LAND-BASED LEARNING: BUILDING BRIDGES BETWEEN INDIGENOUS KNOWLEDGE AND WESTERN SCIENCE

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ABSTRACT

Indigenous communities look for learning opportunities that reflect and build on their cultural traditions, land-based experiences, and worldviews. Western science contrasts with Indigenous ways of learning and knowing since it is more quantitative, analytical and based on experimentation. Yet Indigenous students continue to be underrepresented in the scientific disciplines. One way of addressing such gaps is to bridge the two knowledge systems in ways that simultaneously affirm the importance of both. The research aims to explore how Indigenous knowledge and science might be better integrated and intends to build capacity around both science and traditional culture among Indigenous youth using land-based learning camps. It was combined with participatory action research (PAR) and Indigenous methodology and uses "two-eyed seeing" as a guiding principle in that no one worldview is allowed to dominate over the other. In summer 2019, four camps were conducted across Manitoba (in Brokenhead Ojibway Nation, Keeseekoowenin Ojibway First Nation, Sagkeeng First Nation, and O-Pipon-Na-Piwin Cree Nation) and one in northwestern Ontario (in Couchiching First Nation). The land-based camps prioritized local environmental issues and community engagement by ensuring true and meaningful participation at all stages of the camp and provided Indigenous communities with the opportunity to share the power of knowledge production. Scientists, Elders and knowledge keepers shared their own insights, mostly focusing on local declines in water quality. Camps were generally well received by all host communities. Final reports that provided the outcomes of scientific testing in accessible and impactful ways were especially useful, although they might have better represented Elder teachings. These camps represent a valuable opportunity for communities to build their capacity in the sciences while also affirming the importance of cultural traditions and community aspirations. In so doing, the camps represent an important way of lessening the education gap and of further developing community resilience when it comes to protecting their environments and cultural traditions alike.

Key words: Cultural traditions; Indigenous knowledge (IK); land-based camps; two-eyed of seeing; water quality; western science; youth

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Education offers knowledge, aptitudes, and experiences which are generally regarded as pre-requisites for any modern Canadian to become successful. However, limited financial support, scholastic resources and academic opportunities all act as impediments for Indigenous students trying to access post-secondary education. (Holmes, 2006; Hudson, 2009 ; Malatest & Associates, 2004; Restoule et al., 2013). A relatively small number of Indigenous students graduate from high school, and even when they do, they often lack a basic background in science, mathematics, and computer literacy (Holmes, 2006).

According to recent census data, the percentage of Indigenous people succeeding in post-secondary education has increased from 2006 to 2016, including those obtaining college diplomas (from 18.7% to 23.0%) or university degrees (from 7.7% to 10.9%) (Statistics Canada, 2017). However, people living off-reserve encounter fewer obstacles to access educational opportunities or complete a postsecondary degree than those living on reserve (Statistics Canada, 2017). Geographical location plays a key role in obtaining higher education. The unavailability of universities in close vicinity, the possible threat of social isolation and financial expense of travel all act as barriers (Holmes, 2006). Besides, Indigenous perspectives, knowledge, and culture and appropriate teaching methods are rarely reflected in post-secondary educational curricula; rather, programming is constructed ways that reflect and further the economic and academic of dominant society (Royal Commission on Aboriginal Peoples, 1996). Such discrepancies are greatest around the STEM disciplines (science, technology, engineering, and mathematics). This despite Indigenous scholars having long advocated that school science education curricula be reframed to reflect student cultural backgrounds (Cajete 1994; McKinley, 2005).

The Truth and Reconciliation Committee (2015a) made several recommendations that explicitly related to changes in the education system that would benefit Indigenous communities in Canada, these including eradicating differences in educational school-level funding (#7, 8), sufficient funding for post-secondary education for Indigenous students (#11), and addressing gaps in western curricula while incorporating Indigenous content through legislative action (#10) and the development of culturally appropriate educational curricula (#10). The latter would, in turn, better reflect community values and priorities (#62) as well as land-based and experiential

approaches to learning (#62). A number of different approaches can be taken that would better incorporate community priorities and Indigenous Knowledge in formal education programming. However, such challenges are perhaps of greatest concern regarding the STEM disciplines, especially when it comes to incorporating or even integrating Indigenous Knowledge in curricula in ways that affirm the value of both knowledges (DeCoito & Gitari, 2014).

Indigenous people around the globe are strongly connected with their natural environments. They generally share rich and sustained relationships with and knowledge regarding their lands or territories. These relationships are, in turn, reflected in their cultural, spiritual, and social identities, which signifies the importance of land not only for their livelihoods but also for their ways of life and wellbeing (Stavenhagen, 1990). Nevertheless, throughout the world, Indigenous people are being adversely affected by resource extraction and economic development projects. In Canada, the natural resource sector - which includes water, forestry, mining, and natural gas - plays a vital role in the country's economy. Indeed, in 2015, it represented an economic worth of more than $135 billion or 8.16% of the GDP (Statistics Canada 2017; Nightingale, Czyzewski, Tester, & Aaruaq, 2017). However, such resource extraction widely impacted people living in proximity to these development, most of these being Indigenous communities. For instance, around 65% of all the on-going or proposed intensive resource extraction and manufacturing projects in British Columbia have exposed more than 50% of the Indigenous population in this province, thus leaving them vulnerable to the direct and indirect impacts of associated environmental degradation (Gislason et al., 2017).

In Canada, many studies find that Indigenous communities often carry the disproportionate burden of environmental pollution whether it relate to the pollution of water, air or foods (Venton & Mitchell, 2015). Thus, mercury contamination in Grassy Narrows (Asubpeeschoseewagong Netum Anishinabek), Ontario, more than 50 years after the initial contamination by a nearby pulp and paper mill, subject's community members to the impacts of mercury poisoning while also undermining the consumption of traditional foods, most notably fish and associated livelihoods (Toronto Star, 2016).

Another example in the Pine Point region of Northern Canada, this occurring 25 years following the termination of a large mining operation, shows that the scars of widespread seismic

cutlines through the boreal forest of the landscape still adversely impact wildlife and thus the traplines used by local Indigenous people (LeClerc & Keeling, 2015; Horowitz et al., 2018).

Hydroelectric power has particularly adverse effects on the cultures, food systems, and traditional territories of Indigenous people across Canada. Mega projects such as Site C in British Columbia and Muskrat Falls in Labrador (Papillon & Rodon, 2017). contribute to the degradation of the quality of water, biodiversity, resources, livelihoods, and traditional ways of living. In Manitoba, the hydrological and ecological characteristics of around 30,000,000 acres of northern boreal rivers and forest have been transformed due to Churchill River Diversion and the Lake Winnipeg Regulation projects conducted by Hydro Manitoba. Nonetheless, they disregard the impacts of these projects on the surrounding environment and Indigenous communities living near the Nelson River (Hoffman, 2004).

Water is one of the most rudimentary and crucial resources in any ecosystem; however, in the past few decades the equal distribution and rights of water especially drinking water is rarely maintained and has remained a topic of much disagreement and conflict (Mascarenhas, 2007). In Canada, quality of drinking water, is also a matter of concern since a federal drinking water quality standard was instituted in 1968 (Government of Canada, 2018). Yet many Indigenous communities across Canada have inadequate access to safe drinking water, despite having these rights enshrined in Section 35 in the Canadian Constitution (D) (Bradford, Bharadwaj, Okpalauwaekwe, & Waldner, 2016). To protect people from drinking contaminated water or water that is otherwise not safe to consume, protective measures like drinking water advisories are undertaken by regional health authorities. Currently, there are 61 long-term and 23 short-term drinking water advisories are in effect on the public system on reserve (Government of Canada, 2020).

Over the last 50 years, much research has been conducted to assess such impacts but mainly focused on changes to the environment and any impacts on Indigenous livelihoods. Impacted communities are generally still excluded from meaningful involvement in most stages of this research, even when these studies claim to be participatory in approach (Turreira-García et al., 2018). With respect to education, most approaches to education research and more generally to environmental education are still grounded in western worldviews and under-represent Indigenous values and cultures (Cajete & Pueblo, 2010). This represents one of many barriers to Indigenous youth and education (Bonny, 2018). While commenting on the reintegration of Indigenous

knowledge into the mainstream education in Alaska, Barnhardt (2007) indicates that Indigenous people are confronted the challenge of "living in two worlds", one world he describes as being interior and strongly connected to life, land and culture and other as being exterior, which dominates or marginalizes the interior. The collision that often arises from these two worlds reflects and in turn contributes to colonialization and associated attempts to suppress and assimilate Indigenous rights and sovereignty across North America and around the world. The role that education can play in perpetuating such injustice is perhaps reflected most clearly in Canada through the history of residential schools and associated cross-generational impacts that continue today (Truth and Reconciliation Commission of Canada, 2015a). These long and painful relationships with education continue today and continue to undermine efforts at addressing education-related barriers.

Notably, many studies posit that advancement in academic achievement as well as more engaging and meaningful learning in STEM curricula or any education programmes will be observed if Indigenous communities and their youth can make explicit links between these programmes their own cultural, geographical or environmental settings (Ladson-Billing, 2004; McCarty & Lee, 2014; Upadhyay, Maruyama & Alkrecht, 2017). Indigenous communities generally look for learning opportunities that reflect and are appropriate to their culture and traditions. On contrary, western science is more reductionistic, curriculum-driven and textbook-oriented hence it contrasts with Indigenous ways of learning and knowing (Hogue, 2012). Hogue also included that connecting theory and practice it is crucial to have a proper environment that is accountable and true to Indigenous ways of learning.

To bridge the two knowledge systems, outreach programs can play a significant role as they have the potential to provide a way to enrich skills and stir the interest and shows the correlation between science and regular life (Rahm, Martel-Reny, & Moore, 2005; Thomasian, 2011). To draw attention to this bridging, Alkholy, Gendron, McKenna, Dahms & Ferreira (2017 p9) cites educator Paulo Freire as having argued that

> *"student centered pedagogy increases critical thinking by equalizing all voices and increasing exposure to multiple points of view to recreate knowledge".*

Even post-secondary STEM students can be assisted as well as motivated by the presence of Indigenous Elder co-educators while the importance of learning Indigenous science and the underlying concepts is also endorsed by various studies (Alkholy et al., 2017; Ferreira, McKenna, & Gendron 2014; Lederman 2007). Hence as knowledge keepers of Indigenous science, Elders can not only play the role of Indigenous scientists but also provide valuable insights to the science curriculum (Alkholy et al., 2017).

My research aims to explore how Indigenous knowledge and science might be better integrated as well as intends to build capacity around *both* science and traditional culture among Indigenous youth through the use of land-based learning camps. For ease of understanding, I have separated my thesis paper into six different chapters. In chapter 1, is the introduction, in chapter 2, is the literature review on which my research is based, chapter 3 is the methodology and methods, chapters 4 and 5 are my research findings and discussion and finally chapter 6 is my conclusion and implications. The overall goal of chapter 4 is to explore and describe the role of land-based youth camps that are simultaneously grounded in the science and Indigenous culture in addressing community priorities. The overall goal of Chapter 5 is to critically evaluate the implications of these land-based camps for youth and other community members now and into the future. Finally, Chapter 6 focuses on the general thesis conclusions and implications and further explores my own journey, learning, and growth as a researcher while embarking on this innovative and impactful project.

The overall thesis goal is to explore the role of land-based camps that are simultaneously grounded in the sciences and in Indigenous culture can play in facilitating youth understanding and action regarding the environment.

Its more specific objectives are to:

1. Explore and describe land-based youth camps incorporate both the science and Indigenous culture.
2. Evaluate the successes of these land-based camps and possible ways of addressing any of their shortcomings.
3. Assess how and to what degree this cross-cultural approach shapes and facilitates youth interest and understanding in both the environmental sciences and Indigenous culture.

4. Explore different ways facilitating science-based outreach and exchange regarding the camps with community leaders.

Chapter 2: Literature Review

In any given political system or in institutions, the power lies within the dominant class. However, addressing disparities and providing equal rights to all involves a shift in power relations (Ghosh, 2018). The education system in Canada as it affects Indigenous people has always been grounded in colonialism and, more specifically, in a Eurocentric worldview, which forces Indigenous students to subsume their own culture and traditions within the larger whole (Gahman & Legault, 2019). Although perhaps such assimilation was most clear with respect to residential schools, it still continues at all levels of education – from early to postsecondary. The prevalence of these Eurocentric values in part gives rise to poor performance and higher attrition rates (Simpson, 2004) and in turn threatens to undermine traditional values and ways of being (Blacker, 2021). The further involvement, representation, and acknowledgement of Indigenous land, knowledge in educational institutions are needed to address the concerns and balance such power imbalances and thus played a dominant role in the Calls to Action advocated by the Truth and Reconciliation Commission (Lowan-Trudeau, 2012).

2.1 History

2.1.1 Colonialism

With the support of power and law, colonialism represses the diversity of worldviews to sustain a particular worldview or social structure. Hence, repression, racism and inequality all underlie the fundamental disparity in influence between Indigenous and Western worldviews world over (Bear, 2000). Across North America, Indigenous people have long lived traditional vibrant and prosperous lives enriched by a wide diversity of languages, cultures, spiritualities and knowledges. The root and wellbeing of community existence relied on the passing on knowledge, teachings and traditions from one generation to the next (Barman, Hébert, & McCaskill, 1986; Truth and Reconciliation Commission of Canada, 2012). Indigenous children were raised in an environment where they were taught the value of mutual relationships with both humans and the larger environment, respect, responsibility, sharing and self-reliance. But European dominance or colonialism ignored the value and richness of this culture by labelling it as inappropriate or outdated (Barman et al., 1986). This kind of dominion or control by power has still persists, despite its many evolving forms. According to Goulet, Linds, Episkenew and Schmidt (2011),

"*colonization is not just a process that happened in the past, but is ongoing in the present, enacted in relationships of power and privilege that have been constructed historically through many means, including war, law, policy, theoretical constructs, and the media, to name a few*" (p90). Ongoing disparities when it comes to physical and mental wellbeing are the outcome of this colonization or *historical trauma*, and Indigenous youth continue to suffer in ways that are as harmful as the trauma experiences by their previous generations (Bird-Naytowhow, Hatala, Pearl, Judge, & Sjoblom, 2017; Goulet et al., 2011; Kirmayer, Gone, & Moses, 2014).

2.1.2 Indian Act

In 1876, the federal Indian Act was first adopted to define 'Indian' status under Canadian law, and it in turn was used to control these peoples – and could be removed at will. While a woman who married a man who did not hold Indian status would in turn lose her status, there were also many ways men could lose their status like graduating from a university or serving in the military (Truth and Reconciliation Commission, 2015a). The Indian Act was amended in 1920 to make it obligatory for status children between seven and fifteen to join either day or residential schools (Truth and Reconciliation Commission of Canada, 2012; Royal Commission on Aboriginal Peoples, 1996) which acted to control the lives of these students at their every being (Goulet et al., 2011). From the late 1800s to the mid-1900s, Indigenous teaching or knowledge and culture were systematically eradicated and students 'civilized' in order to remove any trace of the "Indian" from the child (Simpson, 2004; Royal Commission on Aboriginal Peoples, 1996).

2.1.3 Residential Schools

A critical purpose of the Indian Act was to absorb 'Indians' into a Eurocentric Canadian society, a plan that was enacted through the residential school system (Goulet et al., 2011; Royal Commission on Aboriginal Peoples, 1996). More than 150,000 Indigenous children were brought to residential schools and forced to leave their families, cultures and traditional values in order to 'civilize,' educate and convert them to Christianity. As such they represented a longstanding partnership between the Canadian government and Christian churches to better implement the Indian Residential Schools educational system (Royal Commission on Aboriginal Peoples, 1996; Walker, 2009; Truth and Reconciliation Commission of Canada, 2015). This educational system played a significant role in not only undermining Native languages but was also undermined the ability of future generations to access their own Indigenous knowledges and cultures (Simpson,

2004). The residential schools this marked as heartbreaking piece in the history of Canada and the consequences from these harms continue to manifest themselves through the inequalities, discrimination between Indigenous and other Canadians in terms of education, physical and mental wellbeing, economic and social differences (Truth and Reconciliation Commission of Canada, 2015a). These devastating harms have been most recently brought to the forefront by the discovery of 215 unmarked graves of children on the former grounds of the Kamloops Indian Residential School in British Columbia (National Post, 2021).

2.2 Education

2.2.1 Truth and Reconciliation Commission: Calls to Action

In 1969, the residential school system was finally and officially ended, although some government-run schools operated till the 1990s. Since then, former students have told their personal stories of sexual, physical and emotional abuse by the teachers and administrators in these schools (Walker, 2009). On June 11, 2008, on behalf of the Government of Canada, Prime Minister Stephen Harper made a Statement of Apology to former students of Indian Residential Schools and implemented the *Indian Residential Schools Settlement Agreement* as a long overdue attempt to heal, reconcile and resolve this tragic legacy (Government of Canada, 2010; Walker, 2009). To review the history of Canada's Indian Residential Schools, to document the impacts of those schools on Indigenous people and provide a way to reconcile with and heal from these harms, a Truth and Reconciliation Commission (the Commission) was formed with a five-year mandate (Truth and Reconciliation Commission of Canada, 2015; Government of Canada, 2010; Walker, 2009). As Prime Minister Stephen Harper mentioned in his apology, "*(a) cornerstone of the Settlement Agreement is the Indian Residential Schools Truth and Reconciliation Commission. This Commission presents a unique opportunity to educate all Canadians on the Indian Residential Schools system*" (Government of Canada, 2010, p2). While establishing the Truth and Reconciliation Commission, Canada has enrolled itself in *transitional justice initiatives* such as those found in other countries whose governments had perpetuated devastating harms including those in Argentina, Cambodia, Chile, East Timor, El Salvador, Guatemala and many others. The outcomes of the TRC garnered much attention worldwide, especially in the USA and Australia, which both enacted their own versions of the Residential Schools system for their Indigenous populations.

Aboriginal self-determination and Canada's obligations under the numbered Treaties and Canada's endorsement of the *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP) provided a basis for the Commission to be hopeful about this process and generated promising ways of attaining such reconciliation (Truth and Reconciliation Commission of Canada, 2015a). In TRC's final report, the Commission refers that they had found in their own Interim report that "the United Nations Declaration provides a valuable framework for working towards ongoing reconciliation between Aboriginal and non-Aboriginal Canadians." Such agreements thus inspired all the legal bodies involved in the agreement and government officials to follow the framework.

As ensured in Treaties, in international law, and under the Canadian Charter of Rights and Freedoms, education is a central human and Aboriginal right. Indeed, UNDRIP declares that culturally appropriate education is the right of Indigenous people everywhere, which also allows these Peoples to offer and control education systems informed by their own language and culture (Truth and Reconciliation Commission of Canada, 2015a). To make progress on reconciliation and to recognize and rectify residential school legacy and to comply with the declaration, the Truth and Reconciliation Commission made 94 remarkably forward thinking calls to action. In terms of education, some of the fundamental calls to action are: to reduce any differences in funding for education between on reserves and off reserves with respect to First Nations children and post-secondary students (#8, #11); the publication of annual reports on comparisons of educational allocations between on and off reserve students, and an ongoing evaluation of the educational and income attainments of both Indigenous and non-Indigenous people (#9); the full participation and informed consent of Indigenous peoples regarding education legislation that encompasses a pledge to provide adequate funding for initiatives that reflect principles like enhancing educational attainment and success, development of culturally appropriate curricula, keeping the right to Indigenous languages, and respecting and honouring Treaty relationships (#10, #12).

2.2.2 Need for education around STEM disciplines

According to the Royal Commission on Aboriginal People (1996), "education shapes the language and pathways of thinking, the contours of character and values, the social skills and creative potential of the individual. It determines the productive skills of a people*"* (p404).

Education develops a distinctive perspective on life, and in today's world, plays a critical role in shaping the future success of individuals. A country needs to develop robust educational systems for children and youth to nurture their talent and intellectual promise in the future (DeCoito, 2016). To meet the 21st century's challenging needs, knowledge and dexterity in Science, Technology, Engineering, and Mathematics (STEM) is wide recognized as a crucial requirement (Tytler, Osborne, Williams, Tytler, & Clark, 2008). Carnevale et al., 2011 clarify that "the diversion of STEM talent and STEM workers into other occupations results from the increasing value of the competencies—the set of core cognitive knowledge, skills, and abilities that are associated with STEM occupations, and the non-cognitive work interests and work values associated with STEM occupations" (p7-9). Innovation and efficiency are significant criteria for any country's development, and STEM plays a vital role in this regard as it has been applied to define the educational background, employment, and proficiencies (Council of Canadian Academics, 2015). Countries around the world including the United States, Australia, and Canada are consistently trying to focus, introduce, and encourage different initiatives to promote STEM learning among youths (DeCoito, 2016; Tytler et al., 2008).

In Canada, the number of citizens (aged 25 to 64) who had either college or university graduate has increased from 48.3% to 54% since 2006. Among the Organisation for Economic Co-operation and Development (OECD) countries, Canada remains first in this regard (Statistics Canada, 2017). According to Statistics Canada (2017), the percentage of Canadians completing a bachelor's degree or higher and an apprenticeship certificate among young people (aged 25 to 34), has also increased since 2006. They also cited that the percent of educational attainment in post-secondary level (college diploma, bachelor's degree or higher) among First Nations, Métis and Inuit people has also improved in the last 10 years, from 7.7 to 10.9.

The commitment to education among Indigenous people is identical regardless of community or culture. Despite a wide diversity in belief, stories, cultures, and norms, they people also acknowledge that to have a thriving future, the significance of education is enormous (Royal Commission on Aboriginal Peoples, 1996) However, any such grounding in these traditional values and cultures and languages is still rarely reflected in the country's formal education system. In the Royal Commission on Aboriginal People (1996), Indigenous educators mentored and informed their students that such education had the promise to bring fortune to their communities and to nurture their potential. However, 25 years later the conventional

educational system continues to suppress their Indigenous knowledge, leading to high attrition levels throughout. According to the National Household Survey (NHS) (2011), depicted the differences between Indigenous and non-Indigenous people when it comes to 'no certificate, diploma or degree' was dramatic: 28.9% and 12.1% for Indigenous and non-Indigenous people aged 25 to 64, respectively.

The differences in educational attainment regarding STEM disciplines between Indigenous and non-Indigenous students is even more dramatic in Canada (Truth and Reconciliation Committee, 2015). A report was published in consultation with the NSERC Chairs for Women in Science and Engineering in 2018, which analyzed the distribution of gender in the STEM field from National Graduates Survey (NGS) 2000-2009 data and other survey reports (Perreault, 2018). The NGS data depicted the discrepancy between Indigenous and Non-Indigenous students who obtained a degree in the STEM field (Table 2.1). Though the number has slightly improved for Indigenous students from 2000 to 2009, Indigenous people are clearly under-represented in all the STEM disciplines, especially in the Sciences (Table 2.1) (Perreault, 2018). However, when calculated as percentages of the Indigenous and non-Indigenous population of Canada, these differences are not as apparent; since the percentages generally increase over time there is cause for hope. The only such substantial decline anywhere (a minor decline) is with Indigenous students in Biology for 2005.

Table 2 1: Attainment of a degree in the STEM fields among Indigenous and Non-Indigenous students

Year	STEM Field	Biology	Engineering	General Science	Math/Computer Science
2000	Indigenous	135	344	89	329
	Non-Indigenous	10,514	22,160	7,849	14,099
2005	Indigenous	119	544	126	262
	Non-Indigenous	10,903	27,186	7,549	14,964
2009	Indigenous	294	775	189	342
	Non-Indigenous	12,327	29,204	10,854	9,208

Source of data: Perreault, 2018

Barriers including inadequate funding and resources, the lack of Indigenous role models and the prominence of teachers that have little cultural fluency for Indigenous cultures and languages, and of course the absence of relevant Indigenous cultural content continue to undermine science education in schools (Aikenhead & Elliott, 2010). Reasons for the lower participation in STEM in post-secondary education programs, including a concentration on theory and lab, and the absence of Indigenous content and different ways of teaching; and assumptions and ideologies that conflict with Indigenous ways of teaching and learning (Quigley, 2009; Simpson, 2002).

Nevertheless, it will be difficult to address such gaps when educational authorities are themselves unwilling to change and to welcome alternate ways of knowing. For instance, a case study of an undergraduate American Indigenous woman presented a picture of post-secondary education culture, especially around science which has not yet recognized traditional or Indigenous knowledge as a valid or legitimate way of learning and is little inclined to address differences and tensions between Indigenous knowledge and Eurocentric science (Brandt, 2008). This process arguably began in the 19th century when natural philosophy was effectively replaced by modern science, and this advancement was followed by a deep relationship with western thinking and the associated dominance and control of western science over nature (Aikenhead & Ogawa, 2007; Hatcher, Bartlet, Marshall, & Marshall, 2009). Although the importance of Western science and its conventional Eurocentric approaches are often perceived as a guiding principle by many scientists and teachers, its domination is opposed by others who view this "totalizing" as a severe limitation, especially when it comes to including other knowledges into this broader system of understanding and making sense of the world (Aikenhead & Ogawa, 2007).

Changes that emphasize the importance of diversity and inclusion when it comes to such ways of seeing are essential when overcoming the Indigenous/non-Indigenous gaps in the educational system. Brandt (2008) recommends a shift from an academically and industrially practiced stubborn Eurocentric science perspective to science that expresses community concerns and embraces others knowledges, i.e., local or Indigenous knowledges. The First Nations, Métis and Inuit Education Policy Framework emphasized that implementing culturally sound strategies is required to boost the enrollment of Indigenous students in science or more broadly STEM disciplines (Ontario Ministry of Education, 2007). Intricate scientific or technical language, practices and protocols, and their underlying assumptions, often make it challenging for Indigenous students to cope with otherwise Eurocentric approaches. Indeed, a diversity of

approaches are needed to address such challenges before any real change in success levels can be attained in the scientific-educational system (Brandt, 2008).

2.2.3 Indigenous views and western science

Indigenous people and their experience-based knowledge, which is often referred to as Indigenous Knowledge, Traditional Ecological Knowledge, or, more generally, Local Ecological Knowledge (LEK) at first glance appears to play an important role in environmental or ecological research in Canada and around the world (Brook & McLachlan, 2008; Hori et al., 2012), as many scientists increasingly recognize the significance of Indigenous knowledge in their work (McGregor, 2004). For Indigenous people and communities, their knowledges, experiences, and insights into the surrounding environment have played a significant role in their lives since time immemorial. Yet the scientific world continues to peripheralize rather than affirming Indigenous knowledges (Sutherland & Swayze, 2012). Many scholars argue that Indigenous knowledge (IK) is still regarded as complementary if it is given any attention at all (Latulippe & Klenk, 2020). And that the rights and claims of these peoples are as disrespected by dominant science culture as is their Indigenous Knowledge with respect to extensive environmental or resource management (Sandlos & Keeling, 2016).

However, for Indigenous people in Canada, the post-residential school experience still acts as an obstacle to transfer and teach the Indigenous knowledge to the next generation. Indigenous educators feel that the western Eurocentric curriculum still dominates over Indigenous Knowledge and restricts the ability of these peoples to develop the ability to understand and learn these knowledges (Simpson, 2004). As western or science education increasingly focuses on environmental concepts of global concern like climate change, ozone layer depletion, toxicity, it is often overlooked that these concepts may be appeared to have few local implications and may be relatively inaccessible to communities with low levels of formal education (Eijck, 2010). As these areas of study become dominated by industry or government, the emphasis on immediate profit and widespread knowledge production are often promoted at the expense of local priorities and cultures. Community requirements and expectations are barely reflected when developing wide-ranging advancement paths hardly acknowledge the Indigenous knowledge as a contributing resource. But when the opposite happens, not only does Indigenous Knowledge become regarded as a significant cultural component but this change also furthers the engagement of Indigenous

communities, researchers and decision-makers regarding such environmental issues (Robson et al., 2009). Bocking (2016) denotes that the core factors giving rise to environmental concerns, including power or financial inequality and political inclinations, go unnoticed when they are only addressed by and as science. In most cases, both academic and constitutional institutions indirectly require familiarity and full consent with scientific concepts and methods, which ultimately end up excluding Indigenous people and their concerns and experiences (Johnson et al., 2016). When experiential and land-based approaches are taken with respect to science education, these in turn emphasize the applied nature and relevance of the underlying concepts and the importance of local issues (Eijck, 2010). However, even such approaches still ultimately work to exclude Indigenous values and traditions.

2.2.4 Land-based Education

All over the world, western views of *nature* or *natural resources* are usually seen as being of critical importance but the role of dominance and power and anthropogenic activities in environmental decline are increasingly recognized (Scoville, 2020). On the contrary, Indigenous people share a unique relationship with nature, land, and wildlife in ways that act as a dramatic counterpoint to western views. Fishing, hunting, and collecting survival resources and medicinal plants are activities that have long marked Indigenous people's existence. Such activities have been have been practiced for millennia on the *traditional territories* of these peoples (Kunkel, 2017). Land is not just a physical entity for most Indigenous cultures: rather, it is the centre of existence. It represents origins, the source of knowledge, subsistence, essence and well being (Cajete, 1994; Denzin, Lincoln, Smith, Kincheloe, & Steinberg, 2014; Meyer, 2008;). All these epitomize the significance of land as it provides a crucial way to learn and to know. In order to explain the role of land and how it shapes Indigenous research, Manulani Aluli Meyer (2008) elucidates,

> *"Land is our mother. This is not a metaphor… It opens doors to the specificity of what it means to exist in a space and how that existing extends into how best to interact in it.….Land as an epistemological cornerstone to our ways of rethinking is all about relating in ways that are sustaining, nourishing, receptive, wise" (p 4-5)*

Indigenous people often recognize themselves as being immersed in *a sea of relationships*, which is shared and celebrated with their connections to the natural environment- trees, rivers, mountains and other living and non-living beings. They then know the land, learn about all the intricacies and languages of these relationships and through these insights they proceed with learning, i.e. their education (Cajete, 1994). A comprehensive and wholistic perception of physical and mental wellbeing can be obtained through land-based education (Fast et al., 2021). Rather than emphasizing only physical or conventional well-being, World Health Organization (WHO) also signifies the complete understanding of health or well-being by defining it "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (World Health Organization, 2007).

