Health Canada | Santé Canada

Canada

Natural organic matter in drinking water

Ontario Water Works Association
Water Treatment Seminar
March 20, 2018

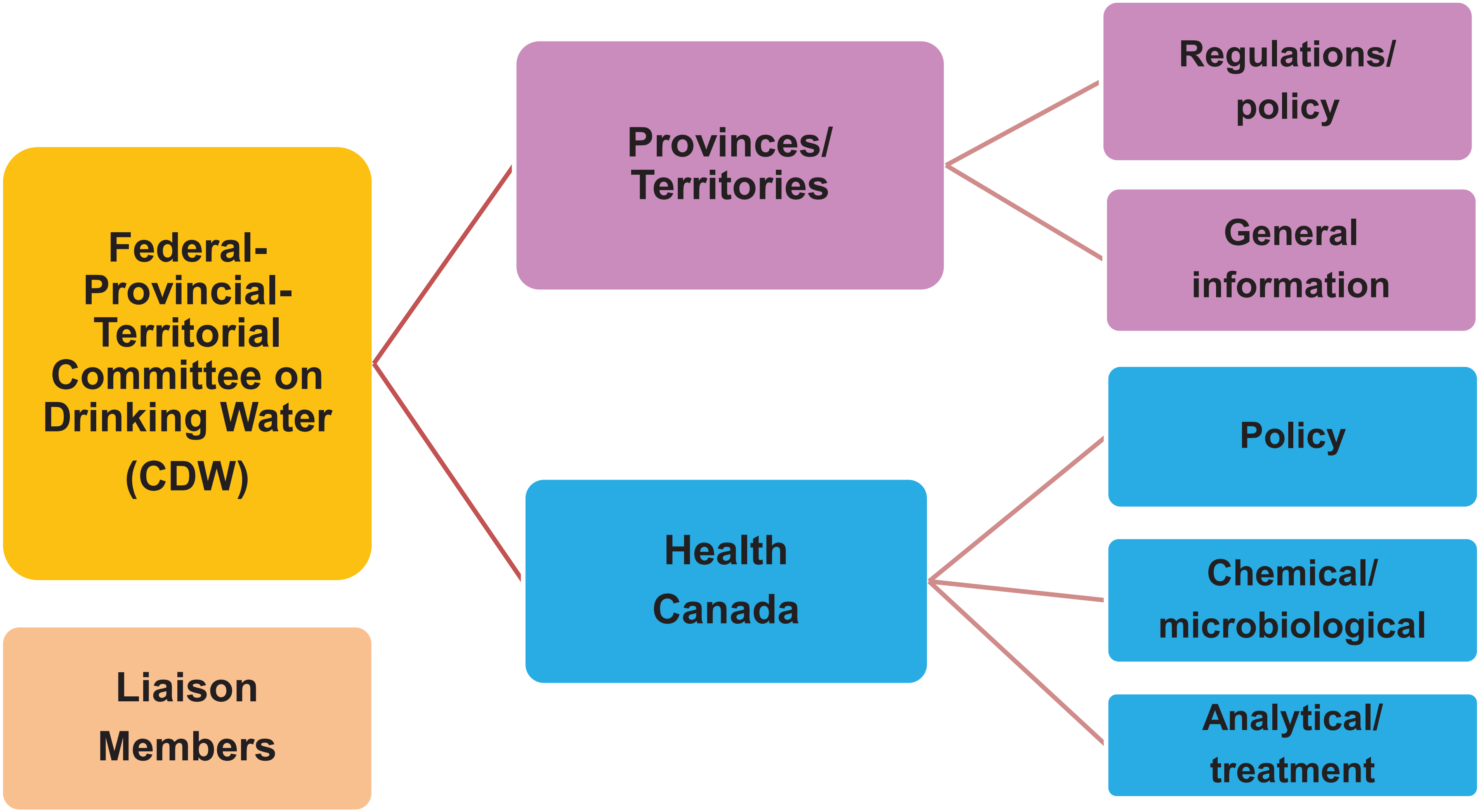
Judy MacDonald, P. Eng.
Water Quality Engineer
Materials and Treatment Section
Water and Air Quality Bureau

YOUR HEALTH AND SAFETY... OUR PRIORITY.

Presentation outline

- Federal-Provincial-Territorial Committee on Drinking Water
  - Committee overview
  - Document development process
- Discuss natural organic matter in drinking water
- Concluding remarks
- Questions

Committee overview



Document development process

Priority setting process

↓ Obtain Canadian exposure data

Document development: health effects, analytical methods, treatment technology and quality control

↓ Peer review

CDW discussion, including risk management, cost considerations and approval to consult

↓ Public consultation

Revised document: health effects, analytical methods, treatment technology and quality control

↓

CDW discussion, including other considerations and final approval

↓

CHE approval → **Publication**

Natural organic matter (NOM) in drinking water

- Added to the priority list in 2010
- Document development started in 2014
- Approved for public consultation at November 2017 committee meeting

Why do we care about NOM?

