



# TECHNICAL Q+A

## ON STORMWATER AND TIRE CHEMICAL TOXICITY TO AQUATIC ORGANISMS

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The following document combines Q&A from two presentations on research into stormwater and tire chemical toxicity led by researchers at the Washington Stormwater Center. The first presentation was at a workshop on February 5, 2021 titled Toxics in Puget Sound hosted by the Stormwater Strategic Initiative Lead Team, part of the Puget Sound recovery system. The presentation was titled “Tires Kill Coho” and was given by Dr. Jenifer McIntyre (Washington State University) and Dr. Edward Kolodziej (University of Washington). The second presentation was for Salmon Safe B.C. on February 19, 2021. It was titled “Car Tires & Salmon Health” and was given by Dr. McIntyre.

Presentation for Tires Kill Coho (Toxics in Puget Sound, February 5, 2021):

<https://pspwa.box.com/s/h6x078v553ky3q8loqfibsrgt0znwf8>

Recording of Car Tires & Salmon Health (February 19, 2021):

<https://salmonsafe.org/tires/>

All of the presentations and documents from the Toxics in Puget Sound workshop—and a February 19th follow-up on strategy development—can be accessed at:

<https://pspwa.box.com/s/q6qfp7yqp2v6ann4vnmi2ma1inarp78s>

## IMPACTS ON SALMON AND OTHER SPECIES

### ***Does 6PPD accumulate in benthic invertebrates?***

Unknown at this time.

### ***Have there been similar observations of coho behavioral effects in other areas along the West Coast and has there been any coordination with municipalities to test for 6-PPD? Any chance that Atlantic salmon could be affected as well?***

Anecdotal observations of similar effects in coho from the Vancouver, BC region and Portland, OR region. We are unaware of any coordinated efforts in other regions to document this mortality phenomenon. No one currently measures 6PPD or its metabolites (including 6PPD-quinone) in receiving waters. 6PPD itself is very difficult to measure accurately because it has a very short half-life (very reactive).

### ***Why does it not affect other salmonids? Why Coho and not Chum?***

Bob, no answer yet. We are making progress on how stormwater/tires/6PPD-quinone make coho sick, which we hope will enable studies that focus on the interspecies differences in sensitivity.

### ***Do you think you will have the same effect if the coho is farm raised?***

*Ed K:* I would guess that if they were exposed to the same levels, it would have the same effect. (Real experts can feel free to correct if I'm wrong)

*Jen M:* we do not see a difference in the field between hatchery-raised and presumed-wild origin coho.

## STORMWATER

### ***Have you looked at 6PPD-Q concentrations at different points after the beginning of a storm event?***

Dr. Ed Kolodziej at UW-Tacoma has been doing exactly that during fall 2020. Results not yet published.

### ***Have you done test on your filtration system after more than 24 hours? The concern is accumulation of 6PPD inside the filter media?***

Having just discovered 6PPD-quinone, we have not yet conducted any studies to look at its accumulation in treatment systems. However, systems treating roadway runoff for many months continue to prevent acute mortality in coho salmon. The question will be when and if the treatment capacity can be overwhelmed.

### ***Can you tell me much about the level of tidal flushing or influence that was present in the areas you found the elevated levels?***

I presume this is regarding measurements in surface waters. Please check with Dr. Ed Kolodziej at UW for information about field sites.

### ***Were these relatively low flow water cycling areas? Trying to understand if this could be a relevant concern in the Lower Fraser Estuary here in British Columbia.***

Please check with Dr. Ed Kolodziej at UW for information about field sites.

**Could these findings be extended to antiozonants in general? (e.g., in building materials).**

Unknown at this time, but antiozonants in general are designed to be highly reactive and will produce transformation products that may not be toxic to biota.

