EPA Tools & Resources Webinar: U.S. Federal Research Action Plan on Recycled Tire Crumb Rubber Used on Synthetic Turf Playing Fields and Playgrounds

Exposure Characterization Final Report (Part 2) Findings and Conclusions

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Agenda

- U.S. Federal Research Action Plan Overview
- Tire Crumb Rubber Characterization (Part 1) Report
  - Recap of 2019 public report
- Exposure Characterization (Part 2) Report
  - Objectives and Approach
  - Results
  - Key Findings
- Overall Conclusions (Part 1 and Part 2)

Background

- EPA, ATSDR, and the Consumer Product Safety Commission (CPSC) launched the Federal Research Action Plan (FRAP) on Recycled Tire Crumb Rubber Used on Synthetic Turf Fields and Playgrounds in 2016.

- EPA and ATSDR released the Tire Crumb Rubber Characterization (Part 1) Report in 2019.

- Following ATSDR's completion of a supplemental biomonitoring study, EPA and ATSDR finalized released the Tire Crumb Exposure Characterization (Part 2) Report on April 16, 2024.

- EPA and ATSDR activities with respect to the FRAP (synthetic turf fields) are complete.

Bottom Line - Playing Fields

In general, the findings from the FRAP study on playing fields (Parts 1 and 2 combined) support the conclusion that although chemicals are present (as expected) in the tire crumb rubber and exposures can occur, they are likely limited; for example:

- ✓ *Generally, only small amounts of most organic chemicals are released into the air through emissions. For many analytes measured during active play at the outdoor fields, next-to-field concentrations in air were not different than background samples while others were somewhat higher.*
- ✓ *For metals, only small fractions (average mean about 3% for gastric fluid and <1% for saliva and sweat plus sebum) are released from tire crumb rubber into simulated biological fluids compared to a default assumption of 100% bioaccessibility.*
- ✓ *In the biomonitoring pilot study, concentrations for metals measured in blood were similar to those in the general population.*
- ✓ *No differences in (polycyclic aromatic hydrocarbons) PAH metabolites in urine were observed in the supplemental biomonitoring study between study participants using natural grass fields and those on synthetic turf fields with tire crumb rubber infill.*

Federal Research Action Plan (FRAP) Overview

Research Context

- There are now 18,000-19,000 synthetic turf fields in the U.S., with 1,200 – 1,500 new or replacement installations each year.
- Most fields use tire crumb rubber as infill material, sometimes mixed with sand; alternative natural or synthetic materials are sometimes used.
- Fields are at municipal and county parks, schools, colleges and universities, professional sports stadiums and practice fields, and military installations.
- Parents, athletes, schools, and communities had raised concerns about potential negative health effects.
- Most studies as of 2016 examining potential exposures had been considered limited.

Federal Research Action Plan (FRAP)

www.epa.gov/tirecrumb

- The FRAP is not a risk assessment nor can the information in the FRAP report be used to identify a level above which health effects could occur.

- Research focus was on understanding exposures:
  - what chemicals are in the material, at what amounts, and how people come in contact with it;
  - exposure is a key component that informs risk.

- First time such a comprehensive study has been conducted in the U.S.

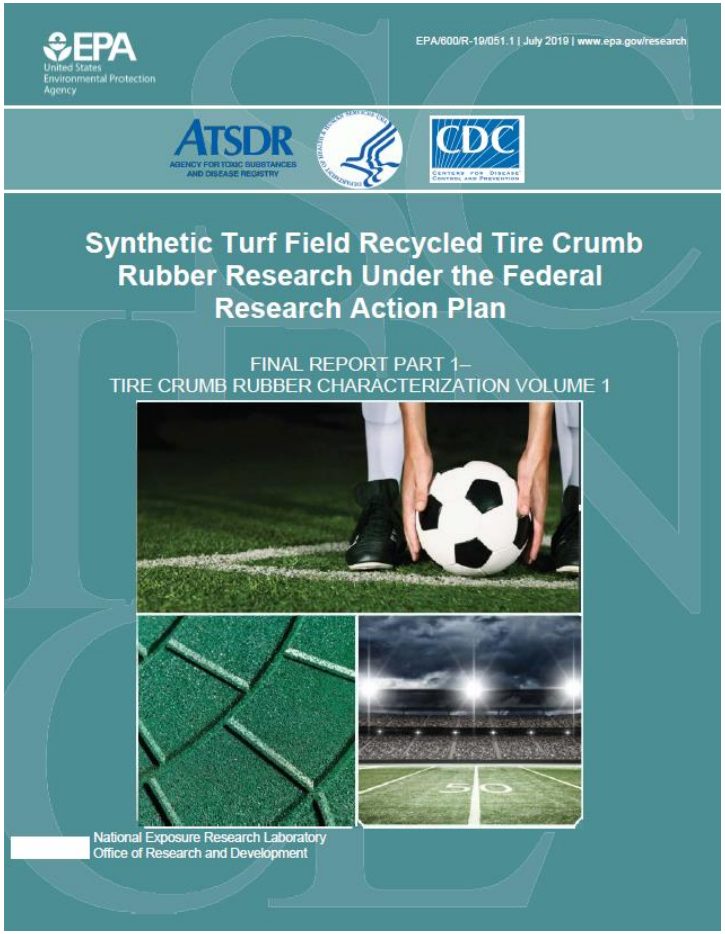
Status of Research Activities

Research Activity	Lead(s)	Status
Literature review and data gaps analysis; industry overview; stakeholder outreach	EPA/ORD, CDC/ATSDR & CPSC	Completed; released with Status Report, December 2016 https://www.epa.gov/chemical-research/december-2016-status-report-federal-research-action-plan-recycled-tire-crumb
Collect tire crumb samples from manufacturing facilities (recycling plants) and synthetic turf fields Tire crumb characterization: chemical constituents; particle size; microbes; emissions; bioaccessibility	EPA/ORD and CDC/ATSDR	Completed; draft report peer reviewed; Part 1 report released to public July 25, 2019 https://www.epa.gov/chemical-research/july-2019-report-tire-crumb-rubber-characterization-0
Exposure Characterization: How people are exposed based on activities on the fields	EPA/ORD and CDC/ATSDR	The report was externally peer reviewed; Release of Part 2 of the report was deferred until after the supplemental CDC/ATSDR biomonitoring study was completed; the report has now been released to public.
Supplemental Biomonitoring Study	CDC/ATSDR	Following COVID delays, work completed in 2023; ATSDR report has been externally peer reviewed and cleared at CDC/ATSDR in January 2024; the biomonitoring report is included as an Appendix in the Part 2 report
Playground Study	CPSC	Completed; national telephone survey of parents on child interaction with playground surfaces (2019 report); technical support activities for preparing for a screening level risk assessment; no assessment currently planned https://www.cpsc.gov/Safety-Education/Safety-Education-Centers/Crumb-Rubber-Safety-Information-Center

Tire Crumb Rubber Characterization
Part 1 Report
Released July 2019

Tire Crumb Characterization Part 1 Report Overview

- On July 25, 2019, EPA and ATSDR released the FRAP Tire Crumb Rubber Characterization (Part 1) report.
- The FRAP report addressed exposure (what is in the tire crumb and how people come in contact with the material) to tire crumb rubber on synthetic turf fields.
- It assessed chemical constituents, microbiological presence, organic chemical emissions, and metals bioaccessibility for tire crumb rubber samples collected from 9 recycling plants and 40 synthetic turf fields around the United States.



https://www.epa.gov/chemical-research/july-2019-report-tire-crumb-rubber-characterization-0

