Quw’utsun Sta'lo' (Cowichan River) watershed: Water quality report for the 2024-25 wet season

3 of 4

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Contributions by Cowichan Tribes, SGS Axys: Pam Mackenzie and Richard Grace.

Editing by Dr. Peter Ross, Samantha Scott and Marie Noel.

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About Raincoast

Raincoast is a team of scientists and conservationists dedicated to safeguarding the land, waters, and wildlife of coastal British Columbia.

Our vision for coastal British Columbia is to protect the habitats and resources of umbrella species. We believe this approach will help safeguard all species, including people, and ecological processes that exist at different scales. Central to our efforts are long-term partnerships with Indigenous communities.

RAINCOAST CONSERVATION FOUNDATION

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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 second wet (winter) season sampling carried out with the support and participation of Cowichan Tribes.

Briefly, the Healthy Waters - Cowichan Tribes team determined basic water properties (temperature, conductivity, pH, dissolved oxygen and turbidity) in situ at sampling sites on December 18, 2024. Water samples were collected from five water categories, including source water (3 samples), stream and river water (3 samples), road runoff (3 samples), tap water (10 samples) and marine water (3 samples). The samples were pooled into composite 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 144 contaminants out of 573 measured in the stream and river category - i.e. fish habitat - for the Quw'utsun Sta'lo' (Cowichan River) watershed, excluding nutrients, fecal coliform and physical parameters. Overall, Quw'utsun Sta'lo' (Cowichan River) water quality was **relatively good.** Additional sampling and analysis will provide additional insight into any sources or activities that may be impacting the health of this valued watershed.

Key findings

- This is the third assessment of water quality in the Quw'utsun Sta'lo' (Cowichan River) watershed; our understanding of water quality will build on the previous assessment, and will grow with additional sampling.
- We collected and analysed water in the Quw'utsun Sta'lo' (Cowichan River) watershed during the wet season (December 18, 2024).
- Road runoff was the most contaminated water category in the dry season; it had the highest concentrations of E.coli, nitrate, PCBs, PAHs and PFAS.

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- Tap water was the second most contaminated water category in the wet season with the highest concentration of BPs, sucralose and pesticides.
- Stream and river water had the highest concentration of PPCPs.
- Source water was the least contaminated than the above water categories in the wet season.
- Overall, the Quw'utsun Sta'lo' (Cowichan River) watershed had **relatively good** water quality in the wet season:
    - There were 10 exceedances of Canadian Environmental Quality Guidelines.
    - Exceedances included:
        - Aluminum and iron in the source sample;
        - Aluminum, iron and copper in the stream and river sample;
        - Aluminum, iron, copper and lead in the road runoff sample;
        - Copper in the marine sample.
    - There was one exceedance of Health Canada Water Quality Guidelines for Recreation.

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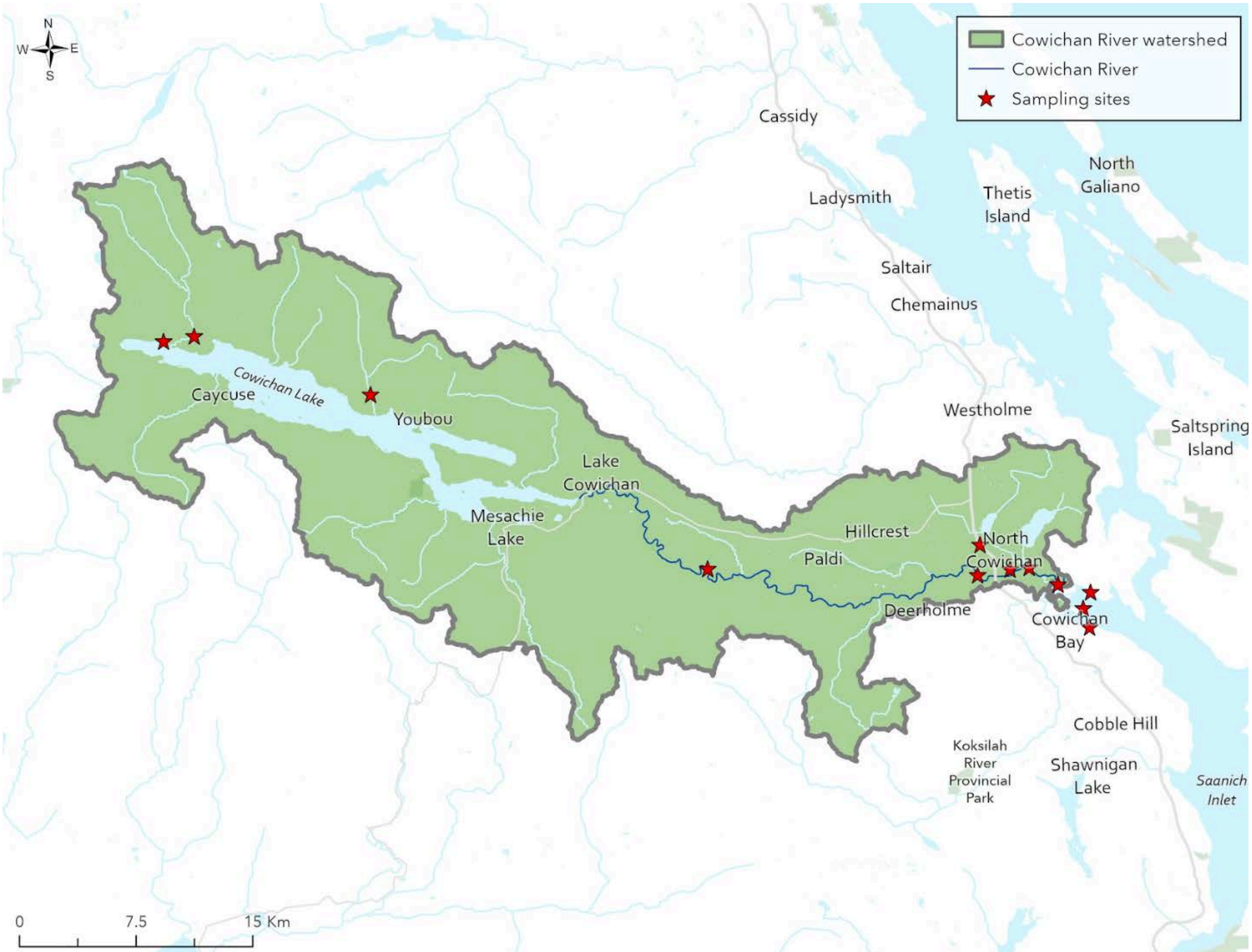
Figure 1: The Quw'utsun Sta'lo' (Cowichan River) Watershed



The Quw'utsun (Quw'utsun Sta'lo' (Cowichan River)) watershed stretches from its source in the Seymour Range surrounding Lake Cowichan to the west, eastwards down to the mouth of Quw'utsun (Quw'utsun Sta'lo' (Cowichan River)) where it meets the Salish Sea in Tl'ulpalus (Cowichan Bay). The people of the Cowichan Tribes have occupied and used their territory for thousands of years, this includes the regions of Cowichan lake, the Cowichan and Koksilah River drainages, the regions around Cowichan Bay, Maple Bay, Shawnigan Lake, the southern Gulf Islands, as well as areas on the mainland, particularly the region of the south arm of the Fraser River. The Quw'utsun (Quw'utsun Sta'lo' (Cowichan River)) watershed covers an area of 921 km2. 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 Cowichan Tribes and the Aquatic Habitat Restoration Fund of Fisheries and Oceans Canada. We are grateful for the enthusiastic support of Tim Kulchyski, Audra Stacey, Clark Johnny Jr. and Jacob Cook. Our thanks to Bethany Coulthard at Cowichan Tribes - Lulumexun for her comments on an earlier version of this report. We acknowledge the expert analytical support of Pam MacKenzie and Richard Grace at SGS-AXYS. We thank Nicole Van Zutphen and Sherwin Arnott for report design. Photo credits: Sam Scott and Peter S. Ross.

Team

- Raincoast Healthy Waters: Peter Ross and Sam Scott
- Cowichan Tribes: Kim Lagimodiere, Tim Kulchyski, Audra Stacey, Clark Johnny Jr., and Jacob Cook

From right to left: Dr. Peter Ross, Kim Lagimodiere, Audra Stacey, Jacob Cooke, Sam Scott, Tim Kulchyski, and Clark Johnny Jr. Photo credit: Dr. Peter Ross

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General introduction

Background

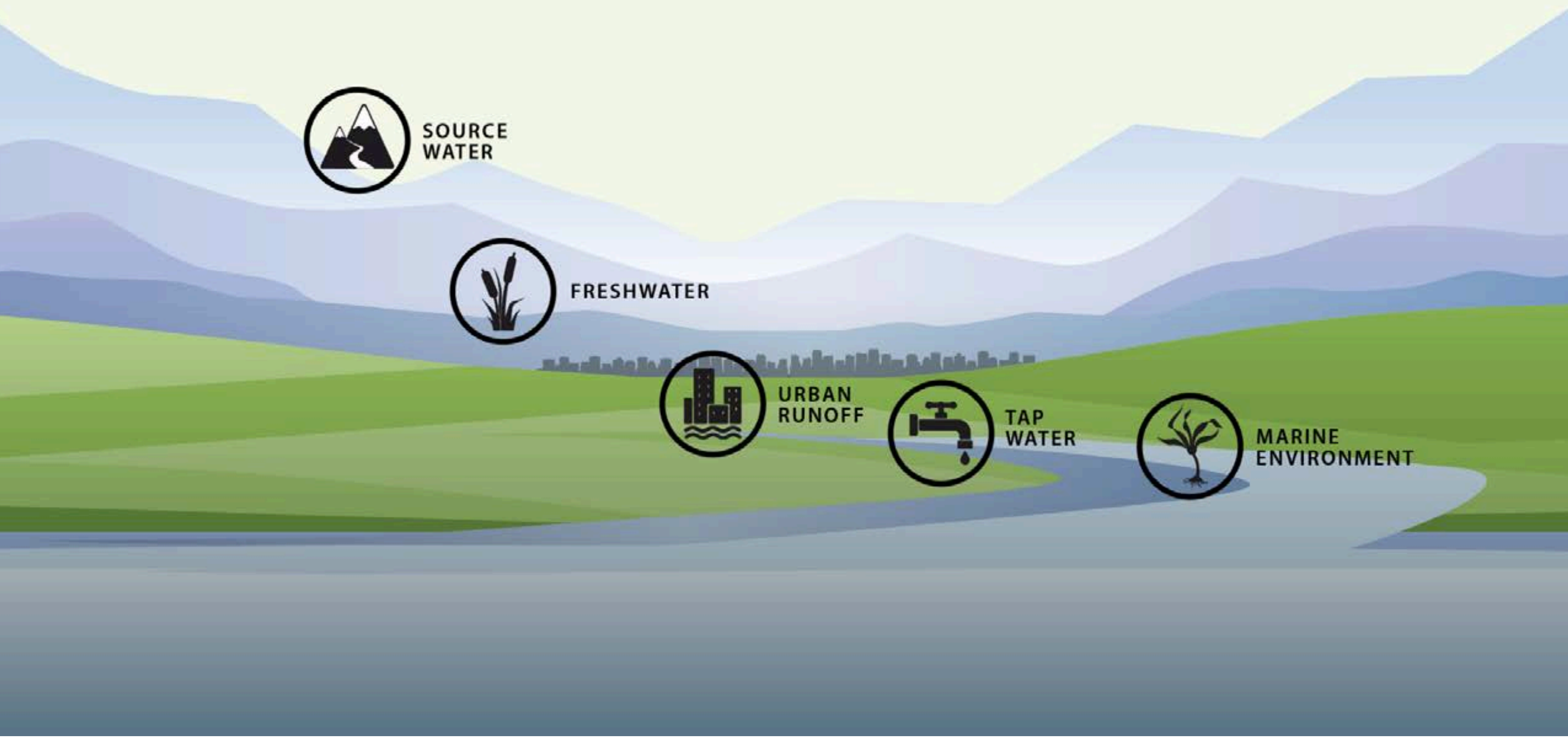
Raincoast's Healthy Waters Program (https://www.raincoast.org/waters/) delivers high-resolution, community-oriented water quality analysis to watersheds across southern British Columbia. The goal of Healthy Waters is to empower communities with the understanding of the status of water quality in their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

Cowichan Tribes is the largest single First Nation Band in British Columbia with over 5,000 members, approximately half of whom live on Reserve. While archaeological evidence indicates that the Cowichan People have been present in the area as far back as 4,500 years, their collective historical memory says that they have been present here since time immemorial.

Cowichan Tribes is made up of seven traditional villages: Kwa'mutsun, Qwum'yiqun', Xwulqw'selu, S'amunu Lhumlhumuluts', Xinupsum, and Tl'ulpalus distributed throughout the Quw'utsun Sta'lo' (Cowichan River) watershed and beyond.

Lulumexun are the Lands and Natural Resources department of the Cowichan Tribes. Lulumexun are caregivers and guardians - preserving and protecting Quw'utsun tumuhw (lands, waters, air) and all beings. They support the advancement of self-governance, the assertion of Quw'utsun Mustimuhw inherent rights and responsibilities, and keep Quw'utsun territory thriving for future generations. Their work includes activities such as, upholding Tumuhw (land code), referrals, environmental monitoring, cultural heritage preservation, fisheries, enforcement, community security and more.

A watershed based approach to sampling



Healthy Waters

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.

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.

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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.

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.

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Methods

Field sampling

A total of 12 water samples were collected from field locations within the Quw'utsun Sta'lo' (Cowichan River) watershed on December 18, 2024 by the Raincoast Healthy Waters team alongside representatives of Cowichan Tribes. An additional 10 samples of tap water were obtained from homes and businesses in the surrounding community on the same day.

