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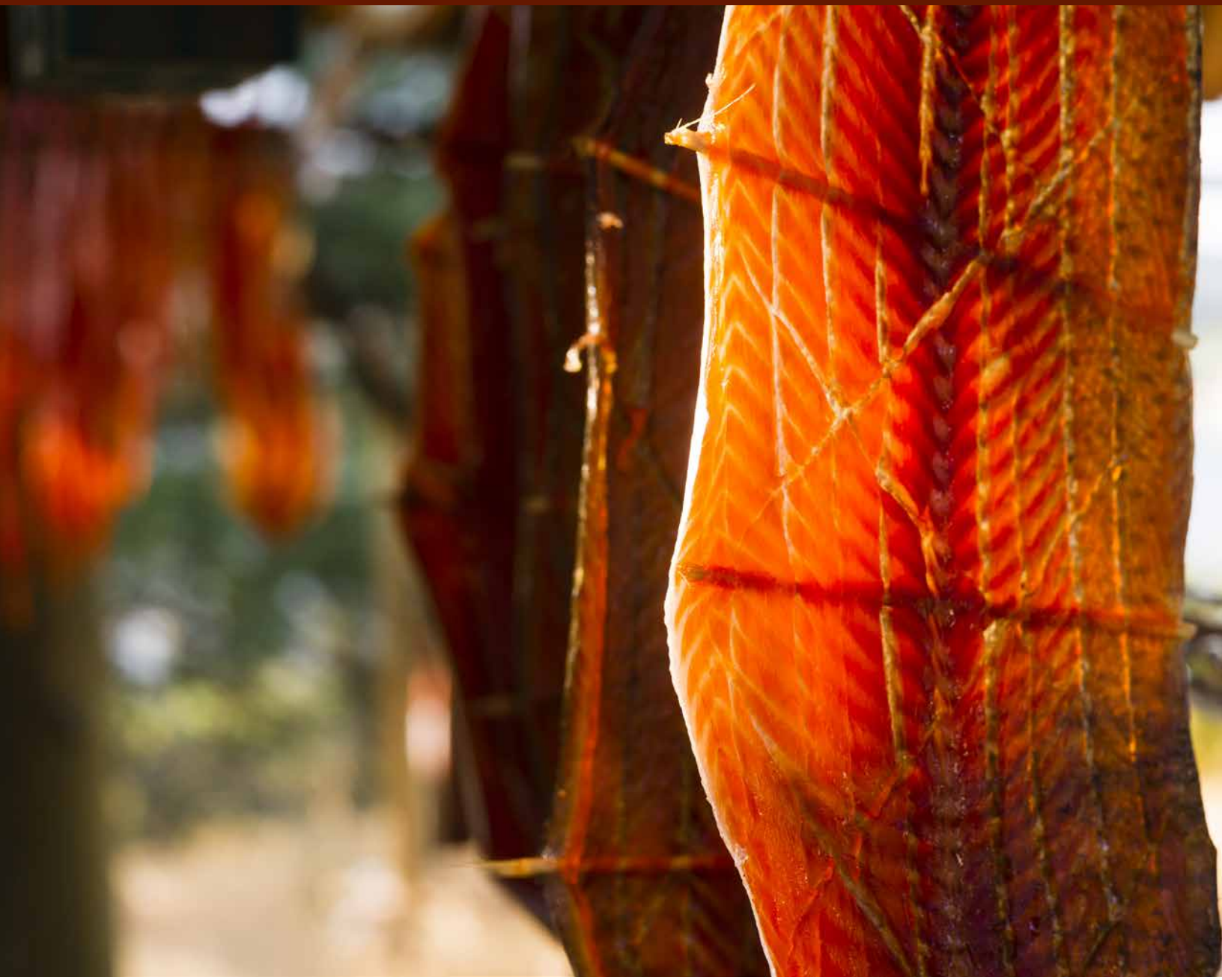
INDIGENOUS FOOD SAFETY AND SECURITY: COMMUNITY ADAPTATIONS IN THE WAKE OF CLIMATE PRESSURES



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INTRODUCTION

Indigenous people have long relied on traditional foods, as they are nutritionally, culturally, and economically important to individuals and communities, and are an important aspect of food sovereignty. Though challenging to define, Indigenous food sovereignty relies on the interconnections among culture, heritage, spirituality, and politics.[1] Conceptually, Indigenous food sovereignty also intertwines with the protection of land systems and, as Morrison expresses, "long-standing sacred responsibilities to nurture healthy, interdependent relationships with the land, plants, and animals that provide us with our food."[2] Yet, many Indigenous people are moving away from traditional foods (land-gathered foods, sometimes referred to as "country foods" or "wild foods")[3] as a result of a multitude of factors, including acculturation, food access and availability, food insecurity, environmental pollution, and climate change.[1] At the same time, traditional food is a fundamental aspect of Indigenous life and well-being; indeed, "cultural practices, such as hunting, gathering, food preparation, and language have been heavily shaped by food availability and accessibility."[4] Furthermore, access to store-bought high-carbohydrate foods has been shown to have negative health effects while traditional foods are often linked to better nutrition and individual health.[4] It is unsurprising, therefore, that many Indigenous people and communities are pursuing ways to both strengthen their connections with local land and food systems and bolster their ability to produce and retain traditional foods.

