Solid Waste Management Practices in Two Northern Manitoba First Nations Communities: Community Perspectives on the Issues and Solutions

by

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ABSTRACT

For many First Nations in Northern Manitoba, solid waste management remains a serious, albeit under-researched, problem. A case study of solid waste management was undertaken in Garden Hill and Wasagamack First Nations, two remote fly-in communities in northern Manitoba. Solid waste management practices were investigated through interviews, participatory documentary video and laboratory analysis. Findings indicated that poor funding, absence of any recycling programs and lack of waste collection services contributed to indiscriminate burning and disposal in public places. Laboratory analyses revealed that soil samples from the dumpsites had arsenic, chromium, lead, zinc and copper above CCME guidelines. These elevated levels of toxic metals are of significant concern as the dumps are both nearby to water bodies, and have no restrictions, such as fence, to prevent public access. Appropriate funding for solid waste programs, including waste collection and disposal facilities, recycling and training programs are highly recommended to safeguard community health.

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GLOSSARY OF TERMS

Aboriginal is a term used to refer to **indigenous or native** people of Canada. Aboriginal peoples in Canada include First Nations (Indians), Metis and Inuit peoples, as stated in section 35 of the Canadian Constitution Act of 1982 (Simeone, 2001).

Band is a community of First Nations people for whom land has been set aside by the Crown (Aboriginal Affairs and Northern Development Canada [AANDC], 2012).

Band council is the governing or administrative body of a band.

Community refers to First Nation's community unless otherwise stated. Literally, a community refers to "a group of people with diverse characteristics who are linked by social ties, share common perspectives, and engage in joint action in geographical locations or settings" (MacQueen et al., 2001, p. 1936).

E-wastes include electronic appliances such as computers, televisions, mobile phones, refrigerators etc. and other electric powered equipment which are no longer functional (Terada, 2012).

End-of-life vehicle (ELV) is a vehicle that is no longer functional, or useful to its lawful owner, and is to be discarded as waste (Simic, 2014). ELVs include abandoned cars, trucks and heavy duty equipment.

First Nation(s) is the term used in Canada to describe aboriginal Indians, either status or non-status (AANDC, 2014).

Landfills are defined as "discrete area of land or an excavation that receives household waste, and which is not a land application unit, surface impoundment, injection well, or waste pile" (Pichtel, 2014, p. 283).

Leachates are liquids that flow through waste materials in a landfill or garbage dump. It is a combination of the moisture that is held naturally by the waste material and the natural precipitation (e.g. rainfall) that comes in contact with the waste material (Pichtel, 2014).

Minister is a person who is a member of the government's cabinet, usually appointed by the prime minister to head a government department. AANDC is the Canadian federal government department involved with matters concerning aboriginal peoples in Canada.

Open Burning is the indiscriminate burning of waste, on open land or in burn boxes, with minimal or no control of the burning processes (Lemieux et al., 2000).

Open dumps are illegal dumpsites of any size or containing any kind of waste material. Open dumping results in the release of toxins into the environment, harbor disease vectors such as rodents and insects, and exposes people to physical injuries from waste sharps (Ogwueleka, 2009).

Remote community is a community that is geographically isolated or rural.

Reserves are villages or settlements whose legal title lies with the Crown, but set aside for the benefit of a group of First Nations peoples. Most First Nations reserves in Canada are remote.

Off-reserves are communities located outside the boundaries of First Nations reserves (AANDC, 2012)

Surface Water are open water features including lake, wetland, marine, bay, spring, pond, marsh, creek, stream, river, estuary etc.

Waste (or garbage) is "any material, non-hazardous or hazardous, that has no further use, and which is managed at recycling, processing, or disposal sites" (Environment Canada, 2013a).

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CHAPTER 1: INTRODUCTION

Poor sanitation and unsafe disposal of solid wastes threaten the well-being of humans living in poor, remote and marginalized communities across the globe, including First Nations (FN) communities in Canada (Owusu, 2010; Zagozewski et al., 2011). Improper disposal of municipal solid waste pollutes the air, water and land resources, and therefore threatens the wellbeing of people, animals and plant species, as well as water. As safe and potable drinking water becomes widely scarce, environmental contaminations attributed to poor sanitation and improper disposal of wastes render water sources unhealthy for people in many areas of both developing and developed countries across the world (Ritter et al., 2002; Reddy & Nandini, 2011; Haribhau, 2012).

Developed countries are typically more progressive than developing counties in terms of human development indices and environmental performances; however, living conditions in indigenous communities in some developed countries are often on par with developing countries (Cooke et al., 2007; Wong, 2012). The poor living conditions are evident in the cases of many indigenous communities, such as First Nations (FN) (status and non-status Indians), Métis and Inuit in Canada (Cooke et al., 2004; Palmater, 2012); Aboriginal and Torres Strait Islander peoples in Australia (Tilbury, 2015; Doyle, 2015); the Māori people in New Zealand (Sibley et al., 2011); and American Indians and Alaska Natives in the United States (Gone & Trimble, 2012). Thus, the overall picture of conditions in developed countries may not totally reflect local realities among indigenous populations. Research (e.g., Altman, 2007; Adelson, 2005; Cooke et al., 2004; Cooke et al., 2007; Sibley et al., 2011; and Doyle, 2015) indicates the poor wellbeing of indigenous peoples in some developed countries and the existence of significant gaps in wellbeing between indigenous and non-indigenous populations. Canada, for instance, is one of the top economies of the world - ranked 8th out of 187 countries on the Human Development Index[1], and 24th amongst 178 countries around the world on the Environmental Performance Index[2]. However, FN communities across the length and breadth of the country still suffer abysmal standard of living and environmental conditions in comparison to the average Canadian standards (Wong, 2012).

The total number of FN communities (also known as reserves) that span the provinces and territories of Canada are 617, according to the Aboriginal Affairs and Northern Development Canada [AANDC] (AANDC, 2015). Sixty-three (63) of these FN communities are located in the Canadian province of Manitoba (AANDC, 2014). About half of the 63 FN communities are located in the far northern part of Manitoba (AANDC, 2014). Approximately one-third of the 63 FN, accounting for more than 50% of Manitoba's on-reserve FN population, are inaccessible by all-weather road (AANDC, 2014). FN peoples in Manitoba speak Cree, Ojibway, Ojibway-Cree, Dakota and Dene dialects, and of the total Manitoba FN population (148, 455) recorded around midyear of 2014, about 59% lived on-reserve (AANDC, 2014). Manitoba is the second largest of all the provinces in Canada, after Ontario, in terms of on-reserve FN population (AANDC, 2014). In Manitoba, the majority of FN people were reported by the media as facing nationwide highest level of racial discrimination off-reserve (MacLean's, 2015) and living under *third world* conditions on-reserves, like other FN communities elsewhere in Canada (CTV News, 2013; CBC, 2015).

Garden Hill First Nation (GH hereafter) and Wasagamack First Nation (WASS hereafter), two remote fly-in communities located north-east of the Canadian province of Manitoba, are among these groups of marginalized and disadvantaged FN communities. For GH and WASS and

[1] United Nations Development Program [UNDP]. (2015). Human Development Index. Available at http://hdr.undp.org/en/countries
[2] Yale University (2015). Environmental Performance Index. Available at http://epi.yale.edu/

many other FN communities in Northern Manitoba, solid waste management among other environmental challenges remains a serious, albeit under-researched, problem. Improper solid waste management raises serious public health and environmental concerns (Owusu, 2010). Of major concern are the practices of unsafe solid waste disposal, such as open dumping and open-air burning, which has been found to have severe health and environmental consequences (Ogwueleka, 2009). Children and adults are exposed to physical injuries and infections from sharps and other hazardous materials present in the waste stream (Rushton, 2003).

Most solid waste disposal sites on FN reserves are unregulated waste dumpsites rather than sanitary landfills meeting government standards (Bharadwaj et al., 2006). Thus, the public health and environmental safety and social acceptability of solid waste management practices in many FN communities across Canada becomes a serious issue (Bharadwaj et al., 2006). Many of the designated waste disposal facilities located on FN reserves, including GH and WASS, have turned into potential hazardous areas filled with all sorts of waste materials (Bharadwaj et al., 2006) with limited or no options for waste diversion and pollution prevention. Therefore, the need to research waste related problems and solutions from community perspectives becomes imperative, in order to protect environmental and community health.

1.1 Problem Statement

Over the years, the consumption patterns of people in GH and WASS have shifted dynamics from mainly organic materials obtained from the land to industrial products such as consumer and disposable goods. The consumption of these industrial products often result in the generation of inorganic waste materials - such as packaging materials, shopping bags, electronic wastes etc. - that require special procedures to dispose of in environmentally sound manners. Recycling programs or local waste collection facilities are nonexistent in GH and WASS.

Therefore, many people in GH and WASS communities resort to unsafe and unsustainable waste disposal practices, such as open dumping and burning, which pose serious threats to the land, air and water sources.

1.2 Objectives

The specific objectives of this research are to: 1) examine the present and historical solid waste management practices in GH and WASS, 2) Analyze the potential environmental and human health impacts of solid waste disposal practices in GH and WASS, 3) Identify barriers and recommend ways to improve solid waste management in GH and WASS.

1.3 Rationale

During the inception of this study, when the researcher first visited the northern Manitoba communities of GH and WASS in the spring of 2014, the first impressions were those of slums in the midst of a picturesque wilderness. Waste materials of different kinds and forms including hazardous waste, such as e-waste and end-of-life vehicles, were seen littering the communities. Collection, treatment and disposal of waste were unorganized and created environmental and aesthetic problems. Not only does the problem of open dumping of waste materials in the communities reflected a deficiency in waste collection and disposal, open dumping also came across as resource wastefulness. In reference to what seems to be the most comprehensive research on solid waste management in FN communities, Zagozewksi et al. considers solid waste management issues in FN communities to be *critical*:

> Where and how to begin waste management programs is a critical issue for First Nations communities with limited resources. The fundamental problem that faces the management of virtually all solid wastes is they comprise complex mixtures. Comprehensive solid waste management incorporates a diverse range of activities including reduction, recycling, segregation (separation), modification, treatment and disposal -- all of which have varying levels of sophistication (Zagozewksi et al., 2011, p. 17).

Hence, there existed the urgent need to engage perspectives within the communities and identify strategies to move the communities towards more effective and efficient solid waste management regimes. Doing this will avail the communities several opportunities to conserve resources, create community empowerment, safeguard livelihoods and protect community health and the environment.

1.4 Significance

Research on solid waste management in Manitoba has been limited largely to urban areas and no research has focused on remote areas especially FN communities without all-weather road access. Therefore, the outcomes of this study give accounts of solid waste management issues in remote FN communities and contribute to existing knowledge on impacts of unsafe disposal of solid wastes on the environment. The outcomes provide background information for decision makers, including government, community organizations and other stakeholders, to make informed decisions when making plans for more efficient and effective solid waste management systems in remote fly-in FN communities.

1.5 Study Area

This research study focuses on two communities (GH and WASS) of the four fly-in FN communities on the Island Lake shore of north-east Manitoba (see Figure 1.1). GH (53.8833^0N, 94.8489^0W) is located approximately 610 kilometres northeast of the provincial capital and major urban city of Winnipeg and 310 kilometres southeast by air from Thompson (Four Arrows Regional Health Authority [FARHA], 2014a). WASS (53.8917^0N, 94.9514^0W) is on the western shore of Island Lake, which is about 607 kilometres northeast of the city of Winnipeg and 281 kilometres southeast of Thompson (FARHA, 2014b). GH and WASS cover land masses of 82.48

and 80.63 square kilometres respectively (Statistics Canada, 2012a; Statistics Canada 2012b). The majority of people living in GH and WASS communities are socially identified as FN people.

GH and WASS are adhesion to Treaty 5 of 1909 and governed upon according to the provisions of Section 35 of the Canadian Constitution Act under a legislation known as the *Indian Act*. The four communities on the Island Lake shore (including GH and WASS) were originally one community until they were broken up by the government and moved from the Old Post to four areas in the Island Lake area. Majority of FN people in GH and WASS speak the Ojibway-Cree dialect (FARHA, 2014a, b; Statistics Canada, 2012a, b). Both GH and WASS communities are rich in traditional history and cultural values that strongly uphold respect for the land.

As of 2011, there were 545 private residences in GH (Statistics Canada, 2012a) and 274 private residences in WASS (Statistics Canada, 2012b). In the same year, population census data estimated the total number of people in GH at 2776 (Statistics Canada, 2012a) and WASS at 1411 (Statistics Canada, 2012b). Previous population data reveal that the populations in these communities are growing at a very rapid rate (Statistics Canada 2012a, Statistics Canada 2012b). The settlement patterns in GH and WASS communities can be described as scattered, rural and geographically isolated. Because GH and WASS communities lack all-weather road networks, accesses are only possible all year round by planes or alternatively by ice-roads in the winter. Ice roads provide access to GH and WASS for about 90 to 120 days between January and April depending on prevailing weather conditions. Ice-roads serve as routes to transport commodities into GH and WASS communities from urban centres at cheaper rates compared with the high costs of air freight (Zahariuk, 2013). The majority of people living in GH and WASS communities are poor and also face the challenges of unsafe drinking water, poor sanitation, overcrowding in homes, food insecurity along with other socio-economic problems which are dominant features of

FN communities in Canada (Kant et al., 2013; Zahariuk, 2013). Table 1.1 below presents a profile of GH and WASS.

1.6 Thesis Lay-out

This study consists of 6 chapters, Chapter 1 is the introductory aspect which includes an overview of the research, the objectives, rationale, significance and a brief description of the study area. Chapter 2 consists of review of literatures relevant to the research context. Chapter 3 describes the approaches to the study. Chapter 4 and 5 contains information on the findings of the research. Chapter 6 provides the concluding statements and recommendations followed by the references and appendix sections

Table 1.1: Profile of Garden Hill First Nation (GH) and Wasagamack First Nation (WASS)

	Garden Hill First Nation	**Wasagamack First Nation**
Population	2776[1]	1411[1]
Land area (km^2)	82.48[1]	80.63[1]
Population density	33.7 per km^2 [1]	17.5 per km^2 [1]
Households	545[1]	274[1]
Employment rate	24.1% of labour force had jobs[2]	28.2% of labour force had jobs[2]
Percentage adult literacy (2005)	18.7% completed secondary school[2]	24% completed secondary school[2.4]
Educational facilities	Day care, elementary and high school	Day care, elementary and high school
Water Supply	Island Lake is the source of water supply. Water supply is channeled to a water treatment plant, chlorinated and distributed to houses through pipes. Some houses had no running water, thus, water is trucked to cisterns[3]	Island Lake is the source of water supply. Water supply is channeled to a water treatment plant, chlorinated and distributed to houses through pipes. Some houses had their water trucked to cisterns, others had no water service[3]
Sewage disposal	Slop-pails, pit latrines, septic systems and batch reactor[3]	Slop-pails, pit latrines and septic systems[3]
Health services	Nursing station	Nursing station
Transportation	Air, Water or Winter roads.	Water or Winter roads (no airport)
Sources:[1] Statistics Canada, 2012a, b; [2] Statistics Canada, 2007a, b, [3] FARHA, 2014a, b [4] Zahariuk, 2013		

