A ubiquitous tire rubber–derived chemical induces acute mortality in coho salmon

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For decades, there has been a mystery plaguing the urban streams of the Puget Sound region near the Salish Sea. Something has been creating a dramatic effect on migrating salmon, especially the coho salmon (*Oncorhynchus kisutch)*. Coho are born in rivers, and when they are young, they migrate to the ocean to grow into fat adults. They spend much of their lives in the ocean growing and becoming strong, and then, when rainwaters swell rivers in the Pacific Northwest, they begin to migrate back to freshwater to spawn in the creeks of their births. It's a lot of work, and this journey is made more difficult in the Puget Sound. The salmon are entering the rivers filled with lots of runoff from urban stormwater, the water that runs over our roads and into stormdrains that drain into creeks, rivers, and bays. Here they are gasping for air, swimming in circles and dying in just hours. This has been coined the term "urban runoff mortality syndrome," or URMS. Between 40-90% of the returning salmon are dying from URMS in about 40% of land in the Puget Sound region. The scientists in this study asked why is this happening? And even more importantly, what is the chemical killing the salmon? Finally, they solved it.

Coho salmon (*photo from NOAA*)

A team of scientists with different areas of expertise worked together to uncover clues. The team included researchers from the University of Washington, Washington State University, and the Center for Urban Waters in Tacoma. The research took many years. Chemistry and biology were both very important in figuring out what is in the water and what it is coming from.

Over 2,000 chemicals were tested in stormwater to answer these questions. Chemicals were tested in a lab, and from there they determined that waters associated with URMS had chemicals present that were similar to road water runoff and particles that get rubbed off of car tires onto streets when cars drive. But what chemical in tires was the culprit? The scientists then used

chemistry again to identify specific toxins and tested them on coho salmon during spawning. Coho behavior was monitored and recorded when each chemical was put into the water they were being kept in. They were kept for varying test lengths of 24-72 hours in the water while having their behaviors monitored.

Time after time, the researchers were coming up short to figure out what specifically is in the stormwater runoff that is so terrible for salmon. Over decades, scientists kept focusing on the problem, until recently, a breakthrough! Researchers know that chemicals and elements have the potential to modify and change into new substances when they come in contact with other chemicals or elements. Just consider oxygen: oxygen contacts other elements, like nitrogen, hydrogen, carbon, and others, and it forms new substances, like water, air, and carbon dioxide. Knowing this fact of chemistry, the scientists considered how the chemicals in the waters they were testing could change when coming into contact with the environment, rather than just studying how they behave in a lab as stand-alone substances. Eureka! A breakthrough occurred.

Through many experiments with individual chemicals, and after reviewing a tire chemical report from the Environmental Protection Agency (EPA), the researchers discovered a chemical in tires that reacts with ozone in the environment. The chemical they tested was N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine, otherwise known as 6PPD. However, the issue wasn't just the chemical itself, but how it interacts in the environment. When 6PPD hits the environment, it becomes 6PPD-quinone. This means the chemical changed its structure. Upon testing salmon with exposure to this chemical, the salmon had exact symptoms as those trying to spawn and migrate in Puget Sound waterways- they were disoriented, they struggled to breathe, they swam in circles, and then they died within 2-6 hours. These results, plus the elimination of many other chemical suspects through testing, helped the scientists determine that they have found the Coho Killer!

The 6PPD chemical is in tires as a protectant to make them last longer and prevent cracking. What types of tires have 6PPD? Unfortunately, all of them. This chemical has been tested in Los Angeles and San Francisco where they are also dealing with issues involving urban runoff into waterways, but it is likely everywhere. URMS events occur in the fall with the fall coho run, but this is also coinciding with the fall rains that begin in the Pacific Northwest. This is bad luck for salmon, because all of the roadway tire dust that has been building during the drier summer months is then getting dumped in large quantities into the water with the salmon following all of the new rain.

The good news is, now that we know of this chemical as being as problem, we can begin to work to fix it. More studies need to be performed on 6PPD to determine its effects on other aquatic species. Many questions still remain that need further investigation. What are the effects of 6PPD on other aquatic species, both in freshwater and saltwater environments? Are old tires more toxic than new tires (so far, signs point to old tires as being worse)? How do we make tires salmon-safe? Does this affect people's health? On a positive note, it has been documented that *bio-filtrat*ion (using environmental substances like leaf litter, mosses, soil, etc.) purifies the toxic water and makes it safe for the salmon. It's an intimidating task to create enough bio-filtration to protect all of the Puget Sound region, and it's also a lot of work to create new environmentally-

safe tires and 6PPD replacements. But, with one step at a time, and with a team of efforts and solutions, we can all work together and hope for a salmon-safe future. It can be done!

Resources:

Article:
https://science.sciencemag.org/content/early/2020/12/02/science.abd6951

Seattle Times Article with video: https://www.seattletimes.com/seattle-news/environment/tire-dust-is-killing-salmon/

Coho photo: https://www.fisheries.noaa.gov/species/coho-salmon-protected