



Is Cardboard Mulch Toxic?

By Robert Turner



Is cardboard mulch toxic? Recent research shows PFAS can accumulate in crop vegetables. A simple home test can reduce risks when mulching with cardboard boxes.

Over the past decade, cardboard boxes have become a frequent visitor to many households, ultimately ending up in landfills and recycling facilities – but also in garden beds. In 2019, Amazon alone shipped about 2.5 billion packages around the world, and this was before the COVID-19 pandemic, when the company estimates its global shipping increased by at least 30 percent. Millions of backyard gardeners use cardboard to control weeds, retain moisture, and regulate soil temperature. Some of us till the carbon-rich cardboard into our soil.

While mulching with cardboard sustainably gives an old box new life, is it safe? Given the prevalence of PFAS – the class of “forever chemicals” mentioned in the Dear Mother department of the December 2023/January 2024 issue – in packaging, we could introduce scary inputs into our soil (and homegrown food) from a seemingly innocuous practice.

Thankfully, by taking precautions and performing a simple home test, you can use cardboard in the garden with lowered risk. But first ...

PFAS Meaning?

PFAS are per- and polyfluoroalkyl substances, a group of nearly 15,000 industrial chemicals characterized by one of the strongest chemical bonds in nature, created when the elements carbon and fluorine fuse together. The bond doesn't easily break apart in the environment (or in our bodies), even over thousands of years, which is why PFAS have come to be called “forever chemicals.”

What Food Packaging Contains PFAS

People assume PFAS are the stuff of recent industrial science. But PFAS have served as a water- and grease-resistance agent in food packaging since the 1950s. Today, their waterproofing properties safeguard clothing, tents, carpet, and firefighting foam. The chemicals also exist in food and cosmetics vessels, from the nonstick coating on pots and pans to shampoo bottles. Most paper straws even include PFAS, allowing them to stand up to liquids, as do molded-fiber bowls marketed as compostable.

In 2021, [The Guardian](#) revealed how chemical manufacturers hid research showing that fluorotelomers, a subgroup of PFAS that the industry had claimed was safe for food containers, may be highly toxic. A more recent study showed how toxic compounds can transfer from packaging into food. These revelations led the U.S. Food and Drug Administration to reach a “voluntary agreement” with several large packaging producers that have committed to a five-year phaseout of fluorotelomers. Yet, fast-food paper boxes, paper cups, microwaveable popcorn bags, and butter wrappers are only some of the packaging that still tests positive for fluorotelomers.



Tests routinely show PFAS in soils, rain and snow, groundwater, tap water, rivers and lakes, the upper atmosphere, food of all kinds, and throughout our homes. The Environmental Working Group maintains a map of known [sites contaminated by PFAS](#), identifying 5,021 of them in February 2024, with locations in all 50 states.

PFAS surround us and bioaccumulate, meaning they move up the food chain. Nearly every human and animal body will now test positive for PFAS. One report by the Centers for Disease Control and Prevention determined PFAS are found in the blood and tissue of 97 percent of the U.S. population.

Human Health Concerns

The most widely studied PFAS, known as “endocrine disruptors,” mess with our hormonal systems. PFAS studies performed on animals – which often expose test subjects to higher chemical levels than humans would normally encounter – have shown PFAS exposure may reduce an animal’s immune response, damage the liver and pancreas, and disrupt development stages in babies (even at low levels). PFAS have been detected in wild marine mammals, seabirds, and land animals worldwide. Polar bears in remote parts of Greenland exhibit levels high enough to cause neurological damage.

Studies on humans show links between PFAS exposure and a wide range of health concerns. Buildup in the body might impede growth and learning, cause behavioral problems, and lead to cancer, immune system disorders, fertility problems, and obesity. One well-studied PFAS subgroup found in drinking water samples, perfluorooctanoic acid (PFOA), has been linked to high cholesterol, ulcerative colitis, thyroid disease, testicular cancer, kidney cancer, and pregnancy-induced hypertension. PFAS can cross the human placenta, meaning babies are born with these industrial chemicals already in their bodies.

Advocates compare the ubiquity of PFAS to the once-common practice of adding lead to gasoline: We're liable to be making a major societal misstep before fully understanding the human health implications of these additives.

PFAS in Agriculture

Food containers aren't the primary way we encounter PFAS. The National Institutes of Health (NIH) found PFAS in the food itself. NIH research shows that a large variety of plant species readily absorb PFAS from the soil, water, and air. Crops absorb PFAS molecules through their roots, but plant leaves can also uptake from the atmosphere. PFAS travel into farm fields through industrial emissions, contaminated irrigation water, leachate from nearby landfills, and pesticides.

