

Listing of Independent Research and Reports (1998-2014) – Artificial Grass

Tabor Academy – Synthetic Turf Athletic Field Evaluation

CDM Smith, March 13, 2014

- The objective of this study was to evaluate the potential water quality impacts of the synthetic turf field at Tabor Academy in Marion, MA.
- Conclusion: "...stormwater runoff from the athletic field is not a source of pollutants/contaminants that would pose a threat to the harbor."

Artificial turf football fields: environmental and mutagenicity assessment

Schilirò, T1, et al., Arch Environ Contam Toxicol, 2013

- The aim of the present study was to develop an environmental analysis drawing a comparison between artificial turf football fields and urban areas relative to concentrations of particles (PM10 and PM2.5) and related polycyclic aromatic hydrocarbons (PAHs), aromatic hydrocarbons (BTXs), and mutagenicity of organic extracts from PM10 and PM2.5.
- Both organic extract mutagenicity values were comparable with the organic extract mutagenicity reported in the literature for urban sites.
- On the basis of environmental monitoring, artificial turf football fields present no more exposure risks than the rest of the city.

Bioaccessibility and Risk of Exposure to Metals and SVOCs in Artificial Turf Field Fill Materials and Fibers

Environmental and Occupational Health Sciences Institute, Robert Wood Johnson Medical School, 170 Frelinghuysen Road, Piscataway, NJ, 2013

- "The SVOCs identified based on library matches of their mass spectra were not present in toxicological databases evaluated and many are ubiquitous part of consumer products. Similarly, the metal concentrations measured in field samples indicate that the risk would be de minimus among all populations expected to use artificial turf fields."

Review of the Human Health & Ecological Safety of Exposure to Recycled Tire Rubber found at Playgrounds and Synthetic Turf Fields

Prepared for Rubber Manufacturers Association by ChemRisk, Inc., August 1, 2013

- A report by an independent environmental firm on the human health and ecological risks from ground rubber in playgrounds and sports fields, and based on a thorough review of studies from advocates and opponents to the use of recycled tire materials.

Artificial turf football fields: environmental and mutagenicity assessment

Department of Public Health and Microbiology, University of Torino, Italy, 2012

Crumb Infill and Turf Characterization for Trace Elements and Organic Materials

Dr. Paul J. Lioy and Dr. Clifford Weisel, Environmental and Occupational Health Sciences Institute, Robert Wood Johnson Medical School, October 31, 2011, Submitted to NJDEP

[An Evaluation of the Health and Environmental Impacts Associated with Synthetic Turf Playing Fields University of Connecticut Health Center](#)

Connecticut Agricultural Experiment Station, Department of Public Health, Connecticut Department of Environmental Protection, July 2010

- The headline from the July 30, 2010 News Release from the Connecticut Department of Public Health announced, "Result of State Artificial Turf Fields Study: No Elevated Health Risk." Comprising separate reports from the four state agencies listed above, the Final Report presents the results of an extensive study into the health and environmental risks associated with outdoor and indoor synthetic turf fields containing crumb rubber infill. "This study presents good news regarding the safety of outdoor artificial turf fields," stated Department of Public Health Commissioner Dr. J. Robert Galvin.
- The above link is to the Overall Executive Summary, which includes links to the News Release, the four separate reports from the state agencies, and the report by the Peer Review Committee from The Connecticut Academy of Science and Engineering (see below).

[Artificial Turf Field Investigation in Connecticut Final Report](#)

Nancy Simcox, Anne Bracker, John Meyer, Section of Occupational and Environmental Medicine, University of Connecticut Health Center, July 2010

[DEP Artificial Turf Stormwater Study](#)

University of Connecticut Health Center, The Connecticut Agricultural Experiment Station, the Department of Public Health and DEP, July 2010

[Human Health Risk Assessment of Artificial Turf Fields Based upon Results from Five Fields in Connecticut](#)

Connecticut Department of Public Health, Program in Environmental and Occupational Health Assessment, July 2010

[Peer Review of an Evaluation of the Health and Environmental Impacts Associated with Synthetic Turf Playing Fields](#)

Connecticut Academy of Science and Engineering, June 2010

[2009 Study of Crumb Rubber Derived from Recycled Tires Final Report](#)

Xiaolin Li, William Berger, Craig Musante, MaryJane Incorvia Mattina, Connecticut Agricultural Experiment Station, Department of Analytical Chemistry, May 2010

[Hydroxypyrene in urine of football players after playing on artificial sports field with tire crumb infill](#)

Joost G. M. van Rooij AE, Frans J. Jongeneelen, International Archives of Occupational and Environmental Health, (2010) 83:105–110

- This study provides evidence that uptake of PAH of football players active on artificial grass fields with rubber crumb infill is minimal. If there is any exposure, then the uptake is very limited and within the range of uptake of PAH from environmental sources and/or diet.

