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## II. TOXICOLOGY AND HEALTH EFFECTS

*In this report, Environment and Human Health, Inc. evaluates the information known about the potential health and environmental risks from exposure to crumb rubber made from recycled tires.*

**H**ealth concerns have been documented in rubber tire fabrication workers that are attributed to exposure to chemicals and dusts. Use of recycled tire shreds or crumbs in athletic fields, gardening and playgrounds involves repeated and direct exposures for both children and adults to tire dust and some chemicals similar to those in tire plants. A comprehensive assessment of the information known about the health risks to the public is necessary to assess safety.

Determination of risks and safety from direct human exposures to mixtures of chemicals and dusts requires a systematic analysis of all data to assure a comprehensive evaluation of the hazard.

### LABORATORY IDENTIFICATION OF COMPOUNDS RELEASED FROM TIRE CRUMBS AND RUBBER MULCH

The Connecticut Agricultural Experiment Station report (See Appendix I), found out-gassing and leaching from synthetic turf rubber crumbs under aqueous ambient temperatures. Several compounds were present, but four compounds gave the highest responses on GC/Mass spectrographic analysis. The four compounds conclusively identified with confirmatory tests were: *benzothiazole*; *butylated hydroxyanisole*; *n-hexadecane*; and *4-(t-octyl) phenol*. Approximately two dozen other chemicals were indicated at lower levels. These chemicals were released in laboratory conditions that closely approximate ambient conditions.

Those chemicals identified with confirmatory analytical studies at the Connecticut Agricultural Experiment Station study have the following reported actions:

- **Benzothiazole:** Skin and eye irritation, harmful if swallowed. There is no available data on cancer, mutagenic toxicity, teratogenic toxicity, or developmental toxicity.
- **Butylated hydroxyanisole:** Recognized carcinogen, suspected endocrine toxicant, gastrointestinal toxicant, immunotoxicant, neurotoxicant, skin and sense-organ toxicant. There is no available data on cancer, mutagenic toxicity, teratogenic toxicity, or developmental toxicity.
- **n-hexadecane:** severe irritant based on human and animal studies. There is no available data on cancer, mutagenic toxicity, teratogenic toxicity, or developmental toxicity.
- **4-(t-octyl) phenol:** corrosive and destructive to mucous membranes. There is no available data on cancer, mutagenic toxicity, teratogenic toxicity, or developmental toxicity.

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The study also detected metals that were leached from the tire crumbs. Zinc was the predominant metal, but selenium, lead and cadmium were also identified.

The identification of toxic actions is based on research reported in the peer-reviewed literature and official listings, such as the Integrated Risk Information System (IRIS) and Toxic Substance Control Act (TOSCA). Many, if not most, of the compounds present in tire crumbs and shreds have been incompletely tested for human health effects. In some cases, a partial assessment can be based on the estimated actions of a chemical class or on structural activity characteristics.

Ascertaining the toxic actions of the chemicals identified in the analytical test is dependent on the levels of research that have been performed and reported in the appropriate literature. A qualitative analysis usually precedes the quantitative analysis to determine potency.


## CANCER

Some of the compounds are identified as known or suspected carcinogens. The following is a discussion of the toxicity and health effects of the agents that have been released from tire crumbs under different conditions. The strongest data available with respect to cancer come from the International Agency for Research on Cancer's study of the rubber industry.<sup>2</sup> Strong and sufficient evidence for cancer in humans was demonstrated in a series of epidemiology studies of rubber fabrication facilities throughout the world. Cancer was also found in some other locations, but the data on exposures were insufficient to attribute a specific work task or exposure to the cancer.

One especially relevant report addressed exposures in a factory in Taiwan that made tire crumbs. In that study, mutagenic actions that were four to five times higher than in controls were shown in extracts of particulate matter collected in the air. These results indicate that the organic-dissolved portion of rubber particles contains various nitre-containing vulcanization stabilizers and accelerators, as well as process degradation products. Benzothiazole and 9-octadecenamide were identified as structures that would be converted to the N-nitrosamines under certain conditions.<sup>3</sup>

An unpublished 2006 Rutgers University study of tire crumbs taken from synthetic turf fields in New York City identified six polycyclic aromatic hydrocarbons (PAHs) at levels that reportedly exceeded the regulatory levels in New York State. These six compounds are highly likely to be carcinogenic to humans. The researchers caution that the availability of the carcinogens in the rubber is not established because solvent extraction was used to release the chemicals from the tire crumbs.





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The Office of Environmental Health Hazard Assessment (OEHHA) of the California Department of Health prepared a report on potential risks, including carcinogenesis, from the use of recycled tire materials on playgrounds.<sup>4</sup>

A literature review of studies of the release of chemicals from recycled tires in laboratory settings and field studies found 49 chemicals, seven of which were carcinogens.

In a study that modeled gastric digestion 22 chemicals were identified.<sup>5</sup> Hand-to-mouth activity was examined using wipe samples; researchers found four polycyclic aromatic hydrocarbons (PAHs) and one metal, zinc. There also were 46 separate laboratory or field studies that reported either volatile organic compounds (20 studies), semi-volatiles (20 studies), or metals (29 studies). Some mentioned particulate collection.

