Comparison of Plant Processes and Operations for Producing Potable Water from the Available Source Water

- Reveal types of **source waters** and the ones that are common in Canada
- Look at many **processes** that are found in water treatment plants
- **Compare Communities'** water plants' processes and operations to their overall data and determine if there is room for optimization
- **Describe further research we will be conducting** in the summer

OVERALL GOAL

Understand which processes contribute to high quality drinking water and understand the role that research can play in achieving that quality

Source Water

- There are 2 types of source water: **Groundwater** and **Surface Water** [6]
- Groundwater includes all water below the soil or between crevices in rock. It also accounts for approximately ¼ of Canadian Source Water[5]
- Surface Water includes all water on the surface, whether that be lakes, rivers, streams, etc...[6]
- Surface water accounts for the majority of Canada's source water and is commonly much more contaminated than groundwater[5]
    - This generally means further treatment is needed for surface water

Communities' Source Water

- Opaskwayak Cree Nation (OCN): Groundwater (Wells)
- The Pas: Surface Water (Saskatchewan River)

(Protected Wells (OCN))

(Saskatchewan River (The Pas))

(Water Education Foundation, 2015) (Mapio, 2016)

Plant Processes Intro

- Coagulation/Flocculation
- Sedimentation
- Filtration
- Chlorination/Disinfection
- UV Radiation
- Ozonation

Which processes are needed largely depend on the quality of the communities' **Source Water** and **Population**

Coagulation/Flocculation

- Preliminary Step in the Water Treatment process
- Chemicals are added to raw water to neutralize particle charges and create floc[9]
- Water is mixed and small suspended particles clump together, forming large particles (floc) which can be easily removed in further stages of treatment[15]
- Coagulant chemicals added range from aluminum based (ex: Alum) or iron based (ex: ferric chloride)[15]
- This process is consistently being upgraded in order to keep turbidity of water below 0.3 NTU[15]

Sedimentation

- Next step in the treatment process
- Water and floc particles enter basins where water moves slowly and heavy particles (floc) settle on the bottom of the basins where it is eventually collected and sent to a landfill[9]

((Left Side) Coagulation) ((Right Side) Sedimentation)

(City of Akron, 2016)

Filtration

- Filtration is another process (not necessarily in this order)[9]
- Water flows to filters where layers of sand, gravel, and other particles collect suspended impurities in the water [9]
- Particles get caught in the spaces between sand particles[2]

(We will be comparing filtration operations in various Northern water treatment plants this summer)

- This process is consistently evolving to filter more efficiently and create purer water
- One form of filtration that we are interested in is Carbon Filtration

Activated Carbon Filtration

- A form of filtration
- Water passes through layers of activated carbon where organic material gets captured by the charged poles of the carbon molecules[3]
  - Ex: Diesel
- Inorganic material may also be captured if particle size is too large to fit between the poles in-between carbon molecules[3]
  - Ex: Mercury

(*Heritage Toronto, 2009*)(*Stevia Technology, 2013*)

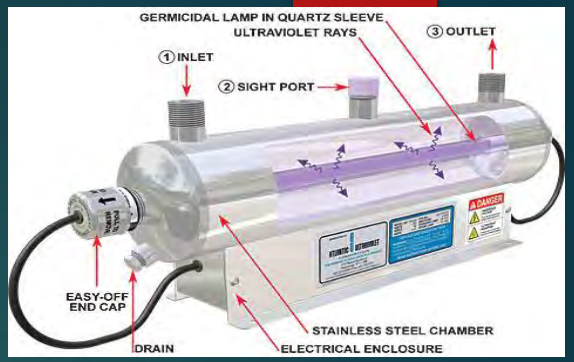
Chlorination/Disinfection

- The most important step in the treatment process[4]
- Chlorine is added to the water to kill bacteria and viruses[9]
  - Ex: E. Coli

