

Collections Related to Synthetic Turf Fields with Crumb Rubber Infill: Responses to Public Comments

During the 60-day FRN period, the Agency for Toxic Substances and Disease Registry (ATSDR) received 83 public comments. Many of the comments (n=24) contained attachments with extensive information and requests. Due to the content and volume of the comments, ATSDR and the U.S. Environmental Protection Agency (EPA) categorized the comments and attachments according to the specific requests contained therein. There are eight different categories and responses: 1) General comments; 2) Comments regarding children and children's health; 3) Comments that were beyond the scope of the current research efforts; 4) Comments on banning/moratoriums and the precautionary principle; 5) Comments with detailed requests; 6) Comments regarding the methodology of the research activities; 7) Comments on epidemiological studies; and 8) Comments on previous research studies. For category-specific comments, please see below. Due to the content of the public comments, a comment may be included in more than one category-specific response. ATSDR and EPA have completed a response for each of the different categories of comments.

1. General comments: ATSDR-2016-0002-0004; ATSDR-2016-0002-0008; ATSDR-2016-0002-0009; ATSDR-2016-0002-0012; ATSDR-2016-0002-0021; ATSDR-2016-0002-0032; ATSDR-2016-0002-0044; ATSDR-2016-0002-0078
2. Comments regarding children and children's health: ATSDR-2016-0002-0005; ATSDR-2016-0002-0015; ATSDR-2016-0002-0016; ATSDR-2016-0002-0020; ATSDR-2016-0002-0035; ATSDR-2016-0002-0040; ATSDR-2016-0002-0046; ATSDR-2016-0002-0048; ATSDR-2016-0002-0049; ATSDR-2016-0002-0051; ATSDR-2016-0002-0052; ATSDR-2016-0002-0056; ATSDR-2016-0002-0058; ATSDR-2016-0002-0059; ATSDR-2016-0002-0061; ATSDR-2016-0002-0067; ATSDR-2016-0002-0069; ATSDR-2016-0002-0073; ATSDR-2016-0002-0075; ATSDR-2016-0002-0079; ATSDR-2016-0002-0085
3. Comments that were beyond the scope of the current research efforts: ATSDR-2016-0002-0007; ATSDR-2016-0002-0008; ATSDR-2016-0002-0013; ATSDR-2016-0002-0022; ATSDR-2016-0002-0024; ATSDR-2016-0002-0027; ATSDR-2016-0002-0028; ATSDR-2016-0002-0030; ATSDR-2016-0002-0031; ATSDR-2016-0002-0034; ATSDR-2016-0002-0039; ATSDR-2016-0002-0040; ATSDR-2016-0002-0046; ATSDR-2016-0002-0056; ATSDR-2016-0002-0057; ATSDR-2016-0002-0058; ATSDR-2016-0002-0062; ATSDR-2016-0002-0064; ATSDR-2016-0002-0065; ATSDR-2016-0002-0069; ATSDR-2016-0002-0074; ATSDR-2016-0002-0077; ATSDR-2016-0002-0079; ATSDR-2016-0002-0080; ATSDR-2016-0002-0083
4. Comments on banning/moratoriums and the precautionary principle: ATSDR-2016-0002-0006; ATSDR-2016-0002-0016; ATSDR-2016-0002-0025; ATSDR-2016-0002-0026; ATSDR-2016-0002-0029; ATSDR-2016-0002-0032; ATSDR-2016-0002-0033; ATSDR-2016-0002-0045; ATSDR-2016-0002-0047; ATSDR-2016-0002-0048; ATSDR-2016-0002-0049; ATSDR-2016-0002-0050; ATSDR-2016-0002-0051; ATSDR-2016-0002-0052; ATSDR-2016-0002-0054; ATSDR-2016-0002-0056; ATSDR-2016-0002-0060; ATSDR-2016-0002-0061; ATSDR-2016-0002-0063; ATSDR-2016-0002-0067; ATSDR-2016-0002-0068; ATSDR-2016-0002-0069; ATSDR-2016-0002-0073; ATSDR-2016-0002-0074; ATSDR-2016-0002-0076; ATSDR-2016-0002-0079; ATSDR-2016-0002-0080; ATSDR-2016-0002-0081; ATSDR-2016-0002-0083

