# WILDFIRE ASH EFFECTS ON WATER QUALITY AND TREATABILITY: ASH IS ASH, OR IS IT?

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## Background

- 66% of North Americans' drinking water sources originates in forested watersheds
- Landscape disturbances can significantly impact the quality and quantity of water in forested regions and challenge drinking water treatment plants beyond their design capacity

Wildfires increase soil erosion and surface runoff → Excessive loads of sediments and burned materials get transported to receiving waters → Key drinking water quality parameters get impacted:
1- Turbidity
2- Organic carbon quality and concentration

Change in dissolved organic carbon (DOC) concentration and quality →
- Taste, Color, Odor ↑
- Coagulant Dosage ↑
- Oxidant Demand ↑
- Disinfection by-products (DBPs)↑
- Sludge Production ↑
- Microcystins ↑
- Fluence required for UV ↑

→
- **Threatens** the provision of **safe** drinking water.
- **Increase** the **cost** of drinking water treatment processes.

→ **No study** has yet addressed DOC related challenges during drinking water treatment

## Research Approach

### Objective

- Identify key watershed and source water quality attributes that affect treatability assessment outcomes by evaluating changes in water quality as a result of the mobilization of post-fire ash:
  - Determination of wildfire ash mass on water-extractable organic matter (WEOM) concentration and yield
  - Determination of the impact of wildfire ash mass on the character of WEOM
  - Investigating the impact of mixing time on wildfire ash WEOM concentration
  - Investigating the impact of mixing time on wildfire ash WEOM character

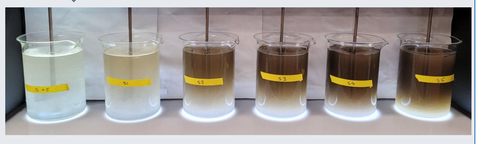
### Experimental Design

- Two sets of experiments was designed to address changes in organic carbon quality and quantity following wildfires

- Six types of wildfire ash were evaluated in each experiment
- All ash was sieved through a 1 mm screen to homogenize solids

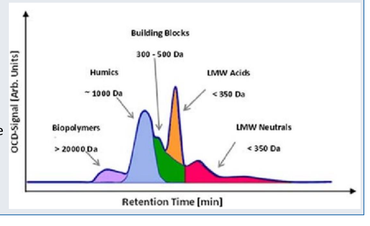

- The ash was added to high quality Elbow River water from Calgary, Alberta

Test 1:
- Different masses of dry wildfire ash, ranging from 0.5 g/L to 5 g/L were added to river water
- Samples were mixed for 24 h and key aspects of water quality were analyzed:
  - pH
  - alkalinity
  - total organic carbon (TOC)
  - dissolved organic carbon (DOC)
  - ultraviolet absorbance at the wavelength of 254 nm ($UV_{254}$)
  - specific ultraviolet absorbance (SUVA)



Test 2:
- Ash (2 g/L) was added to the river water, which was continuously mixed. Water quality was measured over time: 0 min, 30 min, 6 h, 10 h, 24 h, 48 h, 2 weeks, and 3 weeks
- Mixing was designed to ***generally*** represent ash delivery from the landscape to a reservoir in a revering system:
  - vigorous initial mixing (24 h @ 120 RPM)
  - gentle mixing (2 weeks @ 40 RPM)
  - quiescent conditions (no mixing for 1 week)
- Should be noted that two batches of source water (of slightly different quality) were required for this experiment

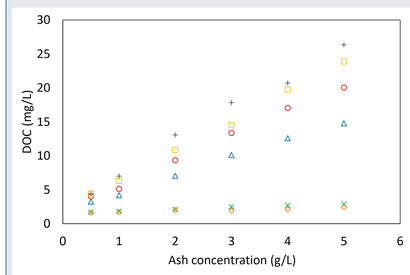
- To inform drinking water treatability implications of changes in DOC, liquid chromatography organic carbon detection (LC-OCD) analysis was used to fractionate DOC into:
  - hydrophobics
  - bio-polymers
  - humic substances
  - building blocks
  - low molecular weight acids (LMW acids)
  - LMW neutrals
- Regulated disinfection by-product (DBP) was evaluated as true formation potential (FP) and at uniform formation conditions (UFC)
  - trihalomethanes (THMs)
  - haloacetic acids (HAAs)

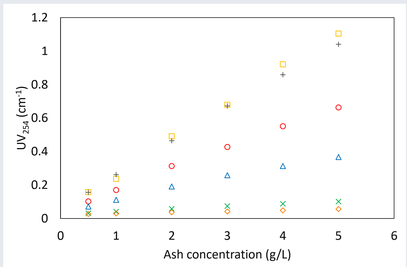



## Results

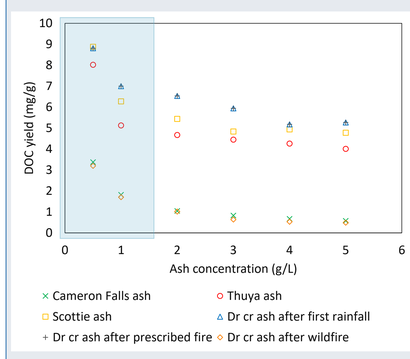
### Ash Dissolution in Water (Test 1)

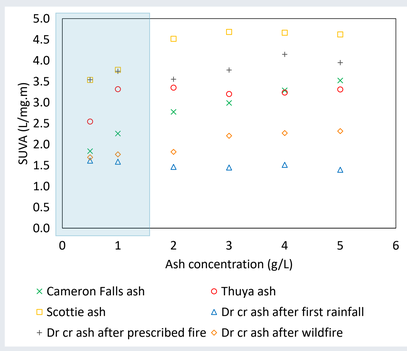
- DOC concentration and $UV_{254}$ increases were *initially* linear with increased ash addition
- Changes in organic carbon concentration and character varied between ash types
- Antecedent rainfall and/or the presence of soil appear especially significant in affecting water quality as a function of mass of solids added