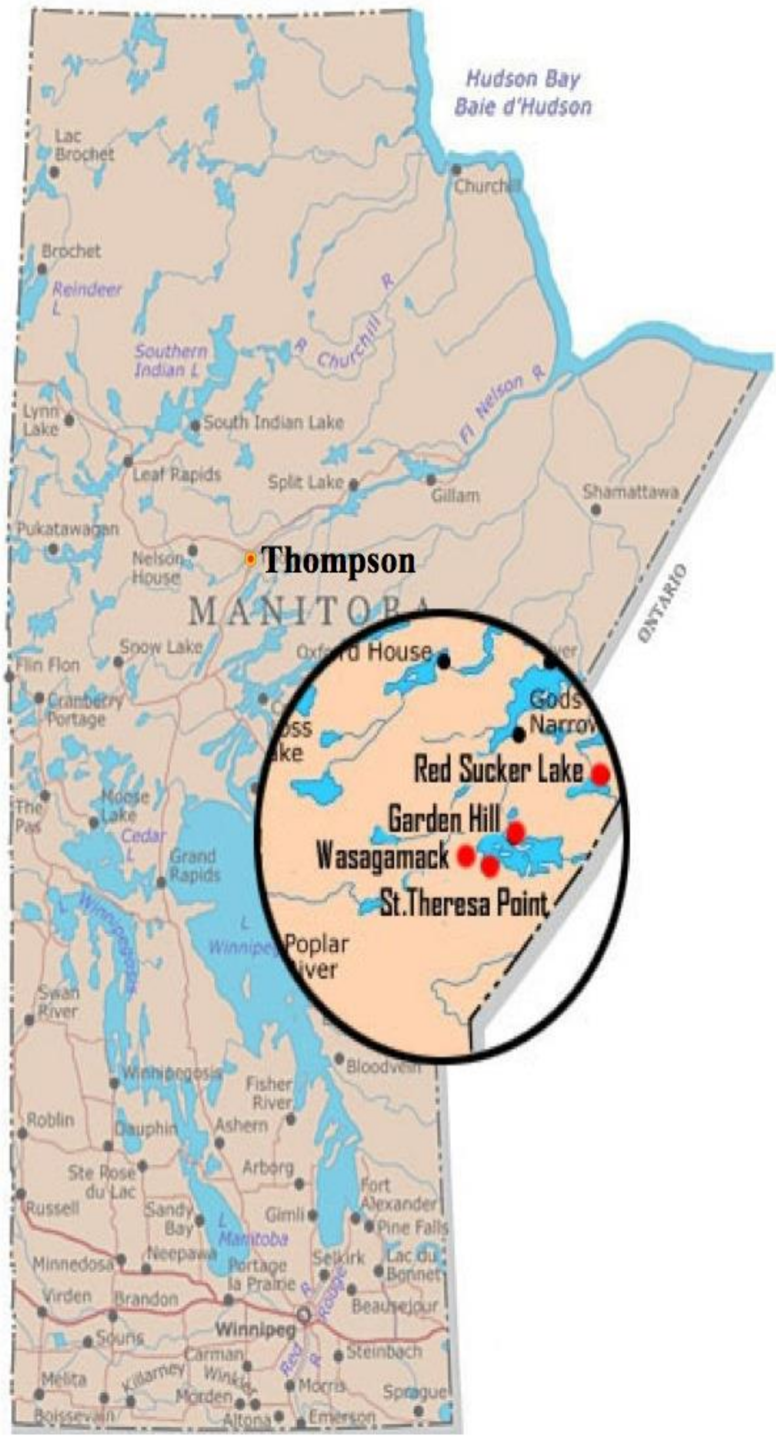

Figure 1.1: Map of Manitoba showing the location of Garden Hill First Nation and Wasagamack First Nation on the Island Lake shore (Source: FARHA, 2013c)

CHAPTER 2: LITERATURE REVIEW

This section provides a general overview on solid wastes, integrated solid waste management and solid waste management options including source reduction, recycling, composting, landfilling and incineration. Topics covered are related to management practices for different kinds of solid wastes.

2.1 Solid Wastes

Solid wastes are commonly referred to as trash, garbage or refuse. According to the European Union (EU) landfill directive, Municipal Solid Wastes (MSW) includes “waste from households, as well as other wastes which, because of its nature or composition, is similar to waste from households” (European Union, 1999). Many jurisdictions handle hazardous wastes, medical wastes, end-of-life vehicles, contaminated soil and agricultural wastes as separate waste streams. In Canada, however, non-hazardous wastes materials from households, commercial and institutional activities, construction and demolition works, are classified as MSW (Environment Canada, 2006)

As discussed by Kipperberg (2007), virtually all human activities produce waste materials that are unsanitary or unsafe. Traditionally, waste materials have been set on fire, buried or disposed on land, and sometimes dumped in the lakes, rivers, oceans and other water bodies (Kipperberg, 2007). Today, these traditional methods of waste management threaten environmental quality and human health due to changes in waste composition (Kipperberg, 2007). However, as raw materials become increasingly scarce and expensive to extract, secondary benefits may be derived from waste materials to conserve resources and prevent environmental pollution (Kipperberg, 2007).

By virtue of responsibilities, solid waste management in Canada is shared among the various levels of government, i.e. federal, provincial (or territorial) and local governments. Solid waste management encompasses series of activities, which begin from the point of waste generation to final disposal. For Canada, Statistics indicated that about 25 million tonnes of MSW were collected for disposal in 2010, of which about 8.06 million tonnes were diverted from landfills through recycling and composting (Statistics Canada, 2010). In First Nations (FN) communities across Canada, however, there have been widespread public concerns about waste-related problems over the past few decades (Bharadwaj et al., 2006). Waste dumpsites on most FN reserves have been reported as lacking environmental protection measures such as cover materials, engineered liners or a leachate collection system and are usually sited without geological considerations (Zagozewski et al., 2011). Open air burning of all kinds of waste materials, ranging from plastic to kitchen wastes, are typically done by residents of these communities on a routine basis to reduce the volume of the waste stockpiles with the prospect that *out of sight is out of mind* (Bharadwaj et al., 2006). However, burning of waste materials results in release of noxious substances, such as dioxin and furan, into the environment and may lead to severe human health complications including respiratory disorders and cancer (Scheinberg et al., 2010).

More so, leachates from waste disposal sites are sources of ground and surface water contamination that can severely impact drinking water quality (Christensen et al., 1998). Research has linked exposure to water pollution from waste disposal sites to human health problems, such as developmental deformities, birth defects and cancer (Kjeldsen et al., 2002). Sayville and Rockford in the United States are well-documented cases where groundwater contaminations were attributed to leachate from waste disposal sites (Shuster, 1976a; Shuster, 1976b). Physical and chemical analysis of soil, groundwater and ash samples collected from waste disposal sites in selected FN communities in Canada yielded results for parameters that exceed the Canadian Drinking Water Quality (CDWQ) and Canadian Council of Ministers of the Environment's (CCME) soil quality guidelines (Bharadwaj et al., 2005 cited in Zagozewski et al., 2011). Hence, in order to prevent environmental pollution and human health problems from poor waste handling, appropriate systems to manage solid waste materials on FN reserves emerge as matters of high importance.

2.2 Solid Waste Management in Canadian First Nations communities

In 2009, a report presented on *Land Management and Environmental Protection on Reserves* by the Office of the Auditor General of Canada (OAG) recognizes environmentally unsafe waste disposal on FN reserves as a significant risk which should be treated as a matter of urgency (OAG, 2009). Efforts by some FN communities to implement sound waste management programs are constrained by factors such as remoteness, funding, jurisdiction and staffing (Bharadwaj et al, 2006). Band offices, tribal councils and Aboriginal organizations are faced with the challenge of balancing infrastructural needs to provide vital community services including medical care, housing, schools, sanitation and water supply against solid waste management (Bharadwaj et al., 2006).

At a governance level, AANDC[3] holds the charter of responsibilities for FN matters, including fiduciaries and land management (Bharadwaj et al., 2008). Amidst other specialized duties, the minister of AANDC takes charge of waste disposal in FN communities, in pursuant to the *Indian Reserve Waste Disposal Regulations* (Bharadwaj et al., 2008). In some instances, the duties of setting up solid waste disposal facilities have been transferred to some FN communities

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[3] Aboriginal Affairs and Northern Development Canada (AANDC) - formerly Indian and Northern Affairs Canada (INAC) – is one of 34 Canadian federal government ministries.

under special agreements contained in the *FN land management regime* (Bharadwaj et al., 2008). For other communities outside the FN land management regime, the *Indian Reserve Waste Disposal Regulations* requires any individual, community or organization who intends to set up waste disposal facilities on FN reserves to obtain permit from AANDC (Department of Justice, 2015). But AANDC has issued only a few permits across Canada and does not adequately conduct environmental monitoring of licensed waste disposal facilities on reserves (Bharadwaj et al., 2008). AANDC also does not provide incentives to encourage such activities (Bharadwaj et al., 2008; OAG, 2009).

In what seems to be one of the few research studies on waste management in FN, Zagozewksi et al. (2011) discovered that community members, especially the elders, are concerned about the human and environmental health implications of poor waste disposal. However, these communities do not possess the required technical and financial capabilities to deal with the problems (Zagozewksi et al., 2011). Funding provided by AANDC is neither sufficient for basic infrastructure nor for provision of environmentally sound waste management facilities (Bharadwaj et al., 2008). This problem of inadequate funding amongst other constraints leaves a huge disparity between environmental protection regulations on FN reserves and off-reserve communities (OAG, 2009). Hence, waste disposal is not regulated in most FN communities across Canada and the impacts on domestic water supply and air quality are ignored (OAG, 2009). In order to address the numerous problems posed by solid waste management practices, many jurisdictions now focus on the implementation of solid waste management initiatives such as Integrated Solid Waste Management, which normally includes waste diversion (recycling and composting) and waste reduction programs and policies (Kipperberg, 2007).

2.3 The Concept of Integrated Solid Waste Management

Municipal solid waste management (MSWM) presents great environmental challenges with regards to the composition, generation, collection, transportation, treatment and safe disposal of waste materials (Nordone et al., 1999; Liamsanguan & Gheewala, 2008; Assamoi & Lawryshyn, 2012). Lehmann (2011) maintained that MSWM is a key aspect in the development of a sustainable city. Thus, the failure of municipalities to manage wastes materials properly leads to serious environmental problems and may sometimes be attributed to lack of financial resources (Guerrero et al., 2013) and absence of well-articulated regulatory regimes (Pokhrel and Viraraghavan, 2005).

In the past decades, a consumption-driven urban society have emerged due to growth of industries and population rises, leading to a rapid increase in the quantities of waste generation especially inorganic wastes which are toxic to human health and the environment. Therefore, conventional solid waste management practices, which focus solely on waste disposal, are no longer appropriate to handle the ever-growing waste stream (Zaman & Lehmann, 2011; United Nations, 2011; Menikpura et. al, 2013). Alternative solid waste management innovations, e.g. re-use, recycling and composting, have been introduced to address the environmental problems associated with MSWM and to maximize economic and social benefits from the waste management sector (Nordone et al., 1999; Rabl & Spadaro, 2002).

Public health concern, environmental protection, resource management, scarcity of land for the construction of waste disposal facilities, institutional issues and public awareness are some of the major drivers of the modern day waste management practices, according to Wilson (2007). In Canada, for instance, better environmental awareness and public outcry on the health and environmental implications of waste incinerations, especially in off-reserve communities, led to the development of more environmental friendly options (Sawell et. al, 1996). Notwithstanding, recycling as one of many environmental friendly options for solid waste management in Canada have not been extended to many FN communities where wastes are poorly managed (Zagozewski et al., 2011). The potential negative impact of poorly managed waste materials on public health and the environment on FN reserves have been scientifically observed by Bharadwaj and her colleagues (Bharadwaj et al., 2008). In similar contexts, Hoornweg & Bhada-Tata (2012) found that implementing safe waste disposal strategies are lesser burdens for communities than to ameliorate the impacts of poorly managed waste.

Generally speaking, MSW are heterogeneous mixtures of different kinds of materials, such as papers, metals, food scraps, glass, electronics etc., comprising of inorganic and organic wastes with different degrees of management sophistication. On this note, Liamsanguan and Gheewala (2008) argued that there is no such waste treatment technology that can exclusively handle all waste fractions. Hence, a mix of various waste treatment technologies and management strategies (such as waste reduction, reuse, recycling, composting, incineration and landfilling) were adapted for an effective and efficient MSWM (McDougall et al., 2008; Menikpura et al. 2013). This new waste management approach that combines various waste management strategies is termed Integrated Solid Waste Management (ISWM).

According to Clift et al., (2000), ISWM ensures that waste materials are managed in the most environmentally appropriate manner and that valuable resources and/or energy are recovered. Koroneos and Nanaki (2012) claimed that an advancement of the ISWM system could trigger improved technologies, policies and programs required to manage MSW in an environmentally sound manner. In a publication titled *Shanghai Manual – A Guide for Sustainable Urban Development in the 21st Century*, the United Nations affirmed the importance of ISWM: “ISWM appreciates local needs and conditions and then selecting and combining the most appropriate waste management activities for those condition" (United Nations, 2011. p7). In addition, Strange (2002) agreed that decisions making in ISWM are based on best options for waste management and cost transparency.

ISWM generally appreciates the need for collaboration between stakeholders (see Figure 2.1) based on the 4R (reduce, recovery, re-use, and recycle) principles that makes up the waste management hierarchy (Hoornweg and Bhada-Tata, 2012). The 4R options were developed to fundamentally complement traditional waste disposal options (i.e. landfilling and incineration), since the later provide more socially and environmentally acceptable functions. It is however noteworthy that final disposal cannot be totally neglected in any solid waste management scheme, because it is difficult, if not impossible, to achieve waste diversion (e.g. recycling) without waste residues. As opposed to waste disposal options, there are many environmental benefits derived from waste diversion which include, but are not limited to, pollution prevention, greenhouse gas emission reduction, energy savings and resources conservation (Mohareb et al., 2004).

2.3.1 Integrated solid waste management framework.

According to Hoornweg & Bhada-Tata (2012), a comprehensive ISWM plan should include: a well-defined objective and follow-up policies, community profiling, waste composition and generation inventories, identification of waste management options for different waste streams, evaluation of applicable options with consideration of technical, environmental, social and economic issues, monitoring and control measures, institutional and regulatory framework, fiscal assessment, source of funding, public consultation and implementation plan.

The ISWM model (see Figure 2.1), established by *WASTE advisers on urban environment and development*, defined the involvement of stakeholders in waste management, an enabling environment and the ISWM elements as a three dimensional system that needs to be considered when developing a solid waste management plan (Guerrero et al, 2013). The major stakeholders identified in previous literatures include: government at all levels (Shekdar, 2009), community members, community-based organizations [CBOs], non-governmental organizations [NGOs] (van de Klunder & Anschütz, 2001; Sujauddin et al., 2008), donor agencies, private sectors, service users (van de Klunder & Anschütz, 2001), government ministries of health and environment (Geng et al., 2009) as well as waste management related businesses (Tai et al., 2011).

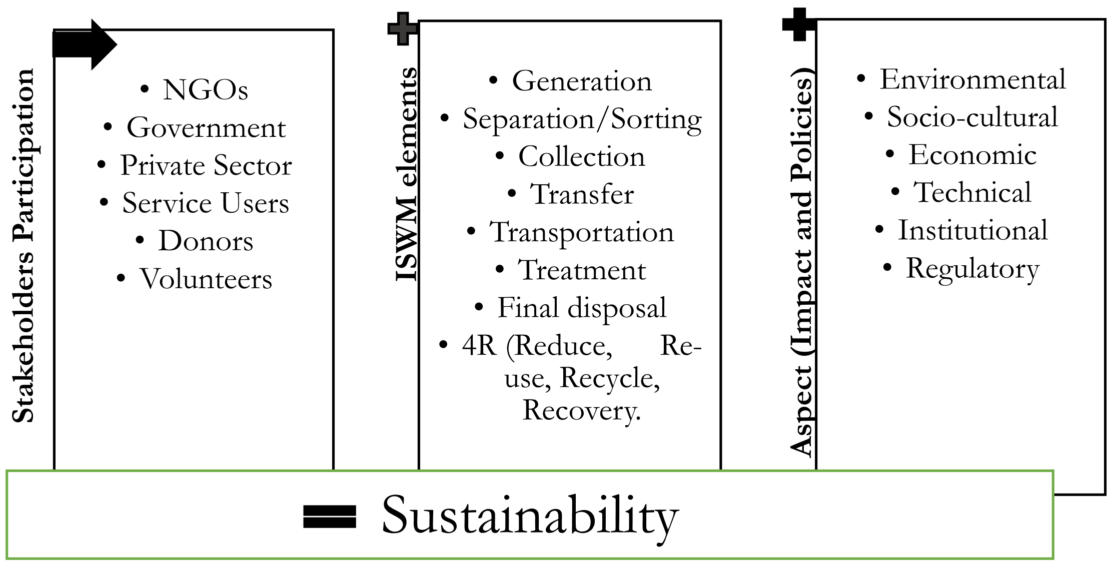

Figure 2.1: The Integrated Solid Waste Management (ISWM) Model (Adapted from van de Klunder & Anschütz, 2001).