[Review of the Impacts of Crumb Rubber in Artificial Turf Applications](#)

Simon, Rachel, University of California, Berkeley, Laboratory for Manufacturing and Sustainability, February 2010

Prepared for: The Corporation for Manufacturing Excellence (Manex)

- "The research conducted by Manex and Berkeley is among the most comprehensive reports to date, reviewing and assessing existing studies from the past 12 years, as well as containing independent analysis. The conclusions of this study validate key findings from other recent studies, demonstrating the materials are both cost-effective and safe."
- Extensive research has pointed to the conclusion that these fields result in little, if any, exposure to toxic substances. A review of existing literature points to the relative safety of crumb rubber fill playground and athletic field surfaces. Generally, these surfaces, though containing numerous elements potentially toxic to humans, do not provide the opportunity in ordinary circumstances for exposure at levels that are actually dangerous. Numerous studies have been carried out on this material and have addressed numerous different aspects of the issue. For the most part, the studies have vindicated defenders of crumb rubber, identifying it as safe, cost-effective, and responsible use for tire rubber.

Recent issues that have surfaced relate to Carbon Black and Lead, however, for the vast majority of applications, serious physical harm has not occurred from these particulates.

- See April 5, 2010 Manex/UC Berkeley Press Release, [Manex and UC Berkeley Issue Study on Recycled Rubber in Artificial Turf Applications](#)

[Safety Study of Artificial Turf Containing Crumb Rubber Infill Made from Recycled Tires: Measurements of Chemicals and Particulates in the Air, Bacteria in the Turf, and Skin Abrasions Caused by Contact with the Surface](#)

Office of Environmental Health and Hazard Assessment, Department of Resources Recycling and Recovery, Editor. 2010, State of California

- PM2.5 and associated elements (including lead and other heavy metals) were either below the level of detection or at similar concentrations above artificial turf athletic fields and upwind of the fields. No public health concern was identified.

[A Scoping-Level Field Monitoring Study of Synthetic Turf Fields and Playgrounds](#)

National Exposure Research Laboratory Office of Research and Development U.S. Environmental Protection Agency, 2009

- This study and statements of safety by the U.S. EPA of synthetic turf fields and playgrounds containing crumb rubber from recycled tires complements the study and statement of safety by the CPSC in 2008 (see below). In its Press Release, the EPA summarized its findings, including the following:
 - The levels of particulate matter, metals, and volatile organic compound concentrations in the air samples above the synthetic turf were similar to background levels;
 - All air concentrations of particulate matter and lead were well below levels of concern;
 - Zinc, which is a known additive in tires...was found to be below levels of concern.
- See December 10, 2009 EPA Press Release, [Limited EPA Study Finds Low Level of Concern in Samples of Recycled Tires from Ballfield and Playground Surfaces](#)

[Air Quality Survey of Synthetic Turf Fields Containing Crumb Rubber Infill](#)

New York City Department of Health and Mental Hygiene, 2009

[An Assessment of Chemical Leaching, Releases to Air and Temperature at Crumb-Rubber Infilled Synthetic Turf Fields](#)

Lim, L. and R. Walker, New York State Department of Environmental Conservation and Department of Health, Editor, 2009

- Initial findings suggested that there was a low likelihood of risk to the environment or public health via drinking water from ground or surface water contamination.
- Further, the concentrations of VOCs and particulate matter detected above the surface of the fields did not exceed background levels, and thus do not suggest an increased risk from the installation of these fields.

[Zinc in Drainage Water Under Artificial Turf Fields with SBR](#)

Hofstra, U., INTRON, March 2009

- On the basis of the new observations, we conclude that, after 7 years of use, zinc does not penetrate the underlays. This is consistent with the laboratory tests, in which it was calculated that zinc leaching will not occur until a period of 230 to 1800 years has elapsed². It can also be concluded that the concentrations of zinc in the drainage water are not significantly higher than the concentrations in the rainwater.
- After 7 years, there is no evidence that the use of rubber infill poses a risk in terms of the leaching of zinc.