- Chlorine is one of the most efficient disinfectants of water known to science[11]
- Chlorine can be found in many forms: Solution or Gas
- Other chemicals such as sodium hydroxide are commonly added after in order to bring pH of water back to original neutral level[2]

(IndiaMart, 2018)(JCI, 2018)

UV Radiation



- An expensive process, but are common among treatment plants[9]
- Water is pumped through chambers that contain ultraviolet (UV) lamps[2]
- In only a few seconds of exposure, the UV light rays penetrate remaining micro-organisms and destroy their ability reproduce[2]
- This means these organisms are no longer able to cause infection or illness and are therefore deemed harmless[2]

(FQMSC, 2017)

Ozonation

- Liquid oxygen ($3O_2$) is pumped into ozone generator creating Ozone ($2O_3$)[12]
- Helps disinfect the water from many pesticides[12]
- Removes organic and inorganic matter[12]
- Removes bad taste and odour from water[12]
- But creates insoluble compounds in water[12]
- Ozonation is usually followed by filtration to filter out any by-products[12]

(*Environmental Science and Engineering 2002*)

Comparing the Communities

- Comparing communities is no easy task
- Highly dependent on Source water quality
- Look at Physical, Chemical Water Quality of raw and treated waters
- Look for discrepancies from Canadian Guidelines for Drinking Water Quality
- Determine whether there are issues
- Look at plant processes and operations and locate source of issue if any exist

The Pas Water Plant

- Built in 1971 received only minor renovations
- Surface Water (Saskatchewan River)
- Flows approx. 1.3 million gallons of potable water daily
- Uses alum in coagulation/flocculation process
- Uses chlorine gas in chlorination process
- Uses anthracite (type of carbon) in filtration process
- Has UV Radiation process at plant
- Chemical analysis shows all within regulation[1]
- Checks are done every day, monitored by computer system[15]

OCN Water Plant

- Built in the early 1990's
- Water source: Protected wells giving extremely clean groundwater
- Produces approx. 1 million litres daily to a population of 3700
- Does not have flocculation process as in the past coagulation agent (potassium permanganate) became too costly and caused issues in filtration process
- Uses activated carbon and other layered sediments in filtration
- Instead the plant uses a pressurized filtration process which removes most of the suspended particles in the water

OCN Water Plant

- Uses sodium hypochlorite solution in chlorination process (cheaper than chlorine gas, but not as strong[4])
- Numbers in chemical analysis show no issues other than water having a very high hardness[7]
  - Water hardness is relatively harmless. Refers to concentration of calcium and magnesium ions in the water[13]
  - According to a paper may cause by Sengupta [14], hardness of water may cause diarrhea but can also have a inverse relationship with cardiovascular disease and some types of cancer

Data

Turbidity (Results measured in NTU)

Community	Raw Source Water	Treated Potable Water
OCN (Groundwater)	0.43	0.31
The Pas (Surface Water)	5.10	0.38

Trihalomethanes (Results measured in mg/L)

Community	Results	Canadian Regulation
OCN (Sodium Hypochlorite Solution)	0.0282	0.1 mg/L
The Pas (Chlorine Gas)	0.089	0.1 mg/L

*All Data retrieved from references 1 and 7

Conclusion

- It is difficult to say at this time whether or not there is one better system than another
- There is a lot to consider when looking at water treatment plants
- Again, plants are dependent on the quality of the source water and the treatment it should be receiving

- Processes Missing ≠ Low Quality Water
- As long as chemical, bacterial, and physical analysis meet regulations the water is potable[7]

Our Future Research!

- Further research with carbon filtration, which organic and inorganic particles it can trap
- Take water samples, learn more about testing the water and test whether certain coagulants, and chlorine solutions are better for example
- Research on Trihalomethanes (THM) formation in water treatment
  - Chlorine creates excess H+ ions in water which may form with carbon and halogens (F,**Cl**,Br,I) to create THMs which are cancer causing carcinogens[13]

(References available on request)