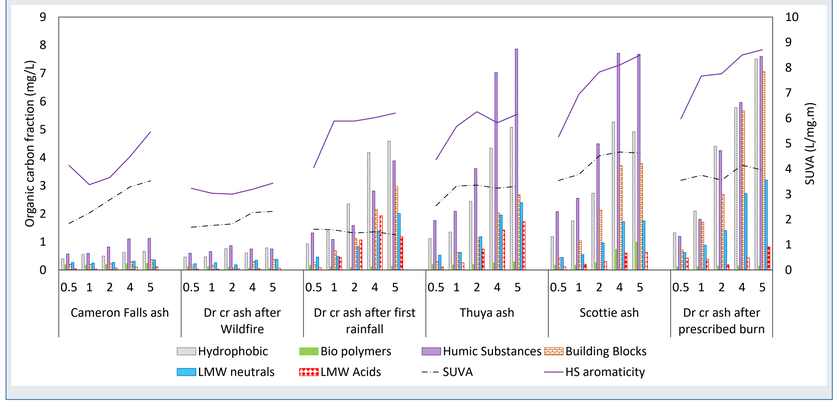




- DOC concentration and $UV_{254}$ increases became non-linear with ash addition to water at concentrations of approximately 2 g/L (when saturation became evident) irrespective of ash type
- Continued ash addition to water beyond approximately 2 g/L increased DOC concentration and $UV_{254}$ but appeared to have relatively negligible impact on SUVA



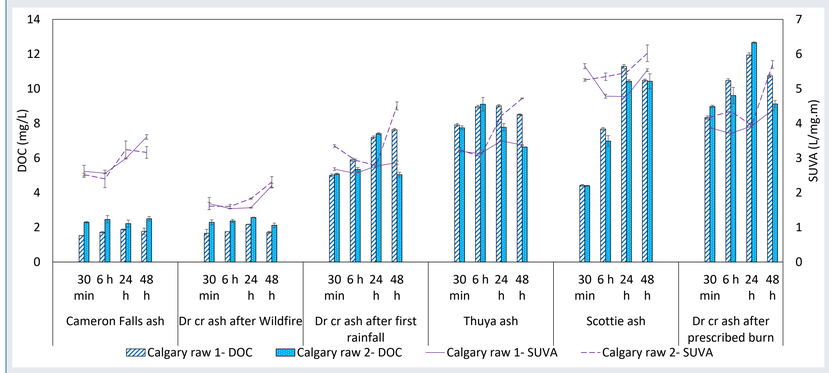

- Ash addition to water increased the concentrations of all DOC fractions, but the increases were not proportional; as expected, the greatest increases were in hydrophobics and humic substances
- Continued ash addition to water beyond the approximately 2 g/L saturation point appears to be driven by humic substances, as evident in the SUVA and HS aromaticity evaluated by LC-OCD
- The impacts of such differences in HS aromaticity on coagulation efficiency and DBP formation have not been systematically investigated




## Results

### Ash Dissolution in Water (Test 2)

- Organic carbon concentration and character change considerably during the first 24 h after ash delivery to aquatic systems
- These differences vary between ash types

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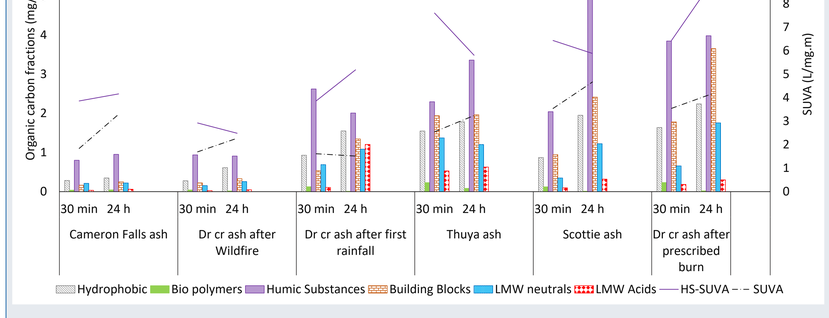
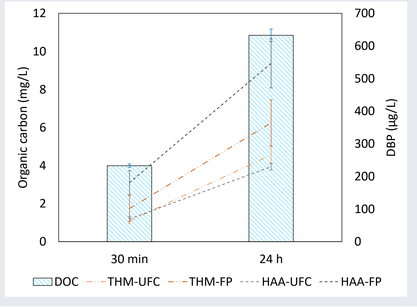



### Disinfection By-Products

- The dissolution-associated shifts in DBP percussors are also reflected in DBP formation
- DBP-UFC is substantially lower than FP for both THMs and HAAs, as would be expected
- These results emphasize that experimental design is critical when conducting lab-scale assessments to inform drinking water treatability after wildfire
- These results further serve as a reminder that DBP-FP data should be interpreted judiciously




## Key Insights

- While all wildfires might not have the same extent of impact on source water quality, when they do have impacts, the impacts are generally similar (i.e., DOC concentration increases especially, humic substances fraction)
- Organic carbon concentration and character change considerably during the first 24 h after ash delivery to aquatic systems
- Saturation of DOC concentration and $UV_{254}$ increases in ash–water matrix become evident at concentrations of approximately 2 g/L irrespective of ash type
- These results emphasize that experimental design is critical when conducting lab-scale assessments to inform drinking water treatability after wildfire