- NOM can contribute to indirect health impacts:
  - Deterioration of pathogen log removal capability
    - NOM exerts a coagulant demand
    - Sub-optimal coagulation conditions if dose not adjusted
  - Deterioration of pathogen log inactivation capability
    - NOM exerts a chemical disinfectant demand and/or interferes with UV disinfection
  - Formation of disinfection by-products (DBPs)
    - All NOM fractions contribute to DBPs
    - Some fractions form more DBPs than others
    - Groundwater can be as reactive as surface water

Why do we care about NOM? (cont'd)

- Potential indirect health impacts (cont'd):
  - Development of distribution system biofilms that can harbour pathogens
  - Increases in lead and/or copper concentrations
    - From the corrosion of lead- and/or copper-bearing materials (e.g., piping, fittings)

Why do we care about NOM? (cont'd)

- Water utilities can be impacted by NOM-caused operational issues:
  - Increased coagulant dose
  - Poor floc formation or settling
  - Shorter filter run times
  - More frequent backwashes
  - Increased sludge production
  - Reduced hydraulic capacity
  - Membrane fouling and associated impacts
  - Reduced effectiveness of adsorption/ion exchange processes

Why do we care about NOM? (cont'd)

- NOM also contributes to aesthetic issues:
  - Colour
  - Tastes
  - Odours

What is NOM?

- Complex mixture of organic compounds varying in:
  – Polarity
    - Hydrophobic or hydrophilic
  – Acidity
    - Acid, neutral or base
  – Charge density
  – Molecular mass
    - High, medium or low molecular weight
  – Biodegradability
    - Biodegradable or recalcitrant

What is NOM? (cont'd)

- Concentration and character is influenced by site-specific conditions:
  - Percent wetlands in the watershed
  - Soil composition
  - Forest cover
  - Retention time
  - Watershed hydrology
  - Flow pathways
  - Channel slope
  - Watershed size

Sources of NOM

- Allochthonous
  - Derived from terrestrial environment
- Autochthonous
  - Derived from the aquatic plants/ microorganisms growing in the water
- Anthropogenic
  - Human activities (e.g., wastewater, stormwater)

Environmental considerations

- Seasonal or weather-related effects can change the concentration and/or relative contribution of allochthonous, autochthonous or anthropogenic inputs:
  - Snowmelt, spring runoff, heavy rain
    - Allochthonous NOM concentration can increase prior to changes in turbidity/flow and can remain elevated after turbidity/flow have returned to baseline conditions
  - Drought and/or algal blooms
    - Autochthonous NOM dominates

Quantifying NOM

- Most common surrogates used to given an indication of the NOM concentration include:
  - Total organic carbon (TOC)
  - Dissolved organic carbon (DOC)
  - UV absorbance (UVA)
    - Various wavelengths (254, 350 and 440 nm) can be linearly correlated to DOC in some fresh waters
    - Linear correlation is less likely in sources with strong autochthonous or anthropogenic inputs or where DOC has been extensively degraded by natural UV light
    - Monitoring over a broader range of wavelengths may be helpful

Quantifying NOM (cont’d)

- UV transmittance (UVT)
  - Mathematically related to UVA
- Colour (or UVA at 440 nm)
- Chemical oxygen demand (COD)
  - Provides an indication of the relative concentration of oxidizable NOM
  - Similar DOC concentrations can produce a wide range of DBPs depending on the “reactivity” or “oxidizability” of NOM

Characterizing NOM

- Specific ultraviolet absorbance (SUVA)
  - UV254 divided by DOC x 100

SUVA (L/mg·m)	NOM composition	UVA	Coagulation	Potential TOC removal using coagulation
<2	Mostly hydrophilic and low molecular weight	Low	NOM has little influence on coagulant dose	0-40%
2 to 4	Mixture of hydrophilic and hydrophobic compounds; mixture of molecular weights	Med	NOM influence coagulant dose	40-60%
>4	Mostly hydrophobic and high molecular weight	High	NOM controls coagulant dose	60-80%

Characterizing NOM (cont'd)