[A Review of the Potential Health and Safety Risks from Synthetic Turf Fields Containing Crumb Rubber Infill](#)

Elizabeth Denly, Katarina Rutkowski, Karen M. Vetrano, Ph.D., TRC, Prepared for NYC Department of Health and Mental Hygiene, May 2008

- 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 (chemicals of potential concern) 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. The risk assessments have been conducted primarily by state agencies, consultants, and industry groups.

[CPSC Staff Finds Synthetic Turf Fields OK to Install, OK to Play On](#)

U.S. Consumer Product Safety Commission, NEWS from CPSC, July 30, 2008

- The CPSC staff conducted tests of synthetic turf products for analysis of total lead content and accessible lead. In the above News Release it concludes that, "young children are not at risk from exposure to lead in these fields."
- For a summary of the analytical methods used and the test results, see [CPSC Staff Analysis and Assessment of Synthetic Turf "Grass Blades"](#).

[Evaluation of Potential Environmental Risks Associated with Installing Synthetic Turf Fields on Bainbridge Island](#)

D. Michael Johns, Ph.D., Windward Environmental LLC, Seattle, WA, February 2008

- Review of available scientific literature and publications in order to provide an assessment about potential risks to the environment from zinc and chemicals contained in crumb rubber infill. "...water that percolates through turf fields with tire crumb is not toxic..."

Evaluation of Playing Surface Characteristics of Various In-Filled Systems

McNitt, A.S., 2008 April 9, 2008

- Total microbial numbers were lower in synthetic turf systems when compared to natural grass fields. Staphylococcus aureus was not found on any of the playing surfaces.

Evaluation of the Environmental Effects of Synthetic Turf Athletic Fields

Bristol, S.G. and V.C. McDermott, Milone & MacBroom, Inc., December 2008

- Heat: On hot sunny days, surface temp of the fibers was 40-50 degrees hotter than ambient temp; air temp at 2' above surface or under cloud cover was near ambient. Crumb rubber was only a few degrees hotter than ambient. Watering the field had a short-term effect.
- Off-gassing: EHHI identified certain compounds of concern in its very limited 2007 laboratory study of the chemicals contained in crumb rubber – benzothiazole, volatile nitrosamines, and 4-(tert-octyl) Phenol. MMI tested for these compounds in the air above the synthetic turf fields with crumb rubber infill at several locations. A "very low concentration" of benzothiazole was found at 1 of 2 fields -- the other compounds were not detected.
- Leaching: Testing done over one year period. Test for zinc, lead, selenium, and cadmium, and compared to lowest aquatic life criterion for each element. Only zinc detected, and then well below water quality standard.

Fact Sheet: Crumb-Rubber Infilled Synthetic Turf Athletic Fields

New York City Department of Health, August 2008

- Our review of the available information on crumb rubber and crumb rubber infilled turf fields indicates that ingestion, dermal or inhalation exposures to chemicals in or released from crumb rubber do not pose a significant public health concern.

Initial Evaluation of Potential Human Health Risks Associated with Playing on Synthetic Turf Fields on Bainbridge Island

D. Michael Johns, Ph.D., Windward Environmental LLC, Seattle, WA, January 2008

- Review of available scientific literature and publications in order to provide an assessment about potential risks of human health to children and teenagers and the risks to the environment from precipitation runoff.

Rubber Crumb Health Risk Evaluation

Lamie, P. Memorandum to: Richard Reine, Director Concord Public Works, April 24, 2007 [cited 2008 4/28]

- There is little exposure to and thus little risk from PAHs or other chemicals associated with ground rubber used in artificial turf fields to the human population.

Synthetic Playfields Task Force Findings and Department Recommendations

San Francisco Recreation and Park Department, 2008

- SFE recognizes that human health risks are minimal from exposure to the crumb rubber infill used with synthetic turf products, according to the OEHHA study.

Environmental and health assessment of the use of elastomer granulates (virgin and from used tyres) as infill in third-generation artificial turf

Dr. Robert Moretto, ADEME / ALIAPUR / FIELDTURF TARKETT, 2007

- According to current research, after a year's experimentation, the results on the 42 physicochemical parameters identified and on the ecotoxicological tests show that water passing through artificial turf using as filling either virgin TPE or EPDM or granulates resulting from the recycling of PUNR are not likely to affect water resources in the short and medium term.
- In conclusion to its study, the INERIS stipulates that the health risks associated with the inhalation of VOC and aldehydes emitted by artificial surfaces on pitches in outdoor situations present no actual cause for concern as regards human health.
- Worst case indoor VOC and aldehyde concentrations do not pose a health concern for adult or child athletes.

