; landfill*</td>
<td>$0</td>
<td>$0</td>
<td>$557,000</td>
<td>$642,000</td>
</tr>
<tr>
<td>Net Present Value</td>
<td>$197,000</td>
<td>$753,000</td>
<td>$1,189,000</td>
<td>$1,676,000</td>
</tr>
</tbody>
</table>

*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

<table>
<thead>
<tr>
<th>Synthetic</th>
<th>Tire crumb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EPDM</td>
</tr>
<tr>
<td></td>
<td>TPE</td>
</tr>
<tr>
<td></td>
<td>Waste athletic shoe materials</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mineral- or plant-based</th>
<th>Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cork</td>
</tr>
<tr>
<td></td>
<td>Coconut hulls &amp; fibers</td>
</tr>
</tbody>
</table>

| Combinations | Acrylic-coated sand |
Infills:
Useful concepts & background information

Multiple materials in each category

Additives

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

Other terminology I’ve found useful to understand

• 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)

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals</td>
<td>Aluminum, arsenic, barium, cadmium, chromium, copper, lead, nickel, zinc</td>
</tr>
<tr>
<td>VOCs</td>
<td>Benzene, benzothiazole, hexane, naphthalene, styrene, toluene, xylenes</td>
</tr>
<tr>
<td>PAHs</td>
<td>Anthracene, benz(a)anthracene, fluoranthene, naphthalene, phenanthrene, pyrene</td>
</tr>
<tr>
<td>Phthalates</td>
<td>Benzylbutyl phthalate, di(2-ethylhexyl)adipate, di(2-ethylhexyl)phthalate [DEHP, a.k.a. bis(2-ethylhexyl)phthalate]</td>
</tr>
<tr>
<td>Other (e.g. rubber curatives)</td>
<td>4-tert-(octyl)-phenol, butylated hydroxytoluene</td>
</tr>
</tbody>
</table>
## Tire crumb: lead and zinc data (examples)

<table>
<thead>
<tr>
<th>Study</th>
<th>Lead</th>
<th>Zinc</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bocca et al. 2009</td>
<td>12 to 46 mg/kg</td>
<td>118 to 19,375 mg/kg (median 10,229)</td>
<td>“concentration range for each metal was wide with respect to the different samples analyzed”</td>
</tr>
<tr>
<td>Simcox et al. 2010</td>
<td>&lt;68.9 to 271 μg/g [equivalent to mg/kg]</td>
<td></td>
<td>Lead concentrations are below the level considered by EPA to present a “‘soil lead hazard’ in play areas” (400 μg/g).</td>
</tr>
<tr>
<td>Marsili et al. 2015</td>
<td>10.76 to 38.99 mg/kg</td>
<td>3,474 to 13,202 mg/kg</td>
<td>9 AT fields in Italy</td>
</tr>
</tbody>
</table>
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>
<thead>
<tr>
<th></th>
<th>Recycled rubber granulate (n=3)</th>
<th>EPDM (n=1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PAHs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total PAHs</td>
<td>Yes (16 PAHs detected; total PAHs 51 to 76 mg/kg)</td>
<td>Yes (5 PAHs detected; total PAHs 1 mg/kg)</td>
</tr>
<tr>
<td><strong>Phthalates</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phthalates – over all</td>
<td>Yes</td>
<td>Yes (lower)</td>
</tr>
<tr>
<td>Dimethylphthalate (DMP)</td>
<td>No*</td>
<td>Yes (3.4 mg/kg)</td>
</tr>
<tr>
<td>Diethylphthalate (DEP)</td>
<td>No*</td>
<td>Yes (1.5 mg/kg)</td>
</tr>
<tr>
<td>Dibutylphthalate (DBP)</td>
<td>Yes (2.6 to 3.9 mg/kg)</td>
<td>Yes (1.6 mg/kg)</td>
</tr>
<tr>
<td>Benzylbutylphthalate (BBP)</td>
<td>Yes (1.3 to 2.8)</td>
<td>No*</td>
</tr>
<tr>
<td>Diethylhexylphthalate (DEHP)</td>
<td>Yes (21 to 29 mg/kg)</td>
<td>Yes (3.9 mg/kg)</td>
</tr>
<tr>
<td>Di-n-octylphthalate (DOP)</td>
<td>No*</td>
<td>Yes (3.2 mg/kg)</td>
</tr>
<tr>
<td>Diisononylphthalate (DINP)</td>
<td>Yes (57 to 78 mg/kg)</td>
<td>No data</td>
</tr>
<tr>
<td>Diisodecylphthalate</td>
<td>No*</td>
<td>No data</td>
</tr>
<tr>
<td><strong>Phenols</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phenols – over all</td>
<td>Yes</td>
<td>Yes (lower)</td>
</tr>
<tr>
<td>4-t-octylphenol</td>
<td>Yes (19,600 to 33,700 µg/kg)</td>
<td>Yes (49.8 µg/kg)</td>
</tr>
<tr>
<td>Iso-nonylphenol</td>
<td>Yes (9120 to 21,600 µg /kg)</td>
<td>Yes (1120 µg /kg)</td>
</tr>
<tr>
<td><strong>VOCs (offgassing test)</strong></td>
<td>Yes (12 detected)</td>
<td>Yes (4 detected, all at lower levels than the recycled rubber granulate)</td>
</tr>
</tbody>
</table>
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