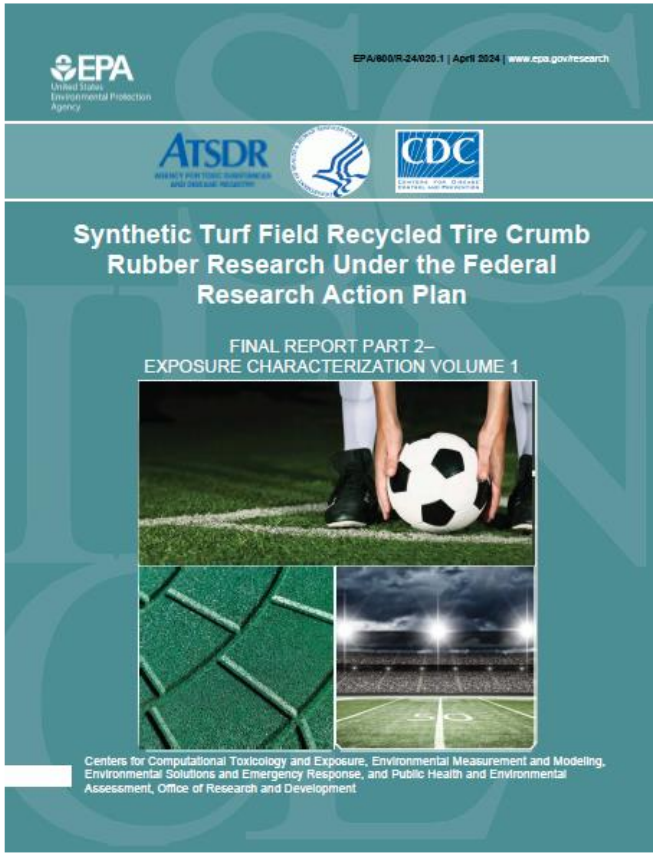
Tire Crumb Characterization – Key Findings

- ✓ In general, and not unexpectedly, the study found a range of chemicals (metals and organic compounds), and all fields tested positive for bacteria.
- ✓ Chemical concentrations were generally similar to those reported in other studies.
- ✓ Bacteria were found at levels similar to those previously reported on common household products.
- ✓ While a range of chemicals were present air emissions of most organic chemicals, and bioaccessibility of metals were low.

Exposure Characterization Part 2 Report

Exposure Characterization Part 2 Report Overview

- On April 16, 2024, EPA and ATSDR released the FRAP Exposure Characterization (Part 2) report.
- The FRAP Part 2 report addressed exposure (how people come in contact with the material) to chemicals associated with tire crumb rubber on synthetic turf fields.



https://www.epa.gov/chemical-research/tire-crumb-exposure-characterization-report-volumes-1-and-2

Exposure Characterization Research Need and Purpose

The published literature review and data gaps analysis identified several exposure-specific data gaps.

- Limited human exposure assessment
- Limited characterization of dermal and ingestion exposure pathways
- Limited biomonitoring
- Small sample sizes

Overall Research Purpose: Characterize exposures or how people are exposed to chemical compounds found in recycled tire crumb rubber based on their activities on synthetic turf fields.

Exposure Characterization
Completed Research Activities

- Field user activity questionnaires (n=32 child and adult participants)
- Pilot study of exposure measurements and biomonitoring during and around play/practice on fields (3 fields, n=25 participants total, 14 with biomonitoring)
- ATSDR supplemental biomonitoring study (n=132 playing on synthetic turf fields; n=29 playing on natural grass fields)
- Athlete micro-activity data (e.g., hand-to-mouth; object-to-mouth; hand-to-turf; body-to-turf) gathering from publicly available video and study participant video (n=60 and n=17, respectively)
- Assessing exposure pathway modeling for six chemicals associated with tire crumb rubber

Exposure Characterization (Part 2)
Key Findings Up Front

- Not unexpectedly, a range of chemicals (including metals and organic chemicals) was found in air, field surface, field dust, and in dermal exposure media.

- Field and dermal measurements (while limited) indicate that people can be exposed to chemicals associated with recycled tire crumb rubber infill material when they use synthetic turf fields; exposures may be higher at indoor fields compared to outdoor fields. Overall, potential exposures are expected to be low.

- For many analytes measured during active play at the outdoor fields, next-to-field concentrations in air were not different than background samples while others were somewhat higher.

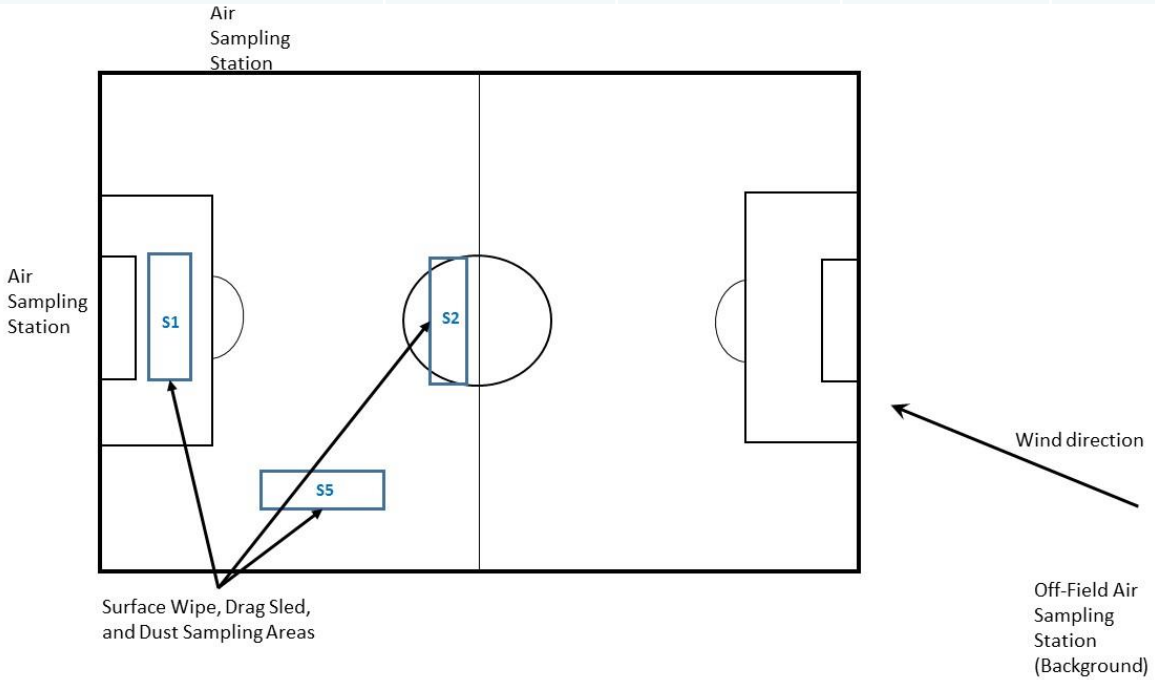
- For study participants, metals in blood and serum and creatinine-adjusted urinary PAH metabolites were similar before and after field activities, with the exception of 2-hydroxynaphthalene, and were consistent with those measured in the general population, with the exception of selenium and 2-hydroxynaphthalene.

- The supplemental biomonitoring study (Part 2 Report Appendix A) further elucidates the initial pilot findings. In general, no differences in urinary PAH metabolites were observed between study participants using grass and synthetic turf fields with tire crumb rubber infill in the supplemental biomonitoring study.