Environmental and Health Risks of Rubber Infill: Rubber crumb from car tyres as infill on artificial turf

Hofstra, U., INTRON, January 2007

- Based on the available literature on exposure to rubber crumb by swallowing, inhalation and skin contact and our experimental investigations on skin contact we conclude, that there is not a significant health risk due to the presence of rubber infill for football players on an artificial turf pitch with rubber infill from used car tyres.

Evaluation of Health Effects of Recycled Waste Tires in Playground and Track Products

California Integrated Waste Management Board, 2007, Integrated Waste Management Board: Sacramento, CA

- Using the highest published levels of chemicals released by recycled tires, the likelihood for noncancer health effects was calculated for a one-time ingestion of ten grams of tire shreds by a typical three-year-old child; only exposure to zinc exceeded its health-based screening value (i.e. promulgated by a regulatory agency such as OEHHA or U.S. EPA). Overall, we consider it unlikely that a one-time ingestion of tire shreds would produce adverse health effects. Seven of the chemicals leaching from tire shreds in published studies were carcinogens, yielding a 1.2×10^{-7} (1.2 in ten million) increased cancer risk for the one-time ingestion described above. This risk is well below the *de minimis* level of 1×10^{-6} (one in one million), generally considered an acceptable cancer risk due to its small magnitude compared to the overall cancer rate (OEHHA, 2006).

Evaluation of health risks caused by skin contact with rubber granules used in synthetic turf pitches

Dr. Christa Hametner, Vienna, Dr. Hans Theodor Grunder, Berlin, 2007

- No significant health risks by either direct contact to rubber granules or by contact to rubber dust - with the exception of the risk of allergic reactions in indoor applications.

Leaching of zinc from rubber infill on artificial turf (football pitches)

Laboratory for Ecological Risk Assessment, 2007

- Human health risks posed by leaching of zinc are negligible as zinc concentrations in the water do not exceed drinking water standards. The risks of zinc to public health are of no concern: the human toxicity of zinc is low and WHO drinking water criteria are not exceeded.

Nitrosamines released from rubber crumb

van Bruggen, M., E.M. van Putten, and P.C.J.M. Janssen, 2007, RIVM: Bilthoven, the Netherlands

- Small quantities of nitrosamines emitted but not detectable in air; nitrosamine related health effects not likely.

Preliminary Assessment of the Toxicity from Exposure to Crumb Rubber: its use in Playgrounds and Artificial Turf Playing Fields

Thomas Ledoux, Ph.D., New Jersey Department of Environmental Protection, June 2007

- With the possible exception of allergic reactions among individuals sensitized to latex, rubber and related products, there was "no obvious toxicological concern" raised that crumb rubber in its intended outdoor use on playgrounds and playing fields would cause adverse health effects in the normal population.

Artificial turf pitches – An assessment of the health risks for football players

Norwegian Institute of Public Health and the Radium Hospital, 2006, Oslo. p. 1-34.

- Recycled rubber granulate contains many chemical substances which are potentially harmful to health. The concentrations of these substances are however extremely low, they are only leached from the rubber granulate in very small quantities and they are only present in low concentrations in the hall air.
- It has been concluded that exposure to benzene and PAHs in the quantities in which they have been measured in the halls will not cause any increased risk of cancer using the halls.
- Chemical substances are released in very low quantities; based on worst case assumptions, use of artificial turf halls does not pose elevated risk; more information needed on natural rubber allergens.

An Open Letter concerning the potential cancer risk from certain granulate infills from artificial turf

FIFA, Prof. Dr. Jiri Dvorak, July 2006

- "The majority of the studies have been on higher surface area particles and have concluded they are currently acceptable. Therefore the larger granules used in artificial turf will have even less potential for emissions. For example a study undertaken by the Danish Ministry of the Environment concluded that the health risk on children's playgrounds that contained both worn tyres and granulate rubber was insignificant. The available body of research does not substantiate the assumption that cancer resulting from exposure to SBR granulate infills in artificial turf could potentially occur."

Measurement of non-exhaust particulate matter

Luhana, L., et al., 2004, Deliverable 8 of European Commission DG TrEn 5th Framework PARTICULATES Project

- In comparison to the indoor fields, 7.5 percent of PM₁₀ at an urban Switzerland curb side sampling location was attributed to tire wear particles. The fraction of PM₁₀ attributed to tire wear particles was 2 percent at an urban background site. The levels of PM₁₀ attributable to ground rubber measured at Norwegian fields appear to be similar in magnitude levels attributed in ambient air near roadways or tunnels. Typical ambient tire wear particle concentrations of PM₁₀ or total suspended particulate are 2-5 µg/m³ for roadways and 10-20 µg/m³ for tunnels. Research to date has shown a highly variable distribution between fine (< 2.5 µm) and coarse (>7 µm) in airborne roadside tire wear particles.