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

Samples were submitted to 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 Quw'utsun Sta'lo' (Cowichan River) watershed

Site Number	Water Type	Site Name	Lat/Long
1	Source	Little Shaw	N 48.921101, W 124.420625
2	Source	Shaw Creek	N 48.923716, W 124.393712
3	Source	Cottonwood Creek	N 48.887494, W 124.240459
4	Freshwater	Cowichan River @ Skutz	N 48.781341, W 123.949751
5	Freshwater	Cowichan River d/s Allenby	N 48.772971, W 123.714219
6	Freshwater	West Quamichan	N 48.776305, W 123.668996
7	Road Runoff	Fishgut	N 48.77564, W 123.685732
8	Road Runoff	Somenos - Bings Creek	N 48.790459, W 123.711280
9	Road Runoff	Kilpahlus	N 48.740577, W 123.618026
10	Marine	Cowichan River @ Tzouhalem	N 48.766047, W 123.644246
11	Marine	Khenipsen	N 48°45'654, W 123°36'964
12	Marine	Wescan E	N 48° 45'104, W 123° 37'377
13	Tap	Tap 10 homes and businesses	various

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Water quality analyses

Table 2: List of analytes, analysis locations, 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	13
Dissolved Oxygen (%, mg/L)	in situ	optical sensor	YSI ProDSS	13
Turbidity (FNU)	in situ		YSI ProDSS	13
Conductivity (uS/cm)	in situ		YSI ProDSS	13
pH	in situ		YSI ProDSS	13
Tier 2				
Total Suspended Solids (TSS)	ALS Environmental	APHA 2540 D (mod)	gravimetry	5
Total Dissolved Solids (TDS)	ALS Environmental	APHA 2540 C (mod)	gravimetry	5
Hardness	ALS Environmental	APHA 2340B	calculated	5
Total Organic Carbon (TOC)	ALS Environmental	APHA 5310 B (mod)	combustion	5
Chemical Oxygen Demand (COD)	ALS Environmental	APHA 5220 D (mod)	colorimetry	5
Biological Oxygen Demand (BOD)	ALS Environmental	APHA 5210 B (mod)	dissolved oxygen meter	5
Nitrate	ALS Environmental	EPA 300.1 (mod)	ion chromatography	5
Ammonia	ALS Environmental	Method Fialab 100, 2018	fluorometry	5
Phosphate	ALS Environmental	APHA 4500-P F (mod)	colorimetry	5
Total Metals	ALS Environmental	EPA 200.2/6020B (mod)	Collision/Reaction Cell ICPMS	5
Total coliform	ALS Environmental	APHA 9223 (mod)	MPN	5

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Fecal coliform	ALS Environmental	APHA 9223 (mod)	MPN	5
E. coli	ALS Environmental	APHA 9223 (mod)	MPN	5
MST (in Development)	RCF Conservation Genetics Lab (PSEC)	In development		5
6PPD-quinone	Pending		LCMS	5
Tier 3				
Alkylphenol Ethoxylates (APEs)	SGS Axys Analytical	SGS AXYS METHOD MLA-004 Rev 07	GC-MS	5
Bisphenols	SGS Axys Analytical	SGS AXYS METHOD MLA-113 Rev 01	LC-MS/MS	5
Multiresidue Pesticides	SGS Axys Analytical	EPA 1699 (mod)	HRMS	5
Per and Poly-fluoroalkyl substances (PFAS)	SGS Axys Analytical	EPA 1633 Draft	LC-MS/MS	5
Pharmaceuticals and Personal Care Products (PPCPs)	SGS Axys Analytical	EPA 1694	HPLC/MS/MS	5
Polychlorinated biphenyls (PCBs)	SGS Axys Analytical	SGS AXYS METHOD MLA-210 Rev 01	GC-MS/MS	5
Polycyclic Aromatic Hydrocarbons (PAHs)	SGS Axys Analytical	EPA 8270/ EPA 1625	GC-MS	5
Sucralose	SGS Axys Analytical	MLA-116	LC-MS/MS	5

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 (ALS and SGS AXYS) 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 contaminants. These levels in blanks 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

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guidelines are derived in consultation with the environment ministers from the federal, provincial and territorial governments. Relevant EQGs and Drinking Water Quality Guidelines (DWQGs) from Health Canada 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 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, BC Working Water Quality Guidelines (WWQGs) are available for some contaminants for which a completed EQG is not yet available.

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 an EQG. EQGs, therefore, serve as a benchmark based on best available evidence at the time of development, and are subject to change as new evidence emerges.

Application of metals guidelines

It is important to note that there are two different types of guidelines for metals (Appendix 2):

- ***Fixed guidelines***: a single guideline concentration that can be applied regardless of water chemistry. This type of guideline can be compared directly to our total measured metal concentrations.
- ***Formula-based guidelines***: a 'moving' guideline for a metal that is dependent on site-specific water chemistry parameters (including pH and/or hardness and/or dissolved organic carbon (DOC). Where possible, we calculated the chemistry-adjusted guideline values to be compared to our total metal concentrations. While pH and hardness were measured as part of the study, DOC

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was not and we calculated adjusted-guidelines using 50%, 75%, and 100% of the measured organic carbon (TOC) (Appendix 3,4) to bracket a reasonable range of DOC concentrations, consistent with literature indicating that DOC typically represents the dominant fraction of organic carbon (BC MoECCS, 1998).

- ***Where dissolved metal concentrations are needed***: Some guidelines require dissolved metal concentrations for the interpretation of guideline exceedances. As we measured total metal concentrations, there are two metals in this category for which we were unable to interpret metal guideline exceedances (Zn, Mn).

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,
- 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. In addition to the guidelines listed in Table 3, Health Canada maintains a Beach Action Value (BAV) for safe recreational use of water based *E.coli* being detected at less than 235 CFU/100 mL.

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	4	2	0	4	4

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Metals	37	18	5	18	17
PAHs	76	1	0	10	10
Pesticides	62	6	0	10	9
PPCPs	141	0	2	1	1
PFAS	40	3	1	1	0
PCBs	209	0	0	5	0
Alkylphenols	4	0	0	1	1
Bisphenols	6	0	1	1	0
Sucralose	1	0	0	0	0
6PPD-Quinone	1	0	0	1	0
Total	*589*	*33*	*9*	*56*	*47*

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.

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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 thought 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 Quw'utsun Sta'lo' (Cowichan River) watershed. Source water sites were found to have the lowest temperature, and the highest dissolved oxygen among samples. Road runoff had the highest conductivity and lowest dissolved oxygen among non-marine surface water samples.

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 Quw'utsun Sta'lo' (Cowichan River) watersheds (WET Season 2024-25)

Analyte	Source (n=3)	Stream and river (n=3)	Road runoff (n=3)	Tap*	Marine (n=3)
Temperature (℃)	5.5 ± 0.06 (5.3-5.7)	7.2 ± 0.04 (7.0-7.3)	8.2 ± 0.44 (7.0-10)	-	7.3 ± 0.07 (7.1-7.6)
DO %	92.7 ± 0.91 (90.3-96.4)	91.4 ± 0.23 (90.3-92.3)	85.3 ± 3.24 (71.0-92.6)	-	89.3 ± 0.59 (87.2-91.3)
DO (mg/L)	11.7 ± 0.14 (12.0-12.3)	11.1 ± 0.02 (10.9-11.1)	10.1 ± 0.48 (8.00-11.1)	-	10.5 ± 0.13 (10.1-11.1)
pH	7.45 ± 0.03 (7.35-7.56)	7.22 ± 0.04 (7.02-7.36)	7.00 ± 0.15 (6.4-7.5)	-	7.19 ± 0.02 (7.10-7.27)
Conductivity (uS/cm)	37.1 ± 3.01 (27.9-48.8)	45.9 ± 1.40 (41.4-54.6)	110 ± 16.1 (49.3-166)	-	5790 ± 1460 (44.9-9560)
Turbidity (FNU)	4.93 ± 0.90 (2.70-9.05)	32.7 ± 6.32 (6.40-55.0)	111 ± 37.1 (8.00-270)	-	33.8 ± 2.30 (26.7-44.2)

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. *We were unable to measure water properties accurately in the tap sample due to logistical constraints associated with individual sample collections.

Conclusions

- Water, temperature, and pH were all within EQGs ranges for protection of aquatic life.
- Turbidity could not be assessed in relation to EQGs as it requires knowledge of background turbidity.

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Coliform bacteria

Capsule

Coliform bacteria in water indicate a potentially serious threat to human health. The highest counts of coliform across all three categories (Total, Fecal and *E. coli*) were all detected in the road runoff sample.

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 of 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 Quw'utsun Sta'lo' (Cowichan River) watersheds (WET Season 2024-25)

Analyte	Source (n=1)	Streams and rivers (n=1)	Road runoff (n=1)	Tap (n=1)*	Marine (n=1)
Coliform, Total	194	2420	12000	<1	>800
Coliform, Fecal	15	133	521	<1	>60
E. coli	6	155	389	<1	>80

Highest counts of the three different categories of coliform bacteria that we tested were all measured in the road runoff sample. * <1 is equivalent to zero.

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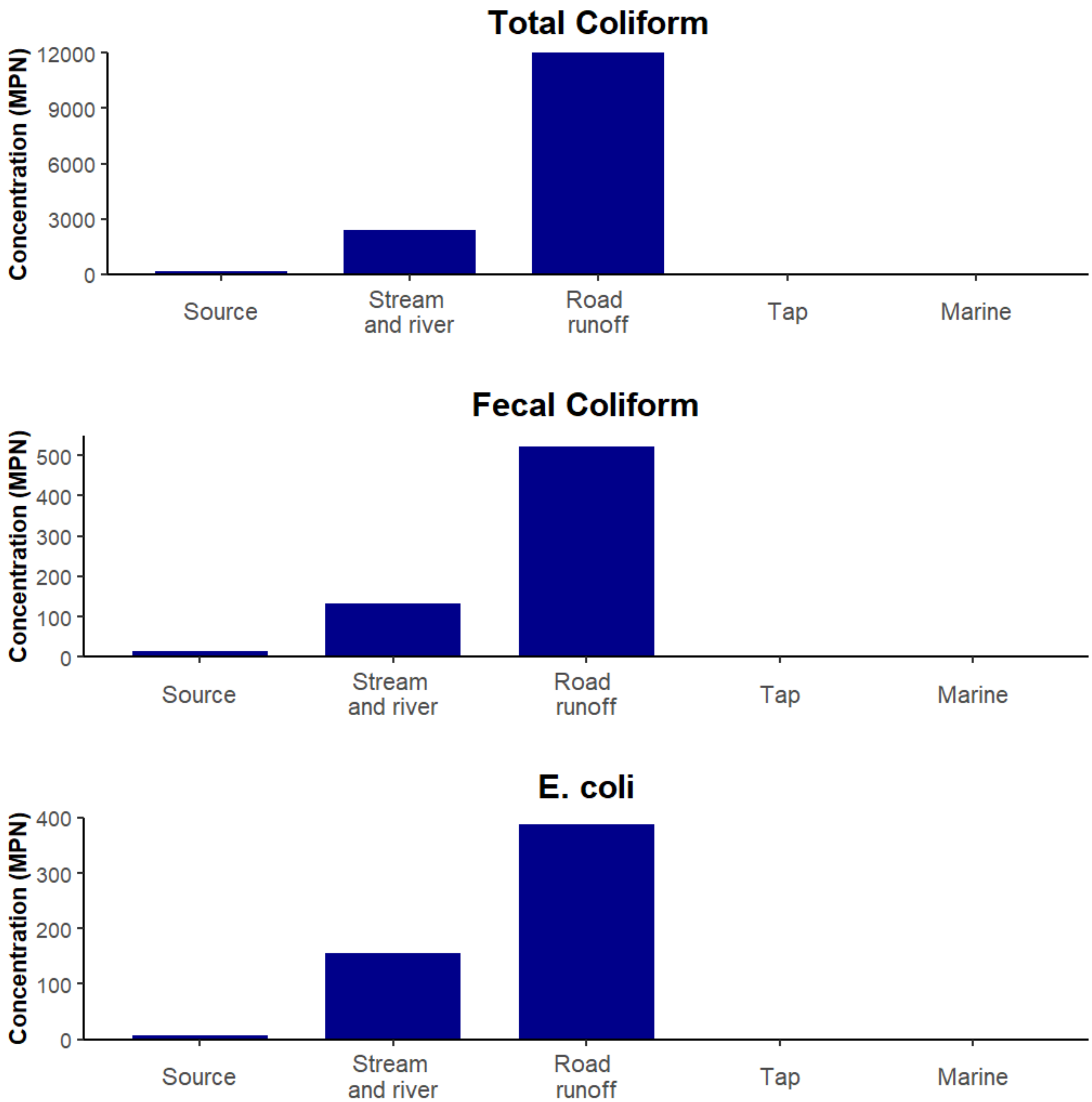
Figure 2: Coliform counts (MPN) in five water categories in the Quw’utsun Sta'lo' (Cowichan River) watersheds (WET Season 2024-25)



The highest concentration of coliform bacteria across all three categories was detected in the road runoff sample. No coliform were detected in the tap or marine samples.

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Conclusions

- *E. coli* concentrations for the five water categories were ranked from highest to lowest as follows: road runoff > stream and river > source > marine = tap.
- *E. coli* values in the road runoff sample exceeded 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 fell below 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 is worth noting that the three creeks sampled in this study are not the municipal source of drinking water provided to communities in the area.
- No coliform were detected in the pooled tap water sample - indicating that there is no risk of fecal contamination in drinking water in the homes tested.

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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 Quw’utsun Sta'lo' (Cowichan River) watershed, and was detected in all five water samples. The highest concentration of nitrate was detected in the road runoff sample.