Colonialism, displacement and their constructed education systems often lead Indigenous youth especially urban youth to feel disconnected with their communities, cultures and ceremonies. In contrast, land-based learning represents a way to address such issue and to confront western education in order to address and restore Indigenous teaching, cultures and the spiritual well-being of the youth (Fast et al., 2021; Radu, House, & Pashagumskum, 2014; Tuck, McKenzie, & McCoy, 2014).

In Canada, school science still generally reflects Eurocentric educational models and their worldviews and thus end up excluding Indigenous Knowledge systems that are essential for Indigenous students to build up curiosity and widen their own views and abilities to reconnect with the environment (Michell, Vizina, & Sawyer, 2008). Stressing the importance of land-based learning in science and environmental education, Cajete (1994) argues that western science is already fading away. It is time to embrace land-based learning for the sustainability and longevity of the planet earth and its many diverse cultures. By integrating land-based knowledge, western science gets a new window to develop its capacity as land-based knowledge brings diversity and empowerment. Building bridges between these two (or many diverse) knowledges provides a way to decolonize, interrogate and revitalize. Instead of rejecting or ignoring one another, such blended or cross-cultural approaches enable all these knowledges to thrive (Datta, 2018).

2.3 Cross-cultural approaches

Although United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) is supported by Canada which carries a substantial potential for reconciliation the genuine involvement a of

Indigenous people in decision-making and their right to free, prior and informed consent (FPIC) over their traditional territories is still highly contentious (Papillon & Rodon, 2017). For instance, many recent development projects. These including the Site C dam in British Columbia, Keeyask generating station in Manitoba and the Muskrat Falls hydroelectric project in Labrador continue to exclude impacted Indigenous communities. As a results Indigenous people become frustrated with and struggles against such projects, which in turn impacts on the sustainability and economy of this country which is still largely based on natural resources (Papillon & Rodon, 2017).

In studies where Indigenous and scientific knowledge is integrated or interchanged, it is crucial to involve community members at all stages of research and development and to incorporate their Traditional Knowledge (TK) in respectful ways (Brook & McLachlan, 2008). This interchange of knowledges can bring synergistic results for both communities and outside actors, as this process acts to affirm the local knowledge while also helping influence and even shape scientific insights (Millar & Curtis, 1999). However, such balanced approaches are still relatively rare. According to Nadasdy (1999) TK is generally qualitative, intuitive, holistic, and oral in nature whereas scientific knowledge is usually quantitative, analytical, reductionist, and literate in nature – differences that undermine any integration or more generally common understanding. In their review of the conservation literature, Brook and McLachlan (2008) show that most cross-cultural studies are dominated by scientific understanding and assumptions and indeed act to marginalize the Traditional Knowledge as well as the knowledge keepers themselves. When incorporated at all, Traditional Knowledge takes a bureaucratic form that is amenable to manipulation by industry and government, but which generally fails to reflect the experiences and concerns of impacted communities (Nadasdy, 1999). Nevertheless, on a more optimistic note, when management systems recognize, respect and integrate local knowledge this not only contributes to in-depth observation and understanding but also to emergent philosophical worldviews and a greater likelihood of attaining sustainability (Heaslip, 2008).

Integration of the two approaches is often reflected in education curricula. Yet as reflected in the education-related calls to action that emerged from the Truth and Reconciliation Commission, it was clear that this had yet to be achieved (Truth and Reconciliation Commission of Canada, 2015a). Aikenhead (2002) argues that this is especially true for the sciences. Indigenous people, their land and the fundamentals of learning are particularly impacted by colonialism which

persists in and dominates most educational institutions and fields of studies, including the sciences and social sciences (Burgart & Hutchins, 2019; Johnson et al., 2016).

To address such gaps, educators and Indigenous scholars throughout the world are trying different ways to evaluate and comprehend the barriers to education, especially with respect to science education that otherwise leads to the marginalization of students whose cultural backgrounds are distinct from conventional science and to ease any differences in and barriers confronted by cross-cultural scientific learning (Aikenhead & Michell, 2011). Azam and Goodnough (2018) also suggest that to encourage and involve Indigenous youth in STEM classrooms, more efficient and culturally knowledgeable educators are also needed. Scholars suggest initiating more cross-cultural approaches, such as the K-12 STEM outreach program in northern Indigenous communities (Bonny, 2018) in order to encourage greater youth interest and success in STEM curricula. The presence of Indigenous worldviews or cultures in curricula and the ways these translate into school science education is, in turn, predicated on the engagement of Indigenous communities in these processes (McRae, 2018).

2.3.1 Two-eyed seeing

Most cross-cultural approaches follow the guiding principle of "Two-Eyed Seeing", Albert Marshall, a respected Indigenous scholar and Elder of the Mi'kmaq Nation brought "*Two-Eyed Seeing*'' into academic circles. 'Etuaptmumk' is the Mi'kmaw word for Two-Eyed Seeing. He specifies that 'Etuaptmumk' or

> "*Two-Eyed Seeing is the gift of multiple perspective treasured by many Aboriginal peoples*."

It can be referred as -

> *"learning to see from one eye with the strengths of Indigenous ways of knowing and from the other eye with the strengths of Western ways of knowing and to using both of these eyes together"* (Hatcher et al., 2009, p1)

The application of the Two-Eyed Seeing, that is the integration of western science and Indigenous knowledge, requires that the best of the two approaches or worldviews be brought to one place where no one approach is dominant over the other (Azam & Goodnough, 2018). Doing so is challenging in the present world, where the universal (and universalizing) knowledge of science dominates discourse and where government and industry ground decision-making in

science-based narratives regarding land, water and resources without discussing the implications of such decisions with Indigenous communities. Western science deals with noteworthy environmental issues like climate change, ozone layer depletion or toxicity but scientists ignore that these concepts may be relatively inaccessible to communities or local people with different cultural frames and low levels of formal education. On the other hand, some leaders recognize the importance of building community capacity in the sciences so that they can more easily and independently participate in and have influence over such decision-making processes (McLachlan, 2017).

Martin, Thompson, Ballard and Linton (2017) provide a case of an Indigenous community that were greatly affected by one-eyed seeing or the Eurocentric worldview. Sayisi Dene First Nation used to be located in Little Duck Lake but in 1956 they are forced to relocate to a 300 by 600-foot camp near a cemetery on the outskirts of Churchill, Manitoba. This forced relocation was a direct result of one-eyed seeing. In 1956, a biologist shared a photo of large number of caribou carcasses lying along the shore and viewed and promoted the photo as mass killing and waste which threatened the caribou population. However, he completely overlooked the fact, that for millennia, Dene people have been storing caribou meat for cold winters when food supply is low. Without any consultation, the government decided to protect the caribou population and so relocated the Dene community. They were forced to move the camp away from caribou migratory routes, and without the proper food, cloths, were deprived of their place-specific cultural practices which ultimately led to the deaths of 117 people, or 45% of the entire community (Malone, 2016; Martin et al., 2017). Although, the government later understood their mistake, it was too late, and the community continues to bear the consequences of this forced relocation. It is therefore clear that “one-eyed seeing” adversely impacts on Indigenous people. Had the government of that time – or of this time - tried to communicate with this and other communities and to incorporate their values and knowledges, they would have understood their cultural, norms and way of living. But failure to do so brought – and continues to bring - disaster.

Consequently, to deal with any environmental crisis and to protect the environment from degradation, the importance of acknowledging traditional practices based on Indigenous knowledge and integrating these with western science or knowledge cannot be denied. However, differences in power and influence need to be acknowledged and acted upon for two-eyes seeing to be successful. If these power imbalances remain, the status quo will never change. It is important

to bring an equal distribution of power among actors and in a way that all such marginalized voices can be heard. A community-based monitoring programme uses a 'three-track' methodology and this methodology provide a encouraging example of alternative way to serve the demand of marginalized communities since it ensure strategic participation and production of their own scientific knowledge (Blacker, 2021; McLachlan, 2014).

2.3.2 Science-based outreach and exchange of knowledge

Indigenous people, their land and the fundamentals of learning are particularly impacted by colonialism which continues to persist and dominate educational institutions and fields of academic study, including the sciences and social sciences (Johnson et al., 2016). Consequently, STEM curricula and related employment fail to affirm Indigenous knowledges and the life experiences and worldviews of Indigenous students (Burgart & Hutchins, 2019). When Indigenous culture and the culture of science reflect enormous differences, then it can act as a barrier or make science unfamiliar or even hostile to Indigenous students as they often grow up seeing the world in way that differ from science and which have special connections to the land, cultures and language. To peruse more meaningful and efficient involvement in decision-making regarding environmental policies and developmental projects, it becomes important for Indigenous communities and institutions to initiate science programs that reflect their own cultures and values and to enhance influence over existing policy frameworks (Diver, 2016; 2017). To boost-interest, involvement and insights about science and its applications, various community engagement programs, communication and outreach activities are initiated, and instead of including only scientists, these initiatives also engage local expertise so that they can celebrate diversity and develop awareness (CAiSE, 2021; Davison, McCauley, Domegan, & McClune, 2008). Such science camps and clubs, and outreach programs play a significant role in fostering curiosity around science and technology and to help develop youth skills for the future (DeCoito & Gitari, 2014; Rahm et al., 2005). Moreover, instead of a closed and confined environment, more casual and interactive settings for learning science are attractive to the youths, especially those who are from a marginalized communities and have less access to and tolerance for more formal teaching pedagogies (Rahm et al., 2005). In Canada, after the 94 Calls to Action from TRC, several innovative initiatives approached Indigenous youth to expand their engagement towards STEM (e.g. 10). Some of these initiatives consider that the integration of Indigenous wisdom and teaching through STEM outreach can provide a more secure place for the Indigenous youth to include their

own insights and experiences (Burgart & Hutchins, 2019). Developing potential leaders and inspiring the youth are the two concerns of Indigenous communities which lead them to initiate Two-Eyed Seeing with respect to STEM disciplines. Instead of introducing an ordinary outreach program for Indigenous youth, such approaches recognize the significance of Indigenous knowledge, value the knowledge keepers-Elders and the role of non-Indigenous scientists in these projects (Burgart & Hutchins, 2019). The integration of Indigenous knowledge on the environment or any impacts on the environment to *scientific discourse* is also desired by the Indigenous communities because this exchange of knowledge provides them with not only recognition of their cultural traditions but also a place for their resource management and decision making regarding these issues (Huntington, 2008).

2.4 Environmental impacts on Environment

2.4.1 Environmental Extraction

In today's world, to sustain most of the critical economic activities, basic supplies are needed which are predominantly reliant on the possession and conversion of the extracted goods from natural resources; mining, oil, gas and agriculture, for instance (Schandl et al., 2016; Schrecker, Birn, &Aguilera, 2018). However, the adverse consequences of these extractions on the environment are inevitable, including alteration in land use, erosion, land degradation, loss of biodiversity, eutrophication, groundwater contamination, flooding, deforestation, toxic pollution and so on (LeClerc & Keeling, 2015; Schandl et al., 2016). Sound air and water quality are some of the most crucial requirements for human health, but environmental decline causes serious illness among people living in close vicinity to degraded sites (NIEHS, 2016). Environmental (in)justice has emerged as an essential concept in North America and was legislated into being by Bill Clinton's Presidential Proclamation in 1993. It has, thus, been defined as

> *"the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies"* (Environmental Protection Agency, 2014, p01).

Indigenous people and communities are closely related and dependent on their local environment for their cultures, traditions and livelihood, so any adverse impacts on the

environment can affect their way of living more significantly. According to Simpson (2002), (Boiral, Heras-Saizarbitoria, & Brotherton, 2020) throughout history, a wide diversity of environmental issues has been encountered by the Indigenous people, which can profoundly affect their traditional way of living. Such degradation is aggravated by colonialism, which further undermines the ability of these people to affect related decision-making or even to advocate for their own rights.

Such disproportionate impacts include flooding in Northern Manitoba (Pimicikamak Cree Nation and O-Pipon-Na-Piwin Cree Nation) and southeastern Ontario (Simpson, 2002) due to hydroelectric development that have little effect on neighbouring (non-Indigenous) urban populations. Indigenous communities confront daily struggles not only for drinking water but also their legally enshrined rights to sustain livelihoods through hunting, fishing, and trapping (Atlin & Gibson, 2017; Datta & Hurlbert, 2019).

In Alberta, Canada due to oil sands development, Indigenous communities noticed alterations in water both in quality and quantity, which leads to algal bloom and subsequently changes in fish health. But government reports or research papers find little if any substantial impacts on the environment much less human health (D'Souza & Parlee, 2016; Natcher et al., 2020). The struggles of Mohawks of Akwesasne in Quebec for their health, land, environment and food and wildlife which are still in the risk of industrial contamination, along with mining (Simpson, 2002), The Innu Nation has faced low-level military flight testing – and now hydro-related flooding in Muskrat Falls - on their land in Labrador (Simpson, 2002). In New Brunswick, in spite of discrimination from the Department of Fisheries in Oceans and hostility by non-Indigenous people, Burnt Church First Nation still practice their traditional activity-fishing lobster (Simpson, 2002). In British Columbia, Blueberry River First Nation suffers socially, economically and culturally as the consequences of the development projects like dams, oil, gas and mine extraction have not yet appropriately handled (Atlin & Gibson, 2017). Instead of focusing only on specific impacts including direct exposure of any resource extraction processes (oil and gas extraction, mining), research should also focus on people who bear the greatest consequences. Yet the impacts of these projects on their health and wellbeing are rarely studied (Brisbois et al., 2019). To address such health issues and to cover the gap in research, more participatory approaches are introduced in research which include local or Indigenous ecological knowledge and engage and

empower the community people who are either Indigenous or otherwise marginalized as they work to mitigate adverse impacts and to assert their own rights (Brisbois et al., 2019; Buse et al., 2018).

***2.4.1.1 Mining*:** People living near mining industries, local or Indigenous, encounter high risk of health hazards due to the increasing bioaccumulation of heavy metals in plants, fish, livestock and wildlife through contaminated surface and groundwater and soils (Bundschuh et al., 2012). In Canada, Newfoundland and Labrador (NL) is well known for its ample supply of Uranium (U). While sites such as the Kitts–Michelin mine was actively worked for decades, the project was stopped after the disapproval by the nearby communities (Makkovik and Postville) due to the lack of their involvement in the project planning and impacts on environment – as well as a reduction in market price for uranium (Wilton 2010; Sarkar et al., 2019). Although the government tried to close off the adits and bury some part of the radioactive piles, they are still exposed where Inuit people hunt, trap and fish. Consumption of traditional foods like fresh and dried caribou meat, rabbits, berries, and fish expose communities to residual contaminants and have adverse impacts on their health (Sarkar et al., 2019).

***2.4.1.2 Agriculture*:** In total, 527,000 km2 of land are designated as agricultural use in the Prairies (the south portions of Alberta, Saskatchewan and Manitoba) of Canada (Farenhorst, Andronak, & McQueen, 2015). The Prairie region started to experience a dramatic change in agricultural practice and an increase in crop production through the introduction of commercial synthetic pesticides, especially broad spectrum herbicides like Glyphosate, the development of new cropping systems and the introduction of commercial no-till seeding equipment (Awada, Lindwall, & Sonntag, 2014). Despite the economic significance of using pesticides in agriculture, several studies have found that pesticide residues in the environment are associated with the non-target species decline including plants, animals, wild bird populations, beneficiary insects, and fishes (McLaughlin & Mineau, 1995; Pimentel et al., 1992; Wilson & Tisdell 2001;).

Swan Lake First Nation (SWFN) has long shown their concerns about the use of pesticides in the on-reserve lands leased to neighbouring farmers and the surrounding cropland in southern Manitoba (McLachlan, 2018). It is apparent from a recent report (cited in McLachlan, 2018) prepared for the Wa Ni Ska Tan Alliance of Hydro-Impacted Communities that many members of SLFN are concerned about traditional use plants and medicines such as berries, sage, weekay (*Acrorus calamus*), and sweetgrass. In the report, they stated as

"...on what everyone is doing to Mother Earth such as water, air and other aspects of environment. There are planes spraying pesticides. What are the results on plants, water, humans (breathing)?" (p24)

Their concerns cannot be overlooked as several studies show how the use of pesticides can adversely affect non-target species; for instance, the combined use of shade, slug predation and spraying of an herbicide led to the eradication of the rare plant Purple Twayblade (*Liparis liliifolia*) from at least one site in Canada. Endangered Prairie species like the Burrowing Owl (*Speotyto cunicularia*) has found affected by the use of Carbofuran (liquid form) (McLaughlin & Mineau, 1995). One of the significant drivers of pollinator decline in Northern Europe is associated with the decline of wildflowers associated with the use of herbicides and flower shortage for flower-visiting pollinators (Biesmeijer et al., 2006). Despite such indications, the implications of pesticide use for Indigenous communities have received little attention in the literature. No significant studies have done yet considering their point of view associated with the use of pesticides and their impacts on traditional ways of living. Due to the lack of scientific studies and evidence, their predictions and concerns are generally ignored, as those are mostly based on their traditional knowledge.

***2.4.1.3 Pulp and paper industry*:** Abundance of natural resources including wood, water, energy, and rising marketplace make it possible for Canada to become one of the leading exporters of pulp and paper products (Bogdanski, 2014; Hoffman et al., 2015). However, by the late 1980s researchers started to document aquatic discharges of effluents containing dioxins and furans from these mills that could have chronic impacts on fish reproduction even at low concentrations (Hewitt, Parrott, & McMaster, 2006; Kringstad & Lindstrom, 1984; Munkittrick, Mcmaster, & Servos, 2013). The outcome Swedish findings played a vital role in Canada, as they prompted studies that examined possible impacts on nearby fish populations and gave rise to standard monitoring programs and associated changes in rules and regulation along with other countries throughout the world (Hewitt et al., 2006; Munkittrick et al., 2013). Evan though a large amount of money is still spent on research either funded by government or industry to mitigate the environmental impact caused by the discharged effluent, fears in nearby Indigenous communities have not dissipated (Lewis, Francis, Francis-Strickland, Castleden, & Apostle, 2020). For instance, the A'se'k – a culturally significant tidal estuary - was the site of food, resources, medicines and spiritual ceremonies for the nearby Pictou Landing First Nation (PLFN), a small Mi'kmaw community in Nova Scotia

(Castleden, Bennett, Lewis, & Martin, 2017; Lewis et al., 2020). However, the provincial government allowed for the dumping of 85 million litres of effluent per day into the A'se'k from the nearby bleached Kraft pulp mill from 1967 until January 31, 2020 (Castleden et al., 2017; Lewis et al., 2020). PLFN lost interest in using the A'se'k for any cultural purposes due to well-warranted concerns about effluents and contaminants. Castleden et al. (2017) documented some of the stories of PLFN community members,

> *It is too bad what happened there; it was such a beautiful place. So now nobody goes down there to hunt or trap, get eels or smelts, snare rabbits or fish…nothing grows there or lives there anymore, and if it did—we would not trust it. Our community has lost their trust in that food, and our connection seems to have suffered too* (p29).

Therefore, it is essential to consider the relationship between Indigenous people with their surrounding environment - air, land, water - when dealing with the impacts on environmental health because these have been disregarded throughout history (Lewis et al., 2020).

***2.4.1.4 Hydroelectric dams*:** Many development projects, including mega dams related to the generation of hydropower, cause adverse impacts, including changes to the flow of rivers, environmental contamination including methylmercury, changes in fish and wildlife populations, and the displacement of entire villages, all of which contribute to a loss of resources, livelihoods and traditional ways of living (WCD, 2000). Mega dams are being built throughout the Global South, including those in the Amazon in Latin America and the Mekkong Delta in Asia, and in many locations across Canada.

Manitoba bears a 100-year history of dam-related impacts on First Nation communities, including the Churchill River Diversion. Manitoba Hydro has constructed many such projects including those associated with the Nelson and Churchill rivers, which have always been considered as significant source of hydroelectric power. Accompanying the development of hydroelectric generating stations on the lower Nelson River, construction on the Churchill River diversion began in 1976 (Martin & Hoffman, 2008). This diversion project and Lake Winnipeg Regulation projects were always regarded as the way of modernization (Hoffman, 2004). However, these projects have in truth had devastating impacts on environments and failed to even

consider the long-term negative cultural and economic impacts on South Indian Lake and five other First Nations communities (Kamal & Thomson, 2013; Kulchyski, 2012). Due to the project-related flooding, O-Pipon-Na-Piwin Cree Nation (OPCN), residents of South Indian Lake were forced to relocate to a nearby inadequate, undeveloped settlement without proper compensation (Kamal & Thompson, 2013; Waldram, 1984; Wa Ni Ska Tan, 2019). It also led the collapse the third largest freshwater fishery in North America, which in turn had substantial adverse impacts on the local economy and the wellbeing of this community and other nearby communities.

Les Dysart, CEO of the Community Association of South Indian Lake, Inc. (CASIL) in an interview with APTN mentioned that,

> *"Hydro operates this lake to extreme water levels and extreme fluctuations – de-watering of the lake, so to speak, four-and-a-half feet. And with some science, we've proven that collapsed our lake whitefish population, which is the backbone of our fishery"* (APTN, 2020).

Another project in Northern Quebec, the James Bay hydroelectric project and the floodwater from the project impacted greatly on the Waswanipi First Nation by interrupting community's oral tradition of storytelling by which Elders convey their wisdom and knowledge about their tradition and cultures to the next generation (Martin et al., 2017). Hence, it is evident that such development projects adversely affect many Indigenous communities when it comes to environmental pollution and with respect to impacts on land, safe drinking water, and traditional ways of living. Yet these same communities realize few if any of the benefits associated with the projects.

2.4.2 Drinking Water Advisories (DWA)

To sustain life or physical well-being, water is undoubtedly most fundamental component and should be accessible to all (World Health Organization, 2017). For Indigenous people, water is more than life; many regard it as spirit, and it is one of the key belief for them (Anderson, 2010). Canada is well-known for its abundant natural fresh water and, in fact, the country ranks fourth in the world in terms of providing renewable freshwater annually (Bradford et al., 2016; Wood, 2013). Yet more than 100 Indigenous communities still do not have access to safe drinking water and year after years boil drinking water advisories (DWA) continue among the First nation communities (Bradford et al., 2016; David Suzuki Foundation, 2018). Safe drinking water has

been and is still a burning issue in many First Nations communities in Canada. Instead of clean water, many get most exposed, 'high risk' water systems which make them more susceptible to waterborne diseases and other possible exposures compared to the non-Indigenous Canadians (Anderson, 2010). The World Health Organization (2017) indicates that drinking contaminated water can lead to serious health hazard and to avoid that initiatives should be taken to enhance drinking water quality whenever needed.

According to Government of Canada (2020), as of December 2020, 58 long-term (LT) DWA are in effect in 40 communities; LT-DWA refers to "long-term drinking water advisories which have been in effect for more than 12 months". To keep people healthy and to prevent from drinking contaminated water, drinking water advisories are put in effect as a preventative action. Equipment breakdown, inadequate disinfection or delayed in emergency repairs of water treatment or distribution systems are some of the most common reasons for these drinking water advisories (FNHA, 2021). Indigenous Services Canada, Health Canada, and Environmental Canada- are the three federal departmental body responsible for drinking water safety (Bradford et al., 2016). Generally, FNHA's Environmental Public Health Services (EPHS) provide advice on safe drinking water and the leadership in each community is responsible to execute the advisory along with others required actions including infrastructure, maintenance, monitoring and proper functioning (Bradford et al., 2016; FNHA, 2021).

On the contrary, over the past two decades, proper and impartial distribution and ensuring of safe drinking water for Indigenous community has become the topic of debate and the complicated regulatory body for drinking water has actually aggravated such disparities (Mascarenhas, 2007; Bradford et al., 2016). Gaps in management, discrimination and ignorance lead many Indigenous communities to battle against water-borne diseases and the effects of water contamination on nerarby environments. For instance, in 2005, due to a possible threat to the quality of potable water and despite being under a boil-water advisory since 1996, 1000 members of the fly-in Kasechewan First Nation in Ontario were relocated and thereafter subjected to mitigative measures including water chlorination to combat diseases associated bacterial contamination (Eggertson, 2006). Obviously, many such concerns related to these drinking water advisories reflect underlying concerns about water quality.

2.4.3 Water quality

The term "water quality" refers to the "express the suitability of water to sustain various uses or processes" (Bartram & Ballance, 1996, p07). Depending on the use of water the need or standard of water quality parameters varies. Canada ranks ninth in the world for water quality based on parameters like dissolved oxygen, pH, conductivity, phosphorus, and nitrogen but industrial development and growing population lead the disposal of contaminants (industrial, municipal or farming) in many of its lakes and rivers which eventually degrade the quality of aquatic ecosystem including fish, raw water for drinking water distribution, and other aquatic creatures (CCME, 2003; Wood, 2013). Concern regarding water quality, either for drinking or aquatic life, is rising across the country especially among Indigenous communities as they have been struggling with this issue for decades. Use of proper indicators or parameters and standard range to measure the parameters is required to deal with the water quality issues (CCME, 2003). For safe drinking water and to prevent contamination and protect aquatic environment, standard guidelines are followed based on scientific procedures where national standards may be included and preference is also given to socio-economic, cultural and environmental context (World Health Organization, 2017). Several parameters (physical, chemical and microbial) are reviewed in order to determine the quality of water (Table 2.2). Some of the notable ones are: color of water; pH-a important parameter that relates to ammonia toxicity and microbial activity; Turbidity- a measure of cloudiness or haziness of a liquid; Dissolved Oxygen (DO), the amount of oxygen dissolved in water or available to aquatic life and closely related to the effects of eutrophication; Total Coliform, sources of which are human and other animal faeces and presence of which indicates a serious disturbance in treatment facilities; and Thermotolerant Coliform or Fecal Coliform, the presence of which indicates faecal contamination and as well as possibilities of presence of other harmful disease-causing pathogens and gastrointestinal illnesses (Table 2.2) (Health Canada, 2019; World Health Organization, 2017).

Table 2 2: Key parameters for water quality as defined by Health Canada (2019) and WHO (2017)

Parameters	Description	Use and Impact	MAC[1] (mg/L)
pH	Generally, pH is a measure of a liquid whether it is acidic or alkaline.	One of the most significant parameters of water quality as it relates to many Other parameters like ammonia toxicity, microbial activity	7.0 to 10.5 Acceptable pH range for fully treated or finished water
Turbidity	It can be described as a measure of cloudiness or haziness of a liquid.	Presence of suspended particles including clays, silts, metal precipitates or decomposed plant and animal debris, microorganisms in water diminishes its transparency. Turbid water promotes or increases bacterial activity in water.	1.0 NTU[2] or less when water enters the distribution system and individual filter results for treated water must be less than 0.1 NTU
Color	Color varies due to the presence of coloured organic matter and is influenced by the presence of iron and other metals	Use as a physical indicator and high level of change in color should be further analyzed to determine other related changes in quality of water.	No health-based guideline value for drinking water
Dissolved Oxygen (DO)	Amount of oxygen dissolved in water or available to aquatic life. It is influenced by the source, raw water temperature, treatment and chemical or biological processes	Low level of dissolved oxygen in water promotes the microbial reduction of nitrate to nitrite and sulfate to sulfide, and increases in the concentration of ferrous iron in solution. Closely related to the effects of eutrophication.	No health-based guideline value for drinking water
Chlorine	Chemical element that has multiple application both industrially and domestically	Mostly use for disinfecting and bleaching in water treatment facilities	None required
Fluoride	Naturally occurring (due to rock and soil erosion)	Moderate dental fluorosis	1.5
Ammonia	Compound of nitrogen and hydrogen and highly soluble in water.	Agricultural and industrial wastes, natural processes are some of the sources as its use as an additive in disinfecting water with chloramines. In water, acts as an indicator for possible bacterial or other contamination	None required
Nitrate	Forms of nitrogen, naturally occurring and produced through	Agricultural runoff, use of fertilizer and domestic sewage, animal wastes are some of the sources. Bottle-fed infants are more susceptible to nitrate and nitrite	45 as nitrate; 10 as nitrate-nitrogen[4]
Nitrite			3 as nitrite;

[1] MAC-Maximum Acceptable Concentration according to Health Canada

[2] NTU-Nephelometric Turbidity Units: Turbidity is measured in NTU by using Turbidimeter which measures the intensity of light scattered at 90 degrees as a beam of light passes through a water sample.

