Human Health Risk Assessment of Artificial Turf Fields Based Upon Results from Five Fields in Connecticut

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Connecticut Dept Public Health

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Background

• Previous air investigations
  – Norway – 3 indoor fields – active play
  – USEPA – 4 outdoor fields – some play
  – NYC/NYS – 2 outdoor fields – some play

• Ingestion studies
  – California OEHHA
  – Norway

• CT study
  – Increasing the database
  – Personal monitoring
  – Indoor field
  – Acute risks
  – Benzothiazole risk assessment
Outline of Connecticut Air Study

July 2009

Summa cans, Personal Monitors, Stationary Monitors, Meterology, Soccer balls

4 Outdoor Fields
- VOCs, SVOCs,
- Rubber SVOCs,
- Nitrosamines,
- PM10, Lead

Air Concs, Lead in Infill/Grass
- HHRA Child & Adult

1 Indoor Field
- VOCs, SVOCs,
- Rubber SVOCs,
- Nitrosamines,
- PM10, Lead

Air Concs, Lead in Infill/Grass
- HHRA Child & Adult
<table>
<thead>
<tr>
<th>Sample Type</th>
<th>VOCs</th>
<th>SVOCs</th>
<th>Rubber SVOCs</th>
<th>Nitrosamines</th>
<th>PM$_{10}$</th>
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<tbody>
<tr>
<td>Personal monitor</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
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<tr>
<td>Stationary on-field 6 inch</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
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<tr>
<td>Stationary on field 3 feet</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Stationary upwind</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Community</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>
Figure 1. Personal sampling for VOCs.

Figure 2. VOC sampling on turf field.
COPCs for RA

• Higher detect than off the field
• Not just in the personal monitors
• 27 COPCs at both the indoor and outdoor fields
  – 14 VOCs
  – 11 PAHs
  – 1-2 targeted SVOCs
  – Miscellaneous SVOCs
Figure 7. Benzene Detects at Artificial Turf Fields (no detects at Field D)
Figure 8. Toluene Detects at Artificial Turf Fields
Figure 9. Methylene Chloride Detects at Artificial Turf Fields (no detects at Fields A or D)
Figure 5. PAHs that were Detected Above Background Concentration

<table>
<thead>
<tr>
<th>PAHs</th>
<th>Field A</th>
<th>Field B</th>
<th>Field C</th>
<th>Field D</th>
<th>Field K</th>
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<tbody>
<tr>
<td>Acenaphthene</td>
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<tr>
<td>Acenaphthylene</td>
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<tr>
<td>Benzo(a)anthracene</td>
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<tr>
<td>Benzo(a)pyrene</td>
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<tr>
<td>Benzo(b)fluoranthene</td>
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<tr>
<td>Benzo(e)pyrene</td>
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<tr>
<td>Benzo(ghi)fluoranthene</td>
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<tr>
<td>Benzo(ghi)perylene</td>
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<tr>
<td>Benzo(k)fluoranthene</td>
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<tr>
<td>Chrysene</td>
<td></td>
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<tr>
<td>Fluoranthene</td>
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<tr>
<td>Fluorene</td>
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<tr>
<td>Naphthalene</td>
<td></td>
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<tr>
<td>1-Methylnaphthalene</td>
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<tr>
<td>2-Methylnaphthalene</td>
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<tr>
<td>2,6-Dimethylnaphthalene</td>
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<tr>
<td>Phenanthrene</td>
<td></td>
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<tr>
<td>Pyrene</td>
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</table>
Figure 2. Benzo(a)pyrene Results Across Fields and Comparison with Background

Concentration (ng/m3)
Figure 4. Naphthalene Results Across Fields and Comparison to Background

Concentration (ng/m³)

<table>
<thead>
<tr>
<th></th>
<th>On Field</th>
<th>On Field</th>
<th>On Field</th>
<th>On Field 6 hr</th>
<th>On Field</th>
<th>Background</th>
<th>Background</th>
<th>Background 6 hr</th>
<th>Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field A</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Field B</td>
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<td>Field C</td>
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<tr>
<td>Field D</td>
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<td></td>
<td></td>
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<tr>
<td>Field K</td>
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<td></td>
</tr>
</tbody>
</table>
Figure 11. Benzothiazole Results Across Fields Not Including Indoor Field

Concentration (ng/m^3)
Figure 12. Benzothiazole Results Across Fields including Indoor Field
Exposure Scenarios