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 Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)

Analyte	Source (n=1)	Streams and rivers (n=1)	Road runoff (n=1)	Tap (n=1)	Marine (n=1)
Hardness	18.5	24.1	48.7	35.3	589
Solids, total dissolved [TDS]	24	36	76	64	3400
Solids, total suspended [TSS]	7.4	40.2	287	<3.0	39.2
Carbon, total organic [TOC]	2.68	4.45	7.97	<0.50	4.91
Biochemical oxygen demand [BOD]	<2.0	<2.0	<2.0	<2.0	<2.0
Chemical oxygen demand [COD]	14	17	53	<10	<100

Table 9: Nutrient concentrations (mg/L) in each water category for the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)

Analyte	Source (n=1)	Streams and rivers (n=1)	Road runoff (n=1)	Tap (n=1)	Marine (n=1)
Ammonia, total (as N)	<0.0050	0.0362	0.0350	<0.0050	0.0468
Nitrate (as N)	0.0820	0.0634	0.985	0.206	0.118
Nitrate + Nitrite (as N)	0.0820	0.0634	0.987	0.206	0.118
Nitrite (as N)	<0.0010	<0.0010	0.0024	<0.0010	<0.010
Nitrogen, total	0.154	0.323	1.52	0.219	0.37

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Phosphate, ortho-, dissolved (as P)	<0.0010	0.0070	0.0272	0.0100	0.0144

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

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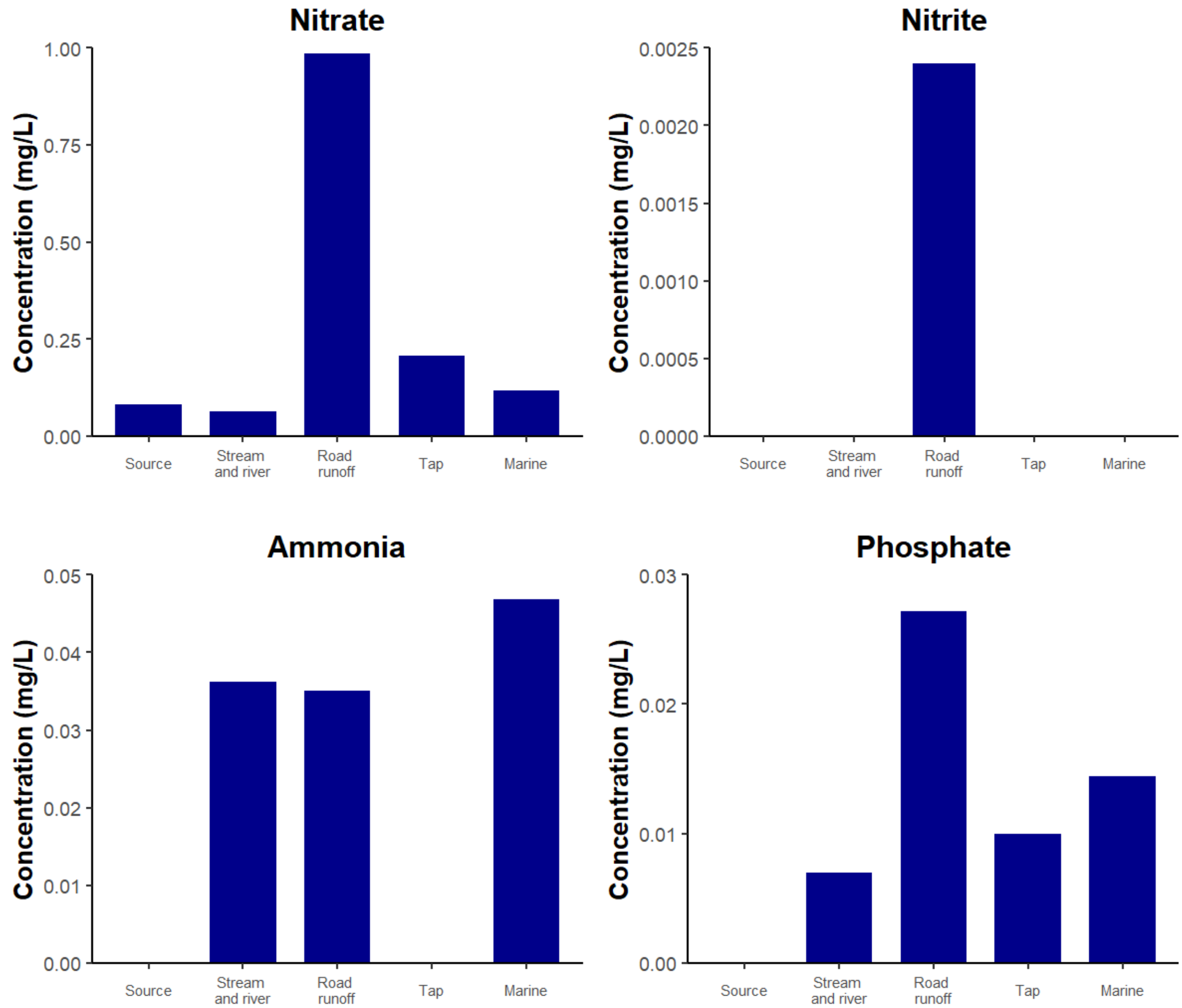
Figure 3: Nutrient concentrations (mg/L) in five water categories in the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)



Nitrate (NO^{-3}) was the most commonly detected nutrient in water samples from the Quw'utsun Sta'lo' (Cowichan River) watershed. The highest concentration of nitrate (mg/L) was detected in the road runoff sample. Ammonia (NH_3) was detected in stream and river, road runoff, and marine water samples, with the highest concentration observed in the marine water sample. The highest concentration of phosphate was detected in the road runoff sample, and nitrite was only detected in the road runoff sample.

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Conclusions

- Nitrate concentrations detected in the five water categories were ranked from highest to lowest as follows: road runoff > tap > marine > source > stream and river.
- Nitrate, phosphate, and ammonia were the most frequently detected nutrients in water samples from the Quw'utsun Sta'lo' (Cowichan River) watershed.
- Road runoff was found to have the highest concentration of nitrate (0.985 mg/L), which was still well below the BC acute guideline value for the protection of freshwater aquatic life (32.8 mg/L), and the BC long-term guideline value for the protection of freshwater aquatic life (3.0 mg/L).
- The marine sample was found to have the highest concentration of ammonia (0.468 mg/L), which was well below the CCME total ammonia guideline value for the protection of freshwater aquatic life (4.84 mg/L for pH = 7 and temperature = 5 ℃), the BC acute guideline for the protection of freshwater life. There is no guideline for ammonia in marine water.
- No nutrient values exceeded available EQGs for the protection of aquatic life.

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Metals

Capsule

Metals can be present in water due to both natural and anthropogenic inputs. Metals were detected in all samples with the highest concentrations reported in the road runoff sample and the lowest in the source sample, for the non-marine samples. Lead was detected in three of the five water samples and did not exceed EQGs or DWQGs. There were ten exceedances of the EQGs for the protection of freshwater life: aluminum (n=3), copper (n=3) iron (n=3) and lead (n=1) with the highest number of exceedances occurring in the road runoff sample. There were no DWG exceedances in the tap water.

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 Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)

Analyte	Source (n=1)	Stream and river (n=1)	Road runoff (n=1)	Tap (n=1)	Marine (n=1)
Aluminum, total	**0.338**	**1.88**	**7.23**	0.013	1.79
Antimony, total	<0.00010	<0.00010	0.00016	<0.00010	<0.0030
Arsenic, total	0.00013	0.00074	0.00204	0.00055	<0.0030
Barium, total	0.00577	0.0163	0.05	0.00352	0.0166
Beryllium, total	<0.000020	0.000037	0.000139	<0.000020	<0.00050
Bismuth, total	<0.000050	<0.000050	<0.000050	0.00005	<0.0020
Boron, total	<0.010	<0.010	0.014	0.019	0.45

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Cadmium, total	<0.0000050	0.0000222	0.0000536	0.0000052	<0.00020
Calcium, total	6.54	7.14	12.1	9.74	44.5
Chromium, total	0.00113	0.00317	0.0107	0.00161	<0.0050
Cobalt, total	0.00021	0.00117	0.00374	0.00018	0.0013
Copper, total	0.00175	**0.00457**	**0.0155**	0.189	**0.0052**
Iron, total	**0.346**	**2.30**	**8.46**	0.028	2.34
Lead, total	<0.000050	0.000432	**0.00212**	0.00111	<0.0020
Lithium, total	<0.0010	0.0012	0.0058	0.0013	<0.025
Magnesium, total	0.537	1.52	4.49	2.67	116
Manganese, total	0.00881	0.081	0.188	0.00076	0.0679
Mercury, total	<0.0000050	0.0000084	0.0000192	<0.0000050	0.0000072
Molybdenum, total	0.000055	0.000142	0.000275	0.000145	<0.0025
Nickel, total	0.00059	0.00234	0.00886	0.00162	<0.0050
Phosphorus, total	<0.050	0.087	0.316	<0.050	<1.0
Potassium, total	0.169	0.505	1.82	0.324	36.4
Selenium, total	0.000063	<0.000050	0.000132	0.000128	<0.0020
Silicon, total	1.9	5.14	14.8	5.12	4.91
Silver, total	<0.000010	0.000011	0.000041	0.00002	<0.00025
Sodium, total	0.831	1.74	8.24	9.96	992
Strontium, total	0.0149	0.0247	0.0692	0.0323	0.737
Sulfur, total	<0.50	<0.50	1.63	1.01	86.8
Thallium, total	<0.000010	<0.000010	0.000031	<0.000010	<0.00050
Tin, total	<0.00010	<0.00010	0.00012	0.00017	<0.0025
Titanium, total	0.0164	0.0962	0.368	<0.00030	0.0965
Uranium, total	<0.000010	0.000037	0.000132	0.000079	<0.00050
Vanadium, total	0.0011	0.00614	0.0206	0.00227	0.0056
Zinc, total	<0.0030	0.0059	0.0313	0.0574	<0.025
Zirconium, total	<0.00020	<0.00020	<0.00060	<0.00020	<0.010
Total Metals	*10.7*	*20.6*	*59.9*	*29.2*	*1286*

Bold indicates a concentration that exceeded an Environmental or Water Quality Guideline. Additional scrutiny of these findings can be found in Appendix 5 and 6, where certain water quality parameters are applied or can be applied for a site-specific evaluation. *BC (Al) or Federal (Fe) Water Quality Guidelines there were calculated using three different %TOC concentrations that allowed us to compare with metal concentrations in a parallel post hoc exercise (Appendix 3,4).

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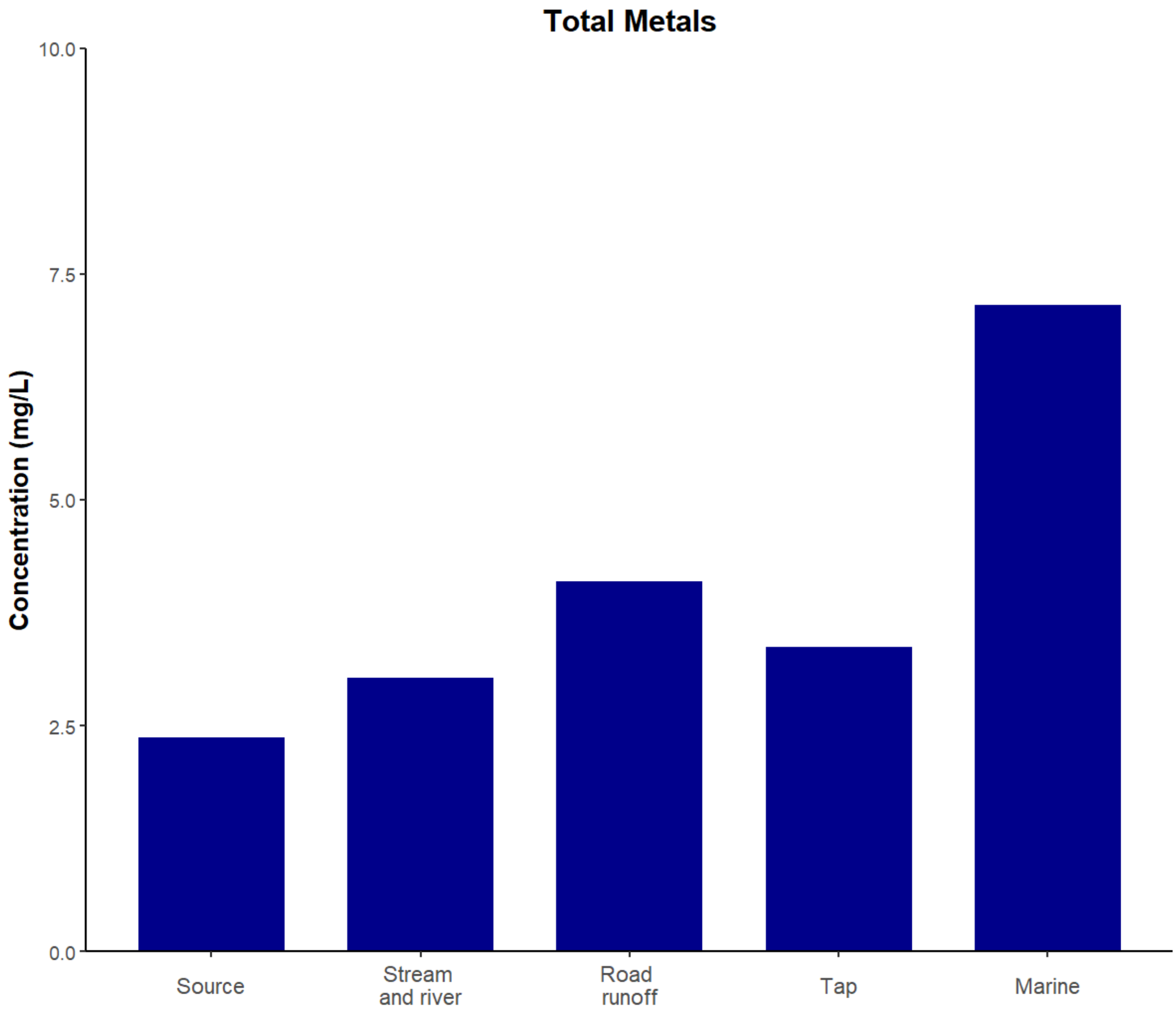
Figure 4: Total metal concentrations (mg/L) in five water categories in the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)



Total metal concentrations are shown with a logarithmic transformation to allow for visualization of the data. The marine water sample had considerably higher concentrations of metals than the four non-marine samples, consistent with its mineral-rich content.