[4] nitrite or nitrite-nitrogen – can be measured as either way

	ammonia during nitrification.	exposure (Methemoglobinemia)[3] through drinking water. Under certain conditions, it can also be carcinogenic	1 as nitrite-nitrogen[5]
Lead	Naturally occurring heavy metal found in the earth's crust.	Responsible for much environmental contamination. In drinking water or distribution systems, leaded pipeline are most common sources for lead. Children are most sensitive to lead toxicity.	0.005 (as low as reasonably achieved)
Copper	Naturally occurring essential element but in water, it's a contaminant	Sources in water largely due corrosion of inner copper plumbing. In short run, has gastrointestinal effects but in long run can affect liver and kidney	2.00
Arsenic	Naturally occurring element in the earth's crust and also exist in natural water	Carcinogenic, skin diseases, neurological effects as well	0.010 (as low as reasonably achieved)
Total Coliform	Sources are human and animal faeces; it is naturally occurring in water, soil and vegetation	Presence indicates a serious disturbance in treatment facilities, regrowth of the bacteria in distribution and storage systems and vulnerability to contamination in non-disinfected groundwater	None detectable/100 mL in water leaving a treatment plant and in non-disinfected groundwater leaving the well
Thermotolerant Coliform or Fecal Coliform	Sources are human and animal faeces (more than 95% as isolated from water are Escherichia coli *(E. coli*) so its presence can be regarded as the presence of *E.Coli*)	Presence indicates faecal contamination and as well as possibilities of presence of other harmful disease-causing pathogens and gastrointestinal illnesses.	None detectable/100 mL

2.5 Community-based monitoring

Boiral et al. (2020) indicate that the involvement of and collaboration with Indigenous communities are an integral measure when developmental or extractive projects impact the environment around them as they feel compelled to protect the places because of their cultural significance and the fundamental source of their traditional foods. It is thus recommended that communities be engaged, if at all possible, especially of adverse impacts are anticipated. Although there has been a noticeable rise in references to Indigenous engagement and cross-cultural collaboration when it comes to natural resource management or environmental research, authentic and meaningful collaboration and building trust and capacity for the future is still lacking (Bullock,

[3] Methemoglobinemia -Known as blue baby syndrome- can increase the risk for bottle-fed infants significantly through the presence of microbial contamination and subsequent gastrointestinal infection

[5] nitrite or nitrite-nitrogen – can be measured as either way

Kirchhoff, Mauro, & Boerchers, 2018; Reo, Whyte, McGregor, Smith, & Jenkins, 2017; Wyatt, Fortier, Natcher, & Hébert, 2013).

It has been observed that when a community is directly affected or assume to be impacted by any environmental problems, communities tend to look for scientific expertise to obtain advanced technical knowledge, even appointing such experts as consultants to address the gaps and evaluate the issues (Bocking, 2019). Involvement of such consultants does little to reduce community reliance on this outside expertise and has amounted to a billion-dollar industry in its own right with little direct benefit for communities. Moreover, the quality of the science is often inadequate, especially when higher standards such as those required by court systems are required and ultimately do little to alleviate community concerns regarding declines in the environment because the data are so poor. Another more productive approach that addresses all these shortcomings is the implementation of community-based monitoring (Bocking, 2019). Therefore, in the long run, Indigenous communities need to develop capacity among them especially around science so that they do not need to seek outside expertise and can then contribute directly to the sharing of information and concerns or decision-making priorities regarding any environmental issues.

Whitelaw, Vaughan, Craig, & Atkinson (2003) defined Community Based Monitoring (CBM)

> "*as a process where concerned citizens, government agencies, industry, academia, community groups and local institutions collaborate to monitor, track and respond to issues of common community concern*" (p 409).

Cross-cultural approaches to CBM go one step further in that they are grounded in both knowledge systems (Wilson, Mutter, Inskster, & Satterfield, 2018). Such approaches can play a key role in sustainability and in adaptive management. CBM can engage local citizens or communities in data collection and the evaluation of monitoring data, which potentially brings a balance between communities and scientists in the research process. The efficacy of CBM depends on the integration and balance of both local knowledge and scientific data in a way that each complement and affirms the other (Brook & McLachlan, 2005). Hence, an effective CBM approach encourages and ensures the involvement of citizens by signifying their contribution in environmental management, participatory community development and policy implementation (Brook et al.,

2009; Pollock &Whitelaw, 2005). Depending on the various approaches applied in the literatures, participation in CBM can be categorized in four ways including the consultative (when scientists reach out to citizens in a peripheral way), the functional (when outreach is operational but defined by scientists), the collaborative (when the involvement of both scientists and citizens is meaningful and shaped by both parties) and the transformative (where the involvement of citizens works to address some broader environmental or social injustice). (Lawrence, 2006; Conrad & Hilchey, 2011). Some notable examples mentioned by Conrad & Hilchey (2011) include the Citizen's Environment Watch (1997), which was launched in communities across Ontario and has worked with hundreds of community groups and school youth to assess the health of local water bodies. Another is the Global Community Monitor (2006), which trained villagers in India in the science of pollution and engaged them in environmental monitoring. This work not only led to the publication of scientific reports over time but also acted as a baseline for the Supreme Court order calling for the establishment of national standards for toxic gases in ambient air. Some cases focus on Inuit fishers and hunters in the Canadian Arctic where they use CBM and their Indigenous knowledge to support the integrated management of marine ecosystems on which their subsistence depends (Berkes, Berkes, & Fast, 2007).

In their review of the CBM literature, Pollock &Whitelaw (2005) suggest that in order to develop the conceptual framework for CBM three general features should be covered, notably the 'Context' (where these initiatives are set according to the community context and are respectful of local culture); the 'Iterative' (easy and flexible for capacity building and repeated use of components at different stages of the projects) and the 'Adaptive' (where sustainability is achieved by stimulating reflexivity as denoted by adaptive environmental management). The motivation which drives involvement in CBM is the desire of participants to 'make a difference' by sharing the monitoring results and to influence decision-making and policy implementation. The success of CBM ultimately relies on strong coordination, collaboration, and sustained participant motivation as well as to what degree these initiatives reflect local priorities and cultural values (Pollock &Whitelaw, 2005). That said, a recent review of" participatory" CBM projects shows that even these initiatives suffer from uneven citizen involvement, this generally restricted to the stage of data collection rather than project design, data evaluation or subsequent outreach, all of which are dominated by scientists (Turreira-García et al., 2018). Most still acted to exclude the priorities of impacted communities, especially Indigenous communities (Turreira-García et al., 2018).

Brook et al. (2009) concluded that to initiate cross-cultural community-based monitoring for resolving environmental issues and deepening the community's network, an additional robust and sustained relationship between Indigenous knowledge and western science knowledge keepers is required.

Chapter 3: Methodology and Methods

3.1 Methodology

The worldview that shapes or informs the ways any researcher develops or build their research questions or objectives and in turn the methods they use to execute their research is generally referred to as *methodology* whereas the *methods* themselves refer to the tools and techniques by which results are obtained and analyzed (Giddings, 2006). In designing my research methodology, I mostly rely on Indigenous research methodology, to understand how to work respectfully with Indigenous people, as well as participatory action research. My background and worldview as an international student also help me make the research a more meaningful mode of action of bringing about change as I will discuss below along with some basic concepts that support and sometimes help to form those methodologies.

3.1.1 Role of theories

Collins and Stockton (2018) state that theory is a source of immense descriptive capabilities in the form of a larger concept that can assemble many others, and the researchers utilize a theory or theories in a conceptual framework to view the progression of their research. To perceive appropriate methodological options, develop research questions and distill goals and objectives, and finally data validation, the support of underlying theory at some point in this process is crucial (Collins & Stockton, 2018). Theories may evolve or develop over time or be created as entirely anew. According to Creswell (2014) “a theory might appear in a research study as an argument, a discussion, a figure, or a rationale and it helps to explain (or predict) phenomena that occur in the world” (p54). All three modes of research including quantitative, qualitative, and mixed methods use theory. Regardless of some “atheoretical” studies, generally, most academic studies at least make explicit use of theory to posit and test ideas and even hypotheses when referring to quantitative and mixed methods research. Theory similarly shapes most qualitative research, although the stance and importance of theory is sometimes challenged (Leeming, 2018).

3.1.2 Inductive vs deductive approaches

Soiferman (2010) points out that there are largely two processes underlying research-inductive and deductive, although the relative importance of each is still discussed. When talking about research approaches normally well-organized/defined deductive approaches are mostly associated with quantitative research methods whereas those derived from applied data and inductive approaches are generally associated with qualitative research (Wyk, 2015). Creswell (2014) concedes that theory is used in most quantitative studies as an object and is subjected to testing and verification through the collection of data whereby any results are used to interpret the fate of the theory in a process that is generally referred to as deduction. On the other hand, he points out that the use of theory in qualitative research varies substantially as the researcher starts the study by collecting data collection and from those data emerge themes that are then generalized into theory or conceptual frameworks, a process known as induction (Cresswell, 2014). In general, it can be said that deductive approaches progress from the 'general to specific' and requires laws, regulations or ethics to form any given stance whereas inductive approaches progress from the 'specific to the general', which comprise involvement with participants, experiences with reality, and observation that gives rise to opinion or insight (Soiferman, 2010). My research is very much grounded in an inductive approach.

3.1.3 Grounded theory

Grounded theory (GT), a methodology that is structured by also flexible was originated by Glaser and Strauss in 1967 (Chun Tie, Birks, & Francis , 2019). For critical qualitative inquiry, the constructivist version of GT "fosters asking probing questions about the data and scrutinizing the researcher and the research process" (Charmaz, 2017, p35) . This constructivist version is an earlier adaptation which then confronted a *epistemological shifts and methodological innovations* that formed the base for GT (Charmaz, 2017). Researchers tend to employ GT when prevailing theories fail to fit with the research process, whereby conceptual approaches engender solely from research data, which in turn articulate with and sometimes challenge larger theories (Elkatawneh, 2016). Charmaz and Belgrave (2019) thus define GT as "an iterative, comparative, and interactive method that begins with inductive data and an inductive, emergent method, which researchers not only can use to conceptualize their data but also to construct imaginative theoretical interpretations" (p743). Hence, the intention is to initiate a theory using an inductive approach arising from data no matter which categories (traditional,

evolved, or constructivist) of GT are involved. Thus, GT works best when insights underlying any given study are limited (Mills, Birks, & Hoare, 2017).

Constructivist GT poses some differences as their focus includes social justice and inequality, such that the constructivist believes that it is the researcher who analyzes the data and classifies rather than theory, and that it is important to be fully aware of and accountable to the process that give rise to research, which in turn holds researchers accountable to participant priorities and experiences, untold stories and intimate conversations (Birks, Mills, Francis, & Chapman , 2009; Charmaz, 2017). In my research, theory plays a role that is secondary to the values and aspirations of all participants, although it is subsequently employed to help make sense of and to generalize the place-based and culture-based specifics of the data.

3.2 Participatory Action Research

As my research focuses on Indigenous communities and their associated concern and wanting to work with them respectfully, I chose Participatory Action Research (PAR) to help ensure that the outcomes had direct and applied beneficial impact.

3.2.1 Action Research

Like its name, Action Research (AR) is focused on action and bringing about social and political change through research, such that it possesses a great amount of flexibility and evolves throughout the process (Dick, 2014). Greenwood and Levin (2007) described AR "as a set of collaborative ways of conducting social research that simultaneously satisfies rigorous scientific requirements and promotes democratic social change" (p2). Based on a participatory worldview, advocates of AR work against inequality and discrimination, while challenging positivist approaches to research that claim to produce knowledge by being value-free and neutral (Brydon-Miller, Greenwoord & Maguire, 2003). A key objective of AR is to generate knowledge that values the daily and often innocuous activities of a person's life, such that this knowledge can play a significant role in maintaining a sustainable association and balance between humans and nature (Reason, Bradbury, & Swantz, 2014).

3.2.2 Participatory Research

Empiricism and positivism have been the most influential research paradigms over the last 100 years and indeed the only approach used until the 1960s, emphasizing rigorous experimental design, statistical accuracy and replicability. Beginning in the early 1970s, a more practical research methodology was first developed in Tanzania; termed "Participatory Research (PR)", this approach shifted the locale of knowledge production from scholars and scientists to marginalized , less privileged people (Hall, 1992).

Hall (1992) draws parallels between Participatory Research and Participatory Action Research (PAR), describing them as "a practice that attempted to put the less powerful at the center of the knowledge creation process; to move people and their daily lived experiences of struggle and survival from the margins of epistemology to the center" (p15). In order to reduce bias and to generate credible knowledge, it is usually considered crucial that scientists or more generally researchers be impartial, independent, and disconnected from the research or field of study. However, Anderson and McLachlan, (2016) argue that with this positivist worldview, scientists or researchers are the only generators or producers of knowledge, and that users of this knowledge are generally limited to certain powerful actors - for instance, government, professionals, or industry. As a result, the most important actor - community or the people who are ultimately most impacted by the research - are hardly involved and ultimately have little influence over either the processes that underlie research or its outcomes. However, participation is not the only solution. Without providing the opportunity for participants to share power and to govern their involvement, any true meaning of participation and democratization cannot ultimately be achieved (Greenwood & Levin, 2007). PAR as a subgenre of AR concentrates more on 'democratization' which means everyone's opinions matter and should be meaningfully incorporated during knowledge production (Fals Borda, 2001). The goal of this knowledge generation is to share control and power with and among people so that it can be used to challenge social injustice. PAR not only strives for social change through the pursuit for knowledge but does so in a way that positions between researchers and the researched shift such that people collect and are connected around otherwise intractable problems and together generate solutions regardless of their societal status in ways that, in turn, resolve these problems (Fals Borda, 2001; Reason et al., 2014; Stapleton, 2018). My research is action oriented in that it is grounded in the aspirations and values of the participating Indigenous communities and

focuses on tangible environmental problems identified by these communities as important while also challenging the orthodoxy of science in solving these problems.

3.3 Indigenous Methodology

> *"The word itself, 'research' is probably one of the dirtiest words in the indigenous world's vocabulary"* (Smith, 1999, p. 1).

Throughout history, Indigenous people have been subjected to research in ways that they had neither control or power over nor received any benefits from (Smith, 1999). In contrast, Indigenous research methodology is about shifting the nexus of power and providing a voice to Indigenous participants throughout the research process - including generating or gathering knowledge, sharing, engagement, and interpretation, as well as respectful and culturally appropriate representation (Kovach 2010). Kovach (2015) emphasizes four key aspects of Indigenous methodologies including- holistic Indigenous knowledge, receptivity and relationship, reciprocity, and Indigenous methods (i.e. storytelling, oral story, sharing knowledge, and unstructured interviews). Wilson (2001) also recognizes that Indigenous methodology naturally encompasses respect, reciprocity, and responsibility, and thus focuses on the primacy of relationship or more specifically the role of relation or accountability rather than of validity, reliability or statistical significance when shaping research. Smith (1999) argues that the stories of Indigenous people around the world have been viewed and shared through the lenses of colonialism or western research, but that for Indigenous people, these stories are also means of their resistance and source of power in ways that simply cannot be achieved by structured interviews, field visits and note-taking. She also acknowledges that some non-Indigenous researchers do manage to show full respect to the communities that they work with and for, and that the community also learns to accept and trust them to share their stories. Yet, given the long histories of research-associated harm that Indigenous people have experiences, given that they are among the most researched people in the world, and given that these histories inevitably give rise to suspicion and in some cases hostility, it is thus crucial to work in inclusive., sustained and accountable ways that generate trust. Despite such misgivings most research, especially positivistic research, continues to employ a 'parachute' approach, whereby researchers come, take data and exit, in ways that provide communities with little to no involvement anywhere in or benefit anywhere from the research process. Such colonial practices need to be challenged and to be replaced by alternative Indigenous-centred approaches. Community-based participatory research

(CBPR) represents a first, albeit still unsatisfactory, step towards a decolonized methodology that has the capability to foreground community values and priorities when conducting research (Castellano, 2004; Castleden, Morgan, & Lamb , 2012).

3.4 My worldview as an international student

I belong to the land of rivers: Bangladesh, a country in South Asia. I started working on my Masters research in September 2017. Before that, I did not have much insight into Indigenous culture, tradition, treaties, and resistance in either Canada or, for that matter, in Bangladesh. However, back home I always cared about the environment and wanted to work for marginalized people who are impacted by the authoritative decision-making and for people whose voices are rarely heard. After attending several gatherings of Wa Ni Ska Tan (an Alliance of Hydro-Impacted Communities) and getting opportunities to meet and learn from Indigenous leaders and knowledge keepers, I then visited a number of Indigenous communities in northern Manitoba. These experiences all served to accelerate my enthusiasm and motivated me to find out more about their experiences with colonialism and what might role I might play in helping address some of these systemic barriers. Attending two courses on qualitative and community-based research (Qualitative Field Methods for Community-based Resource and Environmental Management (NRI 7360) and Applied Qualitative Research: Making a Difference (GEOG 7010)) not only enriched my knowledge regarding the issues that confront Indigenous communities in Canada but also helped me identify the appropriate steps for employing qualitative research as well as Indigenous research methodologies when doing so. This was especially important since my previous academic background had been mostly rooted in western science and quantitative research.

I visited several hydro-impacted Indigenous communities in Northern Manitoba in 2018 on a regional tour organized by Wa Ni Ska Tan and encountered several new experiences. I remember being in Nelson House Cree Nation while sitting in a camp set in idyllic surroundings and having traditional food comprising homemade bannock and fried fish, freshly picked berries. Peter Kulchyski, a Professor in Native studies at the University of Manitoba and a member of the Steering Committee of Wa Nis Ka Tan, told me that “this is the real Canada, what you are seeing and experiencing, and rest is a replica of the USA”. I still remember vividly those words and the communities I visited, because experiences like those helped provide context and helped develop

the respect and the sense of responsibility that are very much required to conduct research in collaboration with Indigenous people.

Another experience I share with Indigenous people is colonization. Though I have no confront it directly, my grandparents and my ancestors before them did. After 200 years of colonization by the British, our subcontinent got their freedom in 1947. Knowing this history, I can relate how it feels when someone's land, language, and culture are taken away and they are forced to live a life that is imposed from outside. Currently, people that are ethnic minorities in my country still have to deal with a myriad of discrimination that includes burning down their houses, invading their land, and forcing them to abandon their traditional livelihoods – all of which are acts that have confronted and still confront Indigenous communities in Canada.

All these experiences have helped me gain more insight and knowledge about Indigenous people and their cultures in this country, and reinforced my interest in conducting a Masters project that they would be useful in helping address such inequities but that would also reflect my existing background in the environmental sciences. My university education back home focused mostly on chemistry, soil science and aquatic science, including water quality assessment, testing, treatment. Moreover, I had an opportunity to work with adolescents and underprivileged children in the education sector in Bangladesh. I believe these experiences will certainly reflect views from a different lens since they have been grounded in the voices of marginalized people that are unheard by government authorities in a so-called "third world" country. Being a part of a research project that supports youths and helps them raise their voices through traditional knowledge, education, and language while also providing opportunities to learn about western sciences and to protect their environment, their land, and culture undoubtedly represents a once-in-a-lifetime opportunity for me as well.

3.5 Methods

As mentioned earlier, research methods generally refer to the tools and techniques that can be used to generate research results through the collection, analysis, and communication of data (Giddings, 2006). To address my research goals and objectives, a wide diversity of methods has been used in this project, including for instance sharing circles, unstructured interviews, use of portable labs, report design, and environmental data analysis. This land-based and youth-centered education programme, 'Kis Kin Ha Ma Ki Win: Learning Science Through the Land',

provided a platform for me to develop and implement all these methods while addressing environmental issues of local concern.

3.5.1 Kis Kin Ha Ma Ki Win

In 2019, a three-year initiative 'Kis Kin Ha Ma Ki Win: Learning Science Through the Land', was undertaken that enabled Indigenous youth to learn and connect with local Elders and knowledge keepers as well as scientists, and university students. These experiences facilitate the exchange of both Indigenous knowledge and western science in order to protect and stand for their land and water through land-based teaching and learning.

To achieve those goals, a variety of activities were developed and initiated in land-based camps including traditional culture, science, arts, and recreational activities. Since connecting Indigenous youths to Elders and thus their traditional culture and language is one of the primary objectives of this project, many of the activities in this regard took the form of oral storytelling, sharing circles, fireside talks and ceremony and prayer – all of which enabled participating youth to build the connections to their culture and community. The program also made use of portable scientific labs that enabled youth to test water quality according to the needs, concerns and interests of their communities. Different environmental art projects that are designed around water complemented these other activities. The overall purpose of these camps was thus to use a wide diversity of cross-cultural methods in a land-based learning environment that were directed at Indigenous youth so that they could better understand western science through an Indigenous lens while also affirming their own traditions and while playing an active role in better understanding and protecting their land.

3.5.2 Camps

The land-based camps run through Kin Ha Ma Ki Win reflect a common ground of local community concerns and issues related to their environment, Indigenous culture and traditions and appropriate scientific methods. Communities and their priorities are reflected at every stage of the whole process of camp design and implementation. At the very beginning, each community take the initiative to contact the Kis Kin Ha Ma Ki Win coordinator through the project website (www.landscience.ca), which then results in conference calls with the coordinator and principal research investigators. Through these calls, the overall intent of the camps, local community concerns regarding the environment and priorities

regarding youth education are discussed as are possible dates and locations. The following diagram represents how each host community is involved in the development of their camp including initial contact, sharing of any their environmental concerns, involving local youth in camp activities, and the evolution of the reports, all of which they completely control and own.

Figure 1: Different stages of the land-based camps and associated community involvement

3.5.3 Host Communities

In summer 2019, four camps were conducted across Manitoba (in Brokenhead Ojibway Nation, Keeseekoowenin Ojibway First Nation, Sagkeeng First Nation, and O-Pipon-Na-Piwin Cree Nation) and in northwestern Ontario (in Couchiching First Nation). Camps ranged in duration from 3-5 days. Local children and youth aged 8-18 participated in these camps and each camp had no more than 20 participating youth, except for Couchiching where 20 additional children from the community daycare attended and participated in a community feast on the last day of the camp. Participants were taught to conduct water quality tests and collect the data alongside scientists.

Elders offered a historical, cultural and environmental context for these scientific tests and other camp activities and helped to interpret any findings.

Figure 2: Location of the five First Nations communities that hosted land-based camps in 2019
Source: https://ontheworldmap.com/canada/province/manitoba/large-detailed-map-of-manitoba-with-cities-and-towns.html

3.5.3.1 Brokenhead Ojibway Nation (date of camp: July 8-10, 2019)

Brokenhead Ojibway Nation is a signee to Treaty 1. It consists of 2,112 people (802 on reserve and 1311 off-reserve) and is situated 75km northeast of Winnipeg, Manitoba (Fig 2 (#1)). The core reserve (Brokenhead 4) is partially situated along Lake Winnipeg and in the Rural Municipality of St. Clements (Fig 2 (#1)). The primary concern for this Anishinaabe (Saulteaux/Ojibwa) First Nation is ensuring a better future for the community including families, youths, and Elders through appropriate education and opportunities (Brokenhead Ojibway Nation, 2014).

Brokenhead Ojibway Nation did not have any particular concern regarding water quality, but they worry about plants especially native medicinal plants. In the Brokenhead Wetlands, they sense that the number of native species is declining and one of the reasons is possibly a corresponding decline in water quality.

3.5.3.2 Keeseekoowenin Ojibway First Nation (date of camp: July 22-24, 2019)

The Keeseekoowenin reserve land is situated near Elphinstone, Manitoba just outside of Riding Mountain National Park (Fig 2 (#2)). It has a population of 1,297, of which 476 members live on reserve and 821 live off-reserve (Government of Canada, 2019). In 1930, the government appropriated the reserve land at Clear Lake during the creation of the Riding Mountain National Park, this without input or the consent of the community. After decades of negotiation, the federal government finally returned 435 ha of the former reserve land at Clear Lake in 2005 along with compensation (Government of Canada, 2011).

Keeseekoowenin Ojibway First Nation is concerned about their treatment plant as it is old and inefficient. They have been sharing these concerns with Indigenous Services Canada and asking for a new treatment facility on multiple occasions, but to no avail. Minimal testing by the government has thus far shown no issues with potable water, but the community senses that bacterial contamination in the water used for drinking as well as domestic purposes is making members sick.

3.5.3.3 Sagkeeng Anicinabe First Nation (date of camp: July 29-August 01, 2019)

Members of Sagkeeng First Nation are of Anishinaabe descent and live at or near the Fort Alexander Indian Reserve #3, located along the Winnipeg River and Traverse Bay (Fig 2 (# 3)). It consists of 21,674 acres of reserve land and has a band membership of 7,637, of which 3,352 live on-reserve and 4285 live off-reserve (Sagkeeng Anicinabe, 2019).

Sagkeeng Anicinabe First Nation is one of many communities that are adversely affected by hydroelectric generating stations (Kulchyski, 2012) as well as upstream intensive livestock (hog) operations. These impacts have affected the flow, depth, and quality of water but also the quantity and health of fish in the river.

3.5.3.4 Couchiching First Nation (date of camp: August 12-14, 2019)

The Couchiching First Nation is located in the Rainy River District near Fort Frances in northwestern Ontario (Fig 2(# 4)). It has a population of 2,648, of which 764 live on-reserve and 1884 live off-reserve (Government of Canada, 2019). It has a vision of incorporating Anishinaabe culture and traditions as an engaging, self-sustaining model community (Couchiching First Nation, 2019).

Couchiching First Nation is a relatively traditional community. They are not only concerned about their water but also soil as both are still affected by a decommissioned pulp and paper mill. They used to drink water from the lake that runs beside the community, but they no longer do so as they feel it is not safe.

3.5.3.5 O-Pipon-Na-Piwin Cree Nation (date of camp: August 20-22, 2019)

Located on the western shore of the South Indian Lake, O-Pipon-Na-Piwin Cree Nation (Fig 2(# 5)) covers around 1,200 square miles of surface area (Hoffman, 2004) and has a population of 1,709, of which 1,126 live on-reserve and 583 live off-reserve (Government of Canada, 2019). They are one of the most hydro-affected communities in Manitoba and have faced the severe adverse consequences of the Churchill River Diversion and its impacts on a once-thriving freshwater fishery since 1976 (Kamal and Thomson, 2013).

O-Pipon-Na-Piwin Cree Nation is severely affected by the Churchill River Diversion. Impacts include the past relocation of the entire community, the devastation of a once-thriving commercial fishery that was the core source of their livelihoods, and associated declines in the consumption of traditional foods and community wellbeing.

3.6 Data Analysis

Environmental concerns raised by each community mostly focused on declines in water quality. A wide diversity of science-based testing that focused on the physical, chemical, and biological parameters of water quality were thus used. Wagtech, a Palintest branded portable lab

was of great use out on the field (Palintest, 2021) since it allowed for the immediate analysis and interpretation of results by camp staff and community members. The Potalab ®+ (C) Advanced Portable Water Quality Laboratory was used for physio-chemical parameters tests including, pH, turbidity, dissolved oxygen, and the presence of inorganic chemicals including chlorine (Cl), fluoride (F), nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_3^-), and arsenic (As) (Fig 3) and the Potalab®+ (M) Advanced Portable Water Quality Laboratory was used for microbiological tests including fecal coliform (*E.coli)* and total coliforms (Fig 4). The Palintest Scanning Analyzer (Fig 5) allowed testing for lead (Pb) and copper (Cu) physiochemical parameters (Palintest, 2021).

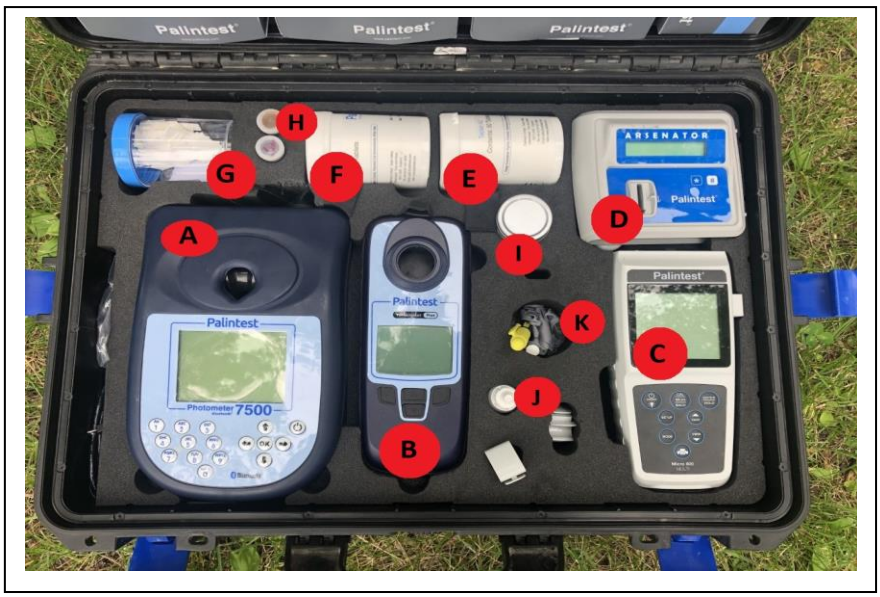


Figure 3: Palintest Potalab®+ (C) Advanced Portable Water Quality Laboratory. Included are: A- Photometer 7500 BT for F, free Cl, total Cl, NO3-, N02-, NH4+; B- Compact Turbimeter to measure Turbidity; C- Digital Conductivity Meter (+ electrode); D- Digital Arse Arsenator to measure Arsenic; E &F- Reagent Tablets (Sodium Borohydride A2); G- Arsenator Filter Papers; H- Cuvettes (+ under Photometer); I- Dilution Tube; J- Silicon Oil; and K- Marker and Lint Free Cloth.

Photo Courtesy: Dylan Kensick.

Figure 4: Palintest Potalab®+ (M) Advanced Portable Water Quality Laboratory. Included are: A- Absorbent Pads; B & C- Petri Dishes (in incubator); D- Instruction Manual; E- Membrane Filtration Unit; F- Hand Vacuum Pump; and G- Media Measuring Device (MMD).

Photo Courtesy: Taylor Galvin.

Figure 5: Palintest Scanning Analyzer SA 1100 to measure lead (Pb) and copper (Cu) in water.

Source: https://www.palintest.com/wp-content/uploads/2019/04/SA1100-Scanning-Analyzer.pdf.

To provide immediate and hands-on learning opportunities for youth, these portable water-testing kits were used in the camps, which allowed participating youth to collect, analyze and make sense of the data alongside the camp staff, Elders and other community members. Any data emerging from the camps were owned, controlled, and possessed by the corresponding host community and will ideally be used when they monitoring changes to their environments into the future.

The data arising from each camp were analyzed. These in part focused on the scientific data associated with the water testing but also those arising from sharing circles and interviews. Qualitative data were codes, and any emergent themes were identified. Attempts were made throughout the process to link the quantitative scientific data with qualitative data grounded in Indigenous experiences and knowledge. These insights were in turn reflected in a written report, where the visualization of the scientific data was conducted in an accessible and impactful way that highlighted both real-life experiences and applied insights in order to make the results more meaningful.