## TIRES

***If it is the reaction of the tire particles with air pollution that causes the transformation to the lethal form, if tires are submerged (i.e., dumped into creeks as garbage or used as bank stabilization), will the reaction still occur to cause fish health impacts and mortalities? Or will the shedding of lethal contaminants continue to occur?***

Great question. Submerged tires will leach 6PPD-quinone that has already formed in the tire surface, but we suspect that new 6PPD-Q will not form underwater.

***Are the same chemicals present in the tires of other modes of transportation, such as bicycles?***

Jen here: Perhaps. There are likely some kind and amount of anti-ozonants in other common-use rubbers made from the same materials as vehicle tires. TBD how relevant these other sources may be.

Ed here: We do not have ingredients data for any of these different products that knowledge is not publicly available. I am sure some types of antioxidants are used in those rubbers too but do not know which ones.

***If you were about to purchase tires for your car, is there a brand or type I should focus on?***

I would love to be able to tell you this, but there is no information available yet into the variability of 6PPD or its transformation products in different tire brands.

***As you know, Okanogan County is much less populated than the Seattle area, and with infrequent rains. I was wondering how long the shed tire particles hang onto a road surface? i.e., if a summer's worth of tire particles will build up on roadways, could a hard rain take months for those contaminants into creeks all at once?***

Interesting question.

The tiniest particles may get blown off of the road from wind and/or turbulence, but the remainder will stay on or near the road. Plenty of particles are also embedded in the surface of the road. All of these will be sources for 6PPD-Q to leach with precipitation. Not all particles are mobilized by runoff when it rains, so those remaining particles will continue to leach chemical into runoff with subsequent rain events.

## 6PPD

***Is there any study regarding the relation between traffic stats on a highway and the 6PPD amount draining to the stormwater system?***

No. All of that monitoring work is yet to be done.

### ***Is the 6PPD a physical contamination or chemical or mix?***

6PPD is a chemical added as a powder to the liquid mixture of chemicals that are made into tires. The molecules present in the tires slowly migrate to the surface of the tire over time (they are insoluble in the tire chemical mixture and so are literally ejected over time). Once near the surface, ozone can reach the chemical and react with it to form 6PPD-quinone. This new chemical can dissolve in water, so when it has reached the surface of the tire or the surface of a particle worn from the tire, the chemical will be dissolved from the tire surface into water.

### ***Is there a point in time where the 6PPD-quinone becomes inert, and if so, any sense of how long it remains active/toxic?***

6PPD-Q will eventually be transformed or metabolized. Ultimately all organic chemicals 'mineralize' given enough time into CO<sub>2</sub> and H<sub>2</sub>O. We have no idea yet how, where, or when 6PPD-Q is further transformed by abiotic factors or metabolized by organisms.

### ***Runoff from direct discharge has been tested. What about discharge from treatment plants? Are their systems able to filter out 6PPD?***

No one knows yet. No studies I am aware of have measured 6PPD in wastewater and no one has yet had a chance to measure 6PPD-quinone in wastewater.

### ***Does 6PPD pose any risks to humans? I.e., swimming or drinking stream water that's been affected?***

Unknown at this time.

### ***Is there a compound that could bind to the 6PPDQ to isolate/ remove it from the water, or could prevent the severity of runoff in addition to green infrastructure?***

Unknown at this time.

## **OTHER USES**

### **Jen, what are your thoughts on tire crumbles on soccer play fields and the impacts on both the health of the kids playing on those fields and the crumbles that get into the surrounding creeks?**

It will be interesting to learn about the sensitivity of human cells to this new chemical we've identified. We do expect crumb rubber to also contain 6PPD and the ozonation product 6PPD-quinone. If inhaled, the quinone would therefore be able to interact with human lung and/or GI tissues.

### **Question for Jen: Were the tire manufacturers open to changing their practices to reduce or eliminate 6PPD in their process?**

Live answered. The industry is working collaboratively with Ecology, WSU and UWT.

