Sqwa:la (Hope Slough) watershed: Water quality report for the 2024 dry season

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Executive summary

Water is essential for life, and steps are needed to understand, protect and restore its health in fish habitat throughout British Columbia. The Raincoast Healthy Waters program was launched in 2023 to establish community-oriented water pollution monitoring in select BC watersheds. Two Healthy Waters sampling events take place every year in each watershed, the first in the dry season (summer), and the second being in the wet season (winter). This report highlights results from the first dry (summer) season sampling carried out with the support and participation of Pelólxw Tribe.

Briefly, the Healthy Waters - Pelólxw Tribe team determined basic water properties (temperature, conductivity, pH, dissolved oxygen and turbidity) in situ at sampling sites on August 1, 2024. Water samples were collected from four water categories, including source water (3 samples), stream and river water (3 samples), road runoff (3 samples), and Fraser River water (3 samples). The samples were pooled into composites by category and then analysed for coliform, nutrients (6), physical parameters, metals (37), pesticides (62), polycyclic aromatic hydrocarbons (PAHs; 76), pharmaceuticals and personal care products (PPCPs; 141), polychlorinated biphenyls (PCBs; 209), alkylphenol ethoxylates (APEs; 4), bisphenols (BPs; 6), per- and poly-fluoroalkyl substances (PFAS; 40), and sucralose. Analysis of 6PPD-Quinone is pending.

We detected 104 contaminants out of 587 measured in the stream and river sample collected within the Sqwa:la watershed, excluding nutrients, fecal coliform and physical parameters. Overall, the Sqwa:la (Hope Slough) watershed had **relatively good** water quality in the dry season, but additional sampling and analysis will provide insight into contamination impacts from forest fires, domestic wastewater, industrial chemicals and runoff (roads, agriculture) on the health of this valued watershed.

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Key findings

- This assessment of water quality in the Sqwa:la watershed reflects the second of several site visits; our understanding of water quality in these watersheds will grow with additional sampling over the coming two years (2025-26).
- We collected and analysed water in the Sqwa:la watershed during the dry season (August 1, 2024).
- The road runoff sample was the sample was the most contaminated water category in the dry season; it had the highest concentration of *E. coli*, metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pharmaceuticals and personal care products (PPCPs), per- and polyfluoroalkyl substances (PFAS), sucralose, nitrate, and pesticides.
- Stream and river water was the least contaminated water category in the dry season.
- Concentrations of *E. coli* and pesticides were notably higher in the dry season compared to the previous wet season sampling.
- Concentrations of sucralose, and PPCPs were notably higher in the previous wet season sampling, compared to the current dry season.
- Overall, the Sqwa:la watershed had **fair** water quality in the dry season.
    - There were seven exceedances of Canadian Environmental Quality Guidelines.
    - There were two exceedances of the Recreational Use Guidelines set by Health Canada (>235 CFU/100ml) in the stream and river, and road runoff samples.

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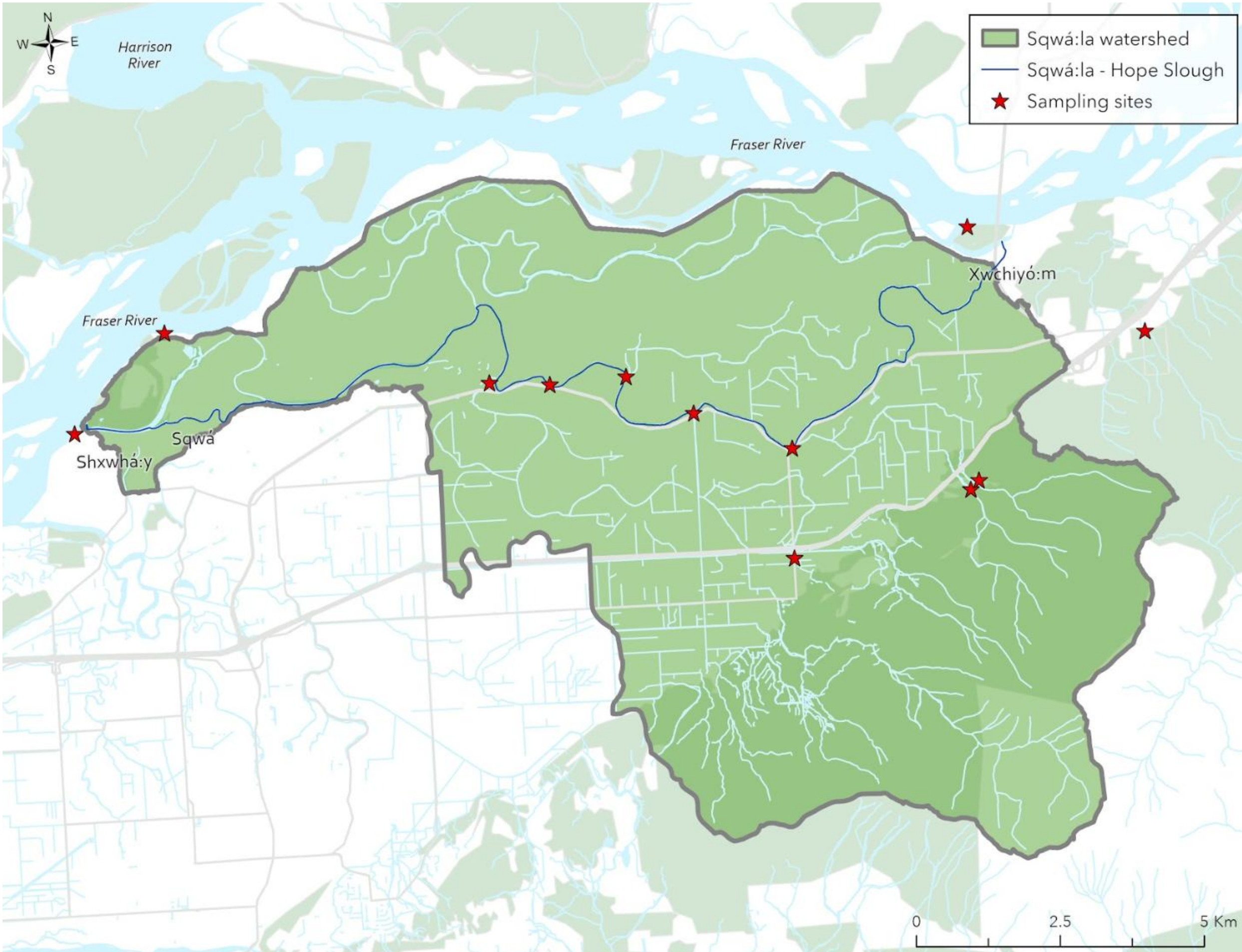
Figure 1: The Sqwa:la (Hope Slough) Watershed



The Sqwa:la (Hope Slough) watershed runs east to west from its source, historically a point of connectivity with the Stó:lō (Fraser River), now down to a confluence with the Fraser, and covers an area of 117 km2. The Xwchíýò:m (Cheam) have lived in the Téméxw for thousands of years. Sampling sites were distributed throughout the watershed in order to capture a wide spatial range for our assessment of the health of fish habitat (Map by Brooke Gerle / Raincoast Conservation Foundation).

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Acknowledgements

We acknowledge the financial support of Pelólxw Tribe. We are grateful for the enthusiastic support of Ernie Victor, Eddie Gardner, the Wildlife and Watershed Technicians, the Snoweyelh Committee members, and Pearson Environmental. We thank Sherwin Arnott for report design, and Brooke Gerle for map creation.

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General introduction

Background

Raincoast's Healthy Waters Program (https://www.raincoast.org/waters/) delivers high-resolution, community-oriented water quality analysis to watersheds across southern British Columbia. The goal of Healthy Waters is to empower communities with the understanding of the status of water quality in their watersheds, to allow for local advocacy regarding both point and nonpoint source pollution.

The Pelólxw people hold profound relationships with the sloughs, islands and river that connects them. The inherent jurisdiction and title of the Pelólxw Tribe people, to the Hope Slough can be traced back to the time of the eternal ancestors who established the ancient connection between the peoples and their territories.

Pelólxw Tribe is currently undertaking a major restoration project at Sqwa:la (Hope Slough), which includes increased water quality monitoring in line with Raincoast's Healthy Waters program.

The wider restoration project, titled Shxwlístexw te Sqwá:la Shxwelí (Care for the Life Spirit of the Hope Slough) encompasses five pillars to support the health of Sqwá:la and the surrounding communities. The five pillars are as follows:

1. Improved flow through Sqwa:la
2. Riparian area restoration
3. Fish habitat restoration
4. Water quality monitoring
5. Community and youth engagement

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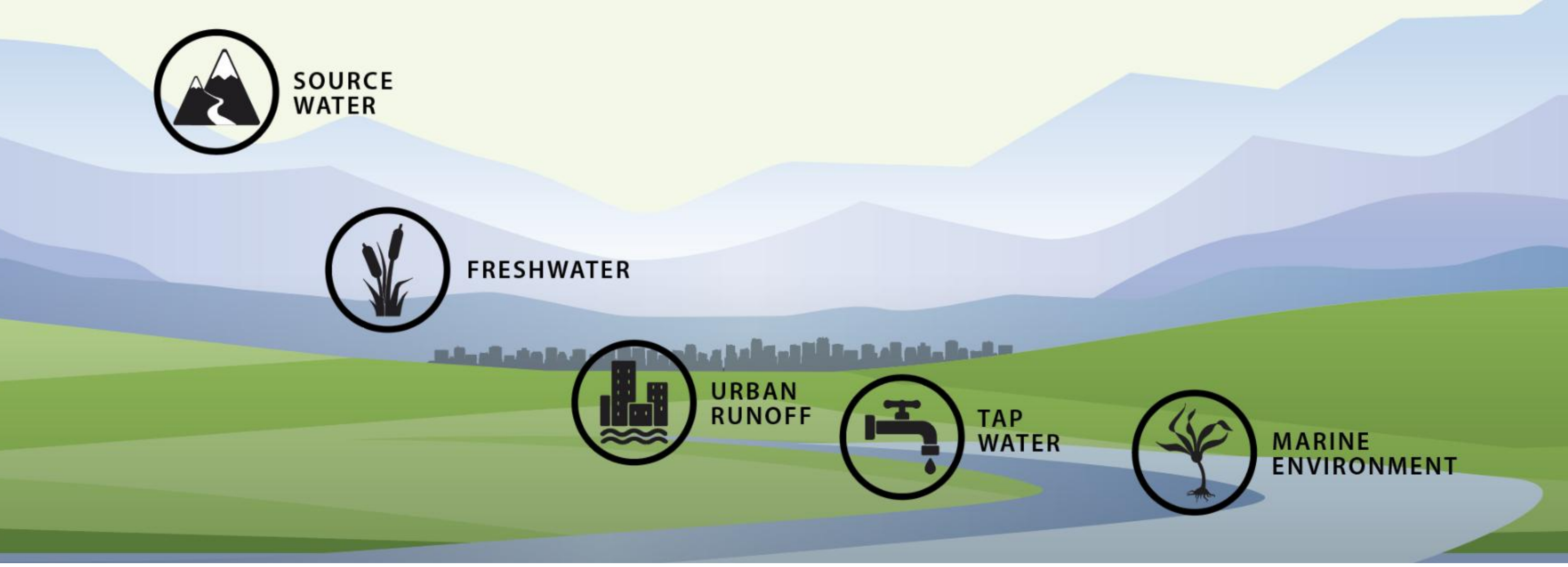

Healthy Waters: A watershed based approach to sampling

We collect samples from five different categories of water in each of our partner watersheds: from source water, upstream of human impacts, down to the marine environment. Collectively, the lessons learned from our partnering watersheds will contribute to a greater understanding of threats to water quality across British Columbia, and ultimately what policy changes can be implemented to preserve the quality of water for the future of salmon, whales, and people.

Source water serves as an upstream reference sample, allowing us to determine which contaminants are being introduced as water traces its path down through the watershed.

Stream and river samples allow us to investigate the quality of fish habitat directly, by collecting samples from streams, creeks, and rivers used by salmon and other fish species (either currently or historically).

Road runoff serves as an impacted sample category of current concern, as many contaminants, including PAHs, metals, surfactants and chemicals such as 6-PPD quinone can be washed off roadways and into fish habitat during rain events.

We include **tap water** samples in our analysis as a way to bring our homes into the conversation - we borrow water from the environment in the form of municipal or well water, and generally return it to aquatic habitats in a more-degraded state in the form of storm and sewage effluent (treated or untreated).

Marine water samples provide insight into those contaminants that may degrade fish and whale habitat in the ocean, and enable an understanding of the contribution of land-based pollutants from the adjacent watershed to the marine environment.

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Methods

Field sampling

A total of 12 water samples were collected from field locations (Table 1) within the Sqwa:la (Hope Slough) watershed on August 1, 2024 by the Raincoast Healthy Waters team alongside representatives of the Pelólxw Tribe.

A portable water properties meter (YSI-ProDSS) was deployed to measure temperature, pH, conductivity, dissolved oxygen and turbidity.

Samples were submitted to three service labs for additional analyses: ALS Environmental, SGS-AXYS, and the Raincoast Conservation Genetics Lab. Contaminant analytes were determined in water samples according to established protocols (see Table 2).

Table 1: Sampling sites in the Sqwa:la watershed

Site Number	Water Type	Site Name	Lat/Long
1	Source	Bridal Creek	N 49.185502, W 121.743575
2	Source	Dunville Creek	N 49.162426, W 121.787167
3	Source	Nevin Creek	N 49.163776, W 121.785107
4	Runoff	Golf Course Ditch	N 49.153338, W 121.830006
5	Runoff	Chapman Slough	N 49.183160, W 121.867512
6	Runoff	Elk Brook	N 49.183412, W 121.900053
7	Freshwater	Big Ditch	N 49.176857, W 121.851945
8	Freshwater	Dunville @ Hope Slough	N 49.170480, W 121.829016
9	Freshwater	Hope Slough @ Reeve	N 49.182605, W 121.885729
10	Fraser	Skway Boat Launch	N 49.179172, W 121.999286
11	Fraser	Island 22	N 49.194091, W 121.976592
12	Fraser	Fraser River @ Ferry Road	N 49.203394, W 121.784325

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Water quality analyses

Table 2: List of analytes, labs, analytical methods, instruments, and number of samples submitted to service labs

Analyte	Laboratory	Analytical Method	Instruments	No. samples analysed
Tier 1				
Temperature (℃)	in situ		YSI ProDSS	12
Dissolved Oxygen (%, mg/L)	in situ	optical sensor	YSI ProDSS	12
Turbidity (FNU)	in situ		YSI ProDSS	12
Conductivity (uS/cm)	in situ		YSI ProDSS	12
pH	in situ		YSI ProDSS	12
Tier 2				
Total Suspended Solids (TSS)	ALS Environmental	APHA 2540 D (mod)	gravimetry	4
Total Dissolved Solids (TDS)	ALS Environmental	APHA 2540 C (mod)	gravimetry	4
Hardness	ALS Environmental	APHA 2340B	calculated	4
Total Organic Carbon (TOC)	ALS Environmental	APHA 5310 B (mod)	combustion	4
Chemical Oxygen Demand (COD)	ALS Environmental	APHA 5220 D (mod)	colorimetry	4
Biological Oxygen Demand (BOD)	ALS Environmental	APHA 5210 B (mod)	dissolved oxygen meter	4
Nitrate	ALS Environmental	EPA 300.1 (mod)	ion chromatography	4
Ammonia	ALS Environmental	Method Fialab 100, 2018	fluorometry	4
Phosphate	ALS Environmental	APHA 4500-P F (mod)	colorimetry	4
Total Nitrogen	ALS Environmental	Chinchilla Scientific Nitrate Method, 2011	colorimetry	4
Total Metals	ALS Environmental	EPA 200.2/6020B (mod)	Collision/Reaction Cell ICPMS	4

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Total coliform	ALS Environmental	APHA 9223 (mod)	MPN	4
Fecal coliform	ALS Environmental	APHA 9223 (mod)	MPN	4
E. coli	ALS Environmental	APHA 9223 (mod)	MPN	4
MST (in Development)	RCF Conservation Genetics Lab (PSEC)	In development		4
6PPD-quinone	Pending		LCMS	4
Tier 3				
Alkylphenol Ethoxylates (APEs)	SGS Axys Analytical	SGS AXYS METHOD MLA-004 Rev 07	GC-MS	4
Bisphenols	SGS Axys Analytical	SGS AXYS METHOD MLA-113 Rev 01	LC-MS/MS	4
Multiresidue Pesticides	SGS Axys Analytical	EPA 1699 (mod)	HRMS	4
Per and Poly-fluoroalkyl substances (PFAS)	SGS Axys Analytical	EPA 1633 Draft	LC-MS/MS	4
Pharmaceuticals and Personal Care Products (PPCPs)	SGS Axys Analytical	EPA 1694	HPLC/MS/MS	4
Polychlorinated biphenyls (PCBs)	SGS Axys Analytical	SGS AXYS METHOD MLA-210 Rev 01	GC-MS/MS	4

Data handling

In some cases, contaminants were not detected in our water samples and concentrations were therefore considered to be 0 for the calculations of totals.

With each batch of samples, analytical laboratories also ran blank samples (e.g. samples that go through the same laboratory processes as our environmental samples) that should, in theory, not contain any contaminants. However, in some cases, blank samples contained low concentrations of some contaminants. These levels were subtracted from the concentrations measured in each of our environmental samples ('blank correction').

Environmental Quality Guidelines

We interpreted contaminant concentrations using three sets of Canadian environmental quality guidelines (EQGs): provincial (British Columbia (BC)), federal, and those developed by the Canadian Council of the Ministers of the Environment (CCME). The latter CCME guidelines are derived in consultation with the environment ministers from the federal,

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provincial and territorial governments. Relevant EQGs and DWQGs are summarized in Appendix 1.