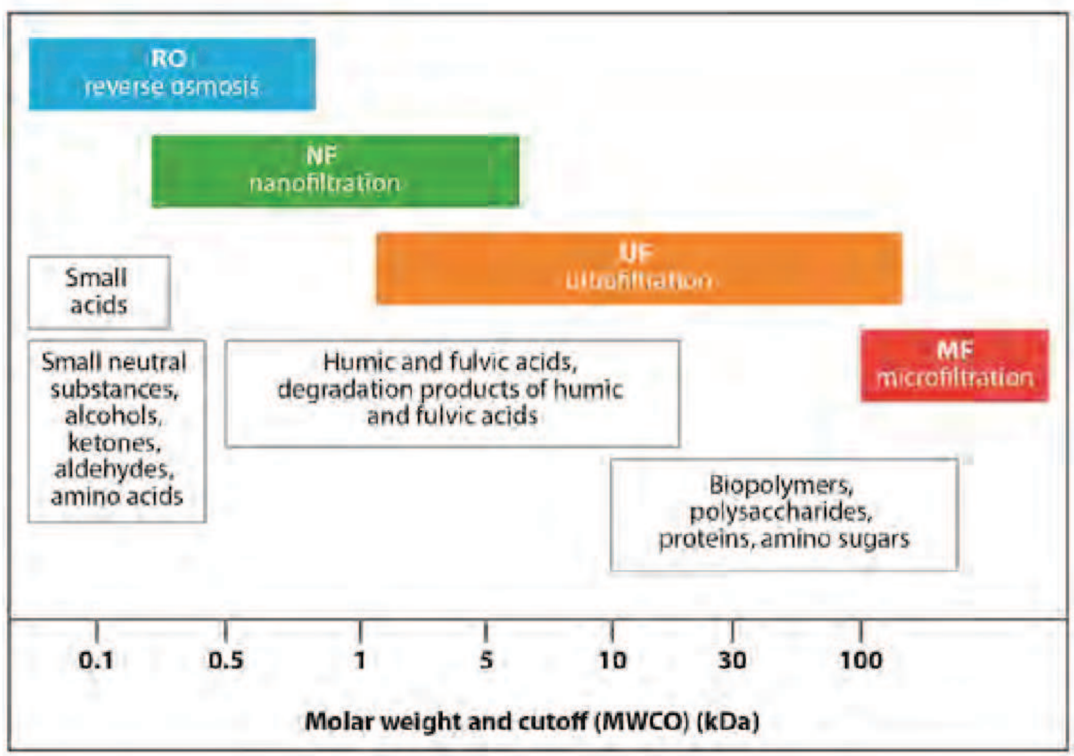
- Chemical usage (e.g., coagulant dose, chlorine demand)
  - Specific dose/demand (e.g., mg/L per mg/L DOC)
- DBP concentrations
  - Actual DBP concentrations
  - Specific DBP yield (e.g., µg DBP per mg DOC) provides an indication of "reactivity"
    - Presence of ammonia, bromide, iodide, sulphur may enhance the reactivity of NOM

Characterizing NOM (cont'd)

- Biological stability
  - Variability in disinfectant residual
  - Biofilm formation rate
  - Changes in corrosion rates
- Other methods
  - Isolation of hydrophobic/hydrophilic and acid/neutral/base fractions
  - Molecular size (<1, 1-10, 10-30 and >30 kDa)
  - Fluorescence (humic-, fulvic- or protein-like compounds)

Treatment

- Optimized coagulation
  - Some NOM fractions cannot be removed using coagulation
  - Jar testing is recommended
- Membrane filtration



Treatment (cont'd)

- Ion exchange
  - Does not remove turbidity
  - May change the chloride-to-sulphate mass ratio
- Activated carbon
  - Pore volume should be in the size range that matches the source-specific NOM
  - Rapid small scale column testing is recommended

Treatment (cont'd)

- Biological treatment
  - Can remove biodegradable NOM component
  - May require oxidation to convert NOM to biodegradable organic matter (BOM)
- Oxidation processes
  - Can result in the reduction of some DBPs while increasing others
  - Consider with caution
  - Focus first on maximizing NOM removal

Monitoring

- Source-specific monitoring plan should be developed to ensure that water utilities are aware of:
  - Raw water quality changes with respect to NOM concentration and character
  - Impact that NOM has on water treatment processes through all water quality conditions
  - Impact that treatment has on NOM concentration and character
  - Impacts on distribution system water quality

Concluding remarks

- Understand your source
  - Baseline conditions
  - Storm/drought conditions
- Treated water targets – guidance only

Parameter	Units	Higher specific DBP yield or Extensive distribution system	Lower specific DBP yield
Colour	TCU	5–10	<15
UV254	cm^{-1}	0.02–0.04	0.02-0.07
UV transmittance	Percent	90–95	85–95
COD	mg/L O_2	<5	<5
DOC – for DBP control	mg/L C	<2	<4
DOC – for biological stability	mg/L C	<1.8	<1.8

More information

- Guideline technical documents
  - https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality.html
- Join our email list
  - https://www.canada.ca/en/health-canada/services/environmental-workplace-health/water-quality/mailing-list-water-quality-environmental-workplace-health.html
- Email
  - water_eau@hc-sc.gc.ca

Questions?

Contact:

judy.macdonald@canada.ca