Field Measurements

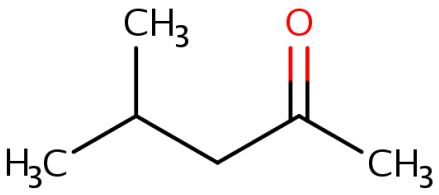
Field Sampling and Conditions

	Outdoor Field 1 Soccer	Outdoor Field 1 Football	Outdoor Field 2 Soccer	Indoor Field Soccer
Number of Days	1	2	4	1
Maximum Air Temperatures	91˚F	84˚F	95˚F	82˚F
Maximum Surface Temperatures	102˚F	91˚F	108˚F	84˚F
Numbers of Athletes	16 - 22	18 - 38	13 - 58	9 - 11

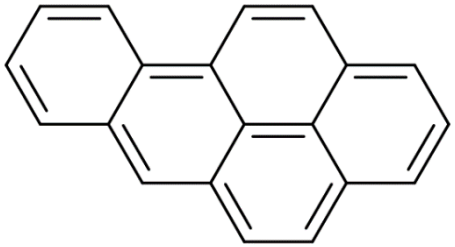


Target Analytes

Methyl Isobutyl Ketone
(Example VOC)



Benzo[a]pyrene
(Example SVOC)



- **Metals - 21 Targeted**
  - Examples: lead, zinc, chromium, cadmium, cobalt
  - Air, dust, surface wipe, dermal media
- **Semi-Volatile Organic Chemicals (SVOCs) – 40 Targeted**
  - Examples: PAHs, phthalates, thiazoles
  - Air, dust, surface wipe, drag sled, dermal media
- **Volatile Organic Chemicals (VOCs) - 30 Targeted**
  - Examples: methyl isobutyl ketone, benzothiazole, styrene, 1,3-butadiene
  - Air medium

Field Measurement Key Observations

- For many analytes at the outdoor fields, next-to-field concentrations in air were not different than background samples;
  - Exceptions included methyl isobutyl ketone, 4-tert-octylphenol, benzothiazole, bis(2-ethylhexyl) phthalate and several PAHs, for which next-to-field measurements were above background levels.

- Air concentrations of many analytes were higher in the indoor field facility compared to background levels and levels measured next to outdoor fields.

- On average, SVOCs and zinc and cobalt, two tire crumb rubber metal constituents, were measured in field dust at lower levels than in tire crumb rubber.

- Many metals and SVOCs associated with tire crumb rubber were measured at low levels in field wipes.

Personal Sampling

Exposure Measurements
Personal Samples

Passive Air VOC Samples

- Radiello passive samplers with Carbopack X
- *Method was not successful*

Dermal Wipe Samples

- Hands – total surface
- Arms & Legs using defined area templates
- Metals using Ghost wipes
- SVOCs twill wipes w 1:1 isopropanol/water

Dermal Measurements - Key Observations

- All metals except selenium were found at measurable levels in dermal wipe samples, but many were measured at median values below 1 ng/cm^2.
- About half of the SVOCs were measured in dermal wipe samples at levels above the method detection limit, but most had median values below 0.2 ng/cm^2.
- Few clear differences in dermal levels were observed between age groups or between football and soccer groups.
- The dermal measurements have limitations (e.g., samples were collected only post-activity, sampling efficiency is uncertain), but provide information that can be used in exposure models to avoid highly uncertain transfer rate estimates for dermal exposures.

Questionnaire and Video Activity Assessment

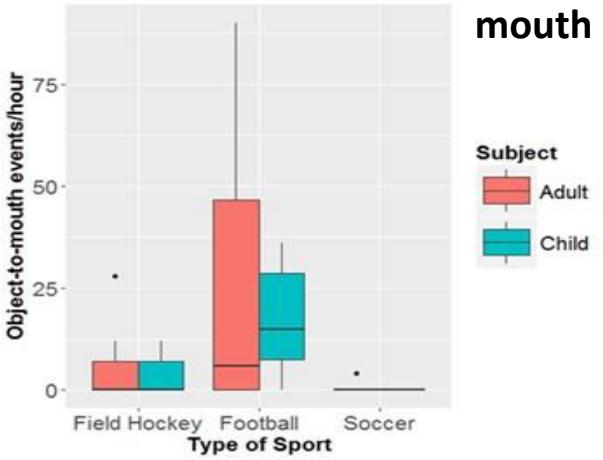
Activity Assessment - Key Observations

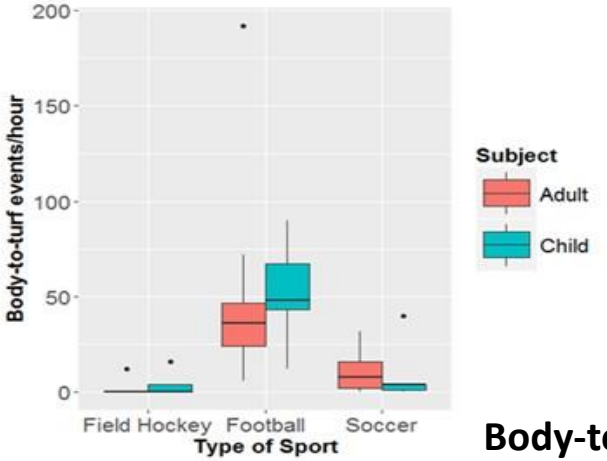
Questionnaire Activity Assessment

- Questionnaires were used to assess how child and adult athletes use synthetic turf fields, their rates of contact with field materials, and related hygiene information.
- Study participants reported via the questionnaires that they engaged in athletic activities through most seasons at both synthetic turf fields and at natural grass fields.
- Physical contact with synthetic turf was frequently reported by participants.
- Participants also frequently reported finding tire crumb rubber on their bodies and in their cars and homes after playing on synthetic turf fields with recycled tire crumb rubber infill.
- The data from the questionnaires helped inform our knowledge of factors that may affect exposure to recycled tire crumb rubber infill used on synthetic turf fields, and the questionnaire can help in the design of activity data collection approaches in larger future studies.

Video Activity Assessment Key Observations

Object-to-mouth





Body-to-turf

- Children and adults were found to have similar contact rate frequencies.
- Some types of exposure contacts were observed more frequently for football players compared to soccer players, such as object-to-mouth contact due to the use of mouth guards.

Exposure Modeling Pathway Assessment

Exposure Modeling Pathway Assessment

- Exposure pathway modeling for athletes using synthetic turf fields with tire crumb rubber infill was performed using measurement data available from previous studies and supplemented with data collected in this study.

- The estimation used six (6) chemicals (pyrene, benzo[a]pyrene, benzothiazole, methyl isobutyl ketone, lead, and zinc) chosen to provide a range of physical and chemical properties.

- In general, estimated daily exposures were $<5 \times 10^{-5}$ mg/kg-day for most chemicals and pathways, with inhalation being the dominant pathway for more volatile chemicals and ingestion being dominant for metals and less volatile chemicals.