The ISWM model as illustrated in Figure 2.1 above is based on the principles of equity, effectiveness, efficiency and sustainability (van de Klunder & Anschütz, 2001). Studies related to the elements of ISWM presented in Figure 2.1 have identified size of household, education and household income as some of the factors that influence waste generation (Sajjaudin et al., 2008). According to Ekere et al., (2009), waste utilization and separation behavior are a factor of gender, peer pressure, land area and house location. Pay as you throw policies (Scheinberg, 2011), as well as the support provided to the private sector and house owners, impact public participation in waste separation activities (Guerrero et al, 2013). Collection and transportation of waste materials are greatly affected by the bin collection system (Hazra & Goel, 2009), infrastructural problems (Moghadam et al., 2009) including bad roads, and inadequate waste haulage equipment (Henry et al. 2006). To this end, Sharholy et al. (2008) suggested an organized informal sector and incentives for small businesses interest in waste reduction, recycling and collection as ways to promote economically reasonable waste collection systems.

As for waste treatment, technical-know-how or skilled man-power capacities is an essential factor (Chung and Lo, 2008). In a study of waste disposal practices in third world communities, Tadessa et al., (2008) found that the availability of waste disposal facilities affected waste disposal decisions by households. In addition, limited supply of waste bins/bags and long distance to the available ones increased the chances of open dumping of wastes (Tadessa et al., 2008). Safe disposal of waste in a sanitary landfill is also hindered by inadequate funds and legislations (Pokhrel and Viraraghavan, 2005). To this end, Asese et al (2009) suggested that a proper legislative framework would foster the development of environmentally safe waste management systems such as ISWM, whilst other scholars have indicated the potential of negative effects from poor solid waste management legislation (Seng et al., 2010; Mrryan and Hamdi, 2006).

At the level of waste diversion and reduction, Gonzalez-Torre and Adenso-Diaz (2005) emphasized that improved community interest in recycling is a result of social influences and regulatory factors. In order to further increase recycling rates, however, there is often the needs to improve marketability and professionalism in the recycling industry, according to Minghua and his colleagues (2009). Furthermore, authors have identified that funding and incentive for recycling initiatives (Henry et al., 2006), encouraging the informal sector (Matete and Trois, 2008) and the establishment of drop-off and buy-back are imperative to foster an increase in recycling rates (Guerrero et al, 2013). In addition to stakeholders' involvement and the elements of waste management, ISWM is also influenced by a third pillar, which are the aspects that facilitate or hinder the performance of the overall system (van de Klunder & Anschütz, 2001). These aspects are grouped into environmental, socio-cultural, economical, technical, institutional and regulatory considerations (van de Klunder & Anschütz, 2001).

2.3.2 ISWM and conventional waste management: a comparison.

In the United Nation's *Declaration for Better Cities and Better Life*, many risks associated with conventional waste management (e.g. open dumping) were identified (United Nations, 2011). In addition, the opportunities that emerged from the ISWM as a paradigm shift were explicitly stated (United Nations, 2011). The United Nations further highlighted that conventional waste management is characterized by a long list of problems including but not limited to:

1) low efficiency, negative health and environmental impacts, and social problems due to lack of comprehensive approach to waste management,
2) waste workers are exposed to various health hazard due to lack of safety measures,
3) child labour is prevalent as witnessed in most low-income societies,
4) consumption driven lifestyle encourages the waste of valuable resources from increased waste generation, community and private sector roles in the overall waste management process is undermined and no attention is paid to improve the system to accommodate newer waste stream and conserve resources (United Nations, 2011).

In contrast, ISWM was presented as a combination of different waste management options with an effective pollution prevention plan. The advantages of ISWM over conventional waste management are that ISWM:

1) minimizes environmental impacts, improves cost efficiency and social acceptability,

2) facilitates recycling of useful resources,

3) encourages stakeholder participation and introduction of innovative technologies,

4) accommodates plans for emerging waste stream such as e-waste, construction and demolition wastes and end-of-life vehicles,

5) enhances the safety of waste workers (United Nations, 2011).

Table 2.1: Possible risk to health and communities from poor waste disposal

Who is at risk?	**Health and environmental impacts**
• Waste workers • Informal waste pickers • Children • Community members • Animals	*Health impacts to waste workers* Human Immunodeficiency Virus, hepatitis, pulmonary disease, tetanus, respiratory problems, skin and stomach infections. *Risk to communities* • Risk to children who live in houses close to waste dump sites exposed to toxics. • People living close to where waste is burned are exposed to air pollution which causes respiratory problems • Leachates from dumpsites could contaminate municipal domestic water sources • Waste dumps serve as breeding ground for disease vectors such as mosquitoes and rats • Dangerous animals could be attracted to waste dump sites. • Indiscriminate waste dumping can cause blockage of drainage which leads to flooding and spread of diseases
Source: United Nations (2011)	

2.4 Management Options for Solid Wastes

There are many options available for solid waste management including but not limited to waste diversion (recycling and composting) and disposal. Since it is impossible to completely divert waste materials through recycling, the remainder of the solid wastes materials generated from human activities ends up being subjected to disposal options, which include landfilling and thermal treatment. Maclaren (1995) and Statistic Canada (2005) have identified landfilling as the most common and cheapest method of waste disposal in Canada. The popularity of landfilling as a waste disposal option in Canada have been attributed to the availability of a large area of unexploited land (Bonam, 2009). In the year 2000, for instance, 95% of the total solid wastes transported to waste management facilities across Canada were landfilled, while the remaining were burned at incineration facilities (Statistics Canada, 2005).

Waste collection, treatment and disposal are the responsibilities of municipal or local governments, while provincial governments set regulations (Environment Canada, 2013a). Since each province operates as an independent unit, regulations often vary among the provinces. Hence, the need for collaboration on certain environmental and resource management issues led to the establishment of Canadian Council of Ministers of Environment (CCME), comprised of representatives from all Canadian provinces and territories (Sawell et al., 1996).

In general, the CCME sets regulatory guidelines and standards for environmental monitoring and also policies that can be adopted into provincial policies (Sawell et al., 1996). Examples are the waste diversion target and the national packaging protocol, as indicated by Sawell et al., (1996). On the other hand, the federal government controls the movement of hazardous wastes and the release of toxic materials into the environment and related activities on federal lands, including FN reserves (Environment Canada, 2013b). Because there are no waste diversion programs in most FN reserves, a large fraction of the waste generated ends up being disposed in open dumps and/or burned in open places (Bharadwaj et al., 2006). The various options for solid waste management in Canada are highlighted in the subsections below.

2.4.1 Waste diversion and reduction.

"The best way to change our garbage treatment is to change our garbage; first, by reducing the amount that goes into the landfill." (Rathje, 1991, p. 130).

Modern waste management strategies, such as ISWM, functions in accordance to the waste management hierarchy, also known as pollution prevention hierarchy. The waste management hierarchy emerged from Ontario Pollution Probe (an environmental NGO) literature in the 1970s (Hoornweg & Bhada-Tata, 2012). The waste management hierarchy started as a 3Rs (reduce; reuse; recycle) conceptual framework. Recently, a fourth ‘R’ was added to introduce material and energy ‘recovery’ into the scheme. The 3R principles form the basis of many European waste management frameworks, which outlines the need to manage wastes differently based on sources and characteristics (Association of Municipalities of Ontario [AMO], 2005).

Grosse (2010) considered waste diversion as a shift in paradigm from unsafe waste disposal, such as open dumping, towards sustainable waste management options that reduce material wastage and minimize the impact of economic growth on natural resources. For example, the EU Landfill directives targeted a 35% reduction, from the 1995 value, of organic wastes disposed at landfill by the year 2020 (Wilson, 2007). Furthermore, Lehmann (2010) noted that landfill ban on certain waste streams have been implemented in several jurisdictions and the ‘zero waste’ concept has continued to garner momentum. Lehmann also contended that the ‘zero waste’ concept shifted focus from the general conception of waste as unavoidable and valueless to a waste prevention and resource recovery driven approach (Lehmann, 2010).

Bonam (2009) in *Understanding Waste from a Climate Change Perspective* considered the waste hierarchy as a tool for waste diversion. The waste hierarchy takes cognizance of the various environmental, economic and social issues connected with waste management by way of prevention and minimization of waste materials. One of the management tools that the United Nations identified as a solution to the numerous problems associated with waste treatment and disposal is the adoption of the waste hierarchy (United Nations, 2011). The benefits of waste reduction as the most favorable option in the waste hierarchy is two-fold. On the one hand, pollution associated with the manufacturing processes is reduced (Hoornweg & Bhada-Tata, 2012). On the other hand, the emission associated with the processes that 'diverted waste' would have undergone is eliminated (Hoornweg & Bhada-Tata, 2012).

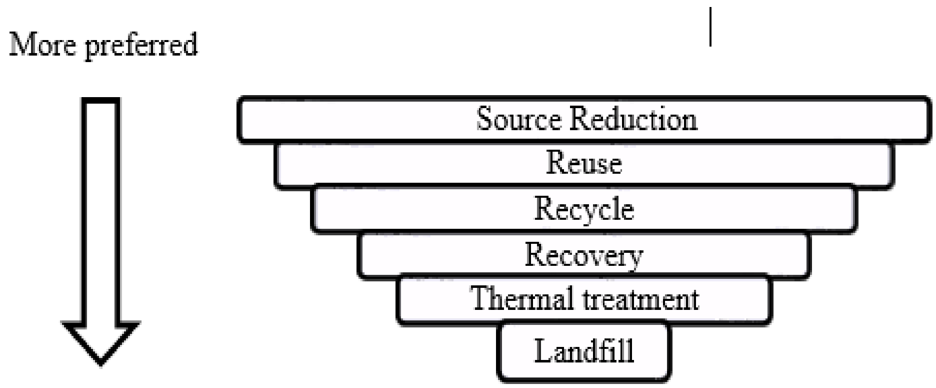

Figure 2.2: Waste Hierarchy (Adapted from Bonam, 2009)

Solid waste management plans have a higher chance of success, in terms of waste diversion from landfill and incinerators, if such plans follow the order of the waste hierarchy (AMO, 2005). For instance, the waste hierarchy incorporated into Nova Scotia's Solid Waste Resource Management Strategy distinguished the province as the only jurisdiction in Canada that achieved the 50% national waste diversion target set by the CCME over a period of ten years, between 1990 and 2000 (GPI Atlantic, 2004). However, Nova Scotia's approaches towards waste diversion came with cost implications, as an additional operating and amortized costs of $23.9 million were expended, according to an estimate by GPI Atlantic (2004).

Nevertheless, the benefits of implementing the waste hierarchy were proven to outweigh the costs (GPI Atlantic, 2004). For instance, the Nova Scotia waste diversion strategy provided Nova Scotia's residents with a net saving of about $31.2 million to $167.7 million (GPI Atlantic, 2004). Recycling and composting were the key approaches adopted by Nova Scotia to reach this milestone (GPI Atlantic, 2004), albeit through combined efforts of different stakeholders including municipalities, industries and the citizens (Government of Nova Scotia, 1995; Nova Scotia Environment, n.d.). Despite the waste diversion milestone achieved by Nova Scotia, GPI Atlantic (2004) noted that waste policy initiatives such as the Extended Producers Responsibility (EPR), hazardous waste monitoring, as well as source reduction may have led to a higher rate of waste reduction and diversion (GPI Atlantic, 2004).

2.4.2 Source reduction.

Waste generation occurs throughout the entire life cycle of a product, from raw material extraction to the manufacture of final consumer product (Bonam, 2009). Thus, source reduction is a waste minimization and pollution prevention strategy that entails design for environment (DfE) in the manufacturing context or an environmentally preferable purchasing (such as bulk purchase, material reuse- reusing bags for grocery shopping and buying refillables and products with less packaging) (KAB, 2013). Source reduction strives to reduce the amount and toxicity of material reaching the waste stream (USEPA, 2013b). According to the National Recycling Coalition (NRC) *Measurement Standards and Reporting Guidelines*, Source reduction is defined as:

> any action that avoids the creation of waste by reducing at the source, including redesigning of products or packaging so that less material is used; making voluntary or imposed behavioral changes in the use of materials; or increasing durability or reusability of materials (NRC, 1989, p.18).

Source reduction influences the overall waste (or pollution prevention) hierarchy, in the sense that the amounts of waste materials to be recycled, combusted or landfilled are reduced (Bonam, 2009). Many programs and policies aimed at source reduction have been implemented in various jurisdictions. Examples of these programs and policies include: EPR or take back systems in Europe and Japan, pay-as-you-throw or user fee, Nova Scotia’s solid waste resource management strategy, and polluter pay principle among others. The polluter pay principle, for instance, places the responsibility of waste management on the generator of the waste. Hence, as polluters recognized the fact that certain waste materials are quite expensive to manage, several means to reduce waste output were devised. In contrast to source reduction, however, it is noteworthy that waste reduction is a broader term that encompasses all waste management strategies (source reduction, composting, recycling) to reduce waste that end up at waste disposal facilities.

2.4.3 Recycling.

"The main challenge of a modern industrial country is to break the historic link between waste creation and wealth creation." (Strange, 2002, p.1)

Recycling as an integrated waste management option is a key element of sustainable development because recycling is critical in the era of resources scarcity (Strange, 2002). The diversion of waste materials through recycling reduces air pollution (dioxin and furan from incinerators), water pollution (leachates from landfilling) and greenhouse gas emission. In Canada, landfills account for about 25% of methane emission (Environment Canada, 2006). The anaerobic breakdown of organic materials in landfill results in the release of certain type of saturated gases, known as landfill gas (LFG), into the environment (Ackerman, 2000). This highly saturated gas comprises of about 60% methane (CH_4) and 40% carbon dioxide (CO_2), other constituents are also present in trace amounts (Spokas et al., 2006). Of the constituents of LFG, methane is the greatest environmental concern, because methane has a much higher global warming potential than carbon dioxide (Forster et al., 2007). However, methane can be captured from landfill and combusted to produce energy for electric power generation (Hoornweg & Bhada-Tata, 2012). The energy production processes produce carbon dioxide, which happens to be a gas of lesser global warming potential when compared with methane (Spokas et al., 2006).

In contrast to the environmental consequences of waste disposal at landfills, recycling reduces greenhouse gas emission from waste materials disposal e.g. paper products by 7.37 MTCE/tonne (metric tons of carbon equivalent per tonne of material) and aluminum by 3.9 MTCE/tonne (Mohareb et. al., 2004). Recycling is also of great economic benefits and creates green jobs. The Canadian Association of Recycling Industry (CARI) noted that the recycling industry in Canada creates more jobs and generates more revenue than other division of the waste industry (CARI, 2014). Recycling embodies a series of activities that convert valuable resources, which may have ended up as waste, into recyclables for raw materials production. Therefore, energy efficiency is increased and the need to further exploit resources for raw material is reduced.

For instance, in the case of metal recycling, the energy efficiency is two to ten times more than extracting metals from ores (United Nations Environmental Programme [UNEP], 2011). In fact, the extraction of metals from ores accounts for about 7% of the world's energy consumption and a major contributor to climate change due to emission of greenhouse gases during the primary production processes (UNEP, 2011). Recycling metals compared to primary production saves a lot of energy, e.g. steel recycling saves up to 75% energy while aluminum and metals of the platinum group saves about 90% (UNEP, 2011). About 16 to 18 million tonnes of scrap metals is recycled in Canada each year (CARI, 2014). The occupations involved in metal recycling activities include haulers, dismantlers, scrap dealers, shredder plant operators etc. (UNEP, 2011). Effective recycling requires sorting of waste materials into fractions (Zickiene et al., 2005). Cleaner and high quality recyclable materials are recovered (upcycling) if waste materials are subjected to sorting at source (Zickiene et al., 2005). However, technologies, such as the Material Recovery Facility (MRF), enhances the potentials for recovery of recyclable materials, which were not sorted at source. In general, recycling improves the availability of resources whilst reducing the overall environmental impact of material production (UNEP, 2011).