## ALLERGIC RESPONSES

Allergies are addressed in studies from both California<sup>6</sup> and Norway,<sup>7</sup> indicating a moderate level of health concern. Inadequate data are available to address the concerns about allergic reactions, but it is possible that sensitized individuals will respond to the exposures. With so many children having asthma today, this is a real concern.

Furthermore, the Norway study<sup>8</sup> indicates high levels of latex exposures from the tire crumbs and recommends that such fields not be installed because of the high prevalence in the population of latex sensitivity.

## SKIN, EYE, AND RESPIRATORY IRRITATION

Skin, eye, and respiratory irritation is the most common action identified in the literature for these chemicals.<sup>9</sup> That probably reflects the regulatory requirement for such testing before the chemical can be shipped in commerce. These studies are the most basic of the toxicology testing schemes expected for materials with continuous human exposures. Based on the chemical structures of the aliphatic chemicals present, it is not surprising that they are listed as severe irritants. The irritation potential of aliphatic compounds increases with chain length up to 10 carbons and with increased branching of the molecules.

## THYROID EFFECTS AND NEUROLOGICAL EFFECTS

Other actions reported are thyroid effects, neurological effects, and systemic toxicity related to the liver and the kidneys. There is insufficient exposure information to assess whether these effects would be seen with the releases from ground-up recycled tires used on synthetic turf fields or in gardening mulch.

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## RELEASE OF METALS TO ENVIRONMENTAL MEDIA

The metals zinc, cadmium, and lead were also identified as contaminants from tire rubber released into ground water.<sup>10</sup> With the exception of zinc, there are insufficient data to assess the health or environmental risks of any of these metals. It appears clear that the zinc levels are high enough to be phytotoxic if they enter the ground water or soil. It is doubtful that there is any human toxicity from zinc at the levels reported, but such a conclusion would have to be tested by more careful study.

## PARTICULATES RELEASED TO THE AIR

Finally, the particulate exposures due to tire dust and chemicals contained in the dust that can be released in the lungs are especially troublesome. Nearly every test adequate to assess the risk that was reported found one or two dozen compounds released from particulates.<sup>11</sup> There are processes in the body that can release the chemicals contained in the rubber particles. Moreover, potent carcinogens are found in the tire dust. Only the assumption of limited exposure could support the conclusions of low cancer risk.

## SUMMARY OF TOXIC ACTIONS

In summary, the toxic actions of concern from the materials that were released from recycled crumb rubber include:

- Severe irritation of the respiratory system
- Severe irritation of the eyes, skin and mucous membranes
- Systemic effects on the liver and kidneys
- Neurotoxic responses
- Allergic reactions
- Cancers
- Developmental effects



## OTHER REPORTS ON RUBBER TIRE CRUMBS WITH ANALYTICAL DATA

A report from the Swedish Chemical Agency (KEMI) lists the materials in tires.<sup>12</sup> Tires contain over 60 different substances—40% is rubber; the rest is carbon black, high aromatic oils, sulfur and various metals. Rubber is elastic polymers. The most common types of synthetic rubber are styrene-butadiene rubber and ethylene propylene rubber. Vulcanizing agents are used in manufacture, and fillers, antioxidants and plasticizers are added for technical properties. A large number of high aromatic oils are added, including polyaromatic hydrocarbons, phthalates that can leach into water, phenols, metals including zinc, and low concentrations of lead.

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## ESTIMATE OF THE SCALE OF EXPOSURES TO BENZOTHIAZOLE FROM TIRE CRUMB IN-FILL ON A SOCCER FIELD



The exposure potential on a soccer field could be quite large. A square foot of a field with between two and three inches of in-fill would have between five and seven kilograms of tire crumbs, which translates to between 11 and 15 pounds. If the findings from Table 2 in the Connecticut Agricultural Experiment Station study (page 30) are used as a reference, the emissions from the square foot of surface would approach four to six grams on a hot day when the surface approaches 60 degrees C (140 degrees F). Considering the actual size of the soccer fields, that would be substantial release into the ambient air. Actual exposure measurements are needed to determine the potential inhalation risks for players on the field or for spectators and nearby residents.

This same scale of analysis is needed for each of the agents shown to be released and the respirable dusts. If the tire crumbs are carried into a building or an automobile, similar analysis is necessary. EHHI has concluded that the currently available information is sufficient to raise plausible concerns for health risks, but is insufficient to determine how large those risks are.

### PROBLEM STATEMENT

The use of recycled rubber as in-fill on athletic fields, as gardening mulch, or subsurface fill under playground equipment involves direct exposures by children and adults to dusts and chemicals that would be released from the tire crumbs. A review of findings from the currently available reports on health and safety found important gaps in the information needed to determine the public health and environmental risks involved. The following is not fully known for ground-up rubber tire products:

- What are the chemicals actually present in the exposure pathways
- How great is the release of chemicals present in rubber dust under the conditions of use
- What are the toxic actions of the chemicals that are released
- What is the amount of exposure(s) from inhalation, dermal contact or ingestion

The gaps in the available information make it difficult to determine whether the proposed use of recycled tire crumbs in playing fields or playgrounds can be deemed safe.