5. Comments with detailed requests: ATSDR-2016-0002-0010; ATSDR-2016-0002-0018; ATSDR-2016-0002-0024; ATSDR-2016-0002-0030; ATSDR-2016-0002-0033; ATSDR-2016-0002-0034; ATSDR-2016-0002-0065; ATSDR-2016-0002-0066; ATSDR-2016-0002-0074; ATSDR-2016-0002-0077; ATSDR-2016-0002-0079; ATSDR-2016-0002-0080
6. Comments regarding the methodology of the research activities: ATSDR-2016-0002-0011; ATSDR-2016-0002-0014; ATSDR-2016-0002-0024; ATSDR-2016-0002-0030; ATSDR-2016-0002-0033; ATSDR-2016-0002-0035; ATSDR-2016-0002-0056; ATSDR-2016-0002-0057; ATSDR-2016-0002-0058; ATSDR-2016-0002-0064; ATSDR-2016-0002-0065; ATSDR-2016-0002-0069; ATSDR-2016-0002-0074; ATSDR-2016-0002-0076; ATSDR-2016-0002-0077; ATSDR-2016-0002-0079; ATSDR-2016-0002-0080; ATSDR-2016-0002-0083
7. Comments on epidemiological studies: ATSDR-2016-0002-0024; ATSDR-2016-0002-0045; ATSDR-2016-0002-0046; ATSDR-2016-0002-0047; ATSDR-2016-0002-0052; ATSDR-2016-0002-0069; ATSDR-2016-0002-0074; ATSDR-2016-0002-0077; ATSDR-2016-0002-0079; ATSDR-2016-0002-0080; ATSDR-2016-0002-0081; ATSDR-2016-0002-0083
8. Comments on previous research studies: ATSDR-2016-0002-0023; ATSDR-2016-0002-0041; ATSDR-2016-0002-0042; ATSDR-2016-0002-0045; ATSDR-2016-0002-0047; ATSDR-2016-0002-0059; ATSDR-2016-0002-0064; ATSDR-2016-0002-0066; ATSDR-2016-0002-0069; ATSDR-2016-0002-0077; ATSDR-2016-0002-0079; ATSDR-2016-0002-0085; ATSDR-2016-0002-0086

General Comments

The EPA and the Centers for Disease Control and Prevention (CDC)/ATSDR, in collaboration with U.S. Consumer Product Safety Commission (CPSC), are working together on the Federal Research Action Plan (FRAP) on Recycled Tire Crumb Used on Playing Fields and Playgrounds. This multi-agency action plan will address key environmental health questions. The overall goal of this effort is to help answer questions about the potential risk associated with the use of tire crumb materials in artificial turf fields. The specific objectives of this effort are to: 1) Determine key knowledge gaps; 2) Identify and characterize chemical compounds found in tire crumb used in synthetic turf fields; 3) Characterize exposures based on participants activities on the fields; and 4) Identify follow-up activities that could be conducted to provide additional insights about potential risks. In addition, CPSC is developing research activities to better understand young children's exposures to tire-derived materials used on playgrounds. Playground research activities are not included in the current Information Collection Request.

To accomplish specific objectives 2 and 3, a 60-day Federal Register Notice (FRN) describing the data collection was posted on www.regulations.gov on February 17, 2016. Briefly, the chemical characterization activity (objective 2) aims to recruit 40 synthetic turf field facilities across the U.S. (10 fields in each of the 4 U.S. census regions), to administer a questionnaire to the field owners/managers, and to collect tire crumb rubber samples from the fields. The questionnaire will seek information about field usage and standard operating procedures for the synthetic turf fields. The crumb rubber infill samples from synthetic turf fields will undergo laboratory analysis for a wide range of metals, volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs).

The exposure characterization activity (objective 3) is a pilot-scale effort focused on collecting information about how people might be exposed to chemicals in tire crumb rubber infill while playing on synthetic turf fields. In this study, we aim to include persons who have the potential for higher exposures, including children. Answers to the questionnaire will help determine adults' and children's activities on synthetic turf fields that may affect their potential exposures to chemicals.

From the exposure characterization activity, a subset of participants, including children, will be asked to participate in an exposure measurements sub-study, which will evaluate several types of samples collected during or following sports or training activities on the synthetic turf field. Samples will include personal air VOC samples and ambient on-field air samples collected during the activity, dermal wipe samples collected immediately following the activity, and field wipe and dust samples collected from field surfaces. The laboratory will analyze on-field air samples for metals, particulates (PM₁₀), VOCs, and SVOCs; and wipe samples for metals and SVOCs. Urine and blood samples will be collected at two time points: pre-activity, and post-activity. These samples will be archived for future analysis.

