April 29, 2016

Leroy A. Richardson, Information Collection Review Office
Centers for Disease Control and Prevention
1600 Clifton Road NE., MS-D74
Atlanta, Georgia 30329.

Federal eRulemaking Portal: Regulation.gov

Re: Docket No. ATSDR-2016-0002

Dear Mr. Richardson,

Conducting additional research into the health and environmental impacts synthetic turf fields with crumb rubber infill is essential. Crumb Rubber turf fields are proliferating quickly through communities with schools and municipalities constructing crumb rubber fields to accommodate kids playing sports of all ages from elementary level on up. In every instance school district and town officials cite industry funded research as a primary demonstration of safety. Inadequate Government documents are of little help in countering such assertions or information the decisionmaking process as, to the degree they exist, they are very limited in scope, they often rely on industry-provided information, and they often rely on an absence of information as somehow supporting a demonstration of no harm. A thorough and independent investigation is essential if we are to protect children, adults and the environment from the harms of crumb rubber artificial turf.

The Delaware Riverkeeper Network would also like to suggest that research into the impacts of other artificial turf infill materials is important given that they too are the subject of a multitude of claims of safety backed by little but industry marketing materials and industry funded research.

I believe it will be important to include an organization like the Delaware Riverkeeper Network among your stakeholders. We have had to engage in significant research into, and advocacy about, artificial turf, its environmental and health impacts on a number of occasions over the past 8+ years. As a result we have a significant and healthy understanding of the science and the issues that have been and need to be evaluated.

I include with this comment a series of fact sheets and informational materials created by my organization to help inform local debates regarding the construction or expansion of artificial turf

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fields. In these materials we cite a number of scientific and government materials that assess the environmental and health impacts of crumb rubber artificial turf. We would like to submit them for the record and your consideration.

Synthetic turf is generally made with rubber from waste tires. Recycled rubber varies considerably in its chemical composition, even when from the same manufacturer.[1] Hazardous substances found in tires may persist in the environment including polycyclic aromatic hydrocarbons (PAHs), phthalates and certain metals. These substances may be bioaccumulative, carcinogenic, reprotoxic, mutagenic and/or endocrine disrupting.[2]

- Most PAHs are persistent, bioaccumulative and carcinogenic.[3]
- Phthalates are generally used as solvents and plasticisers in plastics. Phthalates are not chemically bound to the rubber and as a result can leach from the infill material.[4]
- Phenols likewise are not chemically bound to the rubber and so can leach. Phenols too are persistent and bioaccumulative and can have long-term effects on the environment.[5]
- Among the metals found in tires that may be of concern are zinc, lead, copper, chromium and cadmium. While zinc and copper are essential for living organisms, when absorbed at high levels they become harmful. Lead can affect reproduction, development of the nervous system leading to poor cognitive development, and is a particular threat to fetuses and young children. Chromium is carcinogenic and mutagenic. Cadmium is toxic to humans and if taken in can contribute to poor liver and kidney function, as well as osteoporosis. [6]

Playing on Artificial Turf brings threats of exposure to hazardous substances through a variety of pathways.

Direct human exposure to the hazardous substances contained in the rubber in-fill of artificial turf is believed to occur via three pathways: inhalation, skin contact, and/or ingestion including by children who come into contact with the material.[7]

A 2012 study focused on the threat of lead ingestion from artificial turf noted that lead, in the "case of chronic exposure in early childhood, can induce cell necrosis, nerve behavioral abnormalities and developmental disability, and in the case of long-term exposure it can induce cell necrosis, blood pressure, cancer, and kidney tumor."[8] In this study researchers considered the impacts for lead exposure from children who ingest rubber powder resulting from exposure to crumb rubber infill artificial turf. The research showed elementary school children had a hazard index that exceeded 0.1,

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[1] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 7.
[2] KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.
[3] KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.
[4] KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.
[5] KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.
[6] KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.
[7] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.
[8] Kim, S., Yang, J.-Y., Kim, H.-H., Yeo, I.-Y., Shin, D.-C., & Lim, Y.-W. (2012). Health Risk Assessment of Lead Ingestion Exposure by Particle Sizes in Crumb Rubber on Artificial Turf Considering Bioavailability. Environmental Health and Toxicology, 27, e2012005. http://doi.org/10.5620/eht.2012.27.e2012005.

a level that is considered a "potential for hazard".[9] Middle and high school children were also found to have exposure levels.

In 2011, research conducted for the New Jersey Department of Environmental Protection began investigation into the potential for players on artificial turf fields to be exposed to lead, chromium, arsenic and cadmium as a respirable/inhalable aerosol.[10] In air samples collected from the turf during various levels of activity, researchers detected arsenic, cadmium, chromium and lead, all metals with known human toxicity.[11] "The findings of this study, although limited in scope, raise some concerns with regard to the potential hazards that may exist for individuals and in particular children who engage in sports activities on artificial turf fields."[12] The research demonstrated that activity by players on the fields could suspend contaminated particulates into the air that could be inhaled. "The findings show that both inhalable PM [particulate matter], as well as inhalable lead (when present) are resuspended from even minor physical activity on an artificial surface. These data therefore indicates that human exposure from lead-containing artificial turf fields is not just limited to dermal, but also to inhalation route of exposure."[13] The three potential avenues for lead from artificial turf are the blades of artificial grass, the pigment used for the field markings and lines, and the infill material. Even studies that have not found exposure levels to lead high enough to be of concern in the context of the study conducted are careful to point out: "some health scientists believe that *any* Pb [lead] is harmful to children's neurocognitive development, and that *no* new Pb should be added to their surroundings"[14] and that "…physicians should be aware of synthetic turf as pone potential source of exposure for young children. Health officials investigating elevated blood lead in children should also be aware of synthetic turf as a potential source of lead exposure."[15]

Furthermore, a 2008 study that looked at a variety of contaminants associated with artificial turf did find that the lead present in the rubber granules, while at low levels, was "highly bioaccessible" to synthetic gastric fluid used in their research. This study also found a "slightly worrisome" level of chromium in an artificial turf fiber sample and "high bioaccessible fractions of lead in both synthetic gastric and intestinal fluids.[16]

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[9] Kim, S., Yang, J.-Y., Kim, H.-H., Yeo, I.-Y., Shin, D.-C., & Lim, Y.-W. (2012). Health Risk Assessment of Lead Ingestion Exposure by Particle Sizes in Crumb Rubber on Artificial Turf Considering Bioavailability. Environmental Health and Toxicology, 27, e2012005. http://doi.org/10.5620/eht.2012.27.e2012005.

[10] S.L. Shalat, Sc.D., "An Evaluation of Potential Exposures to Lead and Other Metals as the Result of Aerosolized Particulate Matter from Artificial Turf Playing Fields, Final Report", submitted to NJ Department of Environmental Protection, July 14, 2011.

[11] S.L. Shalat, Sc.D., "An Evaluation of Potential Exposures to Lead and Other Metals as the Result of Aerosolized Particulate Matter from Artificial Turf Playing Fields, Final Report", submitted to NJ Department of Environmental Protection, July 14, 2011.

[12] S.L. Shalat, Sc.D., "An Evaluation of Potential Exposures to Lead and Other Metals as the Result of Aerosolized Particulate Matter from Artificial Turf Playing Fields, Final Report", submitted to NJ Department of Environmental Protection, July 14, 2011.

[13] S.L. Shalat, Sc.D., "An Evaluation of Potential Exposures to Lead and Other Metals as the Result of Aerosolized Particulate Matter from Artificial Turf Playing Fields, Final Report", submitted to NJ Department of Environmental Protection, July 14, 2011.

[14] J. Zhang, I. Han, L. Zhang, W. Crain, "Hazardous Chemicals in synthetic turf materials and their bioaccessibility in digestive fluids," Journal of Exposure Science and Environmental Epidemiology (2008)

[15] G. Van Ulirsch et. al, Evaluating and Regulating Lead in Synthetic Turf, Commentary, Environmental Health Perspectives, Vol 118, No. 10, Oct. 2010.

[16] J. Zhang, I. Han, L. Zhang, W. Crain, "Hazardous Chemicals in synthetic turf materials and their bioaccessibility in digestive fluids," Journal of Exposure Science and Environmental Epidemiology (2008)

In October 2006 and January 2007, respectively, two sites in New York where synthetic turf has been used (a large, then 3 year old, Parade Ground in Brooklyn; a relatively small then 5 month old Sara D. Roosevelt Park in Manhattan) were analyzed. This testing found PAHs at hazardous levels (as per New York standards) at each of the sites. At both sites dibenzo (a.h)anthracene, a probable human carcinogen, was found at hazardous levels, with two other PAH forms, both possible human carcinogens, found at hazardous levels at the Parade Ground site. A 2008 study also found that the rubber granules found in artificial turf fields had PAH levels above health-based soil standards, that there was "low" but not "no" bioaccessibility, and that while levels appear to decline over time this can be altered by the fact that new rubber can be added periodically to compensate for the loss of infill material.[17] Additional research is needed into the pathways by which these substances may be absorbed into the bodies of children and athletes via skin contact, ingestion or other pathways[18] - but the need for additional research does not displace the concerns raised by these findings.

Analyses conducted at the Environmental and Occupational Health Sciences Institute of Rutgers University found the crumb rubber from artificial turf to contain high levels of PAHs, as well as zinc and arsenic.[19] PAHs found to be contained in the crumb rubber "were above the concentration levels that the New York State Department of Environmental Conservation (DEC) considers sufficiently hazardous to public health to require their removal from contaminated soil sites. It is highly likely that all six PAHs are carcinogenic to humans." [20] "The analyses also revealed levels of zinc in both samples that exceed the DEC's tolerable levels." [21] The researchers associated with these findings were careful to state "We want to emphasize that the findings are preliminary. PAHs in rubber might not act the same way as in soil, and we do not yet have information on the ease with which the PAHs in these rubber particles might be absorbed by children or adults -- by ingestion, inhalation, or absorption through the skin. However, the findings are worrisome. Until more is known, it wouldn't be prudent to install the synthetic turf in any more parks." [22]

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[17] J. Zhang, I. Han, L. Zhang, W. Crain, "Hazardous Chemicals in synthetic turf materials and their bioaccessibility in digestive fluids," Journal of Exposure Science and Environmental Epidemiology (2008)

[18] Rachel's' Democracy & Health News #992, Hazardous Chemicals in Synthetic Turf, Follow-up Analyses, April 12, 2007.

[19] Junfeng Zhang, professor and acting chair, Department of Environmental and Occupational Health, the School of Public Health, the University of Medicine and Dentistry of New Jersey and Rutgers University & William Crain, professor of psychology at The City College of New York, president of Citizens for a Green Riverside Park, Hazardous Chemicals in Synthetic Turf, 2006, analyses conducted at at the Environmental and Occupational Health Sciences Institute of Rutgers.

[20] Junfeng Zhang, professor and acting chair, Department of Environmental and Occupational Health, the School of Public Health, the University of Medicine and Dentistry of New Jersey and Rutgers University & William Crain, professor of psychology at The City College of New York, president of Citizens for a Green Riverside Park, Hazardous Chemicals in Synthetic Turf, 2006, analyses conducted at at the Environmental and Occupational Health Sciences Institute of Rutgers.

[21] Junfeng Zhang, professor and acting chair, Department of Environmental and Occupational Health, the School of Public Health, the University of Medicine and Dentistry of New Jersey and Rutgers University & William Crain, professor of psychology at The City College of New York, president of Citizens for a Green Riverside Park, Hazardous Chemicals in Synthetic Turf, 2006, analyses conducted at at the Environmental and Occupational Health Sciences Institute of Rutgers.

[22] Junfeng Zhang, professor and acting chair, Department of Environmental and Occupational Health, the School of Public Health, the University of Medicine and Dentistry of New Jersey and Rutgers University & William Crain, professor of psychology at The City College of New York, president of Citizens for a Green Riverside Park, Hazardous Chemicals in Synthetic Turf, 2006, analyses conducted at at the Environmental and Occupational Health Sciences Institute of Rutgers.

A study by the California Office of Environmental Health Hazard Assessment (OEHHA) summarized 46 studies that identified 49 chemicals which are released from tire crumb. Of the 49, "seven of the chemicals leached from tire shreds were carcinogens. OEHHA calculated a cancer risk of 1.2 in 10 million based on a ***one-time*** ingestion of the tire crumb rubber over a lifetime."[23] While there are limited studies which assert that recycled tire crumb are stable in the gastrointestinal tract and that therefore this is not a pathway for exposure, there are other studies which contradict these findings.[24]

Concerns have been raised about the potential implications of recycled tire in-fill for individuals with latex allergies and that inhalation could result in a systemic response, as opposed to a contact response.[25]

Asserted one analysis, while, "the status of the information about human exposures to recycled tire crumb rubber in-fill … is not sufficient to determine the safety of the use of the product in situations that involve continuous episodes of human exposure;" [26] "the available information is sufficient and strong enough to raise plausible questions with respect to acute toxicity for susceptible persons, and for cancer risks."[27]

Chrysene, a PAH and carcinogen, was found to be ingested as the result of hand-to-surface-to-mouth transfer from playground surfaces made with recycled tires. Assuming playground use for an 11 year period (from age 1 to 12) there was found to be an increased cancer risk of 2.9 in one million (2.9×10^{-6}). This risk is greater than the general cancer risk gauge of one in one million (1×10^{-6}).[28] This research would seem to suggest that repeat exposure over time to the chemicals released from artificial turf increases the associated increase in cancer risk.

