

Synthetic Turf/Recycled Tire Crumb Rubber Research Program

Background and Rationale

Why is exposure to synthetic turf/recycled tire crumb rubber of public health concern?

Public health concern for playing on synthetic turf fields recently has increased due to media reports that young adult soccer players, particularly goalies, are being diagnosed with blood cancers. Over 11,000 synthetic turf fields exist in the United States, and approximately 1,200 are being added annually. In addition to being installed in professional sports stadiums, synthetic turf is increasingly found at public parks and school athletic fields. Currently, limited research is available by which to judge whether playing on these fields impacts human health.

What is crumb rubber?

In a synthetic turf field, infill materials are spread between the “grass” fibers to provide cushioning and traction. The infill typically consists of “crumb rubber”—shredded rubber particles made from recycled automotive tires. Crumb rubber from recycled tires contains numerous potential carcinogenic and toxic substances.¹⁻³

How are humans exposed?

When athletes or children play on synthetic turf surfaces, crumb rubber particles have been found to cling to clothing, hair, and skin. These interactions may result in several potential routes of exposure to tire crumb or chemicals that may leach out of the crumb rubber.

State and Federal Response:

This recent rise in public health concern and the expanding use of synthetic turf/crumb rubber have led to several research efforts at the federal and state level. The California Office of Environmental Health Hazard Assessment (OEHHA) began an Environmental Health Study of Synthetic Turf,¹ and several federal agencies [U.S. Environmental Protection Agency (EPA),² the Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry (ATSDR),³ and the U.S. Consumer Product Safety Commission (CPSC)⁴] launched the Federal Research Action Plan on Recycled Tire Crumb Used on Playing Fields.

NTP Research Program:

In November 2015, OEHHA asked the National Toxicology Program (NTP) to conduct short-term in vivo and in vitro toxicology studies to enhance understanding of potential health impacts of chemicals released from synthetic turf, with an emphasis on crumb rubber in athletic fields. The known constituents (e.g., polycyclic aromatic hydrocarbons or PAHs) in tire crumb have led to the hypothesis that this aspect of synthetic turf has the most potential to pose a human health

¹OEHHA website: <http://oehha.ca.gov/risk-assessment/synthetic-turf-studies>

²EPA website: <https://www.epa.gov/chemical-research/federal-research-recycled-tire-crumb-used-playing-fields>

³ATSDR website: <https://www.atsdr.cdc.gov/frap/index.html>

⁴CPSC website: <https://www.cpsc.gov/Safety-Education/Safety-Education-Centers/Crumb-Rubber-Safety-Information-Center>

risk. This is the focus of NTP's studies. Information gained from these studies will inform OEHHA's evaluation of health impacts associated with the use of crumb rubber in synthetic turf fields and playground mats.

Scope and Objectives

NTP plans to conduct research to address uncertainties regarding potential human exposure and health risks following contact with crumb rubber. NTP's research approach considers potential routes of human contact with crumb rubber and aims to investigate which exposure conditions in an experimental laboratory setting might influence the risk of developing adverse health outcomes. The research is oriented around these key questions:

- What experimental models are useful for characterizing the toxicity of crumb rubber or bioaccessible constituents?
- What routes of exposure are most likely to result in systemic exposure?
- What constituents of crumb rubber are bioaccessible, bioavailable, or both?
- How does the bioaccessibility or bioavailability of constituents vary based on route of exposure?
- Is biological activity or effect evident following exposure to crumb rubber?

By addressing these questions using *in vivo* and *in vitro* models, the NTP research program strives to provide information that OEHHA, our federal partners, and other stakeholders can use to assess the risk of adverse health outcomes and inform human biomonitoring or epidemiological studies.

Planned Studies

NTP plans to address the uncertainties around crumb rubber exposure through studies that characterize *in vitro* bioaccessibility of crumb rubber constituents and *in vivo* feasibility and exposure. The conduct of additional studies will depend on results from this initial phase of testing. Feedback and outcomes from the Federal Research Action Plan and OEHHA study activities also will inform future plans. The study types and purpose are described below.

Test Material Preparation and Characterization

For all studies, NTP is using a single composite crumb rubber test material prepared from commercial crumb rubber materials obtained from multiple sources. In some experiments, size-fractionated material is being used.

The characterization studies aim to examine the test material using a variety of analytical methods. These studies will inform the chemical analysis conducted in the *in vitro* and *in vivo* studies and allow comparison of the test material to samples collected from new and weathered synthetic turf fields as part of the Federal Research Action Plan. To characterize the test material, NTP will use various analytical methods [gas chromatography mass spectrometry (GCMS), liquid chromatography mass spectrometry (LCMS), inductively coupled plasma mass spectrometry, scanning electron microscopy, electron dispersive spectroscopy, and thermogravimetric analysis] to determine morphology and identify constituents of crumb rubber including volatile organic compounds and semivolatile organic compounds, solvent extractables, and metals.

