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Tire Pollution and Coho Salmon



Figure 1: Tires lose about 20% of their weight during their lifetime of wear on the road. The lost material becomes chemical-laced microplastics released into the environment.

Introduction

This past year, you may have heard of a study (Tian et al., 2021) that linked a chemical compound in car tires to major toxicity in coho salmon. This study was the culmination of decades of work by many scientists on “pre-spawn mortality” in coho salmon that were exposed to roadway stormwater runoff. The final study to identify the culprit chemical included many local researchers at the University of Washington Tacoma’s Center for Urban Waters, Washington State University Puyallup, and local offices for state and federal agencies. Their results were published in the journal *Science* in January of 2021. It is worth reviewing the efforts that led to this discovery to show how dedicated scientists and other stakeholders can work together to solve problems and better our understanding of how we impact the world around us. It also illustrates how finding the root of the problem is only half the battle.

The problem

Decades before this study was undertaken, biologists around the Puget Sound had begun noticing an unusual condition that was afflicting adult coho salmon as they returned to streams to spawn. Fish would become disoriented, swimming in circles or in random directions at the water’s surface, mouths gaping open. As the condition worsened over several hours, they would tip over onto their sides, go stiff, and die.



Figure 2: An adult coho salmon makes its way up the Salmon River in Oregon to spawn. Coho salmon proved especially vulnerable to the condition known as “urban runoff mortality syndrome”, which was linked in 2020 to a chemical in car tires. **Image Credit:** [Bureau of Land Management Oregon and Washington](#) / Public Domain. Wikimedia Commons.

Researchers were surprised at two aspects of the disease. First, only coho salmon seemed to be impacted. Other species such as chum or Chinook salmon didn’t appear vulnerable to this particular ailment. Second, there was no obvious culprit that was causing the condition, despite how widespread it was. Fish were becoming sick in the absence of any major chemical spills, pathogen outbreaks, or dangerous environmental conditions like low dissolved oxygen or high-water temperatures. Work on the problem continued, and in 2011 several studies were published that pointed towards a likely culprit: roadway runoff.

Upwards of 50% (sometimes as high as 90%) of fish in urban waterways were contracting the disease, while almost none were in streams in undeveloped areas. Motor vehicles specifically were implicated, as prevalence of the condition was correlated with the proportion of local roads and the extent of impervious surface. In 2017, this relationship was refined even further based on the density of motor vehicle traffic.

Motor vehicles were well known by this time to be the source of many potentially toxic chemicals, including copper and zinc in brake pads, leaking oil, and chemical compounds in tires as they wore down. These can all be carried into streams in stormwater runoff from roadways. Finding the exact chemical causing the condition in coho salmon, however, would prove to be difficult.

The study

Concern about “urban runoff mortality syndrome”, as it came to be known, grew over time. The Puget Sound population of coho salmon are a species of concern under the Endangered Species Act. So, the presence of a toxin that could wipe out 90% of a stream’s adults *before* they could reproduce was certainly a concern. Its connection with urban roadway runoff also meant that the condition would likely become more prevalent as the Puget Sound region continued to urbanize and grow in population.

By 2018, a team of scientists had narrowed the likely cause of the condition to one or more chemicals found in car tires. Much more than just rubber, modern automobile tires contain a multitude of chemicals designed to give the tires better durability, comfort, and performance. As the tires hit pavement and are exposed to the environment, they break down slowly, and bits of tire can be left on the roadway and carried into streams by

stormwater runoff. The toxicity of many of these chemicals is unknown, and so it would take some thorough testing and a creative approach to find the culprit (or culprits) killing coho salmon.

The team that put together the final study (Tian et al., 2021) included 27 researchers from the University of Washington Tacoma and Seattle, Washington State University Puyallup, the University of Toronto Scarborough, and a variety of partner institutions including NOAA, the U.S. Fish and Wildlife Service, and Washington Department of Fish and Wildlife. Starting with over 2,200 possible chemicals, the team divided them into smaller and smaller batches, progressively ruling out any batches that weren't toxic to coho salmon in the lab. This allowed them to test all the chemicals without having to test each one individually. Eventually, a single chemical was found to produce the condition. It had the formula $C_{18}H_{22}N_2O_2$. There was just one problem: it didn't match any known chemicals in automobile tires.

After some more research and testing, the connection became clear when a similar chemical, $C_{18}H_{24}N_2$, called 6PPD, was found in tires. 6PPD helps protect rubber from being degraded from contact with ozone in the air. However, it does this by reacting with the ozone itself, forming the deadly chemical $C_{18}H_{22}N_2O_2$ as a byproduct. The study dubbed this new transformation product "6PPD-quinone", and it proved to be around 100 times more toxic to coho salmon than the original 6PPD. Coho salmon exposed to 6PPD-quinone exhibited all the symptoms of the deadly disease that were present in wild coho, with onset within a couple hours.

The good news was that filtering the water, such as through a soil medium, removed the dissolved 6PPD-quinone, rendering the water safe for coho salmon. The bad news was that 6PPD-quinone is found in just about every car tire around the world, and filtering all stormwater runoff is about as infeasible as it sounds.

The outlook

The breakthrough study that found 6PPD-quinone as the cause of "urban runoff mortality syndrome" has given hope to scientists trying to help coho salmon recover. However, that hope has been tempered by the knowledge of what it will take to get 6PPD-quinone out of our streams. The study's authors proposed several approaches that tire companies and government regulators could take to pursue this, though none are easy. One approach involves adding more stormwater treatment features like rain gardens in certain highly sensitive areas, but there is doubt that treatment alone will remove chemicals from enough streams to completely solve the problem. Another approach is finding a new "greener" chemical to replace 6PPD as an ozone blocker in tires, but this involves significant time and testing to make sure any new chemical is truly safer and still adequately protects the tires. Progress on both of these approaches is already underway, as are additional studies to refine our understanding of the nature and extent of 6PPD-quinone's toxicity.

In the meantime, there are several actions we can take to minimize our own contributions to tire pollution:

1. Make sure you keep your tires properly inflated. This minimizes wear.
2. Replace any damaged tires on your vehicles.
3. Don't store old tires outside where they can contaminate stormwater. Instead, dispose of them properly.
4. Encourage stormwater filtration through soil by limiting unnecessary impervious surface on your property.
5. Drive less aggressively, especially during braking.
6. Drive less overall.

Finally, the study's authors have also framed their work as a cautionary tale. There are thousands of chemicals and even more transformation byproducts that humans release into the environment every day that have not been thoroughly tested for safety. It is likely that more of them might be impacting other species in ways less

visible or dramatic as what has been happening with coho salmon. Additional studies have already begun to look into whether and how 6PPD-quinone impacts other species. The researchers also hope that their method of screening a wide variety of chemicals for safety can be used in other settings to help this kind of research in the future.

Resources

Puget Sound Starts Here is a collaborative effort among many organizations to educate the public about proper stormwater management. Learn more about how you can help here: <https://www.pugetsoundstartshere.org/>

The Washington State Department of Ecology also has a quick 4-page reference on stormwater management for public education: <https://apps.ecology.wa.gov/publications/SummaryPages/0710058.html>

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