

6PPD Subgroup Meeting Agenda

September 27th, 2023

Welcome

Eli Mackiewicz, Co-Chair

Eli briefly went through the agenda and reminded the subgroup of its evolution since its inception a few months after the published discovery of 6PPD-q. Before funding was allotted and directed towards finding solutions, questions regarding this issue were broad: How do we know this is a real problem, and even if it is, how is it my responsibility?

With continuous research updates and funding, questions have shifted to what we can do to advance knowledge and solutions.

Eli also notes he's staying on as chair but is happy to consider a fresh face should the group choose to seek someone new.

Finally, Eli is hopeful for an in-person meeting soon! Perhaps our December 13th or spring quarterly meeting might be held in-person. Contact Eli (emackiewicz@cob.org), Co-chair Abby Barnes (abby.barnes@dnr.wa.gov), or Morgan Baker (morgan.baker@ecy.wa.gov) if you'd like to host or have ideas of how we might all gather.

Updates from the Washington State Department of Ecology (ECY)

Morgan Baker, Madison Rose Bristol

Morgan Baker shared that Ecology has offered to fund 3 SAM studies and presented this offer at the September 13th Stormwater Work Group meeting. The offer is as follows, with links to each proposal embedded:

- A total of \$616,000 of Ecology funding has been offered
- The funding comes from the current biennium legislative proviso, which focuses on stormwater solutions for tire wear particles and related chemicals
- This offer includes funding the entirety of [FP1](#) and partial funding of [FP3](#) (3% of project costs) and [FP8](#) (15%). Ecology's 6PPD stormwater proviso funding expires June 30, 2025, limiting our ability to fund more than what Ecology is currently able to offer. This limitation has also prevented Ecology from offering to fund FP2, which Ecology believes is a strong proposal in the realm of 6PPD stormwater research and management, but whose deliverables are outside of the realm of Ecology's constrained timelines. The implications of this are as follows:
 - Ecology will fund and manage all of FP1, opening up \$315,735 in SAM funding as well as project management capacity for SAM staff.

- If SWG chooses to fund FP3 and FP8, this will open up \$9,000 and \$291,870 in SAM funding, respectively.
- Funding offers from Ecology for FP3 and FP8 are contingent upon the SWG moving forward with both proposals within the current biennium.

To read the full discussion regarding this proposal, please see the most recent [SWG meeting summary](#).

Ecology is also in the late stages of recruitment for two Environmental Engineer (EE2) positions for the 6PPD stormwater team as well as an Environmental Planner (EP2) position that will revolve around developing a Chemical Action Plan for 6PPD.

Ecology's funded stormwater projects are ongoing, and include the following:

- "Stormwater Treatment of Tire Contaminants"
 - Project Lead: Osborn & Evergreen StormH2O Consulting
 - This **completed** project explored the potential effectiveness of BMPs to manage tire wear particles in stormwater via a [literature review](#) published by the Department of Ecology as well as a [particle size study](#) which evaluated how pollutant types and loads vary with particle size. (A two-page fact sheet on this study can be found [here](#).)
- "Testing Removal of 6PPDQ and Coho Salmon Lethality by High Performance Bioretention Media Blends"
 - Project Lead: King County
 - This project is running stormwater samples through columns containing four different types of high performance bioretention soil mixes (HPBSM) to test these mixes' effectiveness at removing levels of 6PPD-q that are lethal to coho salmon.
- "Evaluation of 6PPDQ treatment using soils and sorbent media"
 - Project Lead: University of Washington-Tacoma
 - This project is studying a variety of engineered and natural soils and sorbents to gauge their effects of 6PPD-q levels in stormwater samples, all via an accelerated solvent extraction system, or ASE. It has recently been amended to include targeted measurements of low-levels of organic matter mixed with silica sand, and this mixture's effectiveness at removing 6PPD-q.
- "6PPD-Q Characterization and Protocol Development"
 - Project Lead: Herrera Environmental Consultants
 - This study is testing the influent and effluent waters of TAPE devices – certified stormwater treatment technologies – for the removal of 6PPD-q. It is also developing sampling protocols and examining cross-laboratory sample splits for 6PPD-q recovery.