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Table 11: Lead (Pb) is a noteworthy contaminant in some drinking water samples: Concentrations (mg/L) of lead detected in all five water categories in the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)

Analyte	Source (n=1)	Streams and rivers (n=1)	Road runoff (n=1)	Tap (n=1)	Marine (n=1)
Lead (mg/L)	<0.000050	0.000432	**0.00212**	0.00111	<0.0020

There were no detected exceedances of EQGs or DWQGs with respect to lead concentrations.

Conclusions

- Total metal concentration for the five water categories was ranked from highest to lowest as follows: marine > road runoff > tap > stream and river > source.
- Lead was detected in the pooled tap water sample, and was present at concentrations of 0.00111 mg/L - which was below the limit set by Health Canada for safe drinking water (0.005 mg/L).
- The aluminum concentrations detected in the source (0.338 mg/L), stream and river sample (1.88 mg/L), and road runoff (7.23 mg/L) samples were above the BC EQGs estimated based on water properties at the site (see appendix 3 for calculations). It is possible that the elevated aluminum values are geological in origin.
- The iron concentration in the source (0.346 mg/L), stream and river (2.30 mg/L) and road runoff (8.46 mg/L) samples exceeded the FEQG calculated based on the water properties at the sites (see appendix 4 for calculations). In addition, the source sample also exceeded the BC EQG and all samples also exceeded the CCME EQGs calculated for the water properties at the sites.
- The copper concentration detected in the stream and river (0.00457 mg/L), road runoff (0.0155 mg/L) and marine samples (0.0052 mg/L) exceeded the long-term CCME guidelines for the protection of freshwater aquatic life calculated based on water properties at the site
- Lead concentrations in the road runoff sample (0.00212 mg/L) exceeded the CCME EQG calculated based on the water properties at the site.
- There were no DWG exceedances in the tap water.

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Polycyclic Aromatic Hydrocarbons (PAHs)

Capsule

Polycyclic aromatic hydrocarbons (PAHs) were detected in all five water sample categories, with highest concentrations in the road runoff water sample and the lowest in the tap sample. While the stream and river and road runoff samples had Fl/(Fl+Pyr) ratio suggesting contribution of liquid fuel combustion to the PAHs present in those samples, the marine sample had a ratio suggesting the contribution of combustion of solid fuel such as wood, plant material or coal as the source of PAHs. EQGs were only available for a few PAHs, but no exceedances were observed for any samples. The tap water sample did not exceed the one PAH guideline available for drinking water.

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 five water samples collected in the Quw’utsun Sta'lo' (Cowichan River) watershed during the wet season.

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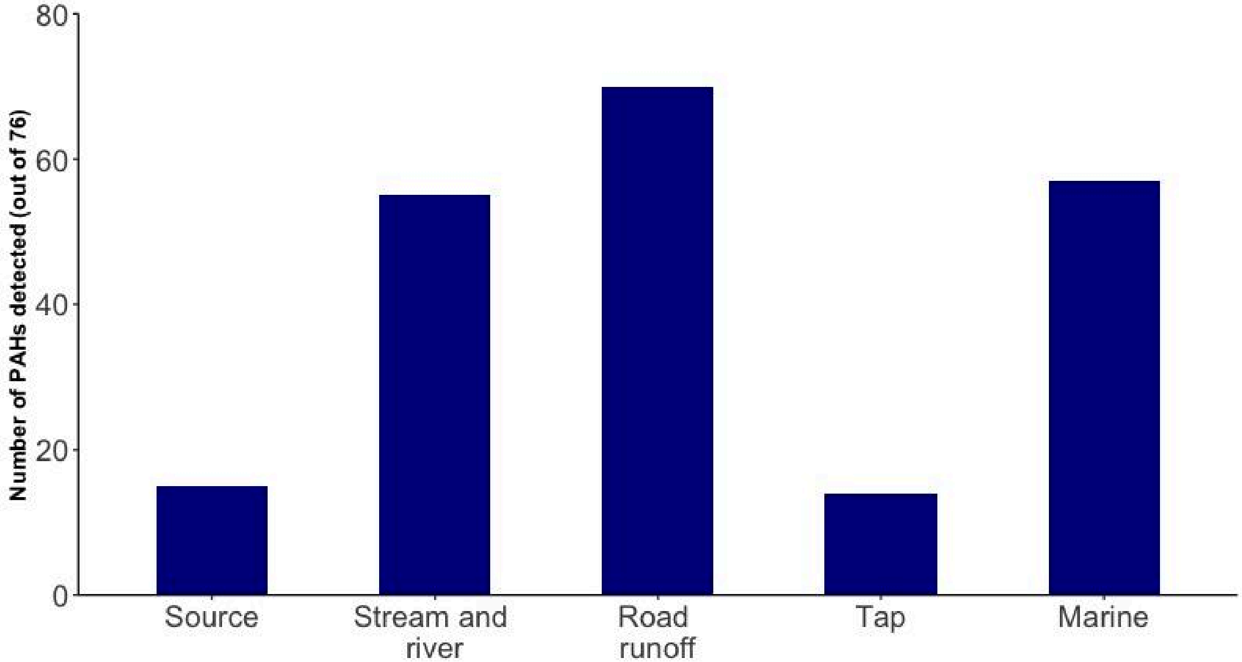
Figure 5: Number of PAHs detected in water samples from the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)



PAHs were detected in all five water categories. The number of PAHs detected ranged from 14 (tap) to 70 (road runoff) with an average of 42.2 ± 11.6.

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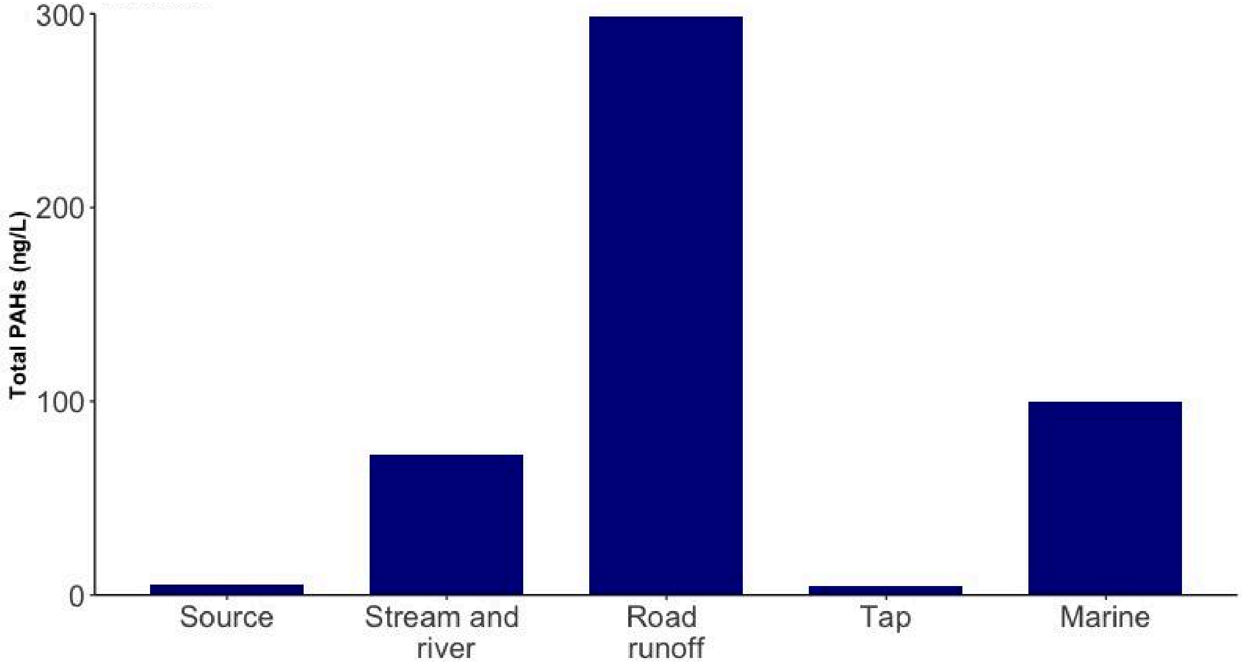
Figure 6: Total PAH concentrations in water samples from the Quw’utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)



Total PAH concentrations ranged from 4.6 (tap) to 299 ng/L (road runoff), with an average across all water categories of 96.3 ± 53.9 ng/L.

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 for all samples, except the source and tap samples..

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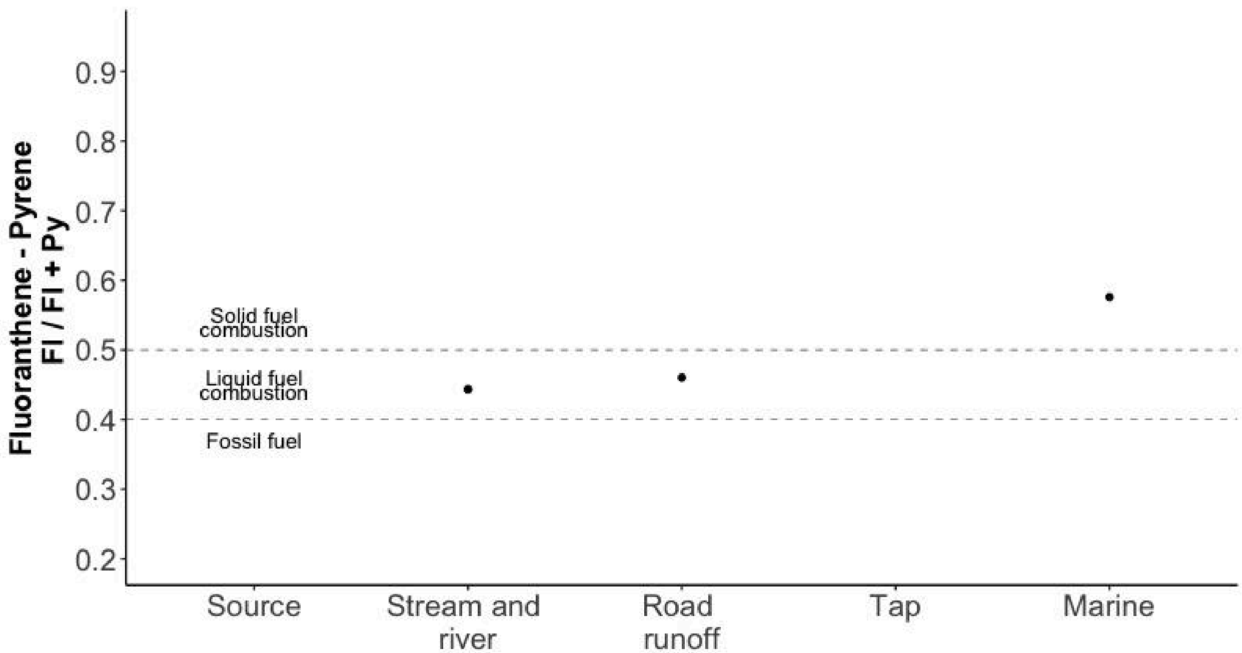
Figure 7: PAH profiles in water samples from the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)



Stream and river (0.44) and road runoff (0.46) samples had Fl/(Fl+Pyr) ratios between 0.4 and 0.5 suggesting a dominance of liquid petroleum product combustion (gasoline, diesel) as a source of PAHS. The marine sample had a ratio higher than 0.5 (0.58) suggesting the contribution of combustion of solid fuel such as wood, plant material or coal as the source of PAHs.

Conclusions

- PAH concentrations were ranked as follows from highest to lowest: road runoff > marine > stream and river > source > tap.
- Total PAH concentrations in Quw'utsun Sta'lo' (Cowichan River) watershed water samples ranged from 4.6 to 299 ng/L.
- Fluoranthene - Pyrene ratios in the stream and river and road runoff samples revealed that PAHs in road runoff originated primarily from the combustion of liquid petroleum products, consistent with nearby vehicle emissions, at least for the road runoff sample..
- The Fluoranthene - Pyrene ratios revealed that PAHs in the marine sample 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,

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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 well below the BC EQGs available for individual PAHs (naphthalene, acenaphthene, fluorene, anthracene, phenanthrene, fluoranthene, pyrene, chrysene, benzo-a-pyrene and benzo-a-anthracene).
- A single DWQG is available for PAHs: benzo-a-pyrene (40 ng/L), which was not detected in the tap water sample.

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Pesticides

Capsule

A limited number of pesticides were detected in all five water samples, with the highest concentrations in the tap water sample, and the lowest in the marine water sample. Alpha-endosulfan was detected in the majority of samples (60%). Out of the pesticides detected in environmental samples, EQGs were only available for endosulfan and no exceedances for this pesticide were observed for any of the water samples. Hexachlorobenzene and quintozene were the two pesticides detected in tap water and there were no DWQG available for these.