- Children 6-18 inhaling measured VOCs/SVOCs
- Adults 30 yrs inhaling VOCs/SVOCs
- Indoor field
- Worst case composite of outdoor field
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Child</th>
<th>Adult</th>
<th>Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>12</td>
<td>30</td>
<td>Child – midpoint of 6-18 yr range</td>
</tr>
<tr>
<td>Years exposed</td>
<td>12</td>
<td>30</td>
<td>Child – youth to high school soccer; Adult – 90th% residence at one location</td>
</tr>
<tr>
<td>Exposure time per event</td>
<td>3 hr</td>
<td>3 hr</td>
<td>Time for soccer match or practice</td>
</tr>
<tr>
<td>Days exposed per year</td>
<td>138</td>
<td>138</td>
<td>4 day/wk for 8 months (spring, fall soccer + 2 months in summer)</td>
</tr>
<tr>
<td>Days exposed per year VOCs</td>
<td>69</td>
<td>69</td>
<td>VOC offgas only in the 4 warm months for outdoor fields; no adjustment for indoor fields</td>
</tr>
<tr>
<td>Ventilation adjustment</td>
<td>3.96</td>
<td>2.64</td>
<td>Child – Adult factor* child factor</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Adult – moderate exercise</td>
</tr>
<tr>
<td>Averaging time (cancer)</td>
<td>25550 days</td>
<td>25550 days</td>
<td>Entire lifespan – 70 yrs</td>
</tr>
<tr>
<td>Averaging time (non-cancer)</td>
<td>4380 days</td>
<td>10950 days</td>
<td>Entire exposure period</td>
</tr>
</tbody>
</table>

Conservative Assumption – highest detect at any field represents that chemical – outdoor assessment is the combination of the high hits – worst case
COPC Toxicity Values

• RfCs and Cancer Unit Risks
  – USEPA IRIS, CalEPA OEHHA, ATSDR
• Acute targets – 3 hr basis
  – CalEPA OEHHA, CTDPH, ATSDR
• Conservative approach
  – Use surrogate value in place of zero toxicity
    • Naphthalenes, PAHs, heptane
• Benzothiazole
  – Chronic non-cancer value – EFSA/NYS
  – Cancer – based upon 2-MBT
  – Acute – based upon formaldehyde
• Children’s cancer potency 3x factor for mutagens including benzothiazole
Benzothiazole Tox Assessment

Benzothiazole: CAS Registry Number 95-16-9

2-Mercaptobenzothiazole: CAS Registry Number 149-30-4
BZT vs 2-MBT

• Metabolism
  – BZT – ring scission - aryl amine and N-OH
  – 2-MBT – conjugation of mercapto group

• Mutagenicity
  – BZT - + in Salmonella with activation –
    • only 1 study available
    • 2-MBT – mixed results – negative in Salmonella but positive in mouse lymphoma and CHO chrom abb with metabolic activation

• Carcinogenicity
  – 2-MBT tested by NTP in rats and mice
    • Tumor increases in adrenals, kidney, pancreas, pituitary, leukemia
    • Associated with bladder cancer in two rubber worker studies
    • Whittaker 2004 calculated a slope factor from the NTP data
      – 6.34E-04/mg-kg-d based upon rat renal tumors
BZT Non-Cancer Targets

• NYS/EFSA RfD-type value
  – 1971 diet study in rats 5.1 mg/kg/d x 3 months
    • No effects found
  – NOAEL divided by 1000 = 5 ug/kg/d
  – DRE yields 18 ug/m3 for *inhalation* reference value

• BZT & 2-MBT may be skin sensitizers
  – 1931 study of BZT – 17 of 43 human subjects were sensitized
BZT Potency as Acute Respiratory Irritant

- Anectodal reports of irritation in workers
- RD$_{50}$ study in mice CPSC (1996)
  - Formaldehyde RD$_{50}$ = 12.9 mg/m$^3$
  - BZT RD$_{50}$ = 235 mg/m$^3$
  - Acute irritant difference = 18
- Formaldehyde concern level = 50 ug/m$^3$
  - 61.5 ug/m$^3$
- Converting to BZT acute irritation = 1100 ug/m$^3$
- Divided by 10 for extrapolation uncertainties
  - Acute air target = **110 ug/m$^3$**
  - BZT treated as if only 1.8 fold less potent that formaldehyde
Figure 13. Cancer Risk Estimates for Indoor and Outdoor Turf Fields

