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Drinking water perception and consumption in Canadian subarctic Indigenous communities and the importance for public health

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Abstract

Resource development and climate change are increasing concerns regarding safe water for Indigenous people in Canada. A research study was completed to characterize the consumption of water and beverages prepared with water and identify the perception of water consumption in Indigenous communities from the Northwest Territories and Yukon, Canada. As part of a larger research program, data for this study were available from a 24-hour recall dietary survey (n = 162), a health messages survey (n = 150), and an exposure factor survey (n = 63). A focus group was conducted with Elders in an on-the-land camp setting. The consumption of water-based beverages in winter was 0.9 L/day on average, mainly consisting of tea and coffee. Of the 81% of respondents who reported consuming water-based beverages in the previous 24 hours of the survey, 33% drank more bottled water than tap water. About 2% of respondents consumed water from the land (during the winter season). Chlorine smell was the main limiting factor reported to the consumption of tap water. Results from the focus group indicated that Indigenous knowledge might impact both the perception and consumption of water. These findings aim to support public health efforts to enable people to make water their drink of choice.

Key words: North, drinking water, Indigenous, risk perception, water consumption, water security

Introduction

Canada has approximately 9% of the world's water supply, but within this country, not everyone has access to safe drinking water (White et al. 2012). In particular, water security is a challenge for Indigenous communities. While definitions of water security vary, they usually center on the concept of a reliable supply of safe water (in both quality and quantity) (Cook and Bakker 2012). As of January 2022, there were 28 Indigenous communities across Canada under a short-term drinking water advisory (Canada 2020b), and 29 communities have long-term advisories (Canada 2020c). While it is unknown whether the number of advisories describes the prevalence of waterborne disease in communities, drinking water advisories have adverse consequences. This includes limiting access to drinking water (Lucier et al. 2020), potentially resulting in an increased consumption of other

beverages, such as sugar-sweetened beverages. This may have health consequences as sugar-sweetened beverages are associated with obesity and type 2 diabetes (Hu and Malik 2010).

Water insecurity in remote Indigenous communities may be associated with indirect adverse health effects (e.g., obesity, diabetes, gastritis, stomach cancer), as well as economic, social, and cultural impacts (Sarkar et al. 2015). Limitations of safe drinking water for Indigenous communities in Canada include reliance on trucked-in water, which is dependent on weather, funding, and personnel. Further challenges are posed by the need to train and retain certified water operators (Bradford et al. 2016). For example, because of an inability to "meet maintenance requirements" (NWT 2020a) one community in the Northwest Territories , has had a boil water advisory in effect since 2004.

Consequently, unreliable drinking water may have contributed to the perception of low-quality water in remote communities. Indigenous Peoples in Canada have not trusted their drinking water supply as much as non-Indigenous peoples do, which is a consequence of the legacy of colonial relations (White et al. 2012). Historical industrial activity has left the northern Canadian Territories (Yukon, Northwest Territories, Nunavut) with numerous polluted sites (e.g., Port Radium Mine), several of which are still being remediated by the government (e.g., Giant mine). As of today, there remain over 2000 sites identified as contaminated across the three Territories (Canada 2020*a*). Recently, gas development, long-range contaminant transport, oil sands development, and climate change (which has resulted in the increased frequency of forest fires, changes to hydrological regimes, and landscape changes due to permafrost thaw) are now increasing community concerns regarding safe water (Medeiros et al. 2017). In addition to chemical pollutants, biological pollutants can also affect the integrity of drinking water (Wright et al. 2018). These issues represent a challenge present from coast to coast to coast.

For example, Inuit communities, which are Indigenous communities traditionally living in the Arctic, have expressed concerns regarding the safety of their drinking water (Wright et al. 2018). Overall, in the population, taste was reported to be the main determinant impacting the perception of water quality. Taste and smell are known to have a significant impact on the risk perception and decisions regarding water consumption practices in communities of the Northwest Territories, Canada (Spicer et al. 2020). Furthermore, the perception of health risks was identified as preventing consumers from drinking from specific water sources (Doria et al. 2009, 2010). Overall, Wright et al. (2018) reported that negative perceptions of tap water were associated with a lower probability of consuming the water in northern Indigenous communities within Canada.

The relationship between water insecurity, unreliable access to safe water, and the impacts of perceived health issues of northern populations create a complex situation. This situation also challenges the ability to promote healthy habits and wellness in northern communities. The Northwest Territories, Yukon, and Nunavut have implemented an initiative for schools to "Drop the Pop", to discourage schools from providing sugary drinks and to encourage students to drink water for healthy development (NWT 2020c).

It has been through community-based projects in environmental health in the Northwest Territories and Yukon, Canada, that our research team investigated the relationship between country foods, nutrition, and contaminant exposure. During the consultation process, community members expressed concerns regarding water safety and contaminant exposure. As part of this dialogue, a water security research component was integrated into the larger project. Water security was explored through a focus group being facilitated via a linked project that promoted on-the-land exchanges around water research in the Sahtú region, Northwest Territories.

