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WASTING INDIGENOUS COMMUNITIES: A CASE STUDY WITH GARDEN HILL AND WASAGAMACK FIRST NATIONS IN NORTHERN MANITOBA, CANADA

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ABSTRACT

A case study of solid waste management in two fly-in Indigenous communities in Canada shows waste management poses high risk to human health and is contaminating land and water. All community members (n=27) who were interviewed in the two communities reported open dumping and burning their waste, including e-waste and healthcare waste. This burning of waste was typically adjacent to each home in the community due to the lack of any waste or recycling collection service or options for recycling or safe disposal. Without a sanitary landfill or recycling programs, non-biodegradable and toxic wastes in these communities contaminate the land and water. Stratified composite soil samples taken at the largest dumpsite in each community revealed that arsenic, lead, chromium, zinc and copper typically exceeded Canadian soil environmental guidelines, including industrial guidelines. Many Indigenous people spoke of the land as sacred and saw themselves as stewards of their territorial land but felt the toxicity of modern waste and the lack of funding or services to deal with it compromised their stewardship role. Waste management of non-biodegradable products, other than burning, was considered to be beyond their control with the few resources available to them.

Keywords: Solid waste management, hazardous waste, contaminants, Indigenous, First Nation, northern Manitoba

INTRODUCTION

Unsafe waste disposal practices prevail in poor and marginalized communities across the globe, [1, 2], but also in Indigenous communities in rich countries. This paper provides a case study of waste management in two fly-in Indigenous communities, Garden Hill (GH) First Nation and Wasagamack (WASS) First Nation. Studies around the world show that inadequate waste management services and infrastructure, as well as an absence of effective institutional capacities result in open dumping and burning of waste, including toxic waste [3].

Convenient curbside collection is considered essential for effective waste management and recycling according to re-

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search around the world [4-8]. Studies showed that people who had to transport their waste for more than 50 meters typically dumped waste in open spaces [9]. For example, research in rural China found most rural domestic waste being dumped along the riverbanks or around farms [10-12]. In rural environments, improper waste disposal contaminates soil, ground water and polluted air in the case of burning waste [13]. Unsafe waste disposal has negative environmental impacts as shown by the finding that 50% of villages in China in 2007 were polluted mainly by rural domestic waste [14]. Dumping and burning waste severely degrades aquatic and land ecosystems, risking the health of nearby residents [15]. Open dumpsites are breeding grounds for disease-carrying vectors, such as rats and mosquitoes [16, 17] that bring additional risk.

The hazards from poor waste management in developing countries are well documented [18, 19], but less so for remote and/or Indigenous communities. Bharadwaj et al., report that many households in Indigenous communities have backyard dumping and burn sites [20] with 100 burn sites for Mistawasis First Nation, which has a population of just over 2000 [20, 33]. Geographical constraints may further restrict the options for solid waste management in the two remote First Nations, as they lack all-weather road access [21].

In contrast to developing countries, developed countries appear to have waste under control. Waste has been collected and managed in cities for centuries. Industrialized countries initiated research on waste management and source-separated collection in the 1960s to try to address the scarcity of natural resources and environmental degradation. Waste management initiatives were implemented in the 1970s, including curbside collection of waste, recycling and extended product responsibility [10]. In most developed countries waste management evolved over the last fifty years from safe disposal in a sanitary landfill to sustainable management including five steps: prevention, reuse, recycle, recovery, and disposal [22-24].

Indigenous communities in Canada, also known as First Nation reserves, have been largely excluded from waste management developments, both in terms of research and operations [20]. Indigenous communities in Canada continue to suffer from an ongoing process of colonization, which has undermined self-determination, including control over waste prevention and management. Colonization restricted Indigenous peoples' access to the land, water and forest in their traditional territory [25] and imposed a foreign system of governance. Colonization also assaulted Indigenous culture through residential school system, which took children away from their families, language, culture and outlawed Indigenous ceremonies and governance. Canada restricted economic and community development on First Nation reserves and usurped their ancestral territories and resources, which impoverishing Indigenous communities and people. When people lack adequate food and housing, waste management funding and regulation are seldom high priorities, thereby contaminating water, food and land [26].

Solid Waste Management in Canada's Indigenous communities. Waste management in Canada's Indigenous communities was recognized as a critical issue in 1995 in the Canadian House of Commons but has yet to be addressed [27, 28]. A survey of 600 Indigenous communities found that most Indigenous communities suffered from unsanitary waste and wastewater disposal systems, in addition to lacking safe drinking water [27]. This abysmal solid waste and water situation on First Nation reserves is attributed to the underfunding of infrastructure on reserves and the lack of capacity-building programs [29-31]. Waste management is not a budget item[32].

Backyard garbage disposal pits are how many people in Indigenous communities dispose of their waste [20]. Most waste pits were used to dispose of household wastes including construction materials, tires, white goods (e.g., refrigerators, stoves, etc.), electronic waste and other toxic materials, such as batteries and Styrofoam. Burning this electronic waste contaminates air with cadmium, manganese and nickel, which risks human health [34].