- “Characterizing stormwater pollutant concentrations in mixed residential and highway runoff in Seattle”
 - Project Lead: King County Environmental Lab
 - This study is seeking to characterize stormwater, testing for a wide range of contaminants, including 6PPD-q.
- “Longevity of bioretention depths for preventing acute toxicity from urban stormwater runoff”
 - Amendment 2 of this SAM study is funded by Ecology and is directed towards 6PPD-q components
 - Project Lead: Washington State University-Puyallup
 - This study is exploring the longevity of bioretention media in an effort to determine if and when that media stops being an effective management tool for 6PPD-q as well as if and when that media begins to release previously captured 6PPD-q.
- “Paired watershed retrofit & restoration study”
 - Amendments 6 and 7 (this is a SAM study with Ecology funding directed towards 6PPD-q components)
 - Project Lead: City of Redmond
 - This 10-year project has a discrete separate pilot-level street sweeping effectiveness study task in which 6PPD-q was added as a new parameter being evaluated. It seeks to study the potential to reduce contaminants in receiving waters and will provide data on the effectiveness of street sweeping.

Madison Rose Bristol notes that Ecology is preparing for an upcoming solicitation and is in the forecasting and strategic planning stages. Some highlights to consider include:

- Current funds for studies stand at about \$2.4 million, with the potential for change as we await SWG funding decisions.
- We are in the final stages of prioritizing research gaps that we can reasonably fund before our funding deadline of June 2025.
- Our current plan includes a solicitation process that will seek out competitive bids from private groups, including consultants, to answer specific research questions.
- Ecology will also be pursuing interagency agreements, or IAAs, in which we can enter contracts with public agencies, universities, and Tribal Nations without the need for a competitive solicitation process.
 - If you are interested in these funding opportunities and would like to explore working with Ecology on 6PPD and stormwater BMPs, please reach out to us!

Madison Rose Bristol madison.bristol@ecy.wa.gov

Morgan Baker morgan.baker@ecy.wa.gov

- NEP will also be releasing an RFP to research stormwater BMPs, toxic hot spots, and contaminants of emerging concern, and information regarding this will be forthcoming!

Questions/Discussion:

Todd Hunsdorfer: King County also has SIL funding to develop a predictive heatmap for 6ppd-q on public roadways

Madison Bristol: NEP Stormwater SIL: the Toxics Pod (*note: this is essentially a type of subcommittee for NEP*) had its first meeting in early October. The Toxics Pod will develop strategic information and recommendations for toxics reduction in stormwater that support and operationalize priorities from the Toxics in Fish Implementation Strategy (TIF IS). If interested in more information about the Pod, reach out to dustin.bilhimer@ecy.wa.gov.

Participant: what will be the size of the awards for the upcoming RFP?

Morgan Baker: We haven't determined how much we will allot for the RFP yet. We will update this group and beyond as soon as we have made these determinations.

Group Discussion

Eli Mackiewicz

Studies of interest for the group:

- [Zhao et al. 2023](#) – Screening *p*-Phenylenediamine Antioxidants, Their Transformation Products, and Industrial Chemical Additives in Crumb Rubber and Elastomeric Consumer Products
 - This study grants information on other products that may have *p*-Phenylenediamines and their transformation products – including that which is found in crumb rubber, a current research gap that is a hot topic.
- [McIntyre et al. 2023](#) – This study highlights bioretention's filtration ability to prevent acute mortality and reduce chronic toxicity for early life stage coho salmon episodically exposed to urban stormwater runoff.
 - Multiple water years have been run through bioretention media and then applied to juvenile coho salmon to check mortality rates; preliminary results indicate bioretention continues to have significant potential as a stormwater management tool for 6PPD-q.
- [Li et al. 2023](#) – First insights into 6PPD-quinone formation from 6PPD photodegradation in water environment
 - The sun may contribute to the transformation of 6PPD to 6PPD-q.

- Eli notes that this may have an implication on things like stormwater pond liners as a source creation of 6PPD-q, as well as other potential sources storm and wastewater managers may need to consider.

Updates on projects from the group:

- From Heidi Siegelbaum: Jen McIntyre and her colleagues recently released [a paper](#) on bioretention and coho mortality in early life stages. If you have any questions, please reach out to Jen at jen.mcyntyre@wsu.edu. Please share widely and reach out to Heidi if you have trouble accessing the paper.