Chapter 4: Exploring and describing the role of land-based youth camps

Background

The policies of conventional school system often overlook the beliefs, knowledges and skills represented by its Indigenous students (Cajete & Pueblo, 2010). The type of knowledge and skills conventional schools offer youth reflects the underlying values of dominant society and are generally classroom-based. In contrast, learning from the land or more generally Indigenous learning principles promote leadership skills, helps develop their identity, fosters connections with cultural traditions, and helps students better understand and acquire other forms of knowledge from the "land" or by exploring the cultural roots (Cajete & Pueblo, 2010; Datta, 2018)). The land consists of the environment, weather, and natural resources. All these affect people's perceptions and worldviews, and the inter-dependence on each on the other (Bhattacharyya, 2012).

With the advent and progression of industry and resource extraction on traditional territories, the movement and ability for communities to connect with the land and with one another is restricted. Consequently, knowledge keepers and Elders have progressively fewer chances to pass their wisdom, experiences and learning to subsequent generations (Simpson, 2004). The Kis Kin Ha Ma Ki Win land-based camps are designed to foster community capacity, especially for the youth with respect to science while also prioritizing and promoting Indigenous knowledge as shared by Elders and knowledge keepers involved in the project. And, in so doing, the project fosters the many connections between science and Indigenous knowledge.

The overall goal of chapter 4 is to explore and describe the role of land-based youth camps that are simultaneously grounded in the science and Indigenous culture in addressing community priorities. In turn, the specific objectives are to explore what environmental concerns confront each community and how these vary among communities and to explore to what degree 'Two-Eyed seeing' principles are reflected in the land-based camps that are grounded in participatory research action (PAR) and in local environmental concerns.

4.1 Pre-camp: Environmental concern and connection to the culture

In order to evaluate the overall accomplishments of the camps, it is important to understand how each of the camps evolved. Kis Kin Ha Ma Ki Win offers the opportunity for each Indigenous host community to set up a land-based camp where Indigenous youth are able to become exposed to and to become excited about science in their own surroundings and to ground these experiences in local environmental issues of concern to the community.

The process begins with each community connecting with the project coordinator for Kis Kin Ha Ma Ki Win. If they are still interested in exploring the opportunity of hosting such a camp, then a conference call is set up which enables both project staff and community representatives to discuss the intent of the project, the location and possible duration of the camp and any environmental issues of local concern. In 2018, most environmental issues were related to water or water quality or associated declines in the environment. Those declines tended to be associated with inadequate water treatment or the impacts of nearby mining, hydro flooding, and agricultural use (Table 4.1).

Table 4 1: Environmental concerns around the communities prior to the land-based camp

Community	Environmental Concerns	Connection to the culture	Duration of the camp
Brokenhead Ojibway Nation	Nothing specific but mostly wants to get an overview of the water quality of the Brokenhead wetlands and river	Concerned about the decreasing number of medicinal plants around the community and proposed to have more nature walk in the community surroundings	3 days
Keeseekoowenin Ojibway First Nation	Water quality of the Community water treatment plant, community well and household water	Proposed to incorporate the land-based camp into their cultural camp	3 days
Sagkeeng Anicinabe First Nation	Hydro-impacted community, concern about the quality of river water and decreasing quantity and quality of the fish population	Proposed to get more involved in cultural activities so that their youth could also learn more about their culture	4 days (participants stayed at night with camp staff)

Couchiching First Nation	Water quality of the river and soil quality in the abandoned paper and plum mill land	They actively maintain their cultural traditions so want them reflected in the camp	3 days
O-Pipon-Na-Piwin Cree Nation (OPCN)	Hydro-impacted community, concern about the quality of South Indian lake water and decreasing quantity and quality of the fish population	Their traditional way of living is being adversely affected by hydro-related flooding and wanted to revitalize them	2 and half days

4.2 Camp arrangement

4.2.1 First day: Introductions to camp participants and equipment

The first day of the camp usually starts with morning prayer where an Elder from the community takes the lead. This was often accompanied by ceremony (e.g. smudging), although not all the camps followed this pattern. This was usually followed by some ice-breaking games by which youths and camp staff introduced themselves to one other (Fig 6). Then, each community initiated a variety of cultural activities, including nature walks, storytelling, water ceremony, the identification of medicinal plants etc. (Fig 7).

Figure 6: Playing an ice-breaking game in Keeseekoowenin Ojibway FN (left).

Figure 7: Blueberries found during nature walk in Brokenhead Ojibway Nation (right).

Photo Courtesy: Karlee Lemus (left) and Donald Dysart (right).

Youth were then asked questions to assess their perspectives on and knowledge of water and science. After a short mid-morning break, a range of scientific terminologies,

including water quality parameters, was introduced and presented with hands-on, real-life examples and sometimes through a power-point presentation to provide additional visual aids (Fig 8). After the lunch break, youths actively participated in collecting water samples in ways that reflected community concerns. Sources ranged from household tap water to water treatment plant to water from nearby rivers (Fig 9). As a part of the science activity, the water quality testing kits were introduced, and youth were taught how to conduct the tests by themselves. Only a few parameters testing were done on the first day to avoid the tediousness of doing multiple, repeated tests. Then arts activities (ice-dyeing) and canoeing, swimming, shelter-building were all introduced as recreational activities that would recharge energy levels and act as a break for the more intensive learning.

Figure 8: Introduction to scientific terminologies in Keeseekoowenin Ojibway FN (left).

Figure 9: Water sample collecting in Couchiching FN (right).

Photo Courtesy: Kianna Durston (left) and Karlee Lemus (right).

4.2.2 Second day: Identifying and answering questions

Although youth were often uneasy about what they were going to do on the first day, they tended to become more confident about their role in these activities as the camps progressed. On the second day, they generally felt more comfortable and aware of what they were going to experience. In most communities, the second day again started with morning prayer and smudging. The rest of the tests on water quality were conducted by youths with the

help of camp staff. On the other hand, cultural learning was taught through medicinal plant picking, walking through wetland trails, visiting ancestral lands, identifying medicinal plants and flowers, fish filleting (Fig 10,11 & 12), and many more.

Figure 10: Walking through wetland trails at Brokenhead Ojibway Nation (left).

Figure 11: Visiting ancestral lands in South Indian Lake (right).

Photo Courtesy: Kianna Durston (left) and Tanjina Tahsin (right).

Some test results, especially for microbiological tests, came out at the end of the second day as they incubated for 18 hours (Fig 13). Arts and recreational activities were conducted.

Figure 12: Elder Norman Guimond teaching how to fillet the fish in Sagkeeng FN (left).

Figure 13: Showing the results of microbiological tests to youth in Couchiching FN (right).

Photo Courtesy: Tanjina Tahsin (left) and Kianna Durston (right).

intermittently and tried to crate fun energy-breaks for the youth, including games such as treasure hunts for traditional-use plants or boardgames like Pictionary.

4.2.3 Last Day: Sharing insights or experience

The last day of the camp represented a wrap-up of previous two days of activities. The significant difference is that after all the usual introductory activities, all the test results from the last two days and interpretation were provided to and discussed among youths, community members and Elders. A sharing circle was then arranged to evaluate the overall camp which involved all participants - youths, community members, Elders, and camp staff. Sometimes, the community the sharing circle was combined with storytelling by Elders as a part of cultural activity. Youth also received a tie-dye tee-shirt, a by-product of the ice-dying that took place earlier on in the camps and that also acted as a camp souvenir (Fig 14).

Figure 14: Youth from Sagkeeng Anicinabe FN showing their tie-dye tee-shirts.

Photo Courtesy: Kianna Durston.

4.3 Camp Activities

Kis Kin Ha Ma Ki Win land-based camps provide Indigenous children and youth with the opportunity to simultaneously learn about their cultural traditions and the science regarding water, plants, fish, wildlife, and human relationships with their environment through land-based teaching.

Activities at the camp were categorized under four different dimensions: culture, science, arts and recreation. Each represented a diversity of activities (Fig 15). The camp schedule was constructed to represent a mix of these four different dimensions so that youths did not feel

overwhelmed by a dependence on any one dimension. Apart from cultural and science activities, arts and recreational activities played a significant role in engaging and energizing the youth.

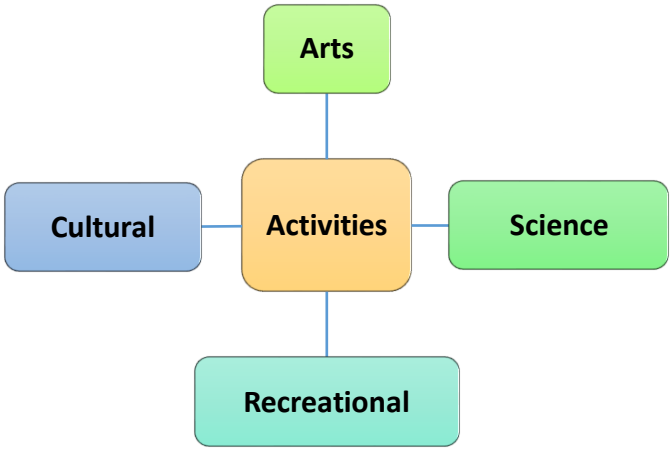


Figure 15: Four different dimensions of activities

These were arranged to allow local youth to know, practise, and affirm the importance of their traditions in their surroundings. To further expand the possibilities of and to facilitate knowledge exchange within the camps, various arts activities were organized which were developed and run by another student researcher (Kianna Durston) as part of her undergraduate Honours project (Durston, 2020) and in Keeseekoowenin some special arts activities were organized and developed by two guest artists and researchers from Indiana State University (Francisco Ormaza and Dana Vanderburgh). These all acted to facilitate personal and collective reflection about what was being learned in the camps.

4.3.1 Cultural activities

To feel and understand nature, its components, and its integrity, all camps arranged cultural activities that would better connect youth to their environments and their traditions. Cultural activities also varied substantially among the host communities, unlike science activities which were introduced from outside and were relatively consistent despite the diversity of environmental issues that they were designed to address. Cultural activities included morning prayers, opening ceremonies such as smudges, water songs, or drum songs all of which reflected the traditions of the community (Table 4.2).

Table 4 2: Variation in cultural activities among the five host communities

No	Activities	Communities				
		Brokenhead Ojibway Nation	**Keeseekoowenin Ojibway First Nation**	**Sagkeeng Anicinabe First Nation**	**Couchiching First Nation**	**O-Pipon-Na-Piwin Cree Nation**
1	Prayer		X		X	
2	Opening ceremonies with smudging		X		X	X
3	Water ceremonies				X	
4	Drumming		X		X	
5	Elder storytelling	X	X	X	X	X
6	Nature walks	X		X		
7	Plants/medicine teachings	X		X		X
8	Medicinal plants/traditional fruit picking			X		X
9	Fish filleting			X		
10	Boat tours to sacred places/old community sites				X	X
11	Sharing circles	X	X	X	X	X
12	Elder cooking			X	X	
13	Testing various traditional drinks (tea)					X
14	Watching films about hydro impacts					X
15	Closing ceremony				X	
16	Community feast				X	

Cultural activities can be characterized as two broad categories- ceremonies and traditional way of learning. These two categories each comprised different cultural activities (Fig 16).

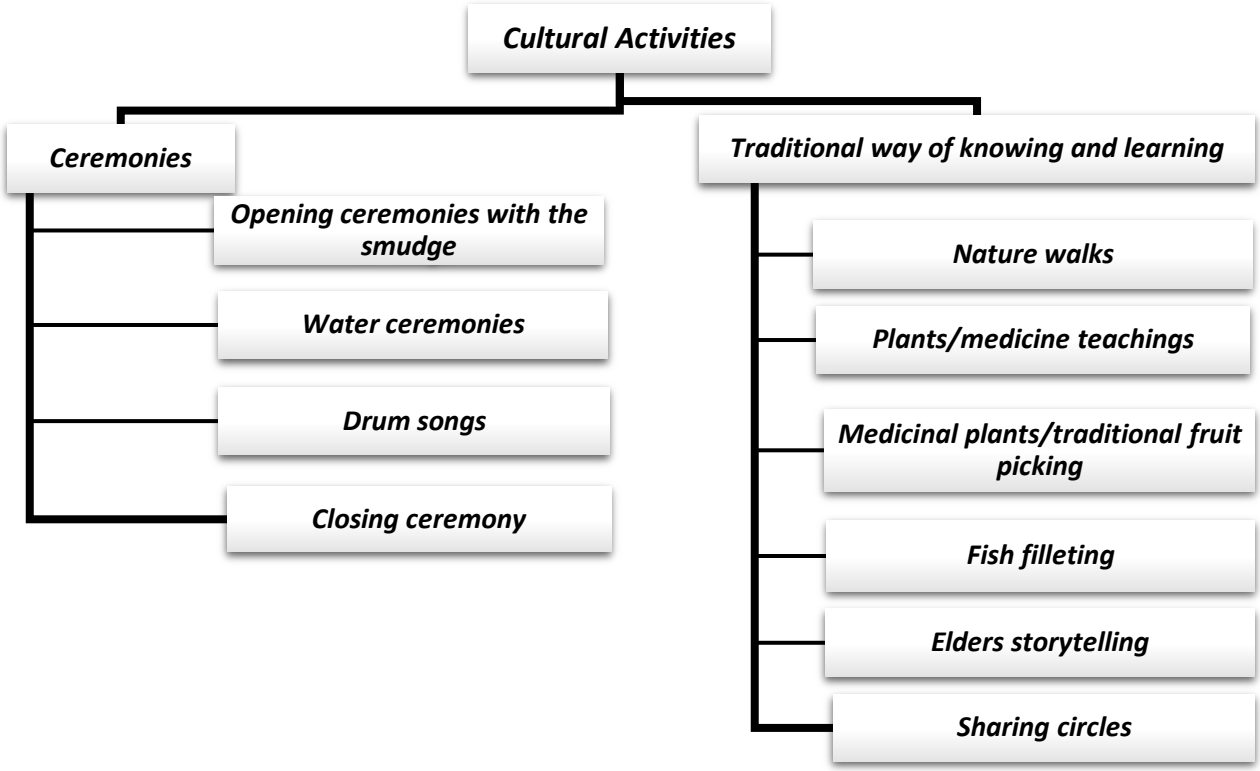


Figure 16: Sub-categories of cultural activities

4.3.1.1 Ceremonies

Indigenous people have deep-rooted and unique ways of expressing their appreciation and reverence of the natural and spiritual world through various traditional acts, including rituals, thanking and ceremonies (Alberta Education, 2004). Ceremonies play a significant role in Indigenous people's spiritual and cultural lives in many traditional communities and a way of being thankful for nature's gifts and the people around them. Throughout the camps, many ceremonies were performed. For instance,

Opening ceremonies with smudges: Among many First Nations and Métis communities, smudging is a well-known tradition that is performed to greet the day or before starting any event. Medicinal plants like tobacco, sweetgrass, sage, and cedar are used in a smudge and burned in a seashell in most camps, and the smoke helped to get rid of the negative energies and let people become calm, focused and connected to the land and one another (OFL, 2018). Keeseekoowenin Ojibway First Nation, Couchiching First Nation and O-Pipon-Na-Piwin Cree

Nation started the camp with opening ceremonies both with morning prayer and a smudge ceremony. During the opening ceremony, all the people who were attending the camp stood still in a circle while an Elder facilitated the morning prayer. Then a youth or community member brought the smudge bowl towards every person so that they could use the smoke to purify themselves if they were so inclined. In Keeseekoowenin Ojibway FN, Elder Warren (also known as Mickey) described the importance of morning prayer, smudging and water. In Couchiching, after opening with a prayer, Elder Florence described the importance of land by stating,

"Just like taking care of our body, we have to take care of our land."
(Elder Florence, Couchiching First Nation, August 12, 2019)

Water ceremonies: Water has always been sacred for Indigenous people, as it has the power of purification. Many also traditionally regard water as the blood of Mother Earth, which carries nutrients into the land, and if it fails to work appropriately, humanity will not survive (McGregor, 2008). For Indigenous cultures, water is an integral element, and its importance is signified by expressing gratitude. Couchiching First Nation was the most traditional of the communities, and they were the only community that performed a water ceremony. Elder Linda brought a jar of water and sang the 'Nibi' or water song. The lyrics of the song were as follows (in English),

"*Water we love*
Water we thank
Water we respect"

While describing the significance of water, she indicated,

Water, so much it offers us, so much we owe to water……water is life
(Elder Linda, Couchiching First Nation, Aug 12, 2019)

After that, she passed the jar so that everyone can have some water to feel it on their skin and be thankful for it.

Drum songs: Indigenous people often traditionally consider the drum not so much as a musical instrument, but, instead, view it as a woman connected to her land. It hence signifies a universal heartbeat of Mother Earth, and the heartbeat is expressed when drumming is performed drum and healing is accelerated by the rhythm (NC, 2020). In Keeseekoowenin Ojibway First

Nation and Couchiching First Nation, drum songs were performed by local knowledge keepers as they feel drumming them connect with their ancestors and to their surroundings (Fig 17),

Figure 17: Drum songs were performed by community members and youths in Couchiching FN.

Photo Courtesy: Tanjina Tahsin.

Closing ceremony: On the last of the camp in Couchiching First Nation, Elders performed a closing ceremony with a prayer. Ceremonies are an integral part of Indigenous life and represent a way to appreciate and to show respect. As a traditional community, Couchiching First Nation integrated cultural activities in all facets of the camp. They even performed a special prayer for the camp staffs to have safe travel as we were returning to Winnipeg after the camp.

4.3.1.2 Traditional ways of knowing and learning

Indigenous knowledge (IK) is generally qualitative, intuitive, holistic, and orally communicated and reflects knowledge, experiences, insight, and beliefs (Stevenson, 1996). Any sign of change in the environment or ecosystem is thoroughly understood by the people who live in the close vicinity and have long-standing and rich relationships to these impacted systems (Kutz & Tomasell, 2019). Participating youth were kept engaged in as diversity of nature-based activities in order to foster a better sensitivity and insight to such changes.

Nature walks: Walking through the bush or surrounding natural environments played a key role in many camps. In Brokenhead and Sagkeeng, a nature walk was arranged so that the youth could better connect to nature, the land which is the root of their origin. In Brokenhead Ojibway Nation, on the second day of the camp, a walk in the Brokenhead Wetland Interpretive Trail was led by Carl Smith where he talked about the four pillars of Brokenhead Ojibway Nation- Interconnectedness, Respect, Purpose, and Balance (Fig 18).

Figure 18: Carl Smith teaching about the four pillars of Brokenhead Ojibway Nation (left).

Figure 19: Carl Smith highlighting the importance of native plant conservation (right).

Photo Courtesy: Tanjina Tahsin (left) and Taylor Galvin (right).

He also introduced a wide diversity of native, medicinal, and rare plants and flowers and described the cultural and environmental significance of these plants (Fig 19 & 20). He also stressed the importance of plant conservation as some were in decline, infected by disease, and their existence threatened.

Figure 20: Native flower Showy lady's slipper (*Cypripedium reginae*).

Photo Courtesy: Tanjina Tahsin.

In Sagkeeng Anicinabe First Nation, Allen Courchene guided youths and camp staff on a hike to Coca Cola falls (Fig 17) and a local cliff-jumping spot. The 45-minute walk extended from the campground through the forest to the river, and while walking, Mr. Courchene shared stories about the past, pointed out some Pin cherries (*Prunus pensylvanica*), for which the Ojibway name is Bawa'iminaan. (Fig 22), for instance. After resting on by the Coca-Cola falls for a while,

Figure 21: Coca-Cola falls and two youths from Sagkeeng Anicinabe First Nation standing.

Photo Courtesy: Karlee Lemus.

participants headed towards the cliff jumping spot where the youths dove into and swim in the water, which was blue, clean and clear enough that one could see straight down to the bottom (Fig 23).

Figure 22: Pin cherries at Sagkeeng Anicinabe FN (left).

Figure 23: Cliff jumping and swimming in clean water at Sagkeeng AFN (right).

Photo Courtesy: Donald Dysart (left) and Tanjina Tahsin (right).

Plants/medicine teachings: On the first day of the camp in Brokenhead Ojibway Nation, Carl Smith gave teachings about many different medicinal plants during the nature walk through the Cultural Village of Brokenhead Ojibway Nation. He spoke about medicinal plants like poison ivy, which acts as both medicine and poison and the Poplar tree's inner bark which is used to cure people with diabetes. In Sagkeeng Anicinabe First Nation, Elder Norman Guimond and Allen Courchene taught about medicinal plants along the river like Lily roots, their uses, and how to harvest them. In O-Pipon-Na-Piwin Cree Nation (OPCN), Elder Minnie, who always relies on medicinal plants, shared her teaching on Indigenous medicinal plants on the second day of the camp.

These included Lavender tea, Weekay[6] , We Ká SKwá[7], Yarrow (white flowers) (Fig 24) and Bardge bark (looks like orangish-yellow and is used as a bandage). Youth and camp staff all had the opportunity to touch and taste some of her medicinal plants and tea.

Figure 24: Picture of Yarrow (white flowers) (*Achillea millefolium*).

Source: https://www.manitoba.ca/agriculture/crops/crop-management/yarrow.html

Medicinal plants/traditional fruit picking: In Sagkeeng Anicinabe First Nation and O-Pipon-Na-Piwin Cree Nation, Elders taught about the uses and importance of medicinal plants or traditional fruits. They also taught how to properly harvest and store these plants. Elder Norman Guimond and Allen Courchene, in Sagkeeng Anicinabe First Nation, led a small team of youths and camp staff to the edges of Maskwa river and taught us how to pick Lily pad roots (Figure 25 and 26). These Lili plant roots was a powerful medicine according to some Indigenous people, and Ojibway name for lily pad root is *akandamoo*[8], which means root of water plant. It is a strong medicine that is used for different medicinal purposes including treating gastro-intestinal/urinary tract problems, reproductive organ problems, the heart and blood. It is also sometimes used topically for epidermal issues.

[6] Native plants found in swap water and have to pull out the root to collect)
[7] Cree name for mint leaves
[8] Indigenous camp staff member Dylan Kensick refers the Ojibway name for lily pad root and its medicinal values

Figure 25: Elder Norman Guimond and Taylor Galvin picking lily pad root (*akandamoo)* (left).

Figure 26: Lily pad roots picked up from Maskwa river (right).

Photo Courtesy: Donald Dysart (left) and Taylor Galvin (right).

Fish filleting: Fish has always been a part of Indigenous culture as traditional food. Many Indigenous communities have long relied on fishing as a livelihood. Many communities are impacted by the dams and hydrogenating stations that are built on nearby rivers. These structures divert the river flows, control the water levels and sometimes even cause massive flooding, for instance, in OPCN. As a result of an associated diversion of the Churchill River, their main livelihood- fishing - was decimated and they were forced to relocate to a place with inadequate facilities. Among the five communities, two communities were impacted by dams - Sagkeeng Anicinabe FN and OPCN. To teach the value of fishing and to embrace the culture of having this traditional food, Elder Norman Guimond brought a bucket of fish that he caught the night before on the second day of the camp in Sagkeeng FN (Fig 27). Youths were excited to see freshly caught fishes most of which were Pickerel (Fig 27). He then taught the youths how to fillet these fish much to their enthusiasm, while also sharing stories about such dish (Fig 28). This activity gave the youth a chance to know their traditions, the importance of these activities both traditionally but also in the current day, and how their ancestors used to live their lives, their food and their activities.

Figure 27: Freshly caught fish (mostly Pickerel) (left).

Figure 28: Elder Norman Guimond teaching participants youth how to fillet locally caught fish (right).

Photo Courtesy: Karlee Lemus (left) and Tanjina Tahsin (right).

Elder storytelling: According to Archibald (2008), "Elders" are highly respected members of First Nations communities, this reflecting their wisdom, which they developed through their life-long experiences, and knowledge as they pass this knowledge (healing, medicinal or storytelling or spiritual) to subsequent generations. Elders are a critical source of Indigenous knowledge, and their importance is well accepted in the literature (Sutherland & Swayze, 2012; Lowan-Trudeau, 2019). Elders participating in these camps shared their life stories, which depicts their endurance, resistance, and attempts to protect their culture, tradition, and land (Archibald 2008).

Storytelling represents a critical way of sharing such experiences and in all five host communities, Elders participated in the camps to pass their wisdom to the next generation, the youth. Although the theme and ground of the stories varies from community to community and from Elder to Elder in each community, the core teachings tended to be similar - the importance of passing on the gift of knowledge, which is one of the key aspects and goal of these land-based camps. During an hour-long session in Brokenhead Ojibway Nation, Elder Rose shared her life story, how things were in the past, the types of foods they used to plant, including cranberries, chokeberries, and their dependence on wild meat and fish. She also pointed out some of the

differences in the environment compared to the last decade, for instance- pollution of river water from the nearby farm agricultural land, which in turn reducing the quantity of wild rice and lowered the number of Muskrats (*Ondatra zibethicus*).

In Keeseekoowenin Ojibway FN, Elder Warren shared a brief story about the importance of water and people's suffering due to the lack of clean water. Whereas in Sagkeeng, Elder Norman, taught the youths some core cultural practices like filleting the fish he had caught the night before. While teaching them to clean and fillet the fish, he described the importance of fish for the Indigenous people, which is still regarded as a traditional food source, and he showed the quality and quantity of fish continued to decline in the Maskaw river. The next day, he also taught about traditional medicines. Throughout the camp Allen Courchene shared stories on how the life in the past used to be, what they used to do and what people ate. As he stayed all three days in the camp with the youths, there was much opportunity for him to share those stories.

In Couchiching, the Elders tended to be more vocal and interactive than other camps; three Elders- Florance, Dickbird, and Linda - were present at the camp for all three days and shared their gifts of wisdom with the youth. On the first day of the camp, they shared stories about the land, how life was before, including in winter, the community, and the importance of these animals.

> *"In winter, hot lunches were made and served in the bushes….On those days, horses life was more valuable than human life"*
>
> *(Elder Dickbird, Couchiching First Nation, Aug 12, 2019)*

They also told stories about the establishment of sawmills, how this industry began and how contaminant leaching continued to affect the soil long after the mills were shut down. They also mentioned the water quality as they used to drink directly from Rainy Lake, but now, they can not, as it is contaminated with human waste and agricultural runoff. On the second day, Elder Dickbird shared stories about the flood in the 1950s and the history of establishing the dam for hydroelectricity. By sharing those stories, Elders showed how they had endured against all the adversity and exhibited tremendous resilience so that the youth could learn from and emulate them and work hard to protect their community, land and the environment.

As with Couchiching, three Elders in OPCN shared their stories over two consecutive days. On the first day of the camp, Elder Kelly Baker talked about the flood that happened in the community due to the Churchill River diversion, the collapse of the whitefish fisheries and losing trapping as a livelihood. Elder Sarah Jones also shared stories about the flood and the subsequent changes including a deterioration in the taste of fish and (rabbit) meat. Then Elder Minnie Moose shared her teachings regarding traditional medicines with youth, community members and camp staff.

***Sharing circles*:** Sharing circles represent a traditional way of exploring, reflecting and communicating issues or problems and finding solutions by supporting and respecting each other views. They also represent an important way to educate and practice culture, including healing, spiritual teaching and oral traditions (Rothe, Ozegovic, & Carroll, 2009; Struthers, Hodge, Geishirt-Cantrell, & De Cora, 2003). These circles enable participants to share their experiences, stories or build a unique storyline through its flexibility and verbal characteristics (Simmons, Bayha, Beaulieu, Gladu, & Manseau, 2012). Although speakers each have the opportunity to share in progressive sequence around the circle, ultimately the process represents an open discussion where every participant can share their views, experiences, or stories. Sometimes, in a traditional circle, speakers will hold something symbolic to the community including rock, feather or seed bag.

These circles were used in every camp so that participants were able to explore their experiences with the camps, which in turn represented. Available opportunity for camp staff to evaluate the strengths and any shortcomings of each camp. They were also used by Elders to share stories in some communities, in OPCN and Couchiching FN, for instance. Generally, in most camps, they started right after sharing the test-results, when participants were asked how they generally felt about the camp, which part of the camp excited them the most, what were the learnings, challenges, and suggestions for improvements. Sometimes, the reflections extended beyond the camps themselves. In OPCN, when a concern was raised about what community can do to keep their traditional knowledge alive. Then the Elders answered, indicating that it was group work: a collective process where everyone had to take the responsibility. They further indicate that the young people maintain these traditions and pass the legacy to future generations. Participants in Sagkeeng FN stayed overnight in the camp with us, unlike the other camps, which

gave us more time to connect with one another and to facilitate relatively long sharing circle (Fig 29). In these circles, each participant shared their feelings about the camp, experiences that included liking the pH and turbidity tests, going down to the rapids, swimming in the crystal-clear water, meeting new people and disliking- mosquito bites during shelter building in the bushes.

Figure 29: Sharing circle in Sagkeeng FN.

Photo Courtesy: Taylor Galvin.

4.4 Indigenous Knowledge shaping science

Indigenous knowledge (IK) in various ways acted to shape and develop science activities in the camps. Knowledge keepers in the community provided insights around nature and specified some of their core concerns related to the environment. All the cultural activities including Elders' story telling, sharing circles and ceremonies helped to mobilize IK which provided an underlying cultural context for the science and helped direct the science curriculum in each camp.

In Brokenhead Ojibway Nation, a walk in the Brokenhead Wetland Interpretive Trail on the second day of the camp was led by Carl Smith as he introduced native, medicinal, and rare plants and flowers and described the cultural and in some cases health-related significance of these plants (Fig 19 and 20). He indicated that they are becoming locally extinct due to diseases and climate change. In the wetlands, many aquatic plant populations were in decline which

makes him concerned about the quality of water in the wetland. As a result, we focused the water quality testing in the waters to see if any underlying problems might be identified. Those that were onserved as relevant included high levels of turbidity as will be discussed below.

