

HAZARDOUS CHEMICALS IN SYNTHETIC TURF: A RESEARCH REVIEW

By William Crain and Junfeng (Jim) Zhang

Across the country, schools, parks, and private sports organizations are installing the "new generation" synthetic turf. It is springier than the old AstroTurf and feels more like natural grass. However, the new turf is being installed before there has been thorough research on its potential health risks. Fortunately, increasing numbers of research agencies are conducting studies. But as we shall see, the studies are often limited and reach premature conclusions about the turf's safety.

Presence of Hazardous Chemicals

Of special concern are the small rubber granules that rest between the turf's plastic blades of grass. These granules, which are the size of grains of rice or smaller (0.5 to 3 mm), contribute to the turf's resiliency. The granules are typically made from large quantities of recycled rubber tires; between 25,000 and 40,000 scrap tires are used to produce the granules for a standard soccer field.[1]

Although the tiny granules (sometimes called the "infill") lie between the plastic blades of grass, they also are common on the surface, so children and athletes come into frequent contact with them. In fact, many players have told us that the granules get into their shoes and wind up in their homes. When we learned that the granules are so accessible to park users, we decided to test samples of the granules to see if contained toxic chemicals found in scrap tires. Specifically, we wondered if they contained any of 15 polycyclic aromatic hydrocarbons (PAHs) on the U.S. Environmental Protection Agency priority pollutant list or heavy metals that also can have toxic effects.

Our first preliminary study[2] analyzed two samples of granules from a New York City Park. The analyses revealed six PAHs at concentrations sufficiently high that the New York State Department of Environmental Conservation (DEC) would have required their removal if the PAHs had been in contaminated soil sites. The six PAHs were: benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(k)fluoranthene, and dibenzo(a,h)anthracene. All six are likely to be carcinogenic to humans.[3]

We also conducted follow-up analyses of granules from two other New York City Parks, gathering two samples from one park and one sample from the other park. We detected three of the same PAHs at elevated levels in at least one of the samples. A particularly hazardous PAH -- dibenzo(a,h)anthracene -- exceeded the DEC soil standard in all three samples.[4] The results of our studies generally conform to those of the Norwegian Building Research Institute.[5]

We also found that the granules contained worrisome levels of zinc and lead.[2] These metals also been detected in research by others, including the Norwegian Building Research Institute[5] and the Rochesterians Against the Misuse of Pesticides (RAMPS).[6] Zinc isn't necessarily harmful. In fact, we need some zinc, and it is included in

multivitamin pills. But excessive zinc produces problems such as stomach cramps and anemia in humans.[7]

Although the detected levels of lead have generally been below contaminated site soil standards set by the New York Department of Environmental Conservation (DEC), many health scientists warn against adding any lead at all to the environment, for even small amounts can contribute to neurocognitive problems in children.[8]

These preliminary studies only indicated that toxicants are present in the rubber granules. The more critical question concerns the bioavailability of the toxicants: Can they leach into the surrounding environment and harm human and non-human organisms? Can they be absorbed into the bodies of children and athletes who use the turf fields?

Leaching into Water and Soil

Numerous studies have demonstrated that chemicals in whole tires, tire shreds, and recycled tire crumbs can leach into water and soil.[9-12] In addition, many of these studies have demonstrated that the chemicals harm or kill aquatic life, including algae, minnows, trout, and frogs.[13] The chemicals also can stunt the growth of land plants.[13] Researchers have been slower to identify precisely which chemicals in the rubber produce the toxic effects, but researchers generally believe that the culprits include metals such as zinc.[9, 13] One investigation implicated PAHs in the death of trout where rubber tires had been placed in water.[14]

Two studies specifically asked what happens when synthetic turf granules are placed in water, and both studies found that considerable zinc was released.[10,11] In a widely cited report funded by a Canadian [*sic*] tire recycling agency, Birkholz and his colleagues[15] discovered that ground-up rubber from a flat playground surface killed aquatic life. Birkholz emphasized that that rubber material was less toxic if it had been on the playground for more than three months, but the effects of ageing merit further study; zinc might actually be released in greater quantities after a few years, as the rubber degrades.[10]

Noting that most of the research on damage to non-human organisms has been conducted in the laboratory, a report by California's Office of Environmental Health Hazard Assessment (OEHHA) concludes that there is little risk in real-life, outdoor conditions. Specifically, the OEHHA concludes that "during rain events" the recycled tire material in play areas is unlikely to leach toxic chemicals in high enough concentrations to harm aquatic life.[16] But the OEHHA's conclusion is speculative; it only cites one study that supports its view. What's more, the study it cites only examined how water quality was affected by a tire trench -- not the tiny rubber particles in synthetic turf that move about and can potentially flow into streams and bodies of water. A study by FieldTurf Tarkett (Nanterre, France) and French research agencies also questions the potential harm of leaching, but FieldTurf Tarkett is the world's largest manufacturer of synthetic turf, so it's difficult to assess its findings.[17] A recent Dutch investigation reaches the more sober conclusion that "the leaching of zinc is a major concern." [18]

Toxic chemicals in rubber material might also leach into human drinking water. So far, the research on this possibility is sparse. The OEHHA report observes evidence of increased quantities of toxic chemicals in groundwater, but the report emphasizes that the contaminants hadn't spread more than a few meters from the rubber sites.[19]

We will now turn to the possibility that the toxicants in recycled rubber can be absorbed by children and athletes from play on synthetic turf surfaces.