Questions/Discussion:

Participant: dock fenders! boat fenders! landscaping! tire bulkheads! tire piles under the state waste management levels! lots of tires in the sunlight.

Abby Barnes: notes she is interested in testing the sediment for 6PPD and is hopeful we'll have an accredited method soon. Also notes she's interested as to how tires are affecting marine environments and cites habitat stewardship measures DNR takes that have helped participants phase out tires from marinas.

Tanya Williams: Tanya shared Manchester Environmental Lab's SOP for 6PPD-q extraction and analysis. This report is publicly available but unpublished – interested parties can access the document here on the SWG page:

https://drive.google.com/file/d/1GtpSjD_vHFI7wucclPds84g---g79e8p/view?usp=sharing

Participant: I am frustrated to hear the focus on research, research, research. I am very skeptical that these bench-scale or pilot studies of BMP effectiveness ignore the real-world reality that the best science does not get implemented consistently across the landscape or over time. Yes, BMP effectiveness depends on the specific technology used, but the most effective BMPs will be useless if they are not implemented consistently and maintained everywhere that tire wear particles can reach waterways. Consider how many waterways remain 303(d)-listed even with pretty standard BMPs that have been "implemented" for decades. What about a research project that estimates the likely implementation success of even the best 6ppd BMP? In my opinion, the 6ppd-q problem does not get solved until 6ppd is phased out of tires.

Participant: Will that SOP be published/posted on ECY's website?

Madison Bristol: Fornow, you should be able to access the file through the SWG page:

https://drive.google.com/file/d/1GtpSjD_vHFI7wucclPds84g---g79e8p/view?usp=sharing

Participant: Copper brake pad linings were phased out over 10 years or so.

Participant I have heard that one reason 6PPD is not included in the permit is the lack of a standardized lab procedure to measure it. Is there now a method that can be widely used?
Madison Bristol: To address the question about permits: The stormwater permits regulate and control many types of pollutants, including 6PPD-q. A pollutant does not need to be specifically listed in the permit for it to be regulated or controlled by the permit. The [Fact Sheet](#) for the draft permits provides the legal and technical rationale for the permit conditions and describes how the permits control tire wear chemicals through new or refined requirements.
Participant: From ECY Fact sheet p44 - "At this point there are no accredited laboratories for 6PPD-quinone sampling. This is important because data collection needs to be reliable in order to develop regulatory processes."

Eli notes that stormwater managers are indeed focusing on real world solutions as research continues.

Presentation

Chelsea Mitchell, Dr. Ani Jayakaran

- “Permeable Pavements Mitigate Emissions of Tire Wear Particles and Tire Additive Chemicals”

Hear PhD candidate Chelsea Mitchell present her research findings on permeable pavement and its potential efficacy as a BMP for 6PPD

- Chelsea is a PhD candidate at WSU under Ani Jayakaran, and she is also now working as a senior ecotoxicologist at King County. This work will include participation in some of the county’s high performance bioretention soil mix (HPBSM) projects.
- Chelsea notes that this project illicit special thanks to Lori Blair and Boeing for funding, field site, and opportunity to conduct some great research projects.
- Another special thanks goes out to the IDEA School in Tacoma, WA, where this project was executed.
- This study focused on permeable pavements and their potential ability to mitigate tire wear particles (TWP) and their leachable contaminants.
- In the US, alone 1.5-2 million tons of TWP are estimated to be generated annually. Global, TWP accumulation accounts for 5-10% of all ocean microplastics.
- With discovery of 6PPD-q as the causal toxicant of Urban Runoff Mortality Syndrome (URMS), there was a push to study permeable pavements as a management tool. Some notes about the study:
 - Permeable pavements are already widely implemented here in WA and worldwide,
 - These pavements primarily control stormwater volume.
 - Fine components of pavement aggregate are left out so that tiny, interconnected voids remain, and these voids hold stormwater.