In Vitro Characterization

The in vitro characterization studies will evaluate the bioaccessibility and biological effects of crumb rubber constituents. Specifically, these studies will:

- Evaluate bioaccessibility of crumb rubber constituents in artificial biological fluids by:
 - Incubating crumb rubber with artificial biological fluids to simulate oral (saliva, gastric, and intestinal fluids), dermal (sweat), and inhalation (lung fluid) exposure routes.
 - Analyzing fluids following incubation using a combination of analytical techniques to identify and quantify potential bioaccessible constituents.
- Evaluate the biological effects of bioaccessible crumb rubber constituents using human lung, skin, and intestinal cell culture models by:
 - Incubating crumb rubber in cell culture media for varying lengths of time and temperatures to produce “conditioned” media.
 - Measuring cytotoxicity (and other endpoints) in cell cultures exposed to conditioned media for varying lengths of time.
 - Exploring approaches for evaluating other endpoints, including genotoxicity.

In Vivo Feasibility and Exposure Characterization

These studies aim to assess the practicality of performing in vivo animal studies with crumb rubber and determine if systemic exposure is occurring. To accomplish this, NTP will evaluate various routes of exposure (e.g., treated bedding, feed, oral gavage, dermal, particulate inhalation, vapor inhalation) using experimental simulations without animals. Considerations for feasibility include generating stable dosing solutions and atmospheres and qualitatively assessing homogeneity of dosing solutions or treated bedding.

For routes of exposure deemed feasible, NTP will perform short-term studies with a rodent model to assess the practicality of exposing animals to crumb rubber. These studies will include endpoints that characterize exposure, either by detecting crumb rubber constituents in biological fluids or using traditional evidence of biological effect.

Research Progress

The following section provides a brief description of completed or ongoing research activities.

Test Material Characterization

- Identification of volatile organic compounds, semivolatile organic compounds, solvent extractables by GCMS, metals, and determination of composition and morphology.
- Identification of solvent extractables by LCMS.
- Bioaccessibility studies and identification of bioaccessible constituents by GCMS and LCMS.

In Vitro Testing

- Cytotoxicity experiments using human lung and skin cell culture models.

- Analysis of conditioned media by mass spectrometry to identify constituents of the crumb rubber that have leached into the media.

In Vivo Feasibility and Exposure Characterization

- Studies using B6C3F1/N female mice exposed via housing on a mixture of bedding/crumb rubber, dosed via feed or oral gavage. Endpoints included for evaluation focus on measuring systemic exposure to crumb rubber constituents, with inclusion of limited toxicity endpoints.

Significance and Expected Outcomes

People who contact recycled tire crumb rubber used in synthetic turf have concerns for their health and the health of their children. A deeper understanding of human exposure and hazard is necessary, and the NTP study of synthetic turf/crumb rubber will provide public health agencies with information on feasibility of various exposure systems and information on exposure/toxicity to inform exposure and health assessments.

In conjunction with the extensive chemical and human exposure conducted as part of the OEHHA study and the Federal Research Action Plan, this work will substantially contribute to what is known about potential human health effects of playing on synthetic turf fields made from recycled tires. Continued communication and collaboration with both research efforts will enable NTP to respond to their findings with additional toxicological testing to focus on specific components, exposure scenarios, and outcomes of most concern this research identifies. Up-to-date information on the NTP Synthetic Turf/Recycled Tire Crumb Rubber Research Program is available at <http://ntp.niehs.nih.gov/go/turf>.

References

1. Cheng H, Hu Y, Reinhard M. 2014. Environmental and health impacts of artificial turf: A review. *Environmental science & technology*. 48(4):2114-2129.
2. Menichini E, Abate V, Attias L, De Luca S, di Domenico A, Fochi I, Forte G, Iacovella N, Iamiceli AL, Izzo P et al. 2011. Artificial-turf playing fields: Contents of metals, pahs, pcbs, pcdds and pcdfs, inhalation exposure to pahs and related preliminary risk assessment. *The Science of the total environment*. 409(23):4950-4957.
3. Ginsberg G, Toal B, Simcox N, Bracker A, Golembiewski B, Kurland T, Hedman C. 2011. Human health risk assessment of synthetic turf fields based upon investigation of five fields in connecticut. *Journal of toxicology and environmental health Part A*. 74(17):1150-1174.