### ***Is 6PPD also used in commercial roofing or asphalt roof tiles?***

*Ed K:* We do not know. Clearly, there are a number of rubber compositions in various consumer products whose chemical composition is a complete mystery, especially with respect to the transformation products they form in the environment. We need to better understand what is used in these products and what happens to these chemicals in the environment.

*Jen M:* Runoff from asphalt roof tiles is low in toxicity compared with some other roofing materials, but that was zebrafish embryos and not coho salmon.

### **We have a lot of athletic fields that might be suspect.**

*Ed K:* If residual 6PPD is still present in crumb rubbers (I think some almost certainly is) used in playing fields and other products, it should form 6PPDQ and other transformation products out on those fields too. I don't know what concentrations looks like, but some is probably there. We hope to conduct some of these studies.

## **GREEN INFRASTRUCTURE**

### ***Do we know that it is the soil specifically that binds the 6PPD in the biofiltration studies?***

We hope to have the opportunity to answer this question. 6PPD-quinone is hydrophobic so we do expect that it will be sequestered by organic matter in the biofiltration studies much the same way as other organic pollutants.

### ***Do you know if anyone has examined the effect of adding biochar to the infiltration galleries to increase removal of 6-PPD?***

No one has had a chance to do this yet. Biochar appears to be similarly effective as compost for many organic contaminants, so I suspect based on our work that biochar will remove 6PPD-quinone.

### ***Bio filtration was mentioned as one method of treatment but could other conventional methods of filtration (such as sand filtration) also possibly be effective?***

No. Sand filtration does not prevent the toxicity. This was directly tested in our study. Sand only stops contaminants that are 'particulate', i.e., bound to particles that can be physically filtered out by sand grains. 6PPD-Q is dissolved in water and passes right through the sand.

### ***Are there any specific green infrastructure BMPs that have been found to be more effective in mitigating the toxicology than others - guidelines on sizing/design criteria?***

Anecdotally based on Dr. Kolodziej's retrospective analysis of water samples from studies on bioretention and bioswales, bioretention (relying on infiltration) removed 6PPD-Q to below detection levels whereas bioswales (relying on horizontal flow over vegetation and compost) removed a majority of 6PPD-Q, but not all.

### ***Has there been any research into manufactured stormwater facilities' ability filter 6PPD quinone? In particular, there are filter media specific to metals removal, are there any media effective at removing the quinone.***

No research has yet been conducted to address this question.

***Is there any research underway looking at the mechanism by which 6PPD is removed by bio-retention? What types of molecules is it binding to? Can it remobilize?***

We have designed a study to investigate these questions but are waiting to see if the study will be funded.

***What do you foresee happening with contaminated soils that result from bioretention filtration systems? (Assuming they will need to be maintained by occasionally removing sediments from these systems)***

Exactly. However, it is possible that organic contaminants including 6PPD-Q will be microbially degraded in bioretention soils rather than building up over time. TBD.

***Do filters in stormwater processing vaults used by jurisdictions remove 6PPD?***

Unknown at this time.

***You referred to green roofs, downspout disconnect etc. on homes. Does that apply to other aspects of stormwater runoff or do roof shingles contain the same problem chemical?***

Roof shingles are unlikely to contain these same chemicals.

## RESEARCH

**Amazing work Jen and team! What are your next research questions?**

*Ed K:* I still want to better understand tire rubber compositions and potential links to water quality. There is still much to learn in these systems, especially with respect to the “trace additives” which always seem to be the problematic components when they get into the environment.

*Jen M:* I want to learn what other species are sensitive to this chemical (and to stormwater more broadly), how 6PPD-quinone triggers the acute mortality in coho and related species, and whether there are sub-lethal effects that we should be concerned with.

**Would drainage from crumb rubber soccer fields generate this?**

*Ed K:* If residual 6PPD is still present in crumb rubbers (I think some almost certainly is), it should form 6PPDQ and other transformation products out on those fields too. I don't know what concentrations looks like, but some is probably there.

**Have you considered genomic or proteomic approaches to begin to find a Mode of Action (MOA)?**

I welcome suggestions!