The hot temperatures create additional concern for exposing players to dangerous toxins. As well explained by a well cited petition to the Consumer Product Safety Commission for rulemaking: "When tires are shredded and pulverized, their surface area increases exponentially, as does the particulate and gas yield from the tire material. Since tires are made of very harmful materials, including 24 gases found to be harmful to humans, carbon black, (a carcinogen which makes up 30% of tires), latex, benzothiazoles, phthalates, lead, mercury, cadmium, zinc and many other known toxins, when the fields heat up, they become increasingly dynamic. Of primary concern is the interaction of particles and gases, 'because when particles adsorb onto the surface of gases, they become 10-20 times more toxic than the materials themselves.' The fields yield continuously, but become more dynamic and more toxic as they heat up."[29]

A Case Study conducted by a group of "physicians and public health professionals working with the U.S. Environmental Protection Agency's Region Pediatric Environmental Health Specialty Unit" found

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[23] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007 citing California Office of Environmental Health Hazard Assessment (OEHHA), Evaluation of Health Effects of Recycled Waste Tires in Playground and Track Products, January, 2007.
[24] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.
[25] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.
[26] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.
[27] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.
[28] Office of Environmental Health Hazard Assessment, Evaluation of Health Effects of Recycled Waste Tires in Playground and Track Products, January 2007. Note -- the 1.2 in 10 million cancer risk found in the OEHHA study was considered by the authors to be an acceptable level of risk as it falls below the general cancer risk gauge of one in one million (1×10^{-6}).
[29] Petition for a Rulemaking on Surface Heat from Artificial Turf, Submitted by PEER to Consumer Product Safety Commission, Sept 6, 2012.

that they could not secure the research and information necessary to establish the safety in use with children of tire crumb used as playground surface.[30] "The use of recycled tire crumb products on playgrounds has had little health investigation. The major unresolved concern is the potential for latex allergy with short-term dermal exposure." [31] "No published information is available specifically regarding exposure to crumb rubber constituents from use of the product on playgrounds." [32]

Excessive heat is a major health threat for those that play on artificial turf.
Extreme heat is a health concern – high surface temperatures found on artificial turf fields can contribute to physiological stress and cause "serious heat-related illnesses".[33] Heat stress, heat stroke and burns are all of concern. In fact, the "New York City Department of Health and Mental Hygiene recognizes excessive surface temperatures as the most important health concern associated with infilled synthetic turf." [34] Studies document that the surface temperature on artificial turf is dramatically increased as compared to surrounding land uses including asphalt – so much so that it is a genuine health threat for players.

Concerns regarding the excessive temperatures range from the implications for players who are already exerting themselves playing in such excessively high temperatures, to the implications for burns when players or pedestrians come into contact with the hot surfaces, to the implications for small children who may come into contact with the extremely hot surfaces during non-sporting events. Research has also concluded that the "heat transfer from the surface to the sole of the individual's foot" could contribute to physiological stress of players. [35]

In a 2002 study it was found that "the surface temperature of the synthetic turf was 37° F higher than asphalt and 86.5° F hotter than natural turf." [36] A study published in the Journal of Health and Physical Education and Recreation showed "surface temperatures as much as 95 to 140 degrees Fahrenheit higher on synthetic turf than natural turf grass when exposed to sunlight." [37] Random sampling at Brigham Young University identified temperatures ranging from 117.38 to 157 degrees on artificial turf while neighboring natural grass areas were in the range of 78.19 to 88.5 degrees Fahrenheit. "Two inches below the synthetic turf surface was 28.5° F hotter than natural turf at the surface."[38] Another study comparing temperatures on artificial turf temperatures with air temperature found that artificial turf ranged from 58 to 75 degrees hotter than measured air temperature.[39] And yet another study considering found ranges of 155.3 to 173.4 degrees on the turf

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[30] M.E. Anderson et al, A Case Study of tire Crumb Use on Playgrounds: Risk Analysis and Communication When Major Clinical Knowledge Gaps Exist, Environmental Health Perspectives, Vol 114, No. 1, January 2006.
[31] M.E. Anderson et al, A Case Study of tire Crumb Use on Playgrounds: Risk Analysis and Communication When Major Clinical Knowledge Gaps Exist, Environmental Health Perspectives, Vol 114, No. 1, January 2006.
[32] M.E. Anderson et al, A Case Study of tire Crumb Use on Playgrounds: Risk Analysis and Communication When Major Clinical Knowledge Gaps Exist, Environmental Health Perspectives, Vol 114, No. 1, January 2006.
[33] T.J. Serensits, A.S. McNitt, D.M. Petrunak; Human health issues on synthetic turf in the USA, Dept of Crop and Soil Sciences, The Pennsylvania State University, IMechE Vol 225 Part P: J. Sports Engineering & Technology, Jan 6, 2011.
[34] T.J. Serensits, A.S. McNitt, D.M. Petrunak; Human health issues on synthetic turf in the USA, Dept of Crop and Soil Sciences, The Pennsylvania State University, IMechE Vol 225 Part P: J. Sports Engineering & Technology, Jan 6, 2011.
[35] T.J. Serensits, A.S. McNitt, D.M. Petrunak; Human health issues on synthetic turf in the USA, Dept of Crop and Soil Sciences, The Pennsylvania State University, IMechE Vol 225 Part P: J. Sports Engineering & Technology, Jan 6, 2011.
[36] Dr. C. Frank Williams and Dr. Gilbert E. Pulley, Synthetic Surface Heat Studies, Brigham Young University.
[37] SportsTurf Managers Association, A Guide to Synthetic and natural Turfgrass for Sports Fields, Selection, Construction and Maintenance Considerations.
[38] Dr. C. Frank Williams and Dr. Gilbert E. Pulley, Synthetic Surface Heat Studies, Brigham Young University.
[39] T. Sciacca, The Thermal Physics of Artificial Turf, January 2008.

fields when air temperatures were in the 76 degree range; and 104.2 to 159.3 degrees when air temperatures were in the 77 degree range. [40]

Research has not found good solutions for the excessive heat levels of turf. Irrigation of excessively hot artificial turf surfaces only provides cooling benefits for about 20 minutes. [41] While irrigation provides cooling for the synthetic turf, in one seminal study lowering the temperature from 174° F to 85° F, after only 5 minutes the temperature quickly rose again to 120°F; after 20 minutes it rose to 164°F.[42] In another important body of work by Penn State, it was found again that irrigation is only successful in reducing temperatures for about 20 minutes, with a rebound to within 10 degrees of the pre-irrigation temperature within 3 hours. [43] The use of white crumb rubber as the infill does not resolve the heat issue. [44] In fact, according to Penn State as part of a study which looked at various color options for infill and temperature, "[w]hile marketing materials may claim lower surface temperatures, no scientific reports exist that substantiate such claims."[45]

Natural grass, by comparison, provides a natural cooling affect and helps to dissipate heat from neighboring developed areas.[46] "The temperature of natural grass rarely rises above 85 degrees Fahrenheit, regardless of air temperature." [47]

The heat impacts of artificial turf need to be considered in the context of today's changing climate. Global climate change is expected to dramatically increase the number of days over 100 degrees in many communities. Depending on how aggressively global warming gasses are reduced in coming years, communities nearby Philadelphia will begin to experience in the range of 10 days (in lower emission scenarios) to 30 days (if higher emission scenarios continue to prevail) over 100 degrees.[48] By later in this century seasonable temperatures are projected to rise 6°F to 14°F in summer (depending again on emission reductions achieved in the future). [49]

Concerns for increased head injuries and bacterial infections as the result of playing on turf are justified.

There is great concern that the increased level of abrasions and burns which result from playing on an artificial turf field as compared to natural grass increases the pathways by which bacterial infections, such as MRSA (methicillin-resistant staphylococcus aureus), can enter the body. As explained in a 2011 Penn State study, "It is important to note that synthetic turf is more abrasive than natural turf grass and, as a result, breaks in the skin are more common, creating a pathway for infection when in

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[40] Penn State's Center for Sports Surface Research, Synthetic Turf Heat Evaluation – Progress Report, January 2012.

[41] T.J. Serensits, A.S. McNitt, D.M. Petrunak; Human health issues on synthetic turf in the USA, Dept of Crop and Soil Sciences, The Pennsylvania State University, IMechE Vol 225 Part P: J. Sports Engineering & Technology, Jan 6, 2011.

[42] Dr. C. Frank Williams and Dr. Gilbert E. Pulley, Synthetic Surface Heat Studies, Brigham Young University.

[43] T.J. Serensits, A.S. McNitt, D.M. Petrunak; Human health issues on synthetic turf in the USA, Dept of Crop and Soil Sciences, The Pennsylvania State University, IMechE Vol 225 Part P: J. Sports Engineering & Technology, Jan 6, 2011.

[44] T.J. Serensits, A.S. McNitt, D.M. Petrunak; Human health issues on synthetic turf in the USA, Dept of Crop and Soil Sciences, The Pennsylvania State University, IMechE Vol 225 Part P: J. Sports Engineering & Technology, Jan 6, 2011.

[45] Penn State's Center for Sports Surface Research, Synthetic Turf Heat Evaluation – Progress Report, January 2012.

[46] James B. Beard & Robert L. Green, The Role of Turfgrasses in Environmental Protection and Their Benefits to Humans, J. Environ Qual. 23:452-460 (1994).

[47] SportsTurf Managers Association, A Guide to Synthetic and natural Turfgrass for Sports Fields, Selection, Construction and Maintenance Considerations.

[48] Union of Concerned Scientists, Confronting Climate Change in the U.S. Northeast ● New Jersey, 2007.

[49] Union of Concerned Scientists, Confronting Climate Change in the U.S. Northeast ● New Jersey, 2007.

contact with an infected surface." [50] There are studies to indicate that turf burns may be facilitating infection by acting as a pathway for infection.[51] Study has found that turf burns increased the risk of infection regardless of the type and timing of care provided the burn. [52]

Older turf fields have been found to have higher microbial populations, as well as higher levels in the higher traffic areas such as the sidelines, thereby suggesting to researchers that microbial populations can accumulate in synthetic turf over time.[53]

Concussions (formally described as Mild Traumatic Brain Injury or MTBI) resulting from sports has, according to the US Centers for Disease Control, reached "epidemic proportions."[54] "'Mild' head traumas, and especially a series of such minor concussions can have long term, negative effects on cognitive function." [55] Study has documented that artificial turf increases the risk of MTBI over natural turf, approximately doubling that risk, as well as causing a greater degree of trauma.[56] According to study, artificial turf presents a 5 times greater risk of the more severe head injury than natural turf, although it is still unknown the particular characteristics of the two surfaces that cause the difference in head injury incidence. [57] Only 31% of the playground surfaces made of recycled tires tested in one research study passed the California State mandated Head Impact Criterion (HIC) of ≤1,000. In this same study 100% of the playground surfaces made of wood chips passed the same standard. [58]

Research shows there are adverse environmental impacts resulting from crumb rubber infill artificial turf; it is also clear that additional study for water and other natural resources is needed.

While it seems well recognized that there is a limited level of assessment and investigation into the environmental impacts associated with artificial turf, a growing body of scientific analysis is

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[50] T.J. Serensits, A.S. McNitt, D.M. Petrunak; Human health issues on synthetic turf in the USA, Dept of Crop and Soil Sciences, The Pennsylvania State University, IMechE Vol 225 Part P: J. Sports Engineering & Technology, Jan 6, 2011.

[51] A High Morbidity Outbreak of Methicillin-Resistant *Staphylococcus aureus* among Players on a College Football Team, Facilitated by Cosmetic Body Shaving and Turf Burns, study conducted 2004 for Connecticut Dept of Public Health, Student Health Services of Sacred Heart Univ, Centers for Disease Control and Prevention, Minnesota Dept of Public Health, Los Angeles County Dept of Health Svces; Dr. S.V. Kazakova et.al., A Clone of Methicillin-Resistant *Staphylococcus aureus* among Professional Football Players, The New England Journal of Medicine, Vol 352:468-475 No. 5, Feb. 3, 2005.

[52] A High Morbidity Outbreak of Methicillin-Resistant *Staphylococcus aureus* among Players on a College Football Team, Facilitated by Cosmetic Body Shaving and Turf Burns, study conducted 2004 for Connecticut Dept of Public Health, Student Health Services of Sacred Heart Univ, Centers for Disease Control and Prevention, Minnesota Dept of Public Health, Los Angeles County Dept of Health Svces.