The British Columbia Ministry of Environment and Climate Change Strategy (BC MoECCS) has developed Water Quality Guidelines (WQGs) that are considered as protective for different water uses. We refer to WQGs and EQGs interchangeably to simplify the use of terminology from different sources across Canada. We apply EQGs for the protection of aquatic life (source, stream and rivers and Road runoff samples) and marine aquatic life (marine water samples). All approved BC WQGs can be found on the BC MoECCS website.

Federal Environmental Quality Guidelines (FEQGs) are developed to support emerging federal environmental quality monitoring, risk assessment and risk management activities, and are derived to complement those developed by the CCME. They are only available for a limited number of chemicals captured in this list of EQGs (Government of Canada, 2024).

In addition, Working Water Quality Guidelines (WWQGs) are available for some contaminants for which a completed EQG is not yet available and can be obtained from various Canadian provincial and federal jurisdictions (primarily the Canadian Council of the Ministers of the Environment (CCME)).

It is important to note that exceeding a WQG/EQG or WWQG does not imply that unacceptable risk exists but rather that the potential for adverse health effects is increased (BC MoECCCS, 2023). Conversely, EQGs may not fully capture the sensitivity of all species to different contaminants, such that adverse effects may occur in some species even at levels below a EQG. EQGs, therefore, serve as a benchmark based on best available evidence, and are subject to change as new evidence emerges.

Drinking Water Quality Guidelines

Guidelines are available to protect human health from different contaminants in drinking water. These have been developed at the federal level by Health Canada in collaboration with the Federal-Provincial-Territorial Committee on Drinking Water (CDW) and other federal government departments (Health Canada, 2022). Guidelines for Canadian Drinking Water Quality are developed specifically for contaminants that meet all of the following criteria (Health Canada, 2022):

- Exposure to the contaminant could lead to adverse health effects in humans;
- The contaminant is frequently detected or could be expected to be found in a large number of drinking water supplies throughout Canada; and,

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- The contaminant is detected, or could be expected to be detected, in drinking water at a level that is of possible human health significance.

In BC, the First Nations Health Authority (FNHA) oversees drinking water safety on reserves, where the Chief and Council are responsible for drinking water infrastructure and monitoring. Monitoring of drinking water relies on meeting the Health Canada DWQGs. Drinking water quality guidelines can be found on the Health Canada website.

Table 3: Analyte classes and number of available Environmental (or Water) Quality Guidelines (EQGs or WQGs) and Drinking Water Quality Guidelines (DWGs) or Objectives

Analyte Class	Number of Analytes Measured	Drinking WQGs	Federal EQGs	BC WQGs	CCME EQGs
Basic Water Properties	5	1	0	4	5
Coliform	3	2	0	0	0
Nutrients	6	3	0	4	4
Metals	37	20	4	20	17
PAHs	76	1	0	10	10
Pesticides	62	6	0	10	7
PPCPs	141	0	1	1	0
PFAS	40	3	1	1	0
PCBs	209	0	0	5	0
Alkylphenols	4	0	0	0	0
Bisphenols	6	0	1	1	0
Sucralose	1	0	0	0	0
6PPD quinone	1	0	0	1	0
Total	*587*	*36*	*7*	*56*	*43*

We applied three sets of EQGs and one set of DWQGs to our water quality data: The Federal government's *Federal Environmental Quality Guidelines* (FEQGs), the BC Government's Approved *Water Quality Guidelines* (BC WQGs), and the Canadian Council of Ministers of the Environment's (CCME) *Canadian Environmental Quality Guidelines* (CCME CEQGs); and Health Canada's Drinking Water Quality Guidelines. These guidelines were all designed to protect aquatic life.

International Guidelines and emerging PFAS concerns

Since it takes many years to finalize guidelines and in light of increasing concerns over PFAS as a contaminant of concern has led to toxicity, Health Canada has also established screening values for nine PFAS (Appendix 4). These screening values provide guidance where there is a need for quick response. In addition, more recently, a 'proposed objective' of 30 ng/l for total PFAS was developed which set out a goal for a maximum level of PFAS in drinking water. This proposed objective is based on the sum of specific individual PFAS (29 individual PFAS that are quantified by US EPA methods 533 and 537.1). This objective, when finalized, will replace the two existing drinking water guidelines and nine screening values (Health Canada, 2023).

There exist several thousand PFAS compounds, but only two are regulated in Canada: PFOA and PFOS, which were banned in 2011. Given the increasing concern over the presence, persistence and toxicity of per- and poly-fluoroalkyl substances (PFAS), Health Canada has developed screening values for a number of PFAS compounds. These are considered as approved guidelines for drinking water quality, they are based on risk assessment approaches that are similar to formal guidelines (Health Canada, 2023). They therefore serve as guidance when evaluating the risk of PFAS exposure from tap water consumption and are considered in the present report.

Given the limited guidance afforded by Canadian guidelines for the rapidly emerging PFAS concerns, we have included guidelines derived internationally for this contaminant class (USA, European Union and WHO).

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Table 4: Environmental Quality Guidelines for PFAS (USA and Canada)

Compound	Guideline (mg/L)	Issuing Agency	Notes
PFOS	0.0068	Canadian FEQG	EQG - PFOA under development
PFOS	3	US EPA	DRAFT EQG - Acute
PFOS	0.0084	US EPA	DRAFT EQG - Chronic
PFOA	49	US EPA	DRAFT EQG - Acute
PFOA	0.094	US EPA	DRAFT EQG - Chronic

Very few Environmental Quality Guidelines are available for PFAS. A Canadian Federal EQG was set for PFOS, while a guideline value for PFOA is currently in development.

Table 5: Drinking Water Quality Guidelines for PFAS

Compound	Guideline (ng/L)	Issuing Agency	Notes
Sum of 25 PFAS	30	Health Canada - Drinking Water Quality Objective	Objective expected to become Guideline
PFOS	600	Health Canada	
PFOS	4	US EPA	New in 2024
PFOA	200	Health Canada	
PFOA	4	US EPA	New in 2024
PFHxS	10	US EPA	
PFNA	10	US EPA	
HFPO-DA	10	US EPA	
Total PFAS	500	EU - Drinking Water Directive	

Most available guidelines address the two PFAS compounds suspected to be of greatest concern to human health: PFOA and PFOS.

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Water properties

Capsule

Basic water properties provided elementary information on the quality of fish habitat in the Sqwa:la watershed. The road runoff sample was found to have the highest conductivity among water categories. The Fraser River and source sites had the highest dissolved oxygen (mg/L). The road runoff sample had relatively low dissolved oxygen levels which were below acceptable ranges for the protection of freshwater aquatic life (using CCME and BC WQGs).

Introduction

Water properties including temperature (℃), dissolved oxygen, conductivity, pH, and turbidity are commonly measured as a preliminary method of assessing the quality of fish habitat. Temperature and dissolved oxygen are of particular significance to fish - as increased temperatures and low dissolved oxygen are often associated with summertime fish kills (La, 2011), a particular concern for sensitive cold-water species such as salmonids. Conductivity and turbidity measurements can act as proxies for total dissolved solids (TDS) (Rusydi, 2018) and total suspended solids (TSS) respectively (Rügner, *et al,* 2013). These parameters can be relevant as increased TDS and TSS in a body of water can indicate contamination from road salt, nutrients, or flushing of disturbed sediments into the waterway. Unusual conductivity measurements suggest the need for more in-depth analysis for contaminants (Ribeiro de Sousa, 2014).

Methods

A YSI ProDSS was used to take three measurements at each site of the following parameters: temperature (°C), dissolved oxygen (mg/L and %), specific conductivity (uS/cm), pH, and turbidity (FNU).

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Results

Table 6: Average water property results for five categories of water sampled in the Sqwa:la watershed (DRY Season 2024)

Parameter	Source (n=3)	Stream and river (n=3)	Road runoff (n=3)	Fraser (n=3)
Temperature (℃)	11.8 ± 0.61 (10.3-14.4)	15.2 ± 0.43 (13.4-16.5)	18.8 ± 0.39 (17.6-20.3)	**20.3 ± 0.16 (19.7-20.8)**
DO %	96.0 ± 0.29 (94.3-97.2)	76.7 ± 7.93 (44.6-99.8)	59.4 ± 13.0 (17.0-116)	109 ± 2.45 (104-120)
DO (mg/L)	10.5 ± 0.13 (9.91-10.9)	7.76 ± 0.86 (4.35-10.4)	**5.55 ± 1.26 (1.55-11.0)**	9.90 ± 0.201 (9.43-10.8)
pH	8.2 ± 0.00 (8.2-8.3)	7.5 ± 0.07 (7.3-7.8)	7.1 ± 0.06 (6.9-7.3)	8.0 ± 0.04 (7.8-8.1)
Conductivity (uS/cm)	274 ± 6.01 (260-298)	295 ± 7.12 (278-324)	437 ± 49.5 (320-635)	146 ± 16.7 (111-215)
Turbidity (FNU)	0.68 ± 0.06 (0.35-1.0)	1.0 ± 0.38 (0.03-3.0)	6.8 ± 2.6 (0.47-21)	27 ± 3.0 (17-43)

Bold indicates a measured value that does not fall within ranges considered protective for freshwater aquatic life. Data presented above represent mean +/- Standard Error of the Mean (SEM), with the Range in parentheses (min-max). DO = Dissolved Oxygen. uS/cm = MicroSiemens per cm. FNU = Formazin Nephelometric Units.

Conclusions

- The highest mean dissolved oxygen (mg/L) was measured in the Fraser River and source water sites.
- The road runoff sample had elevated conductivity compared to other water categories.
- The road runoff (5.55 ± 1.26 mg/L) sites had dissolved oxygen levels that are below the CCME Water Quality Guidelines for dissolved oxygen in freshwater for the protection of aquatic life of 6.5-9 mg/L for cold water ecosystems (early life stages-other life stages).
- The Fraser River sites had temperatures that are above the BC WQG daily maximum of 19 ℃ for the protection of freshwater aquatic life.

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Coliform bacteria

Capsule

Coliform bacteria in water indicate a potentially serious threat to human health. The highest coliform counts were measured in the road runoff sample from the Sqwa:la watershed, across all three coliform categories.

Introduction

Coliform bacteria have historically been used to gauge water quality with respect to implications for human recreational use and drinking water consumption (van Elsas, et al., 2013). Most recently, the spotlight has been on counts (MPN or CFU) of the gram-negative coliform bacteria species *Escherichia coli* as an indicator of recent contamination with wastewater, and to determine the risk to human health posed by consumption and recreational use of waterways (Li, 2021). There are no Environmental Quality Guidelines for coliform bacteria, reflecting the general idea that these potentially pathogenic bacteria are not likely to present a risk to aquatic life.

Results

Table 7: Counts (MPN/100ml) of coliform bacteria in five water categories in the Sqwa:la watershed (DRY Season 2024)

Parameter	Source (n=1)	Stream and river (n=1)	Road Runoff (n=1)	Fraser (n=1)
Total coliform (MPN)	727	>2420	>2420	1300
Fecal coliform (MPN)	18	>2420	>2420	16
E. coli (MPN)	8	866	>2420	17

The analytical method used for the measurement of coliform bacteria is only accurate up to 2420 MPN, values greater than this threshold are reported as >2420 MPN as seen in the road runoff sample.

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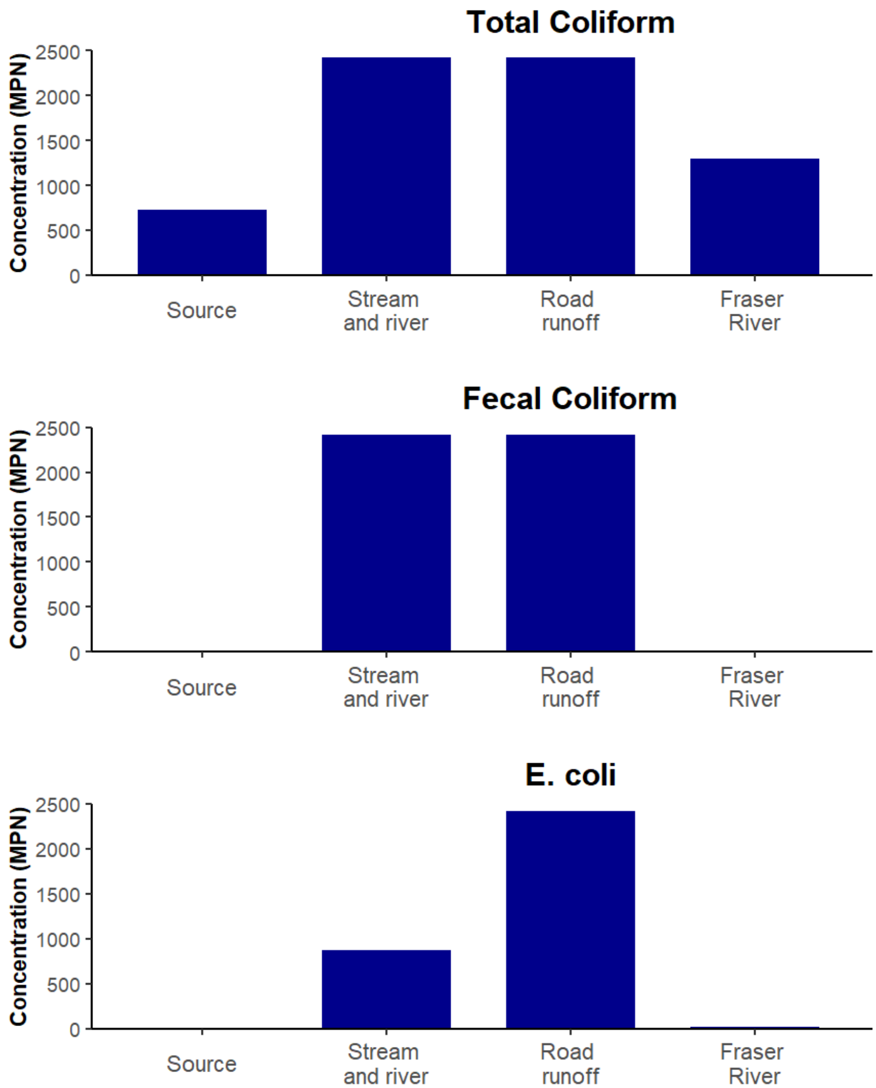
Figure 2: Coliform counts (MPN) in five water categories in the Sqwa:la watershed (DRY Season 2024)



Road runoff had the highest counts for coliform bacteria across all three coliform categories: total coliform, fecal coliform, and *E. coli*. While total coliform are abundantly present in soils and aquatic habitats, fecal coliform and *E. coli* both originate in the digestive tracts of warm-blooded animals such as humans, dogs, or cattle.

Conclusions

- *E. coli* concentrations in each of the four water categories from highest to lowest area were as follows: Road runoff > stream and river > Fraser River > source.
- There are currently no EQGs available for coliform bacteria for the protection of aquatic life.

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- *E. coli* values in the stream and river, and road runoff water samples were above Recreational Use Guidelines set by Health Canada (>235 CFU/100ml). CFU and MPN are both methods for laboratory culture of bacteria, and can be used interchangeably with regards to Guideline values.
- Source water samples were within Health Canada guidelines for raw drinking water sources (<10 MPN/100ml), with this DWQG assuming that municipal, reserve or domestic disinfection processes destroy all coliform prior to drinking. It should be noted that the source water sites included in this study are not currently used as a community source of drinking water.

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Nutrients and Physical parameters

Capsule

Nutrients can readily degrade fish habitat by increasing plant and algal growth and causing a subsequent reduction in dissolved oxygen. Nitrate was the most commonly detected nutrient in the Sqwa:la watershed, and was detected in all samples. Road runoff had the highest concentration of nitrate and nitrite, both of which exceeded available EQGs.

Introduction

Nutrients such as nitrogen and phosphorus compounds can be naturally occurring, and are critical for the health and growth of plants and animals (CCME, 2016). However, nutrients from fertilizers and wastewater that are released into a body of water can put it at risk of eutrophication - a process which is characterized by an overgrowth of plants and algae and resulting in oxygen depletion (Putt, et al. 2019). Eutrophication poses a significant risk to aquatic life, as low oxygen levels create an inhospitable environment for the survival of fish - in particular salmonids who require relatively high levels of dissolved oxygen for survival and reproduction (Davis, 1975).

In addition, some nutrients such as total ammonia are considered to be acutely toxic to freshwater fish species at concentrations that vary by pH and temperature of the water (CCME, 2010).

