Road Hazard: Evidence Mounts on Toxic Pollution from Tires

Highway traffic in Colombo, Sri Lanka. Thilina Kaluthotage/NurPhoto via AP

Researchers are only beginning to uncover the toxic cocktail of chemicals, microplastics, and heavy metals hidden in car and truck tires. But experts say these tire emissions are a significant source of air and water pollution and may be affecting humans as well as wildlife.

By Jim Robbins on September 19, 2023

For two decades, researchers worked to solve a mystery in West Coast streams. Why, when it rained, were large numbers of spawning coho salmon dying? As part of an effort to find out, scientists placed fish in water that contained particles of new and old tires. The salmon died, and the researchers then began testing the hundreds of chemicals that had leached into the water.

A 2020 paper revealed the cause of mortality: a chemical called 6PPD that is added to tires to prevent their cracking and degradation. When 6PPD, which occurs in tire dust, is exposed to ground-level ozone, it's transformed into multiple other chemicals, including 6PPD-quinone, or 6PPD-q. The compound is acutely toxic to four of 11 tested fish species, including coho salmon.

Mystery solved, but not the problem, for the chemical continues to be used by all major tire manufacturers and is found on roads and in waterways around the world. Though no one has studied the impact of 6PPD-q on human health, it's also been detected in the urine of children, adults, and pregnant women in South China. The pathways and significance of that contamination are, so far, unknown.

Seventy-eight percent of ocean microplastics are synthetic tire rubber, according to one estimate.

Still, there are now calls for regulatory action. Last month, the legal nonprofit Earthjustice, on behalf of the fishing industry, filed a notice of intent to sue tire manufacturers for violating the Endangered Species Act by using 6PPD. And a coalition of Indian tribes recently called on the EPA to ban use of the chemical. “We have witnessed firsthand the devastation to the salmon species we have always relied upon to nourish our people,” the Puyallup Tribal Council said in a statement. “We have watched as the species have declined to the point of almost certain extinction if nothing is done to protect them.”

The painstaking parsing of 6PPD and 6PPD-q was just the beginning of a global campaign to understand the toxic cocktail of organic chemicals, tiny particles, and heavy metals hiding in tires and, to a lesser extent, brakes. While the acute toxicity of 6PPD-q and its source have strong scientific consensus, tire rubber contains more than 400 chemicals and compounds, many of them carcinogenic, and research is only beginning to show how widespread the problems from tire dust may be.

Researchers weigh a salmon that died after four hours in a tank filled with road runoff. Ted S. Warren / AP Photo

While the rubber rings beneath your car may seem benign — one advertising campaign used to feature babies cradled in tires — they are, experts say, a significant source of air, soil, and water pollution that may affect humans as well as fish, wildlife, and other organisms. That’s a problem because some 2 billion tires globally are sold each year — enough to reach the moon if stacked on their sides — with the market expected to reach 3.4 billion a year by 2030.

Tires are made from about 20 percent natural rubber and 24 percent synthetic rubber, which requires five gallons of petroleum per tire. Hundreds of other ingredients, including steel, fillers,

and heavy metals — including copper, cadmium, lead, and zinc — make up the rest, many of them added to enhance performance, improve durability, and reduce the possibility of fires.