During the 60-day FRN and public comment period, 83 comments were received, including comments from 29 associations/groups. Per the public's request, the federal agencies extended the

public comment period. The public comments were reviewed and addressed. While additional research questions may require evaluation beyond the scope of this effort, the current work will help answer some of the key questions that have been raised.

Children and Children's Health

A number of commenters raised concerns about the exposures and potential health risks for children coming into contact with synthetic turf fields with tire crumb rubber infill material. Federal researchers understand these concerns, particularly the need to better characterize children's exposure to tire crumb rubber constituents in synthetic turf fields. Children may experience different exposures than adults due to their activity patterns (e.g., increased hand-to-mouth contact) and physiology (e.g. lower body weight). The research described in the multi-agency Federal Research Action Plan (FRAP) is designed to improve our understanding of the chemicals children may be exposed to and to better characterize the inhalation, dermal, and ingestion pathways of exposure.

The two activities described in the FRN are: 1) the chemical characterization of tire crumb rubber infill used in synthetic turf fields; and 2) a pilot-scale exposure characterization study. The chemical characterization study aims to recruit 40 synthetic turf field facilities across the U.S (10 fields in the 4 U.S. census regions), to administer a questionnaire to the field owners/managers, and to collect tire crumb rubber samples from the fields. The questionnaire will include questions regarding field usage and standard operating procedures for the synthetic turf fields. Laboratory analyses will be performed on the crumb rubber infill samples from synthetic turf fields for a wide range of metals, volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs).

The exposure characterization study is a pilot-scale effort aimed at collecting information on how people might be exposed to chemicals in crumb rubber infill while playing on synthetic turf fields. The study will use a questionnaire to determine different activities adults and children have on synthetic turf fields that may affect their potential exposures to chemicals in synthetic turf fields. In this study, we aim to include persons who have the potential for higher exposures, including children. Specifically, we plan to recruit and enroll children ages 7-17 and college-age individuals who engage in physical activities on synthetic turf fields with crumb rubber infill, in addition to adults. In addition to the questionnaire, we will use pre-existing video to collect information on types and frequencies of activities on synthetic turf fields, along with clothing and protective equipment usage. A subset of the participants in the exposure characterization study, including children, will be asked to participate in an exposure measurements sub-study. In the exposure measurements sub-study, several types of samples will be collected. Personal air samples and ambient on-field air samples will be collected during the sports or training activity on the synthetic turf field; dermal wipe samples will be collected immediately following the activity. Air samples will be analyzed for metals, VOCs, and SVOCs; dermal wipe samples will be analyzed for metals and SVOCs. Urine and blood samples will be collected at three time points around the sports or training activity, one sample pre-activity, one sample post-activity, and one sample 24 hours later. These samples will be archived for future analysis. Appropriate steps will be taken to ensure the protection of human subjects in this research, and the research has been reviewed and approved by the CDC Institutional Review Board and EPA Human Subjects Research Review Official.

Several commenters suggested considering the potential for exposures to very young children who may spend time on synthetic turf fields as bystanders. Given the time and resource constraints, we have focused the data collection to children age seven or older who engage in active play on

synthetic turf fields. However, the information we develop from both the tire crumb rubber chemical characterization, and the exposure characterization measurements may allow for modeling of young child bystander exposures.

The information gained from the research activities conducted under the Federal Research Action Plan will help answer some key questions and will be used to identify future follow-up activities that could be conducted to provide additional insights about potential risks. For example, the data from the chemical characterization study and the exposure measurement study will be used for future exposure screening calculations and exposure modeling. These efforts will take into consideration different exposure patterns and physiological parameters that might result in higher exposure potential in children and young adults. . However, the exposure characterization study is a pilot-scale effort and is not a health study, epidemiological study, or a risk assessment.

Beyond the Scope of the Current Research Efforts

The research study titled “Collections Related to Synthetic Turf Fields with Crumb Rubber Infill”, ATSDR received 83 comments during the 60-day Federal Register Notice public comment period. Of these, many comments contained requests and/or comments that are beyond the scope of the research activities outlined in the Federal Research Action Plan and the specific research activities described in the 60-day FRN. For example, the public comments included requests such as toxicity testing including cumulative and/or synergistic effects, performing an epidemiology study, and inclusion of natural grass fields or alternative infill materials, along with the measurement of synthetic grass blades and substrate chemical constituents. The current research effort is aimed at chemical characterization of the tire crumb rubber material and a pilot-scale exposure characterization of high-end users of synthetic turf fields. Due to time and resource constraints, we were not able to incorporate all requests. For responses to specific comments regarding inclusion of playground or play mat materials, the comments have been provided to the Consumer Product Safety Commission.

