Per- and Poly-fluoroalkyl Substances (PFAS) in Artificial Turf Carpet

Introduction

The Massachusetts Toxics Use Reduction Institute (TURI) has received inquiries from municipalities and community members regarding the presence of per- and poly-fluoroalkyl substances (PFAS) in artificial turf carpet. This brief fact sheet provides some basic background information on PFAS and on recent testing for these chemicals in artificial turf as reported by nonprofit organizations. This information is provided under TURI's mandate to provide information on toxic chemicals and safer alternatives to businesses, municipalities, community members and others.

TURI has conducted background research on health and environmental effects of PFAS in its work with the Toxics Use Reduction Act (TURA) program's Science Advisory Board. TURI has neither conducted nor sponsored any laboratory testing of PFAS in turf or other products.

What are PFAS?

PFAS are a category of chemicals that contain multiple fluorine atoms bonded to a chain of carbon atoms. Thousands of such chemicals exist. A study by the Organization for Economic Cooperation and Development (OECD) identified over 4,700 PFAS-related Chemical Abstract Service (CAS) numbers.[1] PFAS chemicals have properties that can be useful in a variety of settings, such as water and stain resistance. They also pose concerns, including persistence, bioaccumulation, and adverse health effects, as summarized below.

PFAS Nomenclature and Vocabulary

PFAS are sometimes described as "long-chain" or "short-chain" based on the length of the fluorinated carbon chain. They can also be categorized and described based on the number of carbons; for example, a PFAS chemical with an 8-carbon chain may be referred to as "C8." For more information, see the ITRC fact sheet "Naming Conventions and Physical and Chemical Properties of Per- and Polyfluoroalkyl Substances (PFAS)."[2]

PFAS "precursors" are complex chemicals that break down into other simpler PFAS compounds ("degradation products"). In addition, some PFAS are fluoropolymers (longer chains of molecules containing carbon and fluorine).

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Persistence

Although there are thousands of PFAS, most of them break down into a common set of degradation products. These degradation products are characterized by very high persistence in the environment.[3] Persistent chemicals do not break down under normal environmental conditions, and some can last in the environment for hundreds of years or longer. As a result, introducing these chemicals into the environment has lasting consequences.

Bioaccumulation

All PFAS pose some degree of bioaccumulation concern, especially in air-breathing organisms.[3] In other words, they can accumulate in plants, animals, and humans.

Health Effects

Due to widespread contamination of drinking water in some areas of the US, the human health effects of certain PFAS have been studied in depth. Other PFAS have been studied in laboratory animals. Because the class of PFAS is so large, many individual PFAS have not been studied in depth. Researchers have emphasized the need to address PFAS as a group rather than one by one. Health effects documented for some PFAS include effects on the endocrine system, including liver and thyroid, as well as metabolic effects, developmental effects, neurotoxicity, and immunotoxicity.[3]

PFAS have been studied by a number of government entities. For example, OECD has done the most comprehensive work on PFAS as a class; the US Environmental Protection Agency (US EPA) has done extensive research on several PFAS compounds; and certain states have researched individual PFAS chemicals in depth.

Drinking Water Contamination

PFAS have been found as drinking water contaminants in many states. For example, the Massachusetts Department of Environmental Protection (MassDEP) has worked with municipalities to gather data on levels of six PFAS in groundwater and drinking water. According to MassDEP, "since 2013, the sum of the concentrations of the six PFAS compounds above 20 ppt [parts per trillion] have been detected at over 20 PWSs [public water systems] in Massachusetts." MassDEP has issued a proposed regulation that would set a Maximum Contaminant Level (MCL) in drinking water of 20 ppt for the sum of the concentrations of these six PFAS. MassDEP has also finalized and adopted standards for groundwater cleanup.[4]

PFAS Testing

PFAS testing is difficult due to the large number of individual chemicals in the class, as well as the very low concentrations at which adverse effects may occur. Additional difficulties result from the fact that while methods have been developed for testing drinking water and wastewater, there are no consistent guidelines for testing solid materials. Some of these difficulties have been addressed through the development of methods for testing the total presence of fluorine-containing organic (carbon-containing) compounds.

In many cases, testing may be conducted for a small group of PFAS that have been a particular focus of regulatory activity. The absence of these chemicals does not indicate that all PFAS are absent. For example, US EPA has published methods for testing just 29 PFAS in water.[5]

Difficulty of Testing Products

Difficulties may be encountered in choosing appropriate test methods for a given material. For example, guidance that has been developed for drinking water is not necessarily applicable to a solid material. In addition, some laboratories use a modified version of a US EPA method; US EPA has not validated these approaches.[5]

In any testing effort, it is important to adopt an appropriate study design. For example, US EPA has provided guidance on approaches to understanding potential leaching of chemicals from liquids, soils and wastes into rainwater. This includes consideration of the acidity of rainwater in certain areas of the US. US EPA recommends choosing an appropriate extraction fluid depending on the relevant environmental conditions in the region.[6]

Total Fluorine Analysis

In addition to testing for individual compounds, it can also be useful to conduct a Total Fluorine Analysis. This can be carried out using Particle-Induced Gamma Ray Emission (PIGE) spectroscopy, and other techniques such as Combustion Ion Chromatography (CIC).