[53] J.J. Bass, D.W. Hintze, (2013) "Determination of Microbial Populations in a Synthetic Turf System," Skyline – The Big Sky Undergraduate Journal, Vol. 1, Iss. 1, Art. 1.

[54] Dr. M. Shorten, J.A. Himmelsbach, BioiMechanica, Sports Surfaces and the Risk of Traumatic Brain Injury citing the US Centers for Disease Control.

[55] Dr. M. Shorten, J.A. Himmelsbach, BioiMechanica, Sports Surfaces and the Risk of Traumatic Brain Injury.

[56] Dr. M. Shorten, J.A. Himmelsbach, BioiMechanica, Sports Surfaces and the Risk of Traumatic Brain Injury.

[57] Dr. M. Shorten, J.A. Himmelsbach, BioiMechanica, Sports Surfaces and the Risk of Traumatic Brain Injury. See also K.M. Guskiewica, N.L. Weaver, D.A. Padua, W.E. Garrett Jr., Epidemiology of Concussion in Collegiate and High School Football Players, Sep-Oct 2000 & Does the Use of Artificial Turf Contribute to Head Injuries, The Journal of Trauma-Injury, Infection and Critical Care, Oct 2002 for the finding that artificial turf increases the level of injury in comparison to natural grass fields.

[58] Office of Environmental Health Hazard Assessment, Evaluation of Health Effects of Recycled Waste Tires in Playground and Track Products, January 2007. Please note that in this study 32 recycled tire playground surfaces were tested as compared to only 5 wood chip playground surfaces.

documenting a concerning level of environmental threat and harm and is further demonstrating the need for more research regarding artificial turf and its ramifications for the environment.

The Connecticut Agricultural Experiment Station conclusively found four compounds which out-gassed and leached into water from synthetic turf rubber crumb under ambient temperatures:

- Benzothiazole (a skin and eye irritant),
- Butylated hydroxyanisole (a "recognized carcinogen, suspected endocrine toxicant, gastrointestinal toxicant, immune toxicant, neurotoxicant, skin and sense-organ toxicant"),
- n-hexadecane (a severe irritant) &
- 4-(t-octyl) phenol ("corrosive and destructive to mucous membranes").[59]

As rubber degrades it can leach toxic substances which can contaminate soil, plants and aquatic ecosystems.[60] Study has concluded that the use of tires in artificial turf has the potential to pollute our environment with PAHs, phenols and zinc[61] and that runoff from an artificial turf field draining to a local creek can pose "a positive risk of toxic effects on biota in the water phase and in the sediment."[62] Other metal contaminants found to leach from tire crumb rubber include zinc, selenium, lead and cadmium.[63] Zinc has also been shown to leach from the artificial turf fibers.[64] Extreme temperatures or solvents are not needed to release these metals, volatile organic compounds or semi-volatile organic compounds from the rubber in-fill of artificial turf into the air or water – release takes place in ambient air and water temperatures.[65]

"Runoff with high Zn [zinc] from synthetic turf fields may produce adverse effects to plants and aquatic life. This is of particular concern given that the leaching rate of Zn [zinc] from rubber granules can be up to 20 times greater than the leaching rate of Zn from agricultural applications of manure and pesticides."[66] Leaching of substances as the result of surface water runoff from precipitation has, by some researchers, been predicted to be the greatest risk for the environment from artificial turf.[67] Study shows there is a risk of local effects for aquatic and sediment dwelling

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[59] The Connecticut Agricultural Experiment Station, Examination of Crumb Rubber Produced from Recycled Tires, August 2007; Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.

[60] Quoting Dr. Linda Chalker-Scott, Washington State University -- Turfgrass Resource Center, Facts About Artificial Turf and Natural Grass; T. Kallqvist, Norwegian Institute for Water Research(NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 17.; Connecticut Agricultural Experiment Station, Examination of Crumb Rubber Produced from Recycled Tires.

[61] T. Kallqvist, Norwegian Institute for Water Research(NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 5; T. Edeskar, Lulea University of Technology, Technical and Environmental Properties of Tyre Shreds Focusing on Ground Engineer Application, 2004 as cited in KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.

[62] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 6.

[63] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.

[64] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 17.

[65] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.

[66] J. Zhang, I. Han, L. Zhang, W. Crain, "Hazardous Chemicals in synthetic turf materials and their bioaccessibility in digestive fluids," Journal of Exposure Science and Environmental Epidemiology (2008)

[67] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 5; NIVA (The Norwegian Institute for Water Research), Evaluation of the Environmental Risks of Synthetic Turf, 2005; KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.

organisms in impacted water courses.[68] Recycled rubber, and associated leachate, has been found to contain a variety of metals (including lead, cadmium, copper, mercury and zinc), as well as organic pollutants such as PAHs, phthalates, 4-t-octylphenol and iso-nonyphenol.[69] The leaching of zinc has been determined to be of major environmental concern.[70] The leaching of zinc increases as the rubber infill weathers over time,[71] it is likely this is the same for other contaminants. While Zinc contributes the most risk, phenols (specifically octylphenol) and PAHs are also of concern.[72] Of the organic compounds at issue, Octylphenol represents the greatest risk, and possibly could occur at levels where hormone disrupting effects are a concern.[73] The varying content of tires makes this threat a moving target.

The Norwegian Institute for Water Research has determined that it is "appropriate to perform a risk assessment which covers water and sediments in watercourses which receive run-off from artificial turf pitches."[74]

While recycled rubber is a greater source of pollution, newly manufactured rubber also contains levels of hazardous substances; in the case of zinc and chromium the levels of recycled and newly manufactured rubber are comparable.[75]

It is predicted that chemicals leaching from synthetic turf materials occurs slowly, and as a result the environmental harms may take place over many years.[76]

Leaching may not be the only source of water contamination from artificial turf. As the artificial turf is used there is a level of "erosion" that takes place and can result in fine particles that could be carried to local waterways. This source of contamination needs study.[77]

The synthetic grass fibers can also be a significant source of pollution, particularly zinc, albeit significantly lesser amounts leach from the synthetic grass than the rubber infill.[78]

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[68] T. Kallqvist, Norwegian Institute for Water Research(NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 5; NIVA (The Norwegian Institute for Water Research), Evaluation of the Environmental Risks of Synthetic Turf, 2005, as cited by KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007; KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007

[69] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 7.

[70] INTRON, Environmental and Health Risks of Rubber Infill, rubber crumb from car tyres as infill on artificial turf, February 9, 2007.

[71] INTRON, Environmental and Health Risks of Rubber Infill, rubber crumb from car tyres as infill on artificial turf, February 9, 2007.

[72] NIVA (The Norwegian Institute for Water Research), Evaluation of the Environmental Risks of Synthetic Turf, 2005, as cited by KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.

[73] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 17.

[74] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 8.

[75] Byggforsk, SINTEF Building and Infrastructure, Potential Health and Environmental Effects Associated with Synthetic Turn Systems, 2004, as referenced in KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.

[76] T. Kallqvist, Norwegian Institute for Water Research(NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 5; NIVA (The Norwegian Institute for Water Research), Evaluation of the Environmental Risks of Synthetic Turf, 2005, as cited by KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.

[77] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 18.

When talking about the use of ground rubber as a supplement to planting soils the North Carolina Department of Agriculture and Consumer Services sent out a notice identifying the risk that zinc leaching from the rubber causes a decline in plant growth "directly attributable to zinc toxicity."[79]

One Norwegian assessment/presentation reported that "recycled rubber was the major source of potentially hazardous substances. An exposure scenario where the runoff from a football field is drained to a small creek showed a positive risk of toxic effects on biota in the water phase and in the sediment. The risk was mainly attributed to zinc, but also for octylphenol the predicted environmental concentrations exceeded the no environmental effect concentration."[80] The hazardous leaching could result in local environmental effect.[81]

Conclusion

Given all of the science on the record that demonstrates artificial turf is a threat to health and the environment, the precautionary principle dictates that artificial turf with crumb rubber infill be recognized as a threat to public health and safety and the environment and that the ongoing expansion and construction of crumb rubber turf fields should be prohibited and those fields that have already been installed should be removed and properly disposed of.

When a community installs a crumb rubber artificial turf field it is forcing children who want to participate in sports to be forced to expose themselves to its hazards. It is simply neither right nor fair for communities, with the support or false sense of security given by an acquiescing government agency, to be making investments that take from parents and kids the ability to decide for themselves what health hazards they are willing to be exposed to if they want to participate in sports. Advancing in anyway the construction and expansion of crumb rubber artificial turf fields is forcing an unfair choice on kids and parents: play sports or protect your health, but you are not allowed to have both.

Respectfully,

Maya K. van Rossum
the Delaware Riverkeeper

P.S. I note, that as a result of my work on this issue, as a parent I have had to pull my son from the township lacrosse team because they started playing on artificial turf this past year. The health impacts of artificial turf are too significant and concerning for me, as a parent, to allow my 10 year old son to play on crumb rubber artificial turf.

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[78] Byggforsk, SINTEF Building and Infrastructure, Potential Health and Environmental Effects Associated with Synthetic Turn Systems, 2004, as referenced in KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.
[79] M. Ray Tucker, Agronomist, Ground Rubber: Potential Toxicity to Plants, Media Notes for North Carolina Growers, North Carolina Dept of Agriculture & Consumer Services, April 1997.
[80] Dr. Christine Bjorge, Norwegian Institute of Public Health, Artificial turf Pitches – an assessment of the health risks for football players and the environment, Presentation at the ISSS Technical meeting 2006, Dresden.
[81] Dr. Christine Bjorge, Norwegian Institute of Public Health, Artificial turf Pitches – an assessment of the health risks for football players and the environment, Presentation at the ISSS Technical meeting 2006, Dresden.

Attachments:
Submitted as part of this comment are fact sheets and an annotated bibliography that discuss the research detailed above as well as additional research speaking about the environmental and public health threats posed by crumb rubber infill artificial turf.

Summary of Research
Assessing the Impacts of Artificial Turf

Updated 4/29/2016

Heat: Research has documented that the surface temperature on artificial turf is dramatically higher than the surrounding land uses including asphalt. Concerns regarding the excessive temperatures range from the implications for players who are already exerting themselves to the implications for burns when players or pedestrians come into contact with the hot surfaces.

1. Petrass, L. A., et al. (2014). Comparison of surface temperatures of different synthetic turf systems and natural grass: Have advances in synthetic turf technology made a difference. *Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology*.
    a. A comparison of surface temperatures of third-generation synthetic turf with a cool climate product that claims to reduce surface temperatures to surface temperatures of natural grass.
    b. Although surface temperatures were lower for the cool climate field compared to other synthetic turf, both types of artificial turf fields were considerably hotter than natural grass with temperatures that were between 12° C (53° F) and 22° C (72° F) hotter.
2. Reasor, E. H. (2014). Synthetic Turf Surface Temperature Reduction and Performance Characteristics as Affected by Calcined Clay Modified Infill. Master's Thesis, University of Tennessee. Available at: http://trace.tennessee.edu/utk_gradthes/2750
    a. Surface temperatures of artificial turf were between 31° C (88° F) and 57° C (135° F).
    b. Although irrigation reduced surface temperatures of artificial turf, increases of 74 to 102% of the pre-irrigation temperature were observed within 30 minutes after irrigation.
    c. Surface temperatures returned to pre-irrigation temperature on all of the treatments between 60 and 120 minutes after irrigation. Therefore, the cooling effect of irrigation will not last the entire length of an athletic competition.
3. Thoms, A. W. et al. (2014). Models for Predicting Surface Temperatures on Synthetic Turf Playing Surfaces. *Procedia Engineering*, *72*, 895-900. Available at: http://www.sciencedirect.com/science/article/pii/S1877705814006699
    a. Artificial turf surface temperatures ranged from -9.8 to 86.4° C (14 to 188° F) to when ambient air temperatures ranged from -0.4 to 37.1° C (31 to 99° F).
    b. Absorption of solar radiation results in increased temperatures on artificial turf surfaces, and high rates of solar radiation are absorbed with minimal light reflectance. Therefore, air temperature in conjunction with solar radiation explained most of the variation in artificial turf surface temperatures.
4. Penn State's Center for Sports Surface Research (2012). Synthetic Turf Heat Evaluation- Progress Report. January 2012. Available at: http://plantscience.psu.edu/research/centers/ssrc/documents/heat-progress-report.pdf

