



Characterization of Recycled Tire Crumb Rubber Used on Synthetic Turf Fields in the United States

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INTRODUCTION

- Recycled tire crumb rubber is used as infill material in synthetic turf playing fields in the United States.
- Concerns have been raised about the safety of this material.
- Prior to 2016, a few studies had been conducted in the U.S. examining crumb rubber constituents. Those studies had been relatively small, restricted to a few fields or material sources, and measured a limited number of constituents.
- This multi-agency research effort, known as the Federal Research Action Plan on Recycled Tire Crumb Used on Playing Fields and Playgrounds (FRAP), is focused on assessing potential human exposure, which includes conducting research activities to characterize the chemicals associated with tire crumb rubber and to identify the ways in which people may be exposed to those chemicals based on their activities on synthetic turf fields.
(<https://www.epa.gov/chemical-research/federal-research-action-plan-recycled-tire-crumb-used-playing-fields>)



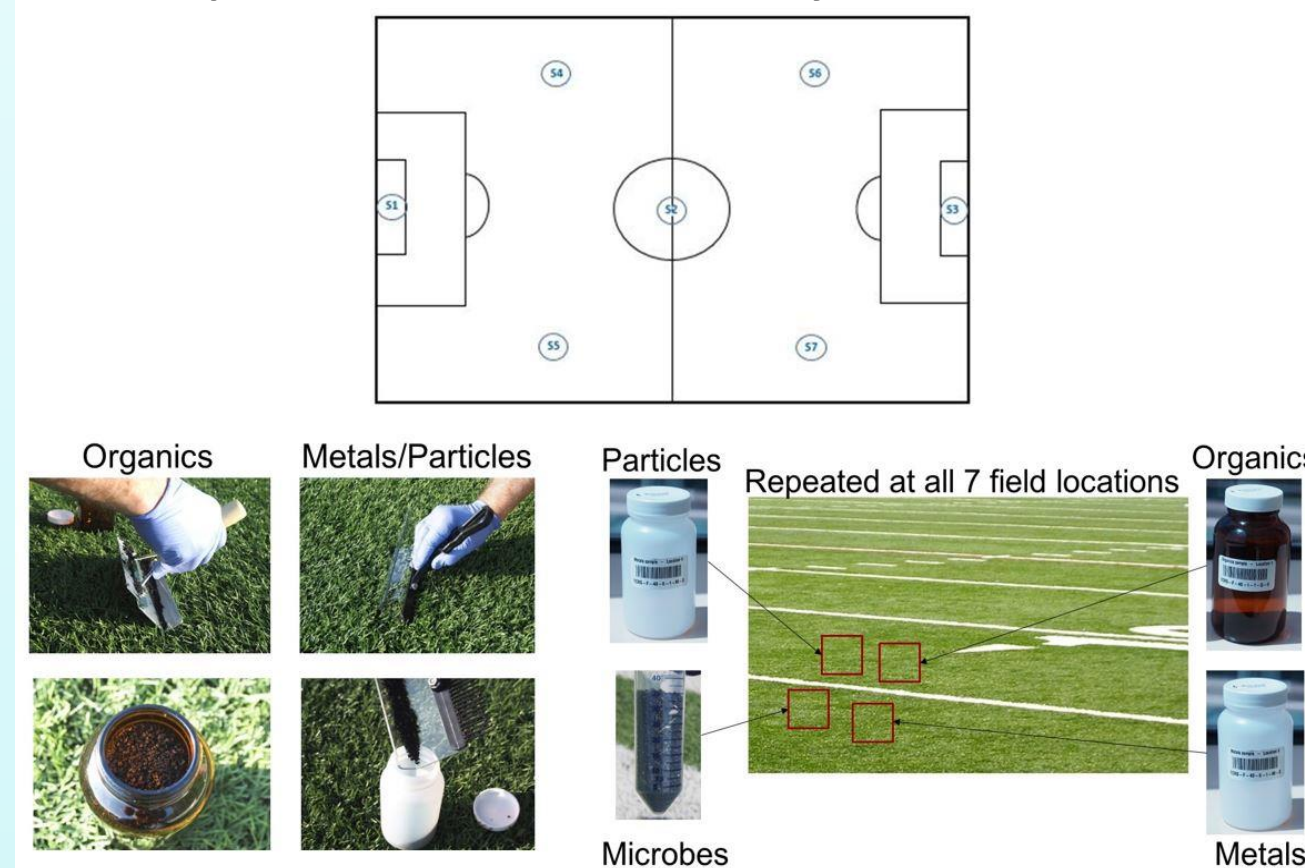
SAMPLE COLLECTION

Numbers and Types of Synthetic Turf Fields and Recycling Plants

Synthetic Turf Fields				Field - Year of Installation	Number
U.S. Census Region	Outdoor Fields	Indoor Fields	Total Sampled	2004 - 2008	11
Northwest	5	4	9	2009 - 2012	19
South	11	2	13	2013 - 2016	10
Midwest	2	6	8		
West	7	3	10		
Total Number of Fields	25	15	40		

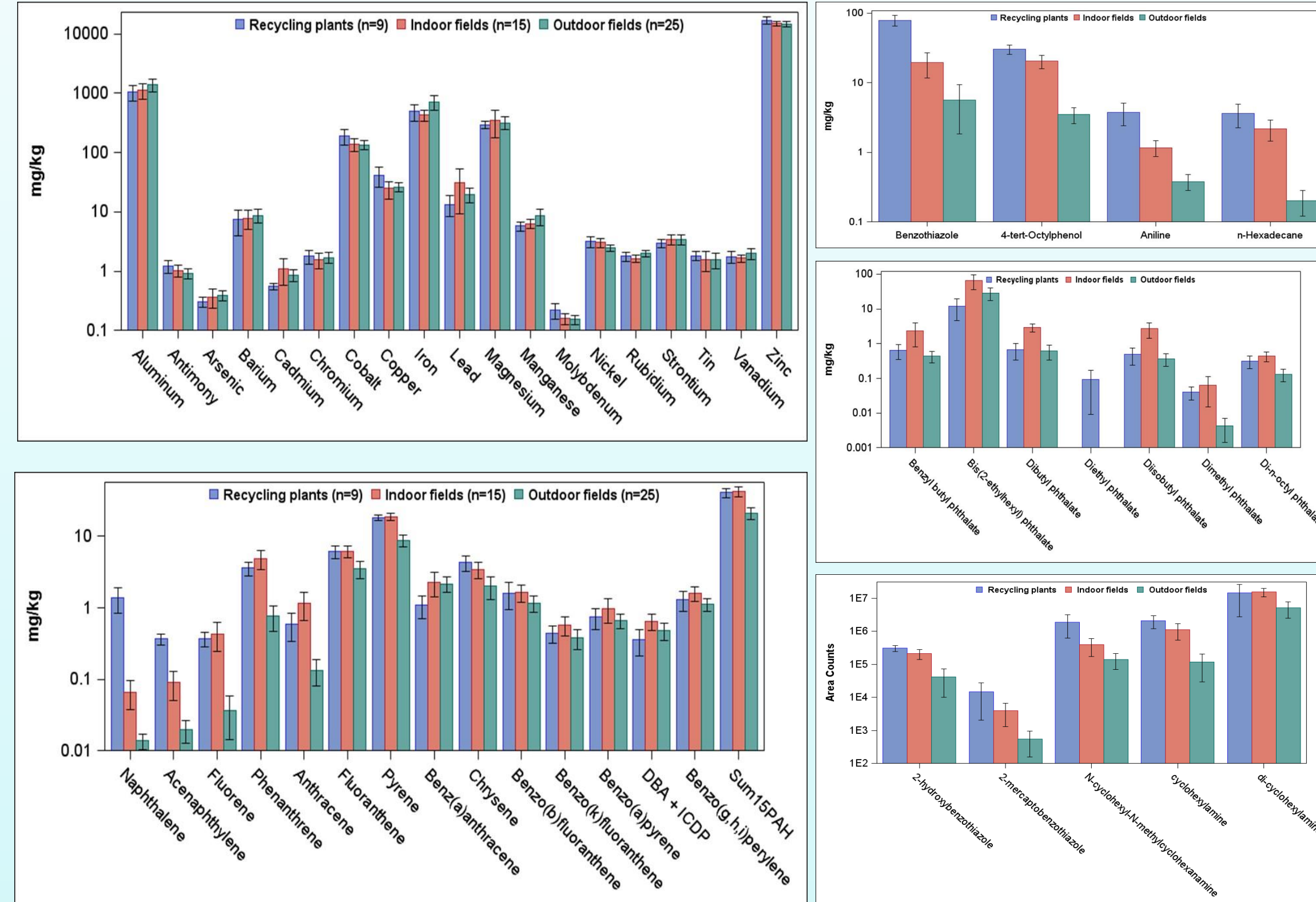
Tire Recycling Plants		Number
Ambient Process		6
Cryogenic Process		3
Total		9

