A REVIEW OF THE POTENTIAL HEALTH AND SAFETY RISKS FROM SYNTHETIC TURF FIELDS CONTAINING CRUMB RUBBER INFILL

Prepared for

New York City Department of Health and Mental Hygiene
New York, NY

Prepared by

TRC
Windsor, Connecticut

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Report Authors:
Elizabeth Denly
Katarina Rutkowski
Karen M. Vetrano, Ph.D.

NYC DOHMH Reviewers:
Andriana Azarias, Nancy Clark, Nathan Graber,
Paromita Hore, Maureen Little

TRC Project No. 153896
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TRC
21 Griffin Road North
Windsor, Connecticut 06095
Telephone 860-298-9692
Facsimile 860-298-6399

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APPENDICES

LIST OF ACRONYMS

°C = degrees Celsius
°F = degrees Fahrenheit
ASTM = American Society for Testing and Materials
BTEX = Benzene, toluene, ethyl benzene, xylene
CalEPA = California Environmental Protection Agency
COPC = Chemical of potential concern
CVAA = Cold vapor atomic absorption
DOHMH = NYC Department of Health and Mental Hygiene
DPR = NYC Department of Parks and Recreation
dw = Dry weight
EPA = United States Environmental Protection Agency, also *USEPA*
EPDM = Ethylene propylene diene monomer
FID = Flame ionization detection
GC/MS = Gas chromatography-mass spectrometry
GI = Gastrointestinal
HA = Highly aromatic
HPLC = High performance liquid chromatography
ICP-AES = Inductively coupled plasma atomic emission spectrometry
ICP-MS = Inductively coupled plasma mass spectrometry
LOAEL = Lowest observed adverse effect level
MEK = Methyl ethyl ketone
MIBK = Methyl isobutyl ketone
MRL = Minimal risk level
MRSA = Methicillin-resistant *Staphylococcus Aureus*
MSDS = Material Safety Data Sheet
NA = Not available
NILU = Norwegian Institute of Air Pollution
NIOSH = National Institute for Occupational Safety and Health
NOAEL = No observed adverse effect level
NR = Naphthalene rubber
NYC = New York City
PAH = Polycyclic aromatic hydrocarbon
PCB = Polychlorinated biphenyl
PM = Particulate matter
PUF = Polyurethane foam
SBR = Styrene butadiene rubber
SCO = Soil cleanup objective
SIM = Selective ion monitoring
SPME = Solid phase microextraction
SVOC = Semi-volatile organic compound
TBBS = N-*tert*-butyl benzothiazole sulfonamide
ToxNet = Toxicology Data Network
TPE = Thermoplastic elastomer
TPH = Total petroleum hydrocarbons
US = United States
UV = Ultraviolet
VOC = Volatile organic compound
ww = Wet weight

EXECUTIVE SUMMARY

1. Background and Purpose of Review

Synthetic turf fields have been installed in many athletic and playing fields throughout New York City (NYC), the United States and the world. The NYC Department of Parks and Recreation (DPR) began installing synthetic turf playing fields in 1997 with a total of 94 installations completed at the time of this report (87 crumb rubber infill fields and 7 carpet-style fields). An additional 68 synthetic turf fields are either planned or under construction around the five boroughs. Of these planned fields, 32 will have crumb rubber infill for use in high impact areas and the other 36 will be carpet-style turf. The carpet-style synthetic fields are part of the PlaNYC effort to address the increased demand for playing space by converting existing asphalt fields into multi-purpose use fields.

Synthetic turf fields are used in NYC parks because they:

- Provide even playing surfaces.
- Have padding that helps prevent injuries.
- Need no watering or mowing.
- Use no fertilizers or pesticides.
- Can be used year-round and in most weather.
- Do not need to be closed to protect or re-sod grass.
- Last a long time with little maintenance.

This report focuses primarily on synthetic turf fields with crumb rubber infill. The infill-type synthetic turf fields in NYC parks contain several layers, including:

- A bottom layer composed of geotextile.
- Middle layers composed of broken stone with plastic perforated pipe for drainage and rubber padding for shock absorbance.
- A top layer composed of carpet with soft, flexible plastic grass.
- Crumb rubber infill made from recycled tires added to the 'grass' layer to provide extra padding, serve as a ballast to hold the carpet down, and keep the grass upright. Sand is sometimes mixed with the crumb rubber.