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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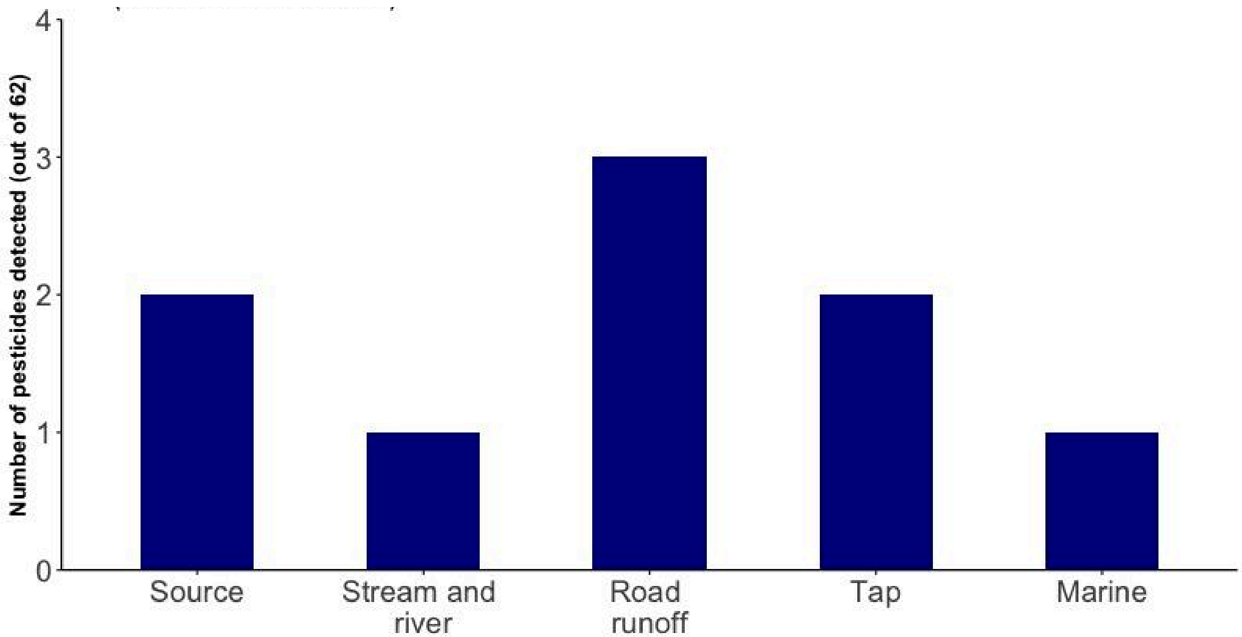
Results

We measured 62 different pesticides, including both legacy and CUPs in the five water samples collected within the Quw’utsun Sta'lo' (Cowichan River) watershed during the wet season.

Figure 8: Number of pesticide detections in water sampled in the Quw’utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)



The number of pesticides detected ranged from 1 (stream and river) to 9 (road runoff) with an average of 1.8 ± 0.4.

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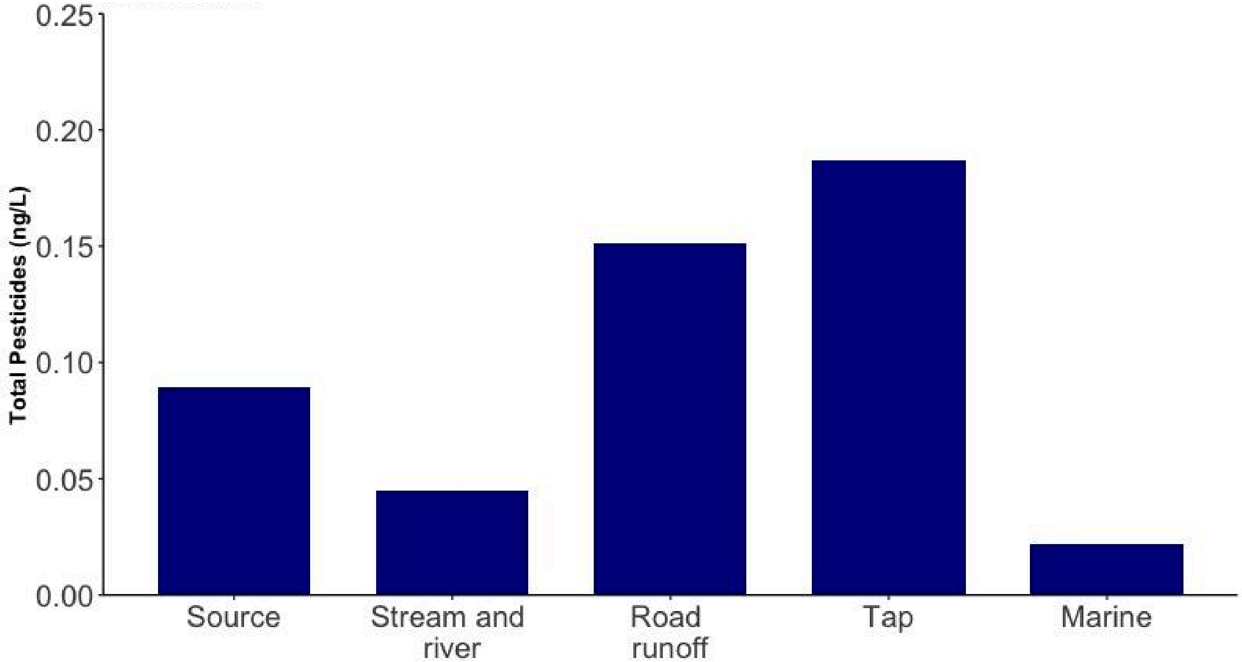
Figure 9: Total pesticide concentrations in water sampled in the Quw’utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)



Total pesticide levels ranged from 0.02 (marine) to 0.19 ng/L (tap), with an average across all water categories of 1.0 ± 0.03 ng/L.

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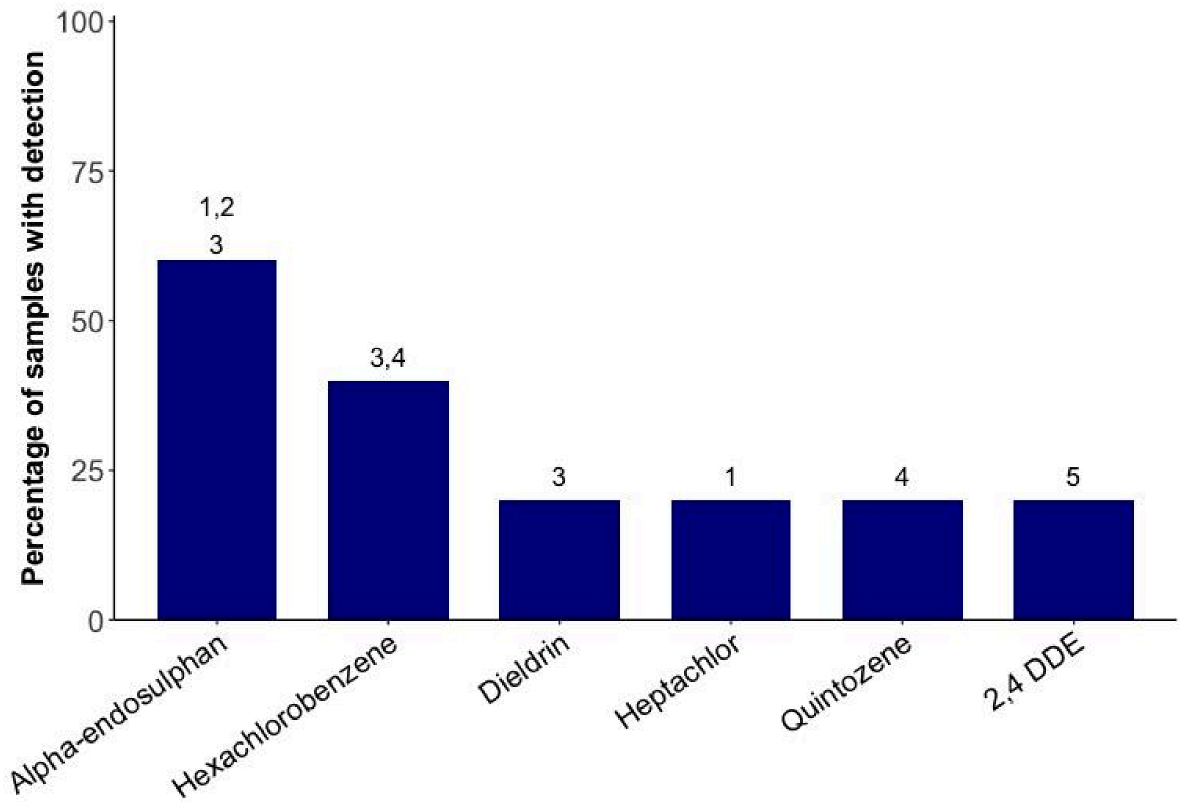
Figure 10: Most frequently detected pesticides in water categories sampled in the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)



Numbers refer to water categories (1: Source, 2: Stream and river, 3: Road runoff, 4: Tap, 5: Marine). For example, tap water had detectable concentrations of hexachlorobenzene and quintozene.

Alpha- endosulfan was detected in the majority of samples (60%). Endosulfan is a restricted-use insecticide and acaricide 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).

Conclusions

- Pesticide concentrations were ranked as follows from highest to lowest: tap > road runoff > source > stream and river > marine.
- Total pesticide concentrations ranged from 0.02 to 0.19 ng/L.

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- All pesticides detected 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 and endosulfan 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 was the only pesticide detected that had EQGs, and its concentration did not exceed the guideline in any sample.
- Canadian drinking water guidelines were only available for six pesticides (atrazine, chlorpyrifos, dimethoate, metribuzin, malathion and simazine), and none were detected in the tap sample.

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. DEET and amphetamine were each detected in all five water samples from the Quw'utsun Sta'lo' (Cowichan River) watershed. The stream and river and marine samples were tied for the greatest number of different PPCP compounds detected. The highest concentration of PPCPs were detected in the stream and river sample, followed by the marine sample.

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. Amphetamine is a recreational drug, and used in medications for the treatment of ADHD.

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.

Results

We detected 26 pharmaceuticals and personal care products in the five water samples collected within the Quw'utsun Sta'lo' (Cowichan River) watershed during the dry season.

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Table 13: PPCP concentrations (ng/L) for all analytes detected in each water category for the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)

Analyte	Source	Stream and river	Road runoff	Tap	Marine
2-Hydroxy-ibuprofen	0	8.39	5.61	0	8.53
Naproxen	0	3.03	0	0	3.60
Caffeine	0	22.5	20.7	0	21.4
Carbamazepine	0	0	0.624	0	0.373
1,7-Dimethylxanthine	0	6.72	0	0	0
Sulfamethoxazole	0	0	3.97	0	0
Iopamidol	0	79.4	0	0	0
Venlafaxine	0	0.506	0	0	0.562
Amsacrine	0	0	0	0	0
Amphetamine	0.404	0.400	0.424	0.454	0.368
Atenolol	0	0	0	0	0.344
Cotinine	0	1.68	0.818	0	2.03
Metformin	0	50.7	8.5	0	53.8
Benzoylecgonine	0	1.85	1.44	0	1.86
Cocaine	0	0.227	0.756	0	0.251
DEET	0.170	0.840	1.26	0.970	0.500
Theophylline	0	20.8	9.76	0	18.3
Total Concentration	*0.574*	*197*	*53.9*	*1.42*	*112*
Total No. PPCPs	*2*	*13*	*11*	*2*	*13*

The highest concentration, and greatest number of PPCPs (tied with the marine sample) were both detected in the stream and river sample. This is likely due to sites in the river being situated downstream of the wastewater treatment plant effluent pipes.

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Conclusions

- PPCP concentrations in each water sample from highest to lowest are as follows: stream and river > marine > road runoff > tap > source.
- The largest number of different PPCP analytes detected was found in the stream and river and marine water samples (n=13).
- There are no EQGs available in Canada for any of the PPCPs we detected in water samples for the Quw'utsun Sta'lo' (Cowichan River) watershed.
- The only PPCP for which there is an environmental quality guideline is Ethinylestradiol (EE), 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 all water samples except the source and marine samples. The highest PFAS concentrations were observed in road runoff water with the lowest being in the source and marine samples. Perfluorooctanoic Acid (PFOA) was the only PFAS detected in the stream and river sample while perfluorooctanesulfonamide (PFOSA) was the only PFAS detected in the tap water sample. Perfluorooctanesulfonamide (PFOSA) was detected in all samples except stream and river as opposed to the wet season when it was only detected in tap water. Nine PFAS were detected in road runoff with perfluorobutane sulfonate (PFBS) and perfluorooctanesulfonic acid (PFOS) having the highest concentrations. None of the samples exceeded the environmental quality guidelines available (PFOS) or drinking water guidelines (PFOS, PFOA, total PFAS), or the new Drinking Water Quality Objective of 30 ng/L for the sum of 25 measured PFAS compounds.

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 film-forming foams (AFFF; 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

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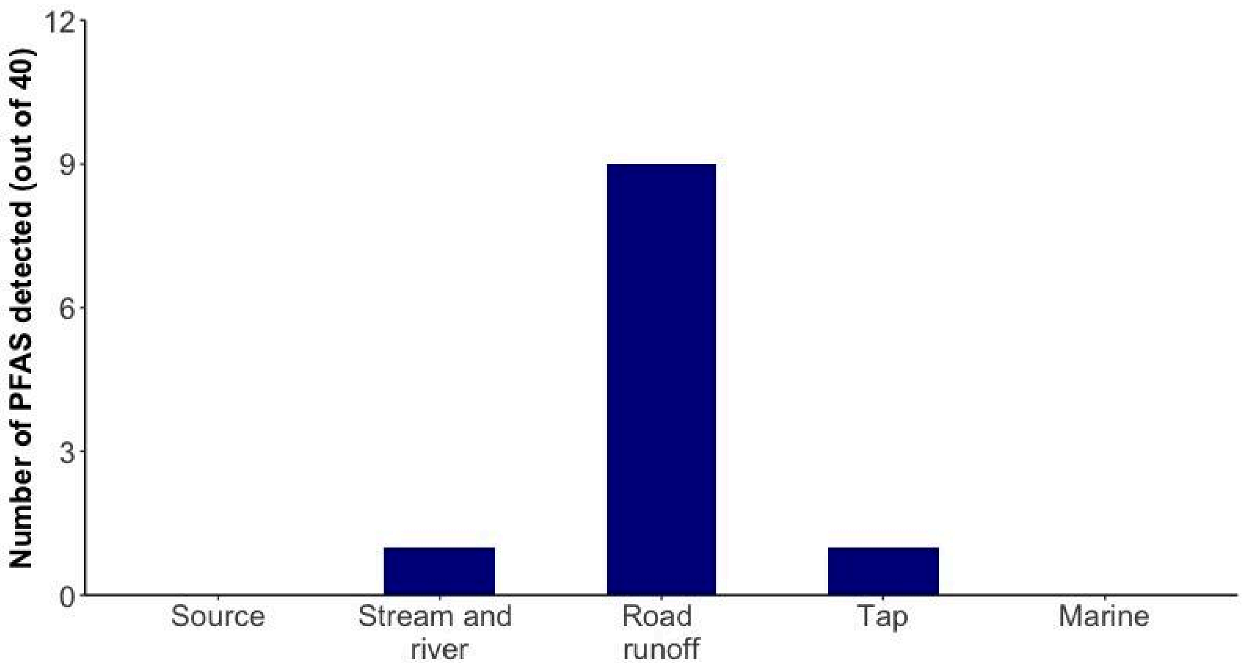
concerns about the many PFAS being detected in the environment is a current priority in Canada (Longpre et al., 2020).