Sample Collection Scheme for Synthetic Turf Fields



METALS AND SVOCs IN TIRE CRUMB

Average Results for Chemicals Associated with Tire Crumb Rubber (mg/kg; with standard deviation)



BIOACCESSIBILITY

Selected Results for % Bioaccessibility of Metals in Three Synthetic Biofluids

Analyte	N	Mean	SD	Min	25 th Percentile	Median	75 th Percentile	Max
Gastric fluid								
Arsenic	82	1.1	1.7	0.0	0.0	0.0	2.4	8.4
Cadmium	82	0.5	0.6	0.0	0.0	0.4	0.7	3.4
Chromium	76	4.1	7.3	0.0	0.8	2.6	5.0	55.1
Cobalt	82	0.3	0.2	0.0	0.1	0.2	0.3	1.2
Lead	82	2.8	2.3	0.2	1.3	1.9	3.3	13.5
Zinc	82	0.9	0.5	0.2	0.6	0.8	1.1	2.5
Saliva								
Arsenic	82	0.2	0.7	0.0	0.0	0.0	0.0	4.5
Cadmium	82	0.0	0.1	0.0	0.0	0.0	0.0	0.5
Chromium	76	0.3	1.1	0.0	0.0	0.0	0.0	8.7
Cobalt	82	0.0	0.1	0.0	0.0	0.0	0.0	0.2
Lead	82	0.0	0.1	0.0	0.0	0.0	0.0	0.5
Zinc	82	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Sweat plus sebum								
Arsenic	82	0.4	0.9	0.0	0.0	0.0	0.0	4.4
Cadmium	82	0.1	0.2	0.0	0.0	0.0	0.1	1.6
Chromium	76	0.8	1.4	0.0	0.0	0.0	1.2	6.8
Cobalt	82	0.1	0.1	0.0	0.0	0.1	0.1	0.5
Lead	82	0.0	0.2	0.0	0.0	0.0	0.0	1.9
Zinc	82	0.1	0.1	0.0	0.0	0.1	0.1	0.3

DISCUSSION

Key Findings

- Most of the target analytes among the 21 metals and 49 SVOCs, and several of the 31 target VOCs, were found in tire crumb rubber collected at fields across the U.S.
- Average concentrations ranged from <1 mg/kg for several metals and extractable SVOCs to up to 15,000 mg/kg for zinc.
- Generally low emissions were measured for most target chemicals, often below the level of detection @ 25°C. Some, but not all chemicals showed higher rates @ 60°C. The highest emissions were measured for methyl isobutyl ketone and benzothiazole.
- Across all metals, the average of mean % bioaccessibility was about 3% for gastric fluid and <1% for saliva and sweat plus sebum.
- When comparing samples from recycling plants vs. fields – most metals were comparable, most organics were lower at fields. A few chemicals were higher at fields vs. plants.
- When comparing indoor vs. outdoor fields – most metals were comparable, many organics were higher at indoor fields.
- When comparing older vs. newer fields – most metals were comparable, at outdoor fields many organics were lower with older field age.