As the climate changes and as other environmental stressors begin to amplify, these food considerations are becoming more and more critical. Indigenous populations and communities have unique food cultures that are very much situated to place, geography, and local customs.[5] Because of this connection to landscapes and natural systems, climatic changes can threaten a group of people that may already struggle to be food secure; one study recently found that food insecurity affects 41% of First Nations households living on reserve in British Columbia.[1] Beyond the loss of hunting opportunities (which has already led to a greater need for community self-reliance), climate change has the potential to impact a host of issues that can have a direct impact on Indigenous food systems.

1. Personal communication with Chief Patrick Michel, Kanaka Bar Indian Band

These include, but are not limited to: unpredictable weather patterns, extreme heat and cold events, less predictable drought conditions; increasingly intense wildfires; irregular water conditions (such as flooding); impacts of invasive species on plants and animals; and decreased access to traditional sources of food[4] (which often include fish, large game, marine mammals, and conservatively over 250 species of plants and other small animals[6]).

As ecosystems try to adapt to climate volatility, so are Indigenous communities striving to become more food self-sufficient — both in reaction to and in anticipation of further climate pressures. This has led some communities to develop alternative food preservation and growing options, adaptations of their own that can help address limited financial resources or access to physical assets. For example, some community members have turned to salvaged or alternative materials (such as discarded lumber and railroad ties) to support food production.[1] Similarly, when building smokehouses or traditional smoking pits for fish and meat preservation, as well as cooking, individuals have used poly tarps rather than traditional materials, such as tree boughs, to retain the smoke.[2] As water becomes a scarcer resource, especially in communities experiencing drought and longer wildfire seasons, rainwater or greywater are being considered for crop irrigation.[3] These instances offer examples of adaptive practices and highlight needs that are becoming more prevalent in many Indigenous communities around the country.

Yet, these adaptations may carry food safety risks of their own. Traditional means of preserving foods and Indigenous food safety practices are recognized as being effective ways to control pathogenic and spoilage bacteria; adaptations to these practices may vary, and some may render traditional methods less-effective than those that have been safely used for millennia.[6] This evidence review was conducted in response to inquiries from several First Nations communities in British Columbia, one First Nation community in Ontario, and an Inuit community in Nunavut, as well as environmental health officers seeking scientific evidence regarding the potential environmental health

2. Personal communication with Patti Joyce, Environmental Health Officer, First Nations Health Authority
3. Personal communication with Chief Patrick Michel, Kanaka Bar Indian Band

risks of various food preparation techniques. The inquiries also sought guidance on techniques that might help minimize potential public health risks while at the same time supporting community efforts to improve food safety in the wake of their adaptation efforts to address climatic pressures.

This review presents evidence on six unique food safety issues, based on adaptation measures taken or planned to be taken to help ensure food security: 1) smokehouse construction considerations; 2) gardening and the use of tires as planters; 3) greywater use in crop irrigation; 4) traditional preservation techniques (specifically sun and wind drying); 5) treated timber and planter boxes; and 6) hydroponic growing systems. Each topic area section presents a detailed description of the inquiry context and concerns raised by the community, highlights specific practices that may cause potential food safety risks, and provides guidance on different possible interventions to minimize risks, which fall broadly into physical, chemical, or technological interventions. This review is meant to assist and guide individuals, Indigenous communities, and environmental health professionals to ensure healthy and sustainable food production, processing, and preservation techniques for improved food safety and security.

METHODS

Each case study was a result of an inquiry from a particular Indigenous community, or from an environmental health professional working with an Indigenous community. Six cases in total were drawn from four different communities: an inquiry about the use of tarps during smoking came from a First Nations community in Central British Columbia; inquiries about railroad ties used in garden beds, public health risks of wind and sun drying food, and greywater used for crop irrigation came from a community in the Nlaka'pamux Nation; an inquiry about risks from hydroponic growing originated from an Inuit community in Nunavut; and a community in the Secwepemc Nation inquired about the use of tires for vegetable garden beds.

For each inquiry, a research question was developed *(See Appendix A)* and key search terms were employed in a selection of online databases. These questions were expanded as relevant food safety literature was identified; the search results therefore captured a greater breadth of potential issues pertinent to the concerns of the communities. Feedback was also solicited from the original communities as well as other Indigenous communities to help target our case studies to specific needs (both of those consulted and the original communities). The source information reviewed here includes peer-reviewed academic studies, grey literature from public health authorities, and consultant reports on contamination risks, as well as other reports and articles. A complete description of the literature search strategy and sources included can be found in Appendix A.

SMOKEHOUSE CONSTRUCTION CONSIDERATIONS

Smoking is a form of food processing traditionally practiced by Indigenous communities on a wide variety of foods, including fish, moose, deer, and birds.[7] While smokehouses were historically constructed using natural materials, environmental health officers have witnessed the construction of permanent or temporary smokers made of non-traditional materials, including poly tarps and canvas.[8,9] These materials are typically more readily available in rural and remote communities than unused conventional building materials (i.e., plywood) and are easy to manipulate around wood frames to construct temporary smokehouses. Concern was expressed that the exposure of these materials to heat in the vicinity of food could lead to contamination of the food items. Upon completion of a preliminary literature search, finding an absence of information about specific food safety risks associated with the use of poly tarps in the construction of smokehouses, the scope of this field of inquiry was expanded to include general risks of polycyclic aromatic hydrocarbons (PAHs) in food smoking to provide more comprehensive guidance on this food processing technique. Smoking as a means of preserving foods can have positive cultural, spiritual, and community impacts, and provides protection from spoilage and disease-causing microorganisms.[10] As PAHs are suspected carcinogens, and food is the primary source of exposure for non-smokers, advice is given to reduce potential exposures.[11]