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   a. This study measured surface temperatures of artificial turf fields between 140.2 and 173.4° F when air temperatures were between 73 and 79° F.
   b. Looking at various color options for infill and temperature, no product significantly reduced surface temperatures. Small reductions in temperature are insignificant when surface temperatures still exceed 150° F. This study concluded that "[w]hile marketing materials may claim lower surface temperatures, no scientific reports exist that substantiate such claims."
   c. Research has not found a good solution for excessive heat levels of turf.
5. Serensits, T. J. et al. (2011). Human health issues on synthetic turf in the USA. *Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology*, *225*(3), 139-146.
   a. High surface temperatures found on artificial turf fields can contribute to physiological stress and cause "serious heat-related illnesses" including heat stress, heat stroke, and burns.
   b. The "New York City Department of Health and Mental Hygiene recognizes excessive surface temperatures as the most important health concern associated with infilled synthetic turf."
   c. Irrigation of excessively hot artificial turf surfaces only provides cooling benefits for about 20 minutes, with a rebound to within 10 degrees of the pre-irrigation temperature within 3 hours.
   d. The use of white crumb rubber as the infill does not resolve the heat issue.
6. Sciacca, T (2008). The Thermal Physics of Artificial Turf. SynTurf.org. Available at: http://www.synturf.org/sciaccaheatstudy.html
   a. A study comparing temperatures on artificial turf temperatures with air temperature found that artificial turf ranged from 58 to 75° hotter than measured air temperature.
7. SportsTurf Managers Association (STMA) (2008). A Guide to Synthetic and Natural Turfgrass for Sports Fields: Selection, Construction and Maintenance Considerations. 2nd edition. Available at: http://www.stma.org/sites/stma/files/STMA_Synthetic_Guide_2nd_Edition.pdf
   a. Artificial turf gets dramatically hotter than surrounding land uses including asphalt with surface temperatures as much as 95 to 140° F hotter than natural grass fields whereas the temperature of natural grass rarely rises above 85° F, regardless of air temperature
8. Williams, C. F., & Pulley, G. E. (2002). Synthetic surface heat studies. *Brigham Young University*. Available at: www.wellesleyma.gov/pages/WellesleyMA_SpragueResources/Synthetic%20Surfaces%20Heat%20Study.doc
   a. Temperature measurements were taken at the surface, above the surface, and below the surface of artificial turf, natural turf, bare soil, asphalt, and concrete.
   b. Surface temperatures of synthetic turf were 37° F higher than asphalt and 86.5° F hotter than natural turf.
   c. Two inches below the surface, synthetic turf was 28.5° F hotter than natural turf.
   d. Although irrigation of synthetic turf resulted in a reduction of close to 90°F, temperatures rose 35° within five minutes and returned to the starting temperature within 20 minutes.
   e. "The hottest surface temperature recorded was 200º F on a 98º F day. Even in October the surface temperature reached 112.4º F."
   f. Brigham Young University has set a surface temperature guideline which restricts play on synthetic turf fields when surface temperatures are potentially hazardous to athletes. This reduces the playing season and eliminates any continuous play benefit that is typically mentioned in favor of artificial turf.
9. Beard, J. B., & Green, R. L. (1994). The role of turf grasses in environmental protection and their benefits to humans. Journal of Environmental Quality, 23(3), 452-460. Available at: https://www.landcarenetwork.org/legislative/TheRoleofTurfgrassesinEnvironmentalProtection.pdf
   a. Synthetic surfaces can be up to 39° C (102° F) hotter than natural turf. Natural turf grass provides a natural cooling affect and helps to dissipate heat from neighboring developed areas.

Health: The impacts of inhalation or ingestion of chemicals continues to be a concern for those playing on artificial turf. Direct human exposure to the hazardous substances contained in the rubber in-fill of artificial turf is believed to occur via inhalation, skin contact, and/or ingestion. Furthermore, there are concerns for increased injuries and bacterial infections when playing on artificial turf.

1. Kim, S., Yang, J.-Y., Kim, H.-H., Yeo, I.-Y., Shin, D.-C., & Lim, Y.-W. (2012). Health Risk Assessment of Lead Ingestion Exposure by Particle Sizes in Crumb Rubber on Artificial Turf Considering Bioavailability. Environmental Health and Toxicology, 27, e2012005. http://doi.org/10.5620/eht.2012.27.e2012005.
    a. Researchers considered the risks for lead exposure from children ingesting rubber powder resulting from exposure to crumb rubber infill artificial turf and found that elementary school students had a hazard index that exceeded 0.1, a level that is considered a "potential for hazard", with middle and high school students also suffering exposure levels.

2. Balazs, G. C., et al. (2014). Risk of Anterior Cruciate Ligament Injury in Athletes on Synthetic Playing Surfaces A Systematic Review. *The American journal of sports medicine*, 0363546514545864.
    a. A systematic review of available literature on the risk of ACL rupture on natural grass versus artificial turf found that there is an increased rate of ACL injury on synthetic playing surfaces for football players.
3. Celeiro, M., Lamas, J. P., Garcia-Jares, C., Dagnac, T., Ramos, L., & Llompart, M. (2014). Investigation of PAH and other hazardous contaminant occurrence in recycled tyre rubber surfaces. Case-study: restaurant playground in an indoor shopping centre. *International Journal of Environmental Analytical Chemistry*, *94*(12), 1264-1271.
    a. The presence of a large number of hazardous substances were found in both the runoff and vapor phase of recycled tire playground surfaces.
    b. Nine polycyclic aromatic hydrocarbons (PAHs) were detected in the runoff/ cleaning water with total PAH concentrations in the ppm (parts per million) range.
    c. The most toxic PAH, benzo[a]pyrene was detected in extracts from playground surfaces.
    d. "The presence and the high concentration of these chemical compounds in playground should be a matter of concern owing to their high toxicity."
4. Laible, C., & Sherman, O. H. (2014). Risk Factors and Prevention Strategies of Non-Contact Anterior Cruciate Ligament Injuries. *Bulletin of the Hospital for Joint Diseases*, *72*(1), 70-5. Available at: http://www.nyuhjdbulletin.org/mod/bulletin/v72n1/docs/v72n1_7.pdf
    a. Since shoe-surface interaction is important for injury prevention, "the optimal surface to prevent injury is outdoors on natural grass."
    b. Artificial turf has a higher friction coefficient and greater ground reaction force, both conditions that increase the risk for injury.
    c. Furthermore, as temperature increases the shoe-surface friction interaction increases and exposes athletes to greater risk of injury.
5. Bass, J. J., & Hintze, D. W. (2013). Determination of Microbial Populations in a Synthetic Turf System. Skyline-The Big Sky Undergraduate Journal, 1(1), 1. Available at: http://skyline.bigskyconf.com/cgi/viewcontent.cgi?article=1000&context=journal
    a. Abrasions, even insignificant ones, from artificial turf can create an entry site for pathogens.
    b. The higher abrasion rate for synthetic turf increases the risk of infection, and the microbial populations found within synthetic turf are a source of pathogens when abrasions occur.
    c. Older turf fields have higher microbial populations, as well as higher levels in the higher traffic areas such as the sidelines. These results indicate that artificial turf poses a greater risk for the spread of pathogens and infections among student athletes.
6. Llompart, M., Sanchez-Prado, L., Lamas, J. P., Garcia-Jares, C., Roca, E., & Dagnac, T. (2013). Hazardous organic chemicals in rubber recycled tire playgrounds and pavers. *Chemosphere*, *90*(2), 423-431. Available at: http://www.elcorreodelsol.com/sites/default/files/chemosphere_maria_llompart.pdf

   a. An analysis of surfaces containing recycled rubber tires confirmed the presence of hazardous substances including PAHs, phthalates, antioxidants (e.g. BHT, phenols), benzothiazole, derivatives, and other chemicals.
   b. The vapor phase above the samples confirmed volatilization of many organic compounds demonstrating that these chemicals can enter the human body through inhalation.
   c. The use of recycled rubber tires for play areas, especially facilities for children, should be restricted or prohibited.
7. Serensits, T. J., McNitt, A. S., & Petrunak, D. M. (2011). Human health issues on synthetic turf in the USA. *Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology*, *225*(3), 139-146.
   a. Synthetic turf is more abrasive than natural turf grass, therefore, "breaks in the skin are more common, creating a pathway for infection when in contact with an infected surface."
8. Shalat, S.L. (2011). An Evaluation of Potential Exposures to Lead and Other Metals as the Result of Aerosolized Particulate Matter from Artificial Turf Playing Fields, Final Report. Submitted to NJ Department of Environmental Protection, July 14, 2011. Available at: http://www.nj.gov/dep/dsr/publications/artificial-turf-report.pdf
   a. In air samples collected from artificial turf during various levels of activity, researchers detected arsenic, cadmium, chromium and lead, all metals with known human toxicity.
   b. This research demonstrates that activity by players on the fields could suspend contaminated particulates into the air that could be inhaled and therefore, human exposure from artificial turf fields is not limited to dermal.
   c. These results "raise some concerns with regard to the potential hazards that may exist for individuals and in particular children who engage in sports activities on artificial turf fields."
9. Van Ulirsch, G. et al. (2010). Evaluating and regulating lead in synthetic turf. *Environmental health perspectives*, *118*(10), 1345. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2957910/pdf/ehp-118-1345.pdf
   a. Artificial turf can degrade to form lead containing dust at levels that pose a health risk to children.
   b. Due to the lack of research, "…physicians should be aware of synthetic turf as one potential source of exposure for young children…" and "Health officials investigating elevated blood lead in children should also be aware of synthetic turf as a potential source of lead exposure."
10. Center for Disease Control and Prevention. (2008). CDC Health Advisory. Potential exposures to lead inartificial turf: Public health issues, actions, and recommendations. June 18, 2008. Available at: http://www.dhhr.wv.gov/oeps/disease/Documents/Advisory_00275.pdf
   a. Artificial turf made of nylon or nylon/ polyethylene blend fibers contain lead and pose a potential public health concern.
   b. The risk for lead exposure is higher for artificial fields that are old, frequently used, exposed to the weather, or demonstrate signs of abraded, faded, or broken fibers. As turf ages, lead is released in dust that could then be ingested or inhaled.
   c. CDC does not know how much lead the body will absorb. However, lead can cause neurological development symptoms and behavioral problems. Children less than 6 years old are more affected by lead than adults and absorb lead more easily.
   d. CDC does not understand the potential risks associated with lead exposure from artificial turf but recommends precautions including aggressive hand and body washing after playing on fields, washing clothes immediately to avoid tracking contaminated dust to other places, and discouraging eating and drinking while on turf products.
11. Han, I. K., Zhang, L., & Crain, W. (2008). Hazardous chemicals in synthetic turf materials and their bioaccessibility in digestive fluids. Journal of Exposure Science and Environmental Epidemiology, 18(6), 600-607. Available at: http://www.nature.com/jes/journal/v18/n6/pdf/jes200855a.pdf

a. Samples from rubber granules and from artificial grass fibers were taken at fields of different ages and analyzed for polycyclic aromatic hydrocarbons (PAHs), zinc, chromium, arsenic, cadmium, and lead. These samples were then analyzed to determine their bioaccessibility in synthetic digestive fluids.
b. The rubber granules found in artificial turf fields had PAH levels above health-based soil standards. Although levels appear to decline over time, this trend can be altered by the fact that new rubber can be added periodically to compensate for the loss of infill material.
c. There was a "slightly worrisome" level of chromium found in artificial turf fiber samples.
d. Lead in artificial fields can come from the blades of artificial grass, the pigment used for the field markings and lines, and the infill material. Although there were relatively low concentrations of lead measured, the researchers were careful to point out: "some health scientists believe that any Pb [lead] is harmful to children's neurocognitive development, and that no new Pb should be added to their surroundings." Furthermore, the lead present in the rubber granules, while at low levels, was "highly bioaccessible" to synthetic gastric fluid.