The objectives of this current work are to: (*i*) characterize the consumption of water and water-based beverages and (*ii*) document the perceptions of drinking water, in subarctic Dene communities in Canada. The aim of this project was to increase understanding of water security issues in subarctic communities with a further goal of supporting public health efforts to promote clean and safe water and improve health by helping people to safely increase their water consumption.

Methods

Design of the project

The water consumption data presented here were collected through a larger project in the north studying the relationship between country foods, nutrition, and contaminant exposure (Ratelle et al. 2018a, 2018b). This project, funded by the Northern Contaminants Program (NCP), took place in 2016–2018 in the Dehcho region (Jean Marie River First Nation, K'atl'odeeche, West Point First Nation, Deh Gah Gotie First Nation, Ka'a'gee Tu First Nation, Sambaa K'e First Nation) and Sahtú region (Tulít'a Got'ı̨nę, Délı̨nę Got'ı̨nę, K'áhsho Got'ı̨nę) of the Northwest Territories. The project was later extended to the Yukon, starting with one community (Old Crow). Data were collected during months of cold weather (November to March). Participating communities are found in **Fig. 1**.

Participant recruitment was undertaken with the support of at least one local coordinator in each community. The recruitment was based on a random selection process (phone calls, going door-to-door) for every community with over 100 residents in conjunction with walk-in recruitment for every community (posters, social media, phone calls, radio, walk-in visits). Mixed methods were used and included food surveys (24-hour dietary recall survey and Food Frequency Questionnaire), a health message awareness and perception survey (Health Messages Survey), a contaminant exposure survey, terminology workshops, and biomonitoring (in hair, blood, and urine). Some variation in project implementation occurred in the Yukon compared with the Northwest Territories. Participants were able to take part in as many components of the study as they wished. Details can be found elsewhere (Ratelle et al. 2018a, 2018b; Drysdale et al. 2021).

Results were returned to participating communities' leadership and individuals in the year following data collection. A secondary analysis of the survey database collected through the biomonitoring program was used to investigate water consumption for this paper. In complement, a focus group was also conducted during an on-the-land cross-cultural Water Knowledge Camp in 2019 to provide context to the data already collected.

Partnership and engagement

This work is based on a community-led initiative. The academic team has worked with collaborators from Indigenous organisations in those regions since 2014 on programs investigating the link among country food (wild food), the environment, wellness, and health. Collaborations were maintained and several projects were adapted to support the evolving environmental health priorities of the Indigenous partners and to improve food systems, water, and food safety and security. Each of the projects includes a Community Research Agreement with the participating communities. Collaborators from the Ɂehdzo Got'ı̨nę Gots'ę́ Nákedı (Sahtú Renewable Resources Board) share the co-authorship of the current manuscript with the academic team. An Indigenous co-author reviewed the manuscript.

Indigenous collaborators initiated the project. They participated in the proposal writing and in the discussions related to the design and methods (e.g., recruitment process, survey refinement, consent, cultural and traditional components). Local community members participated in the data collection. Findings were shared with collaborators and leadership from Indigenous organizations before