- Total
- Benzene
- Methylene Chloride
- Chloromethane
- Benzothiazole
- PAHs

Community Risk Range
Figure 14. Hazard Indices for Non-Cancer and Acute Risk at Artificial Turf Fields

Hazard Index

- Child outdoor
- Child indoor
- Adult outdoor
- Adult indoor

Non-Cancer HI
Acute HI

Elevated Risk
<table>
<thead>
<tr>
<th></th>
<th>Child Outdoor</th>
<th>Child Indoor</th>
<th>Adult Outdoor</th>
<th>Adult Indoor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancer Risk</td>
<td>1.9E-06</td>
<td>3.4E-06</td>
<td>1.1E-06</td>
<td>2.3E-06</td>
</tr>
<tr>
<td>Non-Cancer</td>
<td>0.09</td>
<td>0.48</td>
<td>0.057</td>
<td>0.32</td>
</tr>
<tr>
<td>Acute</td>
<td>0.44</td>
<td>0.96</td>
<td>0.29</td>
<td>0.63</td>
</tr>
<tr>
<td>Key Analytes</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td>Benzene 73%</td>
<td>Benzene 61%</td>
<td>Benzene 73%</td>
<td>Benzene 51%</td>
</tr>
<tr>
<td></td>
<td>MethyleneCl 17%</td>
<td>MethyleneCl 14%</td>
<td>MethyleneCl 17%</td>
<td>MethyleneCl 11%</td>
</tr>
<tr>
<td></td>
<td>Chloro Me 7%</td>
<td>Chloro Me 8%</td>
<td>Chloro Me 7%</td>
<td>Chloro Me 6%</td>
</tr>
<tr>
<td></td>
<td>BenzothiaZ &lt;1%</td>
<td>BenzothiaZ 7%</td>
<td>BenzothiaZ &lt;1%</td>
<td>BenzothiaZ 6%</td>
</tr>
<tr>
<td>Non-cancer</td>
<td>Toluene 19%</td>
<td>Toluene 18%</td>
<td>Toluene 19%</td>
<td>Toluene 18%</td>
</tr>
<tr>
<td>Acute</td>
<td>BenzothiaZ 9.8%</td>
<td>BenzothiaZ 54%</td>
<td>BenzothiaZ 9.8%</td>
<td>BenzothiaZ 54%</td>
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<tr>
<td></td>
<td>Benzene 16%</td>
<td>Benzene 5.6%</td>
<td>Benzene 16%</td>
<td>Benzene 5.6%</td>
</tr>
<tr>
<td></td>
<td>Toluene 6.3%</td>
<td>Toluene 7.6%</td>
<td>Toluene 6.3%</td>
<td>Toluene 7.6%</td>
</tr>
</tbody>
</table>
CASE Review

• Are we overstating the risks?
  – Benzene and methylene chloride not field-related??

• Representativeness of the fields?
  – Our results similar to other studies involving a range of conditions and fields
  – Many different crumb rubber samples tested between WOHL and CAES in offgas studies
  – Still a potentially impt source of variability

• Allergens
  – Latex in natural rubber – 6% of population allergic
    • Warning signs needed?
  – Benzothiazole is a contact allergen

• Toddler/ingestion risks
  – California assumed 10 g crumbs ingested at once
  – Norway – assumed 1g/day over 6 months of play
    • Evaluated acute risks of phthalates and alkylphenols
Summary and Conclusions

• Field investigation able to detect VOCs, SVOCs
  – Particularly BZT, naphthalenes,
• **Indoor results >> Outdoor results**
• Results consistent with previous studies
• No risks particularly elevated or novel relative to background
  – Cancer risk drivers (benzene, methylene Cl)
    • May be partially artifact
  – Acute inhalation risk **borderline at indoor field**
    • Presents an uncertainty
  – PM$_{10}$, Lead, Nitrosamines – not elevated
• Uncertainty: hot weather, fresh rubber
• Uncertainty – allergenicity of the fields
  – Latex antigen and benzothiazole dermal and inhalation exposure
Synthetic turf field investigation in Connecticut.

Human health risk assessment of synthetic turf fields based upon investigation of five fields in Connecticut.

Benzothiazole toxicity assessment in support of synthetic turf field human health risk assessment.
Areas of Recommendation

• Ventilation of indoor fields?
• Install fields in cooler weather or have a “no play” break in period?
• Contact LHD if experience breathing difficulty or allergic skin reaction?