Inhalation

In their widely cited report, Birkholz et al. maintained that inhalation is not "a plausible route of exposure because no volatile compounds would be expected to remain in the shredded, solid material." [20] But as Brown [21] observes, this speculation has turned out to be incorrect. The Connecticut Agricultural Experiment Station recently found that at 60 deg. C (140 deg. F) -- a temperature that synthetic turf reaches in the summer -- the rubber granules off-gassed several hazardous volatile organic compounds (VOCs) into the air. [11]

Three chemicals -- benzothiazole, n-hexadecane, and 4-(t-octyl) phenol -- are irritants to humans; a fourth chemical, butylated hydroxyanisole, has many toxic effects and may be carcinogenic to humans. [22] In addition, in 2006 the Norwegian Institute of Public Health and Radium Hospital observed that several VOCs were released from rubber granules in an indoor facility. [23] Others, including RAMP, also have detected VOCs. [5,6] Although the Norwegian Institute -- as well as the FieldTurf/French agencies [17] -- play down the possibility that the chemicals would remain in the air sufficiently long to cause harm, more research on this question is needed. Research also is needed on the extent to which rubber granules produce particulate matter that aggravates asthma. [21]

Ingestion

Because children's bodies are still developing, they are especially vulnerable to the damaging effects of toxic exposures. Infants and toddlers are also uniquely susceptible to exposure through ingestion because they like to put objects into their mouths. [24] When parents watch games from the sidelines, they frequently let their young children crawl about on the turf nearby, and the children might pick up and swallow the rubber granules. Infants and toddlers also might ingest the granules that wind up in their homes after the games.

Birkholz et al. [15] evaluated the possibility that the ingested crumb material from flat rubber playground surfaces produces cancer. Based on the results of in vitro genotoxicity assays, Birkholz et al. concluded that the risk is negligible; substances extracted from shredded rubber did not damage DNA or chromosomes. However, the investigators did not specify the potentially harmful chemicals they tested. In addition, the fact that the research was funded by the tire recycling industry raises questions in the minds of many.

OEHHA, whose research was commissioned by the State of California, examined the extent to which metals, PAHs, and VOCs might be absorbed through the digestive system. Simulating the environment of the human stomach, the researchers concluded that risks to human health are de minimis.[25] But as Brown[26] notes, the researchers explored only the acute effect of a single ingestion. The researchers acknowledged that if a child ingested some chemicals repeatedly, the results might be different. Their data suggest that the ingestion of several metals, including lead, is of particular concern.

Moreover, the OEHHA investigators only simulated the stomach environment. There is a need to simulate the digestive process more completely -- to include the enzymatic actions of saliva and intestinal fluid as well.

Skin Contact

The results from studies of skin contact are ambiguous. In their main study of dermal exposure, the OEHHA researchers[27] found that one PAH, chrysene, can be absorbed from a playground rubber surface onto a polyester wipe. The authors then estimated that if children engaged in considerable hand contact with the rubber over several years -- and sometimes put their hands in their mouths -- the children would experience an increased cancer risk. This conclusion is based on a fair amount of speculation, but it alerts us to a danger.

In a 2005 study in Denmark, Nilsson et al. placed synthetic perspiration on a tractor tire for one hour but failed to find that any PAHs gravitated to the liquid.[28] However, this study, like the OEHHA research on dermal exposure, examined relatively large rubber surfaces (a playground surface and a tire). The results derived from this approach can be misleading when the actual dermal contact occurs with the tiny rubber granules in synthetic turf. Tiny particles have proportionately larger surface areas. Consequently, toxic chemicals contained in the small granules may be more readily absorbed through ingestion or skin contact.

A recent Netherlands study[10] examined the urine of football players after they had "intensive skin contact with rubber crumb on an artificial field pitch." The urine tests did not "unambiguously" indicate that PAHs had entered the athletes' bodies. Although this is important information, similar research needs to be repeated under a variety of playing conditions and include children.

In Korea, teachers have noticed nose and eye irritation among school children playing on artificial turf surfaces.[29] Others have called for research how dermal contact with rubber infill might cause allergic reactions.[10]

Conclusion

Hazardous chemicals are clearly present in synthetic turf rubber granules that are made from recycled tires. Some metals in the granules, including zinc, leach into water and, if

they behave like the metals in other rubber tire material, they can kill aquatic life. However, it is not yet clear whether this leaching presents a health risk to humans and other species in ordinary life conditions. It also is unclear whether the various toxic chemicals in the rubber granules can be absorbed into the bodies of children and athletes through inhalation, ingestion, or skin contact. Much more research is needed. Although some reports have concluded that the risks are minimal, such conclusions are premature.

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