Results

We measured 40 different PFAS in the five water samples collected within the Quw'utsun Sta'lo' (Cowichan River) watershed during the wet season.

Figure 12: Number of PFAS substances detected in water samples from the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)



PFAS were detected in all samples except the source and stream and river water. The number of PFAS detected ranged from 0 (source and marine) to 9 (road runoff) with an average of 2.2 ± 1.7.

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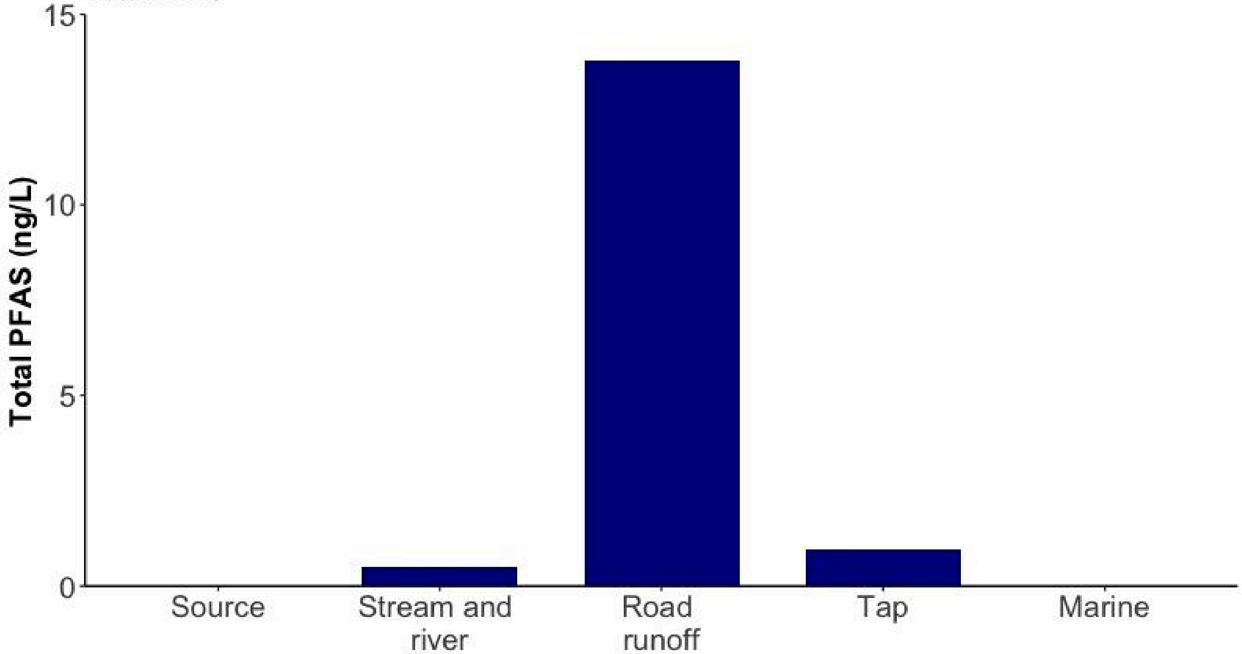
Figure 13: Total PFAS concentrations in water sampled in the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)



Total PFAS levels ranged between 0 (source and marine) and 13.8 ng/L (road runoff) with an average across all water categories of 3.1 ± 2.7 ng/L.

Perfluorooctanoic Acid (PFOA) was the only PFAS detected in the stream and river sample while perfluorooctanesulfonamide (PFOSA) was the only PFAS detected in the tap water sample.

The nine PFAS detected in the road runoff sample were as follows:

- Perfluorobutane sulfonate (PFBS): 2.6 ng/L;
- perfluorooctanesulfonic acid (PFOS): 2.4 ng/L;
- perfluorohexanoic Acid (PFHxA): 2.1 ng/L;
- PFOA: 2.0 ng/L;
- perfluoropentanoic Acid (PFPeA): 1.9 ng/L;
- Perfluorohexane sulfonic acid (PFHxS): 1.0 ng/L;
- Perfluoroheptanoic acid (PFHpA): 0.60 ng/L;
- *N*-Methylperfluorooctanesulfonamide (*N*-MeFOSA): 0.74 ng/L;
- PFOSA: 0.42 ng/L;

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Conclusions

- PFAS concentrations were ranked as follows from highest to lowest: road runoff > tap > stream and river > source, marine.
- Total PFAS levels in water samples collected from the Quw'utsun Sta'lo' (Cowichan River) watershed ranged from 0 to 13.8 ng/L. They were in the lower range of PFAS levels (0 - 138 ng/L) reported for 29 ambient surface freshwater 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).
- The total PFAS concentration detected in the tap water sample was below the new Health Canada Drinking Water Quality Objective of 30 ng/L for the sum of 25 different PFAS compounds.
- Total PFAS levels in drinking water were below the European Union Water Directive drinking water quality guideline (500 ng/L).
- PFOSA was the only PFAS detected in tap water, with this contaminant having no Canadian drinking water guideline.

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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 five water samples, with the highest concentration observed in the road runoff sample and the lowest in the source sample. The source and stream and river samples had the 'lightest' PCB signatures, while the road runoff and marine samples had the 'heaviest' PCB signatures. None of the samples exceeded the water quality guidelines for individual PCB congeners (PCB-77, -105, -126 and -169). However, for total PCBs, the road runoff sample exceeded the BC WQG. No guidelines are available for drinking water.

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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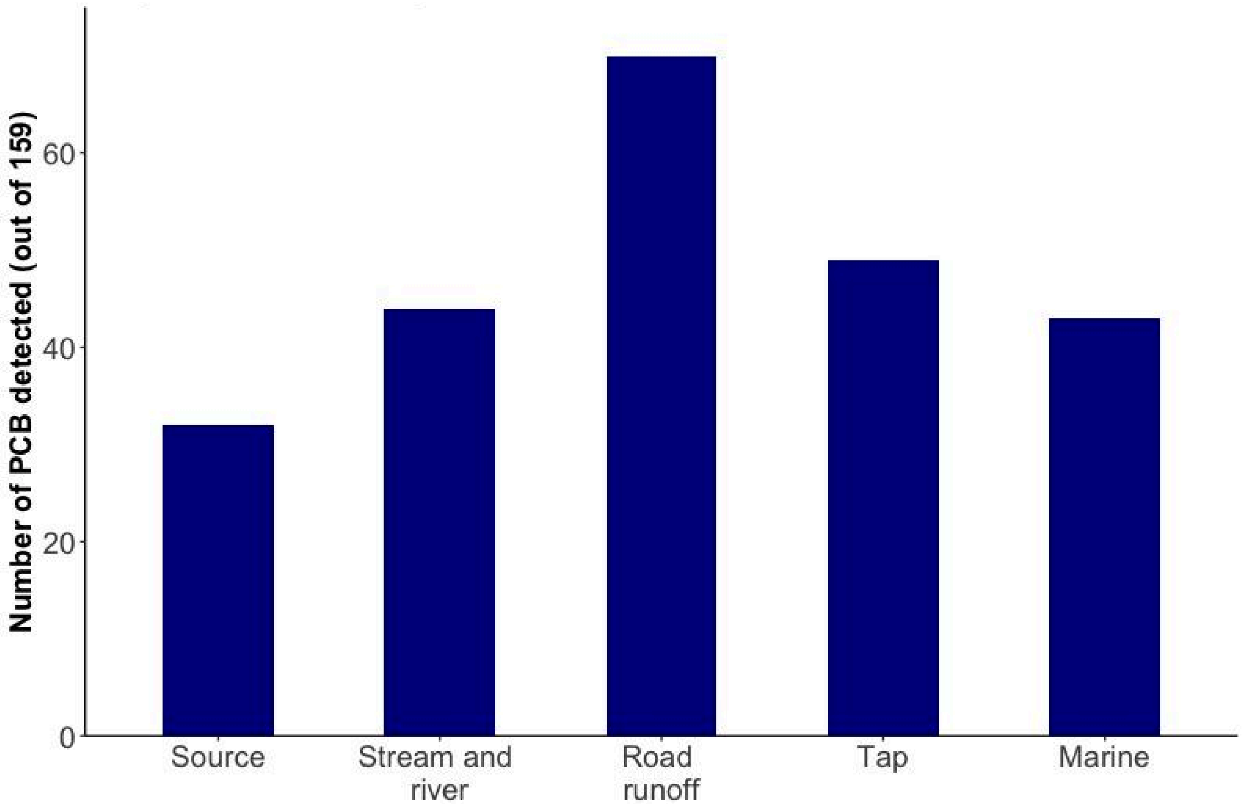
Results

We measured 159 out of a total 209 PCB congeners in the five water samples collected within the Quw’utsun Sta'lo' (Cowichan River) watershed during the wet season.

Figure 14: Number of PCB detections in water sampled from the Quw’utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)



PCBs were detected in all five water categories. The number of PCBs detected ranged from 32 (source) to 70 (road runoff) with an average of 47.6 ± 6.3.

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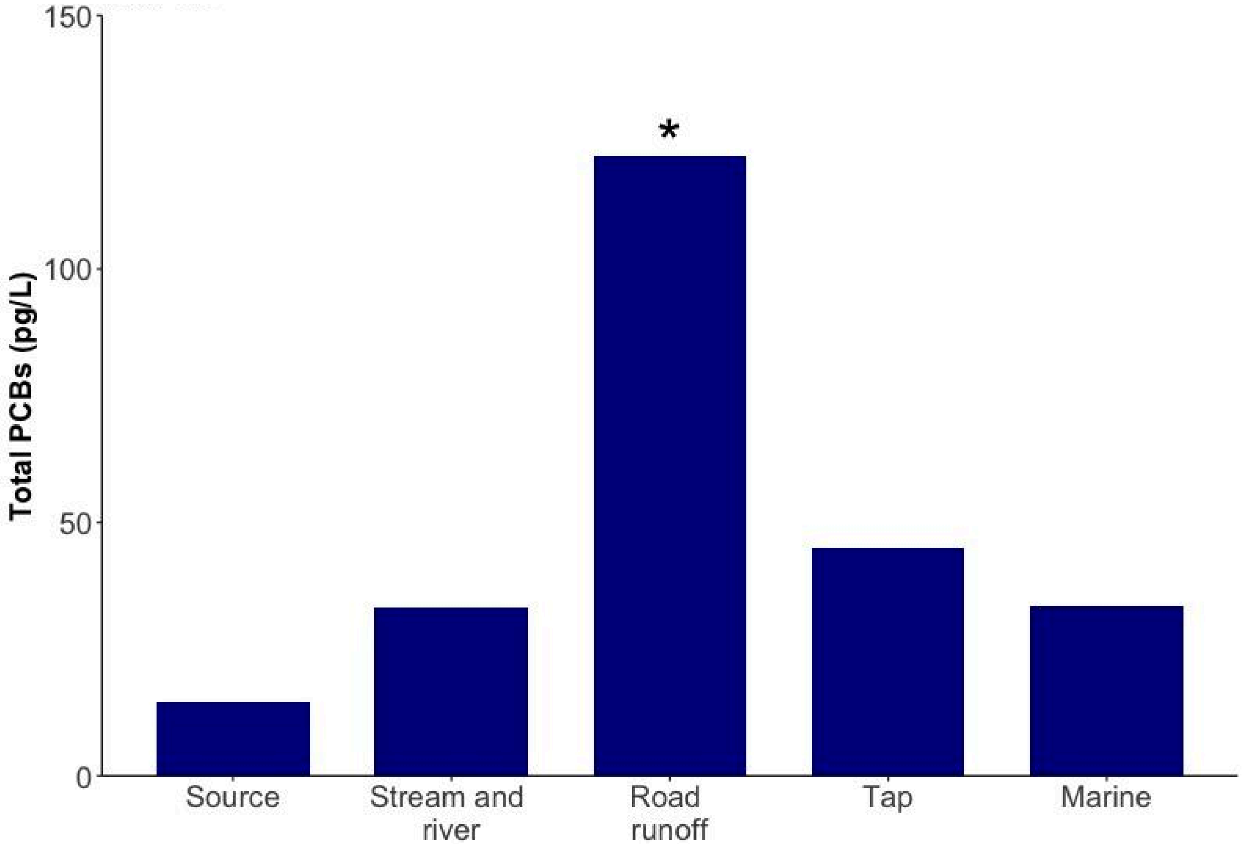
Figure 15: Total PCB concentrations in water sampled from the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)



Total PCB levels ranged between 14.5 (source) and 122 pg/L (road runoff) with an average across all water categories of 49.6 ± 18.8 pg/L (* indicates exceedance of the BC WQG (100 pg/L).

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 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.