In Brokenhead Ojibway Nation, Elder Rose shared her life story, how things were in past, the type of foods they used to eat including plants like cranberries and chokeberries as well as wild meat and fish. She also pointed out some of the differences in the environment compared to the past ten years, for instance- pollution of river water from the nearby farm, agricultural land, and reduction in the quantity of wild rice and the populations of muskrats.

> *"They come to be a part of it even their stories didn't really into what we were doing. It was nice to have them, the youth and the Elder gap being closed in to each other"*
>
> *(Taylor Gavin, Land-based education coordinator, Exit interview, August 30, 2019)*

In Keeseekoowenin Ojibway First Nation, they are mostly concerned about their sole water treatment plant. As a Band Councillor described:

> *"We have 170 houses in the community, and they all rely on the water plant. If anything were to happen to the plant, we wouldn't have clean drinking water. The water plant itself was a temporary fix. It was only supposed to be in place for a few years and it is lived ..well past that cycle. So it was only temporary and now we're using it exclusively for drinking water"*
>
> *(Bradley Burns, Keeseekoowenin Ojibway First Nation, June 14, 2019)*

As a result of such concerns, we focused our water quality testing on the drinking water within the community, and identified tap water samples from peoples' houses, samples from the treatment plant itself, from the school and the band offices etc. So, local concerns regarding water quality shaped our water sampling strategy not only for the camp but also for the subsequent visit. Usually, external researchers decide on the sampling strategy before visiting the community in sharp contrast to our camps.

Elders represent a critical source of Indigenous knowledge in community, and the importance of their views and experiences is well accepted (Sutherland & Swayze, 2012; Gregory Lowan-Trudeau, 2019). Lowan-Trudeau (2019) mentions how a land educator emphasized the

importance of Elders in traditional teaching. Therefore, Elder views on changes in their surroundings are critically important. But many community members also have rich insights into changes in their local environments.

In Sagkeeng FN, a community member indicated her concern about changes in the quality of water and fish health she had noticed.

> *"Oh no! it was clean you know, like now it's just like totally murky, dirty. It changed a lot, the water is very dirty now- very murky. Like I said, I was shocked when I seen the water here and it was red. And I said, the water doesn't look healthy here. I wonder if the fish are healthy here. Like you guys took testing or the water and stuff. Because before I never had a problem if you went swimming and swallowed water. Now you have to be careful, E. coli you know, stuff like that. There's a lot of bacteria in the water. I know there's a lot of bacteria in the water."*
>
> *(Anonymous, Sagkeeng FN, July 31, 2019*)

It was noticed that the color of the river is reddish in color, and when testing was done, a lot of her concerns came true, which are discussed in later. We also conducted tests for E. coli and other bacteria in part using her concerns as a rationale for these tests.

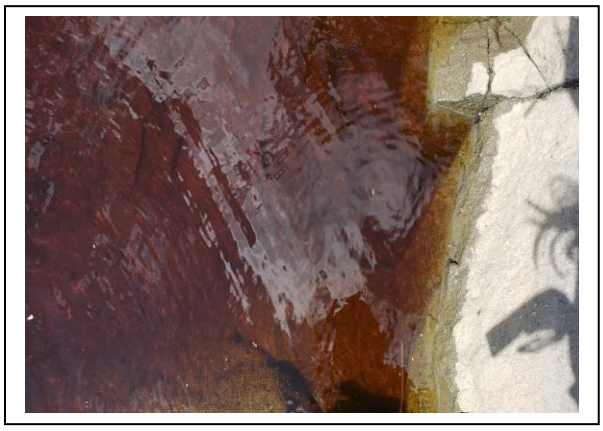


Figure 30: Colour of the Maskwa River water in Sagkeeng First Nation.

Photo Courtesy: Tanjina Tahsin.

Allen Courchene from Sagkeeng First Nation was also concerned about water quality, but he was also thinking about food sources,

"The water quality and algae blooming, and you know, when all the phosphorus coming from farmer's fields, it does have effects. You see the lesions on the fish when you're fishing now, they have like big lesions…I know in some of our other studies that did with kids, we got a lot of fish tested that had big lesions all over them. Bumps and things like that and people are afraid to eat them."

(*Allen Courchene, Sagkeeng FN, July 31, 2019)*

In Couchiching First Nation, Elder Linda indicated some of the probable causes of water contamination which they think degrading the quality of river water as she stated-

"I think a lot of the products that we use. .I have to say the industry and what I was speaking about today, about the aerial spraying for the plants. The aerial spraying that they are using in the logging sites where they have logged. I think that all contributes… I think all these things, whatever we put into the air and on the ground, I believe is eventually going to seep into our water system. And so, I think it's very important to use an environmentally friendly product."

(Elder Linda, Couchiching FN, August 13, 2019)

They also told stories about the establishment of sawmills. How they operated and then how they were decommissioned still affecting the soil. The mills used many chemicals for bleaching, which they dumped into the rivers, and which are still leaching from abandoned sites today. Many members still are concerned about the impacts of these on the land and were interested in having soil tests conducted.

Although beyond the capacity of these youth camps, our intent was to return and to collect soil and water samples that could then be used to test for herbicides used from pulp and paper. in logging practices and contaminants (e.g., chlorinated lignin, resin acids and phenols, dioxins, furans) and some of them are polychlorinated dibenzodioxins and dibenzofurans (dioxins and furans), are persistent and not easy to degrade (Ali & Sreekrishnan, 2001).They associated with effluents. However, the advent of the pandemic prevented this from occurring.

4.3.3 Science activities

One of the crucial aspects of these land-based camps is to teach the youth about science and to demonstrate hand-on activities so that participants can learn how to test water by themselves. The types of scientific activities were similar among all five camps (Table 4.3). All communities were concerned about declines in water quality except for Couchiching First Nation; thus, all the tests were done on water quality. Physiochemical parameters that we were able to test for on our portable lab included pH, turbidity, dissolved oxygen, and the presence of inorganic chemicals (chlorine (Cl), fluoride (F), nitrate (NO^{3-}), nitrite (NO^{2-}), ammonia (NH^{3-}), and arsenic (As), lead (Pb) and copper (Cu)). Microbiological parameters that we were able to test for included fecal coliform (E. coli) and total coliforms bacteria. One of the main reasons for these scientific activities was to encourage an interest in science and make science more comprehensible among Indigenous youth, so preference was given to the tests that youths found of immediate interest. However, to determine water quality, necessary tests were also done. Sometimes, time constraints, unanticipated technical problems limited our ability to conduct all the anticipated tests.

Table 4 3: Types of science activities performed in the land-based camps

	Activities	**Communities**				
		Brokenhead Ojibway Nation	Keeseekoowenin Ojibway First Nation	Sagkeeng First Nation	Couchiching First Nation	O-Pipon-Na-Piwin Cree Nation
1	Introduction to scientific terms and concepts	X	X	X	X	X
2	Water sample collection	X	X	X	X	X
3	Tour of water treatment facilities		X			X
4	Water sample testing	X	X	X	X	X
5	Presentation of test results	X	X	X	X	X
6	Visits to abandoned paper and pulp mill site				X	
7	Soil sampling				X	

4.3.3.1 Introduction to scientific terms: Our focus on scientific activities began by asking participants to relate their experiences with respect to water, science, and its relation or importance between the two (Fig 31). Responses to science varied from research to Bill Nye. For water, the most common term was 'life'. Many also thought that water and science are connected through aquatic habitat or life in water. This reflects that youth valued water but also shows how they relate it to their culture by acknowledging it as 'Life. A brief introduction on water quality parameters (physio-chemical, biological) was then presented to provide basic concepts and a number of scientific terms, their definitions, sources and potential significance for the community. Power point presentation along with real life examples were also used to facilitate learning.

Figure 31: Sticky notes collected from participants to know their understanding and to facilitate discussion.

Photo Courtesy: Karlee Lemus.

4.3.3.2 Water sample collection: To test and analyze water quality, water samples were collected from various sources according to the community concerns (Table 4.4). Among them, household tap water sampling was common for all but Couchiching FN as the community-affiliated organization regularly monitored this. The Brokenhead Wetland was of special concern for that community as there are a number of native plants which were in need of conservation. Water quality in the community well was a matter of concern for Keeseekoowenin Ojibway FN, since water from that well is transported after some disinfecting to community households and used for washing and cleaning. For Sagkeeng FN and OPCN the water quality of the nearby river and lake, respectively, was a significant issue as they are both hydro-impacted communities.

Table 4 4: Various sources of water sample in the land-based camps

	Sources of Water sample	Communities				
		Brokenhead Ojibway Nation	Keeseekoowenin Ojibway First Nation	Sagkeeng First Nation	Couchiching First Nation	O-Pipon-Na-Piwin Cree Nation
1	Household tap water	X	X	X		X
2	Water treatment plant		X			
3	Community Well		X			
4	River water	X		X	X	X
5	Wetlands	X				

4.3.3.3 Water treatment plant tour: In Keeseekoowenin Ojibway FN, they have long been concerned about their water treatment plant. As community chief Bradley Burns referred,

> *"in our community we still need some government help. They have identified that our own water bottling plant is a water treatment plant for the entire community. When it's not, treated water it's just only for drinking. It's not for your household use and they identify it as being. You have a water plant, you have a water treatment facility. That's their assumptions. Meanwhile, we use 100 % untreated water for each household and what it does is, it creates a lot of rust, it creates a lot of problems with appliances, with your laundry, with washing. This is something we put our children in and through. So that's our concern right now."*
>
> *(Bradley Burns, Keeseekoowenin Ojibway First Nation, June 14, 2019)*

Hence, they wanted the participants not only visit the plant but also to collect samples to test the water quality (Fig 32). In OPCN, community members encouraged us to pay a visit in their water-treatment plant so that the youth participant would know where their drinking water comes from and the process of disinfection (Fig 33).

Figure 32: Water Bottling plant in Keeseekoowenin Ojibway FN (left).

Figure 33: Water treatment plant in OPCN (right).

Photo Courtesy: Tanjina Tahsin.

4.3.3.4 Water sample testing: To assess the water samples collected from the various sources several water quality parameters were tested using the portable labs (Table 4.5). Due to some technical difficulties (e.g., low battery levels, delay in receiving some of the test kits, time restrictions), some tests were eliminated.

Table 4 5: List of the water quality parameters tested in the land-based camps

	Physio-Chemical Parameters										Biological Parameters		
Community	pH	Turbidity	Chlorine	Fluoride	Ammonia	Nitrate	Nitrite	Lead	Copper	Arsenic	Dissolved Oxygen (DO)	Total Coliform	Fecal Coliform
Brokenhead Ojibway Nation	**X**	X	X	X	X	X	X	X	*[9]	*[10]	X	**[11]	**[12]
Keeseekoowenin Ojibway First Nation	X	X	X	*[13]	X	X	X	X	X	X	*[14]	X	X
Sagkeeng Anicinabe First Nation	X	X	X	X	X	X	X	X	X	X	X	**[15]	X
Couchiching First Nation	X	X	X	*[16]	X	X	X	X	X	X	X	X	X
O-Pipon-Na-Piwin Cree Nation	X	X	X	X	X	X	X	X	X	X	X	X	**[17]

[9] Due to time constrain, could not run the test
[10] Due to Time constrain. Could not run the test
[11] Technical difficulties (Nutri Disks were not working property)
[12] Technical difficulties (Nutri Disks were not working property)
[13] Due to Time constrain. Could not run the test
[14] As there were no natural water samples
[15] Technical difficulties ((Nutri Disks were not working property so another batch was set to test Fecal Coliform with petri dish and manually made agar nutrients was used)
[16] Due to time constrain, could not run the test
[17] Incubator was running out of charge and needed to be plugged into the car battery but due to this movement, could not provide proper results

Participants actively engaged in the testing. In all camps, these started with the simplest tests, that is pH and turbidity. Participants generally found these of great interest as the test involves change of color (pH) and matched results with a colour-standard (Fig 34). All the tests were done mainly by participants. In the beginning, a demonstration was performed to make to help participants understand better the underlying mechanics and after that, they followed the instructions. All participants were encouraged to perform the tests by themselves (Fig 35).

Figure 34: Brokenhead Ojibway Nation conducting pH tests (left).

Figure 35: Demonstrating microbiological tests in while an Elder observed Couchiching FN. (right)

Photo Courtesy: Taylor Galvin (left) and Karlee Lemus (right).

However, from time to time, supports were provided in order to expedite testing. Following the pH and turbidity tests, microbiological tests were conducted as the prepared samples need to incubate for 18 hours (incubate at 37ºC for Total Coliforms and at 44ºC for Thermotolerant Coliforms[18] according to the Palintest® Potatest®2 Advanced Portable Water Quality Laboratory (microbiological) manual). Youth participants in all the camps were excited to conduct these tests as they were generally already familiar with the terms (primarily bacteria such as E. coli) before the camp (Fig 36, 37, and 38).

[18] Usually, the presence of Thermotolerant Coliforms indicates faecal contamination and different study suggested that above 95% Thermotolerant Coliforms isolated from water are *Escherichia coli* (E. coli) so it can be said that if the Thermotolerant Coliforms is present in water there will be E. coli (a member of the total coliform group) as well.

Figure 36: Conducting microbiological test in Keeseekoowenin Ojibway FN (left).

Figure 37: Conducting microbiological test in Sagkeeng FN (right).

Photo Courtesy: Taylor Galvin (left) and Karlee Lemus (right).

On the second day of the camp, the rest of the chemical tests (i.e. chlorine, fluoride, ammonia, nitrate, nitrite, lead, copper and arsenic) and biological tests (i.e. dissolved oxygen) were conducted (Fig 38). Most of these are quick, although some of the tests need to stand for

Figure 38: Conducting microbiological tests in OPCN (left).

Figure 39: Conducting an ammonia test in Couchiching FN (right).

Photo Courtesy: Tanjina Tahsin.

10 minutes (i.e. ammonia, nitrate and nitrite) to get readings If these were not all completed, a few of the tests were run on the last day.

Brokenhead Ojibway Nation and Sagkeeng FN also took part in testing (Fig 40 and 41). Allen Courchene from Sagkeeng FN, was highly enthusiastic about the tests and tried to learn a few and was even asking the price of the portable lab, wondering if they could afford one for the community so that they could monitor their water quality more regularly.

Figure 40: Carl Smith in Brokenhead Ojibway FN matching pH test color with the color-standard (left).

Figure 41: Allen Courchene conducting a pH test in Sagkeeng FN (right).

Photo Courtesy: Kianna Durston (left) and Tanjina Tahsin (right).

We were then requested by to conduct some further (microbiological) testing by Keeseekoowenin Ojibway First Nation, which required an additional visit. This in part was necessitated because of technical difficulties regarding the additional tests (i.e. the ar adgels ended up being destroyed by the rough roads), although returning did facilitate much more comprehensive testing than would have been possible at the camps themselves.

4.3.3.5 Test results presentation: On the last day of each camp, all test results were analyzed, summarized and made available in a form that was provided to the participants and community at or before the sharing circle (Fig 42 and 43. Results were provided in accessible language with little-to-no jargon so that they were understood by all those present. Of all the communities, Couchiching FN members, especially the Elders, were especially interested in the results, and

they asked many questions in order to better understand their implications. Likewise, in Keeseekoowenin Ojibway FN, community members were also very curious about the results as they had many long-standing concerns regarding (potable) water quality.

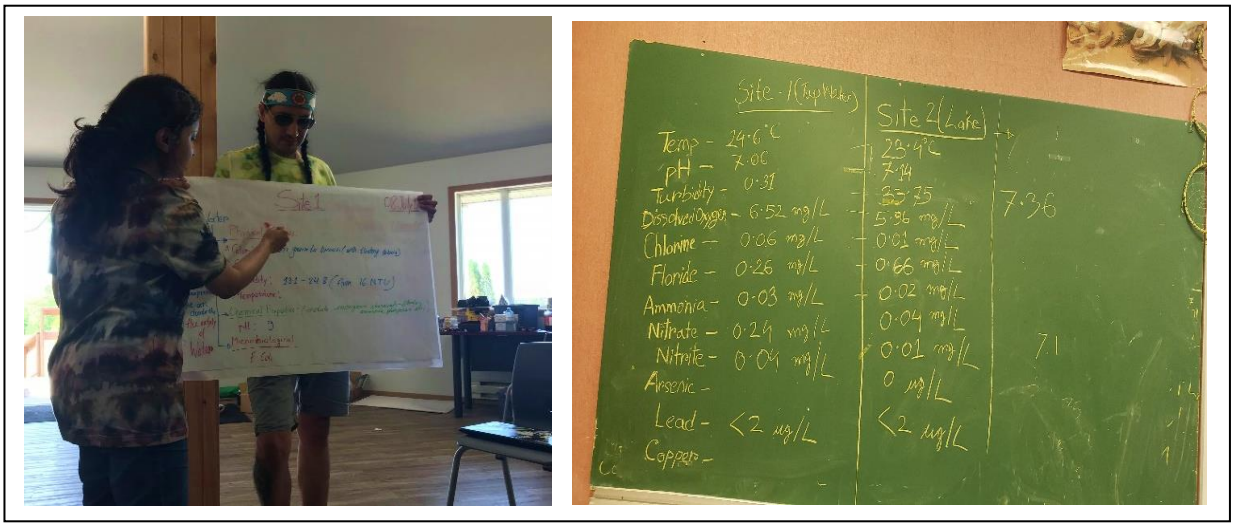


Figure 42: Presenting results in Brokenhead Ojibway Nation (left).

Figure 43: Presenting results in OPCN (right).

Photo Courtesy: Karlee Lemus (left) and Tanjina Tahsin (right).

It was agreed that each community would receive a report that includes details about the test results, reasons and any recommendations.

4.3.3.6 Abandoned pulp and paper mill site visit and soil sampling: According to Elder Dickbird, the Beaver Mill Lumber company was established and started working in early 1900s. Then they stopped and left the Rainy River area. However, he mentioned that other pulp and paper and lumber companies worked there from 1921 to the 1950s. These were then closed down too. When it was asked why they are concerned about the abandoned mills, they replied that they still fear contamination. So, they wanted to test the soil, and soil samples were also collected. However, such testing was not possible with our portable lab. In order to quantify the presence of contaminants (i.e. hydrocarbons, chlorinated carbon) from the sawmill, samples to the required commercial lab within 48 hours. This was not possible, and while our ultimate goal was to return

to community as had been done with Keeseekoowenin Ojibway First Nation, this ultimately was precluded by the onset of the COVID-19 pandemic.

4.4 Variation among the camp and rationales

4.4.1 Number of activities

Despite differences in the. nature of the local environmental concerns among communities, the number and nature of science activities were quite similar among the camps. In contrast, the number and nature of the cultural activities varied significantly among the camps. For example, the first two camps performed fewer activities than the rest of the three camps (Fig 44). This in part reflected our own evolving confidence in and understanding of what might be accomplished in the camps. Over time, our ability to manage the camps and our insight into how to best integrate science, cultural, and recreational activities increased and thus allowed us to incorporate a wider diversity of these approaches over time.

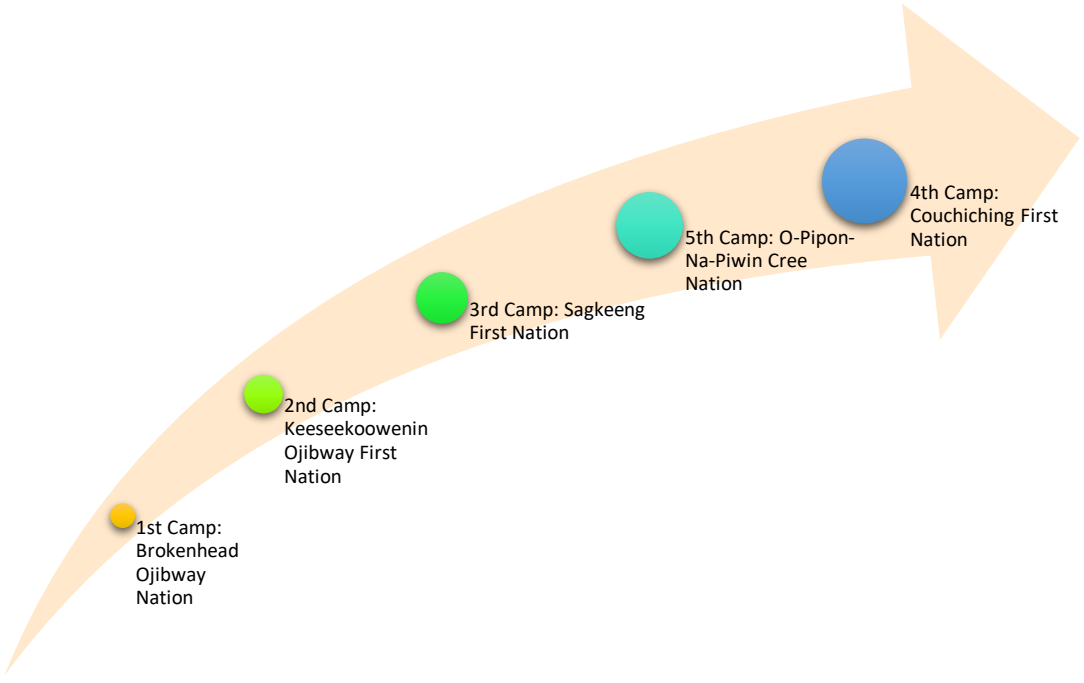


Figure 44: Increasing trend of cultural activities as time passed

Even though in the second camp (Keeseekoowenin Ojibway First Nation) it seems like less cultural activities were performed, two special guest artists and researchers from Indiana (Francisco Ormaza and Dana Vanderburgh) attended that camp only and understood a number of their own activities. These focused on the creation of sketchbooks with fabrics, needles and thread; creating fabric arts with natural ingredients; recording and listening to different water sounds; and dancing workshops focused on these recordings (Fig 45).

Figure 45: Participants in Keeseekoowenin Ojibway FN creating fabric arts with natural ingredients.

Photo Courtesy: Kianna Durston.

At the third camp (Sagkeeng First Nation), participants stayed overnight with the camp staffs at a nearby lodge, which provided more time for staff to connect with youths. As one of the camp staff said in their exit interview,

> *"I really like Sagkeeng, I think it helps to have the kids camp with us just because they're able to build more meaningful connections with us, which lets us know each other better"*
>
> *(Karlee Lemus, camp staff, August 30, 2019)*

Couchiching FN was one of the motre traditional and engaged activities, which provided a perfect opportunity to blend the culture and science activities throughout. As the land-based camp coordinator said,

> *"with Couchiching, they had the drums, we did smudging and the Elders were really interactive and had really great stories. But I've noticed this before because I've been*

to a lot of First Nations in Ontario and they're just very traditional people to begin with. So that it was a lot easier to do that there."

(Taylor Gavin, Land-based Education Coordinator, Kis Kin Ha Ma Ki Win, August 30, 2019)

At the last camp (OPCN), it was not possible to achieve the maximum number of activities due to time constraints. The community had other priorities, which restricted the camp to two and half rather than three days. However, one of the stellar activities that we did at that camp was showing the participants a film about hydro impacts in the community (i.e. Green, Green Water). Youth participants were intrigued by and engaged in the discussion surrounding the film.

4.4.2 Differences in Age

Variations also existed amongst the camps when it came to the number and age of the participants (Table 4.6). The camp at Keeseekoowenin Ojibway FN had the highest total number of participants, but participation was not consistent across all three days. Some came for the first day but did not return thereafter. This also occurred at the camps for OPCN and for Brokenhead Ojibway Nation. Although the total number was lower at Sagkeeng FN, participation was stable in large part because they stayed overnight at the lodge. In Couchiching, the number of

Table 4 6: Variation in age group among the camps

		Communities				
		Brokenhead Ojibway Nation	Keeseekoowenin Ojibway First Nation	Sagkeeng First Nation	Couchiching First Nation	O-Pipon-Na-Piwin Cree Nation
1	Number of participants	6	19	7	8 (+30)	13
2	Average age	17.1	14.6	12.7	12.2	11.2

participants actually increased over time because >30 very young participants from the community day-care center attended the camp on the last day. They had lunch and participated in some recreational activities before leaving. Participant age was greatest in Brokenhead (average

age 17.1) whereas it was youngest in OPCN (average age 11.2) (Table 4.7). Unsurprisingly, this variation in age resulted in many changes to the nature of the camp activities. For instance, the (relatively old) participants in Brokenhead Ojibway Nation seemed less engaged compared to other camps, perhaps because it was also the first camp, and the staff were coping with and learning about the needed approaches and activities. In contrast, at OPCN, some of the (relatively young) participants were highly energetic, and they even insisted on doing more tests. One participant was sad that we were leaving, and wished that we come back,

> *"We want you to come in fall and do more testing"*
>
> *(Anonymous O-Pipon-Na-Piwin Cree Nation, August 22,2019)*

Although only 9 years old, she was very interested in the science activities. She said she wanted to become an environmental lawyer, so she wanted to know about water and the environment. In OPCN and Sagkeeng First Nation, and Couchiching First Nation, some of the younger participants were also much enthusiastic. Allen Courchene from Sagkeeng FN, also thought that younger participants were the most eager to learn,

> *"I think it's better to get them at the junior high level. Start from Grades 5, 6 7 and 8. Because they're more like sponges now and because in high school there already set and then the older, they are already did their program and they know where they're going. But if we start them at the Junior High, that's very interesting. Now when I go to High School and want to take chemistry, I want to take more science courses because I'm interested. Kids that have already finished, most are done by Grade 12, so they're not going to go back and start taking chemistry in different science courses again. Junior High is where it's at and the students are more attentive and they're like sponges, as they want to learn new things."*
>
> (*Allen Courchene, Sagkeeng FN, July 31, 2019)*

However, there was variation regarding such perceptions regarding age. At Keeseekoowenin Ojibway First Nation, Bradley Burns highlighted the importance of attracting older youth and

even adults to the camps in part because of their increased ability to retain information and the ability to link these activities to their community jobs.

> *"If we were going to do capacity building for our own monitoring within a community, I would rather target maybe not that much the youth but a young adult population. T and are still in school. If maybe you were even to test these, these kids tomorrow and say OK let's see what your results are, they may not retain have retained enough. But if we could train some of our staff and say this is your responsibility, now, then they take the job seriously that that's the approach I would do. We have a water plant, and we could train the water plant manager to say OK, now take some tests here and there and OK they would make it a part of their job."*
>
> *(Bradley Burns, Keeseekoowenin Ojibway First Nation, June 14, 2019)*

He was thus more focused on long-term community capacity building, where he found older youth and young adults to be more keen to learn and concerned about the environment, Indigenous culture, and to appreciate the significance of these cultural traditions.

4.4.3 Time frame

The duration of the camp also played a crucial role in shaping the variation among camps. With respect to Sagkeeng FN and Brokenhead Ojibway Nation, the communities are only one hour a part, but the camps differed substantially from one another in terms of activities. This in turn reflected the time duration and mode of each camp. In Sagkeeng FN, all the participants and camp staff stayed in a lodge close to the Maskwa project, which gave them time to connect with each other and where they were not as bound by time restrictions. They were able to swim, canoeing, kayaking and play in the rapids together, and all these activities increase participant enthusiasm about the camp. Allen Courchene was also present for all three days and as a highly experienced teacher, he was able to help coordinate the camp activities and ensure that there was time to adequately engage with all the participants. In Couchiching First Nation, the community representative was very organized and engaged throughout, and so was to help ensure that all the activities, especially the cultural ones, took place on time.

4.5 Discussion

Exploring new initiatives and innovative approaches to learning, reflection are all key aspects of action research (AR) (Clark, Porath, Thiele, & Jobe, 2020). Since it includes flexibility and iterative learning and action (Dick, 2014), it matches well with my own research objectives which also evolved throughout the process. These approaches started with observing different ways of learning, which in turn helped decided which paths would be followed. For instance, throughout the camps, different ways of incorporating the two knowledge systems (cultural traditions and science) were applied and then the path which best suited the desired outcomes was followed. It is thus an iterative and cyclical process of action and reflection.

Participatory action research (PAR)- the subgenre of AR, is more concerned about underlying power issues and dynamics (Greenwood & Levin, 2007), was also reflected in my research. One of the main intents of this project is to give power or voice to Indigenous communities and their youth in order to tell their own stories, concerns, and issues around their well-being, environment, culture, and traditions. Rather than being a process of one-way knowledge production and transmission from knowledge producer to knowledge user, an approach upon which most positivist worldviews are based (Anderson & McLachlan, 2016), my research through the land-based camps provided Indigenous communities with the opportunity to share the power of knowledge production. And, further, represented a platform for real and meaningful involvement in decision-making in every part of the research instead than only of data collection.

From the conceptualization and intent of the land-based camps onwards, the involvement of each community was given the utmost priority. In the pre-camp period, each camp was designed to reflect the host community's local environmental concerns and priorities (Table 4.1). Each community had its own preferences, experience and knowledge which was often overlooked or even ignored by the dominant system or in conventional Eurocentric research. This more participatory approaches were required, which not only helped ensure meaningful involvement but also helped empower communities while doing so (Brisbois et al., 2019; Buse et al., 2018). However, community participation was not limited to providing environmental concerns; instead, they oversaw the cultural activities in these camps. The types of cultural activities varied among the communities because in shaping cultural activities, communities

emphasize their local and place-based tradition, culture, and Indigenous knowledge reflected by Elders and knowledge keepers.