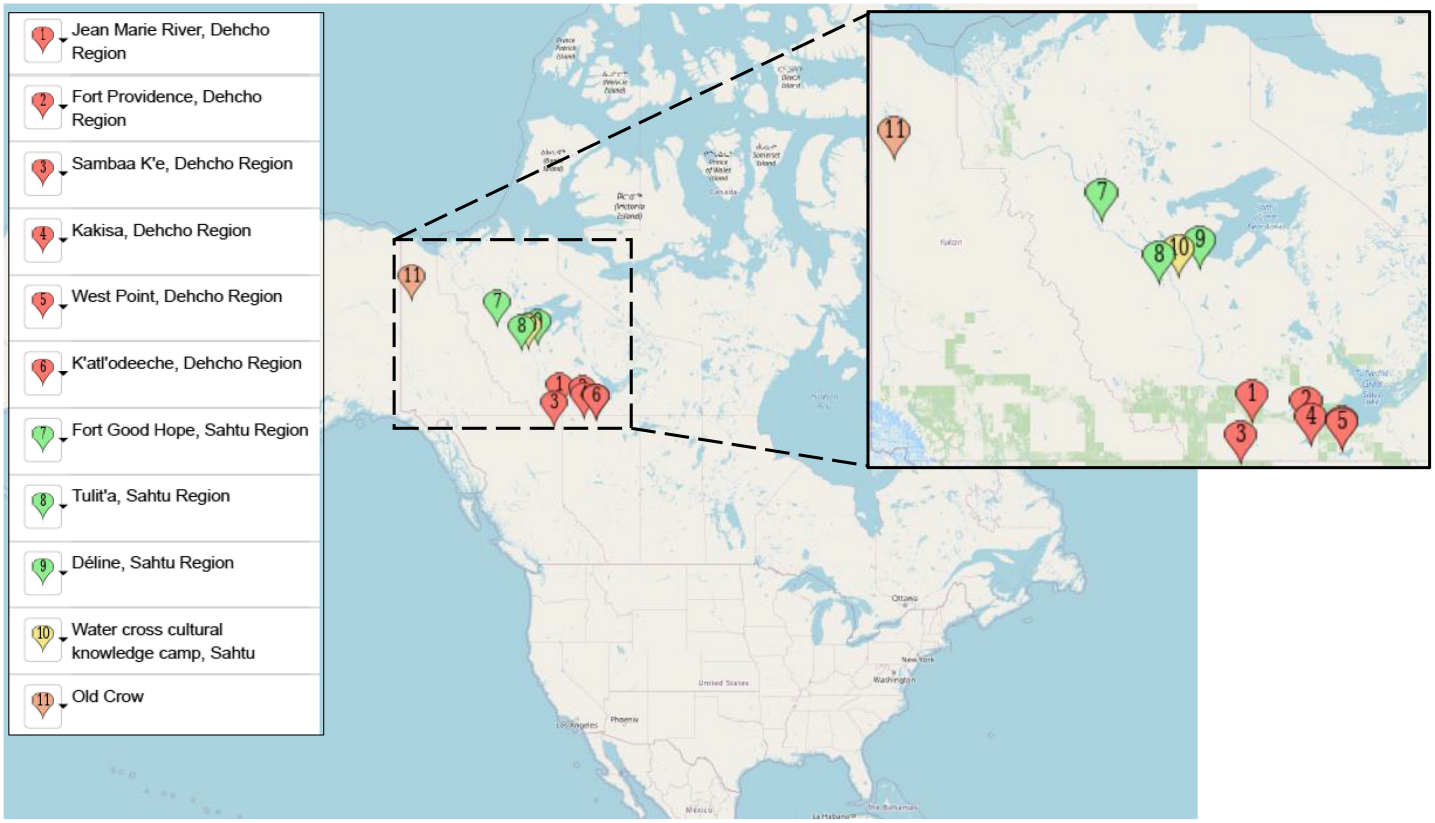

Fig. 1. Participating communities from the Yukon and the Northwest Territories, 2016–2019. Made with Ursus Software, LLC, based on Google mapping data.

publication. The quotations included here were validated by the participants. In these ways, the research team has demonstrated respect towards the First Nations OCAP® principles of ownership, control, access, and possession of data and knowledge (FNIGC 2022).

24-hour dietary recall

The 24-hour dietary recall data are only available from the nine participating Northwest Territories communities. Participants were invited to identify all food and beverages consumed the previous day, using a web-based questionnaire previously developed for studies of food and beverage consumption in First Nations communities (Ratelle et al. 2018b, 2021). The survey is user-friendly and contains a bank of over 900 food options with photos (Hanning et al. 2003). The survey includes questions on portion size (e.g., estimated consumed water in millilitres). The survey includes prompts for participants to facilitate the recall of details of beverages and other food items consumed. During the data interpretation, we consider tap water to include Brita® water, filtered water, and other water. The term "bottled water" includes sparkling water and bottled water. Untreated water from the land was identified if the participant chose the option "at least one ingredient harvested or hunted" when reporting drinking water. This option was available for each of the foods selected by the respondent. No juice or flavored water (marginally consumed by participants) were included in this component. Coffee, tea, and herbal tea were pooled together and are referred to within the text as water-based beverages. An integrated database provided data on nutrient content (e.g., added sugar).

Health Messages Survey

The Health Messages Survey was used in both the Northwest Territories and the Yukon. This survey was extensively described elsewhere (Brandow 2018; Skinner et al. 2021a). The survey was administered using QuickTapSurvey installed on iPads. The survey included sections on awareness of health messages and advisories, behavioural change, risk perception, and personal efficacy as well as sources of information and communication preferences. The questions related to water were: (*i*) Do you have any concerns about the following contaminants or issues? (*ii*) What other contaminants or issues do you have concerns about? (*iii*) Which other items do you think may impact the amount of contaminants you are exposed to?

Contaminant exposure survey

The contaminant exposure factor survey was used only in the Yukon (Drysdale et al. 2021). The survey was administered using QuickTapSurvey installed on iPads. Through this survey, questions were asked regarding alcohol consumption, smoking status, hunting practices, medications, occupation, and other lifestyle factors. The questions related to water were: (*i*) In the last year, did you drink untreated water from the lake, the river, the snow, or the ice? (*ii*) In the last year, was your main source of drinking water bottled water, tap water, or lake or river water.