STUDY AREA

The two communities, Garden Hill (GH) (53.8833^0N, 94.8489^0W) and Wasagamack (WASS) (53.8917^0N, 94.9514^0W) are in the Island Lake region in the north-east

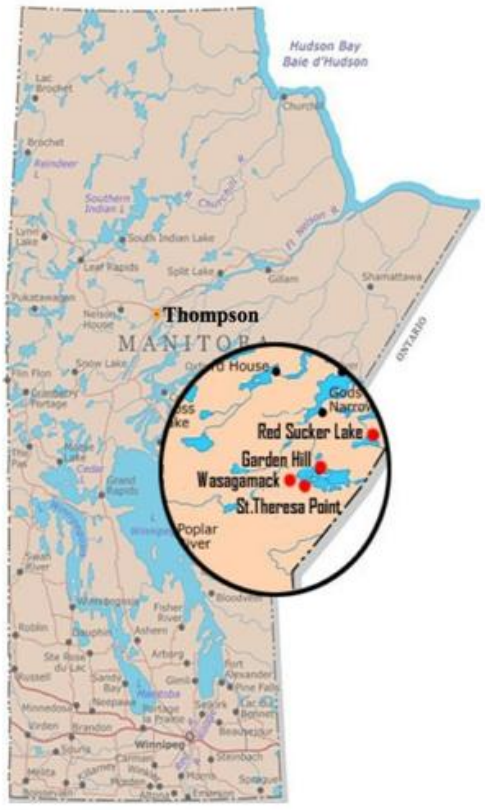

FIGURE 1
Map of Manitoba showing the location of Garden Hill First Nation and Wasagamack First Nation (Source: Four Arrows Regional Health Authority, nd)

corner of Manitoba, Canada (see Figure 1). Both are more than 600 kilometers northeast of the provincial capital, Winnipeg [35, 36]. The 2591 people in GH and the 1403 people in WASS are situated on small reserves, designated by the government, that are 82.48 and 80.63 square kilometers respectively, which is high density for a rural area without any waste infrastructure [37, 38]. In the winter these remote communities build ice roads to access other communities and urban centers.

As of 2016, these communities had 507 private residences in GH and 284 private residences in WASS [37, 38]. Insufficient housing for the large, growing population results in three families living together. The houses in GH and WASS communities are located adjacent to Island Lake, to get drinking and household water from the lake, as up until recently there was no plumbing for drinking water and sewage collection [39-41]. In 2018, many households, estimated at 20% from a recent census survey in GH, have to dump their households "honey buckets", without any cisterns or piped system.

METHODS

Participatory action research was undertaken with people in the communities of GH and WASS regarding solid waste management practices. The research was carefully negotiated with the community to address their concerns about solid waste and goals of getting better waste management programs. Following the First Nation Information Governance Centre research protocol for ownership, control, access and possession (OCAP), permission to conduct the study was obtained from the elected leadership in each community through a Band Council Resolution (BCR) prior to commencing the study [42]. According to Schnarch, OCAP represents "self-determination applied to research" and OCAP principles require researchers to respect that Indigenous communities should have control over research processes in their communities and Indigenous participation should be present in all aspects of research from idea to execution [43].

The three methods applied are described in more detail below:

1. *Interviews*. Twenty-seven (27) community members were recruited for interviews through announcements on the local TV and radio stations and provided a rich understanding of the issues in their community with waste. These 27 community members were of both genders and included 12 elders (55+). Roughly half or 13 community members were from Wasagamack with the other 14 community members being from Garden Hill. As well, five key solid waste management stakeholders in Manitoba (including government officials, First Nation chief executive officers and elected councilors in charge of waste) were interviewed. Interviews were recorded with participant's consent and permission with a digital video camera and notes and then transcribed. A thematic content analysis was carried out on the transcripts to identify key themes.
2. *Sharing Circle*. Two sharing circles were conducted with the band council as well as community members in Garden Hill (GH) and Wasagamack (WASS). Sharing circles allow each person in the group to talk and share their perspectives without interruption, which prevents any one person from dominating the conversation to ensure everyone is heard. These four sharing circles provided community members' insights regarding historical and present solid waste management practices, allowing people to brainstorm waste management solutions. Sharing circles, being an Indigenous research method, was considered appropriate and more respectful than focus groups as it is participant-controlled and inclusive [44].
3. *Environmental sampling and site assessment*. The locations of the main garbage dumpsites in Garden Hill (GH) and WASS were compared to the guidelines for siting waste dumps under *Manitoba Waste Disposal Ground Regulations MR150/91*. Nine different sections of soil from each area were collected to a depth of 25 cm from three different zones at both the GH and WASS dumpsites. The results from these sites were compared with the Canadian Council of Ministers of the Environment (CCME) guidelines for contaminant levels [45] and with background soil samples taken approximately 1000 meters from the waste sites. Composite water samples were also collected from the nearby surface water stream and pond. All soil samples were analyzed for heavy metal concentrations and surface water samples were analyzed for microbial parameters (*E. coli* and total coliform) at a laboratory accredited based on the ISO 17025 standard. Total metals were determined by Inductively Coupled Plasma Mass Spectrometry or ICP-MS. Technology was used to remove interferences, notably collision/reaction cells (CRCs). The concentrations of samples were compared to the CCME soil quality guideline levels for agriculture, residential and parkland, commercial and industrial sites [45] and water quality was compared to Health Canada's Guidelines for Drinking Water Quality and Guidelines for Recreational Water Quality.