In Canada, access to recycling facilities has continued to increase significantly. Between 2000 and 2004, about 75% of the wastes generated in Canada were successfully diverted from landfills and incinerator through recycling (Babooram and Wang, 2007). In a 2007 bulletin, *Environstat,* Statistics Canada noted that people's attitude towards recycling in Canada is neither affected by income nor level of education (Babooram and Wang, 2007). Rather, access to recycling facilities is the major determinant of willingness to participate in recycling programs (Babooram and Wang, 2007). In a book on the subject of solid waste management, Strange (2002) discussed the reasons recycling activities often fail in the market: low cost-benefit; government failure-inadequate policies, which encourages unsustainable practices-; and institutional failure. On the little downside, Bonam (2009) noted that since recycling does not provide 100% waste diversion, environmental impacts are inevitable, because the residue from recycling - though of minor fraction of the initial waste - ends up in landfill.

2.4.4 Composting and anaerobic digestion.

As discussed in section 2.4.3 above, organic waste at landfill contributes to greenhouse gas emissions. Food and yard waste are the major constituents of organic materials in MSW streams (Otten, 2001). Organic wastes make up about 45% of MSW and responsible for leachate and landfill gas emission (Otten, 2001). Thus, diverting organic waste from landfill, by way of composting or anaerobic digestion, will significantly reduce the environmental problems associated with leachates and landfill gas emission (Otten, 2001). Swan (2002) defined the composting process as:

> The controlled biological decomposition and stabilization of organic substrate, under conditions that are predominantly aerobic and that allow the development of thermophilic

> temperatures as a result of biologically produced heat. It results in final product that has been sanitized and stabilized, is high in humic substances and can be beneficially applied to land, which is typically referred to compost (Swan et al, 2002. p73).

In simple terms, composting is the microbial breakdown of organic waste, such as food and yard waste, in the presence of air and moisture to produce compost (City of Winnipeg, 2014). Carbon dioxide, heat, ammonia and water vapours are released as by-products of composting (Otten, 2001; Füleky & Benede, 2010). In the composting process, microorganisms utilize organic matter as substrate thereby breaking organics down into smaller compounds (Gajalakshmi & Abassi, 2008). One of the problems associated with composting is that leachates and a negligible amount of methane is produced, however, such problems can be controlled by using the right proportion of feedstock, proper aeration and regular turning of compost piles (Elliot, 2008)

[Organic Waste + Oxygen + Microbial activities = Compost + Carbon dioxide + Water + Heat]

Overall, the rate of composting is dependent on availability of substrate and other conditions such as Carbon-Nitrogen (C/N) ratio, oxygen, pH, temperature, moisture content and electrical conductivity (Gajalakshmi & Abassi, 2008). Compost is used in organic farming, gardening, horticulture and landscaping, to enrich soil nutrient. As indicated by Mohareb et al. (2004), a 1985 study by Brunt and his colleague indicated that one tonne of organic MSW could produce between 0.3Mt and 0.5Mt of compost. The quality of compost varies with the design of composting facilities, source and proportion of feedstock, composting methods and duration of maturation (Hargreaves et al., 2008). MSW compost is usually characterized by low bulk density and high organic matter content (Soumare et al., 2003). Otten (2001) highlighted some advantages that composting:

1) reduces waste at source to decrease the amount to be sent to landfill;
2) reduces pollution and other environmental effects of landfilling organic waste;

3) increases the life span of a landfill;
4) results in an inert waste stream, which means less daily cover, equipment use and man-hour labour is reduced at landfill sites;
5) is cost competitive and requires little monetary investment, as it is one of the least expensive way of handling organic fraction of MSW;
6) serves as a useful technique in achieving waste diversion targets,
7) can be used in agriculture to improve soil nutrient and can be sold as fertilizer.

However, the use of compost on agricultural land is sometimes restricted due to the possibilities of metal contamination and elevated salt concentration, which can cause stunted growth in plants and destabilizes soil structure (Hargreaves et al., 2008). Nevertheless, metal contamination issues can be controlled by source separation and improved regulatory standards (Hargreaves et al., 2007).

Judging by the increase in the number of composting facilities over a few years, Bonam (2009) admitted that Canadians are more likely to accept a composting facility compared to incinerators (Bonam, 2009). In addition, Tuomela et al. (2010) have described the rate of demand for compost in Canada as significantly high. Enhanced public education and awareness as well as source separation of organic waste can enhance composting (Otten, 2001). Access to curbside collection point is also a key determinant of public participation in composting (Elliot, 2008). High participation rate in composting in Canadian provinces of Ontario, Prince Edward Island, Nova Scotia and New Brunswick were attributed to improved curbside collection (Elliot, 2008).

Unlike composting, anaerobic digestion takes place in the absence of oxygen and involves the decomposition of organic wastes in a closed vessel or digester (Mohareb et al., 2004; Otten, 2001). This process is widely used to produce electrical energy from methane (biogas), which is a by-product of anaerobic digestion (Bonam, 2009). Guelph, New Market and Toronto are some of the locations in Canada where electric powers are being generated from anaerobic digestion of organic waste (Mohareb et al., 2004). Other products of anaerobic digestion include a peat-like residue, which can be used as fertilizer (Mohareb et al., 2004). Anaerobic digestion with energy recovery measures can significantly reduce Canada's GHG emission foot-prints (Mohareb et al., 2004).

2.4.5 Thermal treatments.

Incineration, or established thermal treatment, is the controlled burning or combustion of waste materials at a very high temperature (in excess of about 1000^{o}C) to reduce the volume and generate energy in the form of heat and carbon dioxide (Pichtel, 2014). MSW, hazardous wastes, such as waste from healthcare facilities, and bio-solids are the waste streams currently being incinerated in Canada (CCME, 2007a). Incineration is capable of reducing waste volume by up to 80% (i.e. final volume is only about 20% of initial volume), generating energy at the same time (Mohareb et al, 2004). The waste residues produced during the combustion process take the form of fly ashes or bottom ashes. Whilst fly ashes are the light particles emitted in the form of smoke, bottom ashes are the non-combustible waste materials (e.g. metals, glass) that remain after the burning process. The level of pollutant in fly ashes and bottom ashes may be dependent on the material composition of the waste stream as well as the completeness of the combustion.

Incinerators emit less GHG (i.e. less contribution to climate change) and the ash residues can be used as cement or landfilled (Bonam, 2009). The volume of waste to be landfilled is reduced by incineration, pathogens and hazardous chemical are also eliminated in the process (CCME, 2007a). However, heavy metal quantity in the waste streams is unaffected but the nature and toxicity may undergo changes (Rabl & Sapadaro, 2002). The fact that the residual ashes generated after incineration are only a small fraction of the initial wastes before incineration makes residual ashes more convenient to dispose in a sanitary landfill, according to Rabl & Sapadaro (2002).

In Canada, there is a negative public perception about incineration due to the adverse environmental and health effect of emissions from incinerators (Mohareb et al., 2004). This perception may be long-lasting since pollution was the basis for the Ontario's ban on incinerators in 1992 and 1996 (Mohareb et al., 2004). Some of the negative aspects, which hinders the development of incineration as a waste treatment option in Canada, were outlined by Mohareb et al. (2004) as follows:

1) Incineration produces pollutants such as dioxin and furan, NO_x, carbon mono oxide, particulate matters, oxides of sulphur, Hydrogen halide and heavy metals.
2) Nitrous oxide (N_2O), a NO_x compound, contributes significantly to the GHG emission from high temperature incinerators.
3) One of the power generating incinerators, located in Hamilton, was shut down due to pollution.
4) Operating cost of MSW incineration is higher than conventional waste management options and is neither cost competitive with other waste treatment technologies.
5) In urban area where MSW incineration was said to be cost effective, the emission control system that must be installed to meet regulatory standards is quite expensive.

To address the negative environmental and public health effect of incineration, regulatory standards have been set at provincial and national levels (CCME, 1989). Rather than controlled thermal treatment as in incineration, open air burning of waste materials is the prevalent waste disposal practices on FN reserve across Canada (Bharadwaj et al., 2006). According to the Nunavut Environmental Guideline on burning and incineration of solid waste, Open burning is defined as

> the burning of waste where limited or no control of the combustion process can be exercised by the operator…on the ground or in burn boxes or burn barrel and often does not achieve the temperature or holding times needed for the complete combustion of the waste to occur. (Government of Nunavut, 2012. p9).

Uncontrolled conditions of the open burning processes result in the release of potentially harmful pollutant (such as dioxin and furan) in form of gases and ashes into the environment (air, water and land) (Bharadwaj et al., 2008). Forest fires result from uncontrolled burning due to the release of hot sparks and ember (Government of Nunavut, 2012). Organic wastes that are not completely burned attracts pest and other disease carrying organisms.

2.4.5.1 Dioxin and Furan

Polychlorinated dibenzo (*p*) dioxins and furans (PCDD/Fs) are by-product of incomplete chemical combustion of materials associated with chlorine. Dioxins and furans are noxious, persistent, travel long distance in the atmosphere, and bioaccumulate in the environment to a level that is harmful to humans (Falk et al., 1999; Health Canada, 2005; Humblet et al., 2010). Dioxin and furan are released unintentionally as a trace by-product of combustion processes in incinerators (CCME, 2007a). The potential for the formation of these compounds are increased by incomplete combustion of fuel; presence of chlorinated materials; presence of catalytic metals and carbon source (fly ash surfaces); as well as abnormally low temperature over a period of time during combustion (CCME, 2007a).

In Canada, large scale burning of solid wastes materials is one of the major sources of dioxin and furan release into the environment (Health Canada, 2005), other sources include burning of household waste especially plastics, production of ferrous metal and steel, burning of chemically treated wood, electrical power generation, fuel burning and home heating (Health Canada, 2005). Release of dioxin and furan into the environment on FN reserves have been attributed to open air burning of wastes (Bharadwaj et al., 2008). In terms of health effects, exposure to dioxin had been linked to chloracne (Saurat et al., 2011), cancer (Fingerhut et al., 1991; Consonni et al., 2008), diabetes (Michalek et al., 2008), and hormonal disease (Pavuk et al., 2003).

2.4.6 Landfill.

Historically, landfills were initiated to off-set the negative effects of conventional waste management practices such as open air-burning, open dumping and disposal in water bodies. Today, landfilling -- which involves burial of waste on land -- is a more convenient and relatively cheap alternative for waste disposal but is not free from environmental consequences. A sanitary landfill on the other hand is an engineered method of waste disposal together with environmental protection measures (UNEP, 2005). Sanitary landfilling involves compaction of waste, use of daily cover materials -- such as soil -- to eliminate environmental nuisances, bottom liners, and leachate collection systems, and in some cases, a landfill gas capture system (UNEP, 2005).

Anaerobic decomposition of organic waste disposed at landfill generates LFG and leachate (El-Fadel et al., 1997; Willumsen, 2001; Butt et al., 2008). LFG and leachates are of environmental concern because LFG poses a risk of explosion, odour and global warming effects (Rajaram et al., 2011), whilst leachates have been attributed to water pollution (Kjeldsen et. al, 2002). However, there is a great potential for electrical power generation from LFG, if appropriate measures are put in place to capture these gases (Rajaram et al., 2011).

As aforementioned, landfilling is the most common waste disposal technique in Canada, partly due to availability of large area of underdeveloped land. Whilst recycling and composting are fast becoming the primary methods of solid waste management in Canada, landfills are still very much in operation and still receive a substantial amount of solid wastes (Bonam, 2009). No matter the success rate of waste diversion programs, waste residues, which cannot undergo further treatment, are inevitable. Therefore, landfills cannot be avoided in the overall solid waste management processes (Strange, 2002; Bonam, 2009).

In disproportion with waste disposal in off-reserve communities in Canada, waste disposal sites on FN communities are open dumps rather than sanitary landfills (Bharadwaj et al., 2006). Open dumping involves the indiscriminate disposal of waste with total disregard of possible environmental impacts (Albanna, 2012). Joseph (2002) considered open dumps as a 'primitive stage of landfill development' yet remain the most common method of waste disposal in low income communities owing to their limited budget, lack of facilities and low technical-know-how. Whilst regulatory measures have been put in place to ensure safe disposal of waste across Canada, lack of financial resources and monitoring encourages the failure of regulations on FN reserves (Zagozewski et al., 2011). The practice of open dumping is marred with the release of noxious substances into the environment (Ogwueleka, 2009). Open dumps present serious environmental and public health danger due to release of leachate into surface and groundwater, insect and rodent infestation is also common (Joseph, 2002). Pierce and van Daele (2006) observed that wild animals (such as bears) often visited open dump sites to obtain highly nutritious food, which may pose danger to community safety.

2.4.6.1 Leachates.

Leachates from waste disposal sites are sources of ground and surface water contamination that can severely impact drinking water quality (Christensen et al., 1998; Ali and Young, 2014). Leachate is formed when soluble materials in a waste pile comes in contact with water from various sources, mostly precipitation and initial water content of the waste, or as a by-product of anaerobic decomposition of organic waste (El-Fidel et al., 1997; Renou et al., 2008). The composition of leachate is a reflection of the material content of the waste stream (Pichtel, 2014). Microbes such as bacteria, fungi and actinomycetes are actively present in leachates due to it organic matter content (Pichtel, 2014).

Once leachates flow to the bottom of a landfill, leachates either seeps through to the aquifer or is held in the vadose zone (El-Fadel et al., 1997). Depending on the geological formation of the underlying layers and the lack of systems to prevent the release of leachate into the environment, researchers agreed that leachates contaminate ground water at landfill sites (El-Fadel et al., 1997; Christensen et al., 2001; Renou et al., 2008). The volume of leachate is dependent, to a large extent, on the location of landfill and is a function of climatic conditions, presence of water, waste characteristics, as well as the nature of landfill surfaces and underlying soil (E-Fidel et al., 1997; Christensen et al., 2001). Factors that affect the chemical composition of leachates includes: the age of landfill cell, weather, and moisture content (Pichtel, 2014).

The physical and chemical parameters of environmental concern in leachate include pH, biochemical oxygen demand, total dissolved solid, total suspended solid, salinity and the presence of heavy metals (Pichtel, 2014). Thus, the removal of these parameters from leachates is essential prior to release into water channels (Renou et al., 2008). Toxicity testing of landfill leachates have revealed their potential threat to living organisms and the environment and the need to include several physical and chemical parameters in the analysis of pollutant level (Bernard et al., 1996; Bernard et al., 1997). Table 2.2 highlights the various environmental impacts associated with solid waste management options. Clearly, the leaching of toxins to groundwater is one of the negative impacts of landfilling.

Table 2.2: Environmental impact of solid waste management options

	Landfill	*Composting*	*Incineration*	*Recycling*
Air	Emissions of methane (CH_4) and carbon monoxide (CO) odours	Emissions of methane (CH_4) and carbon monoxide (CO) odours	Emissions of SO_2, NO_x, HCl, HF, NMVOC, CO, CO_2, N_2O, dioxins, furans, heavy metals (Zn, Pb, Cu, As)	Emissions of dust
Water	Leaching of salts, heavy metals, biodegradable and persistent organics to groundwater	N/a	Deposition of hazardous substances on surface water	Wastewater discharge
Soil	Accumulation of hazardous substances in soil	N/a	Landfilling of ashes and scrap	Landfilling of final residues
Landscape	Soil occupancy; restriction on other land uses	Soil occupancy; restriction on other land uses	Visual intrusion; restriction on other land uses	Visual intrusion
Ecosystems	Contamination and accumulation of toxic substances in the food chain	Contamination and accumulation of toxic substances in the food chain	Contamination and accumulation of toxic substances in the food chain	N/a
Urban areas	Exposure to hazardous substances	N/a	Exposure to hazardous substances	

Source: Hester & Harrison (2002, p. 8)[4] ©Reproduced with permission of The Royal Society of Chemistry

2.5 Solid Waste Management Legislation in Canada

In Canada, provincial governments are responsible for setting up regulations that govern environmentally sound and safe disposal of waste materials within their jurisdiction (Environment Canada, 2013a). However, municipalities or local governments are free to adopt waste management approaches that suit their constituencies. Private sector participation is common in most provinces because residents consider them more cost effective and efficient (Statistic Canada, 2005). Virtually all jurisdictions across Canada have adapted the waste diversion approach to control the amount of waste going into the landfill. Voluntary commitment programs, landfill ban, landfill taxes and government grants are some of many effective measures that have been utilized

[4] Hester, R. E., & Harrison, R. M. (Eds.). (2002). *Environmental and health impact of solid waste management activities* (Vol. 18). Royal Society of Chemistry. Page 8

to divert waste (Bonam, 2009). Table 2.3 below outlines the solid waste management related legislations across provinces and territories in Canada.