Focus group

A focus group was conducted during the Water Knowledge Camp in 2019. The Water Knowledge Camp was an on-the-land, cross-cultural knowledge sharing camp that included opportunities to discuss water issues impacting communities in the Sahtú region (Sahtú Renewable Resources Board 2019). The Sahtú region is part of a Settlement Agreement and is Dene and Métis Land. The camp was held in August and Sahtú residents were invited to take part along with water researchers and graduate students. Most participants were from the community of Tulít'a, but other Sahtú communities were also represented. The academic researchers, knowledge users and on-the-land knowledge holders, and youth shared an on-the-land experience filled with demonstrations of research and Indigenous knowledge and conversations and reflection around different forms of knowledge and experiences. This land-based exchange aimed to minimize the colonial approach of research and instead facilitate dialogue (Tuck et al. 2014). During this 7-day camp, participants described several water-related concerns. A structured focus group, which was audio-recorded, included seven key questions that were discussed during a 1-hour time frame. The recording was later transcribed. These seven questions were based on the four dimensions of water security in remote communities: quality, preference, availability, and access (Goldhar et al. 2013). In addition, some prompts moved the direction of the discussion towards technical details, such as individual water tank cleaning. Out of the over 40 participants in the camp, three Elders agreed to take part in the focus group. The focus group took place in English and was facilitated by two trained academics. Out of respect for the community, within this paper we do not mention Indigenous knowledge regarding specific water bodies or water sources (e.g., locations of living/dead water or differences between the types of ice or snow), rather this knowledge will be kept by the members of the community.

Ethics

Free and informed consent was obtained from all participants prior to data collection. Written consent was obtained for all the components, except for the focus group. Focus group participants were invited to provide either oral or written consent. The research was conducted according to the guidelines laid down in the Declaration of Helsinki. Ethics approval was obtained for the NCP funded research by the University of Waterloo Research Ethics Committee (#20173, #20950), the Stanton Territorial Health Authority for Human Research (29/12/2015), the Aurora Research Institute

(#15560, #15775, #15966, #15977, #16021), and Health Canada (REB 2016-0022). Ethics approval was obtained for the Global Water Futures (GWF) funded research by the Wilfrid Laurier University Research Ethics Committee (6171) and the Aurora Research Institute (16594).

Data analysis

The databases automatically created and compiled by each of the electronic surveys in a Microsoft Excel file were imported and then joined together. Descriptive frequencies (n, %, quantity (grams or milliliters)) were calculated using Microsoft Excel, while analytical statistics were calculated using IBM SPSS version 26 (2019, Armonk, NY, IBM Corp). Differences in responses (categorical yes/no) were assessed using the χ^2 statistic. Mann–Whitney tests were used to assess associations between risk perception and quantity of water consumed. The null hypothesis was rejected at $p < 0.05$; therefore, the test was statistically significant. Focus group data from the Water Knowledge Camp were analyzed using dialogic/performance narrative analysis (Smith 2000; Riessman 2008). Narrative analysis allows for the interpretation of text that has a storied form, which was relevant for the way that participants shared their past experiences with water security. Dialogic/performance analysis focuses on the context and view of narratives, which was an important way to analyze these data as participants shared aspects of Indigenous knowledge within the context of their Dene upbringing with their family's view of water.

Results and discussion

Survey participants

A total of 199 individuals from the Northwest Territories took part in the 24-hour dietary recall, and 150 individuals took part in the health messages survey, including 87 from the Northwest Territories and 63 from the Yukon. The age and sex distribution were similar between regions for the Health Messages Survey. The participants of the Health Messages Survey in the Northwest Territories were 44% men and 56% women, with a mean age of 41 (range 12–77) (Skinner et al. 2021*a*). The participants of the Health Messages Survey in the Yukon were 43% men and 57% women, with a mean age of 44 (range 13–76). These demographics were the same for the exposure factor survey in the Yukon. We excluded participants under 16 years of age (n = 37) from the 24-hour dietary recall data reporting as the water consumption and beverages would be different than adults, and not comparable to other available data. The participants of the 24-hour dietary recall in the Northwest Territories were 49% men and 51% women, with a mean age of 47 (range 16–85).

Drinking water and behaviours

From the Northwest Territories participants' answers, we learned that the consumption of water and water-based beverages averaged 0.9 L/day and mainly consisted of tea and coffee. Of the respondents, 19% did not report consuming any water and water-based beverages in the 24 hours prior to the survey (**Table 1**). Of the people drinking water-based beverages, 33% drank more bottled water (average of 0.33 L/day) than tap water (average of 0.24 L/day), and 40% drank more coffee or tea than water (any sources of plain water, average of 0.58 L/day). About 2% of the respondents had consumed water from the land during the previous day, which was in wintertime (between November and March; average of 0.01 L/day).