A review of the literature indicates that meats placed directly in the path of smoke have higher levels of PAHs, and these levels are more elevated in fully smoked salmon and moose meats.[12,13] Generally, fully smoked salmon was found to have lower PAH levels than fully smoked moose.[12] For small fish, levels of the PAH benzo(a)pyrene were found to be much higher when the fish were fully smoked, and hot-smoked, reaching a temperature of 70–80°C.[14,15] Short-term exposure to PAHs may cause acute health impacts, including nausea, vomiting, eye and skin irritation, and difficulty breathing. Long-term exposure has been shown

to cause cancer, kidney and liver damage, and DNA damage affecting reproductive and immune function.[11] There are also potential health risks associated with individuals who are directly exposed to wood smoke and poor air quality, including asphyxiation, carcinogenicity, eye and lung irritation and injury, and inflammation.[16]

Risks of PAH exposure can be reduced by increasing the distance between the food product and the smoke source,[13] and through slightly smoking (rather than fully smoking) foods.[14] When creating smoke sources and constructing smokehouses, to avoid chemical contamination of food items, treated lumber should not be used and galvanized metal should be avoided on the roofs of smokehouses. Racks and shelving in smokehouses should have all oils removed from their surfaces prior to coming into contact with food items.[17] Individuals who are working within smokehouses should ensure proper ventilation in the workspace to avoid personal exposures.[18]

GARDENING AND USE OF TIRES AS PLANTERS

Gardening can be an effective means of ameliorating food security concerns,[19] at the community level. Not only can it reduce the reliance on store-bought produce, which can be economically and geographically unattainable, it also makes accessing vegetables more convenient and reduces barriers to their consumption. Many Indigenous communities have led successful gardening programs, leading to improved community wellness and economic benefits associated with the sale of excess produce.[20] A First Nation Chief, who is leading a successful community garden program, expressed concerns that members of his relatively isolated community would construct personal garden beds out of non-traditional materials due to difficulties in accessing building materials, like lumber and the ease of accessing surplus or waste materials, such as old tires. A literature scan was completed to identify whether the use of tires as an easily accessible garden-bed building material posed a public health risk to consumers of produce grown in these garden beds.

The literature is generally neutral on the risk of using whole rubber tires (whether new or recycled) as planters, and there are few indications of contamination of food from contact with whole tires. Risks are possibly higher when ground or

chipped tires are in contact with food items, due to the greater surface area and likely leaching of chemicals from the tires into the surrounding soil.[21,22] The contaminant of greatest concern is zinc, not from the tires themselves, but from the wires contained within them. Leaching of zinc may be more or less likely depending on the pH of the water (and soil) with which it comes into contact.[21,23,24]

While contact with food from whole tires is likely not a public health concern,[25] the use of these objects in creating planters can lead to additional risks: still water collecting in tires can act as a breeding ground for disease-carrying mosquitoes[26] and tires can act as havens for rodents, wasps, and other animals.[27] Tires are also highly flammable, and there are noted risks of poor air quality and ash pollution from fires associated with the stockpiling and storage of tires.[26]

To maintain low public health risk when using tires in gardens, only whole tires should be used and they should regularly be checked for exposed wires and replaced if any are identified.[21] If the tires are found to be in poor condition, they should be discarded appropriately or coated with a toxic-free sealant to reduce leaching.[27] Soil in tire garden beds should be rotated annually to reduce any contaminant loading in individual beds, and after five years of use, tire beds should only be used for non-edible flowers and decorative plants.[27]

GREYWATER USE IN CROP IRRIGATION

Drought and reduced availability of irrigation water as a result of climate change has been highlighted as a concern for Indigenous communities across Canada.[28,29] In some cases, Indigenous communities are already struggling with inadequate water volumes to meet irrigation and gardening needs and are concerned about the quantity of water their systems can produce.[30] Greywater (non-toilet household wastewater) reuse has been brought forth as a potential alternative means of irrigation that could reduce stress on valuable potable water supplies, while also limiting treatment requirements of wastewater. Greywater reuse systems are not common, and B.C. wastewater legislation, for example, does not differentiate between greywater and blackwater (i.e., sewage).[31] A literature search was completed to identify specific risks of crop irrigation using grey water to identify whether this might be a means to reduce potable water use in gardens.

Blackwater (sewage) is not recommended for irrigation use under any circumstances as it poses a high risk for

human infection, primarily caused by Salmonella, Giardia, and Legionella.[32] Greywater quality varies significantly depending on the individual household.[33] While the public may perceive rainwater to be "clean," it often contains contaminants, including lead, copper, and potential human pathogens from its contact with capturing devices or storage infrastructure, and is not appropriate for use without some form of treatment.[34] Use of greywater or rainwater for irrigation of food crops can lead to food contamination, including uptake of contaminants into edible plant tissue, unless consideration is given to water quality, plant type, and irrigation method.[35]

Drip irrigation of crops, in which small amounts of water are applied closely to the root zone of the plant to avoid evaporation, provides the lowest risk of contamination and the literature supports this methodology for the provision of safe food crops.[36] Tomatoes and fruit trees are more appropriate for irrigation with recycled water than plants such as lettuce and spinach, as the literature shows that contaminants originating from irrigation water do not travel to the edible fruits and drip irrigation is unlikely to come into direct contact with the edible part of the plant due to its distance from the soil.[36,37] Both greywater and rainwater should be assumed to have the potential to contain pathogens and thus be treated and/or disinfected prior to consumption and use in food gardens.[38,39] All water used for domestic purposes, including that which is recycled, should be regularly tested for compliance with relevant water quality guidelines.[39]

It should be noted that certain jurisdictions, including British Columbia and Alberta,[40] and the National Plumbing Code,[41] do not differentiate between greywater and blackwater[42] in wastewater legislation or restrict the use of greywater to toilet or urinal flushing due to the potential for greywater to contain pathogens.[39,43] Regulations and relevant authorities should be considered prior to undertaking any wastewater reuse program.