Key Messages

- In general, and not unexpected, the study found a range of chemicals (metals and organic compounds) in tire crumb rubber samples.
- Chemical concentrations are generally similar to those found in other studies, where these exist.
- While a range of chemicals are present, air emissions of most organic chemicals and bioaccessibility of metals are low.
- In general, the findings from the report support the premise that while chemicals are present as expected in the tire crumb rubber, human exposure may be limited based on what is released into air or simulated biological fluids.
- Overall, we anticipate that the results from this multi-agency research effort will be useful to the public and interested stakeholders for understanding the potential for human exposure to chemicals of potential interest and concern found in tire crumb rubber used on synthetic turf fields.

For More Information Please Visit: www.epa.gov/tirecrumb

GENERAL APPROACH

- For comparative purposes, tire crumb rubber samples were collected from nine tire recycling plants as well as 25 outdoor and 15 indoor synthetic turf fields across the U.S.
- Characterization included direct measurement of metal and SVOC constituents associated with tire crumb rubber.
- Bioaccessibility testing of metals was performed on tire crumb rubber using three types of simulated biological fluids for improving understanding of potential exposures.
- VOC and SVOC laboratory chamber emission experiments provided information about the potential for chemicals associated with tire crumb rubber to be released into the air and to become available for inhalation exposure.
- Differences were assessed for measurements among and between recycling plants and synthetic turf fields.

SAMPLE ANALYSIS

Constituents

Solvent Extraction
SVOCs – GC/MS/MS
SVOCs – LC/TOFMS

Acid Digestion
Metals – ICP/MS

Spectrometry
Metals – XRF
Metals – SEM/EPMA

Particle Characterization
Particle Size – Sieve
Moisture Content
Rubber/Sand Content
Size/Morphology – SEM



Exposure-Related

Small Chamber Emissions
Formaldehyde – HPLC/UV
VOCs – GC/TOFMS
@25 °C and 60 °C

Micro Chamber Emissions
SVOCs – GC/MS/MS
SVOCs – LC/TOFMS
@25 °C and 60 °C

Metals Bioaccessibility
Three Artificial Biofluids:
Sweat+Sebum – ICP/MS
Saliva – ICP/MS
Gastric – ICP/MS

Target Analytes in Constituent Analyses

Metals - 21 Targeted

Lead, zinc, cobalt, arsenic, cadmium, chromium, etc.

SVOCs - 49 Targeted

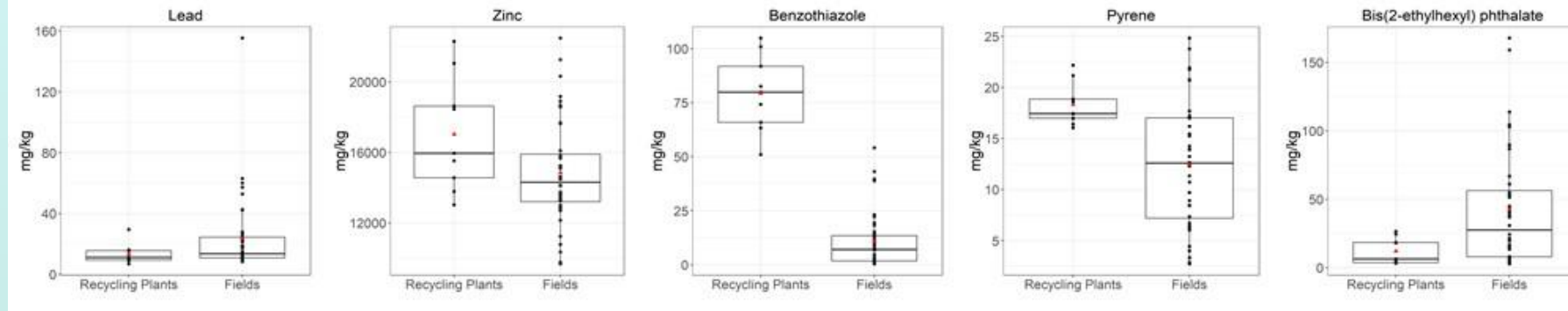
PAHs, phthalates, thiazoles, amines, tire rubber chemicals, etc.