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Results

Table 8: Concentrations (mg/L) of physical and chemical properties in each water category for the Sqwa:la watershed (DRY Season 2024)

Parameter	Source (n=1)	Stream and river (n=1)	Road Runoff (n=1)	Fraser (n=1)
Hardness	43.9	169	120	147
Solids, total dissolved [TDS]	78	254	184	228
Solids, total suspended [TSS]	<3.0	6.6	6.0	<3.0
Carbon, total organic [TOC]	1.83	7.31	11.1	10.0
Biochemical oxygen demand [BOD]	<2.0	<2.0	2.5	<2.0
Chemical oxygen demand [COD]	<10	35	32	24

Table 9: Nutrient concentrations (mg/L) in each water category for the Sqwa:la watershed (DRY Season 2024)

Parameter	Source (n=1)	Stream and river (n=1)	Road Runoff (n=1)	Fraser (n=1)
Ammonia, total (as N)	<0.0050	0.0297	1.10	0.0072
Nitrate (as N)	0.507	0.388	**9.95**	0.126
Nitrate + Nitrite (as N)	0.507	0.396	10.2	0.129
Nitrite (as N)	<0.0010	0.0076	**0.290**	0.0028
Nitrogen, total	0.554	0.643	12.2	0.260

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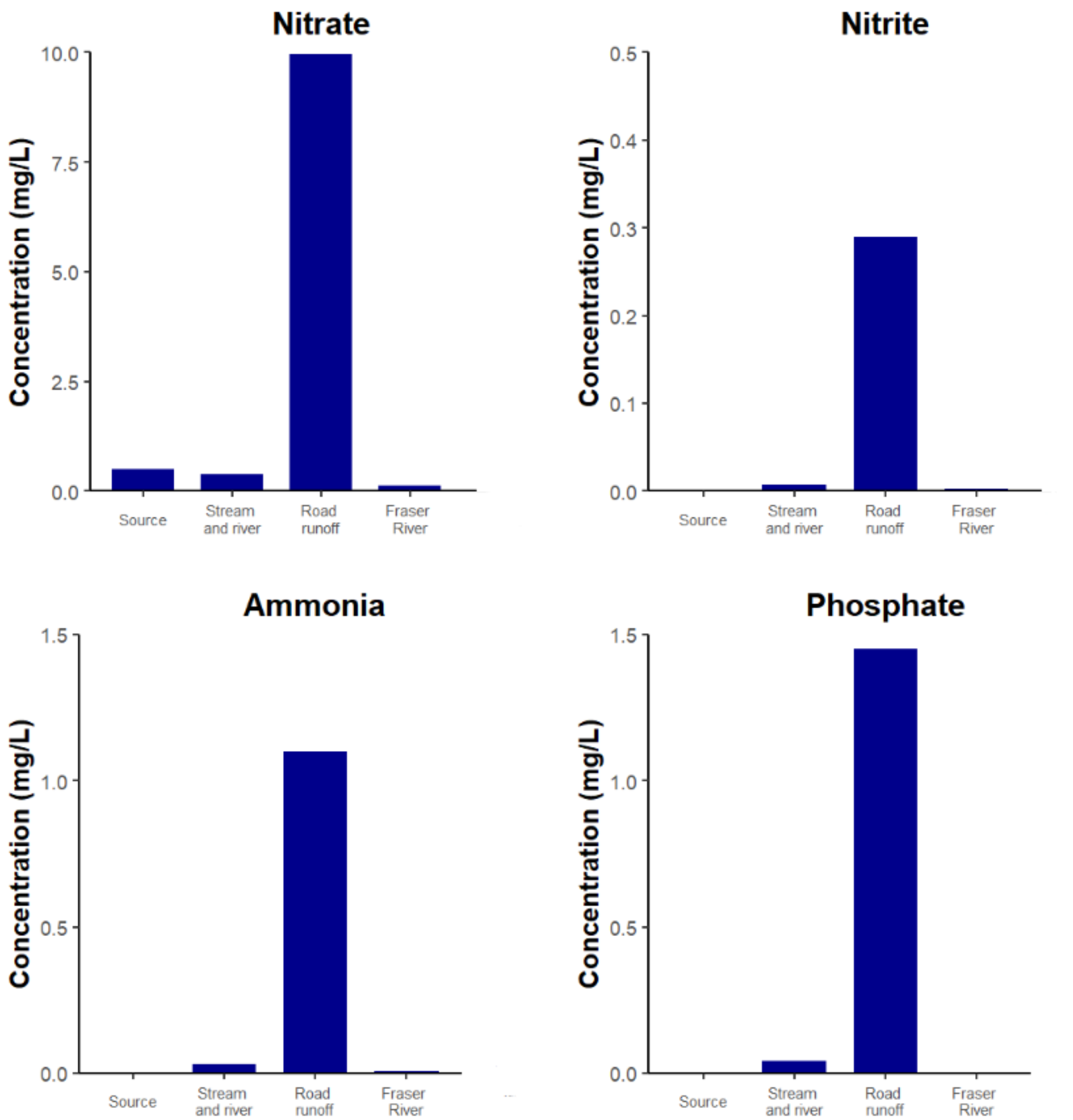
Phosphate, ortho-, dissolved (as P)	<0.0010	0.0418	1.45	0.0031

Water samples were analyzed for the following nutrients: total nitrogen, nitrate (NO^{-3}), ammonia (NH_3), phosphate (PO_4^{3}) and nitrite (NO^{-2}).

Figure 3: Nutrient concentrations (mg/L) in four water categories in the Sqwa:la watershed (DRY Season 2024)



Nitrate (NO^{-3}) was the most commonly detected nutrient in water samples from the Sqwa:la watershed. The highest mean concentration (mg/L) was detected in road runoff samples (3.38 mg/L)). Ammonia (NH_3) was detected in the road runoff sample. Phosphate (PO_4^{3}) was detected in three out of four water samples and was found at the highest concentration in the road runoff sample (0.0785 mg/L). Nitrite (NO^{-2}) was not detected in any of the samples.

Conclusions

- Nitrate concentrations in the four water categories were ranked from highest to lowest as follows: road runoff > source > stream and river > Fraser River.
- Nutrients were detected in samples from all water categories, with total nitrogen being the most commonly detected nutrient across water categories.
- The nitrate concentration in the road runoff sample (9.95 mg/L) exceeded the BC MoE chronic (long-term) guideline for the protection of freshwater aquatic life of 3.0 mg/L.
- The nitrite concentration detected in the road runoff sample (0.290 mg/L) also exceeded both of the BC MoE guidelines for the protection of freshwater aquatic life (acute = 0.06 mg/L, chronic = 0.02 mg/L).

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Metals

Capsule

Metals can be present in water due to both natural and anthropogenic inputs. 23 metals were detected in all of the water samples collected in the Hope Slough watershed. The highest concentration of metals was detected in the road runoff sample.

Introduction

Metals are present in aquatic environments as a result of both natural and anthropogenic sources, with baseline levels reflecting the unique geology of the area surrounding a body of water (Jadaa, et al., 2023). Anthropogenic sources of metal contamination in waterways may originate from industrial effluent, municipal wastewater, agricultural practices, and urban runoff.

Many metals are capable of impacting the health of aquatic life, with some representing a priority concern in fish habitat, including zinc (Giardina, et al., 2009) and copper (Malholtra, et al., 2020).

Results

Table 10: Concentrations (mg/L) of the metals that were detected in all five water categories in the Sqwa:la watershed (DRY Season 2024)

Parameter	Source (n=1)	Stream and river (n=1)	Road runoff (n=1)	Fraser River (n=1)
Aluminum, total	0.0220	0.0138	0.0713	**0.752**
Antimony, total	0.00013	<0.00010	0.00014	<0.00010
Arsenic, total	0.00013	0.00050	0.00136	0.00078
Barium, total	0.0231	0.0337	0.0617	0.0250
Beryllium, total	<0.000020	<0.000020	<0.000020	0.000024
Bismuth, total	<0.000050	<0.000050	<0.000050	<0.000050
Boron, total	<0.010	0.016	0.031	<0.010
Cadmium, total	<0.0000050	0.0000133	0.0000917	0.0000158

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Calcium, total	45.8	44.1	46.5	18.8
Chromium, total	<0.00050	<0.00050	0.00057	0.00123
Cobalt, total	<0.00010	0.00019	0.00090	0.00065
Copper, total	0.00055	0.00137	0.0196	0.00332
Iron, total	0.033	0.299	**1.43**	**1.13**
Lead, total	<0.000050	<0.000050	0.000139	0.000464
Lithium, total	0.0015	0.0013	0.0016	0.0018
Magnesium, total	3.83	5.61	14.2	4.48
Manganese, total	0.00183	0.0307	0.191	0.0459
Mercury, total	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum, total	0.00126	0.00151	0.00541	0.000779
Nickel, total	<0.00050	0.00136	0.00377	0.00257
Phosphorus, total	<0.050	0.087	1.87	<0.050
Potassium, total	0.437	1.46	11.8	1.10
Selenium, total	0.00119	0.000852	0.000609	0.000120
Silicon, total	3.59	5.08	9.11	4.06
Silver, total	<0.000010	<0.000010	<0.000010	<0.000010
Sodium, total	2.73	4.11	7.40	2.43
Strontium, total	0.372	0.364	0.342	0.119
Sulfur, total	11.9	12.3	18.0	4.19
Thallium, total	<0.000010	<0.000010	<0.000010	<0.000010
Tin, total	<0.00010	<0.00010	<0.00010	<0.00010
Titanium, total	0.00096	0.00050	0.00290	0.0271
Uranium, total	0.000067	0.000099	0.000111	0.000255

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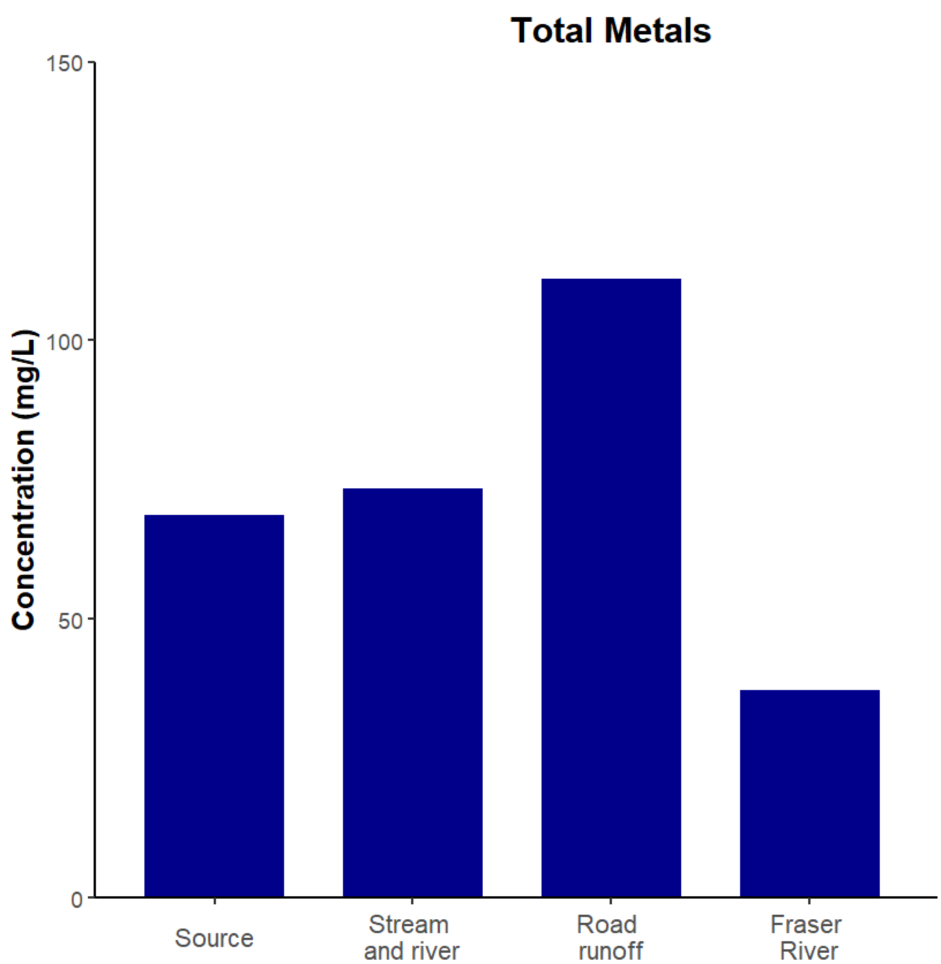
Vanadium, total	<0.00050	<0.00050	0.00102	0.00174
Zinc, total	<0.0030	0.0034	0.0365	0.0033
Zirconium, total	<0.00020	<0.00020	<0.00020	0.00039
Total Metals	**68.7**	**73.5**	**111**	**37.2**

Bold indicates a measured value that does not fall within ranges considered protective for freshwater aquatic life.

Figure 4: Total metal concentrations (mg/L) in five water categories in the Sqwa:la (Hope Slough) watershed (DRY Season 2024)



The road runoff water sample had a slightly higher concentration of total metals than the other three samples.

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Conclusions

- Total metal concentration for the four water categories was ranked from highest to lowest as follows: road runoff > stream and river > source > Fraser River
- The aluminum concentration detected in the Fraser River (0.752 mg/L) sample exceeded the long-term CCME guideline for the protection of aquatic life of 0.1 mg/L (for pH>6.5).
- The iron concentrations detected in the road runoff (1.43 mg/L) and Fraser River (1.12 mg/L) samples both exceeded BC MOE guideline for the protection of aquatic life of 1.0 mg/L.

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Polycyclic Aromatic Hydrocarbons (PAHs)

Capsule

Polycyclic aromatic hydrocarbons (PAHs) were detected in all five water samples, with the highest concentrations observed in the road runoff sample and the lowest in the source sample, similar to the wet season. Average PAH concentrations across all water categories were 1.8 times lower during the dry season compared to the wet season. The PAH profile was variable amongst water types. Common PAHs present at the highest concentrations were C2-Biphenyls present in all samples, similar to the wet season. WQGs were only available for a few PAHs, but no exceedances were observed for any of our samples, similar to the wet season.

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a complex group of compounds found in coal, petroleum and plant materials. They can enter waterways in the form of liquid petroleum products (gasoline, diesel, oil) or via the incomplete combustion of coal, oil, gas, wood garbage or other organic substances. They can occur naturally or as a result of human activities (anthropogenic). In Canada, forest fires are the single most important natural source of PAHs, while anthropogenic sources include residential wood heating, aluminum smelters, creosote-treated products, spills of petroleum products and metallurgical and coking plants (Government of Canada, ECCC and Health Canada, 1994; Marvin et al., 2021).

Hydrocarbons can enter aquatic ecosystems either directly through oil spills or discharges from vessels (Morales-Caselles et al., 2017) or indirectly through atmospheric deposition, runoff and discharge from wastewater treatment plants. Depending on their molecular size, PAHs vary in toxicity and have been classified as toxic under the Canadian Environmental Protection Act (CEPA).

Results

We measured 76 different parent and alkylated PAHs in the four water samples collected in the Sqwa:la watershed during the dry season.

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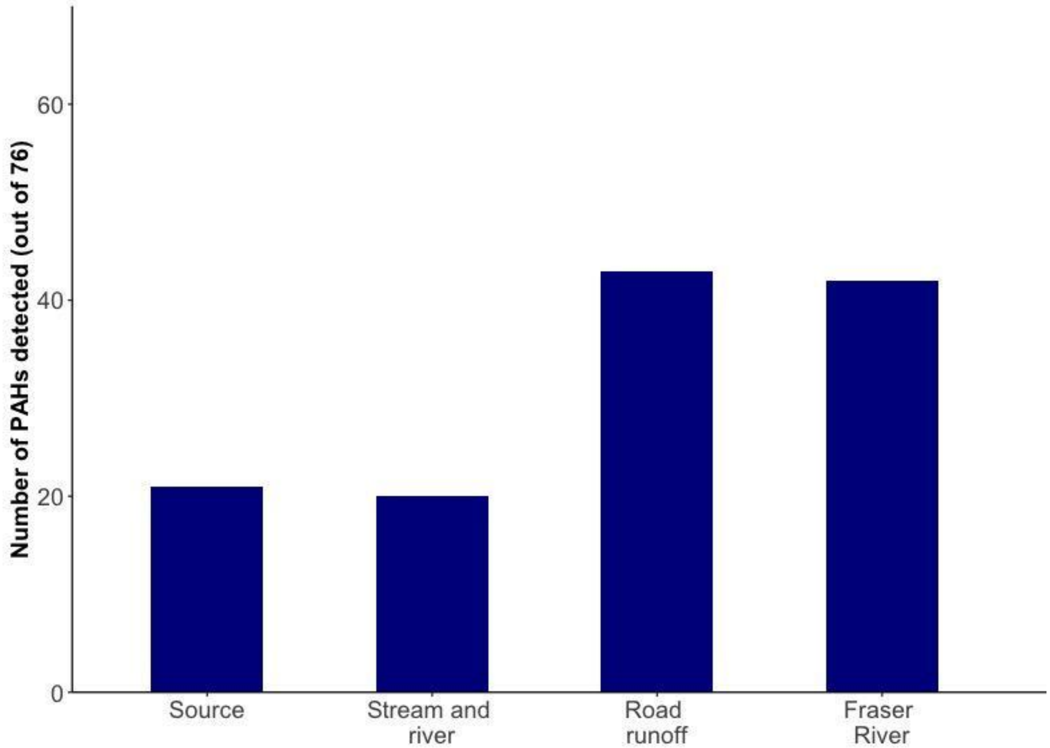
Figure 5: Number of PAHs detected in water samples from the Sqwa:la watershed (DRY Season 2024)



PAHs were detected in all four water categories. The number of PAHs detected ranged from 20 (stream and river) to 43 road runoff) with an average of 31.5 ± 6.4, similar to the wet season.