TRADITIONAL PRESERVATION TECHNIQUES — WIND & SUN DRYING

Indigenous communities have preserved traditional foods using different natural techniques in a variety of landscapes. As these foods continue to be important for Indigenous peoples' physical, mental, and spiritual health, there is strong interest in reinvigorating traditional food systems. Kanaka Bar Indian Band is developing sustainable food systems using traditional methods of food processing alongside new technology, such as permaculture and solar power generation.[44] The community is located near Lytton, British Columbia,[45] which is often the warmest spot in Canada, with low humidity and infrequent summer precipitation.[46] The climate of this traditional territory lends itself to using wind and sun to preserve foods, using the natural elements and low humidity to reduce the moisture in the foods for storage over winter.[47,48] A literature search was completed to identify environmental health considerations for these practices.

Several possible risks have been identified through various studies of these traditional processing methods. Risks have generally fallen into three categories: food spoilage due to inadequate preservation; contamination of food products from either chemical or microbial sources; and the potential for pest and animal attraction. The poor quality of processed fish has most often been a result of unhygienic processing, inadequate salting, unhygienic drying, a lack of

Figure 1. Example of a solar dryer used to preserve fish and meats.

air-tight packaging, and the use of spoiled fish for drying (which is unrelated to the processing technique, but tied to an ineffective method of identifying safe products).[49]

Similarly, preservation techniques that occur in conditions of high humidity can lead to mould before the drying process is fully completed. For example, one study determined that mould grew on all food samples after two months of storage at room temperature.[50] Contamination was found to be a problem in several studies, which found that either most or all food samples had poor microbiological quality and high mycotoxin development.[51,52] Another study identified toxic metals as a contamination risk, finding that more of these metals existed in foods that had been dried using an open-sun method compared to those dried using a solar-drying system, which relies on indirect solar radiation.[53,54] Solar dryers remove the food from direct contact with the atmosphere, thereby reducing the opportunity for contamination. It is also difficult to eliminate contact between fish and flies using traditional fish smoking techniques. Insect infestation has resulted in poorer food quality in at least one study using solar-drying techniques.[55]

Despite these potential risks, several options exist that can moderate and/or eliminate the most problematic concerns. The use of solar dryers (versus sun drying) is chief among the options to reduce food safety risks. Solar dryers have the ability to produce well-dried and dust-free products, reduce toxic metal accumulation, regulate humidity (and therefore help prevent the development of mould), avoid insect infestation and reduce mycotoxin development.[51,55-57] Though evidence consistently identified the advantages of using this type of technology to improve food safety, other studies identified barriers to accessing solar dryers, such as the initial cost and materials required for construction,[54] particularly for rural populations.[55] Furthermore, while there have been numerous studies that suggest solar dryers are an improvement over sun- and wind-drying methods, several issues remain untested, such as efficacy with regard to viral inactivation.[58] More study is needed on these emerging technologies for these technical reasons and with regard to the feasibility of using them in remote Indigenous communities.

Other, non-technological options also exist to improve safety using wind- and sun-drying techniques. For example, adequate salting, air-tight packing of fish, drying food products off the ground and on racks, as well as consistently using hygienic practices during food preparation, have all been shown to reduce risks of these treatment methods.[49,59] Similarly, the use of potable water to clean fish can reduce contamination of the finished products.[59]

It is also worth noting that nutritional quality is relevant to this particular treatment method. Several studies have identified improved nutritional content in meats and fish processed through traditional drying and smoking methods. For example, Ayanwale et al.[60] found that sun-dried samples had higher protein and lower fat content than oven-dried meat. Smoked products have also been found to offer the healthiest advantage, with the lowest values of saturated fatty acids.[61] Smoked fish in particular has been found to have the highest protein content (with mineral levels increased from smoking and sun drying).[62] However, oven-drying methods have been shown to reduce lipid content, increase vitamin A content, and provide the longest shelf life for dried fish.[63] These combined characteristics are worth considering when developing best practices with Indigenous communities that are well contextualized for a variety of needs and concerns.

TREATED TIMBER AND PLANTER BOXES

As noted in above in the section on the use of tires as planters, Indigenous communities expressed concerns about the use of scavenged, waste or non-conventional building materials as planters. One Chief of a community in close proximity to an active rail line[64] identified the use of railroad ties in the construction of planters as they were easily accessible, inexpensive (or free), and properly sized for construction use. The Chief expressed concern that community members would be subjected to contaminants from the railroad ties in contact with food items. The scope of this specific query was expanded to include treated timber based on research findings, and to ensure that advice was relevant to the greatest number of communities.