We received a number of comments suggesting applying research methods to assess the potential for leaching and environmental release into aquatic systems, and to consider other potential exposures such as heat. However, the time and resources are highly constrained. Data will not be collected to directly address the potential for ecological exposure and risks beyond performing chemical characterization of tire crumb rubber material. The study will not address potential heat exposure concerns and injury. While recognizing that there are other aspects of synthetic turf fields that could be studied, the focus of this research will be on the potential for human exposures to chemicals and microbes associated with tire crumb rubber.

Banning/Moratorium and Precautionary Principle

A number of commenters indicated their support of a moratorium on new field construction using crumb rubber, a ban on the use of crumb rubber in athletic fields and playgrounds, or the use of the “precautionary principle,” at least until studies show that there are no health risks to individuals playing on these surfaces. Other commenters indicated that the current studies are inadequate to assess risks to individuals exposed to tire crumb from playing on fields containing this material.

We understand that the public is concerned about the safety of recycled tires used on athletic fields and playgrounds. The federal government is undertaking this study to determine what actions, if any, are warranted with respect to tire crumb. While current studies do not show elevated health risks from playing on fields or other surfaces containing tire crumb, we recognize that there are data gaps and that the existing studies do not comprehensively evaluate the concerns about health risks from exposure to tire crumb. EPA, ATSDR, and CPSC launched this coordinated federal effort to fill these data gaps, particularly with respect to understanding potential exposures to chemicals in the crumb rubber. The findings will provide a better understanding of potential exposures that athletes and others may experience by using synthetic turf fields containing crumb rubber. By the end of 2016, the agencies will release a draft report that describes the findings and conclusions of the work conducted under the Federal Research Action Plan through that point in time. Results of this work can be used to inform decisions by federal, state, and local governments.

Detailed Requests

Of the 83 comments that were received, 18 comments contained specific comments/requests relevant to the current research activities described in the 60-day FRN. For those requests/comments that are within the scope of the current research effort, we endeavored to incorporate the requests into the final research protocol.

Some commenters requested that we consider existing information when designing this study and to consider a broad range of chemical and particle assessments using tire crumb rubber of different ages. For the incorporation of existing information regarding the chemical content of tire crumb rubber, we reviewed and extracted information on what chemicals have been measured in many other studies. In addition, we considered information on chemicals that may be used in tire rubber manufacturing process in our target chemical selection. The research is designed to collect both new/unused material from recycling facilities, and to collect tire crumb rubber from fields that are more than two years old. We will look for evidence in changes in particle size distributions and chemical concentrations across the range of material ages. In addition to target chemical analysis, we plan to conduct 'non-targeted' analysis in a subset of samples to obtain information that may be useful in identifying all of the relevant chemicals that can be measured. Chemical characterization will be performed directly through digestion and solvent extraction procedures which is a necessary step to better understand what chemicals might be available for exposure. Additionally, dynamic emissions chamber testing and bioaccessibility testing will be performed to better understand potential exposures. We will examine chemicals associated with carbon black (e.g. PAHs) and we will attempt to characterize particles in sizes ranges down to nanoparticle size.

Commenters recommended performing bioaccessibility testing with fine particulate associated with tire crumb rubber instead of or in addition to the bulk tire crumb rubber material. Another comment recommended not washing the tire crumb rubber prior to testing to avoid removal of fine particulate. Bioaccessibility testing will be performed with tire crumb rubber collected directly from recycling centers and from synthetic turf fields, and will include the entire range of particulate sizes associated with the material. The crumb rubber material will not be washed or rinsed prior to conducting tests. Based on preliminary work, we do not believe that we can isolate sufficient quantities of very fine particulate from the crumb rubber material to support separate bioaccessibility testing.

Commenters recommended assessing the potential for chemical leaching and environmental contamination as well as performing analyses on the full range of synthetic turf materials including synthetic blades and backing material. The research will focus on tire crumb rubber characterization and the potential for human exposure during field activities. Time and resource constraints preclude inclusion of leaching and environmental impact research at this time. We do not plan on analyzing the synthetic grass blade material at this time, again due to time and resource constraints. If blade materials are collected as a byproduct of tire crumb rubber sample collection, the blade material may be stored for possible future analysis.