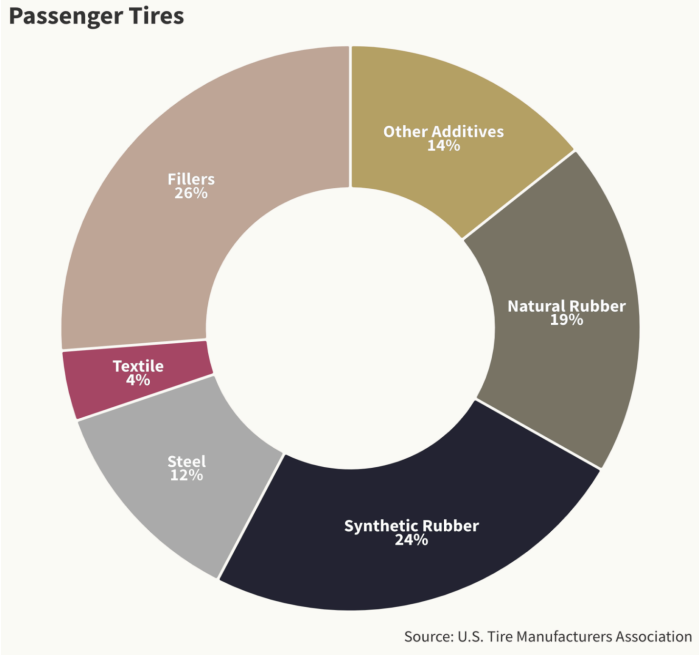
Both natural and synthetic rubber break down in the environment, but synthetic fragments last a lot longer. Seventy-eight percent of ocean microplastics are synthetic tire rubber, according to a report by the Pew Charitable Trust. These fragments are ingested by marine animals — particles have been found in gills and stomachs — and can cause a range of effects, from neurotoxicity to growth retardation and behavioral abnormalities.

Tire emissions from electric vehicles are 20 percent higher than those from fossil-fuel vehicles.

“We found extremely high levels of microplastics in our stormwater,” said Rebecca Sutton, an environmental scientist with the San Francisco Estuary Institute who studied runoff. “Our estimated annual discharge of microplastics into San Francisco Bay from stormwater was 7 trillion particles, and half of that was suspected tire particles.”

Tire wear particles, or TWP as they are sometimes known, are emitted continually as vehicles travel. They range in size from visible pieces of rubber or plastic to microparticles, and they comprise one of the products’ most significant environmental impacts, according to the British firm Emissions Analytics, which has spent three years studying tire emissions. The company found that a car’s four tires collectively emit 1 trillion ultrafine particles — of less than 100 nanometers — per kilometer driven. These particles, a growing number of experts say, pose a unique health risk: They are so small they can pass through lung tissue into the bloodstream and cross the blood-brain barrier or be breathed in and travel directly to the brain, causing a range of problems.

According to a recent report issued by researchers at Imperial College London, “There is emerging evidence that tyre wear particles and other particulate matter may contribute to a range of negative health impacts including heart, lung, developmental, reproductive, and cancer outcomes.”



Yale Environment 360

The report says that tires generate 6 million tons of particles a year, globally, of which 200,000 tons end up in oceans. According to Emissions Analytics, cars in the U.S. emit, on average, 5 pounds of tire particles a year, while cars in Europe, where fewer miles are driven, shed 2.5 pounds per year. Moreover, tire emissions from electric vehicles are 20 percent higher than those from fossil-fuel vehicles. EVs weigh more and have greater torque, which wears out tires faster.

Unlike tailpipe exhaust, which has long been studied and regulated, emissions from tires and brakes — which emit significant amounts of metallic particles in addition to organic chemicals — are far harder to measure and control and have therefore escaped regulation. It's only in the last several years, with the development of new technologies capable of measuring tire emissions and the alarming discovery of 6PPD-q, that the subject is receiving much needed scrutiny.

Recent studies show that the mass of PM 2.5 and PM 10 emissions — which are, along with ozone and ultrafine particles, the world's primary air pollutants — from tires and brakes far exceeds the mass of emissions from tailpipes, at least in places that have significantly reduced those emissions.

Tires release 100 times the amount of volatile organic compounds as a modern tailpipe, says an analyst.

The problem isn't just rubber in its synthetic and natural form. Government and academic researchers are investigating the transformations produced by tires' many other ingredients,

which could — like 6PPD — form substances more toxic than their parent chemicals as they break down with exposure to sunlight and rain.

“You’ve got a chemical cocktail in these tires that no one really understands and is kept highly confidential by the tire manufacturers,” said Nick Molden, the CEO of Emissions Analytics. “We struggle to think of another consumer product that is so prevalent in the world, and used by virtually everyone, where there is so little known of what is in them.”

“We have known that tires contribute significantly to environmental pollution, but only recently have we begun to uncover the extent of that,” said Cassandra Johannessen, a researcher at Montreal’s Concordia University who is quantifying levels of tire chemicals in urban watersheds and studying how they transform in the environment. The discovery of 6PPD-q has surprised a lot of researchers, she said, because they have learned that “it’s one of the most toxic substances known, and it seems to be everywhere in the world.”