Risks from using railroad ties as well as treated timber result from a combination of three factors: 1) PAHs, as well as arsenic, copper, chromium, creosote, boron, and polychlorinated biphenyls (PCBs), can leach into soil from either railroad ties or treated timber[65-69]; 2) opportunistic black yeasts, which can be harmful to humans, grow and thrive on railroad ties, and this growth is further supported when creosote is present on the ties[70,71]; and 3) the greatest human consumption of metals results from eating root crops (such as beets, turnips, carrots, and potatoes) that have full contact with contaminated soil particles throughout their growth cycle.[72]

This confluence of factors has been observed to increase food contamination risks in several studies. For example, Brooks[69] found that migration of PAHs from newly treated ties into soil was high during hot summer months and that less migration occurred when ties were weathered. The study found that no PAHs were lost to the soil by the second summer of use. Other studies did find correlations between PAH levels in plants and soils, suggesting consistent uptake,[67] with copper, chromium, and boron leaching into soils over subsequent years.[68] Perhaps most notably, high levels of creosote in railroad ties were still found even after 75+ years of use, suggesting that leaching may still occur even with weathered materials.[73]

Yet, there are approaches that can both make use of this material and minimize risks to users (and those who consume the produce grown in beds made of these materials). Most studies found that there were distance limits to leaching; for example, Moret et al.[66] identified very high PAH concentrations, up to 1 m from the source of contamination, but also noted that the contamination load decreased rapidly with distance. A more recent study found that PAH impacts were actually limited to 7 cm from the railroad ties (both horizontally and vertically), suggesting that these materials may have little effect if there is care taken to avoid close contact when planting.[67] Similarly, installing a barrier between the treated materials (either lumber or railroad ties) may help alleviate the largest risk of contamination. For instance, one study showed that painting the bottom of copper-, chromium-, and arsenic-treated timber posts reduced the contamination of the surrounding soil by 50–75%.[74] There have also been recommendations to use heavy plastic liners in beds made with these materials to provide further barriers and prevent leaching into soil used for food production.[75] Finally, it is worth highlighting that creosote has, in general, been found to harm plants and restrict growth, so avoiding contact with creosote-treated lumber and railroad ties is recommended in order to avoid food quality issues.

HYDROPONICS

In climates where soil-based growing is unable to sustainably produce food crops, hydroponics can provide a means of producing locally grown, sustainable nutrition. In hydroponic systems, plants are grown in the absence of soil, and instead receive nutrients through liquid solutions.[76] In Canada's northern communities, hydroponics may be used as a way to reduce reliance on expensive imported produce[77] and support food security.[78] Vegetables that are commonly grown hydroponically include leafy greens (e.g., lettuce, cabbage, and spinach), tomatoes, carrots, and peppers.

The literature suggests that while hydroponic systems can produce food where soil-based systems cannot, there are food safety considerations that must be taken into account. Numerous studies have identified the uptake of contaminants of potential concern by plant roots and translocation into the edible portion of the plant, including Salmonella species,[79] human norovirus analogues,[80] microcystin-LR,[81] hepatitis C,[82] and pharmaceuticals.[83,84] Generally the introduction of these contaminants originates with irrigation water[85,86] and the presence of nutrient-rich fertilizer solutions allowed for their proliferation.[87] However, the literature also shows that contamination of seeds can also lead to contamination within mature plants.[88]

As hydroponically grown plants are grown in the absence of soil, some sources of contamination risk are inherently absent (e.g., soil, manure, compost).[89] Notably, the fruits of tomato plants have been shown to not be a high risk for contamination through plant uptake in hydroponic systems, likely due to distance between the root structures and the edible fruits.[85,90]

As contaminated irrigation water and nutrient solutions appear to be the most common sources of risk associated with hydroponically grown foods, the following practices are recommended to reduce risk: 1) water quality testing and the use of clean irrigation water[91,92]; 2) following good agricultural practices and good manufacturing processes at all steps of production, such as healthy workers, high-quality irrigation water, toilet facilities for harvesters, and pest reduction (as outlined by the United States Food and Drug Administration,[93] the United Nations Food and Agriculture Organization,[94] and the Province of British Columbia)[95]; and 3) the use of organomineral nutrient solutions for areas with poor irrigation water quality.[96]