Recent concern about the potential for exposure to chemicals found in crumb rubber, also known as ground rubber, prompted NYC DPR to request assistance from the NYC Department of Health and Mental Hygiene (DOHMH). In response to this request, and with a grant awarded by the New York Community Trust, the DOHMH contracted a private consultant, TRC, to lead an intensive literature review focusing on the potential exposures and health effects related to synthetic turf fields and to identify gaps in what is known.

This report includes an assessment of the currently available literature and is meant to assist athletic field installers and operators in making decisions related to the selection and use of synthetic turf fields. The report is organized into six chapters. The Executive Summary provides a brief overview of the findings of this report. Chapter 1 provides the background and scope of work. Chapter 2 covers the chemical composition of the crumb rubber infill and develops a list of chemicals of potential concern (COPCs). Chapter 3 covers the potential for exposure to and human health effects from the COPCs. Chapter 4 is a review of the physical health effects associated with synthetic turf systems, including the risks for physical injury, heat-related illness, burns and infections with Methicillin-Resistant *Staphylococcus Aureus* (MRSA). Chapter 5 lists benefits associated with using synthetic turf fields. Chapter 6 provides recommendations for the crumb rubber industry and synthetic turf field operators. A summary of the reviewed articles is included as an appendix under the relevant section headings.

2. General Findings

Components of Crumb Rubber

The crumb rubber used in synthetic turf systems is made primarily from recycled waste tires. The tires themselves contain several COPCs, and undergo minimal processing to become crumb rubber. Direct and indirect methods have been used in studies to determine the presence of these COPCs in the crumb rubber. These studies have found polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), benzothiazole, and certain metals. Studies have also identified phthalates, alkylphenols and benzene, which likely become bonded to tires during their use. Direct analyses confirming the presence of these COPCs in crumb rubber have used vigorous extraction methods. Some COPCs have been identified through indirect methods including analysis of leachate in the environment near where recycled tire products were used or in controlled laboratory studies. Because crumb rubber is a recycled material, the presence and concentrations of COPCs is expected to vary between products and even among batches from the same manufacturer.

Potential Health and Safety Risks Associated with Synthetic Turf Fields

For the COPCs in the crumb rubber to be a health concern for users of the fields, users would have to be exposed to high enough concentrations to increase the risk for health effects. The three possible routes of exposure for COPCs from crumb rubber are inhalation, ingestion,

and dermal absorption. Crumb rubber, or the dust generated from crumb rubber, may be accidentally ingested by placing fingers in the mouth or not washing hands before eating and after playing on the fields. Young children on the fields may eat the crumb rubber itself. Dust may be breathed in from playing on the field, or vapors that volatilize from the turf may also be inhaled. Some COPCs may also be absorbed through the skin by direct contact.

To date, eleven human health risk assessments were identified that evaluated exposure to the constituents in crumb rubber. Although each risk assessment was conducted using distinct assumptions and evaluated different concentrations of COPCs in crumb rubber, all had a similar conclusion: exposure to COPCs from the crumb rubber may occur, however the degree of exposure is likely to be too small through ingestion, dermal or inhalation to increase the risk for any health effect. These risk assessments have been conducted primarily by state agencies, consultants and industry groups. They are based upon quantitative measurement of the chemicals from various forms of tires (scrap tire, shreds, tire crumb rubber, recycled tire flooring, etc) with levels derived from leachate studies or ambient air testing. Risk assessments evaluating oral and dermal exposures used these surrogate concentrations for exposure and a number of assumptions pertaining to ingestion rates, dermal contact rates, bioavailability, etc. Thus, these evaluations are theoretical estimates of exposure and risk. However, the highest available concentrations combined with scenarios which overestimated the duration of the exposure make these risk assessments conservative. Similar to the oral and dermal risk assessments, each of the inhalation risk assessments used conservative estimates of exposure and maximum concentrations of indoor air contaminants.

Children, especially very young children, have many characteristics which make them uniquely vulnerable to environmental exposures. Children breathe more air per pound of body weight than adults in the same environment and physical activity adds an additional factor to exposure through inhalation. Children also engage in hand-to-mouth behavior and very young children may eat nonfood items, such as rubber crumbs while on the fields. The protective keratinized layer of the skin is not as well developed in children and increases dermal absorption of COPCs as well as increasing evaporative loss of water on hot days. Children also have many more years to develop diseases with long latency periods after exposure. Risk assessments looking at inhalation, ingestion, dermal absorption and the risk for heat stress would have to combine these considerations to be as conservative as possible. It appears that these considerations were addressed by the reviewed health risk assessments. However, uncertainties

exist in the magnitude of factors to account for children's increased susceptibility. As our understanding of the impact of low-level environmental exposures during childhood increases, the inclusion of new data in future risk assessments may be warranted.