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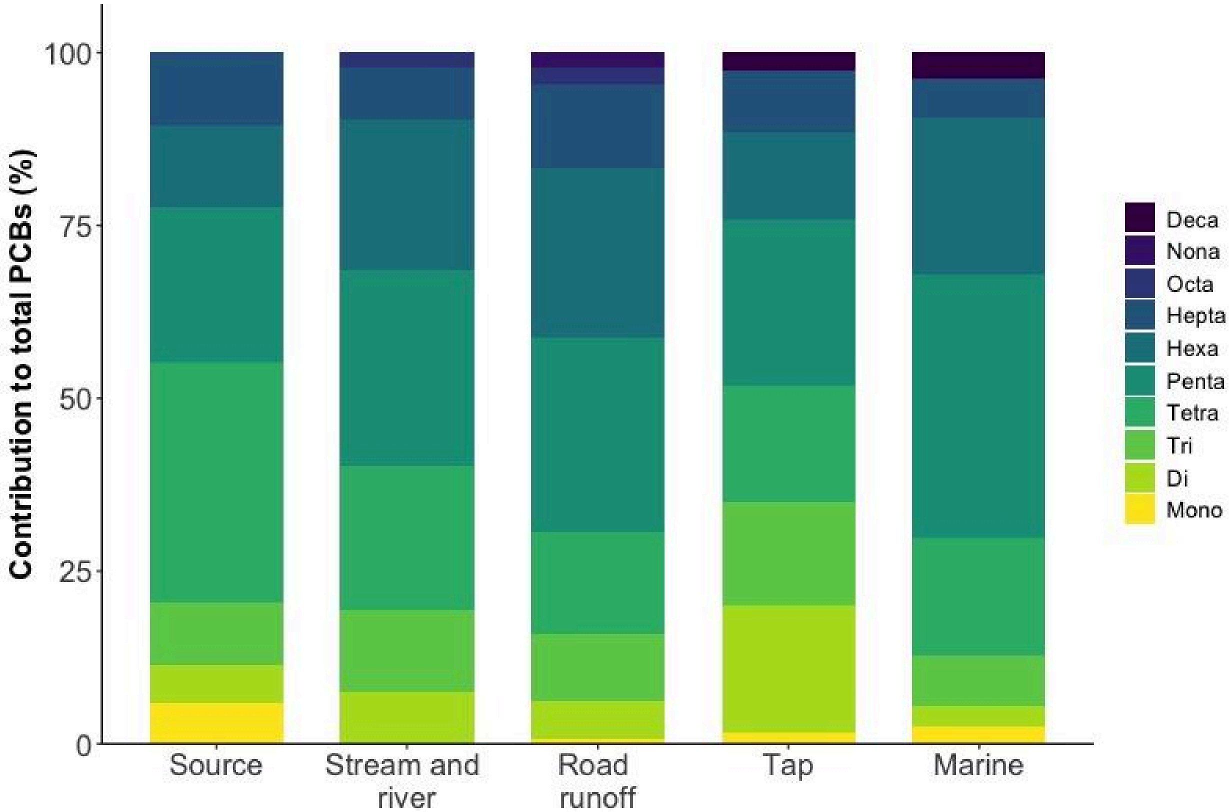
Figure 16: Homologue group contribution to total PCBs in water sampled from the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)



The lighter colours represent 'lighter' PCB homologue groups, such that the source and stream and river water samples had the lightest PCB signatures, followed by the tap water and then the road runoff and the marine samples had the 'heaviest' PCB signatures.

Conclusions

- PCB concentrations were ranked as follows from highest to lowest: road runoff > tap > marine > stream and river > source.
- PCB concentrations ranged from 12.5 to 122.4 pg/L.
- In a recent study of urban-influenced and background stream and rivers samples collected in the northwestern part of Lake Ontario, Zhang et al. (2020) identified PCBs as the dominant compound class measured with levels ranging from 10 pg/L in remote areas to 4100 pg/L in urban areas.
- The PCB levels reported here were in the same range as those reported in the background stream and river samples from the Northwest of Lake Ontario. In their study of air samples in coastal British Columbia, Noël et al. (2004) also observed uniform background levels for this legacy compound.

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- 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.
    - The road runoff sample (122.4 pg/L) exceeded the guideline of 100 pg/L for total PCBs.
- There were no guidelines for PCBs in drinking water in Canada. The US Environmental Protection Agency's enforceable Maximum Contaminant Level (MCL) for PCBs in public water systems is 500,000 pg/L (EPA, 2001), well above the levels reported in the current tap water sample.

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Alkylphenol Ethoxylates

Capsule

Alkylphenol ethoxylates (APEs) are industrial grade surfactants that have been found in wastewater and industrial discharges. The only alkylphenol ethoxylate that was detected in water samples collected from within the Quw'utsun Sta'lo' (Cowichan River) watershed in the 2024-25 wet season was 4-n-Octylphenol, which was detected in two out of five samples, and was found at the highest concentration in the marine water sample.

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 14: Alkylphenol concentration (ng/L) for five water samples from the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)

Analyte	Source (n=1)	Stream and river (n=1)	Road runoff (n=1)	Tap (n=1)	Marine (n=1)
4-Nonylphenols	0	0	0	0	0
4-Nonylphenol monoethoxylates	0	0	0	0	0
4-Nonylphenol diethoxylates	0	0	0	0	0
4-n-Octylphenol	0	0.454	0	0	0.529
Total APEs	*0*	*0.454*	*0*	*0*	*0.529*

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Conclusions

- APE concentrations in water samples from highest to lowest are as follows: marine > stream and river > road runoff = source = tap.
- The only APE that was detected in the Cowichan watershed in the 2024-25 Wet season was 4-n-Octylphenol.
- The concentration of APEs detected in the marine water sample is well below the CCME guideline for the protection of marine life of 700 ng/L for nonylphenol and its ethoxalates.

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Bisphenols

Capsule

Bisphenols are plastic additives with widely reported estrogenic (endocrine disrupting) properties. Bisphenol A (BPA) and bisphenol S (BPS) were the only bisphenol compounds detected in the Quw'utsun Sta'lo' (Cowichan River) watershed. BPA was detected in the tap and stream and river water samples. BPS was detected in the road runoff sample.

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).

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Results

Table 15: Concentration (ng/L) of bisphenols in five water samples from the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)

Analyte	Source (n=1)	Stream and river (n=1)	Road runoff (n=1)	Tap (n=1)	Marine (n=1)
Bisphenol E (BPE)	0	0	0	0	0
Bisphenol F (BPF)	0	0	0	0	0
Bisphenol A (BPA)	0	2.95	0	8.05	0
Bisphenol AF (BPAF)	0	0	0	0	0
Bisphenol B (BPB)	0	0	0	0	0
Bisphenol S (BPS)	0	0	14.7	0	0
Total bisphenols	*0*	*2.95*	*14.7*	*8.05*	*0*

Conclusions

- Bisphenol concentrations in water samples from highest to lowest are as follows: tap > stream and river > road runoff = marine = source.
- The only bisphenol compound that was detected was BPA, detected in the tap and stream and river water samples.
- There is currently no Guideline for Bisphenol A in drinking water from Health Canada.
- A FEQG for BPA is set at 1.4 ug/L, which is much higher than the concentration we measured in the tap water sample.

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Sucralose

Capsule

Sucralose is a popular artificial sweetener (trade name '*Splenda*') used in foods and beverages. This analyte has become an important tracer of human waste in environmental samples. Sucralose was detected in four out of five water samples collected within the Quw'utsun Sta'lo' (Cowichan River) watershed. It was detected at the highest concentration in the tap sample, followed by the marine 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 16: Sucralose concentration (ng/L) in five categories of water from the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024-25)

Analyte	Source (n=1)	Stream and river (n=1)	Road runoff (n=1)	Tap (n=1)	Marine (n=1)
Sucralose (ng/L)	0	43.8	41.5	50	47.2

The highest concentration of sucralose was detected in the tap water sample. The second highest concentration was detected in the marine sample.

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Conclusions

- Sucralose concentrations in water samples from highest to lowest are as follows: tap > marine > stream and river > road runoff > source.
- The highest concentration of the artificial sweetener sucralose was detected in the tap water sample.
- There are no current Canadian Environmental Quality Guidelines available for sucralose.
- There are no current Health Canada Drinking Water Guidelines available for sucralose.

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6PPD-quinone

Capsule

The breakdown product of a UV-stabilizing 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. 6PPD-Q was only detected in the road runoff sample at a concentration below the newly developed BC EQG.

Introduction

6PPD is an anti-ozonant 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 17: 6PPD-Quinone concentration (ng/L) in five categories of water from the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season 2024)

Analyte	**Source** (n=1)	**Streams and rivers** (n=1)	**Road runoff** (n=1)	**Tap** (n=1)	**Marine** (n=1)
6PPD-quinone (ng/L)	0	0	2.33	0	0

6PPD-Q was only detected in the road runoff sample.

Conclusions

- 6PPD-quinone concentrations in water samples from highest to lowest are as follows: road runoff > source = stream and river = tap = marine.
- The BC Ministry of Water, Land and Resource Stewardship released an official short-term acute Water Quality Guideline (WQG) of 0.010 µg/L (10 ng/L) in February 2025. Results from all samples were below this guideline.
- There are no DWQs for 6PPD-quinone.

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- The LC50 (the concentration that is lethal to 50% of an experimental population of individuals within 24 hours) for 6PPD-Quinone in coho salmon is 41 ng/L (Lo et al., 2023).

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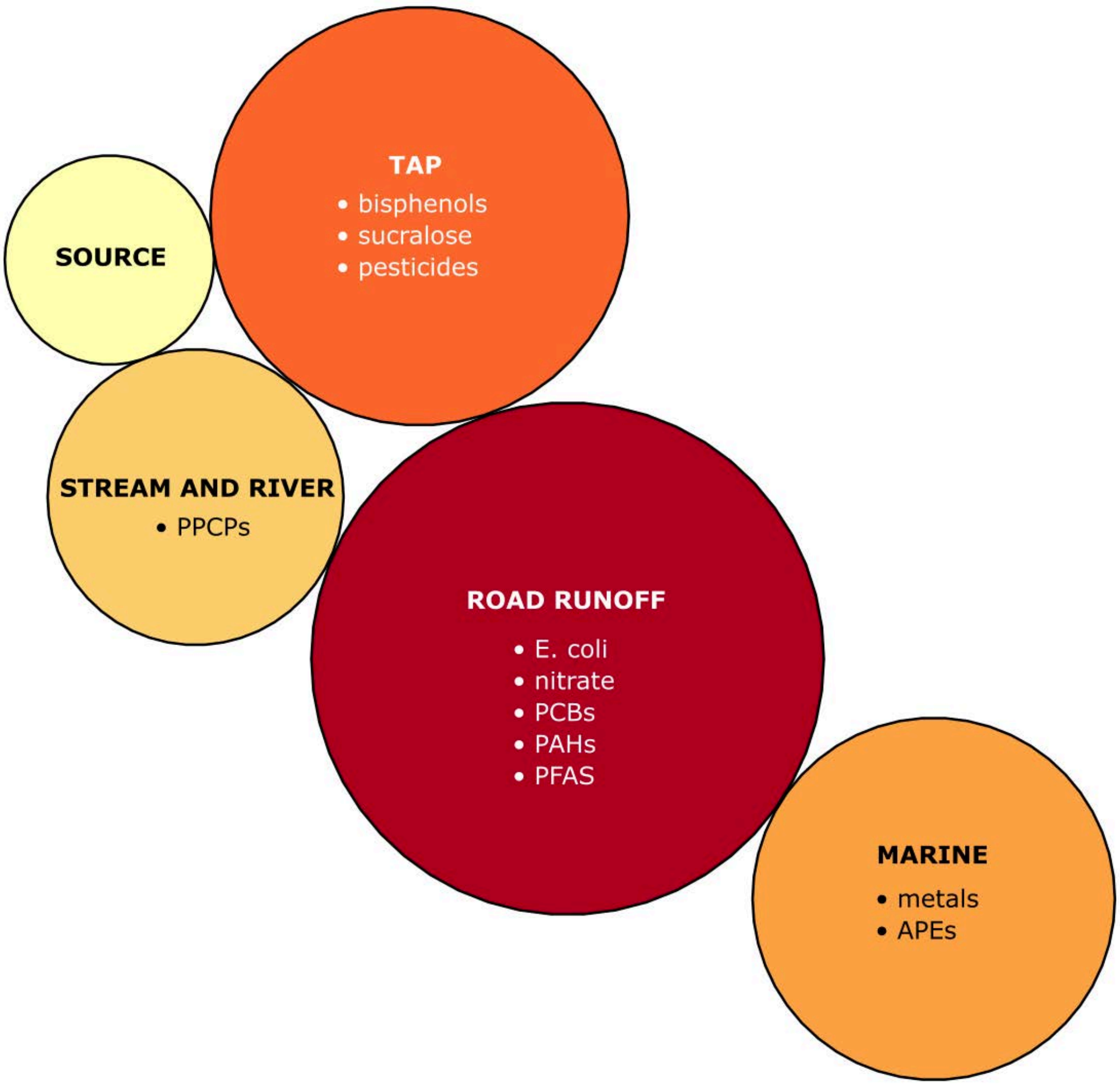
Wet season water quality summary

Figure 17: Water categories for the Quw'utsun Sta'lo' (Cowichan River) watershed ranked by number of contaminant classes detected at highest concentrations in each (WET Season 2024-25).



The larger the circle, the greater the number of contaminant classes that were detected in the highest concentration. Road runoff had the highest number of contaminant classes with the highest concentration (n=5). It was not surprising to find road runoff to be relatively contaminated.

This report encapsulates a single wet season water sampling event comprising pooled samples in five water categories: source water, stream & river water, road runoff, tap water, and marine water.

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Results suggest that Cowichan 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 Quw'utsun Sta'lo' (Cowichan River) watershed. This may, in turn, provide guidance on mitigation, stewardship and restoration initiatives that protect and restore fish habitat throughout the Cowichan watershed. This report is the 3rd of four planned sampling events in the Quw'utsun Sta'lo' (Cowichan River).