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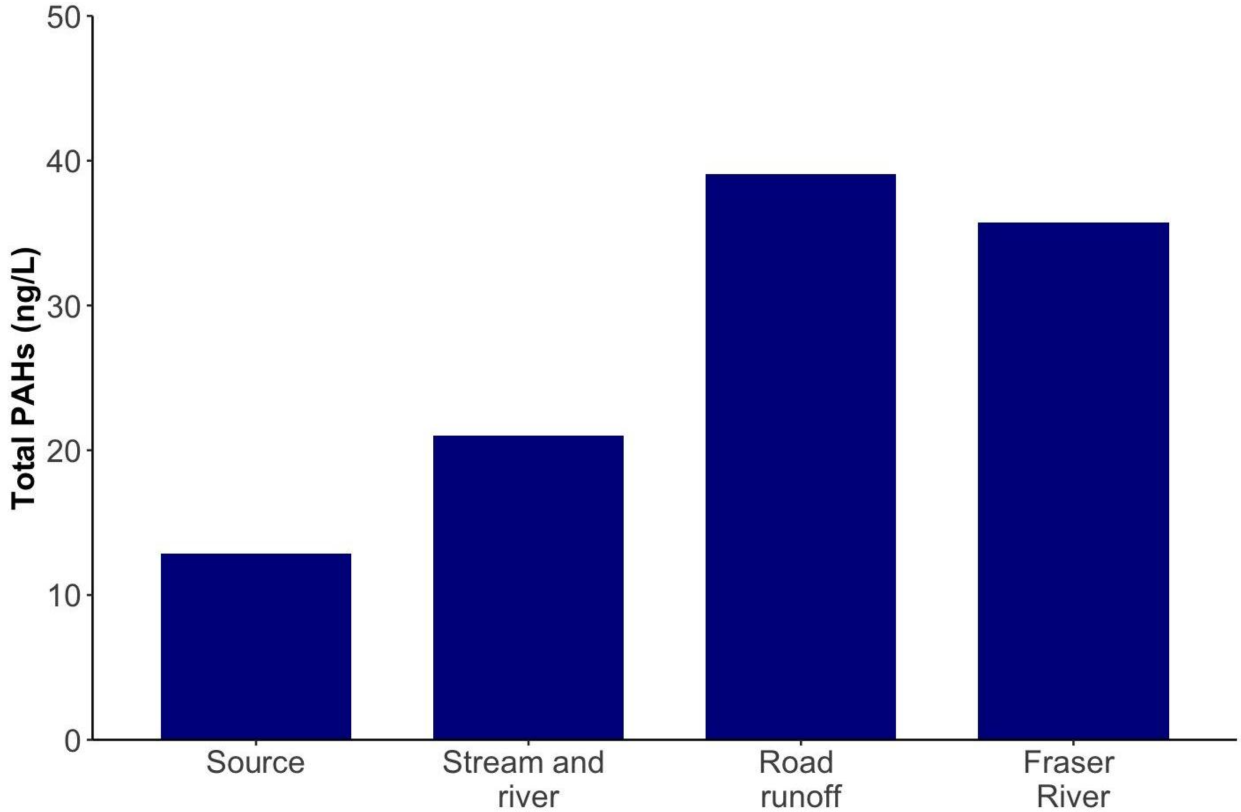
Figure 6: Total PAH concentrations in water samples from the Sqwa:la (Hope Slough) watershed (DRY Season 2024)



Total PAH concentrations ranged from 12.8 (source) to 39.1 ng/L (road runoff), with an average across all water categories of 27.2 ± 6.2 ng/L, half of what was reported during the wet season.

When comparing dry season results with levels from the wet season, we found that:

- PAH levels in the source samples were similar between the dry and wet seasons.
- PAH levels were 1.6, 1.8 and 2.9 times lower in the dry season compared to the wet season for the stream and river, road runoff and Fraser River samples, respectively.

Ratios of certain PAHs can be used to evaluate sources. Given that only a limited number of PAHs were detected in the water samples, the Fluoranthene - Pyrene ratio was the only one that could be calculated reliably.

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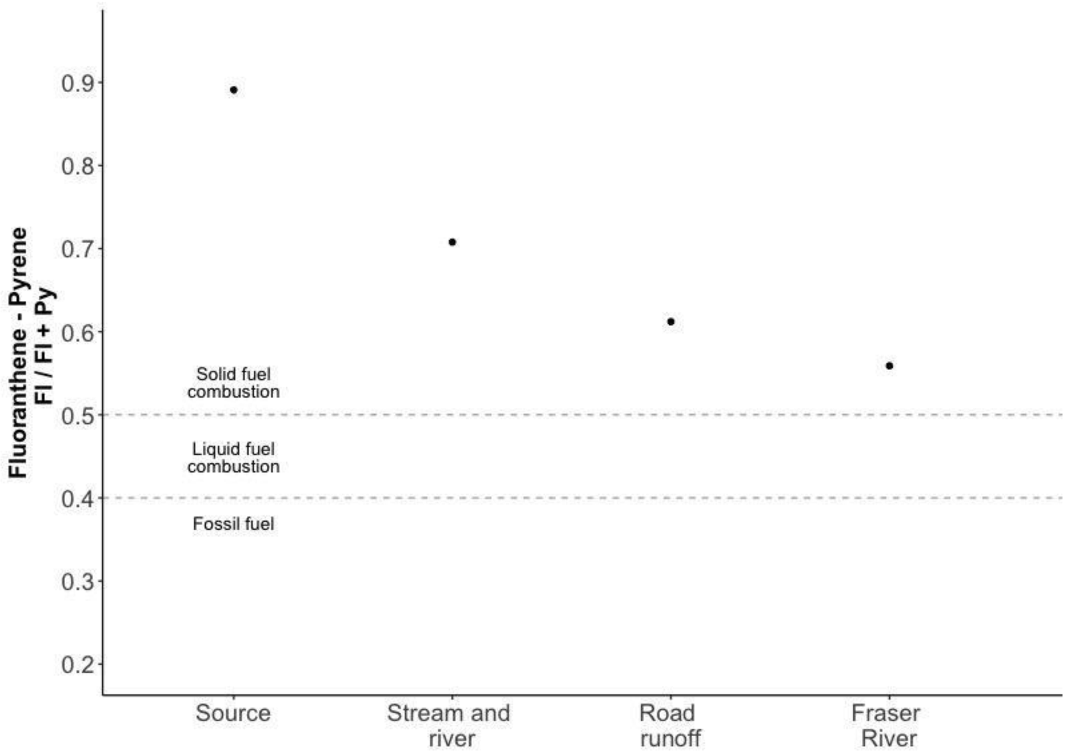
Figure 7: PAH profiles from wood combustion and fuels in water samples from the Sqwa:la (Hope Slough) watershed (DRY Season 2024)



All samples had Fl/(Fl+Pyr) ratios higher than 0.5, suggesting the contribution of combustion of solid fuel such as wood, plant material or coal as the source of PAHs.

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Conclusions

- PAH concentrations were ranked as follows from highest to lowest: road runoff > Fraser River > stream and river > source.
- Total PAH concentrations in Sqwa:la watershed water samples ranged from 12.8 to 39.1 ng/L in the dry season, and were on average half that what was reported during the wet season.
- Fluoranthene - Pyrene ratios revealed that PAHs in all samples originated primarily from the combustion of solid fuel such as wood or plant material. This is consistent with wood burning for heating homes, and wildfires as being major sources of PAHs in Canada (Berthiaume et al., 2021). In addition, biomass burning in Asia has been shown to deliver PAHs to Canada through air masses traveling across the Pacific Ocean (Berthiaume et al., 2021).
- All the environmental water samples were below the BC WQGs available for individual PAHs (naphthalene, acenaphthene, fluorene, anthracene, phenanthrene, fluoranthene, pyrene, chrysene, benzo-a-pyrene and benzo-a-anthracene), similar to the wet season.

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Pesticides

Capsule

A limited number of pesticides were detected in all five water samples, with the highest concentrations in the road runoff water sample, and the lowest in the source sample, similar to the wet season. On average, across all water categories, pesticide levels during the dry season were 12.6 times higher than during the wet season. Beta-endosulphan was detected in all water samples along with atrazine and its breakdown product desethylatrazine. Out of the suite of 12 pesticides that were detected, there were only two that were still in use in Canada at the time of sampling: atrazine and simazine, similar to the wet season. As opposed to the wet season when there were no environmental quality guideline exceedances, the road runoff sample exceeded both the BC and CCME EQGs for endosulphan.

Introduction

Pesticides have been developed to control, destroy or inhibit the activities of pests. They have a wide range of applications in agriculture such as insecticide to prevent crop damage and fungicides to prevent plant disease but also in forestry, industry as well as in our own backyards for lawn care or weed and insect control. In Canada, all pesticides used, sold or imported are regulated by Health Canada's Pest Management Agency (PMRA) (Health Canada, 2007).

While pesticides are mostly applied on terrestrial habitats, they can reach aquatic environments through overspray or drift during application, surface runoff, and through long range atmospheric transport and deposition. It is estimated that 10% of pesticides applied to soil reach non-target areas, leading to their widespread presence in surface waters worldwide (Schulz, 2004; Anderson et al., 2022).

Organochlorine pesticides (OCP) were heavily used from the 1940s to the 1980s, but have been restricted due to their persistence, toxicity and potential for bioaccumulation. Current-use pesticides (CUPs) were subsequently favoured as an alternative to OCPs, and have been widely applied in recent decades (Ding et al., 2023). These tend to be more water-soluble and may be more mobile in fish habitat (Harris et al., 2008).

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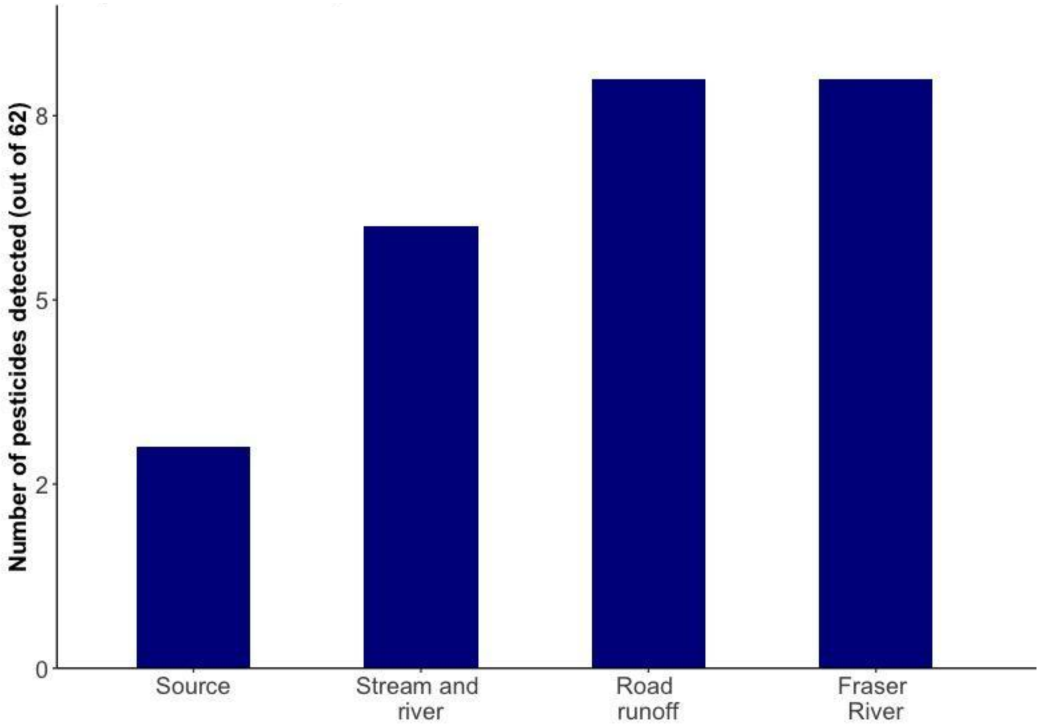
Results

We measured 62 different pesticides, including both legacy and CUPs in the four water samples collected within the Sqwa:la watershed during the dry season.

Figure 8: Number of pesticide detections in water samples from the Sqwa:la watershed (DRY Season 2024)



The number of pesticides detected ranged from 3 (source) to 8 (road runoff, Fraser River) with an average of 6.3 ± 1.2, 1.4 times lower than during the wet season.

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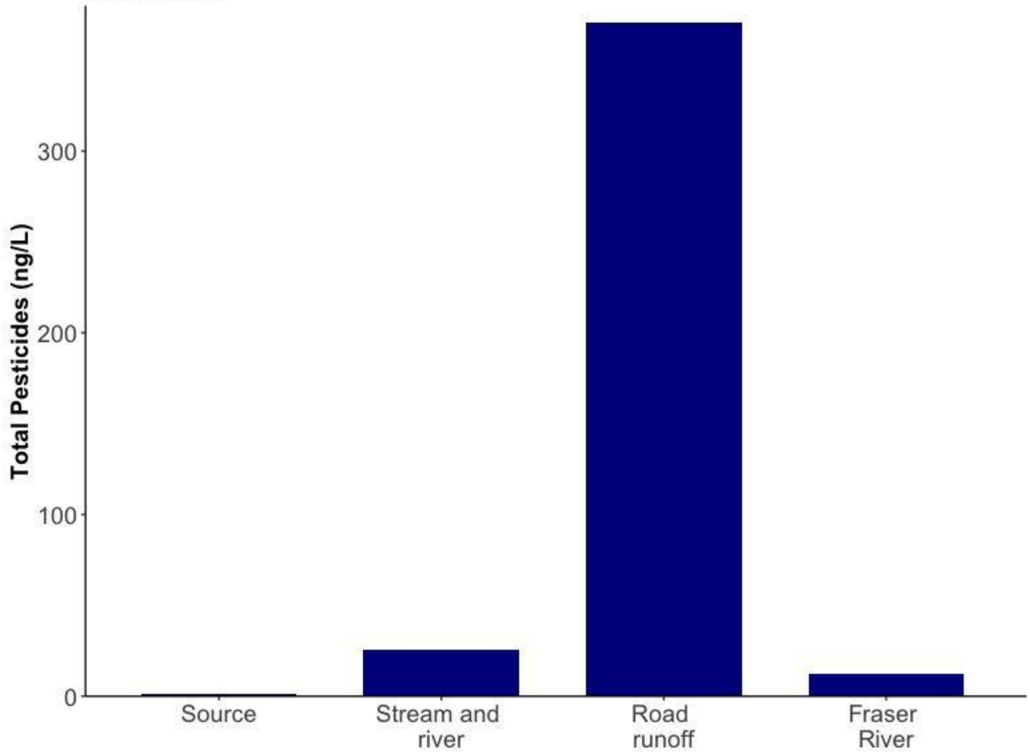
Figure 9: Total pesticide concentrations in water samples from the Sqwa:la (Hope Slough) watershed (DRY Season 2024)



Total pesticide levels ranged from 1.4 (source) to 371 ng/L (road runoff), with an average across all water categories of 102 ± 89.6 ng/L, 13.4 times higher than during the wet season.

When comparing with levels from the wet season, we found that:

- Pesticide concentrations were highest in the road runoff samples in both seasons with levels in the dry season being 28.4 times higher than those reported during the wet season.
- Pesticide levels were lowest in the source samples in both seasons with levels in the dry season being 10.7 times higher than those reported during the wet season.
- Pesticide levels were 2.6, 1.6 and 9.2 times lower in the dry season compared to the wet season for the stream and river, and Fraser River samples respectively.

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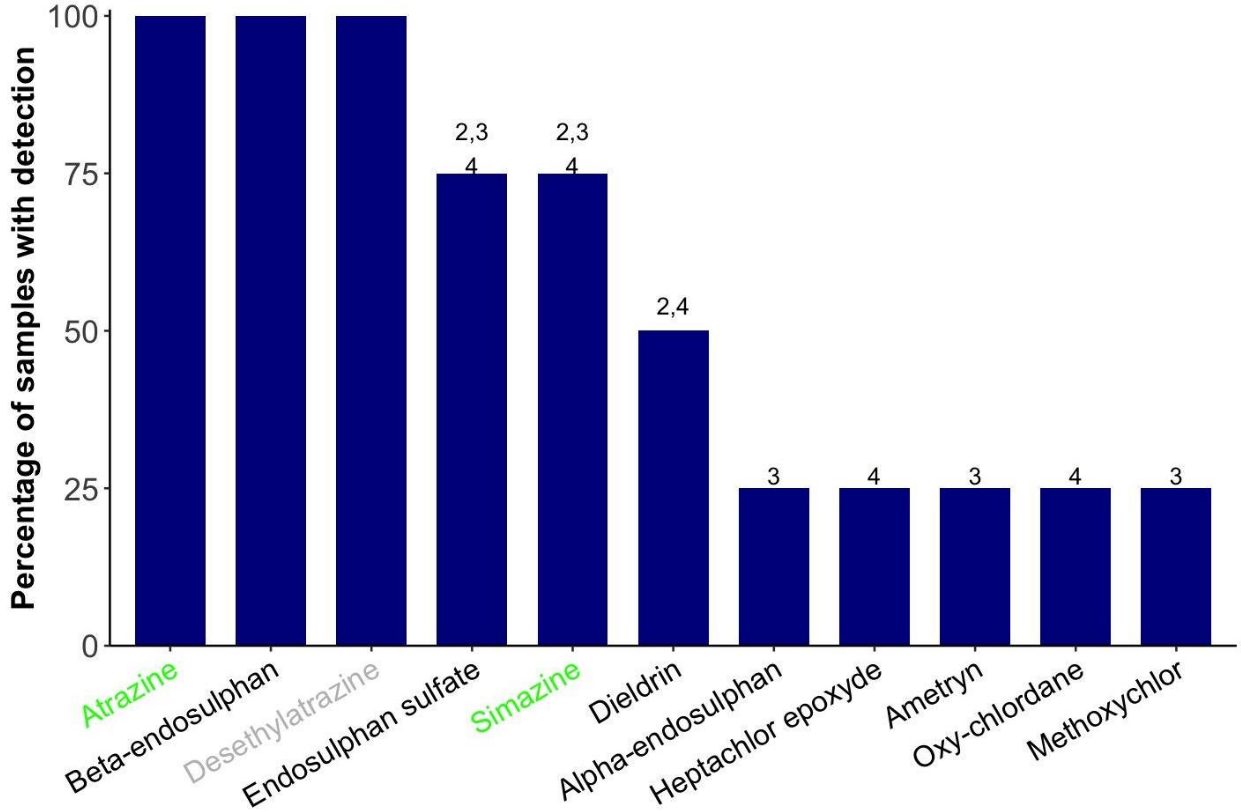
Figure 10: Most frequently detected pesticides in water samples from the Sqwa:la watershed (DRY Season 2024)



Numbers refer to water categories (1: Source, 2: Stream and river, 3: Road runoff, 4: Fraser River). For example, the source sample had detectable levels of atrazine, beta-endosulfan and desethylatrazine. Atrazine and simazine (highlighted in green) were the only pesticides detected still in use in Canada. Desethylatrazine (highlighted in grey) is a breakdown product of atrazine.

Atrazine, beta- endosulfan and desethylatrazine were detected in all samples.