These tests do not look for specific PFAS chemicals. Rather, they look for fluorine atoms as an indicator of the presence of PFAS chemicals. This kind of test can be useful because testing standards have not been developed for all the types of PFAS that are available on the market. These measurements can also be performed on solid samples.

TOP Assay

Another test used to gather information about PFAS present in a sample is a Total Oxidizable Precursor (TOP) assay. This test creates the conditions in which precursors are broken down into degradation products. These degradation products are among the PFAS that can be measured by EPA methods in water. TOP assay enables researchers to detect the presence of precursors, even if they do not know which specific precursors are present.[7]

Understanding Test Results

When interpreting results of testing conducted on products, including turf carpet samples, it is important to understand what test was conducted and what that test has the ability to detect. For example, if a fluoropolymer is present in the product, an appropriate test must be selected to detect its presence.

In summary, lack of detection of one or more specific PFAS does not mean that a material is free of PFAS. To determine whether PFAS are likely to be present, a total fluorine test and/or a TOP assay may be helpful.

Another factor to consider is that in some cases, a test may be carried out only for long-chain chemicals that were used more frequently in the past, or that appear primarily as degradation products in the environment. Knowing the presence of these chemicals is important, but they are not the most likely chemicals to appear in a new product.

PFAS Testing in Artificial Turf Carpet

Determining what chemicals are present in a product can be challenging because chemical contents are frequently not disclosed by the manufacturer. Two nonprofit organizations recently tested artificial turf carpet and found evidence of the presence of PFAS in the material.[8] The nonprofit organizations tested backing of both new turf and older, discarded turf. They also tested a number of samples of artificial grass blades (carpet fibers).

They detected one PFAS chemical in the backing of the new turf sample. Specifically, they detected 6:2-fluorotelomer sulfonic acid (known by the abbreviation 6:2 FTSA). 6:2 FTSA has a 6-carbon chain, and is considered a short-chain PFAS because of the way in which it breaks down. In many cases, short-chain PFAS have been adopted as substitutes for longer-chain PFAS.

They detected perfluorooctane sulfonate (PFOS) in the backing of the discarded, older turf sample. PFOS is a long-chain PFAS that is no longer manufactured in the US due to concerns about health and environmental effects.

They also tested a number of synthetic turf fiber samples and found that all of them contained quantities of fluorine that suggest the presence of PFAS.[8] These quantities were in the parts per million range, but given the large surface areas of a typical turf carpet, researchers note these may represent a source of PFAS in the environment.[9] Research on this topic is still in process and it will be important to review new scientific publications as the work continues.

One possible reason for the use of PFAS in the artificial turf grass blades is to serve as an extrusion aid.[10] That is, PFAS is added to the polymer mixture (which is a non-fluorinated plastic) before it is passed through an extruder. An extruder is manufacturing equipment that melts and forms the polymer mixture into its desired shape. The PFAS helps to prevent the polymer from sticking to the extruder. According to a researcher, artificial turf grass blades were previously made from low-density polyethylene, but the material had poor durability. Newer polymer mixtures have greater durability, but were not compatible with existing extrusion equipment. Therefore, PFAS were added in order to facilitate use of the new polymer mixture with existing equipment.[8,9]

The researchers who conducted this work do not know exactly what types of PFAS may be used as processing aids in this application. They are not present in US EPA's Method 537.1 ("Determination of Selected Per- and Polyfluorinated Alkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry"). Thus, using this US EPA method would not be informative in this application. However, the TOP assay allows researchers to confirm the presence of some type of PFAS. According to researchers, preliminary results on two samples indicated the presence of PFBA, PFBS, FPHxA, PFHpA, PFOA and PFOS in turf carpet fibers that had undergone TOP assay.[9]

Questions about Athletes' Exposure to PFAS

TURI has received questions about the possibility of PFAS exposure associated with playing on artificial turf. PFAS exposure has not been assessed specifically in relation to playing on artificial turf, and studying children's exposures often presents methodological and ethical challenges. More generally, the approach of the Toxics Use Reduction Institute is to identify opportunities to reduce or eliminate the use of toxic chemicals as a means to protect human health and the environment. Eliminating the use of a toxic chemical also makes it unnecessary to assess exposure.

The vast majority of PFAS research to date has focused on the results of ingestion exposure. There is also some emerging information on health effects of dermal exposure to PFAS. Some researchers have suggested that dermal exposure to consumer products treated with PFAS may contribute to over-all PFAS exposure.[11,12] In the absence of more specific information, it may be helpful to follow general guidelines provided by the Icahn School of Medicine at Mt. Sinai and others for helping to minimize exposure to chemicals that may be present in artificial turf.[13]

Learn more about PFAS

Technical fact sheets from the Interstate Technology Regulatory Council (ITRC) are available at: https://pfas-1.itrcweb.org/

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Note: For several points covered in this overview, we have provided the TURA Science Advisory Board's summaries of scientific information as a reference. These summaries draw upon a large set of authoritative government documents and peer reviewed studies.

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The Toxics Use Reduction Institute is a multi-disciplinary research, education, and policy center established by the Massachusetts Toxics Use Reduction Act of 1989. The Institute sponsors and conducts research, organizes education and training programs, and provides technical support to help Massachusetts companies and communities reduce the use of toxic chemicals.

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