Regulators are playing catch up. In Europe, a standard to be implemented in 2025, known as Euro 7, will regulate not only tailpipe emissions but also emissions from tires and brakes. The California Environmental Protection Agency has passed a rule requiring tire makers to declare an alternative to 6PPD by 2024.

A worker takes apart a tire at a recycling shop in Mit al-Harun, Egypt. Khaled Desouki / AFP

Tire companies are conducting their own studies of 6PPD, which they have long considered critical for tire safety, and seeking alternatives. In response to new regulations and the emerging research on tire emissions, 10 of the world’s large tire manufacturers have formed the Tire Industry Project to “develop a holistic approach to better understand and promote action on the mitigation” of tire pollution, according to a statement by the project. The group has committed to search for ways to redesign tires to reduce or eliminate emissions.

One critical area of research is how long tire waste, and its breakdown products, persist in the environment. “A five-micron piece of rubber shears off the tire and settles on the soil and sits there a while,” said Molden. “What, over time, is the release of those chemicals, how quickly do they make their way into the water, and are they diluted? At the system level, how big of a problem is this? It is the single biggest knowledge gap.”

Another area of research centers on the impacts of aromatic hydrocarbons — including benzene and naphthalene — off-gassed by synthetic rubber or emitted when discarded tires are burned in incinerators for energy recovery. Even at low concentrations, these compounds are toxic to humans. They also react with sunlight to form ozone, or ground-level smog, which causes respiratory harm. “We have shown that the amount of off-gassing volatile organic compounds is 100 times greater than that coming out of a modern tailpipe,” said Molden. “This is from the tire just sitting there.”

Scientists found that rain gardens could prevent more than 90 percent of a dangerous tire pollutant from entering streams.

When tires reach their end of life, they’re either sent to landfills, incinerated, burned in an energy-intensive process called pyrolysis, or shredded and repurposed for use in artificial turf or in playgrounds or for other surfaces. But as concern about tire pollutants grows, so do concerns about these recycled products and the hydrocarbons they may off-gas. There is ongoing debate over whether crumb rubber, made from tire scraps, poses a health threat when used to fill gaps in artificial turf. Based on several peer-reviewed studies, the European Union is instituting stricter limits on the use of this material. Other studies, however, have shown no health impact.

Besides California’s requirement to study alternatives to 6PPD, there are a number of efforts worldwide to redesign tires to counter the problems they pose. More than a decade ago, tire makers hoped that dandelions, which produce a form of rubber, and soy oil could provide a steady and sustainable supply of rubber. But tires made from those alternatives didn’t live up to expectations: they still required additives. The Continental Tire Company, based in Hanover, Germany, markets a bicycle tire made of dandelion roots. Tested by Emission Analytics, it emitted 25 percent fewer carcinogenic aromatics than conventionally made bike tires, but the plant-powered tire still contained ingredients of concern.

Rubber made from dandelions. Continental

Other companies are searching for ways to address the problem of tire emissions. The Tyre Collective, a clean-tech startup based in the U.K., has developed an electrostatic plate that affixes to each of a car's tires: The plates remove up to 60 percent of particles emitted by both tires and brakes, storing them in a cartridge attached to the device. The particles can be reused in numerous other applications, including in new tires.

In San Francisco, scientists studying the pollutants in storm runoff found a potential solution: Rain gardens, installed in yards to capture stormwater, were also trapping 96 percent of street litter and 100 percent of black rubbery fragments. In Vancouver, B.C. researchers found that rain gardens could prevent more than 90 percent of 6PPD-q from running off roads and entering salmon-bearing streams.

Tire waste particles, says Molden, of Emissions Analytics, are finally getting the attention they deserve, thanks in part to California's rule requiring a search for alternatives to 6PPD. The legislation "is groundbreaking," he says, "because it puts the chemical composition [of tires] on the regulatory agenda." For the first time, he adds, "Tire manufacturers are being exposed to the same regulatory scrutiny that car manufacturers have been for 50 years."