There were differences in water consumption between men and women in the Northwest Territories. Women tended to drink more in terms of quantity of bottled water, while men were likely to drink water from the land as well as in coffee and tea. In the Yukon (**Table 2**), a smaller portion of women reported drinking often untreated water from lakes, rivers, ice, and snowmelt. However, women reported higher rates of lake/river water as a main source of water than men. Interestingly, fewer

Table 1. Water consumption and diet information from a 24-hour dietary recall from participants aged 16 and over residing in the Northwest Territories (n = 162).

	Men (n = 80)	Women (n = 82)	Both sexes (n = 162)
Participants, %	49.4	50.6	100
Drank any water-based beverage, %	80.0	82.9	81.5
Sources of water[a]			
Drank at least 1.5 L of water (all sources of water), %	18.8	19.5	19.1
Drank water from the land, %	3.8	1.2	2.5
Drank more bottled water than tap water, %	23.8	42.7	33.3
Drank more tea/coffee than water, %	45.0	34.1	39.5
Quantity of consumed water – mean[a]			
Total water sources below, L	1.145	1.189	1.168
Tap water, L	0.199	0.276	0.239
Bottled water, L	0.238	0.417	0.330
Untreated water from the land, L	0.021	0.004	0.012
Tea/coffee, L	0.707	0.496	0.598
Diet[b]			
Added sugar to their water-based beverage, %	59.0	75.5	66.8
Average of added sugar in the water-based beverage, g	94.7	105.5	99.8
Average of added sugar in the water-based beverage as a percentage of total added sugar for the day, %	52.9	51.6	52.3

[a]From respondents who reported drinking any water-based beverage.
[b]The sample size for this question is smaller due to changes in the survey platform. We collected the added sugar profile of 37 men and 37 women participants.

women in the Yukon reported drinking bottled water as a main source of water. In the Northwest Territories, 2.4% of respondents had consumed untreated water the previous day, and 4.5% of respondents in the Yukon mentioned untreated water, in the form of lake or river water, as a main source of their drinking water overall through the year.

Tap water was the main source of drinking water for the Northwest Territories and Yukon respondents (67% and 87%, respectively), which demonstrates the importance of the infrastructure and water treatment facilities in place in the communities (see **Supplementary Material 1**). Comparatively, the Regional Health Survey (RHS) 2015–2016 completed in the Northwest Territories found that only 34% of respondents used tap water as main source of drinking water, whereas 43% relied on bottled water and 16% took water from a river, lake, or stream (Dene Nation 2019). While the importance of untreated water in the RHS seemed elevated compared with results of our study, our results were similar to other Indigenous populations, for instance between 1% and 7% of Inuit participants identified brook water as their primary source of drinking water (Wright et al. 2018). In addition, the water intake reported by respondents was lower than the median amount of water consumed in Canadian Inuit communities (1 L per day) (Wright et al. 2018).

Table 2. Water sources according to the Exposure Factor Survey in the Yukon (n = 63).

Statements	Men (n = 27)	Women (n = 36)	Both sexes (n = 63)
Participants, %	42.9	57.1	100
In the last year, did you drink untreated water from the lake, the river, the snow, or the ice			
Rarely or sometimes, %	48.1	47.2	47.6
Often, %	22.2	16.7	17.4
In the last year, was your main source of drinking water			
Bottled water, %	11.1	2.8	6.3
Tap water, %	85.2	88.9	87.3
Lake/river, %	3.7	5.6	4.5

Table 3. Results from the Health Perception Survey in Northwest Territories (NWT) and Yukon (n = 150).

Statements	NWT (n = 87)	Yukon (n = 63)	NWT + Yukon (n = 150)
Percentage of respondents	58.0	42.0	100
Percentage of respondents who have concerns about chlorine in water	62.1	61.9	62.0
Percentage of respondents who have concerns about metals or heavy metals (mercury, lead, uranium or other)	87.4	74.6	82.0
Percentage of respondents who indicated that water was a source of other contaminants that may impact their overall burden of contaminant exposure.	5.7	0.0	3.3

Perception of water safety

During the consultation meetings, Sahtú people reported that the tap water had a strong chlorine taste, which made the tap water unpleasant to drink ("it tastes bad"). As a result, Sahtú people also consumed water from the land and bottled water. Through the Health Messages Survey, participants mentioned concerns related to contaminant issues in food and water. Unsurprisingly, as was heard during engagement activities, chlorine in drinking water was identified as a contaminant of interest by 62% of participants both in the Northwest Territories and in the Yukon (Table 3). Metals or heavy metals were also a primary concern for 87% of the Northwest Territories respondents and 75% of the Yukon respondents. Fluoride was only identified as a concern by 2% of the Yukon participants and by none of the Northwest Territories participants. It is worth noting that fluoride was not included in the pre-identified options. When asked if there were any other sources or elements not included in the survey (i.e., country foods, store bought foods, cigarette smoke) that may impact the level of contaminants someone is exposed to, 6% of the Northwest Territories respondents typed down water. Finally, open-ended questions provided the opportunity for participants to provide feedback on their concerns regarding contaminants in general. The comments provided included: "Is it the water that is contaminating our country foods?", "Test more lakes (for contaminants)", "contaminants due to the thawing of permafrost and rising water levels". Only one of the perception statements from

Northwest Territories respondents found in **Table 3** were statistically associated with the consumption of water as categorized in **Table 1**, participants who had concerns about chlorine in the water tended to drink more water from the land (untreated water).