VOCs - 31 Targeted

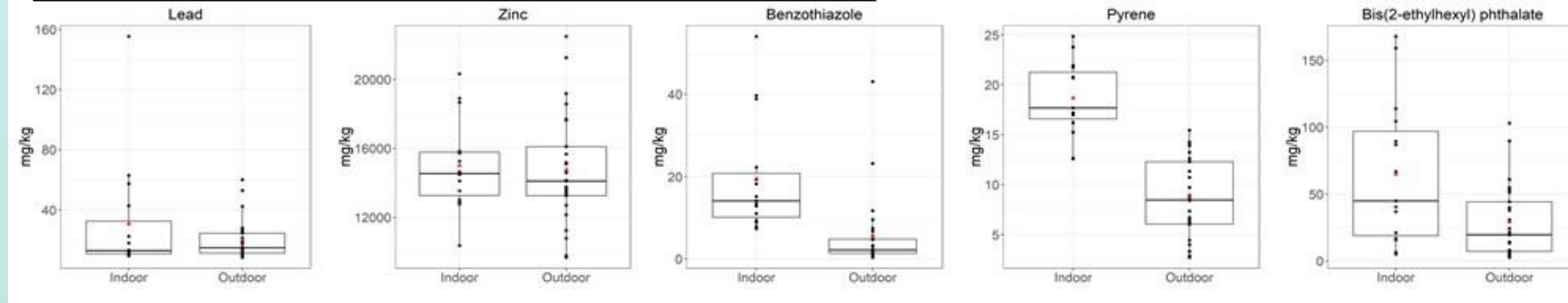
MIBK, benzothiazole, styrene, 1,3-butadiene, BTEX compounds, etc.

VARIABILITY AND DIFFERENCES

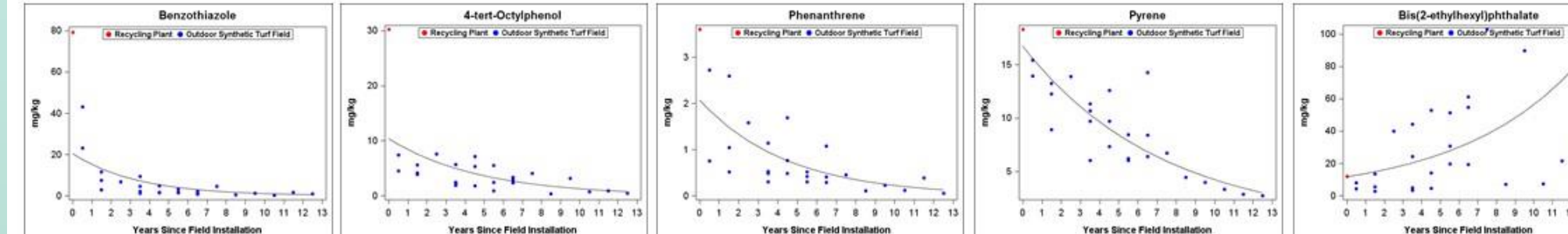
Recycling Plants vs. Synthetic Turf Fields (mg/kg)



Indoor vs. Outdoor Synthetic Turf Fields (mg/kg)

