

SECTION 5

Pesticides

A lake re-emerges: Analysis of contaminants in the *Semá:th Xó:tsa* (Sumas Lake) region following the BC floods of 2021
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PESTICIDES

Capsule

A mix of 40 currently used and legacy (banned) pesticides were detected in the surface waters of the former *Semá:th Xó:tsa* (Sumas Lake) after the catastrophic British Columbia floods of late 2021, with exceedances of Environmental Quality Guidelines observed for chlorpyrifos and endosulfan. Average pesticide concentrations were 135 times higher in Sumas surface waters compared to our upstream reference site at Frost Creek. Pesticide levels in Sumas surface waters increased by 2.8 times in the early weeks after the floods, but declined thereafter, suggesting that flooding resulted in the release of pesticides into fish habitat. Monitoring of these waterways during the growing season would inform risks to salmon during peak pesticide application times, and facilitate the design of best practices to protect and recover fish habitat in the Sumas area.

Introduction

The catastrophic floods of late 2021 in British Columbia and Washington State overwhelmed urban, agricultural and industrial infrastructure in the *Semá:th Xó:tsa* (Sumas Lake) area, raising concerns about the impacts of contaminant discharges into fish habitat. The absence of pre-flood baseline data and ongoing monitoring of freshwater quality in the area highlighted the urgent need for water sampling and analysis to assess the level of risk to fish and the environment.

A pesticide is any substance or mixture of substances intended to control unwanted insects, funguses

and/or weeds (1). There are thousands of pesticide formulations registered for use in Canada (current use pesticides), in addition to many that have been banned but are still present in the environment (legacy pesticides).

Pesticides applied to field crops and terrestrial habitats can drift or move into aquatic systems, where they can cause unintentional impacts to plants, invertebrates and fish (2). Some pesticides are highly persistent in the environment and/or can accumulate in species at higher trophic levels (3,4). Many of these persistent

pesticides are legacy pesticides, meaning they have been banned because of their high risks to human and wildlife health (5,6).

Although current use pesticides are generally less persistent and bioaccumulative, their often heavy use leads to ‘pseudopersistence’ in the environment, where fish and other biota can be chronically exposed to potentially harmful levels (7). Endocrine disruption, impaired immune function, abnormal development,

altered behaviours, reduced growth and feeding, and reproductive impairment have been observed in pesticide-exposed fish, including zebrafish (*Danio rerio*), sheepshead minnow (*Cyprinodon variegatus*), coho salmon (*Oncorhynchus kisutch*), and Chinook salmon (*Oncorhynchus tshawytscha*) (6,8).

Methods

We collected 27 surface water samples from 11 sites in the Sumas Lake area of the Fraser Valley (British Columbia; 10 on December 15, 2021; 9 on December 23, 2021; 8 on January 27, 2022 and February 2, 2022), as well as 4 groundwater samples on February 2, 2022. Two of these samples from Abbotsford groundwater sources will be evaluated separately. Details for sampling sites are listed in the Executive Summary. Samples were stored in the field at 4°C in suitable containers supplied by partnering laboratories, and were submitted to SGS AXYS Analytical Services (<https://www.sgsaxys.com/>) in Sidney BC for analysis of 76 compounds using LC MS/MS (EPA 1633) and their in-house MLA-035 Rev 7 protocol. For Quality Assurance purposes, a laboratory blank and a spiked matrix were included in analyses. Data are presented in nanograms per litre (ng/L).

To interpret the risk of pesticide-related effects in fish and fish habitat at our sample locations, we compared our concentrations of these analytes to the most

protective Environmental Quality Guidelines (EQGs) for fish and fish habitat available in a Canadian provincial or federal jurisdiction. Jurisdictions with EQGs in Canada include British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Canada (federal) and the Canadian Council of Ministers of the Environment (CCME). Environmental Quality Guidelines are not available for all pesticides. Nonetheless, they provide an important benchmark to gauge the health of fish habitat.

We refer to the most protective EQG in Canada herein as the ‘pan-Canadian Environmental Quality Guideline to protect fish and fish habitat’ or the ‘pan-Canadian EQG’.

We report here on total PAH concentrations in 27 surface and 2 ground water samples following the British Columbia floods of late 2021, and evaluate results against pan-Canadian Environmental Quality Guidelines to protect fish and fish habitat.