- [Jayakaran et al. 2019](#) provides an examination of the treatment of suspended solids.
- In studying permeable pavements used abroad, analyses of particles showed that TWP were present 40 times more than any other microplastic captured within the pavement.
- Carbon fibers provided by Boeing were found to strengthen the permeable pavement, which may be important to note for durability purposes.
- The team utilized cryomilled tire particles that were 50 microns in size.
- During testing, tire chemicals peaked early in the second experiment, and then showed steady decline. The maximum 6PPD-q effluent concentration was 49 ng/L.
- Permeable pavements removed more than 96% of the cryomilled TWP mass.
- 6PPD-q removal varied between 52-100%, with one pavement was particularly excellent at managing 6PPD-q. The study also observed mass reductions for most tire chemicals across all pavements.
- In terms of leaching post-TWP capture, study leads considered the possible correlation between retained particles and TWP chemical leaching. Based on the findings, this leaching appeared to occur for a short period of time.
- Challenges of the study included quantifying the mass of effluent tire particles – TWP are light – and determining appropriate influent tire chemical mass to compare to the effluent tire chemical mass, as it was noted that this included a change in material from a solid to a liquid form. The study was also short-term, and longer evaluations of TWP and tire wear chemical breakthrough possibilities with continued stormwater flushing are needed.
- Overall takeaways:
 - The study noted a 96% TWP retention in permeable pavement during study period and observed mass reductions for most tire wear chemicals across all pavements.
 - Permeable pavement may be a good source of management for TWP and tire wear chemicals at their source of generation, as these pavements are adept at capturing TWP and may also help mitigate the release of leachable tire wear chemicals.
 - With proper removal and disposal maintenance, stormwater managers may be able to keep TWP in the pavement before the materials are properly disposed of, effectively keeping them out of the environment.

Questions/Discussion

Participant: How quickly will the voids in the pavement clog with dirt, particles, etc. and no longer be permeable?

Ani (verbal) notes that maintenance is key - and with adequate sweeping, the pavements should stay unclogged for a while, though this is dependent on traffic.

Katie Holzer (verbal) notes that vacuum sweeping is important to keep pavements unclogged. Dependent on many factors, vacuum sweeping is recommended somewhere between monthly and yearly.

Lori Blair: And super thanks to City of Tacoma for connecting us with the iDEA High School!!!

Participant: Sweeping won't collect particles that have migrated below the surface of the pavement, I'd assume.

Ani: yes, that is true

Participant: What about the street sweeping decant?

Eli Mackiewicz: That's on the list of items for study. We're all needing the lab method first (and then the lab equipment needs to be procured). But Bellingham is interested in participating in the decant question. But we drain to marine waters directly. WWTPs that drain to streams are higher priority.

Katie Holzer: Depends how deep. We've had one installed on a major arterial road for 15 years, and it is still draining well with monthly vacuum sweeping.

Ani: We should also point out that these results are still preliminary. We're going through the peer review process now and likely to be revised slightly.

Participant: Sorry for the long message: It appears the method of pollution management is "cessation" of transport of pollutants during storm events? It seems that this may have potential to develop into a pollution "sink" that may require pavement removal over time to remove fine particulates from the base course. On that note, has any research been conducted to determine if chemical/biological processes sub-surface (base course layers) are having an

impact on pollution reduction or degradation of harmful compounds? if it could be shown that the processes sub-surface are able to neutralize harmful compounds I would feel MUCH better about using this as a method of pollution management.

Participant: There is a great Fate and Transport training on PFAS available from NEMA
https://nemallc.com/pfas_training_calendar

Participant: A confounding factor is the half-lives of 6ppd and 6ppd-q, and the relation between the two.

Participant: Congratulations Chelsea on your new role. You will be great!! Thank you for the update today!

Participant: Great first look at a BMP for this emerging toxicant. Chris mentioned he's curious as to where the research study managers think the fate and transport will look like long-term considering concerns about maintenance. What can be done to mitigate for issues like this over time?

Chelsea: with permeable pavements, maintenance is an opportunity for treatment. Particles are likely accumulating in similar places sediments are accumulating in the pavement, which is within the top few inches. Maintenance allows the opportunity to completely remove these particles from the system instead of allowing for continued build up.

Participant: Great presentation and hello from California. Caltrans is touting the use of Open Grade Friction Course, a permeable pavement overlay, for its pollutant removal benefits. However, Caltrans does not have protocol to treat these pollutant sink pavement layers different from other non-permeable pavements that are subject to grinding and reuse at the end of their life cycle. Often, asphalt grindings become property of the contractor whereupon the grindings are sold to private parties and distributed in the environment (e.g., road surfacing, staging areas). There needs to be an end-of-life management plan for these waste materials.