FINDINGS AND DISCUSSION

Part A: Issues identified by community members

Five different themes or issues were identified from interviews and sharing circles with Indigenous community members namely: ubiquitous waste being at odds with community stewardship; underfunding of waste management on reserves; lack of any waste collection; reserves provide a black hole for toxic waste and stewarded products; government neglect; and regulatory limitations.

Ubiquitous waste at odds with community stewardship. All the 12 elders and some of the youth interviewed in Wasagamack (WASS) and Garden Hill (GH) consider the land to be sacred and themselves to be stewards of the land

and felt that litter and contamination was unacceptable. People from both communities expressed a desire for their traditional territory to be preserved in a natural state without incursions from industrial development and free from contamination due to mining, hydro-development water regulation or waste. A welcome sign at the entry point to GH reserve speaks to the importance of the integrity of the land for their culture:

"All of our rights originate from our connection to the land. Our lives, our beliefs and our presence as First Nation people are validated to the land, inhabited by our ancestors since time immemorial. Our land is sacred. It is the living body of our sanctity. The teachings and our customs are implicit and practiced through the integrity that protects and warrants our survival."

Clearly, this sign indicates the respect and high value for the ecological integrity of the land in this community. Throughout history to the present day, Indigenous people in GH and WASS survive off local wild food resources through fishing, trapping, hunting, and gathering with minimal negative environmental impact. Indigenous people have used natural resources sustainably since time immemorial [46]. Bare and Ziegler-Ulsh define sustainable as "a method of harvesting or using a resource that replaces and renews the resource, rather than depleting or permanently damaging it" [47], which is considerate of future generations. Indigenous peoples have an enduring close connection with nature that continues today through a deep understanding of their ecosystem [48].

However, the present lack of waste management with the modern plastic and other toxic wastes, such as e-waste and medical waste, is visibly destroying the land and culture, as displayed by the pile of waste near the sign and around these communities. Litter, construction and demolition debris and hazardous wastes (e-wastes, end-of-life vehicles, diabetic syringes) are ubiquitous along roadways in GH and WASS reserves, as shown in Figure 2. These waste materials were near water bodies and homes, with end of life vehicles and other materials being part of children's playgrounds as captured on video available at https://www.youtube.com/watch?v=EQ1YrQDjvB8.

The increased consumption of processed and packaged store-bought food contributed to a drastic increase in the volume of waste generated over the past few years, according to community members. Colonial pressures and the shift from a nomadic culture to a sedentary lifestyle created greater dependence on market foods [49]. The transition for Indigenous people from sustainable hunter/gatherer to unsustainable and dependent is complex, multi-dimensional and dynamic in nature with colonial, economic, political and social influences [50]. Now most community members consume mainly processed food, with their abundance of packaging, due to their easy access and cheaper price compared to healthy alternatives.

A stark contrast between what people in GH and WASS believed (e.g., sanctity of earth and preservation of the earth) and the unsustainable nature of their waste management was evident. Modern toxic products that litter and contaminate the land clash with traditional, sustainable ways of living off the land. Everyone in GH and WASS that was interviewed felt current waste practices were unsafe and unacceptable but felt that only with proper funding and programs for waste management could ecological integrity be restored.

Underfunding waste management on reserves. Lack of dedicated funding for waste management undermines the safe collection and disposal of waste. No funding is available in the communities for a garbage truck or any truck to allow for

FIGURE 2
Roadside Open Dumping in Garden Hill First Nation

pickup of waste from households at curbside. As well, there is no funding for a scientific and community study to suitably site and develop a sanitary landfill. This lack of funding also means the present waste dump has no dedicated workforce, no fence, no cover materials and no leachate collection system, all of which are required by legislation. No dedicated funding is due to a per capita funding formula inconsiderate of the greater needs and higher costs for remote fly-in northern communities having a few thousand people. In these economically poor communities that have 88% food insecurity and as many as three families or 23 people living in a three-bedroom house due to housing shortages, waste management is a relatively low priority. One community member who works at the band office in Wasagamack stated:

"There are so many things we need to take care of [in the community], especially the problems of overcrowding in our houses. Many people in the communities do not have jobs and we need to provide some form of social assistance. Therefore, there is nothing or little we can do [about] our waste management services."

Waste pick up and management in remote locations requires additional financial supports due to difficult transportation logistics [51]. Getting toxic waste and recycling out of the community is an issue due to the lack of connecting roads and long distances to urban centers that make recycling and proper hazardous waste management cost prohibitive. As well, household collection is challenging and expensive with gasoline costing double the price compared to communities with access roads and poorly maintained roads ruining vehicles.

Product stewards, which are the producer responsibility organizations on behalf of corporations producing the toxic non-biodegradable products, collect eco-fees to provide funding to cover their management and recycling. Community members of these and other First Nations pay eco-fees when they purchase stewarded products (include beverage containers, electronic equipment, tires, batteries) but receive no collection or recycling services in return. These stewarded products (particularly beverage containers and food packaging) comprise a significant proportion of the waste generated in the communities of GH and WASS. These poor communities that cannot afford their own basic waste management, paying into programs that only benefits off reserve communities is a real injustice. Product stewardship programs such as *Recycle Everywhere* exist in places across the province of Manitoba, but not in remote First Nations. In contrast, an elder in WASS described the absence of recycling program in the communities as *Recycle Nowhere* saying: "Anytime I go to Winnipeg, I see these garbage bins with recycle everywhere. In our community, there is nothing like recycling anywhere around."