Of the RHS respondents, 85% considered the main water supply in their home to be safe for drinking year-round (Dene Nation 2019). In contrast, chemicals and chlorine in tap water were concerns reported by half of Inuit participants in 2013 (Wright et al. 2018). The Government of Canada suggests that a private residential drinking water treatment device may be an option for reducing chlorine concentrations in drinking water if consumers find the taste objectionable (NWT 2020*d*). The participants in our project also reported frequent concerns about tap water, which were collected through the Health Messages Survey (i.e., chlorine, fluoride, metals, contaminants). It has previously been found that individuals who were concerned about chlorine levels in tap water and those who negatively rated its quality had decreased odds of consuming tap water (Wright et al. 2018). However, these associations were generally not observed in the current study, and a positive association was observed between concerns about chlorine and consuming more water from the land.

During engagement activities, we frequently heard negative comments related to the taste and odour of the tap water. Unsurprisingly, the potential link between perceived higher cancer rates and water quality was also raised. It is worth noting that there are historical considerations regarding the perception of contaminants and the distrust of the government in disclosing issues in the Northwest Territories (e.g., land contaminated by uranium/radium and gold mines, water downstream of resource development). However, there is limited knowledge available on the extent to which human activities in the region are affecting contaminants levels in the water. Latchmore et al. (2018) acknowledged that historical contexts have shaped water perceptions, which impacts water security. The limited contaminants data that are available in the Dehcho and Sahtú regions in Northwest Territories, as well as around Old Crow, Yukon, do not currently indicate any concerns with water safety. Rather, existing water quality data in each of the participating communities indicate that the tap water is safe to drink.

Studies conducted in several Inuit communities reported the importance of untreated water sources due to municipal water shortages or a preference for untreated surface water. Untreated water was perceived as more familiar, higher quality, and more trustworthy than tap water (Goldhar et al. 2013; Daley et al. 2014, 2015).

Chlorine additives can react with natural organic matter present in the water resulting in unintentional disinfection by-products such as trihalomethanes, which are carcinogenic chemicals (Sadeghi et al. 2019). In addition, they affect the aesthetic quality of drinking water (taste and odour) (Hrudey 2009). These impacts might worsen the perception and consumption of drinking water and have an impact on diets and public health. There are mechanical means to decrease natural organic matter in the drinking water, preventing their formation.

Water-based beverages, diet, and health

Drinking water-based beverages may impact overall health and diet. While drinking water is recommended as a component of healthy living, it is also an alternative to the consumption of sweetened beverages. Of the Northwest Territories respondents, 67% added sugar to their water-based beverages, mainly in their coffee and tea. This represents an average additional 100 g of sugar and 52% of the total added sugar in their diet reported by participants. More women than men tended to add sugar to their beverages. This observation may have an impact on the quality of diets in the communities and underlines the importance of promoting drinking plain water.

Previous research reported that high-sugar-content beverages are the most common alternatives to water among Inuit, particularly for children (Sakar et al. 2015). In our study, the consumption of added sugar through water-based beverages was elevated, mainly for women. Sugar-sweetened beverages are associated with diabetes and other health issues, while plain water has no sugar and does not contribute to daily caloric intake. Insufficient water consumption was identified as a major risk factor for obesity prevalence for American Indians/Alaska Natives (Elwan et al. 2016). On this topic, the Northwest Territories government website recommends "to keep healthy: drink water right from the tap" (NWT 2020b).

Local knowledge and perceptions on water security

Owing to the potential of water perception and awareness to impact the practice of drinking water, the research team was interested in the different dimensions of water security. These include preferences, quality perception, availability, and access to drinking water. The team also wanted to identify some actions that might be taken to improve the perception people in the Sahtú region have of their drinking water. Three Elders (one man and two women) took part in the focus group with a middle-aged man joining us toward the end of the discussion. The first language of these participants was Sahtú Dene (North Slavey), but discussion was mainly carried out in English because of the researchers' inability to speak the local language, with a few words of Dene language from time to time.

The opening question invited participants to share stories related to drinking water. Recently released research (which had appeared in the media) on plastic in the water was mentioned. Participants wondered if the snow was tested. When asked if they would change their behaviour regarding untreated water if they knew there might be plastic in the water, one participant replied:

> "I don't think so. We've always used snow for drinking, I don't think I would. I will just keep melting snow for drinking."—Camilla Rabisca

The question on where participants get their water from stimulated more interest and replies. They mentioned how snow water was used for tea as well as ice from the lake and river. This choice was based on the taste of the water as well as the traditional importance of it.