Table 2.3: Solid waste management related legislation across Canada

Province/ Territory	Legislation
Alberta	Environmental Protection and Enhancement Act
British Columbia	Waste Management Act, Environmental Management Act
Manitoba	The Waste Reduction and Prevention Act
New Brunswick	Clean Environment Act
Newfoundland	Waste Management Regulation (2003) under the Environmental Protection Act
Nova Scotia	Environment Act; Solid Waste Resource Management Regulations
Ontario	Waste Diversion Act; Environmental Assessment Act
Prince Edward Island	Environment Protection Act
Quebec	Environment Quality Act
Saskatchewan	Environmental Management and protection Act; The Municipal Refuse Management Regulation
North West Territory	Waste Reduction and Recovery Act
Nunavut	Environment Protection Act (Nunavut)
Yukon	Solid waste regulation under the Environment Act
Sources: Statistics Canada, 2005 and Hickey et al., 2010	

2.6 Waste Management and Human Behaviour

In the Newfoundland and Labrador Waste Strategy, the provincial Minister of Environment noted that while the government is responsible for making laws that governs waste management within their territories and implement appropriate strategies to manage waste, the success of any waste management policy lies in the hands of the people who will require a change of attitude and behaviour towards handling of waste (Government of Newfoundland and Labrador, 2002). Therefore, an effective waste management plan must consider the behaviours and attitudes of people within the affected areas (Valdivia, 2010). In order to study the best methods for waste diversion, Ferrara and Missios (2005) considered the relationships between recycling and human behaviour in households across Ontario, Canada and arrived at the following conclusions;

1. Charging user fee reduces waste and increases recycling but illegal dumping may occur from inability to pay user fee.
2. Increasing the number of garbage bag limit at curbside (i.e. free units) under the user fee program is counterproductive.
3. Collecting garbage weekly or routinely for recycling increase recycling of some materials such as aluminum and glass, but has negligible impacts on paper and plastic recycling.
4. Requiring compulsory recycling programs increase rate of recycling
5. Allowing limited number of bags at curbsides has negative impact on recycling for some materials especially plastics and toxic chemicals.
6. Curbside recycling increases the recycling rate of non-curb side materials such as toxic chemicals.
7. Recycling intensity is unaffected by level of education attained, with the exception of post-secondary degree which increase the recycling intensity of newspaper, tin containers and toxic chemicals.
8. As individual earnings increases, time becomes more valuable, thus recycling rate for materials like newspaper and toxic chemicals decreases.
9. Impact of household size and age of household head on recycling is negligible, and
10. Homeowners, as opposed to tenants, are strongly connected to their communities and pay attention to perceptions of other community members. Thus, they tend to recycle more.

Although the behavioural characteristics described by Ferrara and Missios (2005) do not correspond to all waste stream and policies, nevertheless, the key findings could inform decisions about possible reactions towards the implementation of waste management programs. Otten (2001), on the other hand, suggested that appropriate public education increases public participation in recycling. In fact, the high rate of organic waste diversion attained in Guelph, Ontario was attributed to compulsory source separation and public education (Otten, 2001)

2.7 Hazardous Wastes

Hazardous waste is any kind and form (solid, liquid, gaseous or sludge) of waste material, which as a result of its characteristic nature and quantity, has the potential to cause harm to human health and/or the environment, either alone or as a mix with other kinds of waste materials (LaGrega et al., 2010). Hence, hazardous wastes usually require a special disposal method to eliminate environmental and public health risks. Hazardous wastes are characterized by ignitability, corrosiveness, reactivity and toxicity (LaGrega et al., 2010). Hazardous wastes emanate from a wide range of sources such as residues from automobile repair operations, household appliances, manufacturing processing plants and healthcare facilities, or obsolete materials such as waste lubricants and pesticides. As a result of the dangerous properties of hazardous waste materials, proper handling of materials during recycling and disposal operations must be ensured.

In terms of hazardous waste regulation, Canada is a party to the United Nations and Organization for Economic Co-operation and Development (OECD) treaties on the management and control of transboundary movement of hazardous wastes (Environment Canada, 2013b). At the national level, according to Environment Canada (2013b), hazardous wastes are managed under the Canadian Environmental Protection Act of 1999 (CEPA 1999), which includes the following regulations;

1) Export and Import of Hazardous Waste and Hazardous Recyclable Material
2) Polychlorinated Biphenyls (PCB) Waste Export Regulations
3) Interprovincial movement of hazardous waste regulations.

4) Transportation of Dangerous Goods Act.

The municipal, provincial/territorial and federal government all play a role in hazardous waste management in Canada. Whilst the municipal governments are responsible for the various activities involved in hazardous waste management within their jurisdictions, provincial governments provide standards and play regulatory roles (Environment Canada, 2013b). In Manitoba, for instance, hazardous wastes are regulated under the *Dangerous Goods Handling and Transportation* (DGHT) *Act* (Government of Manitoba, n.d.). The DGHT *Act* established a system for managing hazardous waste from cradle to the grave (Government of Manitoba, n.d.).

2.7.1 End-of-life Vehicles (ELVs).

By virtue of the toxic components of End-of-Life Vehicles (ELVs), serious environmental and health consequences may arise if ELVs waste streams are not properly handled. ELVs include old and non-functional vehicles that are unable to pass safety tests or those condemned due to accident (Sawyer-Beaulieu & Tam, 2006). ELVs are complex units, which consist of so many parts including tires, glass, batteries, tires, metals, plastics etc. As indicated by Gerrard & Kandlikar (2007), an average car is made up of ferrous material, which is a perfect candidate for recycling, accounting for about 68.3% of a vehicle's weight. Other components are plastics, non-ferrous metals, rubber, glass and fluids contributing to 9.1%, 7.8%, 1.6%, 2.9%, and 2.1% respectively (Gerrard & Kandlikar, 2007). The concerns related to ELVs from a waste perspective are twofold: 1) about 25% of this waste flow is considered hazardous, and 2) about 75% of this waste flow can easily be recycled (Kanari et al., 2003; Simic, 2013).

The modern ways of recycling ELVs help to protect the environment and natural resources, and are socially and economically beneficial (Simic, 2013). ELVs management potentials is greatly influenced by the original vehicle producers and part manufacturers (Simic, 2013).

Therefore, in order to achieve high ELVs recycling rates, automobile products are now designed in such a way that parts can easily be recovered for reused or recycled at end-of-life (EoL) (Simic, 2013). Consequently, a large fraction of ELVs have high recovery and recycling potentials but Canada is still lagging behind in this aspect (Canadian Environmental Law Association [CELA], 2011).

Most jurisdictions, except US and Canada, with advanced automobile manufacturing sector have enacted specific legislations to manage ELVs and set recycling targets (Sakai et al., 2013). These legislations have gone a long way to boost the recovery of ELVs, improve recycling rate, monitors the activities of auto recycler, and encourages design for environment (Simic, 2013). In Canada, an estimated 1.2 million vehicles are retired every year (CELA, 2011; Sakai et al., 2013), creating about 150,000 tonnes of waste (CELA, 2011). Since there are no specific agencies saddled with the responsibility of monitoring ELVs management in Canadian provinces, the actual size of the waste problem is unknown (CELA, 2011).

In other jurisdictions, e.g. European Union and Japan, ELVs undergo a rigorous recycling process, which include depollution, dismantling, shredding, and the residue disposed of in the landfill (Sakai et al., 2013). A critical aspect of ELVs management is the depollution process, which involves the safe removal of hazardous components prior to dismantling in order to prevent the release of toxins into the environment (Sakai et al., 2013). Of the 600,000 per year ELVs estimated in Ontario, only about 35% are managed by members of the Auto Recyclers of Canada (ARC) whose operations are carried out according to strict standards that requires depollution of ELVs prior to shredding (ARC, 2012). The remaining 65% end up in the hands of auto wreckers who dismantle cars for parts (ARC, 2012). It is unknown whether the auto wreckers depollute ELVs prior to dismantling (ARC, 2012).

Despite the environmental and resource management challenges posed by ELVs, it has received little attention by the federal and provincial governments in Canada (CELA, 2011). British Columbia is the only province that has enacted regulations (*Vehicle Dismantling and Recycling Industry Environmental Planning Regulation*) to manage ELVs (CELA, 2011). Overall, the present ELVs management regime in Canada is far less comprehensive when compared to other jurisdiction like the European Union (End-of-life vehicles directives) and Japan (Automobile recycling Law) (CELA, 2011).

Moreover, in 2009, the CCME came up with a nationwide plan to extend responsibility of managing products from production to end-of-life stage in accordance with the EPR initiative (CELA, 2011). Under the EPR initiative, various provincial governments agreed to domesticate the EPR policies to cater for a wide range of product within 6years of the agreement (CELA, 2011). Although, the CCME plan did not consider ELVs as a whole, rather, the plan covers a range of product and parts- such as batteries, used oil, filters, refrigerants, tires, brakes and transmission fluid- that makes up ELVs (CELA, 2011).

2.7.1.1 Hazardous fluids.

Hazardous fluids, such as used motor oil, antifreeze, lubricants, brake oil, etc., are found in ELVs (ARC, 2012). In fact, about 19 liters of fluids can be recovered from a properly depolluted ELV (CELA, 2011). If these materials are allowed to flow freely into the environment, they result in land pollution, drinking water contamination and can impact aquatic ecosystem (Vazquez-Duhalt, 1989). Most of these fluids are made up of toxic compounds such as Polyaromatic Hydrocarbons (PAHs). Benzo (a) pyrene is an example of PAH and a well-known carcinogen. Substantial amount of toxic heavy metals and lubricant addictive may also be present in automobile fluids. Ethylene glycol is one of the major ingredients used in the manufacture of

Antifreeze (Takahashi et al., 2008). Ethylene glycol is sweet to taste, hygroscopic, viscous and highly poisonous (Brent, 2001). Antifreeze could find its way into the environment from radiator leakage or improper handling or vehicle radiator at end-of-life.

2.7.1.2 Waste tires.

Vehicles roll on tires that wear out overtime. Tires constitute about 3% of the overall weight of an ELV (CELA, 2011). When a tire becomes obsolete, such tires are either discarded as waste tires or stored for recycling. Tires are made of hazardous substances and extremely difficult to recycle (Sienkiewicz et al, 2012). The vulcanization process in the manufacture of rubber results in a cross-link structure that makes it difficult to recover raw material, they are also non-biodegradable and requires extreme high temperatures to transform (Sienkiewicz et al, 2012). A typical tire consists mainly of rubber, other components include carbon black, steel belts and textiles. The presence of steel and textile constitutes a difficulty in the tire recycling process because these material need to be separated from the tire mass (Sienkiewicz et al, 2012). On their own, tires may not constitute significant environmental hazards, but when burned, noxious substances are released into the environment. Toxins released from burning and decomposition of tires can pollute water, air and soil. If not properly disposed, tires can hold water, becoming a breeding ground for disease carrying vectors. (Amari et al., 1999).

In the province of Manitoba, joint efforts by industries, retailers, consumers, municipalities, recyclers and processors under the ‘Tire Stewardship’ program have achieved positive results with regards to collection and recycling of waste tires (Tire Stewardship Manitoba, 2015). When a consumer purchases a new tire, consumers in Manitoba (and across Canada) are charged an eco-fee for tire recycling at end-of-life (Tire Stewardship Manitoba, 2015). According to Tire Stewardship Manitoba (2015), there are over 1,400 tire collection points (including retail outlets, landfills and transfer stations) with about a million tires collected annually for recycling. However, collection points are often absent in remote areas and northern Manitoba FN communities.

2.7.1.3 Mercury switches.

Convenience light switches found in hood and trunks of automobiles and anti-braking system (ABS) sensors usually contain a small amount of liquid mercury trapped within a close vessel (ARC, 2012). In Canada, mercury switches are commonly found in vehicles produced prior to 2003 when the use of mercury switch was phased out (Switch Out, 2014). Mercury is a highly toxic metal especially in the organic state – Methyl mercury. Over the past decades, mercury poisoning has continued to draw environmental and public health concern since the Minamata Bay incident in Japan (Kessler, 2013) and a similar case in White dog and Grassy Narrows in Ontario, Canada (Takaoka et al., 2014). Mercury has been attributed to damage of vital organ in the body and bio-accumulates in aquatic ecosystem. However, a national program tagged "Switch out" have been initiated to recover mercury containing convenience light switch and ABS from ELVs, in Canada (Switch Out, 2014).

2.7.1.4 Batteries.

Depending on the type, batteries usually contain heavy metals, such as nickel, lithium, mercury and lead, which are harmful to the environment. In addition, batteries, especially lead-acid batteries, contains concentrated tetraoxosulphate (VI) acid (H_2SO_4) which poses threat to human safety and the environment. Acids are highly corrosive and thus could be injurious to human. Lead is a highly toxic metal even in low concentration (Health Canada, 2004). Once lead gets into the human body, lead particles are trapped in the bone for a long time and can result in elevated blood level of lead (Health Canada, 2004). Exposure to lead is attributed to health conditions such as anaemia, damage to kidney and central nervous system, birth defect, miscarriage or stillbirth (Health Canada, 2004).

2.7.1.5 Refrigerants.

One of the concerns with ELVs is the air-conditioning units that operate on refrigerants. Some known refrigerants contribute significantly to ozone depletion and global warming. Halocarbons, such as HFC-134a (1, 1, 1, 2-tetrafluoroethane, CH_2FCF_3) and CFC-12 (dichlorodifluoromethane) also known as Freon-12 or R-12, are common refrigerant used in vehicle air conditioning units (McCulloch et al., 2003). The use of CFC was discontinued in 1996 due to its ozone depleting potential and was replaced by HFC-134a. CFC-12 was classified as an ozone depleting substance (ODS) in the Montreal protocol on substances that deplete the ozone layer (Manitoba Ozone Protection Industry Association [MOPIA], 2014). ODSs are those substances that are capable of damaging the earth's stratospheric ozone (MOPIA, 2014). Stratospheric ozone shields planet earth from high Solar Ultra Violet (UV) radiation (MOPIA, 2014). On the other hand, HFC-134a, which is not an ODS, have been identified as a potent greenhouse gas and can contribute significantly to climate change due to its relatively high global warming potential (MOPIA, 2014). As a result, provincial legislation in Manitoba, i.e. *Manitoba ODS and other Halocarbons Act and Regulation*, requires the safe disposal of refrigerants by certified technicians (MOPIA, 2014).

2.7.2 Electronic wastes.

E-wastes, also known as waste electrical and electronic equipment (WEEE), refers to obsolete computers, television sets, refrigerators, mobile phones, (Terada, 2012; Kowsar et al., 2013) and any other electric powered appliances (OECD, 2001) which are to be discarded or disposed of as waste. E-wastes are classified as hazardous wastes due to the toxic nature of the constituents of their component, as shown in Table 2.4 (Townsend, 2011; Amfo-otu et. al, 2013).

E-wastes make up 8% by volume of MSW (Babu et al., 2007). In fact, e-wastes are considered to be the fastest growing hazardous waste stream in today's digital world (Widmer et al., 2005). Globally, up to about 50 million tonnes of e-wastes are generated every year (Chen et al., 2011; Premalatha et al., 2013), a large fraction of which comes from developed countries (Chen et. al, 2011) including Canada. E-wastes require more rigorous management systems compared with other kinds of MSW (Widmer et al, 2005). Many jurisdictions, including Canada, have devised environmentally safe and sound ways to manage e-wastes in order to protect public health and the environment and preserve useful resources (Babu et al., 2007).

The most comprehensive laws on e-wastes are the European Union Waste Electrical and Electronic Equipment (EU-WEEE) legislation and the Swiss Ordinance for the Return and take back of Electrical and Electronic (ORDEE). The Extended Producers Responsibility (EPR) initiative serves the most popular policy option to achieve e-waste management objectives (Widmer et al., 2005). Generally, EPR places the financial and technical responsibilities for the management of products at end-of-life on the producers of the products. However, illegal export of e-wastes to regions where there are no environmentally sound e-waste management systems in place is still a major concern (Premalatha et al. 2013). In most cases, e-wastes are falsely labelled and shipped as reusable equipment to developing countries (Widmer et al. 2005).