Results

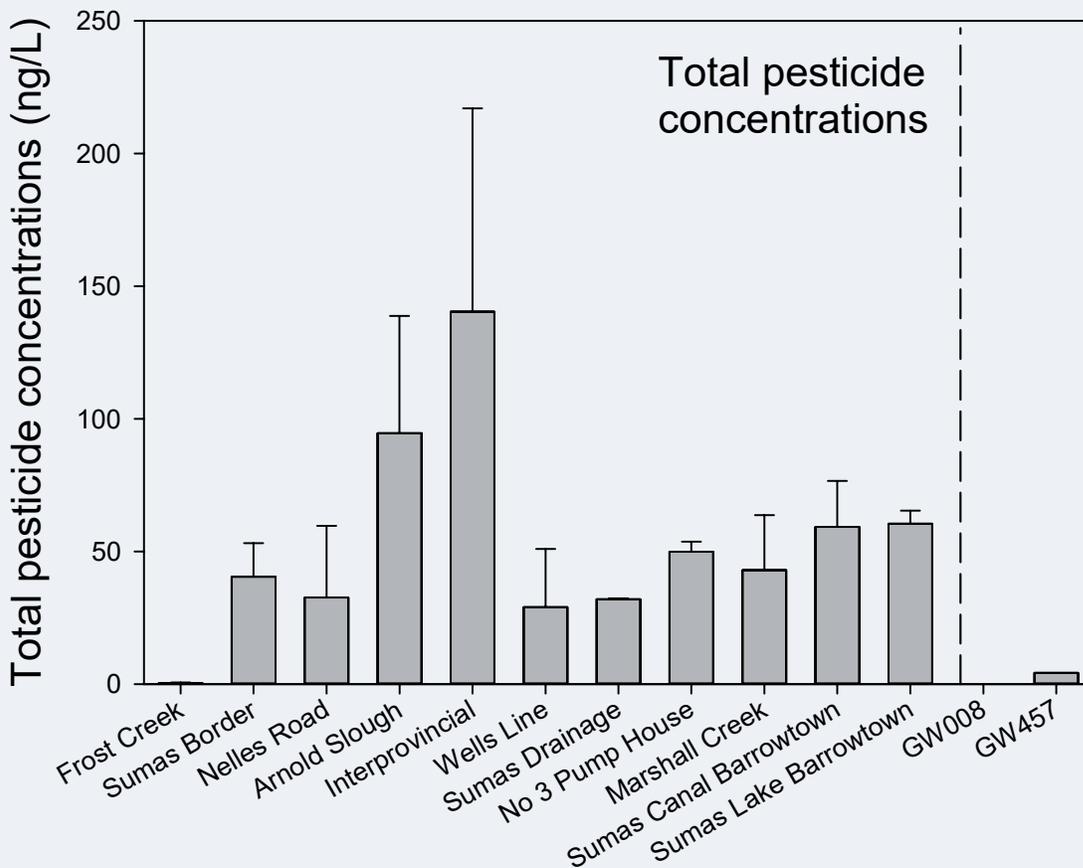
Surface water

- » We detected pesticides at all 11 surface water sites in the Sumas Lake area and two groundwater sites throughout the study period.
 - » Total pesticide concentrations at surface water sites (all detected pesticides summed at each site) averaged 53.0 ± 11.3 ng/L, ranging from 0.4 to 140.5 ng/L.
 - » The average number of pesticides detected at surface water sites ranged from 8 to 21, with an average of 16 ± 1 .
 - » The most frequently detected pesticides at surface water sites were Hexachlorocyclohexane (HCH) isomers (detected at 100% of sites), endosulphan isomers (detected at 100% of sites), nonachlor isomers (detected at 82% of sites), DDD & DDE isomers (breakdown products of DDT isomers, detected at 90% of sites), and chlordane isomers (detected at 82% of sites).
 - » Out of 43 currently used pesticides measured, 14 (33%) were detected at one or more surface water sites, and 2 (5%) were detected at one or both groundwater sites. Out of 34 legacy pesticides measured, 26 (76%) were detected at one or more surface water sites, and 10 (23%) were detected at one or both groundwater sites.
 - » Surface water sites with the highest pesticide concentrations also had the highest number of individual pesticides detected.
- » Total pesticide concentrations were 1.5 times higher (+50%) in Sumas Lake surface water to our upstream reference site (Frost Creek).
 - » The average pesticide concentration increased by 330% between December 15 (2021) and December 23 (2021), and decreased by 77% between December 15 (2021) and January 27 (2022) in surface water samples collected across field sites after the flooding.

Groundwater

- » Total pesticide concentrations at two groundwater sites 008 and 457 averaged 2.8 ± 2 ng/L, ranging from 0.4 to 4.3 ng/L.
- » The number of pesticides detected at groundwater sites ranged from 6 to 9, with an average of 8 ± 2 .
- » The most frequently detected pesticides at groundwater sites were endosulphan isomers and dieldrin, detected at both sites.