12. Brown, D.R. (2007). Artificial Turf: Exposures to Ground-up Rubber Tires. Environment & Human Health, Inc. (EHHI). Available at: http://www.ehhi.org/reports/turf/turf_report07.pdf
    a. Direct human exposure to the hazardous substances contained in artificial turf occurs via three pathways: inhalation as chemicals off gas from the turf, skin contact, or ingestion including by children or infants who come into contact with the material. In the case of allergies (i.e. latex allergies), inhalation could result in a systemic response, as opposed to a contact response.
    b. Extreme temperatures or solvents are not needed to release metals (including zinc, selenium, lead and cadmium), volatile organic compounds, or semi-volatile organic compounds from the rubber in-fill of artificial turf into the air or water – release takes place in ambient air and water temperatures.
    c. While, "the status of the information about human exposures to recycled tire crumb rubber in-fill … is not sufficient to determine the safety of the use of the product in situations that involve continuous episodes of human exposure;" "the available information is sufficient and strong enough to raise plausible questions with respect to acute toxicity for susceptible persons, and for cancer risks."
13. California Office of Environmental Health Hazard Assessment (OEHHA) (2007). Evaluation of Health Effects of Recycled Waste Tires in Playground and Track Products. Report prepared for the Integrated Waste Management Board. Available at: http://www.calrecycle.ca.gov/publications/Documents/Tires%5C62206013.pdf
    a. Based on a review of 46 studies, 49 chemicals that are released from tire crumb were identified.
    b. Of the 49 chemicals identified, "seven of the chemicals leached from tire shreds were carcinogens."
    c. OEHHA calculated a cancer risk of 1.2 in 10 million based on a one-time ingestion of the tire crumb rubber over a lifetime.
    d. Chrysene, a PAH and carcinogen, was found to be ingested as the result of hand-to-surface-to-mouth transfer from playground surfaces made with recycled tires. Assuming playground use for an 11 year period (from age 1 to 12) there was found to be an increased cancer risk of 2.9 in one million from the general cancer risk gauge of one in one million
    e. Only 31% of the playground surfaces made of recycled tires tested passed the California State mandated Head Impact Criterion (HIC) of <1,000. In this same study 100% of the playground surfaces made of wood chips passed the same standard.
14. Crain, W. and Zhang, J. (2007). Rachel's Democracy and Health News #992: Hazardous Chemicals in Synthetic Turf, Follow-up Analyses, April 12, 2007. Available at: http://www.precaution.org/lib/07/prn_synthetic_turf.070405.htm

a. Testing on two sites in New York where synthetic turf has been used (the large, 3 year old, Parade Ground in Brooklyn; the relatively small 5 month old Sara D. Roosevelt Park in Manhattan) found PAHs at hazardous levels (as per New York standards). Dibenzo (a.h)anthracene, a probable human carcinogen, was also found at hazardous levels, with two other PAH forms, both possible human carcinogens, found at hazardous levels at the Parade Ground site.
b. Research into the pathways by which these substances may be absorbed into the bodies of children and athletes via skin contact, ingestion or other pathways, is very limited with additional research needed.

15. Epstein, V. (2007). Texas Football Succumbs to Virulent Staph Infection from Turf. Bloomberg Press, December 21, 2007. Available at: http://www.bloomberg.com/apps/news?pid=newsarchive&sid=alxhrJDn.cdc
    a. Artificial turf is linked with serious and potentially life threatening staph infections including MRSA (methicillin-resistant staphylococcus aureus). MRSA can exploit minor skin injuries such as turf burn, and therefore, MRSA infection rate among players is 16 times higher than the national average.
16. KEMI, Swedish Chemicals Agency (2007). Facts: Synthetic Turf. April 2007. Available: http://www2.kemi.se/upload/trycksaker/pdf/faktablad/fbsyntheticturf.pdf.
    a. Tires contain up to 60 different substances which may be bioaccumulative, carcinogenic, reprotoxic, mutagenic and/or endocrine disrupting.
    b. Most PAHs are persistent, bioaccumulative and carcinogenic.
    c. Among the metals found in tires that may be of concern are zinc, lead, copper, chromium and cadmium. Zinc and copper are harmful when absorbed at high levels. Lead can affect reproduction and development of the nervous system leading to poor cognitive development. Chromium is carcinogenic and mutagenic. Cadmium is toxic to humans and can contribute to poor liver and kidney function, as well as osteoporosis.
17. Mattina, M. I., Isleyen, M., Berger, W., & Ozdemir, S. (2007). Examination of crumb rubber produced from recycled tires. *The Connecticut Agricultural Experiment Station, New Haven, CT.* Available at: http://www.ct.gov/caes/lib/caes/documents/publications/fact_sheets/examinationofcrumbrubberac005.pdf
    a. Multiple compounds out-gas and leached into water from synthetic turf rubber crumb under ambient temperatures including benzothiazole (a skin and eye irritant), butylated hydroxyanisole (a "recognized carcinogen, suspected endocrine toxicant, gastrointestinal toxicant, immune toxicant, neurotoxicant, skin and sense-organ toxicant"), n-hexadecane (a severe irritant), and 4-(t-octyl) phenol ("corrosive and destructive to mucous membranes").
18. Anderson, M. E. et al. (2006). A case study of tire crumb use on playgrounds: risk analysis and communication when major clinical knowledge gaps exist. Environmental health perspectives, 114(1), 1. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1332647/pdf/ehp0114-000001.pdf
    a. A Case Study conducted by a group of physicians and public health professionals working with the U.S. Environmental Protection Agency's Region Pediatric Environmental Health Specialty Unit found that the research and information necessary is not available to establish "the safety in use with children" of tire crumb used as playground surfaces.
    b. "The use of recycled tire crumb products on playgrounds has had little health investigation. The major unresolved concern is the potential for latex allergy with short-term dermal exposure."
19. Crain, W. and Zhang, J. (2006). Rachel's Democracy and Health News #871: Hazard Chemicals in Synthetic Turf. September 7, 2006. Available at: http://www.precaution.org/lib/06/prn_toxins_in_synthetic_turf.060831.htm

a. Analyses conducted at the Environmental and Occupational Health Sciences Institute of Rutgers University found the crumb rubber from artificial turf to contain high levels of PAHs, as well as zinc and arsenic.
b. PAHs found to be contained in the crumb rubber "were above the concentration levels that the New York State Department of Environmental Conservation (DEC) considers sufficiently hazardous to public health to require their removal from contaminated soil sites. It is highly likely that all six PAHs are carcinogenic to humans."
c. "The analyses also revealed levels of zinc in both samples that exceed the DEC's tolerable levels."
d. The researchers associated with these findings were careful to state "We want to emphasize that the findings are preliminary. PAHs in rubber might not act the same way as in soil, and we do not yet have information on the ease with which the PAHs in these rubber particles might be absorbed by children or adults -- by ingestion, inhalation, or absorption through the skin. However, the findings are worrisome. Until more is known, it wouldn't be prudent to install the synthetic turf in any more parks."

20. Kazakova, S. V. et al. (2005). A clone of methicillin-resistant Staphylococcus aureus among professional football players. New England Journal of Medicine, 352(5), 468-475. Available at: http://www.nejm.org/doi/pdf/10.1056/NEJMoa042859
    a. In a study of professional football players from the St. Louis Rams team, all MRSA infections developed at sites of turf burns.
    b. Players reported a higher frequency of abrasions when playing on artificial turf compared to natural grass.
21. Begier, E. M. et al. (2004). A high-morbidity outbreak of methicillin-resistant Staphylococcus aureus among players on a college football team, facilitated by cosmetic body shaving and turf burns. *Clinical infectious diseases*, *39*(10), 1446-1453. (a study conducted for the Connecticut Department of Public Health, Student Health Services of Sacred Heart Univ, Centers for Disease Control and Prevention, Minnesota Department of Public Health, and the Los Angeles County Department of Health Services).
    a. In a study of MRSA outbreaks involving college football players, infection was associated with turf burns from artificial grass. Turf burns increased the risk of infection regardless of the type and timing of care provided the burn. Turf burns may be facilitating infection by acting as a pathway for infection.
22. Shorten, M. R., & Himmelsbach, J. A. (2003). Sports surfaces and the risk of traumatic brain injury. Sports surfaces. University of Calgary, Calgary, 49-69. Available at: http://biomechanica.com/docs/publications/docs/Shorten%20-%20Head%20Injury%20Risk.pdf
    a. There is double the risk of head traumas such as concussions associated with artificial turf compared to natural turf, and artificial turf presents a 5 times greater risk of more severe head injury.
    b. Concussions (formally described as Mild Traumatic Brain Injury or MTBI) resulting from sports has, according to the US Centers for Disease Control, reached "epidemic proportions," and these 'mild' head traumas, especially a series of concussions, can have long term, negative effects on cognitive function.
23. Naunheim, R., et al. (2002). Does the use of artificial turf contribute to head injuries?. *Journal of Trauma-Injury, Infection, and Critical Care*, *53*(4), 691-694.
    a. The impact-attenuating properties of two artificial fields were compared to a grass outdoor practice field. Both artificial surfaces were harder compared to the outdoor grass field. It was concluded that the low impact attenuation of the artificial turf may be contributing to the high incidence of concussion.
24. Guskiewicz, K. M., et al. (2000). Epidemiology of concussion in collegiate and high school football players. The American Journal of Sports Medicine, 28(5), 643-650.

a. In a survey of both high school and collegiate certified athletic trainers representing over 17,000 football players, contact with artificial turf was associated with more serious concussion than contact with natural grass.

Environment: The pollutant substances found in artificial turf contribute to contamination of soil, plants and aquatic ecosystems and pose a risk of toxic effects for aquatic and sediment dwelling organisms. The resulting environmental harm is on-going and long-term, happening over many years. The varying content of tires used for infill of turf systems makes this threat a moving target. A growing body of scientific analysis is documenting a concerning level of environmental threat and harm and is further demonstrating the need for more research regarding artificial turf and its ramifications for the environment.

1. Public Employees for Environmental Responsibility (PEER) (2012). Petition for a Rulemaking on Surface Heat from Artificial Turf, Submitted by PEER to Consumer Product Safety Commission, Sept 6, 2012. Available at: http://www.peer.org/assets/docs/doc/9_6_12_PEER_Petition_heat_rulemaking.pdf
    a. As well explained by an oft cited petition to the Consumer Product Safety Commission for rulemaking: "When tires are shredded and pulverized, their surface area increases exponentially, as does the particulate and gas yield from the tire material. Since tires are made of very harmful materials, including 24 gases found to be harmful to humans, carbon black, (a carcinogen which makes up 30% of tires), latex, benzothiazoles, phthalates, lead, mercury, cadmium, zinc and many other known toxins, when the fields heat up, they become increasingly dynamic. Of primary concern is the interaction of particles and gases, 'because when particles adsorb onto the surface of gases, they become 10-20 times more toxic than the materials themselves.'"
    b. Furthermore, artificial turf becomes more toxic as it heats up.
2. Sadiktsis, I., et al. (2012). Automobile Tires A Potential Source of Highly Carcinogenic Dibenzopyrenes to the Environment. Environmental science & technology, 46(6), 3326-3334. Available at: http://www.locchiodiromolo.it/blog/wp-content/uploads/2012/03/Sadiktsis-et-al-Automobile-Tires-Potential-Source-of-Highly-Carcinogenic-2012.pdf
    a. The variability in PAH concentrations between different tires is large.
    b. Due to "leaching of PAHs from recycled tire rubber material, tires are a source of environmental pollution of PAHs through their entire lifecycle."
3. Connecticut Department of Environmental Protection (2010). Artificial Turf Study: Leachate and Stormwater Characteristics, Final Report. Available at: http://www.ct.gov/deep/lib/deep/artificialturf/dep_artificial_turf_report.pdf
    a. Stormwater runoff from artificial turf contained zinc, manganese, and chromium at levels toxic to aquatic organisms.
    b. Therefore, there is a potential risk to surface waters from the installation of artificial turf. Zinc levels could cause exceedance of acute aquatic toxicity criteria. This risk is especially high for smaller watercourses.
    c. Best management practices and treatment (i.e. wetlands, wet ponds, infiltration structures, compost filter, sand filters, or biofiltration structures) should be used for stormwater runoff from artificial turf fields that discharge to surface waters.
4. Yaghoobian, N., et al. (2010). Modeling the thermal effects of artificial turf on the urban environment. *Journal of Applied Meteorology and Climatology*, *49*(3), 332-345.
    a. An urban temperature model showed an increase in local atmospheric temperatures of up to 4° C (39° F) in areas where natural grass cover had been replaced with artificial turf.
5. Han, I. K., et al. (2008). Hazardous chemicals in synthetic turf materials and their bioaccessibility in digestive fluids. Journal of Exposure Science and Environmental Epidemiology, 18(6), 600-607. Available at: http://www.nature.com/jes/journal/v18/n6/pdf/jes200855a.pdf

   a. Zinc was found to exceed soil limits and the leaching rate from rubber granules was up to 20 times more than the leaching rate from agricultural applications of manure and pesticides. "Runoff with high Zn [zinc] from synthetic turf fields may produce adverse effects to plants and aquatic life."