2.7.2.1 Classification of e-waste.

E-wastes are generally categorized based on product usage. The foremost legislation by the European Union (EU), known as the EU-WEEE directive, establishes ten categories of e-waste as shown in Table 2.4 below. Each category is assigned an acronym and includes equipment that fit the outlined descriptions. Many e-wastes categorizations in other jurisdictional laws outside the EU are based on the categories established in the EU-WEEE directives e.g. Nigeria.

2.7.2.2 Composition of e-waste.

E-wastes comprise a mix of valuable and hazardous materials. For example, the cathode ray tube (CRT) and liquid-crystal display (LCD) found in televisions and computer monitors contain heavy metals, such as lead, mercury and antimony. The market values of elements, driven by scarcity and demand, make the recycling of e-waste economically and socially attractive (Kumar & Putnam, 2008). There are about a thousand different substances that can be found in e-wastes, including trace elements such as arsenic, hexavalent chromium, lead, mercury etc., and brominated flame retardants (BFR) that emits noxious gases (dioxin and furan) when burned (Widmer et al., 2005).

The continuous advancement in the world's ICT sector drives the production of electronic equipment with shorter life span as products become quickly out-of-date. Consequently, the demand for electronics increases likewise the amount of e-waste generation (Kumar et al., 2005). In the past, some electronics, such as computers, attain end-of-life stage in about 4.5 years (Ibrahim et al., 2013). Today, the quest for manufacturer to maximize profit, improve device features, and modernize result in the use of materials that lessens longevity (Ibrahim et al., 2013). Most modern computers and mobile phone devices hardly last for two years. The good news is that electronics are often manufactured with materials that are considered valuable and that can easily be reused or recycled. However, most of the components are toxic and require specialized handling techniques (Adediran & AbdulKarim, 2012).

Table 2.4: Classification of e-waste according to the EUWEEE Directive 2002/96/EC

	Categories	Examples
1	Large Household Appliances (Large HH)	Large refrigerators and air conditioners, kitchen appliances (e.g. dish washer), laundry machines, etc.
2	Small Household Appliances (Small HH)	Pressing iron, food grinder, fan, vacuum cleaner etc.
3	IT and telecommunications equipment (ICT)	Telephone, photocopiers, printing machines, calculators, typewriter etc.
4	Consumer equipment (CE)	Radio, television sets, video cameras, musical instruments etc.
5	Lighting equipment (Lighting)	Lamps of different kind (e.g. Fluorescent, sodium and discharge lamps), luminaries for fluorescent etc.
6	Electrical and electronic tools (E&E tools)	Electric saw and drills, sewing machines etc.
7	Toys, leisure and sports equipment (Toys)	Gaming devices, electric toys, coin slot machines, etc.
8	Medical devices (Medical equipment)	Radiotherapy, Cardiology, Dialysis, Pulmonary ventilators etc.
9	Monitoring and control instruments (M&C)	Thermostats, heating regulators, smoke detectors etc.
10	Automatic dispensers (Dispensers)	All appliances which delivers automatically all kinds of products
Source: Widmer et al. (2005); Ranjana & Selvakani (2012)		

2.7.2.3 Environmental and health implications of improper e-waste management.

Due to the many hazardous components of e-wastes, adverse health and environmental effects may result from improper handling (see Table 2.5). Some major case scientific studies related to the health and environmental concerns of unregulated and unsafe e-waste recycling activities are highlighted in Table 2.6.

Table 2.5: Potential effects of some e-waste constituents on human health and the environment

Substance	Uses	Environmental / Health effects	Route of exposure	Source
Arsenic (As)	Used as doping agent in transistors and Printed Wiring Board (PWB)	Sore throat, tissue damage, irritated lungs, vascular & heart disease, increase the risk of lung, skin and urinary tract cancer	Ingestion of contaminated water or food; inhalation of dust particles and fumes	Frumkin & Thun, (2008); Schmidt (2002); Horne & Gertsakis (2006).
Mercury (Hg)	Contained in sensor and switches; measuring and control devices (e.g. thermostat); batteries; PWB; Cathode Ray Tube (CRT)	Neurological and immunological disorder, brain damage, increase risk of cancer, birth defect, damage to vital organs such as kidney and liver. When inorganic mercury gets into water bodies, it gets converted to methyl mercury, bio accumulates in aquatic organism such as fish	Consumption of seafood from contaminated water; inhalation; trans placental.	Clarkson (1993); Ebdon (2001); Horne & Gertsakis (2006); Bose-O'Reilly et al (2012).
Aluminum (Al)	Structural, conductivity/housing, CRT, PWB, connectors	Skeletal disorder, microcytic anaemia, impaired lung function, Fibrosis, encephalopathy, skin disease, associated with Alzheimer's disease (dementia).	Ingestion (oral), inhalation and skin contact.	Grossman (2006); Verstraeten et al. (2008), ATSDR (2008); Dashkova (2012).
Lead (Pb)	Used as glass panel gasket in CRT; Soldering	Damage to hematopoietic, hepatic, renal and skeletal systems, Central Nervous System damage. Lead accumulates in the environment, toxic to plant, soil and microorganism	Ingestion of contaminated water or food; inhalation of lead containing dust particles; skin contact	Verstraeten et al. (2008); Horne & Gertsakis (2006).
Nickel (Ni)	Used in batteries; Structural, magnetivity / (steel) housing, CRT, PWB	Respiratory problems such as asthma, chronic bronchitis, increase risk of cancer and allergic skin reactions.	Inhalation of dust or fumes containing Nickel, ingestion and absorption through skin contact.	Schmidt (2002), Grossman (2006), ATSDR (2005).
Beryllium (Be)	Used as conductor and connector in mother boards; finger chip.	increase the risk of pulmonary cancer, skin disease and shortness of breath.	Inhalation, ingestion and skin contact	Schmidt (2002); ATSDR (2002), Horne & Gertsakis (2006); Grossman (2006); Five Winds Int. (2001)

Substance	Uses	Environmental / Health effects	Route of exposure	Source
Chromium IV & Hexavalent Chromium (Cr)	Used to prevent corrosion; decorative for steel housing	Allergic reactions, stomach ulcer, damage to pulmonary and renal system, DNA damage, increase risk of cancer.	Ingestion through chromium contained in water, food or soil, Inhalation and dermal absorption.	Schmidt (2002); Dashkova (2012)
Silica	Glass; solid state devices; CRT, PWB	Scarring of the lungs (Silicosis), respiratory problems, lymph node fibrosis	Inhalation	Schmidt (2002); Grossman (2006)
Neodymium	Magnet in loudspeaker magnet and hard disk.	Accumulate in soils and water, lead to increasing concentrations in living organisms and soil, lung embolisms and liver damage	Inhalation	Zamani et. al (2011); Lenntech (n.d.).
Vanadium	Red phosphor emitter/ CRT	Lungs and throat irritation	Inhalation	Schmidt (2002); ATSDR (2012)
Brominated Flame Retardant	Cables, Plastics, printed Circuit boards.	Result in Digestive and lymphatic system cancer	Inhalation	Five Winds International (2001); Dashkova (2012), Brenniman and Hallenbeck (2002).
Cadmium (Cd)	SMD Chip resistor; infrared detector; used as semiconductors	Kidney damage, pulmonary disorder, skeletal problems, lungs problems, carcinogenic to humans. Because Cadmium is highly persisting in the environment, bioaccumulation occur especially in aquatic organism. Groundwater contamination can occur when cadmium leach from plastic	Inhalation of contaminated air and dust particle or ingestion	Horne & Gertsakis (2006); Schmidt (2002).
***Halogenated substances (PVC & PCBs)**	PCBs are used in transformers and capacitors; PVC are used in plastics; computer housing	PVC emits dioxin and furans when materials containing it are burnt. Dioxin and furan are highly toxic to human. PCBs is associated with Neurological and immunological disorder.	Inhalation or ingestion	Horne & Gertsakis (2006)

Table 2.6: Studies on human health and environmental impact of e-waste

Author	Study	Location	Analytical Method	Summary of findings
Asante et al., 2010	Determined the concentration of trace elements and Arsenic speciation in urine samples of informal e-waste recycling workers.	Accra, Ghana	Inductively Coupled Plasma (ICP) mass spectrometer	Concentrations of Fe, Sb, and Pb in urine of e-waste dismantlers exceeded those of reference sites. Arsenic speciation revealed predominance of arsenobetaine and dimethylarsinic acid.
Ha et al., 2009	Analyzed the concentration of metals in soil, air, and human hair collected from e-waste recycling sites and a reference site.	Bangalore, India	ICP mass spectrometer & cold vapor atomic absorption spectrometer	Concentrations of metals (including Cu, Zn, Ag, Cd, In, Sn, Sb, Hg, Pb, and Bi) were higher in samples from e-waste recycling sites.
Wang et al., 2011	Measured urinary levels of Pb, Cd, Mn, Cu, and Zn in people exposed to e-waste dismantling activities.	Taizhou, Zhejiang Southeast China	Atomic absorption spectrophotometry (AAS)	Urinary level of Cd in people around e-waste informal recycling sites were higher than the control groups.
Alabi et al., 2012	Analyzed the levels of heavy metals, Poly Aromatic Hydrocarbons (PAHs), Poly Chlorinated Biphenyls (PCBs) and Polybrominated diphenyl ethers (PBDE) in soil and plants from e-waste dumping sites.	Guiyu, China & Lagos, Nigeria	AAS & gas chromatography/ spectrophotometry.	Soil and plant samples from e-waste dismantling areas in China and Nigeria were contaminated with heavy metals, PAH and PCBs.
Fujimori et al., 2012	Determined the concentrations of 11 metals in soil and dust (including enrichment factors, and hazard indicators) from e-waste recycling sites	Manila, Philippines	ICP-AAS; ICP-mass spectrometry	Dust particles had statistical higher levels of heavy metal contamination and health risk compared to soil.

Tue et al., 2010	Assessed PCBs, PBDEs and HBCDs contamination in human and possible exposure pathways in e-waste recycling sites.	Hai Phong city & Hung Yen, Vietnam	Gas chromatograph	Levels of PBDEs, but not PCBs and HBCDs in breast milk, were higher than in the reference site. PCB was higher in those involved in e-waste recycling
Xu et al., 2014	Examined the effects of e-waste environmental pollutions on male genital health in one of the world largest e-waste recycling centre.	Guiyu, China	Statistical analysis of outpatient information	Morbidity of male genital diseases was higher in Guiyu than in the control area
Guo et al., 2010	Analyzed the concentration of heavy metals (Pb, Cd, Cr, and Ni) in placenta.	Guiyu, China	Graphite furnace atomic absorption spectrometry	High Placenta concentration (PC) of Pb in neonates born in Guiyu than control area. No clear differences in concentration of Cd and Cr were found between the two groups
Wong et al., 2007	Determined trace metal contamination of sediments.	Guiyu, China	ICP-Atomic Emission Spectrometry	Sediments from water bodies in Guiyu were contaminated with metals (Cd, Cu, Ni, Zn, Pb)
Zheng et al., 2008	Investigated the children's Blood Lead levels (BLLs) and Blood Cadmium Levels (BCLs) at an e-waste recycling area.	Guiyu, China	Graphite atomizer absorption spectrophotometer	Higher BLLs and BCLs in children living in Guiyu as compared with those living in reference area.

CHAPTER 3: RESEARCH METHODOLOGY AND METHODS

This chapter provides detailed explanations of the approaches employed to meet the aforementioned objectives in Chapter 1 (section 1.2). Table 3.1 shows the link between the research objectives and methods. The research methodology and methods are described in more details in sections 3.1, 3.2 and 3.3, 3.4 respectively.

3.1 Introduction

This research focused on the critical examination of existing solid waste management practices in Garden Hill First Nation (GH) and Wasagamack First Nation (WASS) communities. To this end, a mixed method approach, which involved both qualitative and quantitative data collection and analyses were utilized (Bergman, 2008). Tashakkori and Creswell (2007) have described the mixed method as an approach to "research in which the [researcher] collects and analyses data, integrates the findings and draws inference using both qualitative and quantitative approaches" (p.3). According to scholars (e.g. Bryman, 2007; Östlund et al., 2011), the application of both qualitative and qualitative methods to study a given phenomenon presents a more holistic view which might not have been possible if a singular approach was utilized. Since the introduction of combining both (i.e. qualitative and quantitative) research methods by Jick (1979), the wide use of the mixed method by many researchers (or investigator) have been improved in the past few years (Östlund et al., 2011). This improvement emerged as a result of the need to embrace pragmatism vis-a-vis the demand in the field of practice, pursuit to reduce the cost of research and the rigorous criteria to obtain research grants (Creswell, 2003; Brannen, 2009; O'Cathain et al., 2007 and Östlund et al., 2011).

To this end, the qualitative and quantitative data collection tools utilized to study solid waste management practices in GH and WASS communities were guided by a participatory action research (PAR). PAR design was employed because the need to bring about change in the communities corresponds with the research objectives that necessitates action oriented research involving community participation. Generally, PAR is based on the principles that support the voice of the disadvantaged and marginalized. Creswell et al. (2007) defines PAR as a strategy of inquiry "in which the researcher and the participants collaborate at all levels in the research process (participation) to help find a solution to a social problem that significantly affects an underserved community (action)" (p. 256). PAR techniques also empower communities to succinctly identify their health and environmental related issues (Bharadwaj et al., 2008).

By ensuring community participation at all levels in the research processes, the relevance and validity of this research were strengthened (Bharadwaj et al., 2008). Community involvement, information and knowledge sharing and education formed the basis of this PAR. As stated by Bharadwaj et al., (2008), the key components of the PAR method in First Nations (FN) communities, which were duly adhered in this research, include:

1. Building relationships among researchers and participants (community members),
2. Obtaining consent from the community leaderships, i.e. band councils,
3. Involving community members in field visits and other research work,
4. Serving the interest and needs of FN
5. Building community capacity through participation of community members in research activities

The PAR approaches have been used in previous studies related to environmental impacts of solid waste disposal practices in FN communities (e.g. Bharadwaj et al., 2008). In this particular research study, ethical, collaborative and respectful partnerships with the communities of GH and

WASS were initiated for the purpose of knowledge sharing on solid waste management practices in the communities.

The studies were conducted in the winter and summer of 2015 following approval by the University of Manitoba Joint Faculty Research Ethics Board (see Appendix A). In adherence to the FN research protocol of Ownership, Control, Access and Possession (OCAP)[5], permissions were obtained from the leadership of the two communities, i.e. the Band Councils[6], prior to the commencement of the research. Over the years, the OCAP principles have become a vital part of research concerning FN people in Canada (Schnarch, 2004). According to Schnarch (2004, p. 1), OCAP represents "self-determination applied to research" and instills FN monitoring of, and participation in, all aspect of a research from idea to execution. Band Council Resolutions (BCR)[7] are important documentations that relate to the OCAP process. The process of obtaining a BCR often includes the presentation of a proposed research project to the band council and a written request for approval. Hence, prior to data collection in the communities, meetings were arranged with the band councils and formal presentations were delivered as a basis for dialogue on the potential risks and benefits associated with the research. Following the receipt of the BCRs from both communities, announcements were made on the local media stations (television and radio) in to ensure adequate awareness and inclusion of community members in the research processes.

[5]OCAP is a trademark of the First Nations Information Governance Centre (FNIGC). The OCAP principles allows First Nations communities an absolute control over research processes in their communities (see http://fnigc.ca/ocap.html)

[6]A band council is the representative and decision making arm of a First Nation community. The band council comprises of a Chief (the head) and councilors. Band council members are elected by community members and form the government of their community.

[7]Band Council Resolutions (BCR) are administrative declarations that express the will of the band council of a First Nation community with respect to a particular subject matter or event. (See https://www.aadnc-aandc.gc.ca/eng/1100100013955/1100100013957).