No waste reduction or recycling programs are available in the communities of GH and WASS. An elder commented on the need to recycle and the danger of burning it:

"We need to recycle especially cans, plastics etc. Burning garbage can result in pollution because there are waste materials that are not meant to be burned. There are batteries in the garbage and we should have proper containers for such products. We need to have a community recycling center and proper incinerator for garbage that can be burned."

Community members in GH and WASS need funding to participate in recycling. In the past, efforts have been made by the youths to organize a local collection drive. Figure 3 shows the youth in WASS community voluntarily collecting and sorting recyclable materials to recycle. The major roadblock for these youths is mainly inadequate funding to ship waste materials out to be recycled, since the cost of shipping the recyclable materials is higher than the value received from scrap metal and other financial incentives.

The main source of packaging, disposable products and

FIGURE 3
Youth in Wasagamack voluntarily collected and sorted a truck load of recyclable waste

toxic products in the communities is the Northwest Companies' Northern Store, which is the only store in both communities. Some community members blamed the lack of recycling initiatives on the lack of corporate responsibility and environmental stewardship of the Northern Store, stating:

"I believe the Northern Store has some responsibility and accountability for the management of waste and for recycling in our communities...I think they should have a responsible attitude towards our waste management here in Wasagamack. Right now, they are not doing anything, but only helping to pile up garbage on our land. The land is sacred to our people."

Since the Northern Store receives regularly truck and plane shipments of products that are toxic and recyclable, this store could backhaul recyclables and hazardous wastes they bring to their communities. At present, that does not occur and trucks and planes return empty. Another elder stated: "We urgently need to introduce recycling programs; we also need someone to train our people on how to sort our garbage for recycling."

Lack of curbside waste collection trashing the community. Local people estimated that 80% to 100% of households dumped or burned in their backyards on a regular basis. Most people interviewed had one burn pit but some households had several of them. Based on visible and often very large burn pits or garbage dumps an estimated 500 burn pits exist in GH and about 300 burn pits in WASS averaging one per residence. These numbers are much higher than the 100 estimated by Bharadwaj et al., for Mistawasis First Nation, which has a population of just over 2000 [20, 33].

Without a curbside collection service for waste or recyclables, each household and business must organize their own waste management system. With most households not owning a car, community members in GH and WASS have to pay $5 to $20 to hire a private hauler (or taxi) to dispose of a few bags of garbage each week, or $100 to $200 to haul larger piles of garbage accumulated over many months in their yard. But most people cannot afford that and so they backyard dump and burn. Garbage is not contained within one dumpsite or a few sites but can be found in hundreds of small dumpsites in almost everyone's yard throughout both communities surveyed. This finding concurs with studies that show people who have to transport their waste more than 50 m tend to dump waste in open spaces [9], as all people have to travel more than 50 m to reach their community dumpsite, which was sited far away from households. Both rural communities in developing countries and Indigenous communities in developed countries both have households burning waste to prevent odors and pests [28].

Garbage dumps are everywhere in these two communities. One community member gave a tour of the many dumps in the community: "Many people bring their garbage here and set them on fire. Some people even throw their garbage in the woods, their backyards or along the roadsides. There are no other options because we don't have recycling [or any proper solid waste management facilities] here in the community." A community member recognized the need for containing the waste, stating: "Garbage is all over the place because our dumpsites are not confined to one specific area. Plastic materials blow all over the place and even into the lake."

Waste dumping next to a home results in toxic exposure of the residents and risk from sharps. Uncontrolled disposal exposes children and adults to physical injuries and infections from sharps and other hazardous materials present in the waste stream and may be a breeding ground for disease-carrying vectors [17, 28]. Without running water or piped sewage in many houses (roughly 20%), dump their sewage in

FIGURE 4
Backyard dumping of waste and sewage at Wasagamack First Nation, which poses threats to health and the environment

the same place as their waste. See Figure 4. People burn garbage to reduce vermin and reduce the waste volume to minimize the impact of waste overtaking their yard and house. In fact, all those interviewed in the two fly-in communities would backyard dump and burn. This research supports the findings of Bharadwaj and her colleagues [26] that many households in Indigenous remote communities used backyard dumping and burn sites.

A high volume of plastics, tires, e-waste and other hazardous materials was found in the household and institutional waste streams in GH and WASS. Figure 5 shows an image of smoldering waste tires at an open dump. One of the community members commented on the negative impacts of open burning on community health: "When we burn our garbage, we do it to get it out of sight, but, there are many chemicals that get released which are not good for our health when inhaled." Burning waste releases contaminants into the air, water and soil, as well as the food chain to bio magnify and bioconcentrate in the local wildlife and plants that they consume as sustenance hunters and fishers [26, 54, 55].