6. KEMI, Swedish Chemicals Agency (2007). Facts: Synthetic Turf. April 2007. Available: http://www2.kemi.se/upload/trycksaker/pdf/faktablad/fbsyntheticturf.pdf.
   a. Hazardous substances found in tires may persist in the environment including polycyclic aromatic hydrocarbons (PAHs), phthalates, phenols, and certain metals.
   b. Most PAHs are persistent, bioaccumulative and carcinogenic.
   c. Phthalates and phenols are not chemically bound to the rubber and as a result can leach from the infill material. These chemicals are persistent and bioaccumulative and can have long-term effects on the environment.
7. Meil, J., & Bushi, L. (2006). Estimating the Required Global Warming Offsets to Achieve a Carbon Neutral Synthetic Field Turf System Installation. *Athena Institute. Ontario Canada.* Available at: http://sfrecpark.org/wp-content/uploads/AthenaICarbonOffsets.pdf
   a. Artificial turf systems have a carbon footprint due to the greenhouse gases emitted during the life cycle of synthetic turf systems compared to natural grass surfaces.
   b. To achieve a 10-year carbon neutral synthetic turf installation, 1861 trees would need to be planted to offset the field's carbon footprint.
8. Källqvist, T. (2005). Environmental risk assessment of artificial turf systems. *Norwegian Institute for Water Research*, 19.
   a. Recycled rubber varies considerably in its chemical composition, even when from the same manufacturer.
   b. Leaching of contaminants from artificial turf as the result of surface water runoff from precipitation is a great risk for the environment. It is predicted that chemicals leaching from synthetic turf materials occurs slowly, and as a result the environmental harms may take place over many years. There is also a level of "erosion" that takes place and can result in fine particles that could be carried to local waterways. Chemicals have even been shown to leach from the artificial turf fibers.
   c. The leachate from artificial turf can contain a variety of metals (including lead, cadmium, copper, mercury and zinc) and organic pollutants (including PAHs, phthalates, 4-t-octylphenol and iso-nonyphenol).
   d. The runoff from an artificial turf field poses "a positive risk of toxic effects on biota in the water phase and in the sediment."
   e. Of the organic compounds at issue, octylphenol represents the greatest risk, and possibly could occur at levels where hormone disrupting effects are a concern.
   f. The Norwegian Institute for Water Research has determined that it is "appropriate to perform a risk assessment which covers water and sediments in watercourses which receive run-off from artificial turf pitches."
9. Thale, S.W. et al. (2004) Potential Health and Environmental Effects Associated with Synthetic Turf Systems-final report. Byggforsk, Norwegian Building Research Institute. Available at: http://www.isss-sportsurfacescience.org/downloads/documents/vskyslv2qq_nbiengelsk.pdf
   a. While recycled rubber is a greater source of pollution, newly manufactured rubber also contains levels of hazardous substances; in the case of zinc and chromium the levels of recycled and newly manufactured rubber are comparable.
   b. The synthetic grass fibers can also be a significant source of pollution, albeit significantly lesser amounts leach from the synthetic grass than the rubber infill

10. Tucker, M.R. (1997). Ground Rubber: Potential Toxicity to Plants. Media Notes for North Carolina Growers, North Carolina Dept. of Agriculture & Consumer Services, April 1997. Available at: http://www.ncagr.gov/agronomi/pdffiles/rubber.pdf
    a. When talking about the use of ground rubber as a supplement to planting soils, the North Carolina Department of Agriculture and Consumer Services sent out a notice identifying the risk that zinc leaching from the rubber causes a decline in plant growth "directly attributable to zinc toxicity."
11. Quoting Dr. Linda Chalker-Scott, Washington State University - Turfgrass Resource Center, Facts About Artificial Turf and Natural Grass. (n.d.) Available at: http://plasticfieldsfornever.org/ArtificialTurfBooklet.pdf
    a. "There is no question that toxic substances leach from rubber as it degrades, contaminating the soil, flora, and fauna and aquatic systems."
12. Turfgrass Resource Center (n.d.) Facts About Artificial Turf and Natural Grass. Available at: http://plasticfieldsfornever.org/ArtificialTurfBooklet.pdf
    a. Part of artificial turf maintenance is the regular replenishment of the infill. Some of the infill is merely settling, but some of it is washing away or literally "walking away" with players after use. The effects of this "runaway" infill are unknown and more research is needed to draw conclusions– where is it going and what impacts is it having?
    b. Maintenance of artificial turf can include application of algaecides or disinfectants to keep the surface clean and application of fabric softener to mask the odor of the artificial turf. What is the final destination of these chemicals and their implications for the environment and those coming into contact with them while playing on the fields?
    c. There is no indication that artificial turf drains more effectively for purposes of a stormwater infiltration system than natural grass. In addition, infiltration systems are designed to work with whatever surface coating they receive from natural grass to porous paving. Although there is no assumed benefit from an infiltration perspective of natural turf or artificial turf, in many cases the complex systems designed for artificial turf fields have experience problems, work incorrectly, or inefficiently.

Fact Sheet

Artificial/Synthetic Turf

While professional sports are turning away from artificial turf, it is gaining ground and use at the local level at schools and community fields. Producers of artificial turf make claims of environment, health and safety benefits associated with artificial turf – when they make these blanket claims they are not giving the full picture.

In terms of environment, health and safety, the jury is still very far out on artificial turf. There continues to be information documenting harm in each of these arenas. Most of all, there is a widespread demonstration and recognition that in terms of environmental, health and safety threats from artificial turf, much more study, analysis and consideration is needed. And whatever the final outcome of the research, manufacturers neglect the reality that as much as they try to mimic natural grass, artificial turf is not grass, and cannot provide the same natural feel, natural look, natural smell and environmental benefits that natural grass provides.

Artificial Turf is generally comprised of plastic fibers (generally made of polyethylene, polypropylene or nylon) attached to a polypropylene or polyester plastic webbing. A combination of sand and rubber, or sometimes rubber alone, fills between the fibers. The source for the rubber infill is generally recycled tires. Sometimes newly manufactured rubber granulate is used but the cost is so much greater than the recycled tire form that it is generally not the substance used. New developments in artificial turf technology seem continually in the works.

Water Quality:

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While it seems well recognized that there is a limited level of assessment and investigation into the environmental impacts associated with artificial turf, a growing body of scientific analysis is documenting a concerning level of environmental threat and harm and is further demonstrating the need for more research regarding artificial turf and its ramifications for the environment.

Synthetic turf is generally made with rubber from waste tires. Recycled rubber varies considerably in its chemical composition, even when from the same manufacturer.[1]

Hazardous substances found in tires may persist in the environment including polycyclic aromatic hydrocarbons (PAHs), phthalates and certain metals. These substances may be bioaccumulative, carcinogenic, reprotoxic, mutagenic and/or endocrine disrupting.[2] The chemicals in waste tires are of such concern that a report published by the Swedish Chemicals Inspectorate recommends: "waste tyres should not be used for synthetic turf surfaces." [3]

- Most PAHs are persistent, bioaccumulative and carcinogenic.[4]
- Phthalates are generally used as solvents and plasticisers in plastics. Phthalates are not chemically bound to the rubber and as a result can leach from the infill material.[5]
- Phenols likewise are not chemically bound to the rubber and so can leach. Phenols too are persistent and bioaccumulative and can have long-term effects on the environment.[6]
- Among the metals found in tires that may be of concern are zinc, lead, copper, chromium and cadmium. While zinc and copper are essential for living organisms, when absorbed at high levels they become harmful. Lead can affect reproduction, development of the nervous system leading to poor cognitive development, and is a particular threat to fetuses and young children. Chromium is carcinogenic and mutagenic. Cadmium is toxic to humans and if taken in can contribute to poor liver and kidney function, as well as osteoporosis. [7]

The Connecticut Agricultural Experiment Station conclusively found four compounds which out-gassed and leached into water from synthetic turf rubber crumb under ambient temperatures:

- Benzothiazole (a skin and eye irritant),

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[1] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 7.
[2] KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.
[3] KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.
[4] KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.
[5] KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.
[6] KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.
[7] KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.

- Butylated hydroxyanisole (a "recognized carcinogen, suspected endocrine toxicant, gastrointestinal toxicant, immune toxicant, neurotoxicant, skin and sense-organ toxicant"),
- n-hexadecane (a severe irritant) &
- 4-(t-octyl) phenol ("corrosive and destructive to mucous membranes").[8]

As rubber degrades it can leach toxic substances which can contaminate soil, plants and aquatic ecosystems.[9] Study has concluded that the use of tires in artificial turf has the potential to pollute our environment with PAHs, phenols and zinc[10] and that runoff from an artificial turf field draining to a local creek can pose "a positive risk of toxic effects on biota in the water phase and in the sediment."[11] Other metal contaminants found to leach from tire crumb rubber include zinc, selenium, lead and cadmium.[12] Zinc has also been shown to leach from the artificial turf fibers.[13] Extreme temperatures or solvents are not needed to release these metals, volatile organic compounds or semi-volatile organic compounds from the rubber in-fill of artificial turf into the air or water – release takes place in ambient air and water temperatures.[14]

Leaching of substances as the result of surface water runoff from precipitation has, by some researchers, been predicted to be the greatest risk for the environment from artificial turf.[15] Study shows there is a risk of local effects for aquatic and sediment dwelling organisms in impacted water courses.[16] Recycled rubber, and associated

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[8] The Connecticut Agricultural Experiment Station, Examination of Crumb Rubber Produced from Recycled Tires, August 2007; Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.

[9] Quoting Dr. Linda Chalker-Scott, Washington State University -- Turfgrass Resource Center, Facts About Artificial Turf and Natural Grass; T. Kallqvist, Norwegian Institute for Water Research(NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 17.; Connecticut Agricultural Experiment Station, Examination of Crumb Rubber Produced from Recycled Tires.

[10] T. Kallqvist, Norwegian Institute for Water Research(NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 5; T. Edeskar, Lulea University of Technology, Technical and Environmental Properties of Tyre Shreds Focusing on Ground Engineer Application, 2004 as cited in KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.

[11] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 6.

[12] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.

[13] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 17.

[14] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.

[15] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 5; NIVA (The Norwegian Institute for Water Research), Evaluation of the Environmental Risks of Synthetic Turf, 2005; KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.

[16] T. Kallqvist, Norwegian Institute for Water Research(NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 5; NIVA (The Norwegian Institute for Water Research), Evaluation of the Environmental Risks of Synthetic Turf, 2005, as cited by KEM, Swedish Chemicals

leachate, has been found to contain a variety of metals (including lead, cadmium, copper, mercury and zinc), as well as organic pollutants such as PAHs, phthalates, 4-t-octylphenol and iso-nonyphenol.[17] The leaching of zinc has been determined to be of major environmental concern.[18] The leaching of zinc increases as the rubber infill weathers over time,[19] it is likely this is the same for other contaminants. While Zinc contributes the most risk, phenols (specifically octylphenol) and PAHs are also of concern.[20] Of the organic compounds at issue, Octylphenol represents the greatest risk, and possibly could occur at levels where hormone disrupting effects are a concern.[21] The varying content of tires makes this threat a moving target.

The Norwegian Institute for Water Research has determined that it is "appropriate to perform a risk assessment which covers water and sediments in watercourses which receive run-off from artificial turf pitches."[22]

While recycled rubber is a greater source of pollution, newly manufactured rubber also contains level of hazardous substances; in the case of zinc and chromium the levels of recycled and newly manufactured rubber are comparable.[23]

It is predicted that chemicals leaching from synthetic turf materials occurs slowly, and as a result the environmental harms may take place over many years.[24]

Leaching may not be the only source of water contamination from artificial turf. As the artificial turf is used there is a level of "erosion" that takes place and can result in

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Agency, Facts: Synthetic Turf, April 2007; KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007

[17] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 7.

[18] INTRON, Environmental and Health Risks of Rubber Infill, rubber crumb from car tyres as infill on artificial turf, February 9, 2007.

[19] INTRON, Environmental and Health Risks of Rubber Infill, rubber crumb from car tyres as infill on artificial turf, February 9, 2007.

[20] NIVA (The Norwegian Institute for Water Research), Evaluation of the Environmental Risks of Synthetic Turf, 2005, as cited by KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.

[21] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 17.

[22] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 8.

[23] Byggforsk, SINTEF Building and Infrastructure, Potential Health and Environmental Effects Associated with Synthetic Turn Systems, 2004, as referenced in KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.

[24] T. Kallqvist, Norwegian Institute for Water Research(NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 5; NIVA (The Norwegian Institute for Water Research), Evaluation of the Environmental Risks of Synthetic Turf, 2005, as cited by KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.

fine particles that could be carried to local waterways. This source of contamination needs study.[25]

The synthetic grass fibers can also be a significant source of pollution, particularly zinc, albeit significantly lesser amounts leach from the synthetic grass than the rubber infill.[26]

Concerns about the environmental and health effects of synthetic turf in European countries is so great that standards and/or guidelines have been set or are under consideration. For example: Germany has set standards for the use of synthetic turf including a maximum allowable level of pollution or contamination of water and soil, with a requirement of regular sampling to ensure these standards are not exceeded. Allowable pollution levels include: lead 0.04 mg/l, cadmium 0.005 mg/l; chromium 0.05 mg/l, mercury 0.001 mg/l and zinc 3.0 mg/l or 0.5 mg/l depending on the testing method used.[27] Holland has also suggested appropriate language for a standard applicable to use of synthetic turf including a ban on the use of carcinogens, mutagenic, reprotoxic, persistent, bioaccumulative and toxic, or very persistent and very bioaccumulative substances in the surface layer of the turf and a limitation on the level of substances in the rubber infill that may cause cancer, may cause heritable genetic damage, may cause cancer by inhalation, are toxic or harmful to aquatic organisms or may cause long term affects on the aquatic environment, that may impair fertility or cause harm to unborn children. Sweden has set guidelines and limiting values for some of the substances that are present in synthetic turf, specifically as it relates to air pollution, soil contamination and water pollution.[28] And because vehicle tires contain levels of several substances of "very high concern", the recycling and use of tires in synthetic turf is apparently in conflict with the Swedish environmental objective of A Non Toxic Environment.[29]

Part of artificial turf maintenance is the regular replenishment of the infill. There is a need for research into the loss of existing infill – where is it going and what impacts is it having?[30]

Maintenance of artificial turf can include application of algaecides or disinfectants to keep the surface clean.[31] Maintenance could also include application of fabric

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[25] T. Kallqvist, Norwegian Institute for Water Research (NIVA), Environmental Risk Assessment of Artificial Turf Systems, December 2005, p. 18.
[26] Byggforsk, SINTEF Building and Infrastructure, Potential Health and Environmental Effects Associated with Synthetic Turn Systems, 2004, as referenced in KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.
[27] KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.
[28] KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.
[29] KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.
[30] Turfgrass Resource Center, Facts About Artificial Turf and Natural Grass.

softener to mask the odor of the artificial turf.[32] What is the final destination of these chemicals and their implications for the environment and those coming into contact with them while playing on the fields? More information is needed on this subject as well.