Table 3.1: Link between objectives and methods

Objectives	Methods
1) Examine the historical and present waste management situations in Garden Hill and Wasagamack FNs.	➢ Participant observations ➢ Open ended interviews ➢ Participatory documentary video
2) Analyze the potential environmental and health impacts of waste disposal practices in Garden Hill and Wasagamack FNs	➢ Environmental sampling (Quantitative)
3) Identify critical issues and provide recommendations to improve waste management practices in Garden Hill and Wasagamack FNs communities	➢ Literature review ➢ Round table discussions

3.2 Case Study Approach as a Strategy of Inquiry

The communities of GH and WASS were selected as the case study to examine solid waste management practices in remote fly-in communities of northern Manitoba. Generally speaking, the selection of an appropriate strategy of inquiry or qualitative research design often depends on the research question (Creswell et al., 2007), or the nature of the research problems (Noor 2008). Case study is among five strategies of inquiry put forward by John W. Creswell, others being grounded theory, phenomenology, ethnography, and narrative (see Creswell, 2007). In the context of this research, the case study approach was employed to address the general issues relating to solid waste management in remote northern Manitoba FN communities and to answer what, why and how questions applicable to case study as a strategy of inquiry (Merriam, 2008; Yin, 2003).

Literally, a 'case' in the context of a case study approach to inquiry refers to an individual, an event, an entity or even a *unit of analysis* (Noor, 2008). This implies that a case study focuses on a specific area of interest and not an entire system. Garden Hill and Wasagamack FNs communities were chosen as a case for this research due to *social exclusion*, *geographical* *constraints* as remote fly-in communities, the *cultural similarities* between the two communities and the *existing collaboration* between the research advisor and the communities. The case study approach was most appropriate because a comprehensive approach to the solid waste management issues in these communities were required and information were readily available through existing collaboration with community members (Noor, 2008).

By definition, the case study research strategy is “an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used.” (Yin, 1984, p. 23). Yin (2003) and Creswell et al (2007) further describe case study as a qualitative strategy which allows a researcher to report a case description upon examination of a wide range of systems over time, involving collection of in-depth, well-informed data from numerous sources (including interviews, surveys, participant observation, document review etc.). It is worthy to note that qualitative and quantitative data are applicable in case study and that data collection methods are non-restricted (Yin, 1981). However, Yin (1984) recommends that researchers must be careful not to interpret case study as basically qualitative research because it can also be based entirely on quantitative data. The most interesting aspect of a case study approach is that it focuses on understanding complex issues and offer solutions, which is in line with the principles of PAR employed in this research. Drawing upon the works of renowned case study researchers in Yin, Stake and Simons, Soy (1997) put forward six procedures for conducting a case study research, as indicated in Table 3.2.

Table 3.2: Case study steps applied to this research (adapted from Soy 1997)

Step 1: Formulated my research question	
General description: frame questions about the given problem in order to determine the research objective. The research question is guided by conducting a literature review to examine previous knowledge about the issue.	1) I identified the problems and seeked to answer relevant questions such as- "What are the perspectives on waste disposal in the communities", "Why are the communities unable to implement sound waste disposal practices", "How can integrated waste system be successfully implemented".
Step 2: Selected case studies and data collection techniques	
General description: design phase of the research. multiple methods in data collection helps to strengthen the case study approach. The researcher predetermines what data to collect and the most appropriate technique to analyze the data to answer the research questions. Collected data is usually qualitative, but it may also be quantitative or both.	2) I acheived a positive working relationships with Garden Hill and Wasagamack First Nations communities. Both qualitative and quantitative data were collected. Data collection involved participation by community members in all aspect
Step 3: Prepared for data collection	
General description: to avoid the researcher being overwhelmed with the large volume of data involved in the case study method, advance preparation assists in managing this large amount of data. Databases are often prepared to assist with organizing and retrieving data for analysis.	3) Before commencement of my research, I presented draft proposal to thesis committee and the band councils of the communities to obtain feedback; I undertook research ethics protocol reviewed by the Joint Faculty Research Ethics Board of the University of Manitoba for approval
Step 4: Collected data	
General description: this involves careful observation of the object under investigation and the identification of underlying factors linked with the observed phenomenon. Multiple sources of evidence must be collected and stored in a comprehensive and systematic manner, in a format that can be easily sorted and referenced	4) I engaged community members in data collection processes. Data collection methods involved multiple sources including site tours, participant observations, interviews, participatory documentary videos and environmental sampling procedures.
Step 5: Analysed the data	
General description: interpretation of data in order to establish a link between the objectives and finding, bearing in mind, the research question. The researcher is open to new information throughout the entire analysis process. The case study method "provides researchers with opportunities to triangulate data in order to strengthen the research outcomes".	5) After I collected all neccesary data, interviews were manually transcribed verbatim. I conducted thematic content analysis of field notes and transcribed interviews to identify themes arising from the discussions with participants.
Step 6: Presented report	
General description: presents data in a way that complex issues are easily understood by the reader, independent of the researcher, allowing the reader to question the study. In order to achieve this simplicity in the report, the researcher may choose to present individual case in separate chapters or even present the case as a story.	6) I wrote short reports for each community with findings and video made available, as well as thesis.

3.3 Qualitative Methods

Qualitative data were gathered through open-ended interviews, personal observations, sharing circles (and round table discussions) and participatory documentary video (PDV) with youths and elders in the communities of GH and WASS. Data collection in the communities was followed by discussions with solid waste management stakeholders in Manitoba. Generally, qualitative research methods rely on understanding many stakeholders' viewpoint, social construction and theory generation (Creswell, 2007).

3.3.1 Open-ended interviews and participatory documentary video.

The interviews focused on key issues related to solid waste management practices, and participants were those directly or indirectly concerned about the subject matter under investigation. Interviews were guided by open-ended questions that not only allow participants to express in-depth opinions and views, but also availed the researcher (interviewer) to show prompt attention to the interviewees (research participant), and subsequently follow-up on discussions (Merriam, 1998; Hay, 2008; Baxter and Jack, 2008). The interviews were conducted in two phases. The first phase involved participants from the communities of GH and WASS, which included youths (above 18 years) and both male and female elders in the communities. A total of 12 interviews were conducted in both communities. Research participants were recruited through announcements on the local TV and radio stations with the help of community members. All the participants were volunteers who underwent informed consent processes, clearly understood the purpose of the research project, and embraced the opportunity to contribute to the discourse about solid waste management practices in their communities. As aforementioned, the interviews were open-ended and allowed participants the freedom to express viewpoints on solid waste management and other critical issues in the communities. The second phase of the interviews were held with five key solid waste management stakeholders in Manitoba. The interviews cut across all stakeholders (including government officials) who are directly involved in solid waste related programs in Manitoba and those who have experience working with FN communities and understands community needs.

Figure 3.1: Researchers on-air with a community member during a presentation at Garden Hill First Nation media station*: Reaching out to community members and sharing knowledge through local media is a way to educate and create awareness on environmental protection.*

During the process of participant recruitment, community members were introduced to the research project and asked to voluntarily participate in discussions on historical and present waste disposal practices in their communities. The announcements were communicated in English and translated to the local Ojibway-Cree dialect by a community member. Community members who agreed to participate in the research were interviewed one-on-one or in groups, depending on the participants' preferences. The process of informed consent was carefully undertaken with each of the participants and written consent forms were signed prior to the commencement of the interviews (see Appendix B). In some cases, interviews with participants were conducted with the assistance of a community member for the purpose of translation from the local Ojibway-Cree dialect to English language and vice versa. Interviews varied in length of time from 10 to 30 minutes. Interview data were collected by note taking, and some were recorded (with participant's consent and permission) using a digital video camera to produce a Participatory Documentary Video (PDV) for the communities.

The aim of a participatory video technique used in this research is to empower community members to tell their own story and voice their genuine concerns about waste management in their communities. Video was also considered to be more accessible to people who were not literate in English or did not have time to read the report. Video is convenient to access in today's digital world. Unlike regular documentaries, a PDV is an in-between concept having some elements of participatory video and some elements of documentary video. It is controlled by the participants and researcher, and lays more emphasis on content rather than artistic appearance. To voice their concerns about the present situation of waste management in their communities, community members in GH and WASS were videotaped by the researcher. Video recordings were stored in password protected secured digital (SD) cards and edited using Final Cut Pro X software. Prior to the release of the final video, video clips were shown to participants and other community members for feedback and final approval. Data collected during the interview processes were transcribed manually and a thematic content analysis was carried out to identify common themes that emanated from participants' contribution to the research study.

3.3.2 Participant observation.

Participant observation is a data collection technique that involves a researcher getting in close contact with participants in their natural setting so that the researcher can gain meaningful and unbiased insight into the participants' lives (Suen & Ary, 2014). According to Narayanasamy (2009), participant observation is done with the intention of gathering data for a particular study.

This study approach is appropriate when researchers are interested in understanding how and why people behave the way they do in their natural milieu. When a tangible amount of time is spent with participants, the researcher understands the community norms and builds trust in relationships that could create a platform where valuable data can be gotten from participants. More so, increased rapport with the participants motivated such groups of participants to go on with usual day-to-day activities and also reduced the possibility of reactions that may have occurred during the interviews (Bernard, 2006).

Figure 3.2: On community tour with one of the research participants in Wasagamack First Nation (Photo Credit: Zacchaeus Harper)

During the field work, the researcher of this study resided in the communities of GH and WASS for a total of 40 days, which presented enough time to observe the daily life in the community particularly related to solid waste management practices. Through participation in cultural activities, such as pow-wow events, camping, school programs, local sport and recreational event, ice-fishing and several TV presentations, the researcher was able to build relationships and trust within the communities. During these periods, site tours and transect walks were observed with community members. Transect walks involve walking around the areas under investigation to observe and understand the situations in the local contexts (Mallik, 2014). On several occasions, community members voluntarily led the researcher on a tour of solid waste disposal sites around the communities.

3.3.3 Sharing circles and round table discussions.

A round table discussion (or sharing circle in FN contexts) is a form of informal, face-to-face, individual or small group interaction involving a researcher, who normally will serve as the facilitator, and participants. A round table or sharing circle encourages the sharing of concerns, ideas and might be geared towards solving a problem. Sharing circles has proven to be an effective way to collect qualitative data in FN communities (Socha et al., 2012; Zagozewski et al., 2011). During the course of this study, four sharing circles were conducted with the band councils, elders and other members of GH and WASS communities. The aim of these sharing circles was to share knowledge on historical and present solid waste management in the communities. In addition, several rounds of discussions were held with solid waste management stakeholders in Manitoba including representatives of producer responsibility organizations (PROs) and government agencies. These discussions were held in order to gain perspectives and understand the barriers and opportunities related to solid waste management in remote northern Manitoba communities.

3.4 Quantitative Methods

Quantitative methods employed in this research were related to the potential impacts of waste disposal on human health and the environment. The study areas for quantitative analysis were the active waste dump sites (the “sites” hereafter) in both communities of GH and WASS. The sites served as dumping grounds for solid wastes generated in the communities. Environmental samplings and laboratory analyses were conducted to determine if there were any significant environmental and health risk associated with disposal activities at the sites. The quantitative approach also served the need of the communities and builds capacity through the involvement of community members in field activities. A total of four youths were engaged in both communities to conduct environmental sampling. The sampling and analytical procedures are discussed in the sections below.

3.4.1 Sampling and analyses.

Soil and water sampling were conducted in the summer of 2015. Prior to sampling, safety procedures were strictly adhered to and sampling tools were thoroughly cleaned using a phosphate free soap and distilled water to avoid cross-contamination. Community members were engaged in the sampling procedures, in accordance with the participatory approach to the research.

3.4.1.1 Soil sampling, preparation and analyses.

Three composite soil samples each (GH1, 2 & 3 and WASS1, 2 & 3) were collected from within the immediate vicinities of the sites (see Figures 3.3 and 3.4). Two background samples (GH-Background and WASS-Background) were collected at random locations upwind at about 1000 meters away from the sites. These random locations were judged to be free from human activities that may have led to environmental contaminations. The purpose of the background samplings was to serve as reference (or control) and to determine and compare the natural concentration of test parameters. Samples GH 1 and WASS 1 were collected from within the perimeters of the sites. Samples GH 2 & 3 and WASS 2 & 3 were obtained from within the center of the sites. In total, eight (8) soil composites, six (6) from the immediate vicinities of the two sites and two (2) background samples, were retrieved for laboratory testing.

Figure 3.3: Map showing the locations of background sampling points and Garden Hill First Nation active waste dumpsite

Soil samples were collected using a clean and rust-free stainless steel sampler (shovel) at a depth of 0-10 cm (Oh et al., 2006; Dao et al, 2013). The sampling areas were divided into grids of 10 sections, sub-samples were collected at random from various quincunx points on each grid section, and then mixed thoroughly to obtain composite sample for each of the three sampling areas on the two sites (Dao et al, 2013; Hu et al., 2014). Composite sampling using grid techniques reduced analytical costs and strived to ensure that the soil samples were representative of the sites. For personal protection and to avoid cross contamination, samples were screened to remove stones, large particles and debris, and mixing was done using a clean stainless steel hand trowel and handled with clean powder-free latex gloves. Soil samples were stored and preserved in clean Ziploc plastic bags while being transferred to the laboratory.

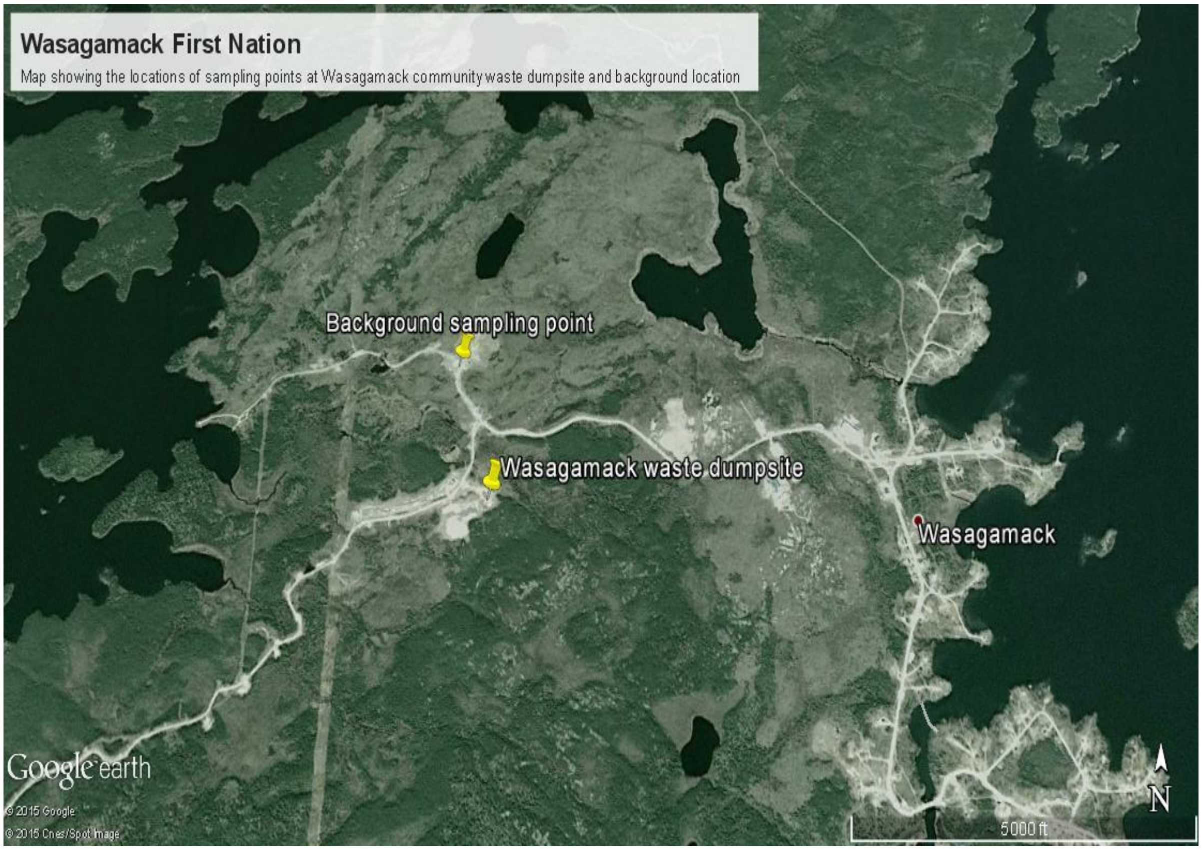

Figure 3.4: Map showing the locations of background sampling point and Wasagamack First Nation active waste dumpsite

Composite soil samples were submitted to Activation laboratories (Actlabs) in Ontario, Canada for analysis. Actlabs is accredited by National Environmental Laboratory Accreditation Conference (NELAC) and Standards Council of Canada (SCC) for International Standards Organization (ISO) 17025. All soil samples were analyzed for the presence of heavy metal concentrations using inductively coupled plasma mass spectrometry (ICP-MS) techniques (see Appendix C). The results of the analysis were compared with Canadian Council of Ministers of the Environment (CCME) soil quality guidelines for land use categories including residences and parkland, agriculture, commercial and industrial land use.