The burning of toxic wastes, including e-waste and vehicles, releases toxic pollutants (including heavy metals), are detrimental to the health of humans, wildlife and to the environment [56], particularly at the low temperatures without pollution control equipment [57]. Whenever plastic materials are subjected to open-air burning, dangerous chemicals such as sulphur dioxide (SO_2), polyaromatic hydrocarbons (PAHs), dioxins, furans and heavy metals, as well as particulates (soot and solid ash residues) are released into the environment [16]. A study found that the burning of e-waste in open air increased the emission of dioxins and furans by up to 100 times higher compared to emissions from household waste [57]. Other studies have found dioxins in soil, air and ash correlated with emissions from burning waste materials [33, 58].

In GH and WASS, open air burning of garbage took place close to forested areas, creating a high risk of starting a forest fire. A youth volunteer fire fighter from WASS talked about fighting a forest fire adjacent to the dump and caused by burning at the dump: "Last summer, we had a big forest fire around the garbage dump. I think somebody set something on fire and the sparks from the burning caused an inferno. It was terrible, the fire almost spread to houses close to the dump. It took us a long time to put out the fire."

Actual forest fire incidents from open air burning of waste materials and near misses occur regularly in GH and WASS, according to youth and elders in the communities and place the community at high risk to fire from burning waste.

Government Neglect and Regulatory Limitations. The federal government, through Indigenous and Northern Affairs Canada (INAC), is in charge of waste disposal on reserves. Clearly, the government is not meeting its responsibilities [59]. The *Indian Act* is the federal law that regulates activities concerning First Nation's peoples [60]. Under the *Indian Act*, the regulations related to waste disposal on reserves is the *Indian Reserves Waste Disposal Regulation CRC c.960* which fails to provide required guidelines on waste collection and recycling. Although some Indigenous communities have passed additional bylaws on waste disposal, limited enforcement occurs under the *Indian Act*. A community member acknowledged the issues related to off-reserve contractors who were dumping mining slag and toxic waste in GH waste dumpsite without any environmental enforcement by the federal government. These enforcement limitations and inadequacy of regulatory standards rationalize the need for the review of

FIGURE 5
Smoldering waste tires, batteries and other hazardous waste in Wasagamack First Nation waste dump

relevant *on-reserve* waste management policies and regulations in consultation with communities and relevant stakeholders including contractors. Waste management on reserves and its enforcement is inferior compared to off reserve management and enforcement [59].

Reserves provide a black hole for toxic waste, stewarded products and recyclables. The amount of toxic waste, which includes valuable metals and recyclable products, is growing in GH and WASS, with few waste management options to deal with these wastes in a fly-in community. Healthcare wastes, such as syringes, leftover drugs, wound dressings, etc., are visible in the garbage dumps and yards of GH and WASS. The nursing station in each community has processes and facilities to collect and store biohazards (especially sharps) at the health center but did not offer programs to take back needles from homes. With these communities having some of the highest rates of diabetes in Canada and the world, many people use syringes several times a day to manage their diabetes with insulin, which after a single use becomes waste.

Healthcare waste presents both physical risks from waste sharps and the transmission of disease through exposure to pathogens [4, 61]. Exposure would increase the risk of contacting life-threatening diseases such as hepatitis, which is linked to liver-related diseases, and human immune deficiency virus (HIV), which destroys the human immune system [4]. Hepatitis is more infectious than HIV, as wastes and sharps can infect for a period up to seven days, which places much of the community at risk [62-68]. Severe Acute Respiratory Syndrome (SARS) is another potential terminal disease associated with improper health care waste management [69].

In both communities, at least two to three end of life vehicles were in the yards of most homes but also in woods and near surface water. Figures 6, 7 and 8 shows how cars are piling up in many locations. These cars add up to ten thousand in GH according to a community member there: "We have counted close to ten thousand abandoned vehicles in our community. We have tried numerous times to get something done about it but nobody seems to be interested. I think we need a crusher and hauling truck to get rid of these junks through the winter roads. It is really causing a lot of nuisance here and there… Everywhere you go, there are junk cars."

People expressed concerns about cars presenting many hazards. These communities lack playground equipment and so children creatively use the windshields as slides and ramps, even when broken. See a video that demonstrates the dangers of children having cars as their only playgrounds https://www.youtube.com/watch?v=pGXWRXcO8xI. A community member showed concern about the potential impacts of junk cars on children and livelihoods in the communities: "Kids play everywhere and they can be injured while playing around the junk areas. Oils, chemicals in batteries and other harmful materials can leak out of these vehicles and contaminate our waters or even harm our fisheries."

The poverty of people on these isolated reserves results in general preference for antiquated cars as means of transportation. Old vehicles that cannot be affordably certified as safe to allow licensing to drive on provincial roads are bought cheaply and driven up on winter ice roads with a temporary 24-hour license. These cars typically are not fixable, particularly as remote community lack any diagnostic equipment to fix electronically complex cars. One community member explains how the bad gravel roads contribute to the short life span of these junk cars: "When you bring vehicles into the communities, they end up as junk in no time because the roads are bad and we don't have trained technicians to repair

FIGURE 6
Poor road conditions in Island Lake shorten the lifespans of private vehicles

FIGURE 7
Derelict vehicles covered in snow in Garden Hill First Nation

FIGURE 8
Open dump at Garden Hill First Nation poses threat to health and environment

our faulty vehicles. We have to pull our vehicles out of the mud all the time, because the roads are not drivable especially during the spring break up."