Commenters noted that when considering potential health risks associated with tire crumb rubber material that relevant exposures are likely to be to a mixture of chemicals. Recommendations including performing toxicity testing on chemical mixtures. It was also noted that any evaluation of toxicity and potential risks must rely on relevant exposure levels, not just the presence of chemicals in the material. The current research is designed to characterize multiple chemical constituents. This is a key first step needed to understand what chemical mixtures may be relevant from an exposure standpoint and will provide information on relevant exposure levels for future toxicity assessment. The research will focus on tire crumb rubber characterization and the potential for human exposure during field activities. Time and resource constraints preclude inclusion of direct toxicity assessment either in-vivo or in-vitro at this time. However, the National Toxicology Program is considering short-term toxicity testing for tire crumb rubber material. We will collate existing toxicity reference information for identified chemical constituents, including the Occupational Health and Safety Administration (OSHA), National Institute for Occupational Safety and Health (NIOSH), and the California Division of Occupational Safety and Health (also known as Cal-OSHA) permissible and recommended exposure limits where they exist.

Commenters requested that the study include other types of infill, and natural grass fields. The research study is exclusively aimed at synthetic turf fields with tire crumb rubber. Due to time and resources constraints, we are not able, within this study, to investigate other types of fields (e.g. natural grass, synthetic fields with natural product infill, synthetic fields with EPDM or TPE infill) with sufficient sample sizes and statistical power. While there is concern about chemical exposures resulting from the use of recycled tire and other materials in synthetic fields, it is important to recognize that chemicals are present in other types of fields, including natural grass fields. Metals (including lead) and PAHs (including benzo(a)pyrene) of concern at synthetic fields with tire crumb rubber infill are also often found in surface soil in the U.S. and are likely to be present at natural grass playing fields. In addition, insecticides, herbicides and fertilizers may be used on some natural grass fields, leading to exposures that may not be experienced by synthetic turf field users. Because many recreational and sports field users spend time on both natural grass and synthetic fields (either concurrently or during different life stages) an understanding of relative exposures across different field types is of interest for future risk assessment and epidemiological investigations.

Inclusion of mucous membranes as a potential exposure pathway was requested by a commenter, and a commenter recommended collecting dermal samples from faces and scalps of field users. For the exposure characterization activity, we do not have resources to support the inclusion of mucous membranes as a potential pathway of exposure, and we do not have collection methods which we know to have necessary sensitivity and accuracy for the range of chemicals of interest. We will collect dermal wipe samples for metals and SVOCs analyses from hands, arms, and legs. We will not collect dermal wipe samples from faces and do not have appropriate sampling methods for scalp dermal sample collection. Additionally, we will collect blood and urine samples which will be archived for future analysis.

Some commenters requested that we establish a scientific review panel. We appreciate the recommendation to establish a scientific review panel. Due to the rapid implementation of this research effort a scientific review panel has not been established at this time. External expert peer

review of the research protocol has been performed. This recommendation will not be addressed as part of the research protocol but will be followed up separately in discussion by the participating organizations.

With regard to the literature review and data gaps analysis being performed as part of this research effort, a commenter identified several journal articles and reports that may have industry sponsorship or funding sources with a suggested potential for conflict of interest. All journal articles and reports included in the literature review will be evaluated on scientific strengths regardless of funding source or potential bias.

For this research effort, all research measurements will be performed by federal research laboratories or their contractors.

Chemical Characterization Methodology

Many people and organizations submitted comments related to research design and methodology considerations. Many comments recommended performing chemical analyses that will identify and provide more information about the many chemicals that may be tire crumb rubber constituents. Other comments recommended that research is needed to better understand variability in chemical constituents and factors that might affect the availability for exposure of chemicals and particles (including nano-sized particles) such as age/weathering and temperature. A number of comments identified the need to better understand potential exposures through the ingestion and dermal absorption pathway, in addition to the inhalation pathway that has been better studied in previous research.