In the camps, Elders played a significant role when it came to community participation; they represent a plethora of Indigenous knowledge and have endured much widespread attempts at governmental assimilation and oppression and are still fighting to protect nature as well as their culture and traditions (Archibald, 2008). The land-based camps serve as an excellent way for connecting Indigenous youth with their roots and to these cultural traditions as there is widespread community concern they the young are disconnected from their culture and knowledge and their past (Fast et al., 2021). In the land-based camps, Elders, through their storytelling, medicinal plant teaching, ceremonies and sharing circles, were able to pass their wisdom and knowledge to the next generation, the youth and in so doing, had the opportunity to reconnect the youth to the land and nature. When asked during the sharing circle and through interviews whether they were satisfied with this cross-cultural co-teaching approach or not, Elders and other community members, even the youth responded in an affirmative way, Participants felt that these camps were not conventional science camps where the dominant voice is western science, and which thus ignored the community traditions and concerns. As an alternative space, it was a place where they also taught Indigenous knowledge to the youth. Still, youth also learnt aspects of western science that were important in their own right but which would ideally enable them to lessen the education gap and develop resilience to protect their environment. Thus, these land-based camps work towards a change and shift where researchers do not study the participants instead work alongside them to achieve the change and focus on 'democratization,' and towards community voices, this a fundamental pillar of PAR ((Stapleton, 2018; Fals Borda, 2001; Reason et al., 2014).

It is crucial to eliminate or lessen any gap between privileged and marginalized people while working for social change. It is still a burning issue when it comes to eradicating the gap in education between Indigenous and non-Indigenous students. According to the Truth and Reconciliation Commission of Canada, to thrive in the twenty-first century, some core principles must be followed for the reconciliation between Indigenous and non-Indigenous people in Canada (Truth and Reconciliation Commission of Canada, 2015b). They emphasize eliminating the gaps between Indigenous and non-Indigenous people in social, health, and economic outcomes, especially in education, and the importance of incorporate more culturally appropriate

curricula for capacity building (Truth and Reconciliation Commission of Canada, 2015b). Although the commission emphasized eliminating the gap in all educational areas, Indigenous students are arguably still most under-represented in the STEM disciplines.

In a classroom setting or even a conventional science camp, Indigenous youth most often find it challenging to understand the relevance of underling scientific concepts and language as they grow up in a different cultural framework where they learn experientially through hand-on approaches, by listening to their Elders and about issues and cultural concepts that are relevant to land, water and environment. It was evident from the Kis Kin Ha Ma Ki Win land-based camps that when scientific terminology and abstract concepts were introduced as part of science activities (Table 4.3), it was hard for Indigenous youth to find value in these although some participants had already encountered such content in school. However, when the significance of knowing the science was explained in relation to their land and environment for instance, importance of water quality testing and how contamination in water either river or lakes or wetlands impact their foods sources and medicinal plants, then they feel better connected to the place-based science activities. This was especially the case when such issues were co-presented by Elders and demonstrated by local knowledge keepers as this highlighted the relevance of this information and perhaps gave it a. like of credibility that would otherwise have been missing. Some participants were keen on developing in-depth knowledge on possible sources of contamination. This was even more evident with respect to the microbiological tests, and in their terms, the tests for bacteria, perhaps because community concerns regarding water quality and especially potable water are so widespread for First Nations communities across the country (Bradford et al., 2016; David Suzuki Foundation, 2018).

The relevance of this issue was exemplified in Couchiching FN, where they hired some technicians to monitor the quality of their tap water quality as they used to have boil water advisory. Before our introduction to the scientific terminology and some of the underlying concepts, the technician was invited to describe his work. As usual, he described how he checked for water quality by sampling for typical parameters, notably the presence of *E. Coli* and pH. Yet, his whole presentations reflected only a scientific point of view even though it was beyond the conceptual reach of the youth participants. The youth remained silent throughout his presentation but as soon as we started our session with questions like *"what did you think bacteria, or a germ is?", "where can you find one?", "what if we found bacteria in our*

drinking water?" and "is it safe?", they then they instantly responded and tried to connect their own ideas with their real-life experiences. Since they have different backgrounds and their traditional ways of understanding are primarily grounded in land-based learning, trying alternative approaches helped mitigate any adversity towards science, to engage their curiosity, to build on their capacity, and to engage actively in these science-based curricula. Such cross-cultural and land-based approaches represent a critical approach to such learning since, in conventional approaches to (science) education, the Eurocentric curriculum dominates over Indigenous knowledges and world views (Simpson, 2004).

Many scholars and Indigenous Elders propose adapting such cross-cultural approaches where "two-eyed seeing" functions as a guiding principle to overcome these obstacles or to bridge the gap between the scientific world and Indigenous knowledge (Hatcher et al., 2009) (Peltier, 2018). My research was paired with PAR and Indigenous methodology and follows such "two-eyed seeing" as did the camps that were the focus of this work. In so doing, the land-based, no one worldview, whether this be either western science or Indigenous knowledge, was allowed to dominate over the other.

Rural or marginalized communities affected by environmental degradation or resource extraction, can benefit from the co-production and teaching of Indigenous knowledge and western science. In part, this helps develop youth capacity in both knowledge systems, where each finds affirmation in and respect by and in turn affirms and respects the other knowledge system (Johnson et al., 2016; Mantyka-Pringle et al., 2017). All the host communities were observing environmental decline and these issues were all long standing and showed no sign of improvement whether this was hydro-related flooding, inadequate water treatment, the impact of upstream agriculture or decommissioned pulp and paper mills (Table 4.1). Although keenly aware of these threats and the impacts these had on land and human wellbeing from perspectives grounded in lived-experience and their cultural traditions, they generally lacked the science-based capacity to document these concerns and associated changes or to raise any science-based data or concerns with decision-makers. Yet the language of dominant society and of decision-making is one of science and, despite many (mostly empty) gestures to the contrary is still ultimately unwilling to recognize or accommodate Indigenous knowledge as valid (Aikenhead & Ogawa, 2007). On the contrary, some scholars believe that Indigenous knowledge grounded in cultural and spiritual perspectives is not only inherently valuable in its own right but that it can

enrich and inform scientific activity, including those related to ecosystems and human health, and in turn can and should play a critical role in informing policy and decision making (Brook & McLachlan, 2008; Finn, Herne, & Castille, 2015). These camps and other equivalent approaches to community-located learning, can play a role in addressing these gaps and ultimately in the long-term help inform community actions that address such shortfalls.

This culture of inclusion and mutual respect but also relevance and action acted as guiding principles for these camps. It was evident from both the activities themselves and from the interviews that the balance between two knowledge systems and in application and relevance was appropriately maintained. Participants also believed that if this kind of cross-cultural integration continues to be carried out in future, that it will undoubtedly support further capacity-building among youth as well as young adults regarding both western science and Indigenous knowledge. In so doing, these activities will help mitigate the long-term impacts of colonialism and the silencing of these community voices that continues to prevail today regarding the environment and wellbeing alike.

Chapter 5: Evaluating the implications of the land-based camps and facilitating science-based outreach and exchange

Background

The legacy of colonial research and associated harms has contributed to First Nations community mistrust of government and university researchers, a hesitancy about sharing personal experiences/information and a reluctance to actively engage in wider systems including governments and other non-Indigenous institutions (The First Nations Information Governance Centre, 2019). These concerns led to an increase awareness of and support for Indigenous data sovereignty, which can be seen as " linked with Indigenous peoples' right to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions, as well as their right to maintain, control, protect and develop their intellectual property over these" (Kukutai & Taylor, 2018, p142). First Nations sovereignty over information and data lead toward achieving and practicing self-governance which has important implications for the way research is conducted with Indigenous communities (The First Nations Information Governance Centre, 2019).

For most First Nations communities, an awareness of the importance of ownership of, control over, access to, and possession of data (i.e. OCAP), has amounted to a recent a call-to-arms as a response to colonialism and its principles as applied to research, monitoring, widespread institutional interest in traditional knowledge and the management of any ensuing information (Schnarch, 2004). Schnarch (2004), also indicates that OCAP is a solution to the existing tangled Indigenous research and for researchers it is a much-required indication of how to proceed regarding such issues. Scholars, especially those specializing in western science consistently overlook the value of IK and their voices in published official and unofficial reports and research as it primarily exists in oral form, and further regarded IK as a threat to their own Eurocentric system of knowledge (Blacker, 2021; McGregor, Whitaker, & Sritharan, 2020).

If some outreach to communities occurs, it is mostly grounded in western science context, loaded with scientific jargon; and is generally far from collaborative in. nature, regarding both outcomes and the processes that underly these interactions with community

(McLachlan, 2018). Such processes surrounding data sovereignty are poorly understood however, as are any action undertaken by researchers to overcome these shortcomings (Jardine & Furgal, 2010). Indeed, the challenges related to research and what constitutes community control goes beyond participation or having the ownership over research data, since communities also need to be engaged when it comes to the ideation and design of this research in order to help ensure the greatest value for participants (Blacker, 2021). Scientists generally now see great significance when it comes to involving locals or citizens in research in part as a response to cutbacks in funding and resources for research and as a way of increasing public literacy regarding science (Ganzevoort, van den Born, Halffman, & Turnhout, 2017; Kappel & Holmen, 2019), but even then the priorities are generally still decided by the scientists far in advance. It is also crucial for the Indigenous communities especially youth as the next generation of community leaders, to have some basic understanding of science-based knowledge because most decision-making regarding resource extraction is informed by science. In this way land-based camps not only serve as a bridge between the two knowledge system but they can also help facilitate community control and sovereignty over data and research as a whole and better enable communities to become fully engaged in science-based outreach and decision-making.

The goal of Chapter 5 is to critically evaluate the implications of these land-based camps for youth and other community members now and into the future. The specific objectives are, in turn, to evaluate the successes of the land-based camps and identify possible ways of addressing any of their shortcomings; to assess how and to what degree cross-cultural approaches to land-based education shape and facilitate youth interest and understanding; and to explore different ways of facilitating science-based outreach and exchange regarding the camps with community.

5.1 Various forms of community outreach

In what ways knowledge is utilized, recognized and how the evaluation is performed by the end or possible user is one of the most significant requirements for defining the useful knowledge exchange (Kadykalo, Cooke, & Young, 2021). It is increasingly expected by Indigenous communities that outsider-researcher should be participatory and community-based, respectful toward Indigenous culture, be mindful of in not explicitly include cultural traditions and Indigenous knowledge. The exchange of knowledge and the role of Indigenous-centred research ethics has also increased as researchers undertake approaches to incorporate these

knowledges and community priorities and to conduct outreach with communities at all stages in the process. (Schnarch, 2004). Science-based outreach regarding these camps was conducted in a number of ways (Table 5.1).

Table 5 1: Hosting communities and ways of knowledge exchange

	Host Communities				
	Brokenhead Ojibway Nation	**Keeseekoowenin Ojibway First Nation**	**Sagkeeng Anicinabe First Nation**	**Couchiching First Nation**	**O-Pipon-Na-Piwin Cree Nation**
Sharing Circles	X	X	X	X	X
Interviews		X	X	X	
Subsequent Visits		X			
Final Reports	X	X	X	X	X

Sharing Circles: Experiences and learning outcomes as well as the strengths and weaknesses of the camps were further explored with participating youth, community members and Elders in sharing circles at the end of each camp (Table 5.1). The nature and intent of such sharing circles was discussed in Chapter 4.

Interviews: Additional insight into the success and shortcomings for each camp as well as ideas for future approaches were provided by complementary interviews with participants, including scientists, Elders, camp staff, and community organizers (Table 5.1).

Subsequent Visits*:* In some cases, it proved necessary to conduct a follow-up visit, especially if data that were generated was seen as having potential adverse health implications and required more comprehensive testing. These visits were designed in collaboration with the host community and ideally resulted in a larger data set that could then better inform any subsequent decision-making. In 2019, two communities expressed a desire for follow-up visits, but the only visit that took place was in Keeseekoowenin Ojibway First Nation (Table 5.1). Due to the COVID-19

pandemic, several other subsequent visits planned for winter and summer 2020 were delayed and then ultimately cancelled.

Final Report: The activities and any test results of each camp were summarized in a 30-40 page final report that was written in accessible language and that summarized any highlights using photos, tables, and figures. These were shared with each community and a follow-up meeting was organized with camp lad-based coordinator and cam staff to address any questions or concerns and feedback.

5.1.1 Development in the camp

5.1.1.2 Presentation style: At the first camp, a power point projector was used, and a presentation was shown (Fig 46). It was developed with the intention to make a stronger understanding on any scientific terminology and concepts and to provide useful visual cues.

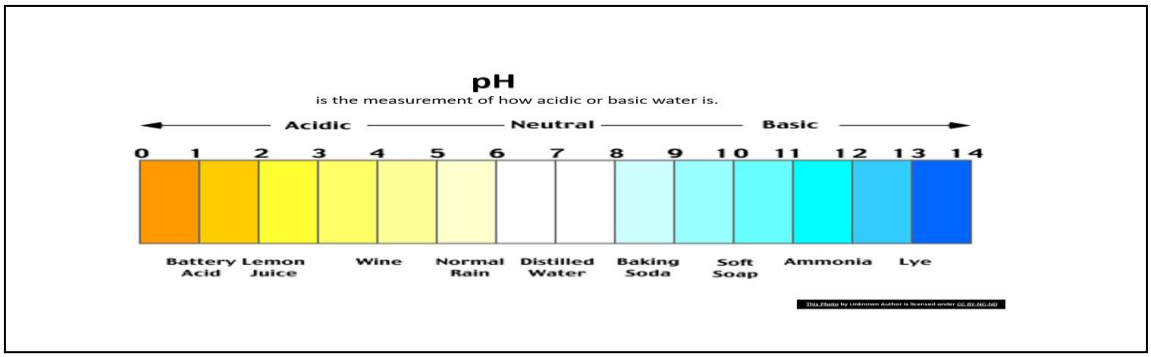


Figure 46: Screenshots of presentation slide for the 1st camp

However, it was noticed that participants were disconnected from the presentations, in part because of the didactic form of the teaching. But also, because it lacked real-life and pragmatic examples as indicated by some Elders. Most of the youths did not have much knowledge of or even interest in such scientific terms and abstract concepts. Then instead of showing the presentation, an oral discussion was used to ease facilitate understanding. Moreover, Elders suggested more real-life examples were provided to facilitate learning and discussion. In Keeseekoowenin Ojibway and Couchiching FN, no power point presentation was given, only oral discussions and question and answer approaches were used to facilitate discussion and to increase participant familiarity with the scientific terms. In Sagkeeng FN

and OPCN, a modified presentation was presented to make it more realistic; thus, for instance, in order to describe pH, examples including tomato juice, orange juice and laundry detergent were provided (Fig 47). To describe bacteria and where it is found, human feces was used as an example as was suggested by Allen Courchene since he thought it would increase student interest and increase understanding. These revised approached helped the participants better understand both concepts and terminology and to make connections between the tests and the underlying reasons for doing the testing. And, ultimately, these changes in approach helped shape and facilitates youth interest and understanding, one of the key objectives of this research.

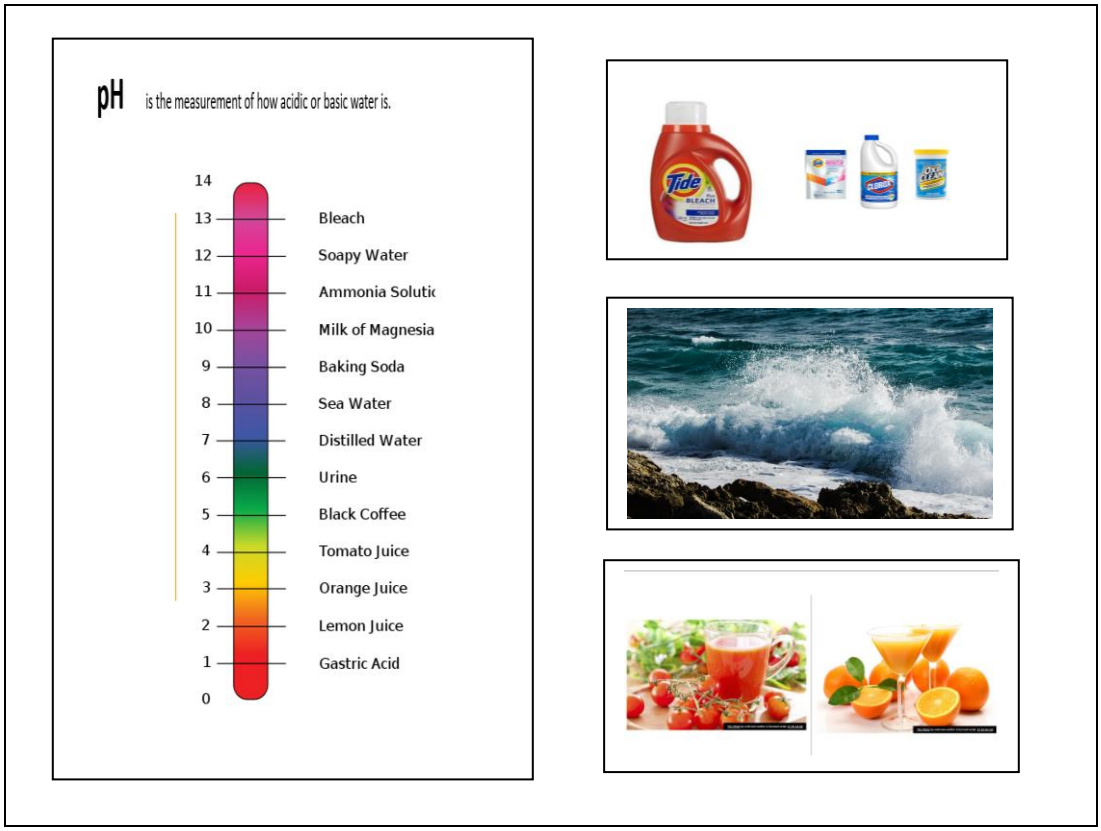


Figure 47: Screenshots of presentation slides from the third camp

5.1.1.2 Field log/Notebook: At the first camp a six-page field notebook that also included an additional page for reflections was created by the camp staff in order document all data that were recorded. This book was then printed and provided to the youths (Fig 48). However, its use writing notes and reflections was questionable, since it was hard for turns to write the notes, it

youth participants to do this while also going for long nature walk, while also collecting samples and doing the tests. Sometimes they lost the notes as well as the log.

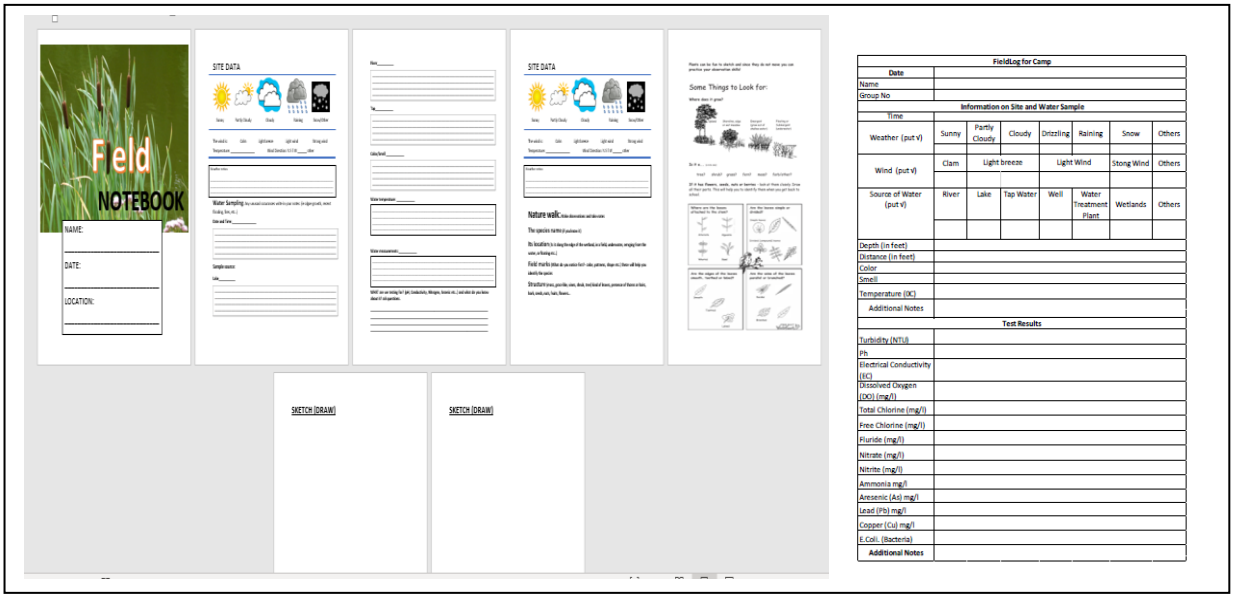


Figure 48: Format of field log

It was also unclear what was expected of them to write, and some felt it is overwhelming for them and so most left the pages blank without writing anything (Fig 49). Ultimately, the use of these field notes was abandoned after the first camp.

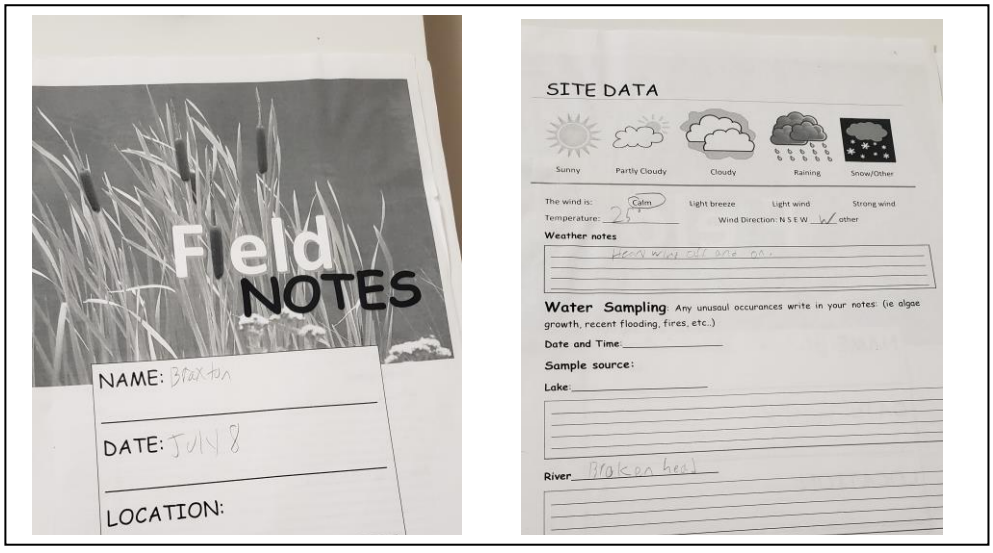


Figure 49: Field notes of one youth participant

Moreover, I felt that the use of these notebooks just perpetuated whatever any other conventional western researcher or scientist would do, using the community participants as data collectors rather than focusing their attention on what is going on and the connections between the science and the underlying cultural traditions and changes in nature. Instead, in last two camps we, hung a big paper and used a whiteboard for taking notes (we were using school rooms) (Fig 42 & 43) where records of all the data were kept. And sometimes we asked the participants to write any results from their testing and in that way, it was more comprehensible and accessible to both the participants as well as to the community members (Elders and teachers) who came to see the camp and the youth.

5.1.2 Feedback from community

5.1.2.1 Overall accomplishment: When evaluating the overall performance of this cross-cultural approach, almost all community members found that the camps were an effective way to build capacity among the youth in terms of science and in cultural traditions, engaging them in understanding and connecting the Indigenous Knowledge in a land-based setting.

> *"The overall camp, the basis is really intriguing that to make…science with the cultural component and in our culture, we see that the life that that water gives us life, but we also look after the… the science approach to it says that certain water can be drunk, certain water can be used for washing… certain water may be contaminated. Our relationship with water is that… we see it as a living being."*
>
> *(Bradley Burns, Keeseekoowenin Ojibway First Nation, June 14, 2019)*

Communities generally found this approach to be very engaging, and many participants expressed interest in having more of these camps in the future.

5.1.2.2 Building capacity in the community: Elders, Chiefs and other community members were asked about the camps whether or not these might potentially play a significant role in building capacity among the youth in future. All agreed and wanted to see more since they addressed a real community need. As community Bradley Burns in Keeseekoowenin FN indicated,

> *"It would be good to see a… some more of that capacity building in the community."*
>
> *(Bradley Burns, Keeseekoowenin Ojibway First Nation, June 14, 2019)*

Similarly, in Allen Courchene in Sagkeeng FN thought that camps that integrated IK and western science and that involved local youth would bring benefits to the community,

> *"Really good. Good. Lots of learning and incorporating a lot of stuff that the kids are having fun but also at the same time learning new technologies. I think, the camp is very successful, and I look forward over the next couple of years to do similar camps that we have different student and youth that will participate because this is so good for our kids to be involved in these types of camps"*
>
> *(Allen Courchene, Sagkeeng FN, July 31, 2019)*

One Elder from Couchiching FN further indicated that he has also learned a lot from the camp,

> *"I have no idea what was going to be like, and I think .... beyond for these kids, I feel like I have learned a lot from it, and I would like to take a course on water. That is…that's getting scary…. I think it is a start. The first camp they had on this, and I think they had built on this thing. Yes, it was a big …it was a learning experience. Thank you."*
>
> *(Elder Dickbird, Couchiching FN, August 13, 2019)*

Elder Linda from Couchiching FN also agreed that the land-based camp successfully addressed local environmental concerns while also connecting the Indigenous youth to the land,

> *"I think the reason behind the camp is to address all the concerns that you know, that would affect the water. Yeah, I think so."*
>
> *(Elder Linda, Couchiching FN, August 13, 2019)*

5.1.2.3 Facilitating youth interest: Shaping and facilitating youth interest and understanding in *both* the environmental sciences and Indigenous culture was one of the critical objectives of the camps. After assessing and discussing this priority with community members, it was clear that this objectives had been achieved, to some extent. However, as such these camps represented only an initial step n this process and needed to run and last longer.

"It's definitely going to give us more of an insight like the kids and insight be cause we do have boil water advisories and how does how do we determine that you know. So, the kids will learn, and then all the other water testing you guys did, like the lead, like what is in our water. So, I think that it's been great."

(Debbie Fairbanks, Couchiching FN, August 13, 2019)

Elders thinks that it was an effective way to begin this process that and involving youth while they were still relatively young would be beneficial since they represent the future of the community. They would eventually pass their camp-related learning to their parents and to the larger community and so assist them to preserve their environment, while keeping water safe and healthy.

"I think, this is really good, and I think it's good to start at that age because this is going to be their future and hopefully as a grandparent and may be with their parents, they can all you know, look at we were doing. To help the situation of maintaining our water, keeping our water clean.".

(Elder Linda, Couchiching FN, August 13, 2019)

One of the crucial aspects of the research is that Indigenous youth felt connected to rather than alienated from the science. Moreover, we tried to make science understandable in order to build interest and to encourage them to want to know more.

"*This was in Keesee one of the girls was really into environment she said that she wanted to get a job in the garden. One girl told me how much she enjoyed like seeing chemical reactions to do that and like she seemed to like the actual change"*

(Kianna Durston, Exit Interview, August 30, 2019)

When it comes to Indigenous culture, utmost importance was given to know, learn, and affirm local community traditions, ceremonies, and knowledge from knowledge keepers and to be suitably respectful and thankful,

"Indigenous culture sees water as a living being, we respect, and we honor and ceremony. It's a co-operative sort of relationship the water. We need the water but when it is contaminated the water needs us as well. The science-based approach helps

identify which water needs the help…so that is what was really intriguing about this program. It's good to see that our youth are engaged, and that they are having a good time."

(Bradley Burns, Keeseekoowenin Ojibway First Nation, June 14, 2019)

Community members were delighted to see their youths connecting to their roots through the camps. It was not only about the youths learning about their cultures, but it also served the community to connect with, learn about and celebrate the traditions.

"Like today when we wanted the cultural components that we learned, I never knew how to pick that water lily route. And I was just impressed by looking at how we do it and even with the young kids that were involved in picking the water lilies. That's a lot of work and I was so impressed that it looked like a pineapple, a huge, long pineapple. Yes, new learning experience every time we go with different cultural and different Elders you always learn something new, so I always appreciated this"

(Allen Courchene, Sagkeeng FN, July 31, 2019)

Reviewing the views of Elders, it can be assumed that the land-based camps were able to create a platform that served and guided the Indigenous youth on how to connect with their culture and at the same time how to broaden their knowledge of science. It might provide a spark of interest and ideally might help them build their own interest in and capacity around science while also increasing awareness around and concern regarding local environmental decline.

5.1.3 Ownership of data

An important issue for many Indigenous people is that of data ownership. When any environmental concerns arise in the vicinity of an Indigenous community, research is often used to conduct by the universities, governments, and industry to mitigate such problems. In the past, little-to-no consultation was performed with Indigenous communities when it came to data collection, and even less was done to make these data accessible to community regardless of local concerns since most of the data were gathered and reinforced by external experts (Royal Commission on Aboriginal Peoples, 1996).

However, when it comes to control and possession of data little has changed; these data are generally still collected and possessed by outside authoritative bodies and researchers. Scientific research has a tendency to use "parachute" approaches which design research, collect data at their convenience and then depart without much if any communication with the community during or after the research (Castellano, 2004; Castleden et al., 2012). Community members rarely have any say and at most they are used to help collect data or to act as key informants. They certainly don't get the opportunity to have ownership over the data. Moreover, they rarely receive any research findings,

> *"'because that's what's happening with us right now, right? The guy just comes to test the water and then it goes to a lab in Winnipeg …that's where he takes his water samples, but we don't know. All he comes back to say is - oh he puts up a sign 'Do not consume the water'."*
>
> *(Anonymous, Sagkeeng FN, July 31, 2019)*

When scientific worldviews are integrated with local or Indigenous knowledge, this enhances the trust in the science which is most often missing when it comes to locals but it also stimulates more acknowledgement of and interest in scientific views in that community (Jasanoff, 2018; Kappel & Holmen, 2019). The land-based camps were designed to keep that in mind, where each community would own, possess and have full access to data - both Indigenous and scientific – and indeed have full ownership and control over the camp-related results themselves.