Figure 5.1: Total pesticide concentrations in surface waters



Total concentration of pesticides, with the average (+/- SEM) for each site over time, from the reference site (Frost Creek) through the agriculturally-intensive Sumas Lake area, and to the two Barrowtown pump stations prior to release into the Fraser River.

Figure 5.2: Frequently detected pesticides in surface waters

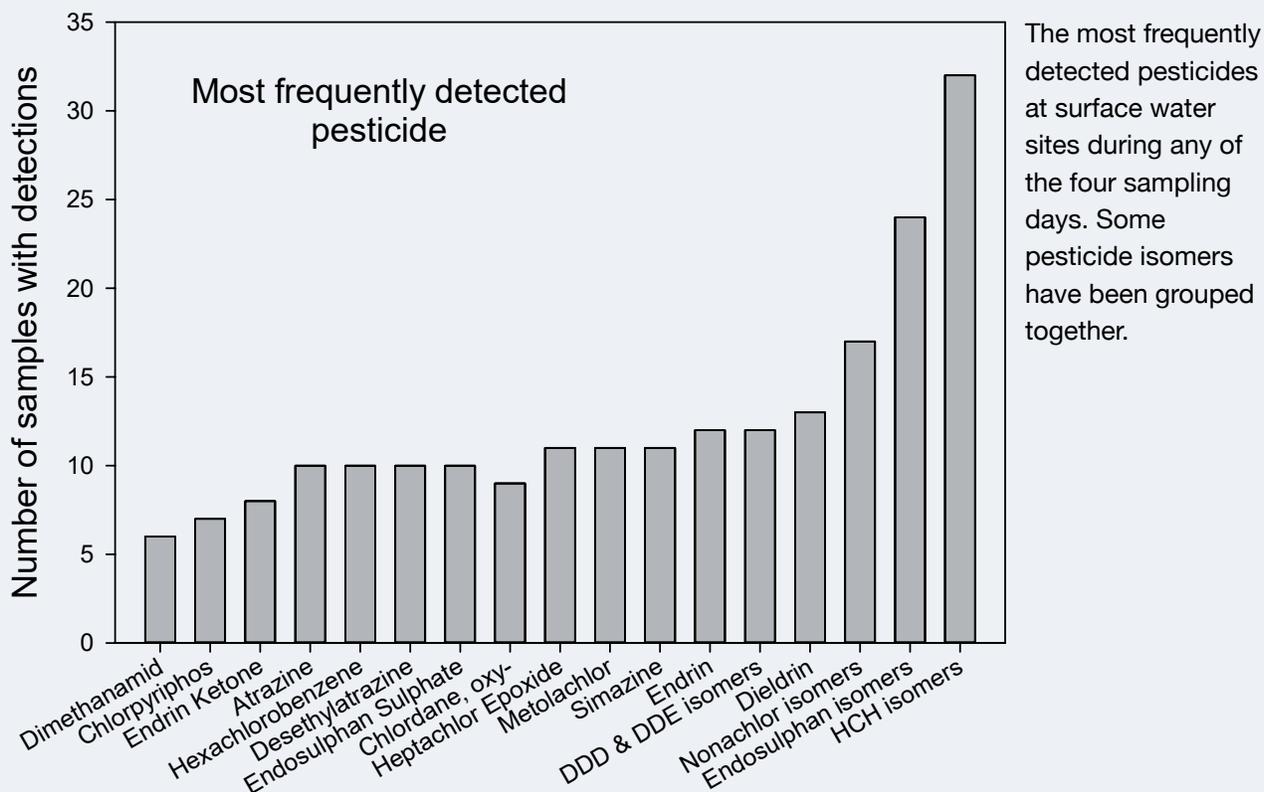
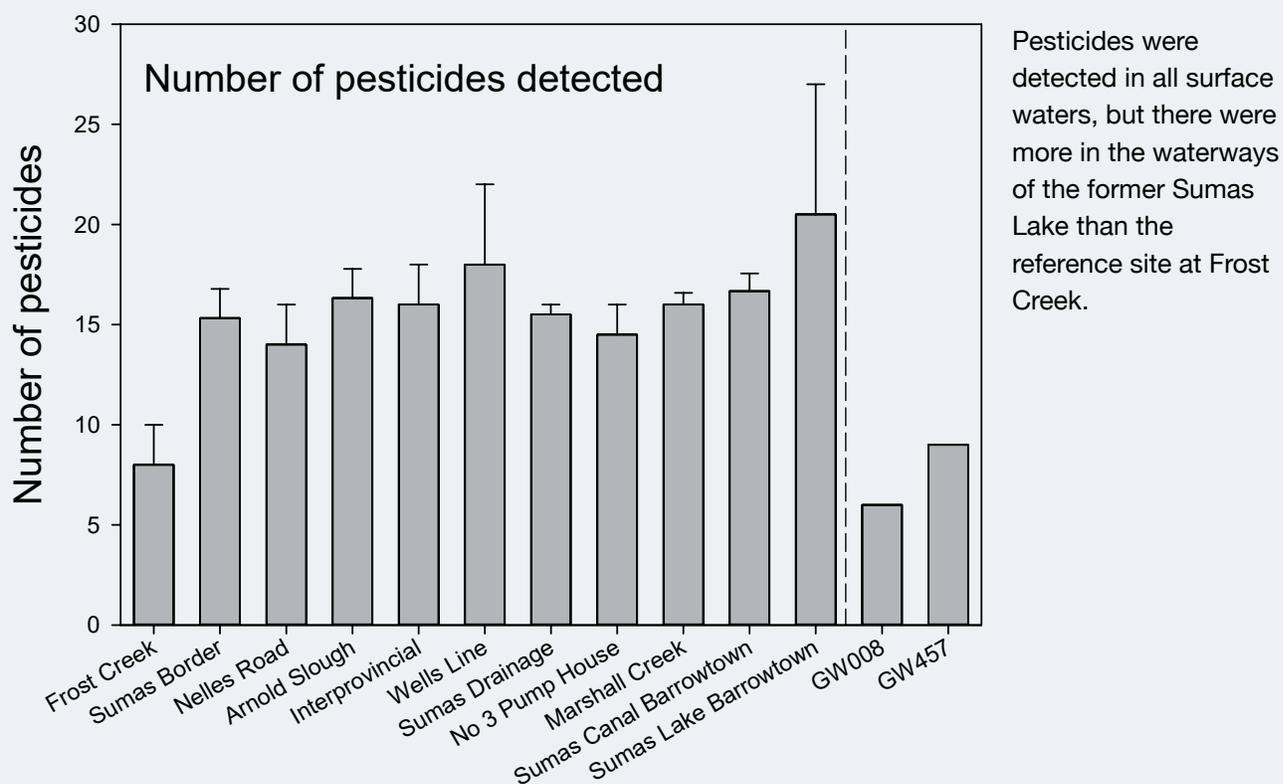


