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Performance of a field-scale bioretention system in removing toxic tire-derived chemicals in stormwater runoff

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The chemical 6PPD-quinone (6PPD-Q), a transformation product of the tire antioxidant 6PPD, has recently been identified to cause acute pre-spawn mortality in coho salmon inhabiting urban streams in the Pacific Northwest region of Canada and the United States and is acutely toxic to other fish species including brook trout, rainbow trout, and lake trout. 6PPD-Q along with other tire-derived chemicals are transported to surface waters via stormwater runoff. Bioretention systems, also known as bioswales or rain gardens, are a widely used infiltration-based stormwater control measure that may be effective at reducing 6PPD-Q concentrations in runoff through sorption to soil media. Although modelling and laboratory studies predict substantial reductions in 6PPD-Q loads when infiltrated through these systems, field-scale testing under natural storm conditions has not yet been conducted.

The objective of this study was to assess the performance of a field-scale bioretention system in reducing 6PPD and 6PPD-Q concentrations and loads in stormwater. Field investigations were conducted at a large bioretention system receiving runoff from a major arterial road in London, Ontario, Canada. Samples of inflow runoff, surface ponding water, porewater, and system effluent were collected during seven storm events in 2025. A suite of fifteen tire-wear associated compounds, including 6PPD and 6PPD-Q, were quantified following solid phase extraction using liquid chromatography-tandem mass spectrometry.

Runoff concentrations of 6PPD-Q exceeded British Colombia freshwater guidelines (10 ng/L) in all samples whereas effluent concentrations were below detection (5 ng/L) in all but two samples with a maximum value of 27 ng/L. 6PPD-Q porewater concentrations were generally below detection, although elevated concentrations (93 ng/L) were detected in porewater at a depth of 50 cm – this may be due to the presence of preferential flow pathways within the bioretention system. In contrast, for other tire-wear compounds, including benzothiazole and benzotriazole, concentrations in both porewater and effluent samples showed little to no decrease from pond and runoff samples.

Overall, these findings provide new evidence regarding the effectiveness of infiltration-based stormwater management systems to mitigate 6PPD-Q and thereby protect sensitive aquatic species in receiving surface waters.