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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

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TSS	Total suspended solids
TWP	Tire wear particle
WQGs	Water Quality Guidelines
WQI	Water Quality Index
WWTP	Wastewater treatment plant

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Appendix

Appendix 1: Environmental and Drinking water quality guidelines relevant for the present study. These guidelines were retrieved in January 2025

Analyte Class	Federal EQGs[1]	BC WQGs		CCME EQGs[2]		Drinking WQGs[6]
		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
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	-
Acenaphthene	-	6	6	5.8	-	-
Fluorene	-	12	12	3	-	-

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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	-	-	-	-
PCB-126	-	0.00025	-	-	-	-
Bisphenols (ug/L)						
BPA	3.5	3.5	-	-	-	-
Alkylphenols (ug/L)						
TEQ[5]	-	1 (long-term)	-	1	0.7	-
PFAS (ug/L)						
Perfluorooctane Sulfonate (PFOS)	6.8 (fresh)	3.4	-	-	-	0.6
Perfluorooctanic acid (PFOA)	-	-	-	-	-	0.2
Pesticides (ug/L)						
Atrazine	-	1.8[5]	-	1.8	-	5
Chlorothalonil	-	-	-	0.18	-	-
Cyanazine	-	2	-	-	-	-
Chlorpyrifos	-	0.02	0.002	-	-	90
Diazinon	-	0.0043	-	-	-	-
Dimethoate	-	-	-	6.2	-	20
Endosulfan	-	0.03 (short-term) 0.0015 (long-term)	0.015 (short-term) 0.001 (long-term)	0.06 (short-term) 0.003 (long-term)	0.09 (short-term) 0.002 (long-term)	-
Hexachlorocyclohexane	-	-	-	0.01	-	-
Malathion	-	0.1	-	-	-	290
Metolachlor	-	-	-	7.8	-	-
Metribuzin	-	1[5]	-	1.0	-	80
Permethrin	-	0.004[5]	-	0.004	0.001	-

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Picloram	-	29	-	-	-	-
Simazine	-	10[5]	-	10	-	10
Pharmaceuticals (ug/L)						
Carbamazepine	-	-	-	10	-	-
Triclocarban	0.150	0.05	-	-	-	-
Tricolsan	0.470 (benchmark)	-	-	-	-	-
6PPD quinone (ug/L)						
6PPDq	-	0.010	-	-	-	-

[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] Some metal guidelines are based on complex formulas that take into account chemical parameters which can be found on the CCME or Government of BC website). [4] Represents CCME guidelines that the BC government has adopted as working water guidelines. [5] The TEQ approach is used to characterize the toxicity of nonylphenol mixtures by expressing the toxicities of each individual compound in common terms and summing them. [6] Drinking Water Quality Guidelines from Health Canada.

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Appendix 2: Federal, CCME, Health Canada, and BC environmental and water quality guidelines for metals (mg/L) analyzed in this study. These guidelines were retrieved in January 2025

Analyte Class	Federal EQGs[1]	BC WQGs		CCME EQGs		Health Canada
		Freshwater	Marine	Freshwater	Marine	
Aluminum[1]	Formula requires unavailable DOC value to calculate	Formula requires unavailable DOC value to calculate	-	**0.005 if pH < 6.5**	-	**2.9**
Arsenic	-	**0.005[2]**	**0.0125[2]**	**0.005**	**0.0125**	**0.01**
Barium	-	-	-	-	-	**2**
Boron	-	**1.2 (long-term)**	**1.2 (long-term)**	**1.5 (long-term)**	-	**5**
Cadmium	-	Dissolved metal guideline. Formula requires hardness to calculate	**0.00012**	**Hardness applied to formula to calculate exceedance**	**0.00012**	**0.007**
Chromium*		0.005 (Cr VI)	0.001 (Cr VI) 0.0089(Cr III)	0.0015 (Cr VI)	0.001 (Cr Vi) 0.0089(Cr III)	**0.05**
Copper	Dissolved metal guideline. Formula requires unavailable DOC, pH and hardness to calculate	Dissolved metal guideline. Formula requires unavailable DOC, pH and hardness to calculate	**0.002 (chronic) 0.003 (acute)**	**Hardness applied to formula to calculate exceedance**	-	**2**
Iron[1]	Formula requires unavailable DOC and pH to calculate	**1 (short-term, total iron)**	**-**	**0.3 (long-term)**	-	**<0.1 (aesthetic)**
Lead	Dissolved metal guideline. Formula requires unavailable DOC and hardness to calculate	Dissolved metal guideline. Formula requires unavailable DOC and hardness to calculate	**0.002 (over 30 days) <0.140 at all times**	**Hardness applied to formula to calculate exceedance**	-	**0.005**
Manganese*	-	Dissolved metal guideline. Formula requires pH and hardness to calculate	-	Dissolved metal guideline. Formula requires and hardness to calculate	-	**0.12**

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Methylmercury*	-	0.00002	0.00002	0.000026 (total Hg)	0.000016 (inorganic Hg)	**0.001**
Molybdenum	-	**7.6 (long-term) 46 (short term)**	-	**0.073**	0	**-**
Nickel	-	Dissolved metal guideline. Formula requires unavailable DOC, pH and hardness to calculate	-	**0.025 if Hardness <60 mg/L Formula using hardness for hardness 60 -80 mg/L 0.150 for hardness >180 Unknown hardness 0.025**	-	-
Selenium	**-**	**0.002**	**0.002 0.001 - water column alert - need to increase fish monitoring**	**0.001**	**0.001**	**0.05 0.01 (BC - water source)**
Silver	**-**	**0.00012**	**0.0005**	**0.00025**	**-**	**-**
Thallium	-	**0.0003[3]**	**-**	**0.0008**	-	-
Zinc*	-	Dissolved metal guideline. Formula requires unavailable DOC, pH and hardness to calculate	0.010[2]	Dissolved metal guideline. Formula requires unavailable DOC, pH and hardness to calculate	-	-

Bold indicates guidelines that were applied.*indicates that we were unable to compare with available EQGs because we did not measure the required analytes. [1] Indicates a formula that requires dissolved organic carbon (DOC) which we did not measure. Guideline values were therefore calculated using DOC set at 50%, 75% and 100% of measured total organic carbon (TOC)(See Appendix 5 and 6).[2] Represents CCME guidelines that the BC government has adopted as working water guidelines. [3] Represents a Working Water Quality Guideline, rather than an approved WQG. Federal EQGs apply to both fresh and marine waters unless otherwise stated. CCME EQGs are reported for long-term effects unless otherwise stated. Formulae for calculating guidelines can be found on the BC MoE website (https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-guidelines/approved-water-quality-guidelines, BC MWLRS 2026) and the CCME website (https://ccme.ca/en/resources/water-aquatic-life).

Appendix 3: BC Aluminum (Al) Guideline calculations using different dissolved organic carbon estimates based on our measured total organic carbon (TOC)

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Site	Measured Al (µg/L)	DOC-adjusted Guideline (50% of TOC) (µg/L)	DOC-adjusted Guideline (75% of TOC) (µg/L)	DOC-adjusted Guideline (100% of TOC) (µg/L)
Source*	338	**86.6**	**112.5**	**135.4**
Stream & river*	1880	**96.9**	**125.9**	**151.6**
Road runoff*	7230	**133.9**	**174.0**	**209.5**
Tap	13	-	-	-
Marine	1790	**-**	**-**	**-**

Bold indicates an exceeded calculated BC Water Quality Guideline (BC MWLRS 2026). We evaluated guideline exceedances under three scenarios: 50%, 75%, 100% of the TOC that was measured in each water sample to approximate a realistic range of possible DOC values, as we did not measure DOC (BC Ministry of Environment and Climate Change Strategy 1998). *We flag any CCME guideline when exceeded, or a BC Guideline with the above deliberations when at least two of the three TOC scenarios produce exceedances. There exists no marine guideline for aluminum in Canada, so this was not included in the calculation of total exceedances.

Appendix 4: Federal Environmental Quality Guideline calculations for Iron (Fe) using different dissolved organic carbon estimates based on our measured total organic carbon (TOC)

Site	Measured Fe (µg/L)	DOC-adjusted Guideline (50% of TOC) (µg/L)	DOC-adjusted Guideline (75% of TOC) (µg/L)	DOC-adjusted Guideline (100% of TOC) (ug/L)
Source*	346	**170**	**280**	**320**
Stream & river*	2300	**270**	**360**	**430**
Road runoff*	8460	**390**	**520**	**640**
Tap	28	-	-	-
Marine	234	**-**	**-**	-

Bold indicates an exceeded calculated FEQG. It is important to note that the FEQG for iron is meant for use in fresh water, rather than in marine water (ECCC 2024). We evaluated guideline exceedances under three scenarios: 50%, 75%, 100% of the TOC that was measured in each water sample to approximate a realistic range of possible DOC values, as we did not measure DOC (BC Ministry of Environment and Climate Change Strategy 1998). *We flag any CCME guideline when exceeded, or a BC Guideline with the above deliberations when at least two of the three TOC scenarios produce exceedances. There exists no marine guideline for iron in Canada, so this was not included in the calculation of total exceedances.

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Appendix 2: Top 6 PAHs with the highest concentrations in each water sample from the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season)

	Source	Stream and river	Road runoff	Tap	Marine
	C2-Naphthalenes *(2.8)*	Perylene *(12.4)*	Perylene *(22.9)*	C2-Naphthalenes *(0.91)*	Perylene *(14.9)*
	2-Dimethyl-naphthalene *(1.0)*	C2-Phenanthrenes, Anthracenes *(4.4)*	C4-Phenanthrenes, Anthracenes *(21.9)*	Phenanthrene *(0.91)*	C2-Naphthalenes *(6.8)*
	2-Methyl-anthracene *(0.4)*	C1-Phenanthrenes, Anthracenes *(3.7)*	C2-Naphthalenes *(15.7)*	C1-Fluorenes *(0.91)*	Phenanthrene *(6.2)*
	C1-Phenanthrenes, Anthracenes *(0.27)*	C4-Naphthalenes *(3.2)*	C3-Fluorenes *(14.2)*	Fluorene *(0.36)*	C1-Phenanthrenes, Anthracenes *(5.3)*
	3-Methyl-phenanthrene *(0.27)*	C1-Fluorenes *(3.1)*	C1-Phenanthrenes, Anthracenes *(13.7)*	C4-Naphthalenes *(0.28)*	C1-Phenanthrenes, Anthracenes *(4.7)*
	C2-Biphenyls *(0.24)*	Phenanthrene *(2.9)*	C3-Naphthalenes *(13.4)*	C1-Phenanthrenes, Anthracenes *(0.25)*	C1-Naphthalenes *(3.4)*
Total concentrations of top 6 (% contribution to total PAHs)	4.9 (87%)	29.7 (41%)	101.8 (34%)	2.7 (59%)	41.2 (41%)

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Appendix 3: The top 6 PCBs in each water category sampled in the Quw'utsun Sta'lo' (Cowichan River) watershed and their concentrations (WET Season)

	Source	Stream and river	Road runoff	Tap	Marine
	PCB-93+95+98+100+102 (2.1)	PCB-153+168 (3.1)	PCB-153+168 (11)	PCB-11 (5.6)	PCB-93+95+98+100+102 (3.2)
	PCB-44+47+65 (1.6)	PCB-118 (2.0)	PCB-129+138+160+163 (9.5)	PCB-93+95+98+100+102 (3.4)	PCB-153+168 (3.1)
	PCB-190 (1.2)	PCB-44+47+65 (1.9)	PCB-118 (5.8)	PCB-153+168 (2.5)	PCB-118 (2.2)
	PCB-153+168 (0.95)	PCB-129+138+160+163 (1.8)	PCB-90+101+119 (5.1)	PCB-90+101+119 (1.8)	PCB-129+138+160+163 (1.9)
	PCB-52 (0.8)	PCB-93+95+98+100+102 (1.8)	PCB-11 (5.1)	PCB-190 (1.7)	PCB-83+99 (1.8)
	PCB-81 (0.76)	PCB-90+101+119 (1.7)	PCB-180+193 (4.9)	PCB-118 (1.5)	PCB-44+47+65 (1.7)
Total concentrations of top 6 (% contribution to total PCBs)	7.3 (22%)	12.3 (27%)	41.3 (34%)	16.8 (51%)	14.0 (96%)

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Appendix 4: Total analyte concentrations in water sampled in the Quw'utsun Sta'lo' (Cowichan River) watershed (WET Season)

Analyte	Source	Stream and river	Road runoff	Tap	Marine
E. coli (MPN)	6	155	**389**	0	0
Nitrate (mg/L)	0.0820	0.0634	**0.985**	0.206	0.118
Metals (mg/L)	10.7	20.6	59.9	29.2	**1286**
Pesticides (ng/L)	0.09	0.05	0.15	**0.19**	0.02
PCBs (pg/L)	14.5	33.1	**122.4**	44.8	33.4
PAHs (ng/L)	5.7	72.3	**298.8**	4.6	99.8
PPCPs (ng/L)	0.574	**197**	53.9	1.42	112
PFAS (ng/L)	0	0.49	**13.8**	0.96	0
APEs (ng/L)	0	0.454	0	0	**0.529**
bisphenols (ng/L)	0	2.95	0	**8.05**	0
Sucralose (ng/L)	0	43.8	41.5	**50.0**	47.2
6-PPDq (ng/L)	0	0	**2.33**	0	0

Bold values indicate the highest concentrations across water categories for each contaminant.

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Appendix 6: Health Canada Screening values for nine different PFAS compounds

Compound Name	Acronym	Screening value (mg/L)	Screening value (ug/L)
perfluorobutanoate	PFBA	0.03	30
perfluorobutane sulfonate	PFBS	0.015	15
perfluorohexanesulfonate	PFHxS	0.0006	0.6
perfluoropentanoate	PFPeA	0.0002	0.2
perfluorohexanoate	PFHxA	0.0002	0.2
perfluoroheptanoate	PFHpA	0.0002	0.2
perfluorononanoate	PFNA	0.00002	0.02
6:2 fluorotelomer sulfonate	6:2 FTS	0.0002	0.2
8:2 fluorotelomer sulfonate	8:2 FTS	0.0002	0.2

Adapted from
https://www.canada.ca/en/services/health/publications/healthy-living/water-talk-drinking-water-screening-values-perfluoroalkylated-substances.html

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