> "I would rather drink snow water than tap water or bottled water. . . . It's fresher. Tea is clear. When you make tea with tap water, it's just really black and it has a film on top when you make tea. It has a film on top. I prefer to drink snow water. . . . We've always used snow. I prefer to use snow water for tea and for drinking. I can't change that, I guess. It's been all my life"—Camilla Rabisca

The focus group participants also discussed how people prefer the taste of the water from where they are from (place-based, wells/tap/lake), and the importance of knowing the water you are drinking, what is in it, and knowing the water system and any additives to it. Participants acknowledge that their natural water is probably one of the best and most pure sources of water on the planet. The participants mentioned how Indigenous knowledge informs people as to where to drink the water from lakes and rivers. For example, the Elders know which animals live in the area. As such, if beavers are numerous, they know not to drink water from the area. Participants also reported the challenges in communication related to water safety, mainly for the Health Authority:

> "I have seen some water advisory; you scare the hell out of people. They get scared and they won't drink water anymore from the lake or fish. You can't do that to people."—Participant who wishes to remain anonymous

Participants also talked about local concepts of dead water and living water. Good water, or living water, is water that flows, moves, and is indirectly oxygenated, whereas dead water, which is not safe to drink, is stagnant water where algae can develop more easily. The next topic discussed was whether participants thought that their water was safe to drink. Similar to the survey participants, the focus group participants expressed concerns about chlorine in tap water. The smell and the taste were indicators of elevated chlorine in the water.

> "We hardly drink tap water because, as I said, sometimes you smell chlorine and sometimes you taste it."—Participant who wishes to remain anonymous

While discussing concerns related to tap water, participants also discussed the water delivery system. Water is delivered a few times a week to each house in a tank that may be cleaned once a year by the owner. There are costs associated with this cleaning, and participants reported they do not know the best practices for cleaning the tank. Bleach was commonly mentioned as being used in the cleaning.

Bottled water was not mentioned much within the focus group, probably because it was extensively discussed previously during the camp. People reported occasionally drinking bottled water mainly for the convenience as well as for its plain taste compared with tap water.

Then, the group discussed if and why limiting the amount of drinking water. Participants reported not drinking much tap water because of the bad taste. In addition, there is a historical context to not drinking water. Traditionally, parents taught their children not to drink water, but instead broth and tea. The participants mentioned their confusion towards the current advice given by doctors who recommend drinking more water.

> "When I was growing up, we hardly ever drank water, but we do drink broth. It could be fish broth. It could be meat broth."—Participant who wishes to remain anonymous

> "We were encouraged not to drink too much water. I am still trying to figure it out. There must have been a reason.... All doctors are saying drink a lot of water and it's healthy. The Dene people our age—and I don't know about the young people—we didn't grow up like that. In the wintertime, it's a broth. Yes, a lot of that stuff, but water directly, no."—Walter Bezha

In terms of required actions, the importance of informing people about water for drinking was mentioned. It included when and how to clean water tanks, where water is safe to drink, and the environmental challenges of bottled water. However, it was also reported that government health authorities were taking actions related to drinking water in the communities without consulting community members.

Water was discussed from a holistic perspective, which might have an impact on people's trust in water safety. It was mentioned that it is important to thank the water and "pay the lake", which is a custom to honour the natural surrounding by providing a small gift (e.g., tobacco, tea). It ensures that water is good for people, good to drink, and safe to travel on. Participants expressed that everything is connected, and water is life.

> "I seen everything connected, everything. Water, land, grass, animals, people, all connected.... We are put on Earth not to own anything. We are to take care of each other, take care of the animals, the fish, birds, everything. We cannot control anything. That's not our work. Our work is just to take care. We need to take care of each other, take care of the water. ... We take care of the water because water is our life."—Participant who wishes to remain anonymous

The focus group discussed and explored sources of water, preferences, determinants, and the traditional perspective on drinking water. The discussion topics and information gained from the focus group is context dependent and obtained in a site surrounded by nature. The contextual evidence obtained by this group might be different in an urban environment and the findings of this discussion group may not represent the perceptions of the whole community.

The Indigenous perspective on water and the holistic knowledge that water is the source of life was mentioned. Living and dead water is a concept shared by other Indigenous groups (Latchmore et al. 2018). Water plays a central role in keeping the traditional way of life alive in Indigenous communities.

There are scientific reasons to justify the differences in the taste, odour, and appearance of tea prepared with tap water versus snow/ice water. The thin, dark layer floating on the surface of the tea is a combination of oil from the tea leaves and insoluble compounds such as calcium and magnesium (Franks et al. 2019). These dissolved compounds can be present naturally in unfiltered hard water, but precipitated by heating water (e.g., calcium carbonate). As snow does not pass through the ground and does not accumulate ground minerals, the water hardness of snow is usually low. Indigenous knowledge informs Western science, which can bring hypothesis of these situations.