Potential health and environmental effects linked to artificial turf systems – final report

Plessner, Thale S.W., Lund, J. Ole, Norwegian Building Research Institute, September 2004

- Rubber granules contain lead, cadmium, copper, mercury, zinc, PAHs, phthalates, 4- toctylphenol and isononylphenol.
- Concentration of lead, cadmium, copper and mercury in the rubber granules is below the Norwegian Pollution Control Authority's normative values for most sensitive land use and probably does not constitute an unacceptable environmental risk in the short or the long term.
- Concentrations of zinc and PAH in the recycled rubber granules exceed the Norwegian Pollution Control Authority's normative values for most sensitive land use. The concentrations of dibutylphthalate (DBP) and diisononylphthalate (DINP) exceed the PNEC values for terrestrial life.
- Concentration of isononylphenol is above the limits specified for cultivated land in the Canadian Environmental Quality Guidelines.
- Leachate from the recycled granulates contain zinc, polycyclic aromatic hydrocarbons (PAH), phthalates and phenols. The concentration of zinc indicates that the leachate water is placed in the Norwegian Pollution Control Authority's Environmental Quality Class V (very strongly polluted water), but is lower than the permissible zinc concentration in Canadian drinking water. The concentration of anthracene, fluoranthene, pyrene and nonylphenols exceed the limits for freshwater specified in the Canadian Environmental Quality Guidelines.
- The recycled rubber granulates give off a significant number of alkylated benzenes in gaseous form. Trichloromethane (sample 1) and cis-1,2-dichloroethene (sample 5) were also found.

Toxicological Evaluation for the Hazard Assessment of Tire Crumb for Use in Public Playgrounds

Birkholz, D.A., K.L. Belton, and T.L. Guidotti, J. Air & Waste Management Association, July 2003

- "Genotoxicity testing of tire crumb samples following solvent extraction concluded that no DNA or chromosome-damaging chemicals were present. This suggests that ingestion of small amounts of tire crumb by small children will not result in an unacceptable hazard of contracting cancer."
- We conclude that the use of tire crumb in playgrounds results in minimal hazard to children and the receiving environment.
- Extracts were not genotoxic and exposure potential in children deemed minimal; tire rubber at playgrounds does not pose a health hazard to children.
- An exposure assessment performed to address the potential health risks to children playing in facilities where tire crumb is used as ground cover concluded that there was little potential for an exposure sufficient to cause adverse health effects in children.

Child-Specific Exposure Factors Handbook

U.S. EPA, National Center for Environmental Assessment—Washington Office, September 2002

- Supplemental chronic risk estimates based on a child's typical incidental ingestion rate of 100 mg/day, as prescribed by the U.S. EPA's Child-Specific Exposure Factors Handbook, indicate that regular exposure (e.g., regular play on ground rubber filled athletic fields) to ground rubber for the length of one's childhood does not increase risk of cancer above levels considered by the state of California to be de minimus (i.e. a lifetime excess cancer risk of 10^{-6}) or pose a likelihood of non-cancer effects (i.e. hazard index less than one).

Five Year Study of the Water Quality Effects of Tire Shreds Placed Above the Water Table

Humphrey, D.N. and E.K. Lynn, Department of Civil and Environmental Engineering, University of Maine, March 2001

- Tire shreds have a negligible impact on groundwater quality at neutral pH.

Emission Characteristics of VOCs from Athletic Tracks

Chang, F.H., et al., J Hazard Mater, 1999. 70(1-2): p. 1-20

- From 67 to 160 °F, the vapor pressure of benzothiazole increases by a factor of almost 40. However, based on a study of a synthetic rubber athletic track, total VOC emissions are estimated to increase by a factor of only 2 over the same range. No exposure estimates or risk calculations were determined based on results from this study. However, total VOC concentration at breathing height above the track was 0.39 $\mu\text{g}/\text{m}^3$.

Environmental Impacts of Recycled Rubber in Light-Fill Applications

Liu, Helen S., et. al., Department of Plastics Engineering, University of Massachusetts Lowell, August 1998

- Recycled rubber derived from scrap tires is a safe recyclable material. Based on the evidence presented, the overwhelming conclusion is that it would be reasonable to recommend use of recycled scrap tires in civil engineering applications.