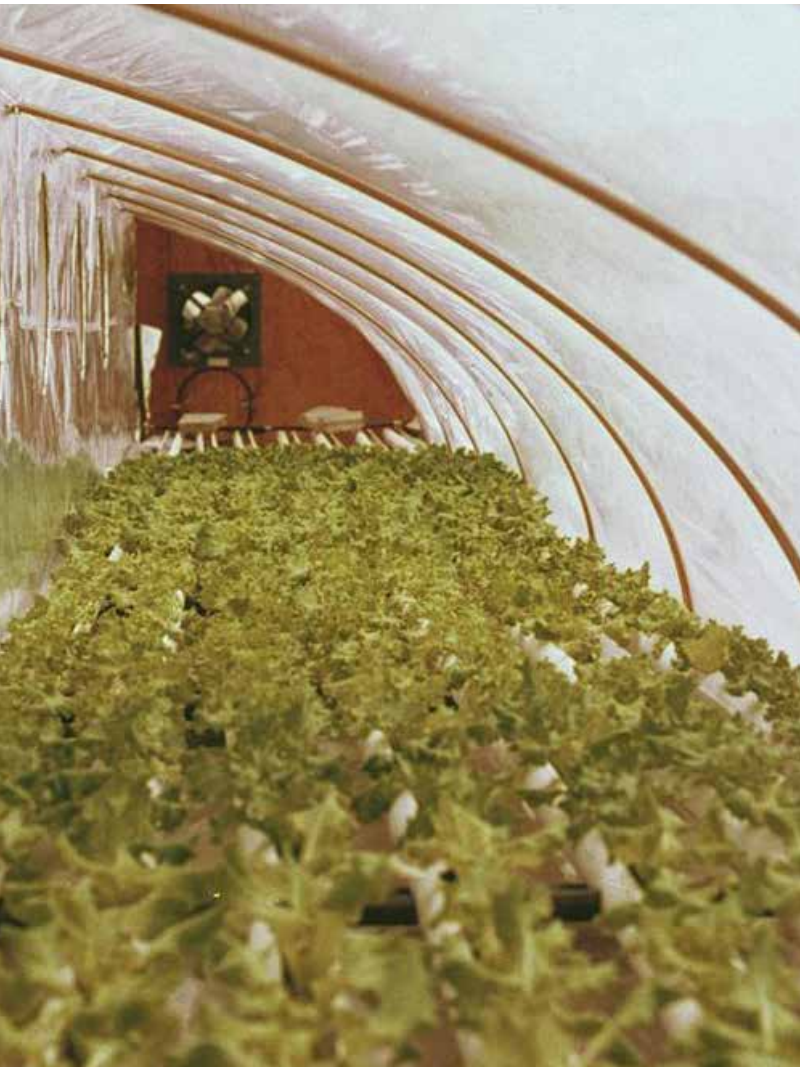
RECOMMENDATIONS

The cases described above reflect only a few of the potential areas where Indigenous communities — and their partners in environmental public health — can act to improve food safety and food sovereignty. The food safety risks encountered in the process of strengthening Indigenous food security can be reduced, and in many cases eliminated if appropriate steps are taken. While not all interventions will necessarily fall into these categories, defining steps to be taken into either physical, chemical, or technological measures may help to clarify necessary labour and resources associated with each risk mitigating intervention. This is not an exhaustive set of recommendations but rather is meant to provide guidance to communities and public health professionals as they seek to improve community health outcomes.

Physical Interventions

Physical changes to food processing and production environments can take many forms, but with reference to the risks outlined in the cases above, the most pertinent changes often involve creating barriers, reducing contact areas, and increasing physical distance between food items and possible contamination sources. Key recommended physical interventions include:

- Increasing the distance between smoke source and food items processed using smoke; this should also include partially smoking food items to reduce exposure to PAHs (note that shelf stability of specific lightly smoked foods should be confirmed);
- Drying food items away from contamination sources, such as on racks and off ground systems;
- Consistently using hygienic practices when handling and packaging food (which includes the use of air-tight packing);
- Using only whole tires (to avoid increased contact surface area with soil) and being vigilant about exposed tire wires (and removing them if found);
- Rotating soil in garden beds made of tires, treated lumber, or other chemically treated materials such as railroad ties;
- Avoiding close contact (and providing distance) when planting close to treated lumber and railroad ties;
- Installing barriers such as heavy plastic liners or using sealants that are non-toxic (e.g., by painting treated materials with these sealants, including tires) to prevent leaching; and
- Avoiding the use of treated materials for food production purposes after five years.



Chemical Interventions

While physical interventions involve reducing or removing contact points with contaminated materials, chemical interventions focus on removing contaminants themselves. This can span many different food processing techniques, but lessons remain drawn from a straightforward guiding principle: if possible, remove contaminant sources entirely. This may include, but is not limited to:

- Avoiding the use of treated lumber and galvanized metal in the construction of structures coming into contact with food items;
- Removing any existing oils and chemicals from surfaces;
- Treating irrigation water and disinfecting tools prior to use in food processing, which includes the use of clean and/or treated water in hydroponics;
- Eliminating potential bacterial growth by adequately salting food products;
- Using potable water (or a drinking water source) rather than grey or blackwater for cleaning food products (such as fish, meats, and vegetables);
- Avoiding items that have been treated with creosote, such as used railroad ties; and
- Using organomineral nutrient solutions in regions with poor irrigation water quality.

Technological Interventions

This last type of intervention relies on the use of specific equipment to improve food safety outcomes. Purchasing, installing, and maintaining these types of technological systems is often very resource intensive and may be beyond the financial means of many communities. Yet, implementing systems that have the potential to increase food sovereignty as well as food safety can have other positive impacts on communities. Hence, balancing these costs and benefits is a worthwhile exercise, particularly given the advantages they often provide when it comes to reducing environmental health risks. Some technological interventions may include:

- Installing drip irrigation systems to reduce water evaporation (and therefore improve water conservation practices), as well as avoid contamination with plant sections that are to be consumed;
- Installing ventilation systems to reduce food contact with PAHs from smoke but also to provide safer working environments for individuals processing smoked foods;
- Instituting water quality testing systems both for hydroponic systems and for regular crop irrigation water; and
- Using solar dryers to reduce dust on food items, lower toxic metal accumulation, and regulate humidity (to avoid mould growth).

Given the complexity of food production and the climatic pressures that threaten Indigenous food security, it is essential that tools be developed and shared among Indigenous communities so that they may thrive as these environmental changes take root in their communities. Growing understanding about food safety risks and how to avoid or reduce them can contribute to this goal, hopefully improving both awareness and capacity around solutions. This approach to food safety can therefore directly improve health outcomes as adaptations become stepping stones toward sustainable, healthy food systems.