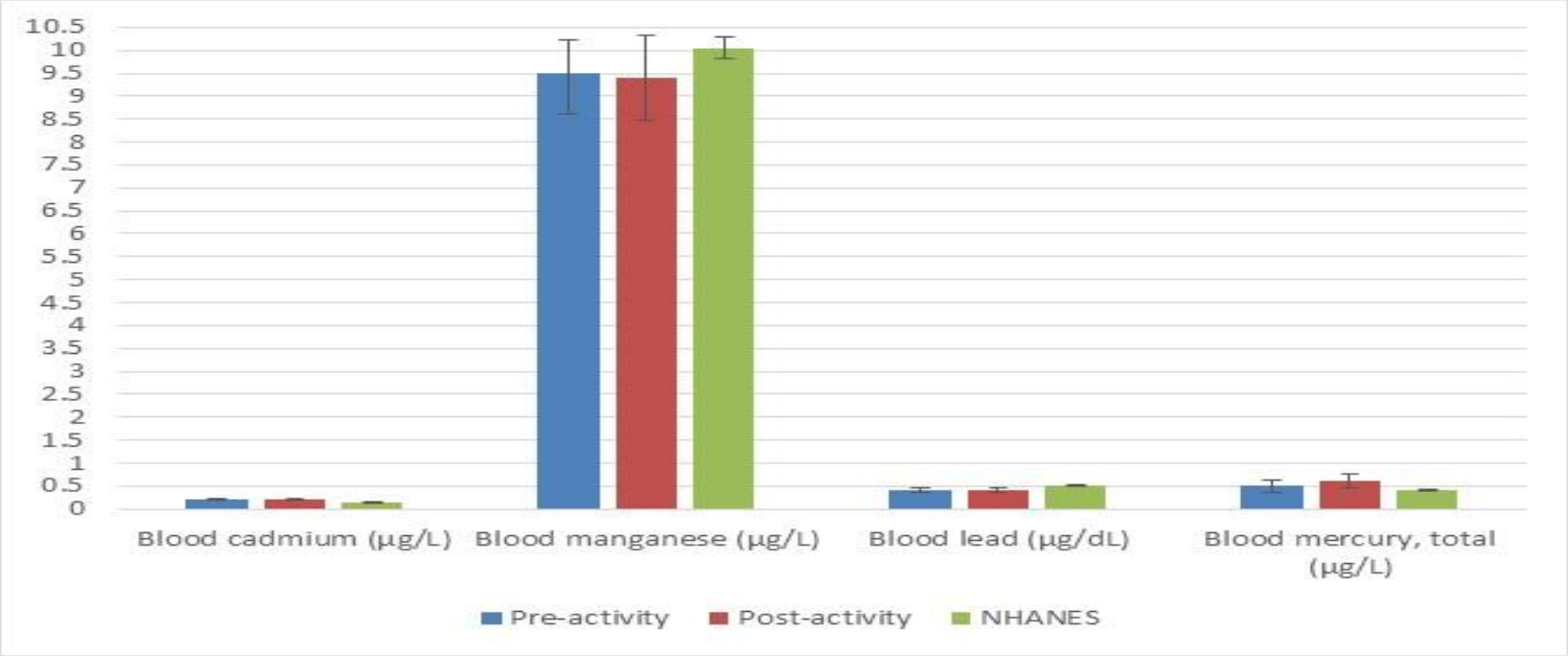
- The data collected from the study improved the estimates, however, the results still carry a degree of uncertainty associated with limited data availability and model parameters (e.g., ingestion rates and dermal adhesion values for tire crumb rubber and field dust).

Biomonitoring

Biomonitoring

- A pilot study was conducted where pre- and post-activity urine and blood samples were collected for three fields.
  - Whole blood samples were analyzed for cadmium, manganese, lead, mercury, and selenium.
  - Serum samples were analyzed for copper, selenium, and zinc.
  - Urine samples were analyzed for metabolites of the PAHs naphthalene, fluorene, phenanthrene, and pyrene.
- An additional supplemental study was completed where participants were recruited from two outdoor and one indoor synthetic turf fields with tire crumb rubber infill and two co-located natural grass fields.
  - Pre- and post-activity urine samples were collected from 132 synthetic turf field users and 29 natural grass field users.
  - Urine samples were analyzed for metabolites of the PAHs naphthalene, fluorene, phenanthrene, and pyrene.

Biomonitoring Results Key Observations



For study participants, metals in blood and serum and creatinine-adjusted urinary PAHs were similar before and after field activities, with the exception of 2-hydroxynaphthalene, and were consistent with those measured in the general population.

Supplemental Biomonitoring Study Findings

- Pre- and post-activity differences in urinary PAH concentrations were **not** associated with field type (synthetic turf fields with tire crumb rubber infill vs natural grass fields).

- Results for pre- and post-activity urinary PAH metabolite differences varied by statistical method with the best predictor of post-activity PAH concentration being pre-activity concentrations.

- Except for 2-hydroxynaphthalene, pre-activity PAH concentrations were lower than those in the U.S. population (NHANES 2015-2016).

Overall Conclusions

Bottom Line - Playing Fields

In general, the findings from the FRAP study on playing fields (Parts 1 and 2 combined) support the conclusion that although chemicals are present (as expected) in the tire crumb rubber and exposures can occur, they are likely limited; for example:

- ✓ *Generally, only small amounts of most organic chemicals are released into the air through emissions. For many analytes measured during active play at the outdoor fields, next-to-field concentrations in air were not different than background samples while others were somewhat higher.*
- ✓ *For metals, only small fractions (average mean about 3% for gastric fluid and <1% for saliva and sweat plus sebum) are released from tire crumb rubber into simulated biological fluids compared to a default assumption of 100% bioaccessibility.*
- ✓ *In the biomonitoring pilot study, concentrations for metals measured in blood were similar to those in the general population.*
- ✓ *No differences in PAH metabolites in urine were observed in the supplemental biomonitoring study between study participants using natural grass fields and those on synthetic turf fields with tire crumb rubber infill.*

Additional Considerations

- The FRAP supports the findings of limited exposure, as reported in studies from RIVM and ECHA as well as the chemical assessments from the NTP:

  - ✓ The Netherlands National Institute for Health and Environment (RIVM) released a December 2016 report, updated in March 2017, titled “Evaluation of health risks of playing sports on synthetic turf pitches with rubber granulate”. https://www.rivm.nl/en/rubber-granulate/research-into-rubber-granulate-on-turf-fields-in-2016/scientific-report

  - ✓ The European Chemicals Agency (ECHA) released a report in February 2017 titled “Annex XV Report; An Evaluation of the Possible Health Risks of Recycled Rubber Granules Used as Infill in Synthetic Turf Sports Fields”. https://echa.europa.eu/-/recycled-rubber-infill-causes-a-very-low-level-of-concern

  - ✓ The National Toxicology Program (NTP, 2019) conducted chemical assessments and short-term toxicity studies on the recycled tire crumb rubber material itself, not specific chemical constituents found in the material. https://ntp.niehs.nih.gov/whatwestudy/topics/syntheticturf

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Additional Technical Information

Exposure Measurements
Field Environment

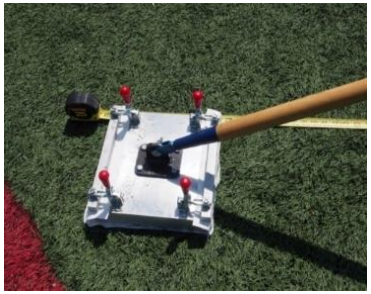
Air Samples

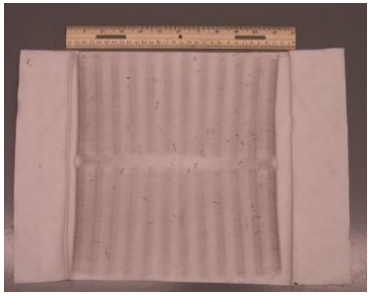
- Next to field and upwind sites
- Total suspended particulates
- Metals
- SVOCs
- VOCs (active + passive)