- Atrazine is a selective herbicide still in use in Canada to control grass and broadleaf weeds in crops (corn and sorghum in Canada). In light of additional scientific information becoming available regarding potential human health (drinking water) and environmental risk from atrazine in surface water, Health Canada initiated, in 2017, a special review of all registered pest control products containing atrazine (Health Canada, 2023). Health Canada is currently consulting on its second special review of atrazine (Health Canada, 2023).

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- Endosulfan is a restricted-use insecticide and acaracide used to control a broad range of insect and arthropod pests on a wide variety of food, feed and ornamental crops (Health Canada, 2011). The commercial mixture contains both alpha- and beta- endosulfan. endosulfan has been banned in Canada since 2016 and is banned or restricted in most other countries (ECCC, 2023).

Simazine was another pesticide detected that is still currently in use in Canada as a herbicide used to control weeds in various crops, at airports, and along shelterbelts and rights-of-way, as well as being used in aquatic weed control in ditches, farm ponds, fish hatcheries, aquaria, and fountains (Health Canada, 2016).

When comparing the dry and wet seasons, there were some similarities with the current use pesticides atrazine and simazine detected in the majority of samples during both seasons.

Conclusions

- Pesticide concentrations were ranked as follows from highest to lowest: road runoff > stream and river > Fraser River > source.
- Total pesticide concentrations ranged from 1.4 to 371 ng/L with an average across all water categories 13.4 times higher in the dry season than during the wet season.
- All pesticides detected, except atrazine and simazine, were no longer in use in Canada at the time of sampling. Their detection likely reflects historical use nearby as well as deposition following long-range atmospheric transport. Interestingly, hexachlorobenzene, endosulfan and simazine were the most abundant pesticides detected in air samples collected from four mountains across British Columbia, including Grouse Mountain in North Vancouver (Ding et al., 2023).
- Endosulfan, atrazine and simazine were the only pesticides detected that had EQGs, and their concentrations did not exceed these for most categories of water, similar to the wet season.
    - the one exception was endosulphan in road runoff (sum alpha- and beta-endosulphan = 5.5 ng/L) that exceeded both the BC (0.7 ng/L) and CCME EQGs (3 ng/L for long-term effects) for the protection of aquatic life.

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Pharmaceuticals and Personal Care Products

Capsule

Pharmaceuticals and Personal Care Products (PPCPs) are a category of contaminants that can enter the environment via wastewater, and are typically not removed during treatment. Metformin, Penicillin G, and DEET were detected in all water samples collected in the watershed. Cotinine was detected in three out of five water samples. The highest total concentration of PPCPs was detected in the source sample (90.3 ng/L). The greatest diversity of PPCP compounds was measured in the road runoff sample (n=7).

Introduction

Pharmaceuticals and Personal Care Products (PPCPs) comprise a wide range of products and chemical formulations. The common link among these compounds is their use in human health, veterinary health and personal care. Many PPCPs are introduced into the environment via wastewater streams, and are not reliably removed during treatment at wastewater treatment plants (WWTPs).

Pharmaceuticals may enter the environment by way of WWTP effluent, land-applied biosolids and/or septic tank failures (Metcalfe et al 2004). Monitoring of source water is deemed an important means of assuring the safety of drinking water, especially First Nations (Schwartz et al., 2021). However, the lack of Environmental Quality Guidelines and Drinking Water Quality Guidelines in Canada for PPCPs and internationally constrains a fulsome risk-based evaluation of environmental concentrations (Lee and Choi, 2019).

DEET (N,N-diethyl-meta-toluamide) is a widely used insect repellent. Penicillin G is a broad-spectrum antibiotic used to treat bacterial infections. Metformin is a drug commonly prescribed for the treatment of diabetes and pre-diabetes, and functions to lower the blood glucose levels of users. Caffeine is a plant-derived stimulant found in widely-consumed beverages.

Caffeine has been used as an indicator of human wastewater in the environment - as it is relatively stable and persistent in surface waters, but sucralose is increasingly used in its place.

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Results

Table 11: PPCP concentrations (ng/L) for all analytes detected in each water category for the Sqwa:la watershed (DRY Season 2024)

Analyte	Source (n=1)	Stream and river (n=1)	Road runoff (n=1)	Fraser River (n=1)
2-Hydroxy-ibuprofen	0	0	0	0
Cefotaxime	0	0	0	0
Penicillin G	6.41	4.47	4.10	6.07
Caffeine	0	7.13	18.8	0
Carbamazepine	0	0	0	0
Amphetamine	0	0.049	0	0
Atenolol	0	0	0.313	0
Cotinine	0	0.405	1.69	0.424
Metformin	0.223	2.13	17.6	6.03
Cocaine	0	0	0	0
DEET	83.6	3.76	7.79	2.28
Theophylline	0	0	15.3	0
Total PPCP Concentration	**90.3**	**17.9**	**65.6**	**14.8**
Total No. PPCPs	*3*	*6*	*7*	*4*

Conclusions

- PPCP Concentrations in each water sample from highest to lowest are as follows: source > road runoff > stream and river > Fraser River.
- There are no EQGs available in Canada for any of the PPCPs we detected in water samples for the Sqwa:la watershed.
- The only PPCP for which there is an environmental quality guideline is Ethinylestradiol (EE) - not detected here - which is used widely as one of the hormonal components of birth control - as it has been shown to negatively impact both reproductive and immune function in some fish species.

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Per- and poly-fluoroalkyl substances (PFAS)

Capsule

Per- and poly-fluoroalkyl substances (PFAS) were detected in two (stream and river, road runoff) of the four water samples in the dry season compared to the wet season when they were detected in all samples. The highest PFAS concentration was reported in the road runoff sample. Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonamide (PFOSA) were detected in the stream and river and road runoff samples. None of the samples exceeded the currently available environmental quality guidelines (PFOS), similar to the wet season.

Introduction

Per- and poly-fluoroalkyl substances (PFAS) are large group (~15,000 compounds) of human-made substances used in a wide variety of products such as food packaging, non-stick cookware, clothing, and cosmetics, but also lubricants, oil/water repellents, and notably - aqueous firefighting foams (AAAF; Barzen-Hanson et al., 2017). They are extremely stable and therefore persistent in the environment, which has led to the use of the term "forever chemicals" for this category of chemical.

PFAS can be released into the environment from point sources such as manufacturing plants, or sites where firefighting foams have been used. PFAS can also be released through consumer use and disposal of PFAS-containing products. PFAS has been found in all environmental compartments (Moller et al., 2010; ECCC and Health Canada, 2023).

Evidence of adverse effects on the environment and on human health has led Canada to prohibit the manufacture, use, sale, offer for sale and import of a limited number of PFAS including perfluorooctanesulfonic acid (PFOS), perfluorooctanoic Acid (PFOA), long-chain perfluorocarboxylic acids and their salts and precursors under the *Prohibition of Certain Toxic Substances Regulations* and the *Canadian Environmental Protection Act* (CEPA) (ECCC and Health Canada, 2023b). Advancing regulatory aspects pertaining to rapidly emerging concerns about the many PFAS being detected in the environment is a current priority in Canada (Longpre et al., 2020).

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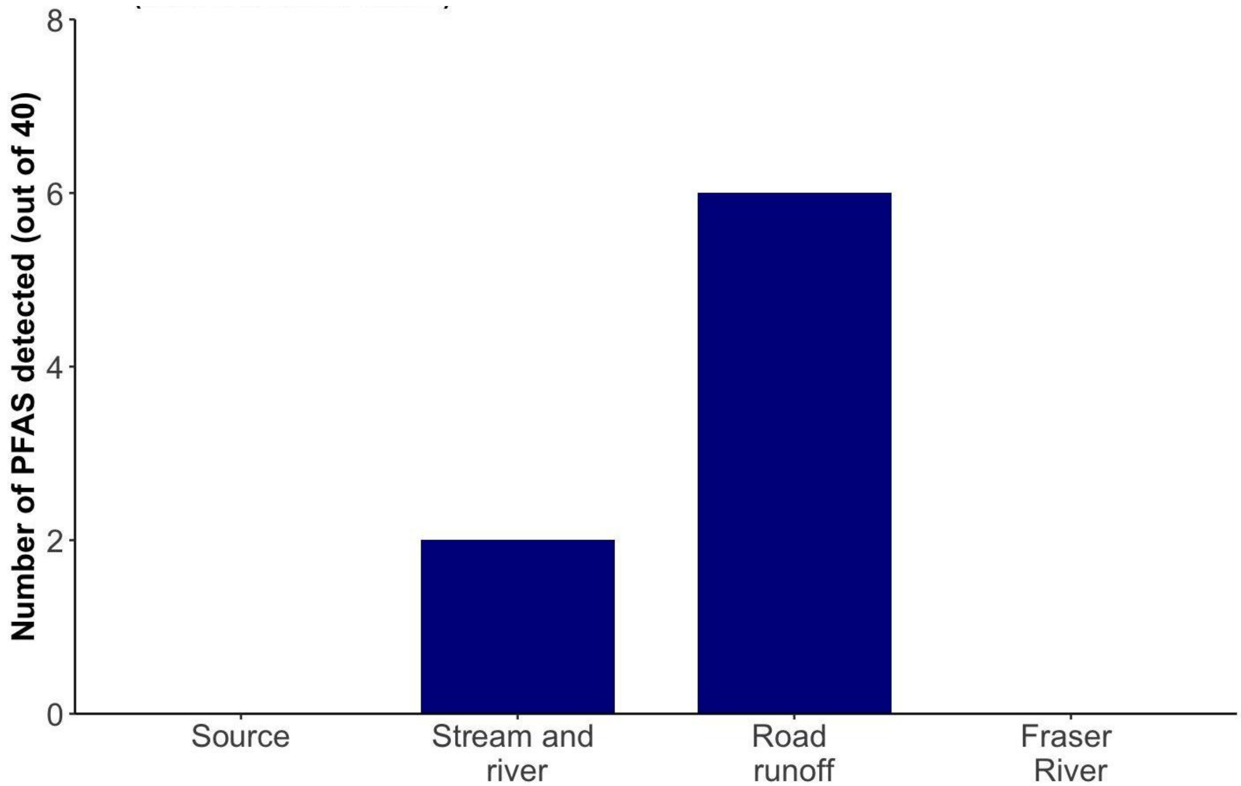
Results

We measured 40 different PFAS in the four water samples collected within the Sqwa:la watershed during the dry season.

Figure 11: Number of PFAS substances detected in water samples from the Sqwa:la watershed (DRY Season 2024)



PFAS were only detected in the stream and river, and road runoff samples as opposed to all samples during the wet season.. The number of PFAS detected ranged from 0 (source and Fraser River) to 7(runoff), similar to the wet season.

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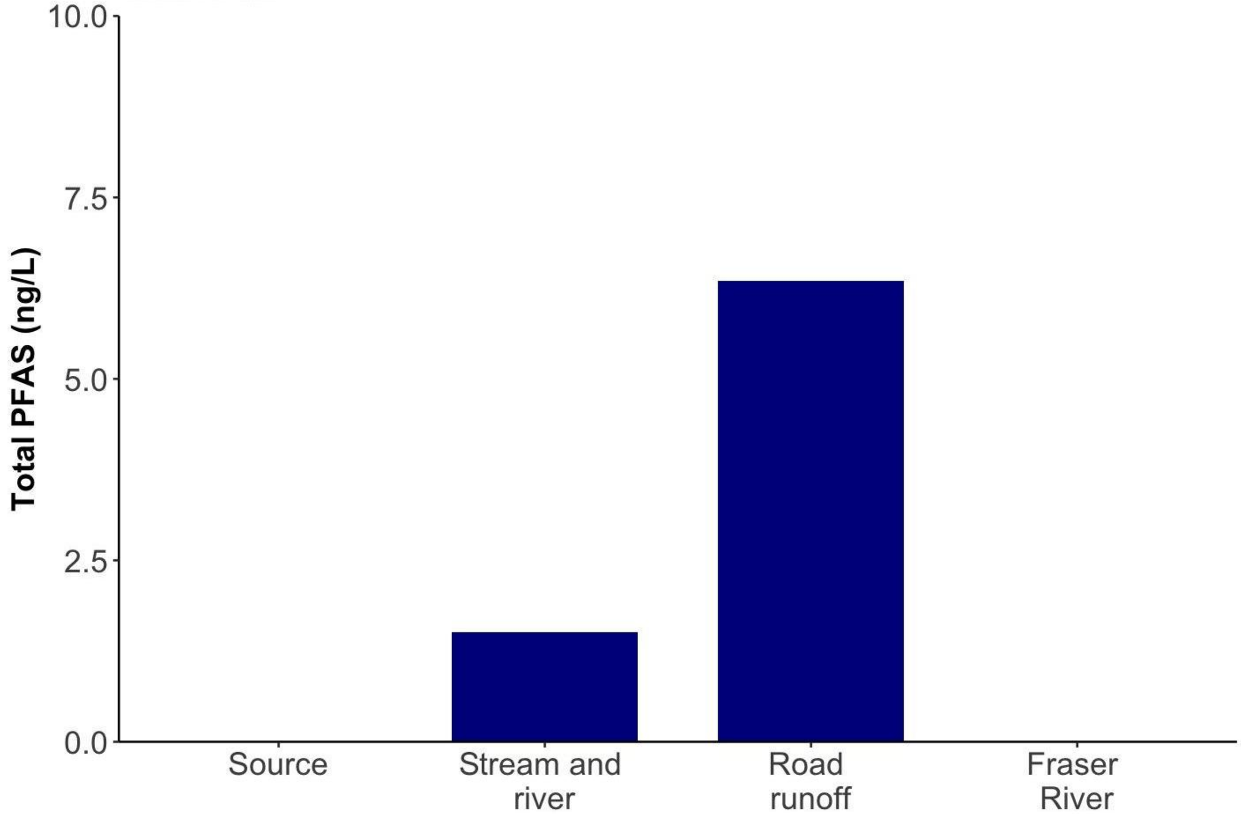
Figure 12: Total PFAS concentrations in water sampled in the Sqwa:la watershed (DRY Season 2024)



Total PFAS levels ranged between 0 (source and Fraser River) and 6.4 ng/L (road runoff) with an average across all water categories of 1.9 ± 1.5 ng/L, 2.5 times higher than during the wet season.

When comparing with levels from the wet season, we found that:

- PFAS concentrations were highest in the road runoff sample compared to other water categories in the dry season, similar to findings from the wet season.
- While total PFAS concentrations were 0.84 and 0.49 ng/L in the source and Fraser River sample, respectively, during the wet season, they were not detected during the dry season.
- Total PFAS levels were 3.2 and 4.9 times higher in the stream and river and road runoff samples, respectively, during the dry season compared to the wet season.

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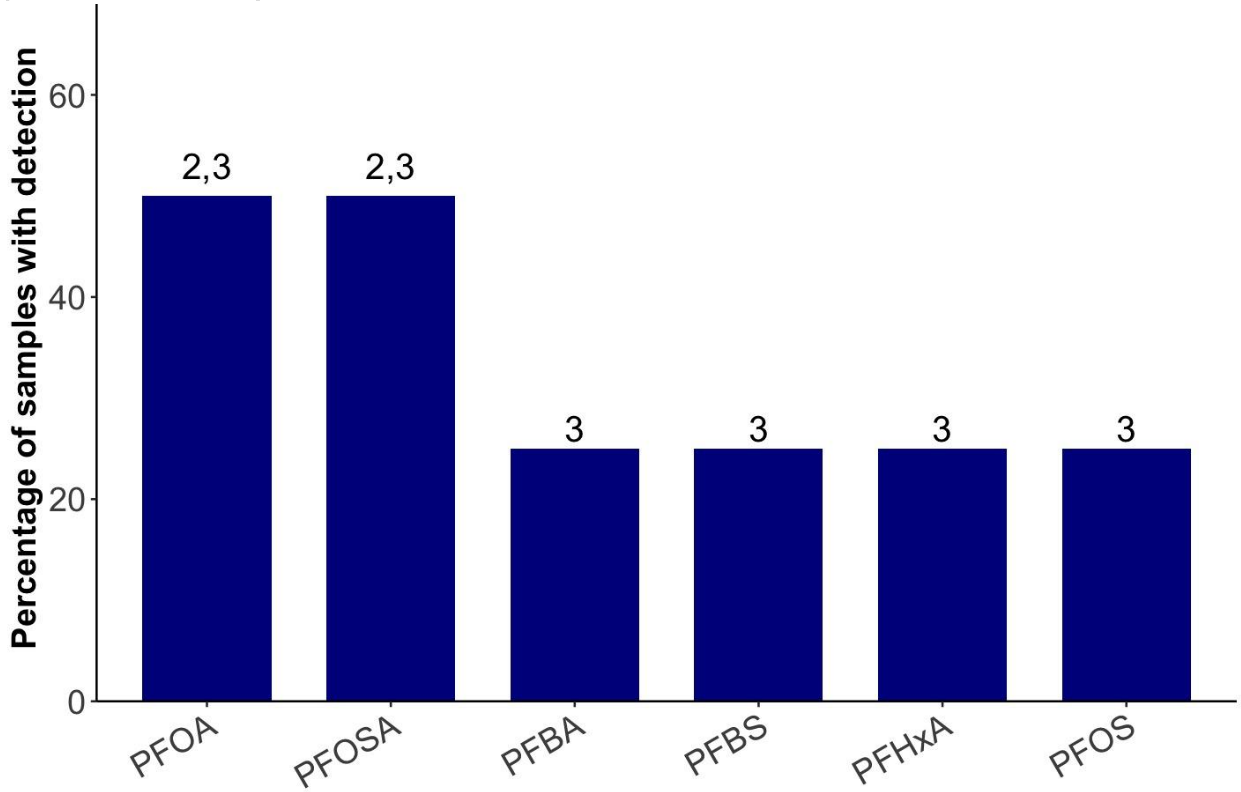
Figure 13: Most frequently detected PFAS in water sampled in the Sqwa:la watershed (DRY Season 2024)



Numbers refer to the water category (1: Source, 2: stream and river, 3: road runoff, 4: Fraser River). Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonamide (PFOSA) were the only two PFAS detected in both the stream and river and road runoff samples.