## TRANSPORTATION AND REGULATION

***In addition to source control, has there been discussion about aligning with public transportation and transit agencies in the area to support transportation methods that do not use tires with 6PPD?***

Great question! These conversations are beginning to take place. Please encourage your local jurisdiction to move in this direction!

***Could it be there is a traffic/trip density trigger for loss, something that is seen in Seattle but not other areas of Washington or Oregon?***

Yes.

***Have you discussed 6PPD-Quinone safer alternatives with the Safer Choice program through EPA?***

Not yet. It would be great if they got involved.

***Thoughts on the role that regulatory agencies (i.e. EPA in the U.S., Dept. of Ecology in WA or federal government depts in Canada) can or should play in encouraging the timely cooperation of the tire manufacturing industry?***

We have regulations that are sticks (e.g., Clean Water Act (CWA), tribal treating rights,) to move towards safer alternatives to 6PPD in tires, but I'd love to see more carrots, too.

***More of a policy question: would these findings allow for a new tax/charge on tire sales as a source of funds specifically for implementing green infrastructure to treat road runoff? Any existing policy examples?***

Great idea. I have no clue.

***In terms of public and decision-maker messaging, I'm concerned that a focus on controlling 6PPD at the source, getting it out of tires, might weaken interest in implementing green stormwater infrastructure. Is your research showing other chemicals, maybe not as toxic as 6PPD, that are detrimental to aquatic health and still require treatment by green stormwater infrastructure? How would you message this issue to decision-makers?***

I agree this is a messaging concern. There are plenty of other chemicals in stormwater that we want to treat before they reach receiving waters for which green infrastructure is well suited.

***What are the state regulators (e.g., WA Dept of Ecology) doing in response? are there any suggestions that the NPDES permit held by WSDOT or other transportation departments may need to be revised or reissued?***

Some of the actions being taken by WA Ecology of which I am aware is supporting additional research and developing a certified method for analytical measurement of 6PPD-Q in water samples.

## INDUSTRY RESPONSE

### ***Does the tire industry have an alternative to 6PPD?***

*Ed K:* The industrial chemical literature seems to suggest many options for antioxidant and antiozonant chemistries in rubber products. I am not aware of what the tire industry is doing in this space, most all chemical compositions of products, even ones widely dispersed in the environment, are not publicly accessible knowledge or documented in any systematic way. This remains a substantial barrier to truly understanding that chemicals are reaching the environment and what risks they pose to the environment or humans.

### ***What has been the response from the tire industry so far?***

<https://www.ustires.org/ustma-statement-regarding-university-washington%E2%80%99s-research-6ppd-quinone-and-coho-salmon>

### ***Has a tire treatment been tested to safely remove the "brown" quinone from surface of sidewalls of tires?***

No.

### ***Is use of 6PPD ubiquitous within the tire industry? Are there any tire brands or manufacturers that do not use it or use an alternative?***

It appears that 6PPD is used ubiquitously. Similar anti-ozonants may produce a similarly toxic transformation product. Unknown yet if there are significant differences among brands or manufacturers.

### ***Do we know what year they began using this chemical treatment in tires? It was discovered in the 1950s and became common perhaps in the 1970s (?)***

The Encyclopedia of Industrial Chemistry states that "IPPD is being increasingly replaced by 6PPD." But I could not ascertain the date the statement was relevant. Would have to check previous editions to know when it was added.

### ***How long do you think before we have a Coho Salmon-Safe certified tire, assuming that is a goal for source control?***

That is certainly a goal of ours (the researchers). I suspect it may be a tragically long time before the SS tire is actually available. I hope to be proven wrong.

### ***Does your team have a website that provides a summary of this project?***

This might do it. <https://www.wastormwatercenter.org/tiresandsalmon/>

### ***Thank you for the excellent presentation and for the relentless work on this vexing issue!***

## CONTACTS

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