Field Surface Wet Wipe Samples

- Metals - Ghost Wipes
- SVOCs – Cotton twill with 1:1 isopropanol/water

Exposure Measurements
Field Environment






Drag Sled Samples

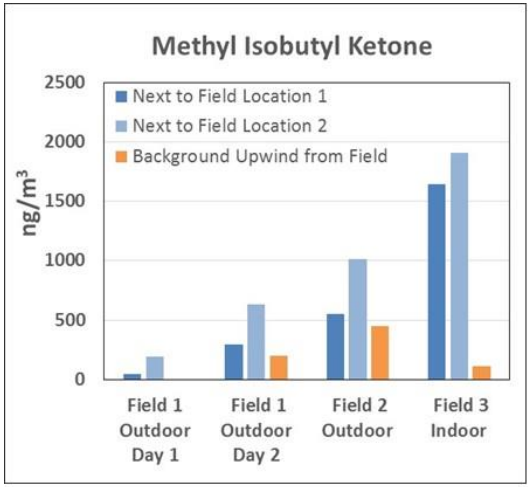
- For 'transferrable' SVOC residues
- Standardized weight/pressure

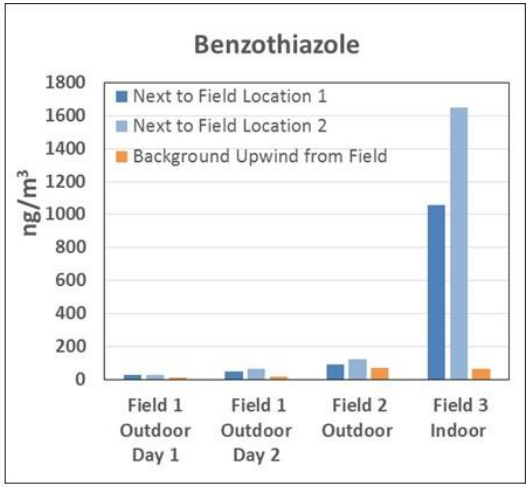


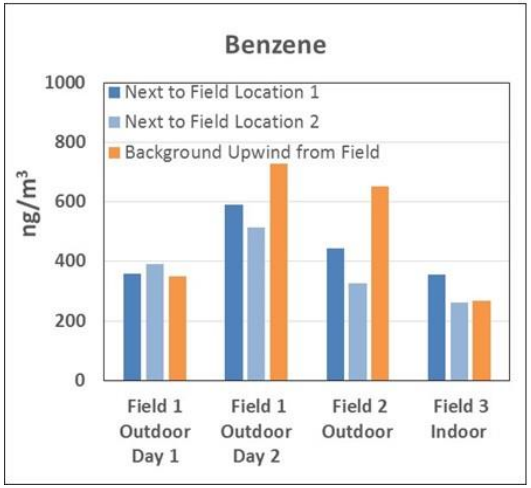

Field Dust Samples

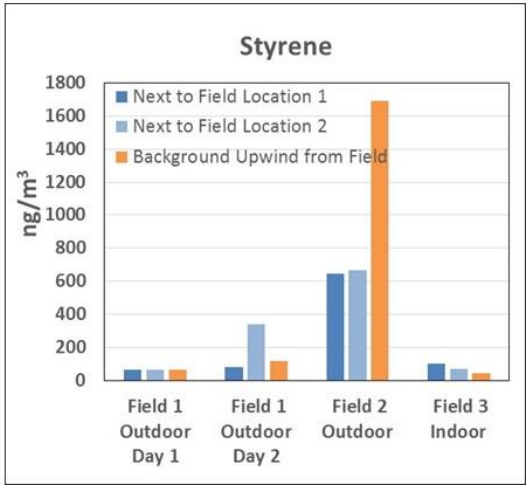
- Metals and SVOCs
- On-field sieving of surface dust
- 150 µm sieve

Field Measurements
Example Results - Field Air VOCs









Air samples were collected for VOC, SVOC, metal and total suspended particulate (TSP) analysis at three synthetic turf fields during warm to hot weather, while athletic teams practiced.

For many analytes at the outdoor fields, next-to-field concentrations in air were not different than background samples; exceptions included methyl isobutyl ketone, 4-tert-octylphenol, benzothiazole, bis(2-ethylhexyl) phthalate and several PAHs, for which next-to-field measurements were above background levels.

Air concentrations of many analytes were higher in the indoor field facility compared to background levels and levels measured next to outdoor fields.

Field Measurement Specific Findings

Field Dust

- On average, SVOCs were present in field dust at concentrations similar to, but lower than, those measured in the tire crumb rubber infill.

- Zinc and cobalt, two tire crumb rubber metal constituents, were measured in field dust at lower levels than in tire crumb rubber.

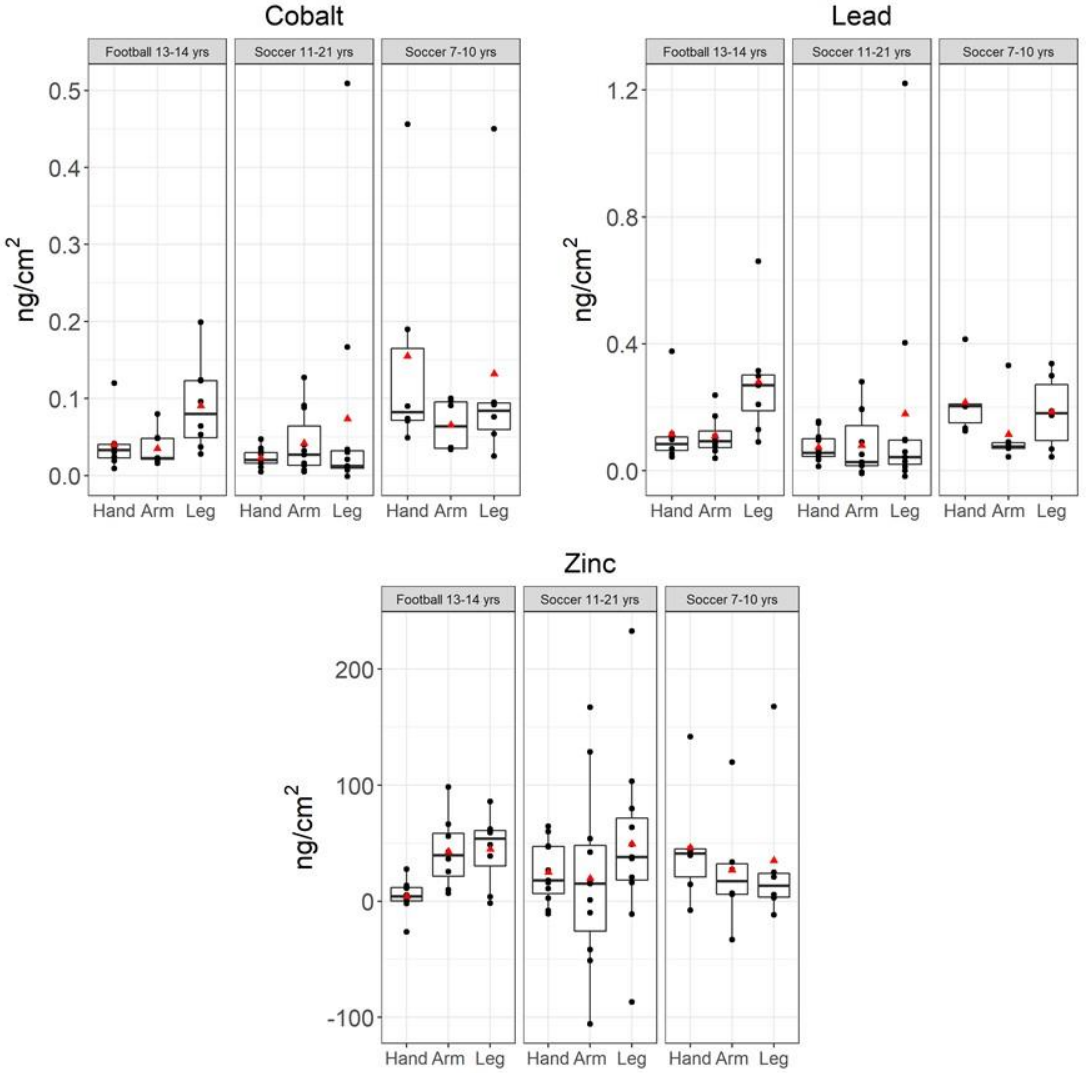
- Other metals, such as lead, were present in field dust at levels higher than those measured in the tire crumb rubber, suggesting potential sources other than the rubber.