Federal researchers understand the interest and importance of better characterization of the potential exposure to tire crumb rubber constituents in synthetic turf fields. Methodological limitations of previous studies have resulted in some data gaps. One of the data gaps and one of the concerns expressed by a number of people is that previous studies have not consistently attempted to measure the wide range of chemicals potentially present in tire crumb rubber in a comprehensive way, coupled with measurements that provide insight on potential exposures to these chemicals. With regard to chemical constituent characterization, few studies were able to apply a diverse array of analytical methods for measuring a wide range of potential tire crumb rubber chemical constituents which may include many metals, volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs) on the same samples collected from many fields. While many research efforts have included metals such as lead and zinc, or organic chemicals such as polyaromatic hydrocarbons (PAHs) and benzothiazole, only a few studies have attempted to measure some of the many other chemicals potentially used in tire manufacturing.

We have decided to apply a range of analytical methods to more completely and comprehensively examine potential chemical constituents in the tire crumb rubber material and through testing that may provide more insight on the potential for exposure (including emissions testing and bioaccessibility measurements). This will allow for evaluation of relevant constituents with more confidence that key constituents are not missed. Our extensive research target chemical list was primarily based on reports from previous research as well as from information sources describing chemicals that may be used in rubber and tire manufacturing. While many of the chemicals may prove not to be measurable at detectable levels, we will try to address this data gap and concern as comprehensively as possible. We have elected to apply two strategies for analysis. We have included many compounds (e.g. PAHs, phthalates, benzothiazole, 2-mercaptobenzothiazole) that have been identified in previous research or are of potential concern; we will perform fully quantitative targeted analysis for these chemicals. However, given the large range of other chemicals potentially used in tire rubber manufacturing, we will also apply suspect screening analysis through analysis of chemical standards for many other compounds (which may also allow semi-quantitative reporting) that will provide chromatographic retention and mass spectra confirmation of suspect compounds. We will also conduct a subset of non-targeted analyses which will allow us to generate exact chemical formulas, retention indices, and mass spectra that can be further evaluated if/as needed based on criteria such as relative abundance. Through this process, we expect to identify key chemicals of interest for exposure and toxicological assessment. We will

apply GC/MS methods, including TOFMS, for VOCs, and we will apply both GC/MS/MS and LC/TOFMS methods for SVOCs in order to identify a wide range of chemicals with different chemical/physical properties. We will also apply ICP/MS methods to measure a large number of potential metal constituents.

Concern has been expressed regarding the potential variability in chemical constituents and particles across different fields resulting from different ages, weathering conditions, source materials, and other factors. The study is designed to characterize variability through collection of material from up to nine recycling facilities and forty synthetic turf fields (2 or more years old) selected across the US. The study will also examine indoor and outdoor fields. This design will allow comparison of unused material to material that has aged under different time, weathering and ventilation-related effects. The tire crumb rubber will be examined not only for chemical constituents and particles, it will be subjected to dynamic chamber testing and bioaccessibility analyses to allow examination of these factors on potential exposures. Some commenters recommended a representative nationwide sampling design that would allow for inferences to the universe of US fields and provide a larger sample size for more statistical robustness for factor assessment. While this might be a preferable design from many aspects, the time and resource constraints do not allow for a representative sampling design.

Methods will be applied to assess a wide range of potential chemical constituents not only through direct acid digestion (for metals) and solvent extraction (for organic chemicals) of tire crumb rubber but also to better understand the potential for exposure to chemicals using dynamic chamber testing and bioaccessibility testing. Two different types of laboratory chamber testing will be applied to measure emissions of VOCs and SVOCs. Concerns have been raised about the potential for increased emissions and exposures that may occur when fields reach very hot temperatures. Therefore, laboratory chamber tests will be conducted at two different temperatures, including a temperature that may represent a warm indoor facility (25 °C/77°F) and an upper temperature that approaches what has been reported for synthetic field surfaces under hot ambient conditions (60 °C/140 °F).

Another limitation of existing research is the information regarding the potential for exposure to tire crumb rubber constituents through the dermal and ingestion pathways in addition to the inhalation pathway which has been better studied. We are applying methodology to address this limitation in three ways. In the tire crumb rubber characterization research we are applying bioaccessibility methods to assess the potential for absorption of metals and SVOCs using simulated biofluids (e.g. saliva) to better understand dermal and ingestion exposure pathways. In the exposure characterization research, we are collecting activity information to reduce reliance on default assumptions for a number of relevant exposure parameters, including frequency and duration of field uses, dermal contact rates, and hand-to-mouth activities that influence exposure through all pathways. We also are collecting field and personal samples relevant for improving our understanding of potential exposure; personal and field samples include dermal wipes for metals and SVOCs, field surface wipe samples, and field dust samples that will provide insight into exposures from multiple pathways.