When comparing dry season findings with wet season findings, the following similarities were observed: Perfluorooctanesulfonamide (PFOSA) was detected in the stream and river sample during both seasons.

There were also some differences between dry and wet seasons. While perfluorooctanesulfonic acid (PFOS) and perfluorobutane sulfonic acid (PFBS) were the only two PFAS detected in road runoff during the wet season, they were also detected during the dry season in addition to four other PFAS: Perfluorooctanoic Acid (PFOA), PFOSA, perfluorobutanoic acid (PFBA), perfluorohexanoic acid (PFHxA).

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Conclusions

- PFAS concentrations were ranked as follows from highest to lowest: road runoff > stream and river > source = Fraser River.
- Total PFAS levels in water samples collected from the Sqwa:la watershed ranged from 0 to 6.4 ng/L, 2.5 times higher than during the wet season.
- PFAS concentrations in all samples were in the lower range of PFAS levels (0 - 138 ng/L) reported for 29 ambient freshwater surface sites across Canada between 2013 and 2020 (ECCC and Health Canada, 2023).
- All the environmental samples were below the available EQGs (PFOS: Federal Environmental Quality Guideline (FEQG) = 6.8 ug/L; BC Working Water Quality Guideline (WWGG) = 3.4 ug/L), similar to the wet season..

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Polychlorinated Biphenyls (PCBs)

Capsule

Despite having been targeted for phase out in Canada in 1977, with some closed uses allowed until December 31, 2029, industrial PCBs continue to be found in the environment, reflecting their stability and persistence. Polychlorinated biphenyls (PCBs) were detected in all four water samples, with the highest concentration observed in the source sample. The lowest PCB concentration was reported in the Fraser River sample. Road runoff and Fraser River samples had the lightest PCB signature, while the source and stream and river samples had the 'heaviest' PCB signature. There were no exceedances of the Water Quality Guideline (WQG) for the protection of aquatic life for total PCBs, similar to the wet season.

Introduction

Polychlorinated biphenyls (PCBs) comprise 209 congeners that are structurally related but have differing degrees of chlorination. The commercial production of PCBs began in 1929, after which they were heavily used in electrical and hydraulic equipment, as well as in paint additives, sealing and caulking compounds and inks. Due to their adverse health effects, the production of PCBs was banned in the late 1970s around the world (Othman et al., 2022). PCBs are among the first 12 Persistent Organic Pollutants (POPs) - often referred to as the "dirty dozen" - defined by the Stockholm Convention, an international treaty aimed at eliminating or restricting the production and use of POPs (UNEP, 2025).

PCBs were never produced in Canada, but were widely used, and are currently specified on the List of Toxic Substances under the Canadian Environmental Protection Act (ECCC 2010). Despite restrictions beginning in 1977, PCBs continue to pose a threat due to their persistence in the environment and their release from products that were manufactured before the ban, and/or were improperly disposed of (Othman et al., 2022). Closed use applications in the electricity generation sector may continue in Canada until final phase out in December 2029 (ECCC 2023). Military uses of PCBs may continue thereafter.

In British Columbia (BC), PCBs remain the number one contaminant of concern in marine food webs with the iconic killer whales being among some of the most-PCB contaminated marine mammals in the world (Ross et al., 2000). Regulatory steps in the 1970s and since have led to declining PCB concentrations in aquatic animals in BC (Ross et al., 2013).

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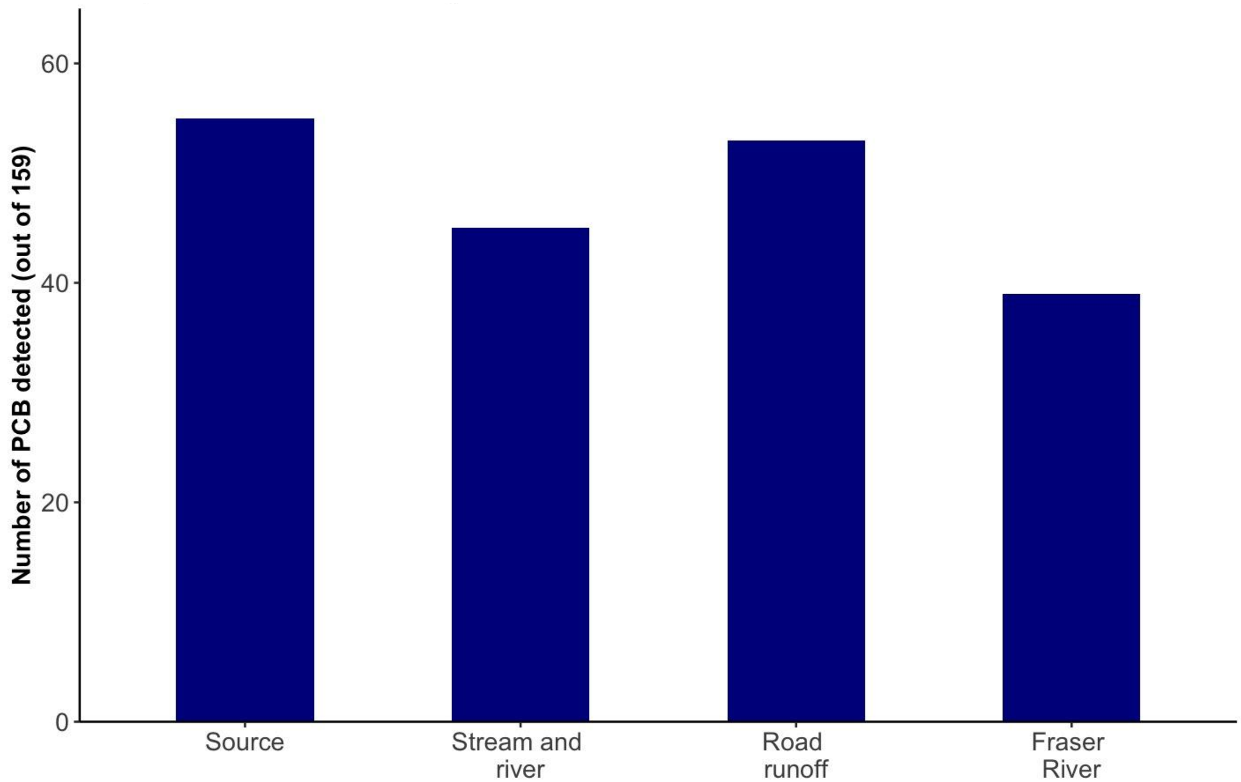
Results

We measured 159 out of a potential 209 PCB congeners in the five water samples collected within the Sqwa:la watershed during the dry season.

Figure 13: Number of PCB detections in water sampled from the Sqwa:la watershed (DRY Season 2024)



PCBs were detected in all five water categories. The number of PCBs detected ranged from 39 (Fraser River) to 55 (source) with an average of 48.0 ± 3.7, 1.6 times lower than during the wet season.

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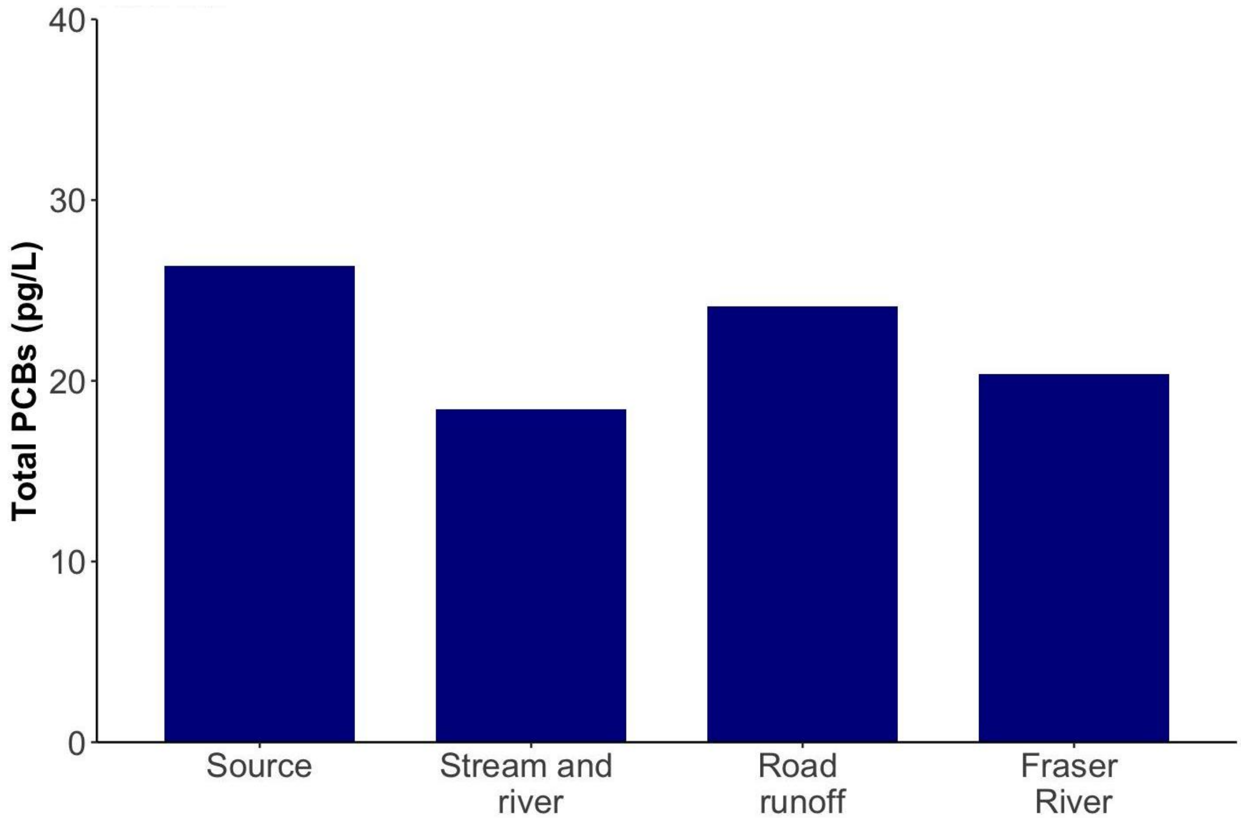
Figure 14: Total PCB concentrations in water sampled from the Sqwa:la watershed (DRY Season 2024)



Total PCB levels ranged between 17.7 (Fraser River) and 42.8 pg/L (source) with an average across all water categories of 30.5 ± 6.7 pg/L, half what was reported for the wet season.

When comparing with concentrations from the wet season, we found that:

- PCB concentrations were lower during the dry season for all water categories except for stream and river water samples which had similar PCB levels between the two seasons.
- The biggest difference in PCB concentrations was for Fraser River water samples with levels being 3.8 times lower during the dry season compared to the wet season.
- PCB levels were 1.5, and 1.8 times lower in the dry season compared to the wet season in source, and road runoff samples, respectively.

The 209 individual PCBs have different degrees of chlorination, with each individual PCB containing between 1 and 10 chlorine atoms in their structure. PCBs can be categorized by

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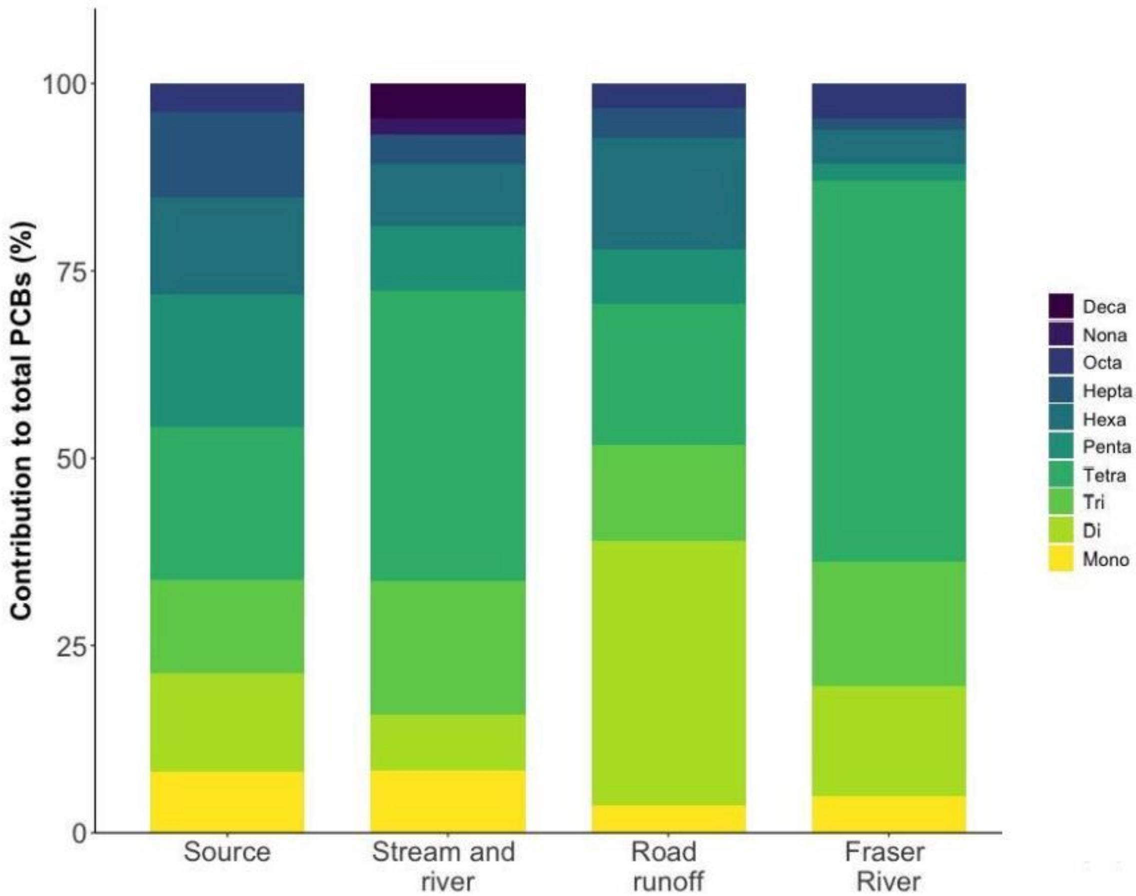
their degree of chlorination into homologue groups. For example, all PCBs with one chlorine will fall into the mono-chlorinated homologue group and all PCBs with five chlorines will fall into the penta-chlorinated PCBs. In general, the more chlorines bound to a biphenyl ring, the 'heavier' the PCB molecule is. Heavier PCBs tend to not travel far from their sources, whereas lighter PCBs are more volatile and can undergo long-range transport. PCBs are strongly lipophilic - fat-soluble - such that they have a tendency to bind to organic particles and fatty tissues, rather than dissolve in water.

Figure 15: Homologue group contribution to total PCBs in water sampled from the Sqwa:la watershed (DRY Season 2024)



The lighter colours represent 'lighter' PCB homologue groups, such that the road runoff and Fraser River samples had the lightest PCB signature, while the source, and stream and river samples had the 'heaviest' PCB signature.

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Conclusions

- PCB concentrations were ranked as follows from highest to lowest: source > road runoff > stream and river > Fraser River.
- PCB concentrations ranged from 17.7 to 42.8 pg/L in the dry season, with an average across all water categories approximately half what was reported during the wet season.
- PCB concentrations fell generally within results from urban-influenced and background stream and river samples collected in the northwestern part of Lake Ontario, where Zhang et al. (2020) identified PCBs as the dominant contaminant class measured with levels ranging from 10 pg/L in remote areas to 4,100 pg/L in urban areas.
- In their study of air samples in coastal British Columbia, Noël et al. (2004) also observed uniform background levels for this legacy compound, providing one explanation for the detection of PCBs in all water samples.
- Water Quality Guidelines) were available for four individual PCBs (PCB-77, -105, -126 and -169), as well as total PCBs.
    - There were no exceedances for any of the individual PCBs or total PCBs, similar to the dry season.

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Alkylphenol Ethoxylates

Capsule

Alkylphenol ethoxylates (APEs) are industrial grade surfactants that have been found in wastewater and industrial discharges. 4-n-Octylphenol was the only APE detected in dry season water samples - the Fraser River sample (1.95 ng/L).

Introduction

Alkylphenol ethoxylates are non-ionic surfactants used in industrial and consumer applications. APEs and their breakdown products are considered estrogenic and can disrupt reproductive development in fish. These surfactants can be released into the environment via municipal and industrial discharges (Lalonde et al, 2021). Once released, APEs may reside in aquatic sediments and/or undergo some breakdown into shorter chain APEs; their half-life is estimated at over 60 years (Shang et al, 1999).

The endocrine-disrupting potential of APEs and their breakdown products in fish and wildlife has represented a concern in receiving waters around municipal wastewater treatment plants (La Guardia et al, 2001).

Results

Table 12: Alkylphenol concentration (ng/L) for water samples from the Sqwa:la watershed (DRY Season 2024)

Analyte	Source (n=1)	Stream and river (n=1)	Road runoff (n=1)	Fraser River (n=1)
4-Nonylphenols	NA	0	0	0
4-Nonylphenol monoethoxylates	NA	0	0	0
4-Nonylphenol diethoxylates	NA	0	0	0
4-n-Octylphenol	NA	0	0	1.95
Total Alkylphenols	**NA**	**0**	**0**	**1.95**

NA here indicates that the source water sample for APEs was lost at our partner lab, so we do not have data for this sample. NQ indicates that the concentration was flagged as "Not Quantifiable" by our partner lab.