With junk cars, that are unsafe, sent up north rather than being recycled and safely disposed of, communities will require support by producer responsibility organizations (PROs) to depollute, collect and transport toxic components of end of life vehicles on reserves, including batteries, mercury switches, electronic components and oil filters. However, PROS are not prepared to pay for the cost of shipping which is the major barrier.

Part 2: Assessing how present waste disposal siting and operations measure up to regulatory standards and guidelines

Garbage dumpsites in Garden Hill (GH) and Wasagamack

[WASS] were compared to Manitoba's regulation for siting waste dumps and the CCME guidelines for contaminant levels. Regarding siting waste dumpsites GH and WASS broke all the *Waste Disposal Ground Regulations MR150/91* under the *Manitoba Environment Act 1991*. Table 1 shows how guidelines were surpassed for the waste dumpsites in both GH and WASS. The regulation requires waste sites be located at least 1000 m from surface water but the garbage dump at GH is less than 100 m uphill from a creek and the WASS garbage dump is less than 200 m from a pond. Drinking water is jeopardized by the siting of dumps adjacent to a stream or pond that flows into surface water, where the water treatment plant gets its water. As well, the requirements for a 100m buffer from waste site to public roads is not met: the only access road to the gravel pit, golf course and the winter road to Red Sucker Lake First Nation runs right through the middle of the waste site, in GH. Thus, people for work at the gravel pit go through the waste site at least four times a day. Although burning is not allowed by the *Waste Disposal Ground Regulations MR150/91* and *Indian Reserve Waste Disposal Regulation CRC c.960*, burning of waste occurs every day to make up for the lack of any protocols to cover waste or cover material such as soil, to reduce vermin, including mice, rats and large brown bears, which are a daily sighting at dumps. The waste dumps in both communities were open to the public at all times without any fence to restrict access. Humans and wild animals roamed freely around the garbage dumps and were directly exposed to garbage hazards and pollutants, which were not covered over by fill to reduce exposure. Clearly fencing requirements are not met but neither are covering and leachate collection requirements met.

Are the dumpsites contaminated above guidelines for health and environment? Laboratory analysis of stratified composite soil samples from the dumpsites for arsenic, lead, chromium, zinc and copper typically exceeded CCME soil environmental guidelines, including industrial guidelines. CCME guidelines are in place to protect health and the environment. All samples taken at the waste sites were elevated compared to the levels in background samples. For example, chromium levels at waste-sites in both communities, exceeded the parkland, residential, commercial and industrial guidelines for all dumpsite samples. An analysis of arsenic, lead, cadmium and zinc and copper in the soil found higher levels than for background levels in all cases and typically exceeded CCME either parkland, residential, commercial and industrial guidelines for soil.

Figure 9 shows that levels of lead contamination in the waste site were very high for both communities, exceeding the parkland and residential standard for soil in both GH and WASS and also the commercial standard in WASS. Figure 10 shows the levels of chromium were very high, exceeding the parkland, residential, commercial and industrial guidelines for all samples in both communities and one sample was 30

TABLE 1
Guideline for siting and operation of waste dumpsite applied to main waste dump at Garden Hill First Nation and Wasagamack First Nation

Manitoba Waste Disposal Ground Regulation, MR 150/91	Garden Hill First Nation	Wasagamack First Nation
1) At least 1000 meters (m) from surface water	Proximity to nearby creek located less than 100 m downhill with runoff from the waste dumpsite, based on slope, ending up in the surface water less than 500 m downhill.	Pond located less than 200 m downhill with runoff from the landfill, based on slope, ending up in the water
2) At least 100 m from any public road or railway, excepts the access road to the waste disposal ground	The public road passes through the waste dumpsite that is the only thoroughfare in Garden Hill First Nation to gravel pit and winter road to Red Sucker Lake First Nation.	Public road less than 100 m away from the waste dump site
3) At least 400 m from any dwelling existing at the time the waste disposal ground is established.	Old and new waste dumpsite located right beside a gas station and dwellings	Old and new waste dumpsites located close to industrial sites and adjacent residents.
4) Fencing of not less than 1.8 m in height	No fencing or any barrier at the waste dump site to prevent public access	Fencing at the waste dumpsite is dilapidated allowing unrestricted access by human and wildlife
5) No burning especially close to forested areas	Burning of waste took place on a regular basis and close to tree lines	Burning of waste took place on a regular basis and close to tree lines
6) Covering of not less than 15 cm in thickness and leachate collection	No covering and leachate collection at the waste dumpsite	No cover and leachate collection at the waste dumpsite

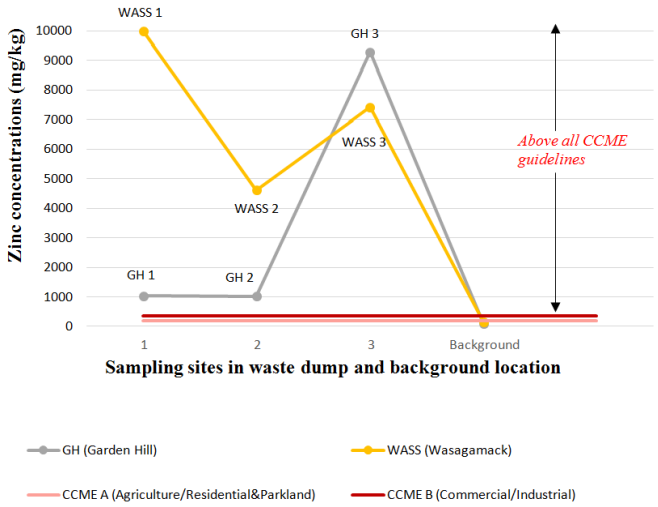

FIGURE 9
Zinc levels at Garden Hill and Wasagamack First Nation soil at waste sites and background location