There has been considerable interest in better understanding inhalation exposures to VOCs, SVOCs and particulate matter for people engaged in active play or training on synthetic turf fields. In the exposure characterization portion of the study, we have included these air sampling measurements for two locations near on-field active play areas and at one off-field upwind location to assess background ambient air contributions to the measurements. We will include a small personal passive air sampler with a relatively high sampling rate for participants to measure VOCs during their active play/training. While recognizing the value of including personal particulate and/or SVOC sample collection as many have recommended, we decided not to include those personal measurements. The reasons include concerns for injury potential for participants wearing the sampling equipment during intense active play/training; the burden of wearing the equipment, especially for young children; the way it might alter activity patterns (e.g. reluctance of soccer goalies to dive while wearing the equipment); uncertainty in how size-selective PM sampler actually perform under intense movements and impacts; and the very small air volumes that can be collected in a typical 1 or 1.5 hour play/training activity which would make accurate and useful measurements difficult.

We are also aware of concerns regarding potential exposures to small particulates, including nano-sized particles, through all exposure pathways. Analyses are planned for particle-size characterization of bulk material collected from recycling centers and synthetic fields, including determination of the nano-sized fraction. In addition, dust, surface wipe, and dermal wipe samples will be collected that will better characterize potential exposures to fine particles.

Epidemiological Study

Some commenters recommended that an epidemiological study be conducted, and/or an investigation into a potential cancer cluster from playing on synthetic turf fields. The current work being conducted under the Federal Research Action Plan (FRAP) is not an epidemiological study, but is a critical step needed to fill data gaps. The FRAP activities will fill essential data and knowledge gaps regarding the chemical constituents in tire crumb rubber and the potential for human exposure during activities on synthetic turf fields. Additionally, the results will be used to identify follow-up activities, potentially including epidemiological studies, which could be conducted to provide additional insights about potential risks.

When evaluating the feasibility of conducting a health study or an epidemiological study, there are many different criteria that must be considered such as study design and methodologies, exposure characterization, sample size, statistical analysis, results interpretation, and risk characterization. These criteria must be carefully evaluated prior to initiation of a health study in order to ensure meaningful results that are helpful to the affected community (or individuals). Additionally, a true exposure-response relationship can only be determined when data on actual exposures are available. However, for some contaminants of concern, exposure information can be difficult to obtain due to the short half-lives of some chemicals. For example, arsenic has a half-life of 3 days therefore only recent exposures can be assessed. Therefore, it is necessary to determine what chemicals an individual could potentially be exposed to prior to conducting a biomonitoring or other health study.

When conducting studies to investigate adverse health effects, the analysis of a large number of health outcomes increases the rate of false positives, meaning the higher number of outcomes (i.e. diabetes) the more likely to find an association where one does not truly exist. Additionally, including information on self-reported symptoms and diseases that have not been confirmed, can introduce bias into the analysis. Epidemiological studies without participant exposure information for the chemical of concern are not designed for, nor are they able to determine a causal association with an adverse health outcome. When conducting studies investigating cancer incidence, the same principles apply.

For cancer cluster investigations, the CDC defines a cancer cluster as “a greater than expected number of cases that occurs within a group of people in a geographic area over a defined period of time” (MMWR 2013). The CDC has outlined a four-step process for evaluating suspected cancer clusters. The FRAP activities that are being conducted by CDC/ATSDR in collaboration with U.S. EPA will provide essential information that can be used to determine if future investigation of adverse health effects, including cancer, is warranted and feasible.

Previously Published Studies/Literature Review

Public commenters provided information on science resources and publications on a wide range of topics, including those focused on tire crumb rubber and synthetic turf fields, which is the focus of the literature review and data gaps analysis being performed as part of this research effort. The following publications and reports identified by commenters have been included among the many journal articles and reports in the literature review and data gaps assessment being performed under the Federal Research Action Plan.

Milone and MacBroom, Inc., Evaluation of the Environmental Effects of Synthetic Turf Athletic. (2008). http://www.actglobalsports.com/media/Milone_MacBroom.pdf.

Dorsey, M J; Anderaon, A; Ardo, O; Chou, M; Farrow, E; Glassman, EL; Manley, M; Meisner, H; Meyers, C; Morley, N; Rominger, K; Sena, M; Stiefbold, M; Stites, B; Tash, M; Weber, E; Counts, P. (2015). Mutagenic Potential of Artificial Athletic Field Crumb Rubber at Increased Temperatures. The Ohio Journal of Science 115(2).