> *"We can trust the results. It's not a government-sponsored test and then at the end of the day of 'just say it's fine, move on to the next level' and we have more concerns. Just so that it's fine, you know with no results just it's fine."*
>
> *(Bradley Burns, Keeseekoowenin Ojibway First Nation, June 14, 2019)*

On the last day of the camp, all the results including the findings themselves along with a brief analysis of these same findings were shared with the community. A more detailed report was promised to each community, which would be written in simple language in a form that was easily accessible to all the community members.

5.1.4 Mix-matching with recreational activities

One of the key features of the camps was that it not only incorporated IK and western science, but that it also provided space for youth entertainment and a diversity of recreational activities (Table 5.2). The schedule of the camp was made in a way that no single element could overpower others.

Table 5 2: List of recreational activities in the camps

	Activities	Communities				
		Brokenhead Ojibway Nation	**Keeseekoowenin Ojibway First Nation**	**Sagkeeng Anicinabe First Nation**	**Couchiching First Nation**	**O-Pipon-Na-Piwin Cree Nation**
1	Sketchbook making		**X**			
2	Painting using materials from nature		**X**			
3	Dance workshop and games		**X**			
4	Ice-dyeing workshop	**X**		**X**	**X**	**X**
5	Watercolor painting			**X**	**X**	
6	Canoeing	**X**		**X**		
7	Swimming		**X**	**X**		
8	Shelter building			**X**		
9	Water balloon/water gun fights		**X**	**X**	**X**	**X**
10	Badminton	**X**				
11	Baseball		**X**			
12	Manhunt		**X**	**X**	**X**	

A break to go swimming or kayaking or even shelter building in the bush (Fig 50 & 51) gave youth participants time to absorb Elder their stories while also providing more time for testing, which sometimes needed 10-20 minutes resting period in order to get results.

Figure 50: Sliding in the rapids in Sagkeeng FN (left).

Figure 51: Shelter building in Sagkeeng FN (right).

Photo Courtesy: Tanjina Tahsin (left) and Taylor Galvin (right).

Sometimes, cultural teachings also incorporated entertainment activities. For instance, in Sagkeeng FN, as the youth stayed in camp whole day and night, they got more time to spend in the camp. Therefore, there was much time for many games and lots of swimming. One such game was a scavenger hunt, where youth were divided in two groups and asked to hunt for hazel nuts, raspberries, bird egg and wildflowers and so on (Fig 52). In that way the entertainment activities also serve the objectives of the camp.

Figure 52: Items from a scavenger hunt in Sagkeeng FN.

Photo Courtesy: Taylor Galvin.

5.1.5 Challenges

Nothing in the world is achieved without confronting barriers or challenges. From the initiation to the ending, a number of challenges were faced in each camp. First, this project represented a new initiative. Communities were very interested in organizing and hosting camps, and the camps were scheduled week by week.

> "*That was probably just because there was so much interest in the camp. Like so many people were contacting us at the same time. So I would book them a week, a week, week, week. Not knowing whether they would or would not work"*
> *(Taylor Gavin, Land-based education coordinator, Exit interview August 30, 2019)*

If large intervals had been maintained between each camp this would have allowed for more reflection on any shortcomings and how these might be overcome. For instance, it was planned to build a poster to ease the understanding of the scientific terminologies, including more visualizations and more real-life examples. However, due to time constraints, those posters were never created. Alternative methods had to be developed and adopted to overcome such shortcomings.

Secondly, many technical difficulties arose in large part because the lab equipment only arrived two weeks before the first camp. Indeed, some of the microbiological equipment failed to arrive on time and was thus excluded form the first camp. A lot of calibration were required for all the equipment. Although this was done before heading out for the camp, something always happened including charges that didn't last long enough and more calibration was needed on-site which was time-consuming.

> *"About the equipment, like one of the pieces of equipment was not working. We returned it, but we did not get it back in time for the South Indian Lake…. equipment has some issues like calibration and other issues, but we didn't get time to fix all these. So, the equipment just sat in the lab".*
>
> *(Tanjina Tahsin, Exit interview, August 30, 2019)*

The community also confronted some challenges, like sometimes they were not fully prepared what they were going to do or say, in part because we failed to make adequate connections between the intent of the camps and the knowledge that each Elder held,

> *"They did all show up and they all like partook but some of them just seemed kind of lost on what to talk about……then we just had to give then more detailed guidelines because I know if they knew what they were going to talk about specifically that they would have a lot more to say about it."*
>
> *(Taylor Gavin, Land-based education coordinator, Exit interview, August 30, 2019)*

Finally, the youth sometime got distracted and were less connected to the camp activities despite all of our efforts. In some places, youth were paid by the community to be there, it was like there summer job, but this was usually just a small honorarium.

> "*There were some folks like really not interested. We tried to get them interested but they don't want be there"*
>
> *(Kianna Durston, Exit Interview, August 30, 2019)*

They seemed to enjoy the arts activities, including a tie-dye tee-shirt which they made from ice-dying (Durston, 2020). However, there was lots of turnover. Some youths did not attend for all three days, some coming on the first day or the last day only,

> *"I feel like they were like coming -go type of thing, doesn't work as well"*
>
> *(Karlee Lemus, Exit Interview, August 30, 2019)*

Consequently, this occasionally created a gap in understanding and prevented some youth from connecting to all the aspects of the camp.

5.2 Post camp activities

5.2.1 Exit interviews

The exit interview was conducted to have a documented insights that can be used in my and Kianna research projects (Durston, 2020) and to write reports for the funders and the communities. Dr. Stephane McLachlan facilitated the interviews though I am calling it an interview, but it was more like focus group discussion where both positives and any shortcomings of the camps were discussed, and how the former might be expanded upon, and

the latter overcome. Thus, ideas were generated that might shape the development of future camps and possible alternative plans were also explored. Among the five camp staff, four including me, attended and provided their views. Discussions focused on youth engagement but also emphasized community engagement. They also recognized that there was a diversity of community attitudes and experiences towards the camps and potential environmental concerns. Some communities were very clear about what they wanted to see in the camps and what their environmental concerns were, like Couchiching First Nation, whereas some didn't have any particular concerns regarding the environment like Brokenhead Ojibway Nation.

The interview started with marking the camps as a whole, on a scale of 1 to 10, 10 being perfect and 0 being disastrous and the results ranged between 7 to 8.

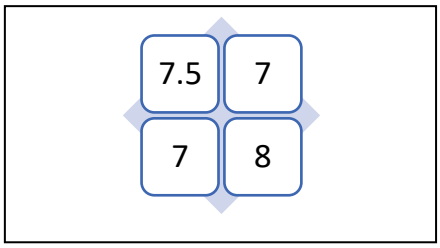


Figure 53: Marking of the overall camp by the camp staffs

After getting everyone's marking, it could be assumed that for a new initiative like this that the camps as a whole went well.

"So obviously to get 7 or 8s, lots of things had to work very well"

(Dr. Stephane McLachlan, Exit interview, August 30, 2019)

Despites the overall success of the camps, there were some shortcomings as well, as will be discussed below. In terms of picking their favorite camps, three among the four chose Couchiching First Nation and other chose Sagkeeng Anicinabe First Nation. They found that Couchiching First Nation presented a perfect example of a cross-cultural approach and an appropriate integration of IK and western science. When it comes to structuring or shaping the camp, Couchiching was very clear what they wanted. Even the Elders were enthusiastic about better understanding the science behind the contamination of water and developing ways to find this out,

"Couchiching was the first time where Elders very eager to learn about the (scientific) results, and they were asking questions like why this happened"

(Tanjina Tahsin, Exit interview, August 30, 2019)

And were also interested in how the science might be applied to improve the quality of the water

"They all wanted to know what can do now to make our water better".

(Karlee Lemus, Exit Interview, August 30, 2019)

Then, comes the future plans for the camps starting with follow-up camps. Keeseekowenin Ojibway First Nation was the first in the list as they clearly had showed much interest in a follow-up camp or simply that the staff visit again to test more sites. Since we were not able to properly conduct the microbiological test due to technical error, they wanted to ensure that these tests were retaken, and that additional testing was conducted. Other communities were also lined up for follow up tests especially for winter 2019.

A one-day workshop was also proposed during this debriefing where all communities (some of the member of the community and youth) would participate and shared their views. After that, features of the reports were discussed, and what might be done to make them more visually appealing and accessible to the host communities was further explored.

Several other recommendations were suggested to incorporate in future camps, these as follows:

- Big posters focusing on scientific terminologies and concepts (simple language and more visualization)
- More technological supports as most of the campgrounds were in the field and to perform some tests, further power supply was needed.
- Number and age of participants in the camps. Some suggested bigger groups divided into two whereas some recommended not more than 10 participants in a group. Others recommended having older youth in one camp and then youth less than12 years of age in the other.
- Incorporate more cultural activities including a plant-based section and even more science related to other aspects of the environment, for instance a soil-based camp where basic knowledge on soil would be provided.

- More social media involvement- Facebook, Instagram, website, blogs to facilitate outreach with communities and more active engagement with participating youth
- Some basic rules and regulations to maintain appropriate and respectful behavior in the camp, not only for the youth but also for camp staff.

5.2.2 Subsequent visit

Due to technical problems (Nutri disk media was not working properly, so in this we usedculture media) microbiological tests i.e., presence of harmful pathogens like bacteria was interrupted in Keeseekowenin Ojibway First Nation. Furthermore, leadership wanted to expand the number of original sites for the water quality testing. They recognized that the water bottling plant was the only source of their drinking water, but that it was old enough to increase the possibility of contamination by bacterial. They had been requesting Indigenous Services Canada for a replacement treatment facility for a number of years, but to no aval. Although, the agency did monitor and test for water quality, especially for bacteria, on regular basis, few results were shared, and the community questioned them regardless. Thus, the community wanted their own testing and results. On October 2, 2019, a follow-up visit was made to Keeseekowenin in order to reassess the microbiological quality of its water.

5.2.2.1 Sampling sites: Water samples were collected from ten sites of which four were public sites and rest of the six from private households. Among the six samples, five of them were tap water which is generally not used for drinking (except in Site 3) and one sample was collected from the large water bottles that are supplied by water bottling plant. Public sites included raw water coming directly from the well into the water bottling plant, treated water just before filling the bottles, water directly from well and from community health center (Table 5.3).

Table 5 3: Description of sample sites in Keeseekowenin Ojibway First Nation

Site No	Name of the Site	Source of Water				Use of Water			
		Directly from Well	From Well to tap water via cistern	From Well to tap water	From Well to bottled water via treatment plant	Drinking	Cleaning and washing	For treatment plant	To fill up Cistern
Site 1	Community Health Center		X				X		
Site 2	Household A			X			X		
Site 3	Household B				X	X			
Site 4	Well A	X							X
Site 5	Well B	X						X	
Site 6	Water bottling plant				X	X			
Site 7	Household C			X			X		
Site 8	Household D			X			X		
Site 9	Household E		X				X		
Site 10	Household F			X			X		

5.2.2.2 Results: Potalab +(M), a portable water quality test kit was used to test the microbiological quality of water. Thermotolerant coliforms (sometimes called Faecal Coliforms) and total coliforms were tested by setting different incubation temperature (44^0 and 37^0 Celsius, respectively). Usually, the presence of thermotolerant coliforms indicates faecal contamination and different studies suggest that above 95% thermotolerant coliforms isolated from water are dominated by *Escherichia coli* (*E. coli*) (Bartram & Pedley, 1996) if the thermotolerant coliforms are present in water there will be *E. coli* (a member total coliform group) as well (Health Canada, 2006) . According to Health Canada (2006), faeces of humans and other animals are the source of *E. coli*, and if there is any *E. coli* are found in water, this indicates both faecal contamination as well as possibilities of the presence of other harmful disease-causing pathogens.

E. Coli or Faecal coliform (Thermotolerant coliforms): The test results indicated that there was no faecal coliform present in either drinking or non-drinking water. According to Health Canada guideline (2019) the *E. coli* should be none detectable per 100 mL water. The findings from these tests showed that none of the sample sites surpassed the Maximum Acceptable Concentration

(MAC) of *E. coli* or faecal coliforms in water (nondetectable in 100 mL water) (Fig 54) indicating that the water samples were free from faecal contamination.

Figure 54: Absence of *E. coli* or faecal coliform in drinking water (sample from Site 3)

However, the absence of *E. coli.* does not assure that the water is free from other disease-containing pathogens like viruses or protozoa, so that regular monitoring and further advanced testing might be required to more thoroughly assess potential microbial contamination.

Total coliforms: Meanwhile testing for total coliform revealed different results; even in drinking water, Total coliform was found (site 3). Although the amount was very low, any presence is not acceptable since Health Canada guideline MAC is that none be detectable/100 mL (Table 5.4). However, no coliform was detected in the water from the water bottling plant (WBP) (site 6, Table 5.3) which is one of the main sources of drinking water in the community. The sample was collected from the plant just before filling up the big blue jugs that are then delivered to households and public buildings for drinking purposes.

Table 5 4: Total coliform test results in drinking water (site 3 and site 6) and non-drinking water (site 1,2,4,5,7,8,9,10)

Site Number	Name of the Site	Total coliform CFU*/100 ml Water
Site 1	Community Health Center (CHC)	0.6
Site 2	Household A	6
Site 3	Household B	2
Site 4	Well A	0
Site 5	Well B	0
Site 6	Water Bottling Plant (WBP)	0

Site 7	Household C	0
Site 8	Household D	16
Site 9	Household E	0.6
Site 10	Household F	1.2

*Colony forming units (CFU) is a unit used in microbiology to estimate the number of viable bacteria in a sample

Total coliforms were subsequently detected in five other sites where water is used for nondrinking purposes like cleaning, washing, and two were directly from wells. One of the sites (Household D) (site 8 in Table 5.3) showed >10 CFU in 100 mL water whereas the recommended MAC is none in 100 mL water. The rests were 6, 1.2, 0.6 and 0.6 CFU for sites 2, 10, 1, and 9, respectively. Thus, these results still showed the presence of total coliforms in water which certainly exceeded the MAC in water. In Figure 55, yellow circles indicate the presence of total coliforms (although these can be seen better under a microscope).

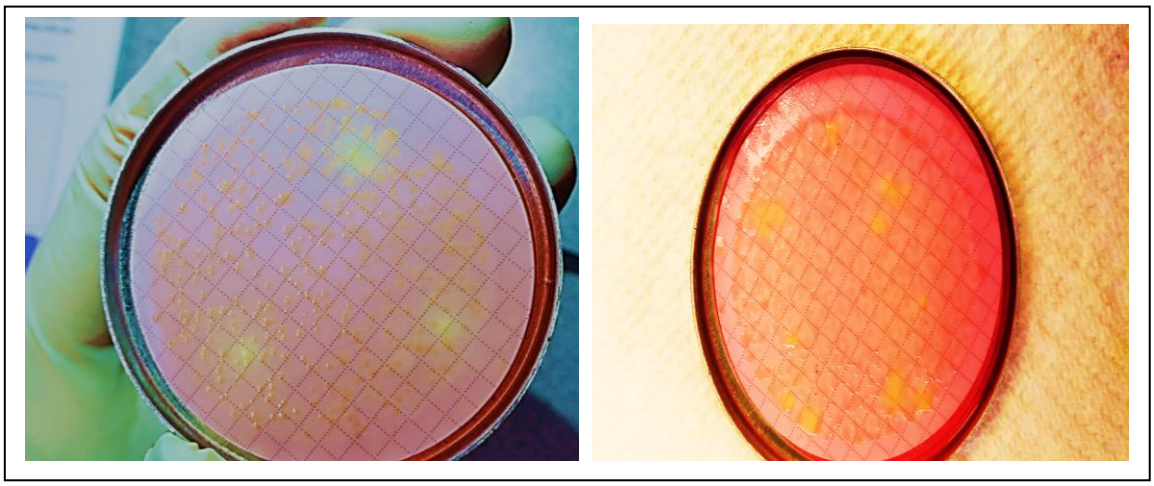


Figure 55: Presence of total coliform (yellow circles) in petri dishes; Site 3 (left) and Site 8 (right)

The people living in household B and D were immediately informed over the phone about these findings and asked to talk to the community to deal with it. The household member informed us during sample collection that some technicians from ISC had previously come and collected water samples to test but that they were never informed about the results and were just asked not to drink the tap water although they were not using the water for drinking purposes. However, they did use the water for washing and for laundry, which still put them at risk.

5.3 Report writing and Findings of the tests results in the camp

Soranno, Cheruvelil, Elliott, & Elliott (2015) argues that to have a true engagement and democratization in the field of science, it is crucial that research findings or data be provided to the public in an accessible form and that this is particularly important for scientists who work in partnership with citizen scientists and for communities who are impacted by decision-making regarding natural resources. Yet it is still commonplace for communities to never hear back from technicians and scientists collecting data, or should they hear back, that the data be provided in a format that is effectively inaccessible (Soranno et al., 2015).

Researchers are developing ways to better facilitate science communication and to better share scientific results that are not only accessible but more importantly understandable to all level of spectators regardless of their education background (Kappel & Holmen, 2019). Such issues were of critical importance when writing reports for each community, and priority was given to writing in a plain and simple way with minimal scientific jargon. Writing reports (Fig 56) for the community is one important way of exchanging knowledge and in living up to the principles of OCAP. Thus the reports were structured in order to emphasize simple language, but also incorporated many pictures, color-coding, real life examples and the paraphrasing of complicated terms.The reports start with the acknowledgement of people were directly involved in the camps including leadership, community liaisons, Elders and knowledge keepers, youth and camp staff (Fig 51). Each then provided a summary of the camp including background, rationale, findings, and any implications.

Figure 56: Screenshots of the Brokenhead community report

A brief description of all the camp activities was presented including cultural, arts, recreational and science-based activities along with corresponding pictures. When it comes to share scientific results, I tried to explain scientific terms with figures and other images instead of writing complicated sentences. When the findings of the tests were presented, I used a traffic-light approach or labelling (green-yellow-red), but instead of using three colours I added a fourth colour (orange) (Table 5.5). The use of these intuitive color coding schemes provides immediate understanding of the responses or results whereas the use of numerical value needs requires additional explanation and is sometimes still inaccessible to non-scientists. In terms of the color, green indicated GOOD or results that fell under the Maximum Acceptable Concentration (MAC) (Table 2.2). Yellow indicated FAIR or results that were equal to or just above the MAC and that needed regular monitoring. Orange indicated MARGINAL or results that fell above the MAC, and that needed preventative action and regular monitoring. Finally red indicated POOR or results that were above the MAC, that needed immediate preventative action as well as regular monitoring (Table 5.4).

In terms of the findings, most of the parameters were under the MAC allowed by Health Canada (2019) and the CCME (2019) (Table 5.5). However, turbidity, dissolved oxygen and Total Coliform were most often problematic as is presented below (Table 5.5).

5.3.1 Turbidity

In all the camps except for Couchiching First Nation, turbidity is above the MAC (Table 2.2). The following figure 57 can clearly indicates differences in turbidity among communities (yellow in Brokenhead, orange in Sagkeeng and red in OPCN). Since OPCN is the one of the hydro- impacted communities and subjected to frequent flooding it is perhaps unsurprising that differences in water color and the presence of bubbles can easily be detected with the naked eye. Community members indicated that it was not like that prior to the building of the Churchill River Diversion and the water had been clear and that fish were easily visible before. However, the situation has now clearly changed for the worse.

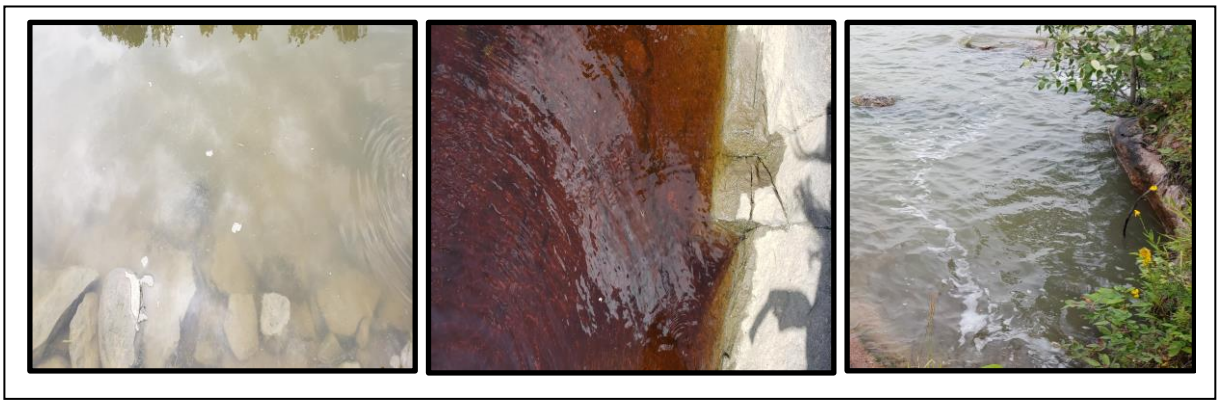


Figure 57: Water quality in three communities: Brokenhead Ojibway Nation (left), Sagkeeng FN (middle) and OPCN (right).

Photo Courtesy: Tanjina Tahsin.

5.3.2 Dissolved Oxygen (DO)

Brokenhead was particularly interested in testing the quality of water in the Brokenhead Wetlands especially DO, since this was one of the major local environmental concerns. As they anticipated, the quality of water is degrading since some plant species had been locally extirpated and some plant populations were in decline. Testing clearly showed the lower levels of dissolved oxygen**.** According to the Canadian water quality guidelines for the protection of aquatic life (CCME, 1999), the guideline value for DO in freshwater is much higher than analyzed value which is not a good sign, and such low levels of DO may threaten nearby aquatic plants. Apart from Keeseekoowenin Ojibway FN, water samples were collected mostly from

natural sources in Brokenhead, Sagkeeng, Couchiching and OPCN and all of these has lower levels of DO. Levels were again low enough that they pose a threat to aquatic life.

5.3.3 Total and Fecal coliform

Details of Coliform was discussed above. During in-camp. testing, total coliform was found in Couchiching First Nation (Fig 58) and OPCN and Fecal Coliform was found in Sagkeeng FN. In Couchiching FN, the CFU was on average 7/100 mL water and in OPCN it was 5/100 mL water. However, in OPCN, our microbial incubation lab was running out of charge, and we had to plug it into a car battery. This resulted in the shifting of the equipment which could have impacted the results Although the amount is very low in the water, according to the Health Canada (2019), Guidelines for Canadian Drinking Water Quality "the sources of total coliforms are human and animal faeces; naturally occurring in water, soil and vegetation and maximum acceptable concentration (MAC) is none detectable/100 mL in water leaving a treatment plant and in non-disinfected groundwater leaving the well" (p04). In that case, assuming the results are real, this is a matter of concern and worthy of follow-up testing at least.

Figure 58: Counting of CFU and note taking by the youth in Couchiching FN. Photo Courtesy: Tanjina Tahsin.

In Sagkeeng Anicinabe First Nation,fecal coliform were only found in one petri dish and there was only one CFU. Since Health Canada (2019) recommend none detectable per 100 mL water even the one per 100 mL is not acceptable as it was tap water used for washing and other purposes (but not for drinking).

Table 5 5: Findings of the water sample tests in the camp

Community	**Physio-Chemical Parameters**										**Biological Parameters**		
	pH	Turbidity	Chlorine	Fluoride	Ammonia	Nitrate	Nitrite	Lead	Copper	Arsenic	Dissolved Oxygen (DO)	Total Coliform	Fecal Coliform
Brokenhead Ojibway Nation													
Keeseekoowenin Ojibway First Nation													
Sagkeeng Anicinabe First Nation													
Couchiching First Nation													
O-Pipon-Na-Piwin Cree Nation													

For further understanding a complementary grading system was also included in the reports. Thus, A was good, B was satisfactory, C was not good, and D was poor. Since we are all familiar with grading systems, its use would help make results more understandable. An example of the color coding and grading system is presented in Figure 59.

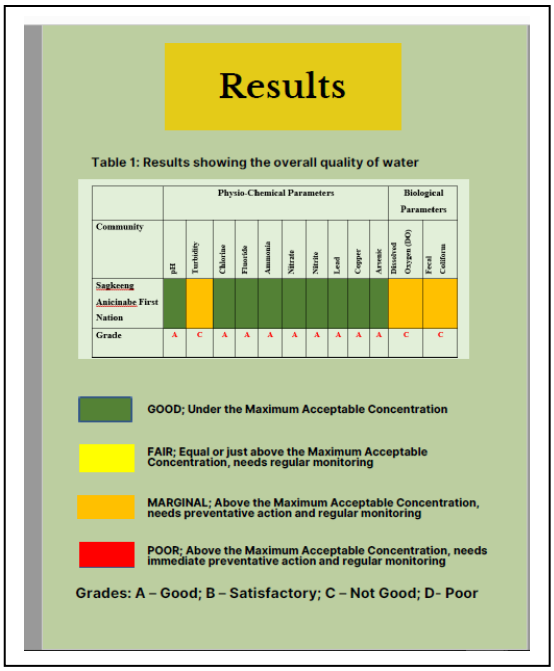


Figure 59: Water quality analysis results in Sagkeeng FN community report

After presenting the test results, each of the parameterswas individually discussed and more details were presented to facilitate understanding (Fig 60).

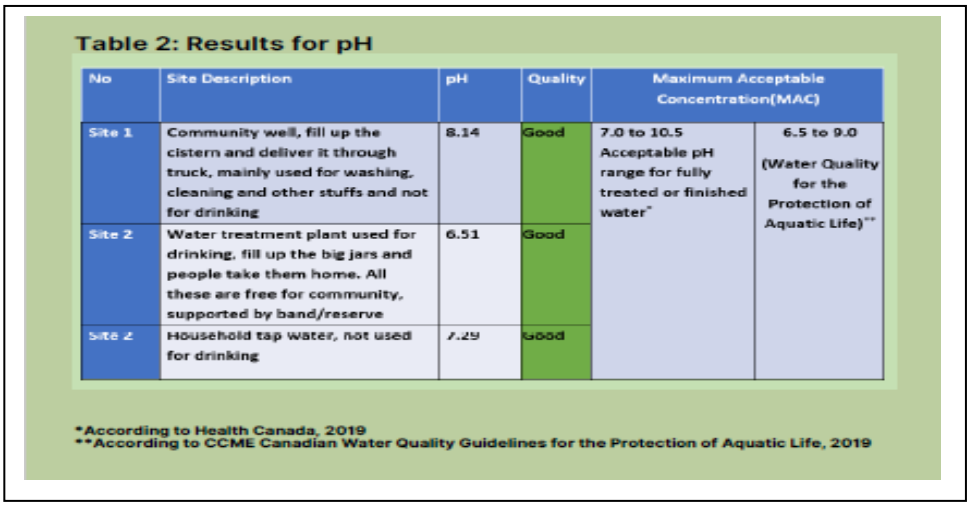


Figure 60: Presentation of pH test results from the Keeseekoowenin Ojibway FN community report

During the camps, I also used various real-life examples to help the youth understand what pH ,meant, since most had never heard of it. I found such examples were very helpful when explaining the meaning of various terminologies and the underlying concepts. Therefore, for the reports, instead of using only the range (0-14) and a name of the example, I have used Infographic characters/elements (Fig 61). All the reports featured the use of accessible and impactful Infographics (Canva, https://www.canva.com).

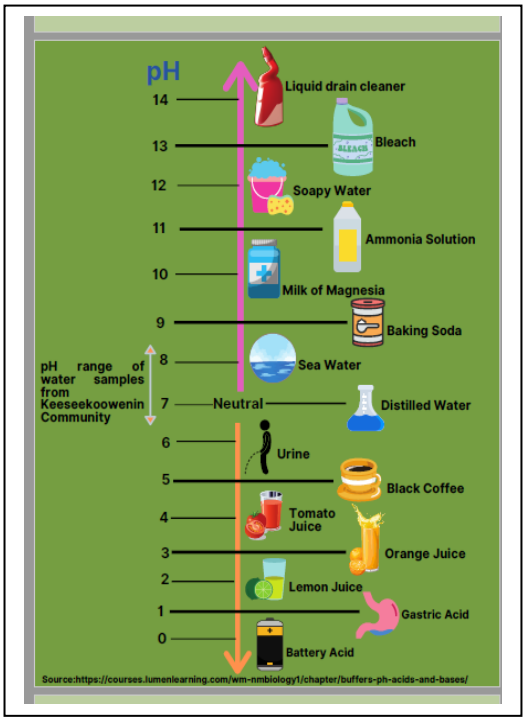


Figure 61: Description of pH ranges in community reports

Similar approaches were used all the other parameters including their sources, how they were incorporated into the environment and any possible harmful effects (Fig 62).