Due to the distinct physical characteristics of synthetic turf systems, there has also been concern over potential adverse health effects not related to chemical exposure. The potential physical health effects associated with synthetic turf systems include heat-related illnesses, burns, injuries and infections.

Heat-Related Illness - Synthetic turf fields with crumb rubber have heat-absorbing properties and can retain elevated temperatures at their surface. This increase in temperature of the turf system may increase the risk of heat-related illness among field users.

Physical Injuries - Concerns over the potential for increased injuries associated with the use of synthetic turf systems have led to a number of studies among athletes to evaluate any differences in injury rates, injury types, and lost time between synthetic and natural turf materials. These studies have shown either no major differences in the incidence, severity, nature or cause of injuries sustained on natural grass or synthetic turf by men or women, or that injury rates are similar but that the type of injury varies between the two surfaces.

Bacterial Infections - Concerns have been raised over the potential for bacterial infections, such as MRSA infections, to occur in athletes playing on synthetic turf. Studies among school and professional athletes have shown that although synthetic turf abrasions provide a means of access for infections, transmission of infection occurs via physical contact, sharing of equipment, and poor sanitary practices. Another study found that synthetic turf systems are not a hospitable environment for microbial activity. However, an increased number of abrasion injuries could increase the risk of various infections if other safeguards aren't maintained.

3. Data Gaps and Recommendations

Certain knowledge gaps associated with exposure to synthetic turf fields have been identified. Highlighted gaps, and recommendations to address them, are listed below:

Gap: Consistent test methods for determining the chemicals in crumb rubber made from different source materials and from different processing techniques.
Recommendation: The crumb rubber industry should provide information on the COPC content of products and documentation on the testing methods and criteria used to identify COPCs. Consistent and validated testing methods should be established through an objective process and complied with by the industry. This information, along with the heat absorption and injury properties of synthetic turf, should be provided to prospective buyers.

Gap: Outdoor air concentrations of COPCs on both newly installed and older synthetic turf fields. Most of the data generated have been from indoor synthetic turf facilities.
Recommendation: Field operators should measure air concentrations of COPCs and particulate matter above outdoor fields to give more representative data related to use of playing fields in urban parks. Measurements taken on a hot, calm (no wind) day would represent a worst case scenario.

Gap: Background air concentrations of COPCs in New York City. Many of the COPCs found in crumb rubber are also present in the urban environment, but there is little available data on background levels of these COPCs.
Recommendation: When conducting air studies over fields with crumb rubber, air measurements should also be taken simultaneously at nearby off-field sites, as well as on natural and/or asphalt fields, to provide comparative data on exposures related to urban environments.

Additional Recommendations:

Heat: The primary health concern with the use of synthetic turf fields is the potential for causing physical health effects associated with heat stress and dehydration. It is recommended that field operators assess the feasibility of adding shaded areas and easy access to drinking water near playing fields. It is also recommended that field operators educate field management staff, coaches and athletic staff, field users, and parents on the potential for heat-related illnesses, and how to recognize and prevent heat-related symptoms and illness.

Purchasing Protocol: Field operators should adopt protocols for selecting and purchasing synthetic turf and crumb rubber products. Such protocols should include requirements for suppliers and manufacturers to provide available information on: chemical content of products, potential COPC emissions from products over time, heat absorbency characteristics, injury factors and other relevant health and safety information. In addition, protocols should provide for the continuous evaluation of new technologies, health and safety factors, and best practices for use and maintenance of synthetic turf fields.

4. Conclusions

This comprehensive review of the available literature on the potential health effects of crumb rubber infill from synthetic turf fields has demonstrated that the major health concern from these fields is related to heat. COPC concentrations from the crumb rubber vary depending on the type of crumb rubber, the method of extraction used for analysis, and the media measured (crumb rubber, air, leachate). Eleven different risk assessments applied various available concentrations of COPCs and none identified an increased risk for human health effects as a result of ingestion, dermal or inhalation exposure to crumb rubber. However, additional air studies at synthetic turf fields as well as background air measurements would provide more

representative data for potential exposures related to synthetic field use in NYC, particularly among younger field users.

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