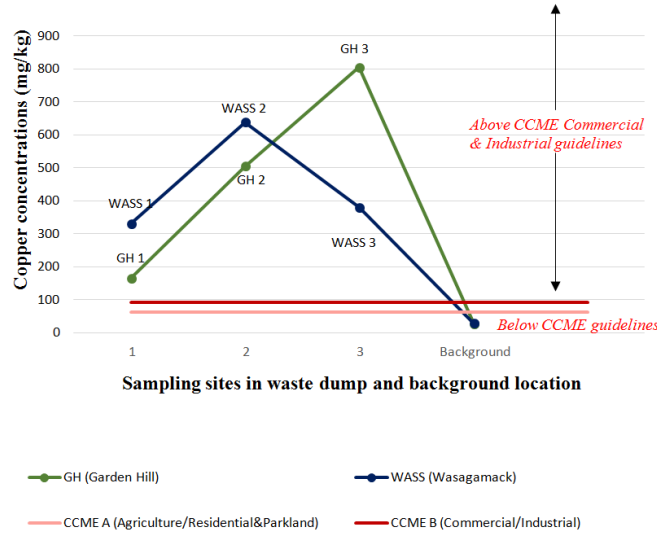

FIGURE 10
Copper levels in Garden Hill (CH) and Wasagamack (WASS) First Nations' soil at waste sites

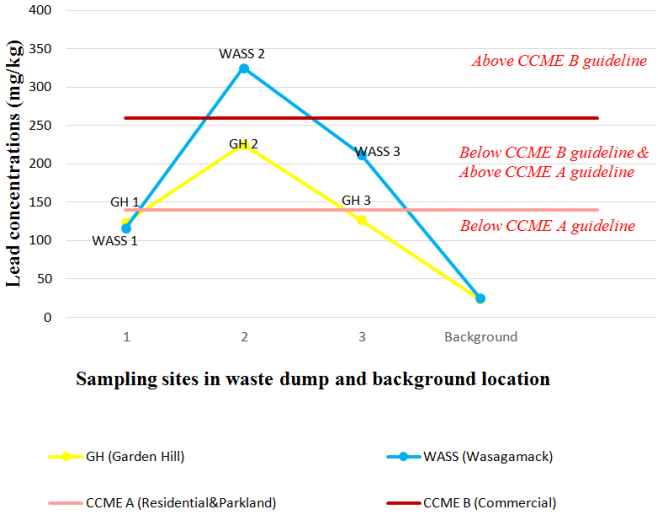

FIGURE 11
Lead levels in Garden Hill First Nation (GH) and Wasagamack First Nation (WASS) soil waste sites

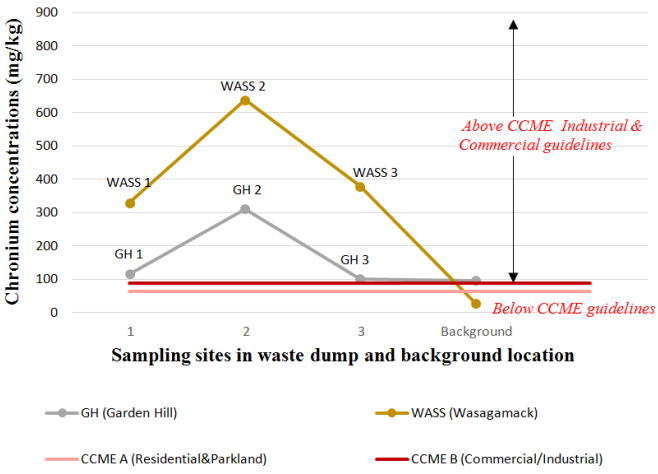

FIGURE 12
Chromium levels at Garden Hill and Wasagamack First Nations' soil at waste sites and background location

times background levels. Figure 11 shows arsenic levels exceeded parkland, residential, commercial and industrial guidelines for all WASS samples and for one sample from GH with two samples being 100 times background levels. Figure 12 shows zinc levels exceeded parkland, residential, commercial and industrial guidelines, surpassing the background level for all samples by 1000 times. Figure 13 shows all dumpsite samples in both communities exceeded parkland, residential, commercial and industrial guidelines and surpassed the background level by more than 1000 times for copper levels in both communities.

Since open burning of waste is commonly done nearby to households in GH and WASS, there are significant risks of toxic exposure to humans. Toxic metals emissions from waste sites increase the risk of cancer, birth defects and are known to harm the human respiratory and immune systems [70, 71]. The risk of human exposure to toxic materials is proportional to the distance human habitation to the burning areas [72, 73] and the distance of the dump to houses was approximately 800 m in GH and about 1500 m in WASS. For the backyard burning, the close proximity to human habitation increases the risk of exposure to toxic contaminants. Also, concentrating the waste to burn at the dumpsites poses a hazard due to more waste being burned in this location with the lack of any pollution control equipment or smokestacks to disperse the toxic contaminants or leachate collection.