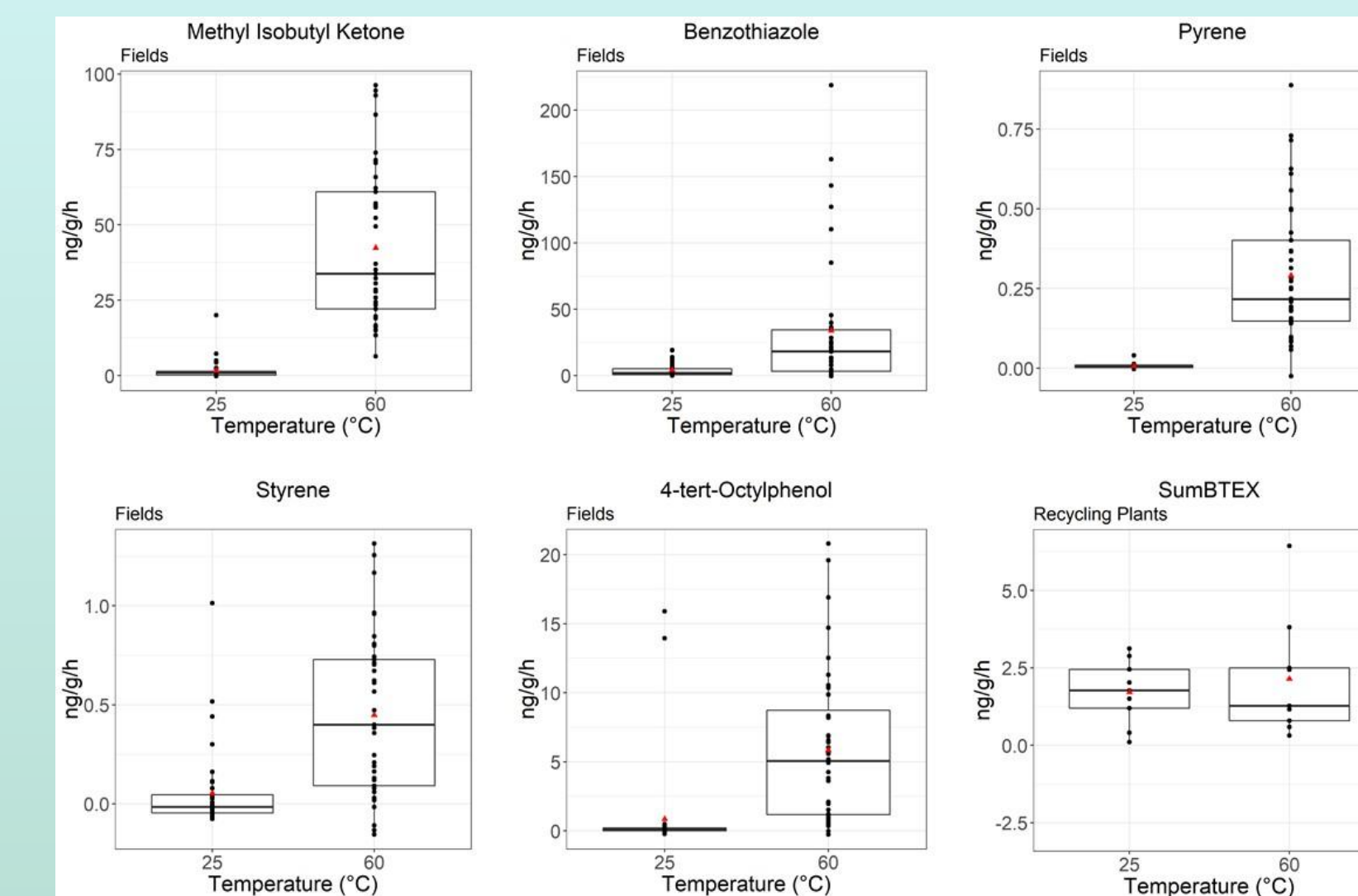


Outdoor Synthetic Turf Fields with Different Installation Ages (mg/kg)



EMISSIONS

Selected Results for Emissions Measured in Chamber Experiments at 25 °C and 60 °C (ng/g/h)



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