Surface Wipes and Drag Sled

- Many metals were measured in field surface wipes at average values below 2 ng/cm^2, while zinc and metals typically found in soil were measured at higher levels.

- SVOCs associated with tire crumb rubber were measured at low levels in field wipe and drag sled samples, with average transferrable levels generally below 0.2 ng/cm^2.

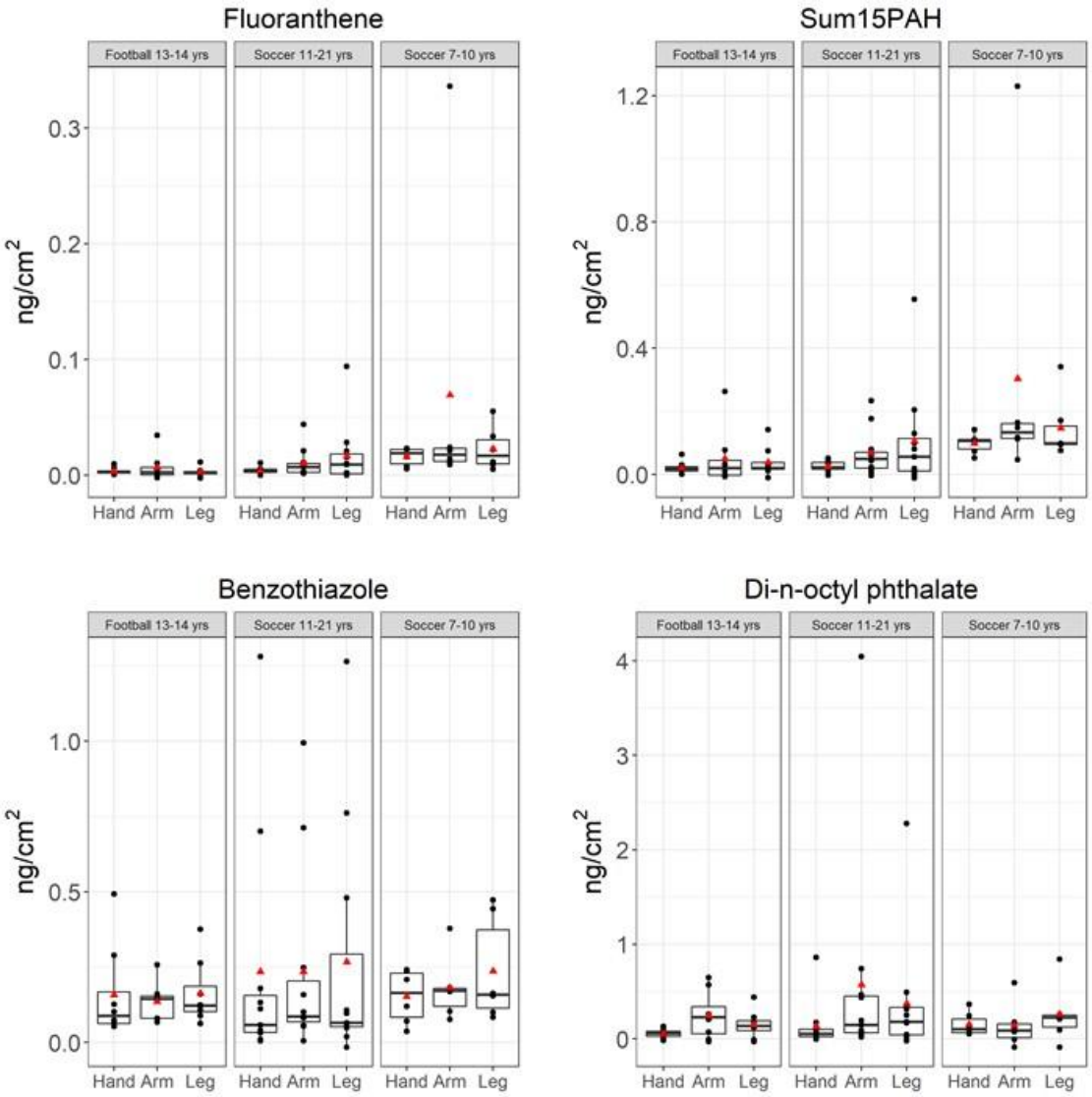
Personal Measurements
Example Results - Dermal Metals



All metals except selenium were found at measurable levels in dermal wipe samples.

Many metals were measured in dermal wipe samples at median values below 1 ng/cm^2, while zinc and other metals typically found in soil were measured at 4.1 to 140 ng/cm^2.

Personal Measurements
Example Results - Dermal SVOCs



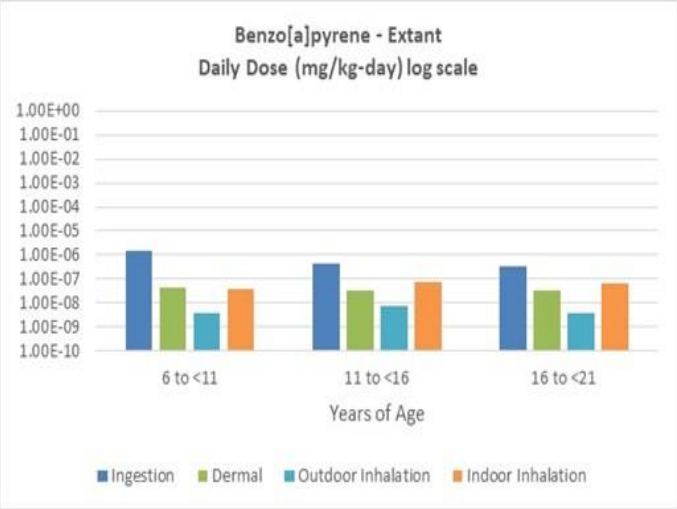
About half of the SVOCs were measured in dermal wipe samples at levels above the method detection limit.

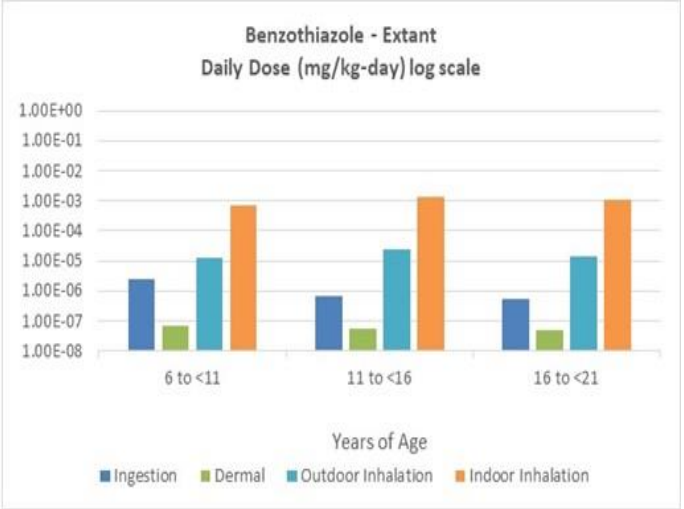
Most SVOCs had median values below 0.2 ng/cm^2, with up to 0.21 ng/cm2 for 4-tert-octylphenol, 0.69 ng/cm2 for n-hexadecane, and several phthalates with median levels up to 7.0 ng/cm^2.