Regions of the country where wastewater is reclaimed and used for irrigation are particularly susceptible. The state of Maine's Department of Agriculture, Conservation and Forestry (DACF) established a \$60 million fund to help farmers whose land tested positive for PFAS contamination, likely because of recycled wastewater used for irrigating and biosolids (sludge) from treatment plants. The practice of applying wastewater residuals to farmland is an approved practice by the Environmental Protection Agency (EPA) nationwide, and the original sources of forever chemicals in reclaimed water are nearly impossible to determine. The first-of-its-kind DACF fund will provide impacted farmers with financial assistance, purchase contaminated farmland from willing sellers, and accelerate research to help inform on-farm management decisions.



While different crops show variation in the degree to which each takes up PFAS, for the most part, higher concentrations in the soil mean greater bioaccumulation of forever chemicals in all plants. My takeaway from all of this research is that PFAS can enter our bodies when we eat plant foods, so we should be conscious of what we put into our soil – or on top of it, in the case of cardboard mulch.

Is Cardboard Mulch Toxic?

The standard cardboard box consists of wood pulp, glue, and ink for lettering. The outer layers of cardboard are manufactured from the long wood fibers of softwood trees, and the middle, corrugated sections are made from shorter hardwood fibers. The glue holding fibers together is typically a corn-based starch adhesive safe for your garden. (Glues are also made from rice, wheat, and potatoes.) The standard black ink used on most shipping boxes is also vegetable-derived and harmless for garden applications. Unrelated to PFAS, some cardboard contains antimicrobial chemicals to prevent bacterial growth, which may impact healthy microbial life if the cardboard is used as ground cover.

Because much of the cardboard I use in my garden comes from Amazon boxes, I emailed a representative at Amazon about its practices. They told me toxic chemicals aren't used on company packaging, and the company doesn't spray its boxes. Amazon says it strives to incorporate as much recycled cardboard into its boxes as possible – and herein lies a potential risk. Corrugated cardboard boxes are the most recycled packaging material in the United States, according to the EPA. The cardboard is re-pulped, separated, bleached, screened, and cleaned to eliminate contaminants, but not PFAS chemicals. Because recycling mixes paper and cardboard from different sources, it's easy to include PFAS-coated material.

Don't let this information completely derail your garden plans. Even if PFAS chemicals from food packaging make their way into recycled shipping boxes, the concentration of PFAS molecules will be greatly reduced, minimizing the risk of plant uptake later on.

What You Can Do

PFAS molecules are now so prevalent that it's impossible to escape them completely. Cardboard mulch doesn't appear to add significant risk, and the benefits of sustainably reusing a box likely outweigh potential risks. Still, reduce your risk as much as possible. See "Test Your Cardboard," below, for a simple test you can perform for peace of mind.

Use only brown boxes in your garden, because they retain the natural color of tree pulp. Never use white boxes or those with colorful printing or wax coatings. Bleached boxes can contain chlorine and dioxin. Black inks, usually vegetable-based, should be OK. Remove labels, which often have chemical coatings for weatherproofing. Despite many plant-based glues, others have unsafe chemicals, so you may want to cut off a seam where a box is glued together. Remove any staples.

To help the cardboard break down into carbon molecules, cover it with leaves, straw, or wood mulch to retain moisture and help soil microbes do their business. Never use colored or dyed decorative wood mulch in the garden.

Test Your Cardboard

PFAS change surface tension to repel liquids, such as oils, fats, and water. Check for PFAS in cardboard by conducting a simple “bead test” using olive oil. The test relies on the opposing polarity between olive oil and fluorinated molecules, which causes a droplet of oil to form a distinct bead in the presence of PFAS. Beading doesn’t definitively mean PFAS are present, but it is one indicator. Inks or wax coatings can interfere with results.

To perform a bead test, simply drop a small amount of olive oil onto cardboard and watch what happens after a minute or so. Does the droplet soak in, spread out, or form a perfect little bead? Try testing both sides of the cardboard.



Soaking in likely means no water- or grease-proof barrier is present. Spreading out indicates the possible presence of a grease-proof barrier; however, spreading out suggests no physical repulsion between the oil and the surface material, so the cardboard was most likely sealed with a non-fluorinated (PFAS-free) finish. A perfect bead could indicate the presence of PFAS; this oleophobic function is difficult to replicate in non-fluorinated materials.

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