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Conclusions

- Total APE concentrations are ranked from highest to lowest: Fraser River > road runoff = source = streams and river.
- APEs were detected in one out of four water samples.
- The only APE detected in the samples was 4-n-Octylphenol.
- The detected concentrations in the water samples from the Sqwa:la watershed in the WET season are well below the long-term CCME guideline for the protection of freshwater aquatic life for nonylphenol and its ethoxylates of 1000 ng/L.
- APE concentrations were only detected in one sample during this dry season sampling, compared to the previous wet season sampling where they were detected in four samples.
- In the Fraser River sample APEs were detected at a 2.2x lower concentration during this dry season sampling event, compared to the previous wet season sampling.

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Bisphenols

Capsule

Bisphenols are plastic additives with widely reported estrogenic (endocrine disrupting) properties. Bisphenols were detected in all of the water samples collected from the Sqwa'la watershed, and BPA was the only bisphenol detected in the watershed.

Introduction

Bisphenols are used widely in the manufacturing sector, and are primarily used in the production of plastics and resins. Both single and multi-use plastic containers are frequently produced using bisphenol compounds, the most popular of which is Bisphenol A (BPA). Bisphenols are endocrine-disrupting chemicals that have been found to negatively impact reproductive development in fish, amphibians, and mammals (Faheem and Bhandari, 2021; Marlatt, *et al.* 2022).

BPA has come under intense regulatory scrutiny in recent years. The widespread use of these chemicals in food packaging, beverage containers, and in water delivery systems has led to exposure in the general population, and associations with adverse outcomes in humans (Rochester 2013).

Results

Table 13: Concentration (ng/L) of bisphenols in water samples from the Sqwa:la watershed (DRY Season 2024)

Analyte	Source (n=1)	Stream and river (n=1)	Road runoff (n=1)	Fraser River (n=1)
Bisphenol E (BPE)	0	0	0	0
Bisphenol F (BPF)	0	0	0	0
Bisphenol A (BPA)	8.88	2.37	9.38	7.25
Bisphenol AF (BPAF)	0	0	0	0
Bisphenol B (BPB)	0	0	0	0
Bisphenol S (BPS)	0	0	0	0
Total bisphenols	**8.88**	**2.37**	**9.38**	**7.25**

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Conclusions

- Total bisphenol concentrations in water samples from highest to lowest are as follows: road runoff > source > Fraser > stream and river.
- BPA was detected in four out of five samples, and was detected at the highest concentration in the road runoff sample.
- BP concentrations were detected in all five samples during this dry season sampling.
- BPs were detected at a 1.2x higher concentration during this dry season sampling event, compared to the previous wet season sampling.

Sucralose

Capsule

Sucralose is a popular artificial sweetener (trade name '*Splenda*') used in foods and beverages. Because it survives the wastewater treatment process, sucralose has become a useful tracer of domestic wastewater. Sucralose was detected in three out of five water samples collected within the Sqwa:la watershed. It was detected at the highest concentration in the road runoff sample.

Introduction

Sucralose (*Splenda*) is an artificial sweetener used in the production of sugar-free food and beverage products. Its popularity and its resistance to breakdown during the wastewater treatment process have led to its adoption as a useful tracer of human wastewater infiltration (Oppenheimer et al., 2011). It is not generally considered to be toxic, such that its utility as a tracer provides an opportunity to better understand the source of other more harmful pollutants in a given body of water.

Sucralose is not fully metabolized by the human body following consumption, and is not removed during the wastewater treatment process. Therefore, its detection in environmental samples indicates the presence of treated or untreated sewage (van Stempvoort et al., 2020).

Results

Table 14: Sucralose concentration (ng/L) in categories of water from the Sqwa:la watershed (DRY season 2024)

Analyte	Source (n=1)	Stream and river (n=1)	Road runoff (n=1)	Fraser River (n=1)
Sucralose (ng/L)	0	0	26.8	14.4

Sucralose was detected in the highest concentration in the road runoff sample. The second highest concentration was detected in the Fraser River sample. No sucralose was detected in the source water sample.

Conclusions

- Sucralose concentrations in water samples from highest to lowest are as follows: road runoff > Fraser > stream and river = source.

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- There are no current Canadian Environmental Quality Guidelines available for sucralose.
- There are no current Health Canada Drinking Water Guidelines available for sucralose.
- Sucralose concentrations were detected in two samples during this dry season sampling, compared to the previous wet season sampling where it was detected in three samples.
- On average, sucralose was detected at a 40x lower concentration during this dry season sampling event, compared to the previous wet season sampling.

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6PPD-quinone

Capsule

The breakdown product of an anti-oxidant and anti-ozonant chemical in vehicle tires (6PPD-Quinone) has been associated with significant and repeated instances of coho salmon mortality events in Washington State and in British Columbia. Measurements for this contaminant are pending.

Introduction

6PPD is a chemical that is added to automotive tire rubber during the manufacturing process in order to extend the life of tires. When 6PPD comes into contact with air, it oxidizes and becomes 6PPD-quinone - a transformation product that in recent years was discovered to be lethal to Coho salmon (*Onchorhynchus kitsutch*) at low concentrations (Lo et al., 2023; Tian et al., 2021). 6PPD-quinone is the causative agent of what has been deemed Urban Runoff Mortality Syndrome (URMS) - which has seen mortality rates of up to 90 percent. Research is being conducted to assess the risk to other fish species.

Results

Table 15: 6PPD- quinone concentration (ng/L) in categories of water from the Sqwa:la watershed (DRY Season 2024)

Analyte	Source (n=1)	Stream and river (n=1)	Road runoff (n=1)	Fraser River (n=1)
6PPDq (ng/L)	Pending			

Low levels of 6-PPD-Quinone were detected in water samples from the Sqwa:la watershed.

Conclusions

- The BC EQG 6PPD-Quinone in the freshwater environment is 10 ug/L.
- There are no DWQs for 6PPD-quinone.

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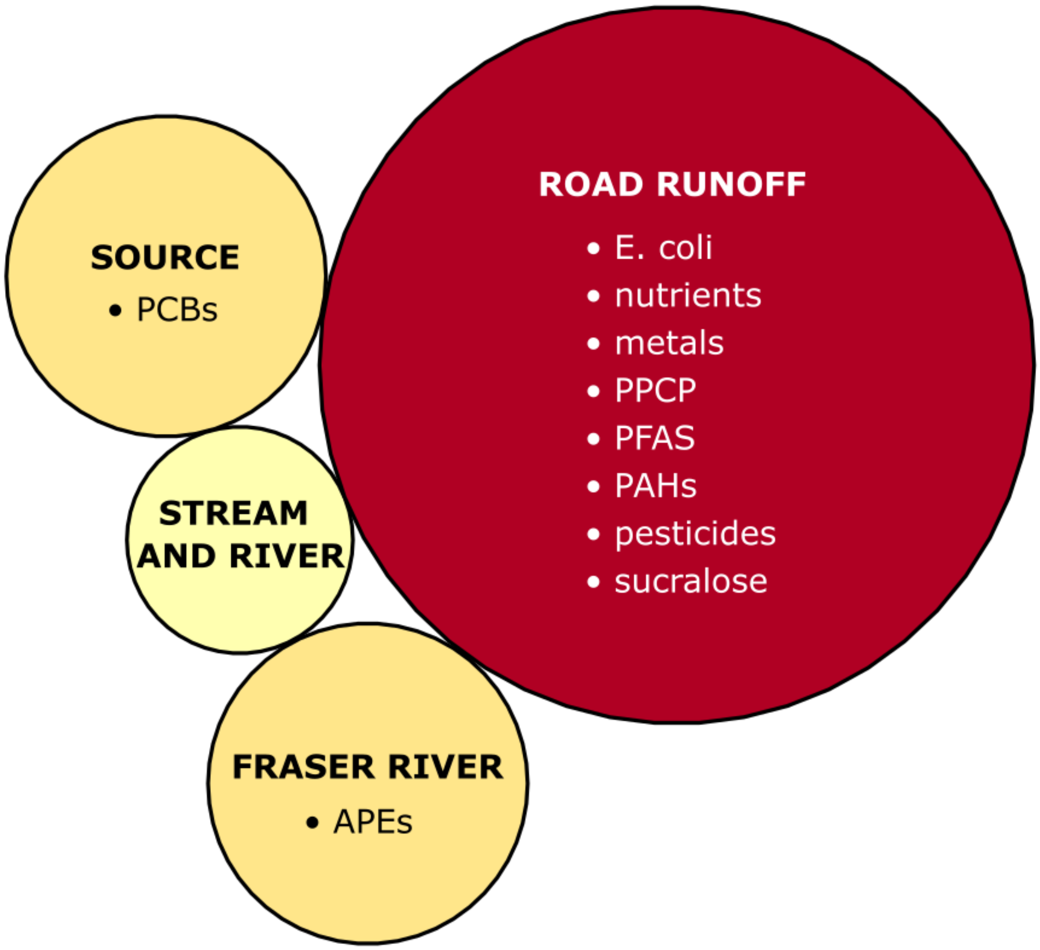
Dry season water quality summary

Figure 16: Water categories for the Sqwa:la watershed ranked by number of contaminant classes detected at highest concentrations in each (DRY Season 2024)



The larger the circle, the greater the number of contaminant classes that were detected in the highest concentration. The road runoff sample had the highest number of contaminant classes with the highest concentration (n=8).

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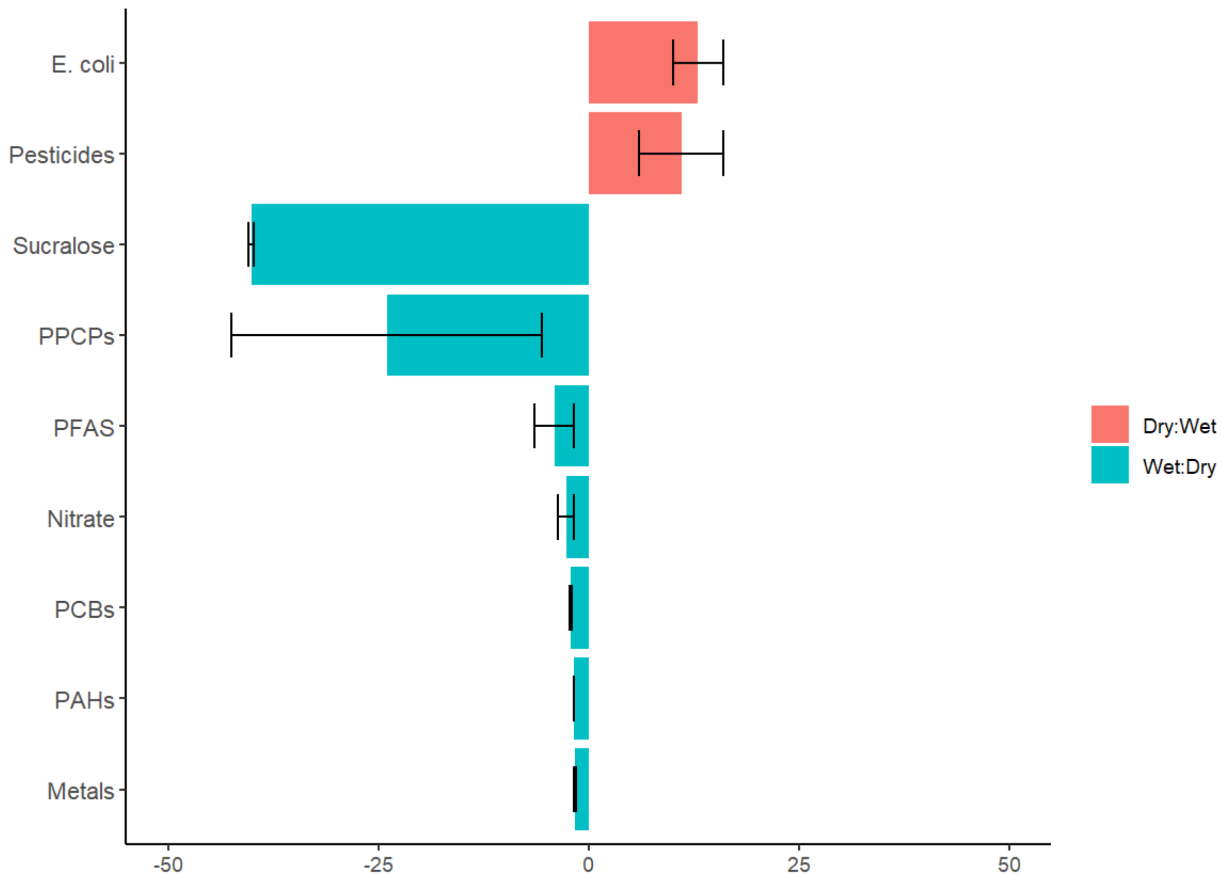
A comparison of wet and dry season water quality

Figure 21: Seasonal differences were observed in the different analyte classes that were detected in the Sqwa:la watershed



This figure indicates whether 'concentration' or 'dilution' occurs between dry and wet seasons. The bars depict the number of times greater the total concentration of the 9 analyte classes were observed in both the wet and dry season, with those in pink being higher in the dry season, and those in blue being higher in the wet season.

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This report encapsulates a single dry season water sampling event comprising pooled samples in four water categories: source water, stream & river water, road runoff, and Fraser River water. This report is the 2nd of four planned sampling events in the Sqwa:la watershed.

Results suggest that Sqwa:la waters are in relatively good condition, but follow-up study is warranted to confirm or build upon initial observations of some contaminants of concern in the watershed. Collectively, these findings will provide an integrated evaluation of the contaminants, activities and sectors that are influencing water quality in the Sqwa:la watershed. This may, in turn, provide guidance on mitigation, stewardship and restoration initiatives that protect and restore fish habitat throughout the Sqwa:la watershed.

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List of acronyms

Abbreviation	Meaning
APE	Alkylphenol ethoxylates
BC EMA	British Columbia Environmental Management Act
CCME	Canadian Council of Ministers of the Environment
CEC	Contaminants of Emerging Concern
CEPA	Canadian Environmental Protection Act
CUP	Current-use pesticide
DO	Dissolved oxygen
DRIPA	Declaration on the Rights of Indigenous Peoples Act
ECCC	Environment and Climate Change Canada
MOE	Ministry of Environment
MST	Microbial Source Tracking
NP	Nonylphenol
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls

PFAS	Polyfluoroalkyl substances
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
POP	Persistent organic pollutant
PPCP	Pharmaceutical and personal care products
PVC	Polyvinyl chloride
TDS	Total dissolved solids
TOC	Total organic carbon
TSS	Total suspended solids
TWP	Tire wear particle
WQGs	Water Quality Guidelines
WQI	Water Quality Index
WWTP	Wastewater treatment plant

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References

Krista A. Barzen-Hanson, Simon C. Roberts, Sarah Choyke, Karl Oetjen, Alan McAlees, Nicole Riddell, Robert McCrindle, P. Lee Ferguson, Christopher P. Higgins, and Jennifer A. Field. 2017. Environmental Science & Technology *51*: 2047-2057. DOI: 10.1021/acs.est.6b05843

Berthiaume, A., Galarneau, E., & Marson, G. (2021). Polycyclic aromatic compounds (PACs) in the Canadian environment: Sources and emissions. Environmental Pollution, 269, 116008. DOI: 10.1016/j.envpol.2020.116008

Canadian Council of Ministers of the Environment, 1999. Canadian Sediment Quality Guidelines for the protection of aquatic life: Endrin. https://www.ccme.ca/en/res/endrin-canadian-sediment-quality-guidelines-for-the-protection-of-aquatic-life-en.pdf

CCME (Canadian Council of Ministers of the Environment). 1999. Canadian water quality guidelines for the protection of aquatic life—Dissolved oxygen (freshwater). Winnipeg. https://ccme.ca/en/res/dissolved-oxygen-freshwater-en-canadian-water-quality-guidelines-for-the-protection-of-aquatic-life.pdf

Canadian Council of Ministers of the Environment. 2010. Canadian water quality guidelines for the protection of aquatic life: Ammonia. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg. https://ccme.ca/en/res/ammonia-en-canadian-water-quality-guidelines-for-the-protection-of-aquatic-life.pdf

CCME (Canadian Council of Ministers of the Environment). 2016. GUIDANCE MANUAL FOR DEVELOPING NUTRIENT GUIDELINES FOR RIVERS AND STREAMS. https://ccme.ca/en/res/guidancemanualfordevelopingnutrientguidelinesforriversandstreams.pdf

Davis, J. 1975. Minimal Dissolved Oxygen Requirements of Aquatic Life with Emphasis on Canadian Species: a Review. Journal of the Fisheries Board of Canada. DOI: 10.1139/f75-268

Ding, Y., Hayward, S. J., Westgate, J. N., Brown, T. N., Lei, Y. D., & Wania, F. (2023). Legacy and current-use pesticides in Western Canadian mountain air: Influence of pesticide sales,

DOI: 10.70766/16224.5

source proximity, and altitude. Atmospheric Environment, 308, 119882. DOI: 10.1016/j.atmosenv.2023.119882

Dongyoung Lee, Kyungho Choi. 2019. Comparison of regulatory frameworks of environmental risk assessments for human pharmaceuticals in EU, USA, and Canada. Science of The Total Environment 671, 1026-1035. DOI: 10.1016/j.scitotenv.2019.03.372

Environment and Climate Change Canada (ECCC), 2023. Update on Canada's National Implementation plan – Under the Stockholm Convention on Persistent Organic Pollutants. https://www.canada.ca/content/dam/eccc/documents/pdf/cepa/En14-517-2023-eng.pdf. Accessed in May 2024.

Environment and Climate Change Canada (ECCC) and Health Canada, 2023. Draft State of Per and polyfluoroalkyl substances (PFAS). https://www.canada.ca/en/environment-climate-change/services/evaluating-existing-substances/draft-state-per-polyfluoroalkyl-substances-report.html. Accessed in May 2024.