The phthalates may have been present from other sources in addition to, or instead of, field materials.

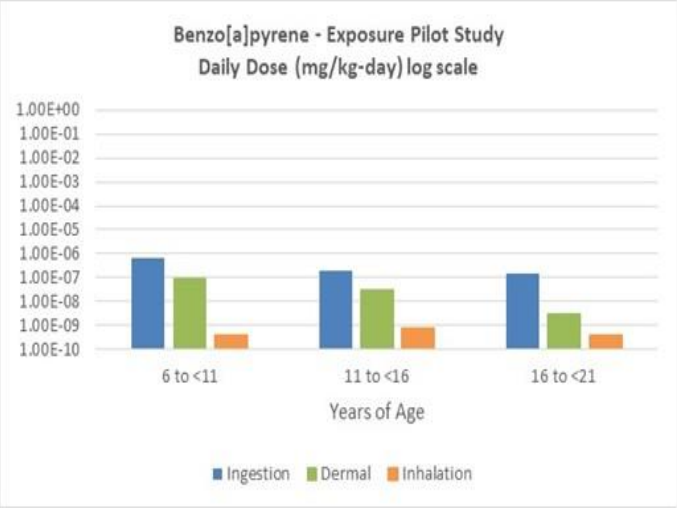
Exposure Modeling Pathway Assessment Example Results