Table 2 shows that total coliform and *E. coli* are elevated downstream from the waste sites in both communities at levels that exceed guidelines for drinking water, recreation water and Manitoba effluent discharge. This finding shows runoff from waste sites is occurring and negatively impacting water quality. *E. coli* is a pathogenic microbe that makes this water

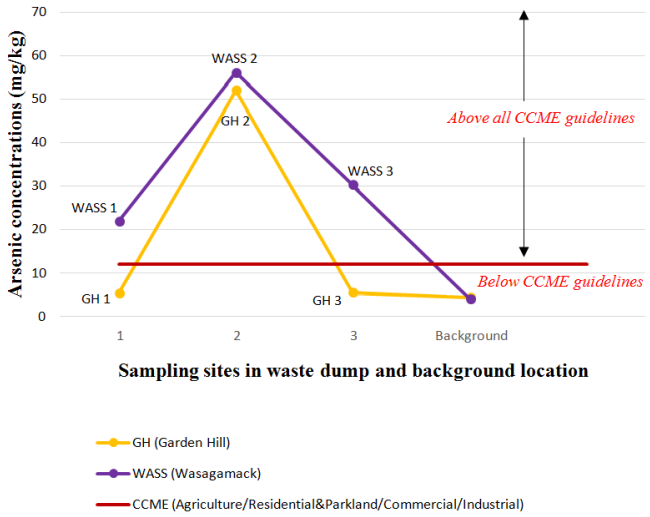

FIGURE 13
Arsenic levels in Garden Hill and Wasagamack First Nations soil at waste sites

TABLE 2
Summary of microbial parameters in water samples from nearby surface water

Samples	Sampling location	E. coli (MPN/100ml) *	Total Coliform (MPN/100ml)
GH water	nearby creek downhill at the waste site	411	>2420
WASS water	nearby creek (less than 200m) downhill waste site	1900	>2420
	Guidelines		
Health Canada (drinking water)		0	0
Health Canada (recreation water) for one-time samples.		≤ 400	N/A
Manitoba effluent discharge (MSW, 2011)		200	200

*MPN: stands for most probable number

unsafe to drink or swim in at any level above zero due to its high risk to health [74-76]. The downstream water is potentially contaminated from people dumping their sewage at the dump as many houses are not connected to a sewer system. As well, fecal matter comes from diapers disposed of at the site. The unrestricted public access to the sites and close proximity of the sites to water features exposes community members to pathogenic microbial contaminations and infectious disease [77]

CONCLUSION

The widespread contamination from the improper siting of waste sites and lack of waste management programs in Indigenous communities denotes environmental injustice in the rich, developed country of Canada. Garden Hill (GH) and Wasagamack (WASS), like most Indigenous communities in Canada, are underdeveloped, lacking resources and infrastructure, without sanitary landfills, waste trucks or paid waste workers, which results in contamination and higher risk from waste.

Waste toxicity has changed but not waste management in remote Indigenous communities. Burning and dumping in community members' backyards and the waste sites was acceptable for organic waste in a traditional society that wasted nothing. The waste management programs practiced in these Indigenous communities today are centuries old but can no longer safeguard environment and health with modernity's toxic products and the increased density of populations. These practices are, in fact, highly dangerous with modernity's throwaway plastic, metal and toxic products. Consumption has changed over time towards a higher volume of waste and also more toxic and non-biodegradable products in these Indigenous communities without practices of waste management keeping up. The high volume of modern plastic, haz-

ardous and disposable products result in significant health, safety and environmental risks in Indigenous communities. Community members want programs and funding to ensure waste management is safe. Without funding, community agencies including schools, businesses and health centers, can device methods to collect toxics and recyclables for safe storage but not ship them. However, funding and programming must be made available to ship toxic and recyclable materials to recycling centers or hazardous waste sites as flying out or shipping on winter roads curtails a large price and requires capacity building of waste managers.

Solid waste management in Indigenous communities is similar or worse than in developing countries according to this study and other studies of First Nations [2, 26, 33]. Although most developed places have evolved waste management to involve safe disposal in a sanitary landfill, as well as recycling, many Indigenous communities in Canada and other marginalized countries around the world are far behind with neither curbside pickup nor sanitary landfill [2, 26, 33, 78]. Clearly, the risk from waste and toxic products being everywhere, exposing children, youth and adults to physical injuries, infections from sharps and hazardous materials, is unacceptable. Therefore, solid waste management collection in GH and WASS needs to be considered a mandatory service and basic human right requiring urgent attention to safeguard community health. The status quo of the community waste dumpsite both in GH and WASS is high risk, breaking all the *Waste Disposal Ground Regulations MR150/91*. The waste dump in both communities contaminates water and land, which risks human, wildlife and ecosystem health. High levels of contaminants, such as lead, arsenic, copper, zinc and chromium in soil surpass CCME parkland, residential, commercial or industrial guidelines at the waste sites as well as resulting in high levels of *E. coli* in water. Funds must be made available for the construction and maintenance of a well-engineered landfill that meets environmental standards. The siting of this waste dump must be carefully done away from water, housing and public roads.

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