Giardina A, Larson SE, Wisner B, Wheeler J, Chao M. Long-term and acute effects of zinc contamination of a stream on fish mortality and physiology. Environ Toxicol Chem. 2009 Feb;28(2):287-95. doi: 10.1897/07-461.1. PMID: 18937529. DOI: 10.1897/07-461.1

Government of Canada, Environment and Climate Change Canada and Health Canada, 1994. Canadian Environmental Protection Act – Priority substances list assessment report – Polycyclic Aromatic Hydrocarbons. https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/contaminants/psl1-lsp1/hydrocarb_aromat_polycycl/hydrocarbons-hydrocarbures-eng.pdf. Accessed in May 2024.

Government of Canada, 2017. Toxic substances list – hexachlorobenzene (HCB). https://www.canada.ca/en/environment-climate-change/services/management-toxic-substances/list-canadian-environmental-protection-act/hexachlorobenzene.html. Accessed in May 2024.

Health Canada, 2007. Pesticides and Health. https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/contaminants/pesticides-eng.pdf. Accessed in May 2024.

Health Canada, 2010. Polychlorinated biphenyls. https://www.canada.ca/en/health-canada/services/chemical-substances/fact-sheets/chemicals-glance/polychlorinated-biphenyls.html. Accessed in May 2024.

Health Canada, 2011. Discontinuation of endosulfan. https://publications.gc.ca/collections/collection_2011/sc-hc/H113-5-2011-1-eng.pdf. Accessed in May 2024.

Health Canada, 2016. Special review of simazine: proposed decision for consultation. https://publications.gc.ca/collections/collection_2016/sc-hc/H113-5-2016-9-eng.pdf. Accessed in May 2024.

Jadaa, W., Mohammed, H.K. 2023. Heavy Metals – Definition, Natural and Anthropogenic Sources of Releasing into Ecosystems, Toxicity, and Removal Methods – An Overview Study. J. Ecol. Eng. 2023; 24(6):249-27. DOI: 10.12911/22998993/162955

La, Van T. and Cooke, Steven J.(2011) 'Advancing the Science and Practice of Fish Kill Investigations', Reviews in Fisheries Science, 19: 1, 21 — 33, First published on: 15 December 2010 (iFirst) DOI: 10.1080/10641262.2010.531793

La Guardia, M.J., Hale, R.C., Harvey, E., and Mainor, T.M. 1999. Alkylphenol Ethoxylate Degradation Products in Land-Applied Sewage Sludge (Biosolids). Environ. Sci. Technol. 1999, 33, 9, 1366–1372. DOI: 10.1021/es980966z

Lalonde, B., Garron, C. Nonylphenol, Octylphenol, and Nonylphenol Ethoxylates Dissemination in the Canadian Freshwater Environment. *Arch Environ Contam Toxicol* 80, 319–330 (2021). DOI: 10.1007/s00244-020-00807-x

Li E, Saleem F, Edge TA, Schellhorn HE. Biological Indicators for Fecal Pollution Detection and Source Tracking: A Review. Processes. 2021; 9(11):2058. DOI: 10.3390/pr9112058

Lo, B. P., Marlatt, V. M., Liao, X., Reger, S., Gallilee, C., Ross, A. R. S., Brown, T. M. (2023). Acute Toxicity of 6PPD-Quinone to Early Life Stage Juvenile Chinook (Oncorhynchus tshawytscha) and Coho (Oncorhynchus kisutch) Salmon. Environmental Toxicology and Chemistry, 42(4), 741-947. DOI: 10.1002/etc.5568

Longpré, D., Lorusso, L., Levicki, C., Carrier, R., and Cureton, P. 2020. PFOS, PFOA, LC-PFCAS, and certain other PFAS: A focus on Canadian guidelines and guidance for contaminated sites management. *Environmental Technology & Innovation 18*, 100752. DOI: 10.1016/j.eti.2020.100752

Malhotra, N., Ger, T-R., Uapipatanakul, B., Huang, J-C., Chen K. H. C., Hsiao, C-D. 2020. Review of Copper and Copper Nanoparticle Toxicity in Fish. Nanomaterials. 10(6), 1126; https://doi.org/10.3390/nano10061126

Marvin, C. H., Berthiaume, A., Burniston, D. A., Chibwe, L., Dove, A., Evans, M., ... & Tomy, G. T. (2021). Polycyclic aromatic compounds in the Canadian Environment: Aquatic and terrestrial environments. Environmental Pollution, 285, 117442. DOI: 10.1016/j.envpol.2021.117442

Mehwish Faheem, Ramji Kumar Bhandari, Faheem, M., and Bhandari, R.K.. 2021. Detrimental Effects of Bisphenol Compounds on Physiology and Reproduction in Fish: A Literature Review. Environmental Toxicology and Pharmacology. Volume 81: 103497. DOI: 10.1016/j.etap.2020.103497.

Metcalfe, C., Miao, XS., Hua, W., Letcher, R., Servos, M. (2004). Pharmaceuticals in the Canadian Environment. In: Kümmerer, K. (eds) Pharmaceuticals in the Environment. Springer, Berlin, Heidelberg. DOI: 10.1007/978-3-662-09259-0_6

Möller, A., Ahrens, L., Surm, R., Westerveld, J., van der Wielen, F., Ebinghaus, R., and de Voogt, P. 2010. Distribution and sources of polyfluoroalkyl substances (PFAS) in the River Rhine watershed. Environmental Pollution 158: 3243-3250. DOI: 10.1016/j.envpol.2010.07.019

Noël, M., Dangerfield, N., Hourston, R. A., Belzer, W., Shaw, P., Yunker, M. B., & Ross, P. S. (2009). Do trans-Pacific air masses deliver PBDEs to coastal British Columbia, Canada?. Environmental Pollution, 157(12), 3404-3412. DOI: 10.1016/j.envpol.2009.06.025

OppenheimerJ., Eaton, A., Badruzzaman, M., Haghani, A.W., and Jacangelo, J.G. 2011. Occurrence and suitability of sucralose as an indicator compound of wastewater loading to surface waters in urbanized regions. Water Research 45: 4019-4027: DOI: 10.1016/j.watres.2011.05.014.

Othman, N., Ismail, Z., Selamat, M. I., Sheikh Abdul Kadir, S. H., & Shibraumalisi, N. A. (2022). A review of polychlorinated biphenyls (PCBs) pollution in the air: where and how much are we exposed to?. International journal of environmental research and public health, 19(21), 13923. DOI: 10.3390/ijerph192113923

Putt AE, MacIsaac EA, Herunter HE, Cooper AB, Selbie DT. Eutrophication forcings on a peri-urban lake ecosystem: Context for integrated watershed to airshed management. PLoS One. 2019 Jul 24;14(7):e0219241. DOIi: 10.1371/journal.pone.0219241. PMID: 31339893; PMCID: PMC6655610.

Ribeiro de Sousa, D.N., Mozeto, A.A., Carneiro, R.L., Fadini, P.S. 2014. Electrical conductivity and emerging contaminant as markers of surface freshwater contamination by wastewater,
Science of The Total Environment, Volume 484:19-26. DOI: 10.1016/j.scitotenv.2014.02.135. (https://www.sciencedirect.com/science/article/pii/S0048969714003295)

Rochester, J.R. 2013. Bisphenol A and human health: A review of the literature, Reproductive Toxicology 42: 132-155. DOI: 10.1016/j.reprotox.2013.08.008

Ross, P. S., Ellis, G. M., Ikonomou, M. G., Barrett-Lennard, L. G., & Addison, R. F. (2000). High PCB concentrations in free-ranging Pacific killer whales, Orcinus orca: effects of age, sex and dietary preference. Marine Pollution Bulletin, 40(6), 504-515. DOI: 10.1016/S0025-326X(99)00233-7

Ross,P.S., Noël,M., Lambourn,D.M., Dangerfield,N., Calambokidis,J.C., and Jeffries,S.J. 2013. Declining concentrations of PCBs, PBDEs, PCDEs and PCNs in harbor seals from the Salish Sea. Progress in Oceanography 115: 160-170. DOI: 10.1016/j.pocean.2013.05.027

Rügner, H., Schwientek, M., Beckingham, B. et al. Turbidity as a proxy for total suspended solids (TSS) and particle facilitated pollutant transport in catchments. Environ Earth Sci 69, 373–380 (2013). DOI: 10.1007/s12665-013-2307-1

Rusydi, A.F. 2018 IOP Conf. Ser.: Earth Environ. Sci. 118 012019. DOI: 10.1088/1755-1315/118/1/012019

Schulz, R. (2004). Field studies on exposure, effects, and risk mitigation of aquatic nonpoint-source insecticide pollution: A review. Journal of environmental quality, 33(2), 419-448. DOI: 10.2134/jeq2004.4190

Schwartz, H., Marushka, L., Chan, H.M. *et al.* Pharmaceuticals in source waters of 95 First Nations in Canada. *Can J Public Health* 112 (Suppl 1), 133–153 (2021). DOI: 10.17269/s41997-021-00499-3

Shang, D., Macdonald, R.W. and Ikonomou, M.G. 1999. Persistence of Nonylphenol Ethoxylate Surfactants and Their Primary Degradation Products in Sediments from near a Municipal Outfall in the Strait of Georgia, British Columbia, Canada. E*nviron. Sci. Technol.*: 33, 9, 1366–1372. DOI: 10.1021/es980966z

UNEP. 2025. United Nations Environment Programme: Stockholm Convention on Persistent Organic Pollutants. Accessed June 2025: https://www.pops.int/partners/unep/overview/tabid/255/default.aspx

van Elsas, J.D., Semenov, A.V., Costa, R., Trevors, J.T. Survival of Escherichia coli in the environment: fundamental and public health aspects, The ISME Journal, Volume 5, Issue 2, February 2011, Pages 173–183. DOI: 10.1038/ismej.2010.80

van Stempvoort, D.L., Brown, S.J. Spoelstra, J., Garda, D., Robertson, W.D., and Smyth, S.A.. 2020. Variable persistence of artificial sweeteners during wastewater treatment: Implications for future use as tracers. Water Research 184: 116124. DOI: 10.1016/j.watres.2020.116124.

Appendix

Appendix 1: Environmental and Drinking water quality guidelines relevant for the present study. These guidelines were retrieved in May 2024.

Analyte Class	Federal EQGs[1]	BC WQGs		CCME EQGs[2]		Drinking WQGs
		Freshwater	Marine	Freshwater	Marine	
Basic Water Properties						
Temperature	-	19 (short-term)	+1°C per hour change from background	narrative	max change of +0.5°C per hour	-
pH	-	6.5-9.0	7.0-8.7	6.5-9.0	7.0-8.7	7.0-10.5
Dissolved oxygen	-	>8.0 (long-term) >5.0 (short-term)	-	6.5-9.5 mg/L	80 mg/L	-
Conductivity	-	-	-	-	-	-
Turbidity	-	-	-	narrative	narrative	≤ 1.0 NTU
Metals (mg/L)						
Aluminum	-	variable	-	0.005 if pH < 6.5	-	2.9
Lead	-	3 when ≤ 8 mg/L CaCO3 (short-term)	<140 ug/L	equation	-	0.005
Nutrients (mg/L)						
Nitrate (as N)	-	3.0 (long-term) 32.8 (short-term)	3.7 (long-term)	550	200 (long-term) 1500 (short-term)	10
Nitrite (as N)	-	table	0.02 when Cl- ≤ 2 (long-term) 0.06 when Cl- ≤ 2 - (short-term)	0.06	-	1.0
Ammonia (Total as N)	-	table	table	table	-	-
Phosphate	-	0.015 (long-term)	-	-	-	-
Coliform						
Total coliform	-	-	-	-	-	0
Fecal coliform	-	-	-	-	-	0
E. coli	-	-	-	-	-	0
PAHs (ug/L)						
Naphthalene	-	1	-	1.1	1.4	-

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Acenaphthene	-	6	6	5.8	-	-
Fluorene	-	12	12	3	-	-
Anthracene	-	4	-	0.012	-	-
Phenanthrene	-	0.3	-	4.4	-	-
Fluoranthene	-	4	-	0.04	-	-
Pyrene	-	0.02	-	0.025	-	-
Chrysene	-	-	0.1	-	-	-
Benzo-a-anthracene	-	0.1	-	0.018	-	-
Benzo-a-pyrene	-	0.01	-	0.015	-	0.04
PCBs (ng/L)						
Total PCBs	-	0.1	-	-	-	-
PCB-105	-	0.09	-	-	-	-
PCB-169	-	0.06	-	-	-	-
PCB-77	-	0.04	-	-	-	-
PCB126	-	0.00025	-	-	-	-
Bisphenols (ug/L)						
BPA	1.4	-	-	-	-	-
Alkylphenols (ug/L)						
4-Nonylphenols	-	1 (long-term)	-	-	-	-
PFAS (ug/L)						
Perfluorooctane Sulfonate (PFOS)	6.8 (fresh)	3.4	-	-	-	0.6
Perfluorooctanic acid (PFOA)	-	-	-	-	-	0.2
Pesticides (ug/L)						
Atrazine	-	1.8[3]	-	1.8	-	5
Chlorothalonil	-	-	-	0.18	-	-
Cyanazine	-	2	-	-	-	-
Chlorpyrifos	-	0.02	0.002	-	-	90
Diazinon	-	0.0043	-	-	-	-
Dimethoate	-	-	-	6.2	-	20
Endosulfan	-	0.0007 (active ingredient)	-	0.06 (short-term) 0.003 (long-term)	0.09 (short-term) 0.002 (long-term)	-
Malathion	-	0.1	-	-	-	290
Metribuzin	-	1[3]	-	1.0	-	80
Permethrin	-	0.004[3]	-	0.004	0.001	-
Picloram	-	29	-	-	-	-

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Simazine	-	10[3]	-	10	-	10

[1] Federal EQGs apply to both fresh and marine waters unless otherwise stated. [2] CCME EQGs are reported for long-term effects unless otherwise stated. [3] Represents CCME guidelines that the BC government has adopted as working water guidelines

Appendix X: Top 6 PAHs with the highest concentrations in each water sample from

	Source	Stream and river	Road runoff	Fraser River
	C2-Biphenyls *(4.5)*	Naphthalene *(5.7)*	C2-Biphenyls *(8.4)*	C4- Phenanthrenes Anthracenes *(3.5)*
	C2-Naphthalenes *(1.9)*	C2-Biphenyls *(2.7)*	Phenanthrene *(3.1)*	C2-Biphenyls *(3.5)*
	C1-Naphthalenes *(1.0)*	C1- Naphthalenes *(2.1)*	Fluoranthene *(2.4)*	Retene *(3.2)*
	C1-Biphenyls *(1.0)*	Phenanthrene *(1.4)*	Naphthalene *(2.1)*	Naphthalene *(2.9)*
	Naphthalene *(0.78)*	C2- Naphthalenes *(1.4)*	C1- Biphenyls *(1.8)*	Phenanthrene *(2.4)*
	2 Methyl-naphthalene *(0.67)*	2 Methyl-naphthalene *(1.3)*	C1- Naphthalenes *(1.8)*	C1- Naphthalenes *(1.9)*
Total concentrations of top 6 (% contribution to total PAHs)	9.7 (75%)	14.5 (69%)	19.6 (50%)	17.4 (49%)

the Sqwa:la watershed (DRY Season)

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Appendix X: The top 6 PCBs in each water category sampled in the Sqwa:la watershed and their concentrations (DRY Season)

	Source	Stream and river	Road runoff	Fraser River
	PCB-44+47+65 (3.1)	PCB-44+47+65 (2.9)	PCB-11 (12.5)	PCB-44+47+65 (2.7)
	PCB-93+95+98+100+102 (2.7)	PCB-64 (0.98)	PCB-44+47+65 (3.2)	PCB-7 (2.4)
	PCB-3 (2.0)	PCB-1 (0.97)	PCB-52 (1.7)	PCB-64 (1.2)
	PCB-9 (1.7)	PCB-209 (0.95)	PCB-194 (1.3)	PCB-52 (1.2)
	PCB-152 (1.7)	PCB-52 (0.87)	PCB-181 (1.3)	PCB-37 (0.59)
	PCB-205 (1.7)	PCB-118 (0.80)	PCB-35 (1.3)	PCB-1 (0.57)
Total concentrations of top 6 (% contribution to total PCBs)	12.9 (30%)	7.5 (37%)	21.3 (52%)	17.7 (49%)

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Appendix X: Total analyte concentrations in water sampled in the Sqwa:la watershed (DRY Season)

	Source	Stream and river	Road runoff	Fraser River
E. coli (MPN)	8	866	**>2420**	17
Nitrate (mg/L)	0.507	0.388	**9.95**	0.126
Metals (mg/L)	68.7	73.5	**111**	37.2
Pesticides (ng/L)	1.4	25.5	**371**	11.9
PCBs (pg/L)	**42.8**	20.4	41.2	17.7
PAHs (ng/L)	12.8	21.0	**39.1**	35.7
PPCPs (ng/L)	90.3	17.9	**65.6**	14.8
PFAS (ng/L)	0	1.5	**6.3**	0
APEs (ng/L)	NA	0	0	**1.95**
bisphenols (ng/L)	8.88	2.37	**9.38**	7.25
Sucralose (ng/L)	0	0	**26.8**	14.4
6-PPDq (ng/L)				

Bold indicates the highest concentrations across water categories for each contaminant.

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Appendix 4: Ratios between average values of each contaminant class for the two sampling seasons (WET and DRY).

	Dry/wet ratio	Wet/dry ratio
E. coli *(MPN)*	13	0.3
Nitrate (mg/L)	1.0	2.7
Metals (mg/L)	0.7	1.6
Pesticides (ng/L)	11	0.2
PCBs (pg/L)	0.6	2.1
PAHs (ng/L)	0.7	1.8
PPCPs (ng/L)	19	24
PFAS (ng/L)	2.4	4.1
APEs (ng/L)	0.1	2.2
bisphenols (ng/L)	-	0.2
Sucralose (ng/L)	0.5	40
6-PPDq (ng/L)	-	

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