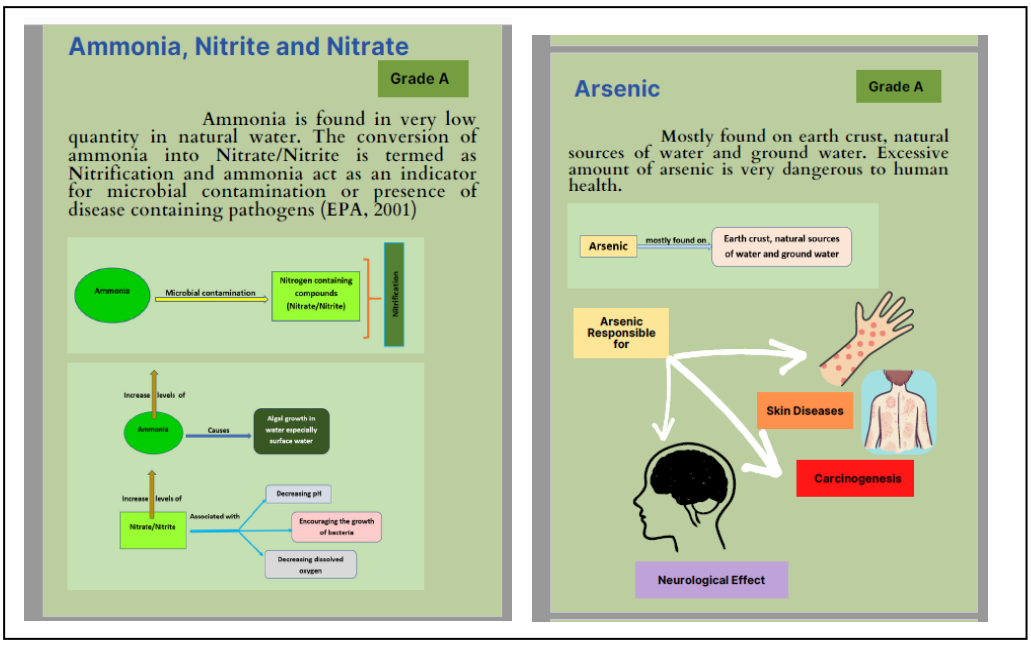


Figure 62: Presentation of different scientific parameters in the community reports

5.4 Feedback from community

On April 24,2021 a brief interview was organized with Kis Kin Ha Ma Ki Win Land-based Education Coordinator (an Indigenous woman from Brokenhead Ojibway Nation) and camp staff Dylan Kensick, whose family roots are in Winnipeg, Selkirk, and Sagkeeng First Nation. Although Taylor was present in all the campa as a Coordinator she was also a primary liaison with all the communities. Both Taylor and Dylan have been working on the project over the last two years.

The COVID-19 pandemic prevented us from arrange any workshop with the host communities in summer 2020 to get their feedback after the camps and reports. Hence, an interview was arranged with both Taylor and Dylan to provide feedback on the reports as well as on the camps. Taylor mentioned that the communities were pleased to see the way the reports were prepared, and they were working to find a way to make those reports available to other community members.

> *"I've spoken with* (Elder) *Carl Smith on many occasions. He liked the report. He liked the way that it was structured and that it was easy to follow the language. The language was more simple to read obviously, it wasn't just a bunch of University jargon where*

some community members may or may not be able to follow or understand it. And right now, we are in the process of making the report available to community members."

(Taylor Galvin, Land-based education coordinator, Kis Kin Ha Ma Ki Win, April 26, 2021)

Dylan was only present for the last camp in OPCN. However, he was later involved in other communicational and learning activities for Kis Kin Ha Ma Ki Win specially around medicinal plants and in building and maintaining the project website. As he stated that,

"I think most communities definitely have some sort of land-based learning program like this. But I think our program definitely helps them with maybe setting a structure and we obviously will bring resources is that they might not have access to like water quality testing equipment stuff"

(Dylan Kensick, communication coordinator Kis Kin Ha Ma Ki Win, April 26, 2021)

However, some communities were upset for the delay when it came to receiving the reports. They also provided some feedback which could have added in the reports and would add extra value if added in any future reports. They would like to see the concern they were having before the camp in the reports as well, which will be added in the future.

"I think that we could possibly maybe add more, more community involvement in the reports. What I mean there is by like maybe providing more quotes or of what the youth had thought about the camps, kind of incorporating their perspectives……I think there should be more I know that we do provide information about what is going on here, but I think maybe more information".

(Taylor Galvin, Land-based education coordinator, Kis Kin Ha Ma Ki Win, April 26, 2021)

In terms of reflecting the ability to bridge IK and western science, they suggested that more IK be incorporated into the reports since each community have unique cultural teaching. I had only summarized the cultural activities and Taylor had only provided one section on the importance of cultural activities in the camp in each report. Nevertheless, more writing on Elder teachings and including their quotes would not only acknowledge the importance of their teaching but would serve as a way of honoring them as well.

Finally, among the five camp staff members, I was the only non-Indigenous person. I was also only one who had a graduate level educational background in the sciences, although both Dylan and Taylor are majoring in the environmental science. So, I asked them what the views of the community regarding my presence and involvement in the camp. Fortunately, they valued it as positive and very much appreciated my involvement,

> *"I think you're doing an amazing job; you're learning about what it's like to work with First Nations people which I think is very vital in anybody's educational journey because the more that you're comfortable working with Knowledge Keepers and Elders and really learning how to integrate that traditional ecological knowledge into your schoolwork, this will be very beneficial to you in the long run"*
>
> *(Taylor Galvin, Land-based education coordinator, Kis Kin Ha Ma Ki Win, April 26, 2021)*

Dylan also supported this perspective. Although we only participated in one camp together, I have since worked with him on other activities related to Kis Kin Ha Ma Ki Win,

> *"I agree with Taylor. You're pretty awesome to work with and definitely know what you're doing in terms of from what I seen in the camps. You know the science of water quality and stuff and I mean yes, so it's awesome to have you on the team".*
>
> *(Dylan Kensick, communication coordinator Kis Kin Ha Ma Ki Win, April 26, 2021)*

As they both think that more integration with IK in environmental sector will be seen to address any environmental crisis in the coming years, as a student of environment, this learning and engagement will enrich my knowledge and change my perspectives and result in my own personal growth.

> "*I think you're doing a great job with working with these communities that you've never visited before and built most connections with them and you know I think you're an absolute delight to work with. And I thank you for all the hard work that you've put into the Kis Kin Ha Ma Ki Win project since its inception".*
>
> *(Taylor Galvin, Land-based education coordinator, Kis Kin Ha Ma Ki Win, April 26, 2021)*

I can not agree with them more. It has certainly played a significant role in shifting my perspectives towards two-eyed seeing and the integration of IK and western science. From an individual whose background was entirely grounded in science where space for this kind of inclusion was almost non-existent to then become a person who has learnt to value, respect and acknowledge local or Indigenous knowledge and has become open to incorporate their teachings into her current research, this has represented a valuable opportunity for me to grow both as a researcher and as a person.

5.5 Impacts of the COVID-19 pandemic

The coronavirus disease (severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)) was first identified in Wuhan, China in December 2019 and the World Health Organization declared a Public Health Emergency of International Concern regarding COVID-19 on January 30, 2020, and later declared a pandemic on March 11, 2020 (COVID-19 pandemic, 2021). The ongoing deadliest pandemics in history has already resulted more than 175 million cases, with more than 3.79 million confirmed deaths as of June 13, 2021 (COVID-19 pandemic, 2021).

This pandemic has affected every realm of human life both professional and personal. Kis Kin Ha Ma Ki Win land-based camps are no exception. There were at least seven communities scheduled to host camps in summer 2020. Unfortunately, all of them were cancelled due to the pandemic. It was impossible to visit any communities during the pandemic and such restriction are still in place today. We had planned a one-day workshop where all five hosting communities would have invited and where the results would have been presented and discussed by all attendees. Again, follow up visits to some of the communities were also planned for winter and summer 2020 even for fall 2020 as well. However, nothing worked out and all the plans for community work are still on hold,

> *"My intention was after our first year, going into our second year, we've known how to make these camps better we learnt from our mistakes the previous year but that never happened. So the next time we actually get to go in and do these camps again is kind of going to be like going in blind all over again. It's now been two years since our first round of camps. It'll be interesting to see what happens but for sure like the pandemic and Covid it has definitely put a damper on our project".*

(Taylor Galvin, Land-based education coordinator, Kis Kin Ha Ma Ki Win, April 26, 2021)

It has also I affected the communities that were expecting to arrange the camps and summer is a time when many traditional activities like cultural camps and pow-wow are normally organized. Although the camp staff members and communities have not yet lost hope and thus the planning of alternative activities that best suit this year's anticipated host communities are again underway,

> *"Dylan and I are working hard to try and keep everything afloat and hopefully this coming summer, we'll be able to get out there and will be able to work with the youth and work with communities and help them with some environmental monitoring"*
> *(Taylor Galvin, Land-based Education Coordinator, Kis Kin Ha Ma Ki Win, April 26, 2021)*

These alternate and virtual ways of continuing camp activities include the use of social media, websites, and video. In summer 2020, two Indigenous students also involved in this project were unable to visit any communities, but they still learned how to test for water quality using water samples from the Red River. Taylor and Dylan led the team and developed resources that focused on the use the portable water testing kits. They have also made some booklets on fish, wildlife and medicinal plants. I am now working on a water booklet that focused on the properties of water, ways of contamination and prevention. Kis Kin Ha Ma Ki Win has just hired a videographer from one of the northern communities to implement some of these alternative methods in order to better connect with the communities and help initiate such efforts in the best possible ways, this despite the ongoing pandemic.

5.6 Discussion

Indigenous communities have always been subjected to enormous research interest, the majority of which has rarely reflected their priorities or engaged them in meaningful ways since most has been initiated, funded by, and carried out by non-Indigenous researchers and institutions (The First Nations Information Governance Centre, 2019; Kukutai & Taylor, 2018). Science plays a critical role in documenting and shaping responses to important environmental issues like climate change, deforestation, loss of deforestation but generally overlooks the value of local and Indigenous knowledge and its potential role in bot understanding and responding to such concerns. This was certainly true for all the communities that hosted our land-based camps, where environmental issues including declines in medicinal plant populations, changes in river

watercolor, the quality of tap water, contamination by abandoned pulp and paper mills, and flooding by hydro stations have been and are still being ignored. In most cases such concerns have gone unnoticed by governments for decades.

For instance, in Keeseekoowenin Ojibway First Nation, they have been trying to replace the existing water treatment plant (WTP) for years as the community felt that it was old and for not working efficiently but their voices go unnoticed. Without any scientific evidence of their own and in the face of testing data generated by outside technicians that have not been adequately shared with the community, their concerns have been ignored by Indigenous Services Canada. Although during our initial testing in the camp, we didn't find anything of real concern but were limited by what can be tested using the portable lab as well as some mechanical errors of our own. During the follow-up visit the presence of total coliform was detected at five sites including private household, although unfortunately one of them water was used for drinking purposes. Our own testing was also limited in number, since only 10 sites were sampled, and these were only conducted once. However, our preliminary results seem to support the community concerns regarding their treatment facility, have generated data that they own and understand and trust. Moreover, these results definitely warrant subsequent and more comprehensive testing, this conducted in a way that involved the community and that generates data that will be trusted.

Similarly, in Brokenhead Wetlands, members were concerned about the declines of plants in the wetlands and felt that something wrong with the water and wanted it tested. We found that the Dissolve Oxygen (DO) level was Marginal and above the Maximum Allowable Concentration (Table 5.4) and was not adequate for aquatic life. Thus, these results support community concerns while also affirming their knowledge of land and environment as well as their experiences. Regardless of any outcomes, the act of listening to and acting on their concerns was well received. In so doing, we acknowledged the value of their knowledge, recognized and respected their priorities and took appropriate measures to deal with the issues.

Kukutai and Taylor (2018) indicate that in Eurocentric research, Indigenous communities are mostly treated as a source of and sometimes collectors of data if they are recognized at all instead of acknowledging their concerns and regarding them as collaborators and partners in these activities. Scientists rarely describe their activities in simple and accessible language to get

the informed consent and even more infrequently return back to the community with their findings. And when they do it is uncommon that the results are provided in a language or using a process that is readily understood by the community. When it comes to communicating science and technology it is crucial to use language that is appropriate for the given audience; and the term “general public”, is vague term since every audience has its distinct level of understanding. As such, science communication should be guided by audience perspectives not those of the researchers (Porter, 2002). However, Kappel and Holmen (2019) found that “the literature attempting an empirical evaluation of science communications efforts is scarce” and although efforts are made to enhance social acceptance in the society issues related to trust remain less explored, especially for BIPOC.

For First Nations communities, the relationships with their cultural knowledge or scientific information that they have acquired is something that they own and in theory the latter become their data. But possession is something more precise, which is a way to claim and protect ownership (Schnarch, 2004). However, it become a matter of concern when the data are owned by one body while being possessed by another, which may give rise to mistrust (Schnarch, 2004). Indigenous people have well warranted mistrust of the system due to its misuse of scientific data in the past and in some case this misuse continues, as exemplified by the recent misuse of health data regarding Indigenous people by the Thunder. Bay police during the Covid pandemic (Global News, 2020). Consequently, when science communication occurs, it is crucial to do so in an inclusive way and with language that is accessible in order to gain trust and community approval.

Therefore, when writing our community reports, utmost importance was given to use of simple and accessible language, pictures, other visual elements, pleasing layout and an avoidance of scientific jargon (Fig 56, 58 & 59). Communities also find the reports to be structured in ways that reflected their needs. However, they also wanted to incorporate more IK and culture throughout so that Elders and Knowledge Keepers would feel respected and honoured and so that youth could revisit those stories and their connections with the camps. Moreover, to enhance the significance for data and trust for possible future use regarding decision-making, these sharing of these data in ways that participants and leadership would have access was also essential and basic (Freitag, Meyer, & Whiteman, 2016; Soranno et al., 2015).

To meet acceptance and to build trust in and capacity regarding science, underlying barriers need to be addressed. For instance, Indigenous youth often find the language of science in school curricula to be very challenging due to lack of Indigenous content, connection and ways of teaching; and cultural beliefs and perspectives (Simpson, 2002; Quigley, 2009). This difference in culture between Indigenous and western science worldviews act as a barrier. To break through and to bridge these gaps when it comes to school curricula, both parties need to understand and respect the other's culture. Western science is criticized for propagating the concept of only knowledge '*worth knowing'* as it is abstract and logical (Wilson & Mcvittie, 2007) and given its dominance in society today, these assumptions need to be challenged.

However, to initiate more meaningful and efficient involvement in decision-making and to practice self-governance, to make informed choices, and to have the ability to achieve career success in science and technology fields, there is a sense that Indigenous communities also feel the need to learn the language of and to build capacity around science (Wilson & Mcvittie, 2007). Several science-based projects focusing on outreach have been initiated which reflect traditional values and cultures while also seeking to enhance capacity around science (Diver, 2016; 2017). Indigenous scholars, Elders and Knowledge Keepers also play a central role in these initiatives, so the diversity and proper inclusion of culture and language is maintained (CAiSE, 2021; Davison et al., 2008). In our project the land-based camps were designed to bridge the two cultures. On one hand, the camps provided the opportunity for youth to build their capacity or at least incite the interest in both science and Indigenous Knowledge regarding the land in the present but also into the future, so that participants could better contribute to and engage in meaning decision-making regarding their land, environment, policy and any development projects.

For me as a researcher or more precisely as a learner, I have learnt a tremendous amount about these communities and traditions and still want to know more about the IK. Since my background was deep-rooted in western science, the whole concept of integration was a completely a new way of thinking for me. Throughout the whole research process, I have evolved in so many ways. It started with changing the ways of communicating science including changes in presenting scientific terminologies, writing reports for communities in accessible language and my involvement with youth out on the land, the latter which was at first the most challenging for me but with time something I also learned to appreciate and value. At the last

camp in OPCN, when a youth was upset that we were leaving and that she would not be able to do any more testing and wanted us to come back in fall, this indeed made my and our whole effort in building interest, capacity and connection worthwhile. The number of youth who are genuinely interested in these camps may be less than ideal for now but every excited participant counts since it is a long journey, one that cannot be achieved in a single land-based camp or even over a single summer. Achieving the goal of building such bridges between these two worldviews, needs continued and consistent collaboration and mutual respect.

Chapter 6: Conclusion and Implications

From the initiation of my research forwards, the aim was to explore the integration of Indigenous knowledge (IK) and western science and to see how land-based camps might be used to build youth capacity in both. Since my research process follows an iterative and cyclical process of action and reflection and evolved throughout the process, this approach best suited a conceptual frame of Action Research (AR) (Dick, 2014) . One of the most important purposes of my research was to bring about change in power inequality or more specifically to provide a voice to host Indigenous community through their youth so that their concerns would be better heard, and so fit even better with an approach grounded in Participatory Action Research (Greenwood & Levin, 2007). To achieve the goals of the research, the overall performance of the land-based camps was evaluated as was our cross-cultural approach that was conducted to facilitate Indigenous youth interest and understanding in both the environmental sciences and in Indigenous knowledge. Finally, various ways of science-based outreach and exchange of knowledge with host communities was also explored and evaluated.

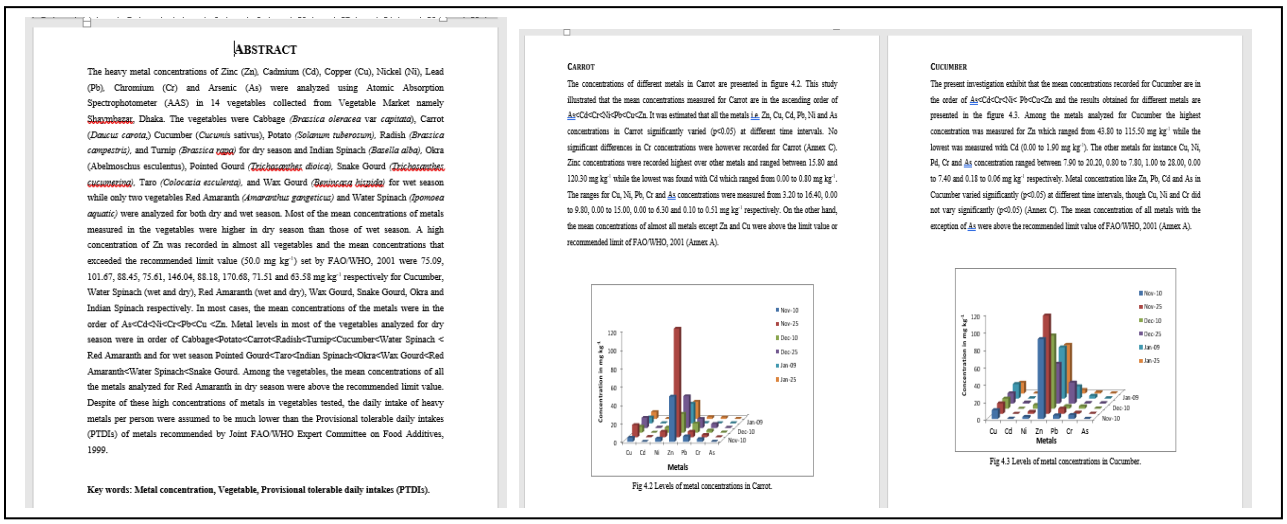
From the pre-camp to the post-camp period, the priorities and concerns of each host community were given the highest prominence and reflected throughout our activities. This in part reflected the unique and place-based experiences and traditions of each community and the diversity of local environmental concerns that each wanted to address. Today, our world only understands and values the language of science, but science inherently carries and reflects a legacy of colonialism. The dominant Eurocentric approaches to science tends to overlook the priorities or local concerns of Indigenous communities – in Canada and elsewhere in the world. Conventional scientific research prefers to deal with heavy wight issues like climate change and the biodiversity crisis which is very generic and operates at the global scale, and local issues and concerns go unnoticed and unheard. The land-based camps prioritize those local issues and community engagement which is ensured through true and meaningful participation at all stages of the camp and in ways that affirm the importance of each host community as a coproducer of knowledge. In this way, we acknowledge the Indigenous knowledge and cultural traditions of each host community in the same way as we do the scientific knowledge. Through storytelling, medicinal plant teaching, ceremonies and sharing circles in each land-based camp, Elders find a

way to connect to and share their valuable knowledge with the youth, while the youth also get the opportunity reconnect with their land, learn and to encounter and better understand these Indigenous teachings.

Although the Truth and Reconciliation Commission of Canada highlights the importance of eliminating gaps between Indigenous and non-Indigenous people in education, and the importance of building capacity through the incorporation of more culturally appropriate curricula (Truth and Reconciliation Commission of Canada, 2015b), the presence of Indigenous students in the STEM disciplines is still poor and far behind that of other Canadians. The Kis Kin Ha Ma Ki Win land-based camps provide a space for youth and community to break through the longstanding barriers represented by science and by science-centered curricula. The integrity of this learning resulted in the increase in understanding and application of relevant scientific knowledge while Elders and Knowledge Keepers as co-producers of this knowledge stressed the relevance of this science when addressing local environmental concerns.

In terms of both knowledge systems and this larger system of integration, my own positioning has changed. My educational background back home very much relates to science but in here in Canada, I have found myself in different places. First, as an international student and then as a woman of color, and where both positions are underrepresented in dominant society in this country. From those positions, I can easily connect with Indigenous perspectives of the legacy of colonialism and how it still affects every aspect of their live and the Indigenous ways of living. The 200 years of colonial history of our subcontinent (South Asia) has arguably played a significant role in nurturing some stereotypes especially when dealing with marginalized people - which is, disturbingly, what I have also witnessed happening to Indigenous people here in Canada since my arrival. Those experiences make me choose a position that independent of my educational background. Yet, there are also some other details which have helped me evolve as a learner and researcher during my Masters studies.

Back home, in 2011, I wrote and defended a thesis in partial fulfillment for a Master's degree in soil, water and environment focusing on environmental science. My thesis title was *"Metal concentrations in the commonly sold vegetables in Dhaka city market and probable health risks"* (Fig 63). It was focused on heavy metal contamination (zinc, cadmium, copper, nickel, lead, chromium and arsenic) in 14 different vegetables collected from a very popular vegetable market in Dhaka city.



ABSTRACT

The heavy metal concentrations of Zinc (Zn), Cadmium (Cd), Copper (Cu), Nickel (Ni), Lead (Pb), Chromium (Cr) and Arsenic (As) were analyzed using Atomic Absorption Spectrophotometer (AAS) in 14 vegetables collected from Vegetable Market namely Shayubagar, Dhaka. The vegetables were Cabbage *(Brassica oleracea* var *capitata)*, Carrot *(Daucus carota,)* Cucumber (*Cucumis* sattivus), Potato *(Solanum tuberosum)*, Radish *(Brassica campestris)*, and Turnip *(Brassica rapa)* for dry season and Indian Spinach *(Basella alba)*, Okra (Abelmoschus esculentus), Pointed Gourd *(Trichosanthes dioica)*, Snake Gourd *(Trichosanthes cucumerina)*, Taro *(Colocasia esculenta)*, and Wax Gourd *(Benincasa hispida)* for wet season while only two vegetables Red Amaranth *(Amaranthus gangeticus)* and Water Spinach *(Ipomoea aquatic)* were analyzed for both dry and wet season. Most of the mean concentrations of metals measured in the vegetables were higher in dry season than those of wet season. A high concentration of Zn was recorded in almost all vegetables and the mean concentrations that exceeded the recommended limit value (50.0 mg kg^{-1}) set by FAO/WHO, 2001 were 75.09, 101.67, 88.45, 75.61, 146.04, 88.18, 170.68, 71.51 and 63.58 mg kg^{-1} respectively for Cucumber, Water Spinach (wet and dry), Red Amaranth (wet and dry), Wax Gourd, Snake Gourd, Okra and Indian Spinach respectively. In most cases, the mean concentrations of the metals were in the order of As<Cd<Ni<Cr<Pb<Cu <Zn. Metal levels in most of the vegetables analyzed for dry season were in order of Cabbage<Potato<Carrot<Radish<Turnip<Cucumber<Water Spinach < Red Amaranth and for wet season Pointed Gourd<Taro<Indian Spinach<Okra<Wax Gourd<Red Amaranth<Water Spinach<Snake Gourd. Among the vegetables, the mean concentrations of all the metals analyzed for Red Amaranth in dry season were above the recommended limit value. Despite of these high concentrations of metals in vegetables tested, the daily intake of heavy metals per person were assumed to be much lower than the Provisional tolerable daily intakes (PTDIs) of metals recommended by Joint FAO/WHO Expert Committee on Food Additives, 1999.

Key words: Metal concentration, Vegetable, Provisional tolerable daily intakes (PTDIs).

CARROT

The concentrations of different metals in Carrot are presented in figure 4.2. This study illustrated that the mean concentrations measured for Carrot are in the ascending order of As<Cd<Cr<Ni<Pb<Cu<Zn. It was estimated that all the metals i.e. Zn, Cu, Cd, Pb, Ni and As concentrations in Carrot significantly varied ($p<0.05$) at different time intervals. No significant differences in Cr concentrations were however recorded for Carrot (Annex C). Zinc concentrations were recorded highest over other metals and ranged between 15.80 and 120.30 mg kg^{-1} while the lowest was found with Cd which ranged from 0.00 to 0.80 mg kg^{-1}. The ranges for Cu, Ni, Pb, Cr and As concentrations were measured from 3.20 to 16.40, 0.00 to 9.80, 0.00 to 15.00, 0.00 to 6.30 and 0.10 to 0.51 mg kg^{-1} respectively. On the other hand, the mean concentrations of almost all metals except Zn and Cu were above the limit value or recommended limit of FAO/WHO, 2001 (Annex A).

Fig 4.2 Levels of metal concentrations in Carrot.

CUCUMBER

The present investigation exhibit that the mean concentrations recorded for Cucumber are in the order of As<Cd<Cr<Ni< Pb<Cu<Zn and the results obtained for different metals are presented in the figure 4.3. Among the metals analyzed for Cucumber the highest concentration was measured for Zn which ranged from 43.80 to 115.50 mg kg^{-1} while the lowest was measured with Cd (0.00 to 1.90 mg kg^{-1}). The other metals for instance Cu, Ni, Pd, Cr and As concentration ranged between 7.90 to 20.20, 0.80 to 7.80, 1.00 to 28.00, 0.00 to 7.40 and 0.18 to 0.06 mg kg^{-1} respectively. Metal concentration like Zn, Pb, Cd and As in Cucumber varied significantly ($p<0.05$) at different time intervals, though Cu, Ni and Cr did not vary significantly ($p<0.05$) (Annex C). The mean concentration of all metals with the exception of As were above the recommended limit value of FAO/WHO, 2001 (Annex A).

Fig 4.3 Levels of metal concentrations in Cucumber.

Figure 63: Screenshots of my previous Masters thesis focusing on heavy metals in vegetables in Bangladesh

There was and is a growing concern among developing countries - including Bangladesh - around the elevated levels of heavy metals in the urban environment due to rapid urbanization and industrial development (Khillare, Balachandran, & Meena, 2004; Sharma, Agrawal, & Marshall, 2008; Ahmed & Gani, 2010). One of the key pathways to heavy metal exposure to human is through contamination in the food chain (Khan, Ibrahim, Ahmad, & Anwar, 2008). A pilot survey was conducted among a few community people who usually buy vegetables from a selected market to assess daily intake of vegetables per person and other information including food habit, knowledge regarding vegetables contamination, and long-time chronic diseases. Hence, it can be said that my thesis was solely grounded in western science and fully concentrated on knowledge generation and procedures that are ostensibly bias-free and validated in the scientific society.

As a student researcher, back then I never felt the obligation to share the results with community people whom I have interviewed (they were very few) although any level of contamination would adversely impact their health. I rather, restricted my research results and recommendation towards the powerful authorities in society including professionals and scholars. A few months after my thesis was completed, I met someone whom I interviewed. He asked me about the results of the research, was there anything to be concerned about. I just replied in a one-sentence answer that there was nothing to worry and recommended washing his vegetables properly instead of explaining the findings in any further detail. My background influenced my assumption that he and other participants would not understand those scientific terms like metal concentration in ppm or daily intake of heavy metals per person.

However, now my current thesis represents an integration of Indigenous or local knowledge and western science and is grounded in PAR and Indigenous methodologies and followed the principle of "two-eyed seeing". This integration has provided me a completely different perspective on how things should work. PAR has allowed me to think that to bring any change or work against power-inequity through research it is vital to acknowledge the participant views and rights, to relocate participants at the center of knowledge production, and to ensure true and meaning involvement in decision-making at every stage of the research process. People who are vulnerable to any kind of environmental degradation have the right to know what is going on or details about any research conducted related to those issues around them and need to be fully engaged in this work for it to have any meaning. Data sovereignty which has emerged as a critical concern for many Indigenous communities has reinforced their right to know and to have ownership and control over any results.

Now, when I reflect on my earlier research, I think that I could - and should - have answered or approached to the person in a way that was very different than the one I chose to pursue at the time. I should have made an effort to share the findings of this work to everyone I interviewed in a simple and accessible language which they could understand rather than assuming they would not have the capacity to understand. My subsequent work experience with marginalized rural communities (under an international NGO) in Bangladesh, especially with rural woman, also made me understand how authoritative bodies or dominant powers in society work. They mostly focus on their own institutional goals and achievements rather than the needs and priorities of the communities they claim to serve.

However, the situation and attitudes have been changing gradually for the last few decades, at least in Canada if not in Bangladesh. Many researchers and educators from universities and organizations has come forward to lessen the gap between IK and western science and to make science more attractive to Indigenous students. They are promoting science, especially STEM, to Indigenous students and various outreach programmes have been initiated and implemented in culturally appropriate ways. They have been an increase in financial support as well. For instance, in the University of Manitoba, they mentioned "t*here is a range of financial aid opportunities (6 to 7 scholarships and bursaries) for Indigenous students are available, both internally and through external partners*" (University of Manitoba, 2021). They refer to the increasing number of Indigenous students in education or science education and also highlight some of the extraordinary achievements by Indigenous students in very public ways. But then the question arises - is this support sufficient and are they only highlighting the achievements of the 'cream of the crop', and what about the average or below-average students? And what about the communities in which these students reside? Universities have severely restricted and effectively prohibited field research involving Indigenous communities over the last year due to the COVID-19 pandemic. On one hand they are promoting and prioritizing education for Indigenous students but on the other hand they are prioritizing lab-based science research over community-based field research over this pandemic period. During such hard times, community also need support and they are still dealing with the environmental decline reflected in this research. These questions need to be answered and issues should be addressed to eliminate such gaps, to restore the balance with Indigenous communities and when connecting Indigenous knowledge and western science. In the future, there will be an even greater need integrate to these knowledge systems and to learn from the knowledge of these communities when dealing with yet unanticipated environmental crises through education programmes and beyond. This can in part be achieved by engaging and applied land-based science initiatives like Kis Kin Ha Ma Ki Win, which should be initiated not only to build bridges between the two worldviews but also to help empower Indigenous communities. Such activities can play a critical role in helping support both truth and reconciliation moving forward.

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