Marsili, L; Coppola, D; Bianchi, N; Maltese, S; Bianchi, M; Fossi, MC. (2014). Release of Polycyclic Aromatic Hydrocarbons and Heavy Metals from Rubber Crumb in Synthetic Turf Fields: Preliminary Hazard Assessment for Athletes. Journal of Environmental and Analytical Toxicology 5:(2).

Shalat, SL. (2011). An Evaluation of Potential Exposures to Lead and Other Metals as the Result of Aerosolized Particulate Matter from Artificial Turf Playing Fields. Submitted to the New Jersey Department of Environmental Protection. <http://www.nj.gov/dep/dsr/publications/artificial-turf-report.pdf>.

Pavilonis, BT; Weisel, CP; Buckley, B; Lioy, PJ. (2013). Bioaccessibility and Risk of Exposure to Metals and SVOCs in Artificial Turf Field Fill Materials and Fibers. Risk Analysis, 34: 44–55.

Claudio, L. (2008). Synthetic Turf: Health Debate Takes Root. Environ Health Perspect. 116(3): A116–A122.

Connecticut Department of Environmental Protection (CDEP). (2010) Artificial Turf Study: leachate and stormwater characteristics. http://www.ct.gov/deep/lib/deep/artificialturf/dep_artificial_turf_report.pdf.

New York Department of Environmental Conservation (NYDEC). (2009). An assessment of chemical leaching, releases to air and temperature at crumb-rubber infilled synthetic turf fields. http://www.dec.ny.gov/docs/materials_minerals_pdf/crumbrubfr.pdf.

Kim, S; Yan, JY; Kim, HH; Yeo, IY; Shin, DC; Lim, YW. (2012). Health Risk Assessment of Lead Ingestion Exposure by Particle Sizes in Crumb Rubber on Artificial Turf Considering Bioavailability. Environ Health Toxicol. 27:e2012005.

Kim, HH et al. (2012). Health Risk Assessment for Artificial Turf Playgrounds in School Athletic Facilities: Multi-route Exposure Estimation for Use Patterns. *Asian Journal of Atmospheric Environment* 6(3): 206-221.

Commenters also identified publications and reports on a wider range of science topics including toxicity, epidemiology, and risk assessment that were not focused on or applied to synthetic turf fields and tire crumb rubber. In many cases the information was provided as part of recommendations on interpreting synthetic field and tire crumb rubber research data in a health or risk assessment context. Some examples of cited literature are shown below. We appreciate the information provided, however, the current research effort is focused on tire crumb rubber characterization and exposure characterization. Therefore, at this time, we will not be considering these more general literature sources directly in our literature review and data gaps assessment.

Braun et al. (2016). What can epidemiological studies tell us about the impact of chemical mixtures on human health? *Environmental Health Perspectives* 124(1):A6 - A9.

Goodson et al. (2015) Assessing the carcinogenic potential of low-dose exposures to chemical mixtures in the environment: the challenge ahead. *Carcinogenesis* 36(Supplement 1): S254 - S296.

Browne MA, Dissanayake A, Galloway TS, Lowe DM, Thompson RC. (2008). Ingested microscopic plastic translocates to the circulatory system of the mussel, *Mytilus edulis* (L). *Environ Sci Technol*. 2008 Jul 1;42(13):5026-31.

Chelsea M. Rochman, Mark Anthony Browne, Eunha Hoh, Hrisi K. Karapanagioti, Lorena M. Rios- Mendoza, Hideshige Takada, Swee Teh, Richard C. Thompson. (2013). Classify plastic waste as hazardous. *Nature* 494(7436):169 - 171.

Several commenters also cited information available on internet sites. For example, an Environment and Human Health, Inc. (EHHI) web site posts findings from a Yale University study that lists a number of organic chemicals identified as tire crumb rubber constituents, along with classifications as carcinogens or irritants. This information was cited by a number of commenters. We were unable to identify publications or reports describing the research, methods used to identify chemicals, quality control and quality assurance procedures, and the sources of toxicity information used to support classifications. (We also note that the chemical 2-mercaptobenzothiazole was listed twice among the '12 carcinogens' category at the EHHI web site). We are unable to evaluate information when presented only as findings on web sites without additional supporting documentation, and such information will not be included in the current literature review and gaps assessment.