Participant: Another interesting study related but not the same: Lokesh et al. 2023 Investigation of 6PPD-Quinone in Rubberized Asphalt Concrete Mixtures.
<https://pubs.acs.org/doi/10.1021/acsenvironau.3c00023>

Eli (verbal): Eli summarized the overarching theme of the questions from the chat regarding maintenance, and notes that stormwater managers could potentially use a "sacrificial" sand layer under the pavement with hatches for sand removal. Eli also notes there is not much standardized info here.

Chelsea (verbal): Chelsea notes that the team can't speak from their results to how treatment is occurring but considers what may be happening based on other BMPs. 6PPD-q is organic and very sorptive, and initial short-term removal seen is likely due to that adsorption. This could be happening within the pavement's intentional void spaces or onto particles within those void spaces. There has been an extensive study on hydrocarbons taking place in permeable pavement, and there are biofilms in permeable pavement field sites. Permeable pavements can also be augmented to facilitate bacteria growth in which the mineralization of organics can be seen.

Ani: Tire wear particles are very hydrophobic, and this could lead to other questions: at what point do you fill up all the voids in the pavement? Is there a limitation to this? No answers yet, but we know maintenance is key. And like everything we build, there is a certain lifecycle for these systems.

Participant: Another interesting study related but not the same: Lokesh et al. 2023 Investigation of 6PPD-Quinone in Rubberized Asphalt Concrete Mixtures. <https://pubs.acs.org/doi/10.1021/acsenvironau.3c00023>. Also - asphalt features can impact the generation rate of tire particles so higher friction --> higher number of particles.

Participant: What ASTM committee is looking at microplastics?

Tanya Williams: Chris French can you please send me additional information on the microplastics research with ASTM? tanya.williams@ecy.wa.gov

Participant: Also - asphalt features can impact the generation rate of tire particles so higher friction --> higher number of particles. So, municipalities might want to reconsider the use of asphalt chip-seal road maintenance overlay. A noticeably rougher surface than standard hot-mix asphalt replacement.

Participant: and/or - site GSI bioretention with road features in mind; where rougher surfaces or quick patches are needed...site treatment BMP retrofits?

Lori (verbal): we've been funding this permeable pavement study for over 5 years. We want to continue to explore if we make it stronger with composite material. There is no more existing funding for this research, but Lori notes the IDEA high school has been a fantastic partner. If anyone else has money, the facility is completely set up with various types of permeable pavement. Lori also went on to thank Dana Deleon for her role in this study.

Katie Holzer (verbal): Katie notes that in general, we're finding 80% removal with variations of permeable pavement. She also notes that treatment also does seem to still be occurring after 15 years with monthly sweeping, and captured materials don't seem to be leaching into the system. Please email me if you want to see any of the results and I'm happy to share them with you: katie.holzer@greshamoregon.gov

Chelsea: dropped her contact info: chelsea.mitchell@wsu.edu or chemitchell@kingcounty.gov

Eli (verbal): Eli notes that biofilm could be utilized in more treatment options, and that it works well for phosphorus removal. He encouraged considering biofilm for permeable pavement.

Participant: Was there mention that these permeable pavements are not as strong as the normal roads we have on our highways? If so what is the advantage of these permeable roads?

Chelsea: yes, they are weaker but part of the larger study this work is a part of is focused on strengthening permeable pavements with carbon fibers.

Participant: permeability over impervious surfaces

Katie Holzer: They can be as strong! Contact me!

Participant: They reduce road splash

Wrap up

Eli Mackiewicz

- Eli announces his ability to stay on to chair the subgroup! We are all, of course, thrilled – though Eli does note that should the group or the SWG at large seek new representation, he is happy to allow for “new blood.”
- Forecasting next quarterly meeting
 - ECY request for proposals updates
 - SWG funded projects

Discussion:

Sean Dixon: thanks for staying on as our leader Eli for another two years! (three?)

Tanya Williams: Thanks, Eli! Great presentation, Chelsea!

Zackary Holt: Eli, you are a rockstar! thanks for steering the ship!

Stefan Grozev: Thank you, Eli!