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APPENDIX A — SEARCH METHODOLOGY

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Rapid literature searches were conducted to locate articles in support of case studies relevant to topics included in this evidence review. The searches aimed to capture scientific and grey literature relevant to each topic, with specific interest in environmental health and safety aspects. Bibliographies of retrieved articles were scanned to further retrieve more extensive and detailed information on a particular aspect of interest. Any related articles and suggested articles appearing within the search engine were also considered for inclusion. This process subsequently aided in refining search terminology and finding additional and specific articles of interest.

Inclusion of articles with publishing dates from years 2008–2018 were preferable, but articles were not excluded by date if their material was of particular interest or the date of publication did not adversely impact the quality of evidence. Grey literature was included for descriptive and illustrative purposes. The search was restricted to English language articles, and it was completed in July 2018 for five of the six case studies; the hydroponics case study was completed in October 2018.[4]

In brief, articles were identified though EBSCOhost (to access MEDLINE, CINAHL, PsycINFO, Biomedical Reference Collection, and Academic Search Complete), Ovid (to access Elsevier Science Direct, Evidence Based Medicine, SAGE journals online, and Cochrane Database of Systematic Reviews), and Google Scholar (to access books, book chapters, older articles, and articles from journals not indexed through major database platforms). We used broad keywords and search statements which are indexed below by topic area.

Additional description of search engines/databases for sources of information:

- University of British Columbia Library — Ebscohost (includes Medline, Cinahl, Academic Search Complete, ERIC, etc.)
- A full list of databases included in this search engine can be found here
- Pubmed
- ScienceDirect
- Ingentaconnect
- Embase
- Web of Science
- Indigenous Journals (UBC Library)
- Google Scholar
- Google

4. In addition to the literature searches completed for the topic areas described, a rapid literature search was conducted for the broad topic, "Traditional foods and impact of climate change (indigenous)" on June 21, 2018, to locate further literature and context for this evidence review.

Search Terminology (provided by Topic Area below)

Topic Area #1: Smokehouse Construction Considerations (e.g., use of poly-tarps, building smokehouses)

Sample PECO Statements and Search Terms (with selected variants and Boolean operator combinations)

POPULATION:

- (indigenous OR aboriginal OR tribal OR "first nation" OR indian OR band OR reserve OR metis OR inuit OR salish OR dene) *(specific/additional First Nations may be considered)
- (north OR arctic OR canada OR canadian OR "british columbia" OR alberta OR saskatchewan OR manitoba OR ontario OR quebec OR "nova scotia" OR "prince edward" OR "new brunswick" OR labrador OR newfoundland OR nunavut OR territories OR nunavik OR yukon OR "west coast")
- smokehouse

EXPOSURE:

- (polyethalene OR PET OR poly OR tarp)

COMPARATOR:

- (design OR construction OR material OR build)
- (cook OR smoke OR food)

OUTCOME:

- (contamination OR chemical OR carcinogen OR PAH OR pollution OR "air quality")
- (health OR safety OR illness OR toxicity OR toxic OR toxin OR contaminate OR contamination OR residue)
- (illness OR PAH OR pollution OR "air quality")
- ("eye conjunctiva" OR "eye irrita*" OR "skin irrita*" OR "throat irrita*" OR "rash" OR "nasopharyngeal mucosa" OR lysis OR asthma OR rhinitis)
- (cough OR wheez* OR sneez* OR headache OR nausea OR vomit* OR "difficulty breathing" OR "breathing difficulty")
- ((ocular OR respiratory) AND symptom)
- ((irritat* OR constrict*) AND (eye OR mouth OR throat OR skin))

Topic Area #2: Gardening and Use of Tires as Planters

Sample PECO Statements and Search Terms (with selected variants and Boolean operator combinations)

POPULATION:

- (container OR planter OR plot OR bed OR farm OR backyard)

EXPOSURE:

- (tyre OR tire OR rubber OR "crumb rubber")

COMPARATOR:

- (food OR garden OR grow OR cultivate OR farm OR crop OR vegetable OR strawberries OR potato)
- ("urban farm*" OR "urban agriculture" OR "community garden*" OR "school garden" OR "backyard farm*" OR "guerilla garden*" OR "vacant lot" OR "city garden*" OR "abandoned lot" OR "allotment garden" "roof garden*" OR "zero-acreage farm*" OR "food-growing")

OUTCOME:

- (health OR safety OR illness OR toxicity OR toxic OR toxin OR contaminate OR contamination OR leaching OR "soil pollution" OR leach OR leachate OR residue)
- (metal OR lead OR zinc OR copper OR arsenic OR cadmium OR molybdenum OR cadmium)
- (ascetone OR aniline OR arsenic OR barium OR benzene OR benzothiazole OR cadmium OR chloroethane OR chromium OR cobalt OR copper OR "flame retardant" OR isoprene OR latex OR lead OR manganese OR mercury OR ketone OR naphthalene OR nickel OR nylon OR phenol OR pigments OR hydrocarbon OR PAH OR polyester OR rayon OR styrenebutadiene OR toluene OR trichloroethylene OR zinc)

Topic Area #3: Greywater use in Crop Irrigation

Sample PECO Statements and Search Terms (with selected variants and Boolean operator combinations)

POPULATION/PROBLEM:

- irrigation OR irrigate OR water

EXPOSURE:

- (wastewater OR greywater OR graywater OR "grey water" OR "gray water" OR "recycled water" OR potable OR runoff OR run-off OR "untreated water" OR "surface water" OR rainwater OR "water quality" OR "available water")
- ("irrigation water" OR "water harvest" OR roofwater OR "roof water")

COMPARATOR:

- (food OR garden OR grow OR cultivate OR farm OR crop OR vegetable OR strawberries OR potato)
- ("urban farm*" OR "urban agriculture" OR "community garden*" OR "school garden" OR "backyard farm*" OR "guerilla garden*" OR "vacant lot" OR "city garden*" OR "abandoned lot" OR "allotment garden" "roof garden*" OR "zero-acreage farm*" OR "food-growing")

OUTCOME:

- (health OR safety OR illness OR toxicity OR toxic OR toxin OR contaminate OR contamination OR leaching OR "soil pollution" OR leach OR leachate OR residue OR pesticide OR herbicide)
- (metal OR lead OR zinc OR copper OR arsenic OR cadmium OR molybdenum OR cadmium)
- (pathogen OR e-coli OR diarrhea OR stomach OR cramp OR salmonella OR escherichia OR disease OR diarrhoea OR risk); specific additional outcomes:
- Escherichia coli O157: H7
- Staphyloccocus aureus
- Pseudomonas aeruginosa
- Salmonella spp.
- Campylobacter jejuni
- Listeria monocytogenes
- Shigella sonnei
- Yersinia enterocolitica
- Enterococcus hirae
- Norovirus surrogates (feline calicivirus)
- Aspergillus brasiliensis spores
- Clostridium difficile spores
- Candida albicans

Topic Area #4: Traditional Preservation Techniques (i.e., wind & sun drying)

Sample PECO Statements and Search Terms (with selected variants and Boolean operator combinations)

POPULATION:

- (fish OR meat OR venison OR salmon OR caribou OR elk OR deer OR tilapia OR salmon OR sockeye OR chum OR coho OR trout OR halibut OR duck OR pheasant)
- ("traditional food" OR "food preparation" OR "food method" OR "country food" OR "food safety" OR "food security" OR "food access")
- (indigenous OR aboriginal OR tribal OR "first nation" OR indian OR band OR reserve OR metis OR inuit OR salish OR dene) *(specific/additional First Nations may be considered)

EXPOSURE:

- (dehydration OR dehydrate OR dehydrating OR drying OR preservation OR preserving OR preserve)

COMPARATOR:

- (sun OR "solar energy" OR wind)
- ("available water" OR drying OR rack)

OUTCOME:

- ("food safety")
- (health OR safety OR illness OR poisoning OR contamination OR contaminate)
- (pathogen OR e-coli OR diarrhea OR stomach OR cramp OR salmonella OR escherichia OR disease OR diarrhoea OR risk)

Topic Area #5: Treated Timber and Planter Boxes

Sample PECO Statements and Search Terms (with selected variants and Boolean operator combinations)

POPULATION/PROBLEM:

- ("railway ties" OR crossties OR "rail ties" OR lumber OR timber OR "wood sleepers" OR "building material")

EXPOSURE:

- (contaminat* OR soil OR pollut* OR leach* OR hydrocarbon OR PAH OR POP OR gasoline OR preservative OR creosote OR arsenate)

COMPARATOR:

- (container OR planter OR plot OR box)
- ("urban farm*" OR "urban agriculture" OR "community garden*" OR "school garden" OR "backyard farm*" OR "guerilla garden*" OR "vacant lot" OR "city garden*" OR "abandoned lot" OR "allotment garden" "roof garden*" OR "zero-acreage farm*" OR "food-growing")
- (food OR garden OR grow OR cultivate OR farm OR crop OR vegetable OR strawberries OR potato)

OUTCOME:

- (safety OR illness OR toxicity OR toxic OR contaminate OR contamination OR residue OR leach OR leachate)
- (health OR safety OR illness OR poisoning)
- (metal OR lead OR zinc OR copper OR arsenic OR cadmium OR molybdenum OR cadmium)
- (guidance OR guideline OR standard OR legislation)

Topic Area #6: Hydroponics

Sample PECO Statements and Search Terms (with selected variants and Boolean operator combinations)

POPULATION:

- (band OR "first nation" OR "Inuit" OR "indigenous" OR "aboriginal" OR "Metis" OR dene OR reserve OR indian OR tribal OR tribe) *(specific/additional First Nations may be considered)
- (north OR arctic OR canada OR canadian OR "british columbia" OR alberta OR saskatchewan OR manitoba OR ontario OR quebec OR "nova scotia" OR "prince edward" OR "new brunswick" OR labrador OR newfoundland OR nunavut OR territories OR nunavik OR yukon OR "west coast")

EXPOSURE:

- (hydroponic OR nutrient OR solution)

COMPARATOR:

- ("urban farm*" OR "urban agriculture" OR "zero-acreage farm*" OR "food-growing")
- (food OR garden OR grow OR cultivate OR farm OR crop OR vegetable OR strawberries OR potato)

OUTCOME:

- (safety OR illness OR toxicity OR toxic OR contaminate OR contamination OR residue OR leach OR chromium OR selenium)
- (health OR safety OR illness OR poisoning)
- (pathogen OR e-coli OR diarrhea OR stomach OR cramp OR salmonella OR escherichia OR disease OR diarrhoea OR risk)

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