• Sole Revolution
  – “Polymers include:”
    • Bromo Butyl or Brominated Isoprene Isobutylene Rubber (BIIR)
    • Nitrile or Acrylonitrile Butadiene Rubber (NBR)
    • Butadiene Rubber (BR)
    • Isoprene Rubber (IR)
    • Natural Rubber (NR)
Waste athletic shoe materials

• Nike Grind
  – EN71-3
  – Nike Finished Product Restricted Substance List (RSL)
    • “... includes strict and progressive limits on heavy metals (lead, cadmium, chromium and mercury), azo dyes, phthalates, formaldehyde, volatile organic compounds and PAHs.”
    • “Nike's website does not detail the chemicals used in the shoe rubber that becomes Nike Grind, but Greg Rossiter, a company spokesman, said in a statement that the company excludes substances that are deemed hazardous for consumer goods.”
Waste athletic shoe materials

• Like other products, may contain vulcanizing agents, antioxidants, colorants, stabilizers, plasticizers.

• Allergic reactions to additives used in shoe rubber
  – 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: Envirofill (a product of USGreentech)
  - Sand
  - Proprietary acrylic
  - Microban antimicrobial
  - Pigment
Acrylic-coated sand

• **Microban®**
  – Likely to be triclosan or triclocarban
    • Triclosan: GreenScreen® Benchmark 1 (“Avoid: Chemical of High Concern”)
      – PBT
      – Acute & systemic human toxicity
      – Very high ecotoxicity
      – Chronic aquatic toxicity
    • FDA has recently taken action to ban triclosan and triclocarban in over-the-counter hand and body washes.
Plant-based infill

• Sample products:
  – Limonta Sport, “Geo Plus” – “woody fibers”
  – Field Turf, “Purefill” – cork
  – Shaw Sports, “Geofill” – coconut (husks & fiber)
    • Patent also notes the product could contain “resilient particulate materials such as rubber . . .”
  – Greenplay USA, “Greenplay” – unknown

• Additional layers (pad and underlayment) should also be researched
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?
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 very 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
  – Getting a clear picture just about the chemicals is difficult – and they are numerous!

• 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 from private groups

• Alternatives assessment – questions re: scope & approach
**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

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

• Main turf page:
  – Artificial turf overview fact sheet (4 page)
  – Alternatives assessment – in sections
    • Introduction; cost analysis; physical & biological hazards; overview of infills; tire crumb infill; EPDM infill
    • Contact us directly for draft infill chapters not yet posted online
  – Resource guide
  – Comments on WA DOH report (January)
  – Links to federal resources
  – Springfield – organic lawns video
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


Resources from state agencies

http://guides.turi.org/artificialturf
Thank you

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Other on-going discussions
State of knowledge on tire crumb

• Very detailed information available on chemicals present in tire crumb
  – Much less information available on the alternatives
• Some limited information available on exposures
• Existing knowledge of effects in rubber workers, tire crumb manufacturing
• Multiple risk assessments
• No epidemiological studies to date
• California OEHHA
  – 3 year study, to be completed June 2018
  – Synthetic turf & playground mats made from recycled waste tires
  – Analyze samples, develop exposure scenarios, conduct risk assessment.
  – Possible future study would examine actual exposures through measurement of biological specimens or use of personal monitors.

• Federal study
  – EPA, CPSC, ATSDR
  – Status report with extensive literature review published December 2016

• Note: Recent WA Dept of Health report
  – Compared subset of Coach Amy Griffin’s list with a large denominator of estimated expected cancers.
  – Revised April 2017: “Our investigation was not designed to determine if soccer players in general were at increased risk of cancer due to exposures from crumb rubber in artificial turf.”