Traditionally, water consumption in areas where there was no filtered water was limited, and instead drinking broth or tea was promoted. The use of boiled water ensured that risks from microorganisms were minimized. Drinking boiled water (i.e., broth) echoed what doctors now say about drinking filtered water. Now that people have easy access to filtered treated water, tap water seems to be a sensible solution, and the promotion of water can be an effective strategy to curb sweetened beverage consumption.

Through this project, we characterized the consumption of water and water-based beverages in subarctic Indigenous communities in Canada. Numerous residents mentioned prior to the project implementation and during the engagement activities, consultation processes, and public meetings that many have stopped drinking from local water sources and had concerns about the safety and contamination of tap water and natural sources. As such, this research component was to understand the extent of this situation and perception.

Climate change has and will continue to affect water in the Northwest Territories and Yukon, such as by the thawing permafrost disturbing the chemistry of waterbodies (Kokelj et al. 2009). Warmer temperatures are also expected to increase waterborne diseases (Dudley et al. 2015). Additionally, wildfires can release significant amounts of organic matter and heavy metals into water, which may have an impact on the water treatment infrastructure and operations in communities (Bladon et al. 2014). Climate change might also affect the strong taste that communities reported in their tap water (Health Canada 2021). Finally, climate change will also impact water storage and might decrease water availability in some parts of the Northwest Territories (Dibike et al. 2017).

In 2012, the Northwest Territories Community-based Water Quality Monitoring program was implemented that aimed to increase the role of communities in water monitoring at specific untreated water sites across the territories (MACA 2016). This included some sites along the Mackenzie River, which is the main source of water for the water plants in several participating communities (**Supplementary Material 1**). Treated water is also tested frequently by water treatment plants and quality control is monitored. In the Northwest Territories, testing and reporting to officials is required under the Public Health Act. There are daily tests for chlorine and turbidity, monthly bacteria tests, quarterly tests for trihalomethanes, and annual chemical tests for metals completed by the local,

trained officer and enforced by verification from the Municipal and Community Affairs (MACA) Environmental Health Officer.

Several stakeholders ensure that drinking water is safe in the Northwest Territories, including the community government, MACA, Public Works and Services, Health and Social Services, Environment and Natural Resources, and the Water Boards (MACA 2020). Despite this collective effort, there are still instances of tap water being unsafe to drink; a boil water advisory is still in effect in one community of the Sahtú region (NWT 2020*a*). Research in other Indigenous communities has shown that water in homes served by cisterns and water trucks more frequently have unacceptable levels of *Escherichia coli*, even if the water was free of those bacteria when leaving the water treatment plant. Therefore, these residents have a higher risk of contracting waterborne illnesses (Farenhorst et al. 2017).

A stronger collaboration with Indigenous partners is required to effectively promote treated tap water as people's drink of choice. Regardless of access to safe tap water, Indigenous communities will continue to consume water from untreated sources for cultural and spiritual practices that date back to precolonial times (Latchmore et al. 2018). An increased protection of source water can improve drinking water quality, while also supporting reconnection with the land for Indigenous people in Canada (Patrick 2011). Health risk assessments should consider the importance of untreated water to northern Indigenous communities.

Conclusion

The importance of water to the wellness of remote northern communities is rooted in the four dimensions of water security: quality, preference, availability, and access (Goldhar et al. 2013). While water fulfills essential needs such as drinking and cooking, Indigenous groups depend on an additional dimension of water security, as ice and waterbodies are used for transport (e.g., ice road, boat) and access to traditional country foods. Water is linked with a sense of identity and place as regions are often described according to the traditional place name related to water. Water has spiritual and cultural dimensions in the participating communities. Frequent water contamination, low trust in water safety, low trust in water testing results, unreliable water delivery services, taste and odour issues, and insufficient water quantity have contributed to water insecurity in Indigenous communities and resulted in disproportionate water-related challenges in northern Canada. Bottled water consumption is not sustainable, and climate change will continue to affect the ecosystem and water quality and quantity. While the consumption of water is essential to healthy living, it is important to design effective public health strategies by understanding the perception of the issue, as well as water-related behaviour. It is necessary to continue working collaboratively to secure access to drinkable water and improve water safety and security in northern Canada.

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Author contributions

MR, AS, and KS conceived and designed the study. MR, AS, DS, and KS performed the experiments/collected the data. MR analyzed and interpreted the data. MR, AS, BDL, LA, DS, AS, and KS contributed resources. MR, AS, BDL, LA, DS, AS, and KS drafted or revised the manuscript.

Competing interests

The authors report no conflict of interest.

Data availability statement

All relevant data are within the paper and in the Supplementary Material.

Supplementary material

The following Supplementary Material is available with the article through the journal website at doi:10.1139/facets-2021-0094.

Supplementary Material 1

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