Figure 5.3: More pesticides in Sumas waters



Conclusions

There were up to 2 exceedances of our pan-Canadian Environmental Quality Guidelines per surface water site in a given sample and no exceedances were observed in groundwater samples. In total there were 12 individual exceedances across 5 of the surface water sites across 3 sampling days:

- » 10 exceedances for chlorpyrifos (Ontario Provincial Water Quality Objectives (PWQO) of 1 ng/L)
- » Two exceedances for alpha-endosulphan (BC long-term Working Water Quality Guideline (WWQG) of 0.7 ng/L).

Out of the 12 individual exceedances, No. 3 Pump House site had 4 exceedances in two sampling days: 2 for chlorpyrifos and 2 for alpha-endosulphan. A previous analysis of surface water runoff in the Fraser Valley in 2003-05 detected chlorpyrifos concentrations between 100 and 750 ng/L, with detection in 58% of all samples (7). Alpha-endosulphan was also detected in 67% of samples, with concentrations up to 5.47 ng/L (9).

Chlorpyrifos is an insecticide that is currently used in Canada with heavy restrictions; however, it is in a two-year phase out period for canola and garlic crops (10). Alpha-endosulphan is a legacy insecticide that has been prohibited in Canada since December 31, 2016 (11).

Elevated concentrations of chlorpyrifos has the potential to suppress fish immune systems (12), while elevated concentrations of endosulphan has been linked to abnormal development of spine and tails in zebrafish embryos (13).

Previous studies found currently used pesticides simazine and atrazine in the top 10 pesticides by concentration in Nathan Creek (located in Abbotsford), measuring 22.3 ng/L and 3.94 ng/L respectively (14). In our sampling, both simazine and atrazine were also in the top 10 pesticides by concentration, averaging 6.8 ± 1.5 ng/L and 5.8 ± 1.3 ng/L respectively. However, there were no exceedances in pan-Canadian EQGs for the protection of aquatic life for either pesticide (10,000 ng/L for simazine (WWQG) and 1,800 ng/L for atrazine (WWQG)).

The presence of pesticides in Sumas Lake surface water suggests that monitoring would document how aerial drift and stormwater runoff contributes to the introduction of pesticides into fish habitat. Exceedances of EQGs for two pesticides highlights the potential for impacts on fish and fish habitat in the Sumas Lake area, especially since measurements here were made outside of the growing season for crops when pesticides are typically applied.

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