Stormwater:

There is no indication that artificial turf drains more effectively for purposes of a stormwater infiltration system than natural grass. In addition, infiltration systems are designed to work with whatever surface coating they receive from natural grass to porous paving. It should be noted that while generally there can be no assumed benefit from an infiltration perspective of natural turf or artificial turf, there are instances where schools have experienced problems with the drainage of their artificial turf fields.[33]

Natural grass provides a level of evapotranspiration, pulling water out of the soil and subsurface and releasing it to the air, providing benefits in reducing the volume of runoff that results from a site and/or needs to be addressed by other stormwater management strategies. Artificial turf has no evapotranspiration capabilities.

Grass does provide a level of pollution filtering and therefore water quality protection for nearby waterways. While this filtering may be limited in the case of turf grass; such filtering is nonexistent with artificial turf.

Heat Island Effect – for Human Health and Surrounding communities:

Extreme heat is a health concern. Studies document that the surface temperature on artificial turf is dramatically increased as compared to surrounding land uses including asphalt.

In a 2002 study it was found that "the surface temperature of the synthetic turf was 37° F higher than asphalt and 86.5° F hotter than natural turf."[34] A study published in the Journal of Health and Physical Education and Recreation showed "surface temperatures as much as 95 to 140 degrees Fahrenheit higher on synthetic turf than natural turfgrass when exposed to sunlight."[35] Random sampling at Brigham Young University identified temperatures ranging from 117.38 to 157 degrees on artificial turf while neighboring natural grass areas were in the range of 78.19 to 88.5 degrees Fahrenheit. "Two inches below the synthetic turf surface was 28.5° F hotter than

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[31] Turfgrass Resource Center, Facts About Artificial Turf and Natural Grass.
[32] Turfgrass Resource Center, Facts About Artificial Turf and Natural Grass.
[33] Turfgrass Resource Center, Facts About Artificial Turf and Natural Grass.
[34] Dr. C. Frank Williams and Dr. Gilbert E. Pulley, Synthetic Surface Heat Studies, Brigham Young University.
[35] SportsTurf Managers Association, A Guide to Synthetic and natural Turfgrass for Sports Fields, Selection, Construction and Maintenance Considerations.

natural turf at the surface."[36] And still another study comparing temperatures on artificial turf temperatures with air temperature found that artificial turf ranged from 58 to 75 degrees hotter than measured air temperature.[37] While irrigation provided significant cooling for the synthetic turf (lowering the temperature from 174° F to 85° F) after only 5 minutes the temperature quickly rose again to 120°F; after 20 minutes it rose to 164°F.[38]

Concerns regarding the excessive temperatures range from the implications for players who are already exerting themselves playing in such excessively high temperatures, to the implications for burns when players or pedestrians come into contact with the hot surfaces, to the implications for small children who may come into contact with the extremely hot surfaces during non-sporting events. Particularly when installed in already built up areas, what affect does the extreme heat associated with artificial turf have on the surrounding community in terms of temperature?

Natural grass, by comparison, provides a natural cooling affect and helps to dissipate heat from neighboring developed areas.[39] "The temperature of natural grass rarely rises above 85 degrees Fahrenheit, regardless of air temperature." [40]

The heat impacts of artificial turf need to be considered in the context of today's changing climate. Global climate change is expected to dramatically increase the number of days over 100 degrees communities in our region experience. Depending on how aggressively global warming gasses are reduced in coming years, communities nearby Philadelphia will begin to experience in the range of 10 days (in lower emission scenarios) to 30 days (if higher emission scenarios continue to prevail) over 100°.[41] By later in this century seasonable temperatures are projected to rise 6°F to 14°F in summer (depending again on emission reductions achieved in the future). [42] Educators and decisionmakers selecting artificial turf based on its long-term viability and community impacts should consider the affect of global climate change to magnify the heat impacts of artificial turf.

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[36] Dr. C. Frank Williams and Dr. Gilbert E. Pulley, Synthetic Surface Heat Studies, Brigham Young University.
[37] T. Sciacca, The Thermal Physics of Artificial Turf, January 2008.
[38] Dr. C. Frank Williams and Dr. Gilbert E. Pulley, Synthetic Surface Heat Studies, Brigham Young University.
[39] James B. Beard & Robert L. Green, The Role of Turfgrasses in Environmental Protection and Their Benefits to Humans, J. Environ Qual. 23:452-460 (1994).
[40] SportsTurf Managers Association, A Guide to Synthetic and natural Turfgrass for Sports Fields, Selection, Construction and Maintenance Considerations.
[41] Union of Concerned Scientists, Confronting Climate Change in the U.S. Northeast ● New Jersey, 2007.
[42] Union of Concerned Scientists, Confronting Climate Change in the U.S. Northeast ● New Jersey, 2007.

Health Issues:

Direct human exposure to the hazardous substances contained in the rubber in-fill of artificial turf is believed to occur via three pathways: inhalation, skin contact, or ingestion including by children or infants who come into contact with the material.[43]

In October 2006 and January 2007, respectively, two sites in New York where synthetic turf has been used (the large, 3 year old, Parade Ground in Brooklyn; the relatively small 5 month old Sara D. Roosevelt Park in Manhattan) were analyzed. This testing found PAHs at hazardous levels (as per New York standards) at each of the sites. At both sites dibenzo (a.h)anthracene, a probable human carcinogen, was found at hazardous levels, with two other PAH forms, both possible human carcinogens, found at hazardous levels at the Parade Ground site. Research into the pathways by which these substances may be absorbed into the bodies of children and athletes via skin contact, ingestion or other pathways, is very limited with additional research needed.[44]

A study by the California Office of Environmental Health Hazard Assessment (OEHHA) summarized 46 studies that identified 49 chemicals which are released from tire crumb. Of the 49, "seven of the chemicals leached from tire shreds were carcinogens. OEHHA calculated a cancer risk of 1.2 in 10 million based on a ***one-time*** ingestion of the tire crumb rubber over a lifetime."[45] While there are limited studies which assert that recycled tire crumb are stable in the gastrointestinal tract and that therefore this is not a pathway for exposure, there are other studies which contradict these findings.[46]

Concerns have been raised about the potential implications of recycled tire in-fill for individuals with latex allergies and that inhalation could result in a systemic response, as opposed to a contact response.[47]

While, "the status of the information about human exposures to recycled tire crumb rubber in-fill … is not sufficient to determine the safety of the use of the product in situations that involve continuous episodes of human exposure;"[48] "the available

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[43] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.
[44] Rachel's' Democracy & Health News #992, Hazardous Chemicals in Synthetic Turf, Follow-up Analyses, April 12, 2007.
[45] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007 citing California Office of Environmental Health Hazard Assessment (OEHHA), Evaluation of Health Effects of Recycled Waste Tires in Playground and Track Products, January, 2007.
[46] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.
[47] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.
[48] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.

information is sufficient and strong enough to raise plausible questions with respect to acute toxicity for susceptible persons, and for cancer risks."[49]

There is great debate about whether artificial turf can increase exposure to, and infection from, MRSA (methicillin-resistant staphylococcus aureus). Reports including a December 21, 2007 article in the Bloomberg Press reporting the affliction of an 18 year old football player from MRSA as the result (according to the boy's doctor) of an abrasion he received from playing on artificial turf, and citing other findings linking MRSA infections with artificial turf,[50] are a great concern for parents and sports players alike. Defenders of artificial turf often refer to studies like that of the Penn State Department of Crop and Soil Sciences which finds that *Staphylococcus aureus* is commonplace in the human environment, including on both artificial turf and natural grass fields.[51] But even this study acknowledges that there is no conclusive evidence currently available that the source of bacteria causing the infections of sports players is not artificial turf. In addition, the study does not consider the link between burns sustained while playing on artificial turf and available bacteria as a pathway for infection. New studies are emerging that demonstrate that turf burns may be facilitating infection by acting as a pathway for infection.[52] Study has found that turf burns increased the risk of infection regardless of the type and timing of care provided the burn. [53]

Concussions (formally described as Mild Traumatic Brain Injury or MTBI) resulting from sports has, according to the US Centers for Disease Control, reached "epidemic proportions."[54] "'Mild' head traumas, and especially a series of such minor concussions can have long term, negative effects on cognitive function." [55] Study has documented that artificial turf increases the risk of MTBI over natural turf,

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[49] Environment & Human Health, Inc., Artificial Turf, Exposures to Ground-Up Rubber Tires, 2007.
[50] *Texas Football Succumbs to Virulent Staph Infection from Turf*, December 21, 2007, Bloomberg Press.
[51] Penn State Department of Crop and Soil Sciences, A Survey of Microbial Populations in Infilled Synthetic Turf Fields.
[52] A High Morbidity Outbreak of Methicillin-Resistant *Staphylococcus aureus* among Players on a College Football Team, Facilitated by Cosmetic Body Shaving and Turf Burns, study conducted 2004 for Connecticut Dept of Public Health, Student Health Services of Sacred Heart Univ, Centers for Disease Control and Prevention, Minnesota Dept of Public Health, Los Angeles County Dept of Health Svces; Dr. S.V. Kazakova et.al., A Clone of Methicillin-Resistant *Staphylococcus aureus* among Professional Football Players, The New England Journal of Medicine, Vol 352:468-475 No. 5, Feb. 3, 2005.
[53] A High Morbidity Outbreak of Methicillin-Resistant *Staphylococcus aureus* among Players on a College Football Team, Facilitated by Cosmetic Body Shaving and Turf Burns, study conducted 2004 for Connecticut Dept of Public Health, Student Health Services of Sacred Heart Univ, Centers for Disease Control and Prevention, Minnesota Dept of Public Health, Los Angeles County Dept of Health Svces.
[54] Dr. M. Shorten, J.A. Himmelsbach, BioiMechanica, Sports Surfaces and the Risk of Traumatic Brain Injury citing the US Centers for Disease Control.
[55] Dr. M. Shorten, J.A. Himmelsbach, BioiMechanica, Sports Surfaces and the Risk of Traumatic Brain Injury.

approximately doubling that risk, as well as causing a greater degree of trauma.[56] According to study, artificial turf presents a 5 times greater risk of the more severe head injury than natural turf, although it is still unknown the particular characteristics of the two surfaces that cause the difference in head injury incidence. [57]

Costs:

It is generally agreed that artificial turf costs more to install than natural grass, while natural grass costs more to maintain. Installation and maintenance costs for each must be assessed on a case by case basis depending on site specific conditions. But generally speaking, when the installation and maintenance costs of artificial turf are assessed for the life span of the turf, particularly when the cost of disposal is added, the cost of installing and maintaining natural grass is far less. The guaranteed life and/or lifespan of artificial turf is 8 to 10 years.[58] Some attempt to claim a longer life in order to assert a lower annual cost.[59] Comparative cost figures for artificial turf and natural grass include:

	Artificial Turf	Natural Grass
Source: San Francisco Rec and Parks[60]		
Installation	$800,000	$260,000
Annual Maintenance	$6,000	$42,000
Cost of Disposal	Unknown but significant as a hazardous waste	$0
Average annual cost for guaranteed life of 8 years.	$106,000	$74,500
Average annual cost for life of 10 years	$86,000	$68,000
Average annual cost for life of 15 years (maximum life span seen asserted in the	$59,333	$59,333

[56] Dr. M. Shorten, J.A. Himmelsbach, BioiMechanica, Sports Surfaces and the Risk of Traumatic Brain Injury.

[57] Dr. M. Shorten, J.A. Himmelsbach, BioiMechanica, Sports Surfaces and the Risk of Traumatic Brain Injury. See also K.M. Guskiewica, N.L. Weaver, D.A. Padua, W.E. Garrett Jr., Epidemiology of Concussion in Collegiate and High School Football Players, Sep-Oct 2000 & Does the Use of Artificial Turf Contribute to Head Injuries, The Journal of Trauma-Injury, Infection and Critical Care, Oct 2002 for the finding that artificial turf increases the level of injury in comparison to natural grass fields.