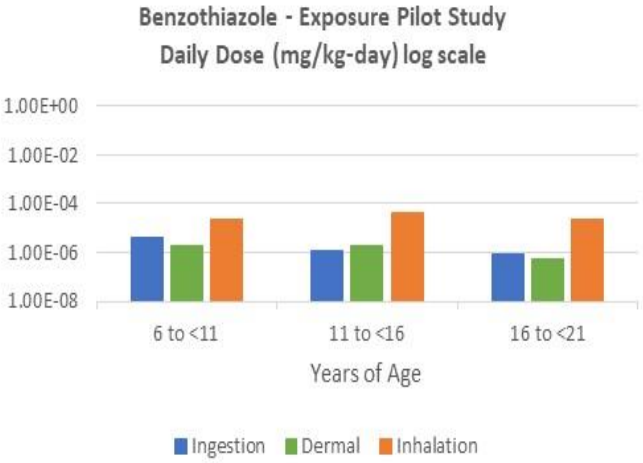
Results from previous studies



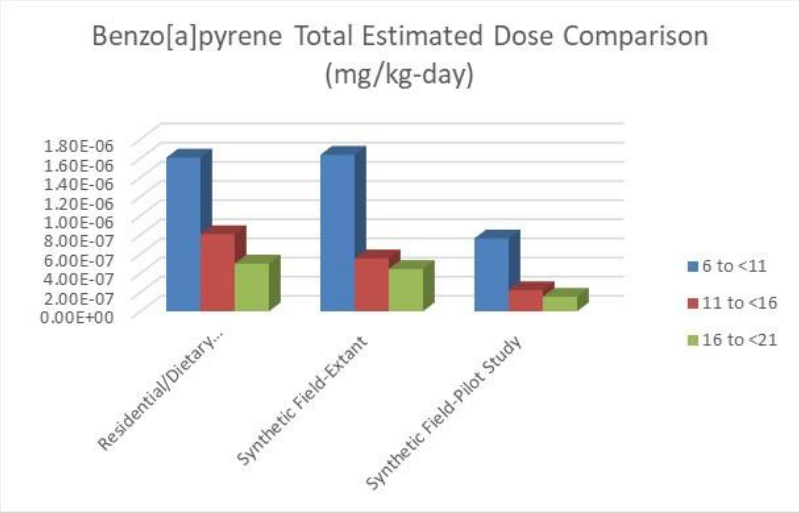


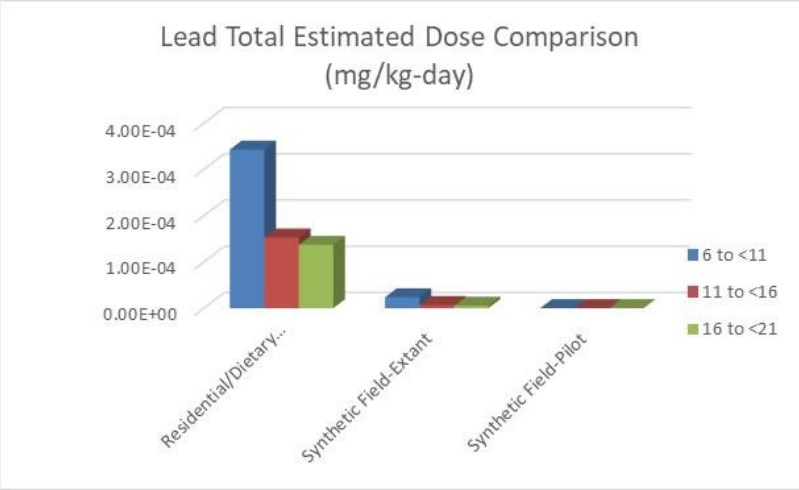
Including results from this pilot study





Exposure Modeling Pathway Assessment Example Results



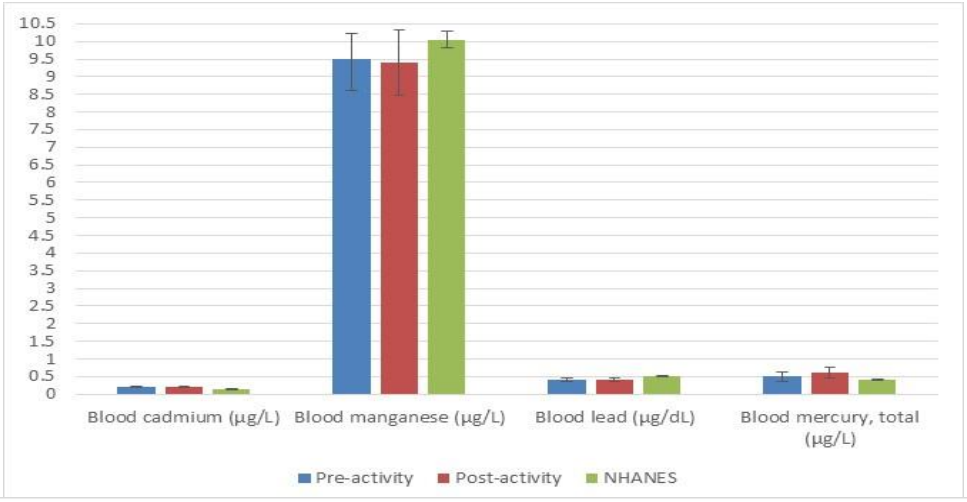


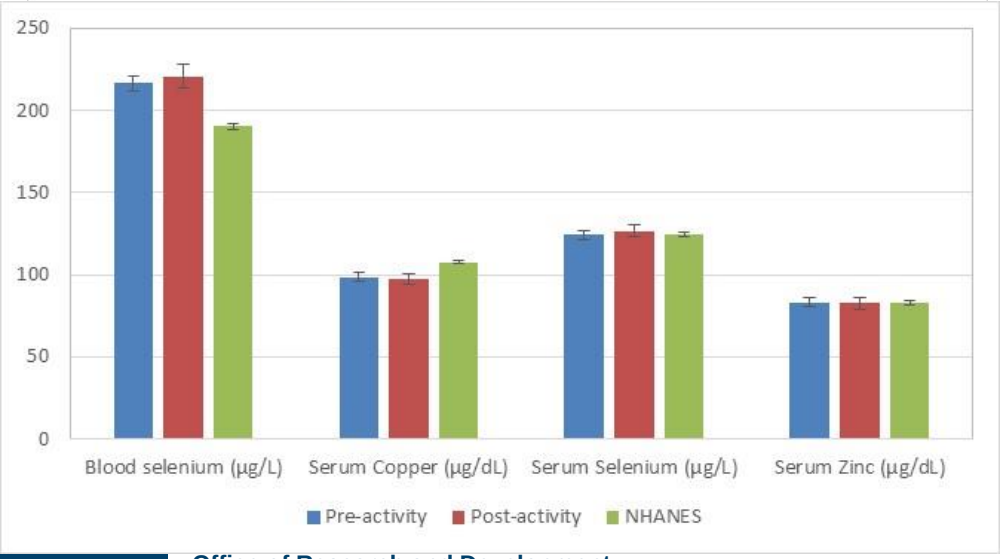
In general, estimated daily exposures were <5 x 10^{-5} mg/kg-day for most chemicals and pathways, with inhalation being the dominant pathway for more volatile chemicals and ingestion being dominant for metals and less volatile chemicals.

While the data collected from the study improved the estimates, the results still carry a degree of uncertainty associated with limited data for factors like ingestion rates and dermal adhesion values for tire crumb rubber and field dust.

Additionally, data limitations remain for other parameters required for modeling exposures for synthetic turf field user scenarios including airborne particle sizes; particle ingestion rates; and inhalation, ingestion, and dermal absorption rates for some chemicals.

Biomonitoring Results
Pilot Study Blood





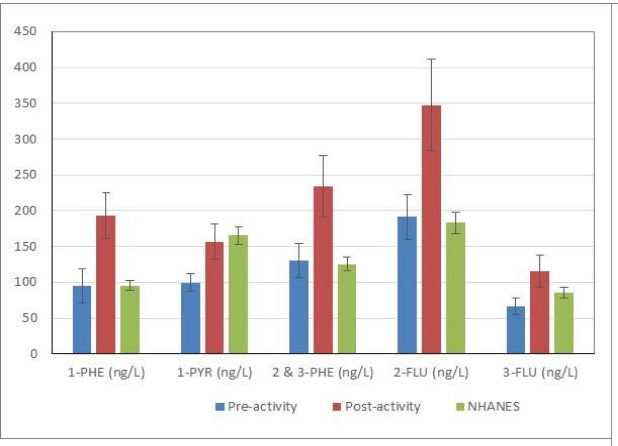
An increase in metal concentration was not observed after practice.

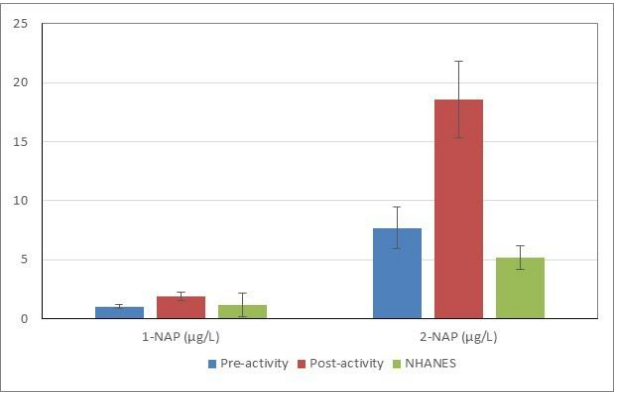
However, blood selenium levels, both pre- and post-activity, were higher than the geometric mean for participants aged 11 – 21 in the 2013-2014 National Health and Nutrition Examination Survey (CDC NHANES 2013 – 2014). Selenium was not found above detection limits in tire crumb and other field environment matrices.

With the exception of blood selenium, body burden levels of metals in these study participants were consistent with those found for the general population (CDC NHANES 2013 – 2014, participants aged 11-21).

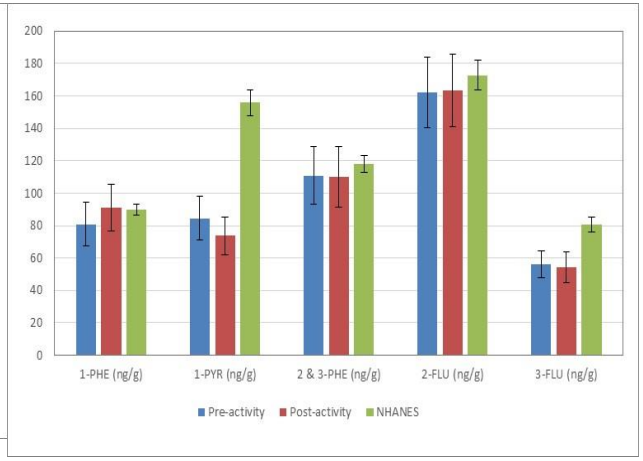
Biomonitoring Results
Pilot Study Urine

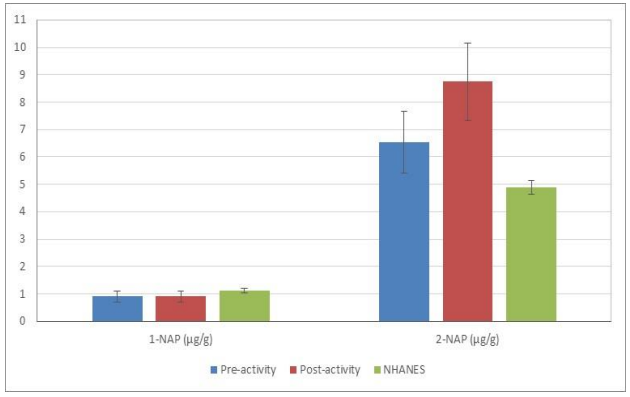
Unadjusted





Creatinine-adjusted





Significant differences in mean concentrations were observed when comparing pre- and post-activity levels for the **unadjusted** PAH metabolites.

In comparing pre- and post-activity **creatinine-adjusted** measurements for these PAH metabolites in urine, there was no significant difference in pre- and post-activity concentrations, except for 2-hydroxynaphthalene.

When compared with PAH analytes reported in NHANES 2013-2014 for participants aged 11 to 21, the geometric mean for all **unadjusted** urinary PAH metabolites post-activity was higher than the NHANES geometric mean, with the exception of 1-hydroxypyrene. The geometric mean for **creatinine-adjusted** urinary PAH metabolites was similar to the NHANES geometric mean, with the exception of 1-hydroxypyrene and 3-hydroxyfluorene which had higher geometric means in NHANES.

Supplemental Biomonitoring Study

- In 2022, ATSDR conducted a follow-up supplemental biomonitoring study to evaluate and characterize human exposure potential to PAHs during play on synthetic turf fields with tire crumb rubber infill.
- Participants were recruited from two outdoor and one indoor synthetic turf fields with tire crumb rubber infill and two co-located natural grass fields.
- Pre- and post-activity urine samples were collected from 132 synthetic turf field users and 29 natural grass field users.
- Urine samples were analyzed for metabolites of the PAHs naphthalene, fluorene, phenanthrene, and pyrene