[58] Turfgrass Resource Center, Facts About Artificial Turf and Natural Grass.

[59] San Francisco Recreation & Parks, Natural and Synthetic Turf: A Comparative Analysis, December 20, 2005.

[60] San Francisco Recreation & Parks, Natural and Synthetic Turf: A Comparative Analysis, December 20, 2005.

literature)		
Source: Facts About Artificial Turf and Natural Grass[61]		
Cost of construction and maintenance per sq. ft.	$7.80 – $10.75	With high quality soil amendments $6.50 – $7.95 With native soils $2.50 – $5.25
Cost of disposal per sq. ft.	$1.75 - $2.25	$0
Springfield College case study installation and maintenance average annual cost during 8 year guaranteed life of artificial turf – no disposal costs included	$105,000 ($800,000 install & annual maintenance of $5,000) For a 10 year life the figure is $85,000; for 15 years it is $58,377	$78,000 ($400,000 install & $28,000 annual maintenance) For a 10 year life the figure is $68,000; for 15 years it is $54,666
Source: A Guide to Synthetic and Natural Turfgrass for Sports Fields.[62]		
Cost of installation per square foot	$7.80 to $10.75	$2.50 to $5.25 if done with native soils $3.50 to $5.25 if done with combination of native soils and sand. $6.50 to $7.95 if done with sand and drainage
Annual Maintenance	$5,000 to $25,000	$4,000 to $11,000 as per the case studies provided
Disposal per square foot – note this cost does not include the cost of transportation or landfill	$1.75 to $2.25	$0

[61] Turfgrass Resource Center, Facts About Artificial Turf and Natural Grass.

[62] SportsTurf Managers Association, A Guide to Synthetic and natural Turfgrass for Sports Fields, Selection, Construction and Maintenance Considerations. While the cost figures in this document focus on the southeast, the figures provide a sound comparative for the relative cost figures provided.

surcharges for environmentally controlled products		

Artificial turf made from rubber contains a number of hazardous substances. As a result disposal is neither easy nor cheap. It is important to identify and consider the cost of disposal when considering an investment in artificial turf. The life expectancy of artificial turf generally ranges from 8 to 10 years[63] – therefore disposal of artificial turf should be amortized over this time frame.

Miscellaneous:

Artificial Turf is available for use immediately upon installation. Natural Turf generally requires 2 growing seasons before it should be heavily used.[64]

One of the biggest supporting assertions for artificial turf is the increased level of playing time it provides. While natural grass may not equal artificial turf in playing time, natural soil and grass science has progressed significantly, greatly increasing its durability for sports. Modern natural grass sports fields include sand in their soil profile to resist compaction and a combination of grass varieties. Natural grass is becoming the preferred surface for a number of professional sports teams.

Natural grass fields require regular maintenance including, mowing and watering, and may also result in the use of fertilizers and potentially herbicides. But there are less environmentally harmful alternatives available for maintenance including electric mowing equipment and environmentally sensitive lawn care strategies that do not rely on environmentally harmful chemicals. A number of schools, including Radnor Township, Delaware County, PA, have successful policies that prevent the use of dangerous chemicals on school grounds.

Artificial turf also requires regular maintenance. Artificial turf maintenance includes sweeping, dragging and watering to provide a clean and uniform appearance.[65] In addition, as the result of wear, the infill may need periodic replenishment. [66] Management of an artificial turf field requires special knowledge inseam repair and snow removal. [67] Special solvents and cleansers are needed to remove tough debris. [68]

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[63] Turfgrass Resource Center, Facts About Artificial Turf and Natural Grass.
[64] Communication with Nancy Bosold, Extension Educator, Turfgrass Management, Penn Stat Cooperative Extension, Berks County, Aug 15, 2007.
[65] SportsTurf Managers Association, A Guide to Synthetic and natural Turfgrass for Sports Fields, Selection, Construction and Maintenance Considerations.
[66] SportsTurf Managers Association, A Guide to Synthetic and natural Turfgrass for Sports Fields, Selection, Construction and Maintenance Considerations.
[67] SportsTurf Managers Association, A Guide to Synthetic and natural Turfgrass for Sports Fields, Selection, Construction and Maintenance Considerations.

Artificial turf is at risk of damage from plastic bottles, cigarettes and/or gum as well as general trash thrown on the field. When damaged special repairs may be needed. Artificial turf also becomes a recipient of a variety of bodily fluids which cannot be cleansed by natural action as is the case with natural grass. Maintenance can include application of algaecides and fabric softener to mask the odor of the artificial turf. [69]

Artificial turf systems that claim chemical treatment is not required do not seem to provide a mechanism for handling the germs associated with the bodily fluids on the turf when there is an absence of rain or when it is captured and reused in newly emerging artificial turf cooling systems.

It is important to note that the environmental, health and safety impacts of artificial turf are in need of further study by independent experts. Until such time as there are conclusive findings regarding the environmental, health and safety impacts of artificial turf the Precautionary Principle would direct decisionmakers away from artificial turf and towards the traditional use of natural grass for sports and public play fields.

Updated: February 25, 2008
Dated: September 9, 2007

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[68] SportsTurf Managers Association, A Guide to Synthetic and natural Turfgrass for Sports Fields, Selection, Construction and Maintenance Considerations.
[69] Turfgrass Resource Center, Facts About Artificial Turf and Natural Grass.

Artificial Turf Fact Sheet Temporary Addendum.

Chrysene, a PAH and carcinogen, was found to be ingested as the result of hand-to-surface-to-mouth transfer from playground surfaces made with recycled tires. Assuming playground use for an 11 year period (from age 1 to 12) there was found to be an increased cancer risk of 2.9 in one million (2.9×10^{-6}). This risk is greater than the general cancer risk gauge of one in one million (1×10^{-6}).[1] This research would seem to suggest that repeat exposure over time to the chemicals released from artificial turf increases the associated increase in cancer risk.

Only 31% of the playground surfaces made of recycled tires tested in one research study passed the California State mandated Head Impact Criterion (HIC) of $\leq$1,000. In this same study 100% of the playground surfaces made of wood chips passed the same standard.[2]

When talking about the use of ground rubber as a supplement to planting soils the North Carolina Department of Agriculture and Consumer Services sent out a notice identifying the risk that zinc leaching from the rubber causes a decline in plant growth "directly attributable to zinc toxicity."[3]

A Case Study conducted by a group of "physicians and public health professionals working with the U.S. Environmental Protection Agency's Region Pediatric Environmental Health Specialty Unit" found that they could not secure the research and information necessary to establish the safety in use with

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[1] Office of Environmental Health Hazard Assessment, Evaluation of Health Effects of Recycled Waste Tires in Playground and Track Products, January 2007. Note -- the 1.2 in 10 million cancer risk found in the OEHHA study was considered by the authors to be an acceptable level of risk as it falls below the general cancer risk gauge of one in one million (1×10^{-6}).

[2] Office of Environmental Health Hazard Assessment, Evaluation of Health Effects of Recycled Waste Tires in Playground and Track Products, January 2007. Please note that in this study 32 recycled tire playground surfaces were tested as compared to only 5 wood chip playground surfaces.

[3] M. Ray Tucker, Agronomist, Ground Rubber: Potential Toxicity to Plants, Media Notes for North Carolina Growers, North Carolina Dept of Agriculture & Consumer Services, April 1997.

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children of tire crumb used as playground surface.[4] "The use of recycled tire crumb products on playgrounds has had little health investigation. The major unresolved concern is the potential for latex allergy with short-term dermal exposure." [5] "No published information is available specifically regarding exposure to crumb rubber constituents from use of the product on playgrounds." [6]

Analyses conducted at the Environmental and Occupational Health Sciences Institute of Rutgers University found the crumb rubber from artificial turf to contain high levels of PAHs, as well as zinc and arsenic.[7] PAHs found to be contained in the crumb rubber "were above the concentration levels that the New York State Department of Environmental Conservation (DEC) considers sufficiently hazardous to public health to require their removal from contaminated soil sites. It is highly likely that all six PAHs are carcinogenic to humans." [8] "The analyses also revealed levels of zinc in both samples that exceed the DEC's tolerable levels." [9] The researchers associated with these findings were careful to state "We want to emphasize that the findings are preliminary. PAHs in rubber might not act the same way as in soil, and we do not yet have information on the ease with which the PAHs in these rubber particles might be absorbed by children or adults -- by ingestion, inhalation, or absorption through the skin. However, the findings are worrisome. Until more is known, it wouldn't be prudent to install the synthetic turf in any more parks." [10]

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[4] M.E. Anderson et al, A Case Study of tire Crumb Use on Playgrounds: Risk Analysis and Communication When Major Clinical Knowledge Gaps Exist, Environmental Health Perspectives, Vol 114, No. 1, January 2006.
[5] M.E. Anderson et al, A Case Study of tire Crumb Use on Playgrounds: Risk Analysis and Communication When Major Clinical Knowledge Gaps Exist, Environmental Health Perspectives, Vol 114, No. 1, January 2006.
[6] M.E. Anderson et al, A Case Study of tire Crumb Use on Playgrounds: Risk Analysis and Communication When Major Clinical Knowledge Gaps Exist, Environmental Health Perspectives, Vol 114, No. 1, January 2006.
[7] Junfeng Zhang, professor and acting chair, Department of Environmental and Occupational Health, the School of Public Health, the University of Medicine and Dentistry of New Jersey and Rutgers University & William Crain, professor of psychology at The City College of New York, president of Citizens for a Green Riverside Park, Hazardous Chemicals in Synthetic Turf, 2006, analyses conducted at at the Environmental and Occupational Health Sciences Institute of Rutgers.
[8] Junfeng Zhang, professor and acting chair, Department of Environmental and Occupational Health, the School of Public Health, the University of Medicine and Dentistry of New Jersey and Rutgers University & William Crain, professor of psychology at The City College of New York, president of Citizens for a Green Riverside Park, Hazardous Chemicals in Synthetic Turf, 2006, analyses conducted at at the Environmental and Occupational Health Sciences Institute of Rutgers.
[9] Junfeng Zhang, professor and acting chair, Department of Environmental and Occupational Health, the School of Public Health, the University of Medicine and Dentistry of New Jersey and Rutgers University & William Crain, professor of psychology at The City College of New York, president of Citizens for a Green Riverside Park, Hazardous Chemicals in Synthetic Turf, 2006, analyses conducted at at the Environmental and Occupational Health Sciences Institute of Rutgers.
[10] Junfeng Zhang, professor and acting chair, Department of Environmental and Occupational Health, the School of Public Health, the University of Medicine and Dentistry of New Jersey and Rutgers University & William Crain, professor of psychology at The City College of New York, president of Citizens for a Green Riverside Park, Hazardous Chemicals in Synthetic Turf, 2006, analyses conducted at at the Environmental and Occupational Health Sciences Institute of Rutgers.

Connecticut is currently considering legislation to provide $250,000 of funding for a study into the toxicity of artificial turf athletic fields.[11]

One Norwegian assessment/presentationconcluded that while indoor artificial turf fields were not generally an elevated health risk, studies to date could not eliminate the concerns associated with development of airway allergies and made a point of noting "a link between exposure to phthalates and the development of asthma/allergies". [12] Phthalates is one of the contaminants of concern found in artificial turf crumb rubber. [13]

The Norwegian assessment/presentation also reported that "recycled rubber was the major source of potentially hazardous substances. An exposure scenario where the runoff from a football field is drained to a small creek showed a positive risk of toxic effects on biota in the water phase and in the sediment. The risk was mainly attributed to zinc, but also for octylphenol the predicted environmental concentrations exceeded the no environmental effect concentration." [14] The hazardous leaching could result in local environmental effect.[15]

Of interest – William Carin, OpEd, NY Times, ***Turf Wars***, September 16, 2007.

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[11] *An Act Concerning a Study of the Toxicity of Artificial Turf Athletic Fields*, Raised Bill No. 361, February Session 2008.

[12] Dr. Christine Bjorge, Norwegian Institute of Public Health, Artificial turf Pitches – an assessment of the health risks for football players and the environment, Presentation at the ISSS Technical meeting 2006, Dresden.

[13] KEM, Swedish Chemicals Agency, Facts: Synthetic Turf, April 2007.

[14] Dr. Christine Bjorge, Norwegian Institute of Public Health, Artificial turf Pitches – an assessment of the health risks for football players and the environment, Presentation at the ISSS Technical meeting 2006, Dresden.

[15] Dr. Christine Bjorge, Norwegian Institute of Public Health, Artificial turf Pitches – an assessment of the health risks for football players and the environment, Presentation at the ISSS Technical meeting 2006, Dresden.