3.4.1.2 Water sampling, preparation and analyses.

At each of the sampling sites, integrated grab water samples were collected and composited. The purpose of water sampling was to ascertain the potential impacts of waste disposal on water quality. Samples were drawn from water features in close proximity downstream to the sites by immersing a clean two-liter plastic container. The water samples were poured and sealed in appropriately labeled bottles. Water samples were preserved in ice-chilled coolers at an average temperature of 4^0C prior to submission to the laboratory (ALS Laboratories in Winnipeg) for testing within 24 hours of sample collection. Generally, samples were handled with separate Nitrile gloves and separated during transportation to avoid potential cross contamination. A total of two water samples, one from each of the sites were collected for microbial parameters (E. coli and total coliform). The results were compared with Health Canada's *Guidelines for Canadian Drinking Water* (Health Canada, 2013a) and guidelines for *Canadian Recreation Water Quality* (Health Canada, 2013b).

3.4.2 Regulatory guidelines.

The rate and frequency of exposure to contaminants for humans and eco-receptors are related to the nature of land use around the sites, the activities on site and ease of access to the site environmental media (CCME, 2006). The soil depth described by CCME as exposure risk to humans are related to soil particles near the surface, defined as not exceeding 1.5 m of the soil profile (CCME, 2006). According to the CCME (2006) protocol for the derivation of Environmental and Human Health Soil Quality guidelines[8], the soil quality guidelines for human health (SQG_{HH}) and Environment (SQG_E) are harmonized for all land use categories, such that the

[8] Guidelines are numerical limits recommended to protect and maintain specified uses of soil, water and sediment.

lowest values become the final guideline for the protection of both human and ecological health (CCME, 2006). SQG_E takes into consideration the exposure-receptor pathway such as direct uptake by flora and fauna, nutrient cycle, wildlife intake of contaminated soil and food, and the spread of contaminants through groundwater to sources of water for wildlife and aquatic life (CCME, 2006). $SQG_{HH,}$ on the other hand, considers the route of exposure, escape of contaminants into human habitats, spread of contaminants through groundwater to potential water sources and human uptake of contaminated food (CCME, 2006).

The guidelines for the assessment of contaminated sites consider land use as an important factor, guidelines for certain parameters also pertain to soil texture (CCME, 2006). The CCME guidelines present target values for various contaminants including heavy metals for the protection of environment and human health associated with four land uses: agricultural, residential/ parkland, commercial, and industrial (CCME, 2006). Concerns for surface water features are usually related to the health of aquatic life as contained in CCME's *Freshwater Aquatic Life Guidelines* (CCME, 2007b), which also relates to plant and its bioaccumulation of contamination to wildlife, fish and humans. However, the use of surface water for purposes such as swimming have prompted the applicability of guidelines such as the Health Canada's *Guideline for Canadian Recreational Water Quality* (GCRWQ) which include measures for microbial parameters such as *E. coli, faecal coliform and total coliform* (Health Canada, 2012a). Health Canada's *Guidelines for Canadian Drinking Water Quality* (GCDWQ) (Health Canada, 2012b) is applicable as Island Lake uses its surface water for drinking purposes.

In Manitoba, there are environmental standards set by the provincial government to manage and operate waste dumpsites within its provincial jurisdictions. As both Garden Hill FN and Wasagamack FN are located within Manitoba, the Manitoba *Waste Disposal Grounds Regulation*, under the Manitoba *Environment Act 1991*, was used as a reference to determine how the community active dumpsites conform with environmental standards for siting and operating a waste disposal site. The Manitoba *Waste Disposal Grounds Regulation* specifies standard operating procedures for different categories of waste dumpsites including those serving a population between 1000 to 5000 persons (i.e. Class 2), which corresponds with Garden Hill and Wasagamack FN communities. According to the Manitoba *Waste Disposal Grounds Regulation*, a dumpsite should be located as follows:

i. at a minimum distance of 100 meters from any public road or railways, unless the road leads only to the waste disposal ground
ii. at a minimum distance of 1000 meters from any surface water features
iii. at minimum distance of 400 meters from any dwelling
iv. at least 400 meters from any cemetery
v. at minimum proximity of 400 meters from any potable water well

Other criteria for operating Class 2 waste dumpsites, according to the regulation, include restrictions on burning of waste as well as requirements for regular waste compaction and soil covering to a thickness of at least 15 centimeters, leachate collection and the construction of a fence of at least 1.8 meters in height to contain the solid waste within the active waste disposal area (The Environment Act 1991).

CHAPTER 4: SOLID WASTE MANAGEMENT PRACTICES IN GARDEN HILL FIRST NATION AND WASAGAMACK FIRST NATION IN NORTH-EAST MANITOBA

4.1 Introduction

Disposal of municipal and hazardous wastes threaten the public and environmental health of First Nations (FN) communities (Bharadwaj et al., 2006). As far back as 1995, the Canadian House of Commons recognized unsafe solid waste disposal as one of the key environmental challenges facing FN communities across Canada (Maslowski, 1999). In the same year, a survey of 600 FN communities conducted by Indian and Northern Affairs Canada (INAC), now Aboriginal Affairs and Northern Development Canada (AANDC), revealed that a significant number of the surveyed FN communities lacked access to safe drinking water and suffered from unsanitary waste disposal systems (Maslowski, 1999).

Today, after more than two decades, the critical problems related to waste disposal in FN communities have not been addressed (Zagozewksi et al., 2011). The concerns are most evident in remote, fly-in FN communities, including Garden Hill First Nation (GH) and Wasagamack First Nation (WASS) in northern Manitoba, which are the focus of this research. In Manitoba, twenty-three (23) of the sixty-three (63) FN communities are fly-in communities, inaccessible by an all-weather road. The minister of the AANDC within the provisions of Section 5 of the *Indian Reserve Waste Disposal Regulations*, under the *Indian Act*[9], designates the responsibilities for the management of waste disposal sites on FN reserves (Department of Justice, 2015). Yet, most of

[9] The Indian Act, which was first enacted in 1876, is the principal statute through which the federal government of Canada governs First Nations people, their bands, and the system of First Nation reserves (see http://laws-lois.justice.gc.ca/eng/acts/i-5/)

the waste disposal sites on FN reserves[10] are left unattended and in shambolic states (Zagozewski et al., 2011).

Authors and environmental activists like David McRobert and Tyler Edwards believe that major issues concerning FN communities are rarely the priorities of the federal and provincial governments (McRobert & Edwards, 2012), stemming from a long history of colonization, as well as social, economic and political marginalization. Even the public debates ahead of the 2015 Canadian federal elections had FN issues left in the shadows of top discussions (McDonald, 2015). Apparently, this lack of government attention has made critical public services, such as solid waste disposal in many FN communities, to be unsafe, unsustainable, as well as critical issue that requires urgent attention (OAG, 2009). Unsafe conditions of solid waste management practices are particularly true in the case of many FN communities in northern Manitoba where extreme poverty and remote road access undermine environmental protections (Inez M., personal communications, 2015). Therefore, this section examines perspectives and issues related to solid waste management practices in GH and WASS. The aim is to better understand the solid waste management needs of the communities from community perspectives, in order to inform decisions and influence action towards better practices.

4.2 Method

As mentioned in the previous chapter, participatory action research (PAR) approach was employed throughout this research. Qualitative methods of data collection included open-ended interviews; sharing circles (and round table discussions), participant observations; and participatory documentary video techniques with community members in GH and WASS and waste experts from outside the communities.

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[10] Reserves in Canada are land areas set aside under the Indian Act (section 18) for the use of First Nation bands (see http://laws-lois.justice.gc.ca/eng/acts/i-5/page-10.html#h-13)

4.3 Findings and Discussions

The themes that emerged from analyzing the different qualitative data were centered on:

i. Solid waste management practices are challenging the traditional beliefs in GH and WASS.
ii. Unsafe methods; prevalence of open dumping areas and junkyards around the communities
iii. Backyard burning of wastes and its impacts on community health
iv. Unsafe disposal of plastics and other toxic materials (such as e-wastes, tires, lead batteries, etc.)
v. Risks of forest fire from open burning practices
vi. Hazardous and plastic wastes dominate FN waste require better management approaches.
vii. The steps contributing to waste problems in GH and WASS
    a. <u>Solid waste storage</u>: lack of adequate waste receptacles for storage of waste generated in the households
    b. <u>Solid waste collection and transportation</u>: absence of door-to-door/curbside waste collection services and proper waste storage issues and formal/informal recycling services
    c. <u>Solid waste disposal:</u> the absence of properly sited, engineered sanitary landfills that meet government standards
viii. More sustainable solid waste management options for the communities
ix. The hazardous and bulky wastes dilemma

These will be described in the sections below followed by a comparison of solid waste management practices in FN with developing nations; and barriers towards implementing better solid waste management approaches in GH and WASS.

4.3.1 Solid waste management practices are challenging the traditional beliefs in GH and WASS.

From personal observation and interviews, a difference between what people in GH and WASS believed (e.g., sanctity of earth) and what they could do (or did) in terms of solid waste management was clearly evident. This implies that contemporary consumption and throwaway habits were not consistent with traditional ways of living in the communities. For example, the people in GH believed that the land is sacred (see Figure 4.1):

> *All of our rights originate from our connection to the land. Our lives, our beliefs and our presence as First Nation are validated to the land, inhabited by our ancestors since time. 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.*

Figure 4.1: Welcome sign in Garden Hill First Nation

Every sentence in the quote above reiterates the magnitude of respect and value that the people in GH and WASS communities held for their land. Traditionally, the land serves as a fundamental livelihood resource and is culturally significant to FN people. Throughout history, FN people in GH and WASS have survived off the land through fishing, trapping, hunting, and gathering with minimal environmental footprints. Thus, the people regarded themselves as stewards of the land with the duty to preserve their traditional heritage and pass on the teachings for the benefit of future generations. Ironically, the signboard that conveyed the message was positioned just ahead of a heap of solid waste materials buried in the snow, near the whole message and beside a body of frozen lake (Figure 4.1).

Solid waste materials, like food scraps, used packaging and recyclables (such as paper, glass, plastics and nylon), left-over medications, construction and demolition debris and hazardous wastes (e-wastes and end-of-life vehicles) were common sights on GH and WASS reserves. Often, these waste materials were found near water bodies, littering public places and yards of homes, including children playgrounds, creating an unsanitary living environment. These solid waste management scenarios and reactions from a few community members are captured in the participatory documentary video (see video at https://youtu.be/EQ1YrQDjvB8).

From numerous interactions with community members in GH and WASS, concerns over the solid waste management practices and its impacts on community health were growing. One of the common themes that emerged were centered on respect and care for Mother Nature. However, many community members in GH and WASS suggested that junkyards were building up in the communities that were once regarded as a pristine lake environment and that they were not happy with this change. Findings revealed that perceptions about solid waste management practices in both communities of GH and WASS were identical, that current waste practices were unsafe and unacceptable to their culture, way of life and health but that there were no other options without funding or programs.

4.3.2 Unsafe methods; prevalence of open dumping areas and junkyards around the communities.

The majority of community members relied on open dumping and open air burning as methods of waste disposal. Open dumping and open burning of waste materials in GH and WASS were considered unsafe and unsustainable. These methods of waste disposal do not belong in the waste management hierarchy due to high risks of pollution to the environment, which are considered unacceptable for modern waste. In general, the waste hierarchy ranks waste management options based on their environmental suitability and social acceptability (Barret & Lawler, 1997). Although Barret & Lawler (1997) have questioned the applicability of the waste hierarchy to sparsely populated remote communities, like GH and WASS, due to economic concerns. However, the risks to community health and environment from these unsanitary waste management practices create an urgent need to develop a better solid waste management strategy.

Proper solid waste management is not available in GH and WASS. There are no amenities to properly store waste generated within the households, a lack of centralized waste collection systems, and absence of well-planned disposal facilities and the faraway location of the designated garbage dumps from many households. These lack of services and infrastructure were the major causes of indiscriminate open dumping and open air burning of waste materials in GH and WASS. Off-reserve contractors who worked in the communities were observed leaving hazardous wastes behind, which was unsafe and endangered the community. According to a community member who led a tour of open dumps in the communities, many people burn their garbage or throw out in the community, rather than in dump, as shown in Figure 4.2 below:

> *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 road sides. There are no other options because we don't have recycling [or any proper solid waste management facilities] here in the community.*

Many community members in GH and WASS complained about the lack of solid waste infrastructures in the community and felt concerned about the environmental and community health risks.

Figure 4.2: A community member led a tour of open dumps in Garden Hill First Nation

4.3.3 Backyard burning of wastes and its impacts on community health.

Elders and youths in GH and WASS raised significant concerns over the potential negative effects of solid waste management practices, particularly open air burning, on community health. Even though burning helps to reduce the pile of garbage in the absence of alternative options, many community members were concerned about the pollution that results from such activities. 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.*

Open air burning of waste observed in GH and WASS communities involved combustion at very low temperatures without emission control measures of well-managed municipal solid waste incinerators (see Figure 4.3). The indiscriminate open dumping and uncontrolled open air burning of a variety of waste materials, particularly in burn barrels and open dumps, are major sources of PAHs, dioxins and furans and other toxic pollutants (including heavy metals) to the environment (Scheinberg et al., 2010). In previous studies related to the practices of burning waste materials in FN, there were evidences of high concentration of dioxin and furans (Bharadwaj et al., 2008). Contamination of plant materials within the vicinities where open air burning of wastes took place has also been observed in other areas (Ok et al., 2002).

At certain concentrations, toxic pollutants such as particulate matter, metals, dioxins and furans have the potential to cause harm to animals and humans. In relation to poor solid waste management, airborne emission of dioxins and furans are traced to open burning of waste materials from household sources (Lemieux et al., 2003). In GH and WASS, many household wastes including food scraps, packaging, papers, plastics, furniture, e-wastes, batteries, etc. were subjected to burning. In previous studies, Gullet et al. (2001) and Lemieux et al. (2003) have confirmed the emission of dioxin and furan from smoldering waste material containing paper, food scraps, packaging material, glass wares, leather, metal, etc., from household sources, even when the waste materials are kept in burn barrels. Similarly, a previous empirical study by Lorber and his colleagues has also demonstrated a correlation between dioxins in certain environmental media (i.e. soil, air and ash) and the emissions from burning waste materials (Lorber et al.; 1998). In another study, Gullet and his colleagues further observed that the emission of dioxin and furan can be aggravated when e-wastes are burned in open air (Gullet et al., 2007), as observed in GH and WASS. When compared to emissions from burning household wastes, the emission from e-waste can be up to 100 times higher (Gullet et al., 2007).

Since open burning of waste is common in the immediate vicinities of households in GH and WASS, there are great possibilities of significant risks of human exposure to dioxins and furans and other toxics. The risk of human exposure to these toxics is proportional to the distance of human habitation to the burning areas (Oh et al, 2006; Zhang et al., 2014). In reference to CCME's guidelines, the maximum acceptable concentration (MAC) for dioxin and furan is presented as 4 ngTEQ/kg[11] (Bharadwaj et al., 2008). In fact, dioxins and furans above MAC were detected in soil and groundwater samples collected from garbage dumpsites at a FN community located in neighboring Canadian province of Saskatchewan where open air burning of waste took place (Bharadwaj et al., 2008). As such, dioxins and furans values are likely to exceed MAC in places like GH and WASS where open burning of wastes takes place on a regular basis.

4.3.3.1 Unsafe disposal of plastics and other toxic materials (such as e-wastes, tires, lead batteries, etc.).

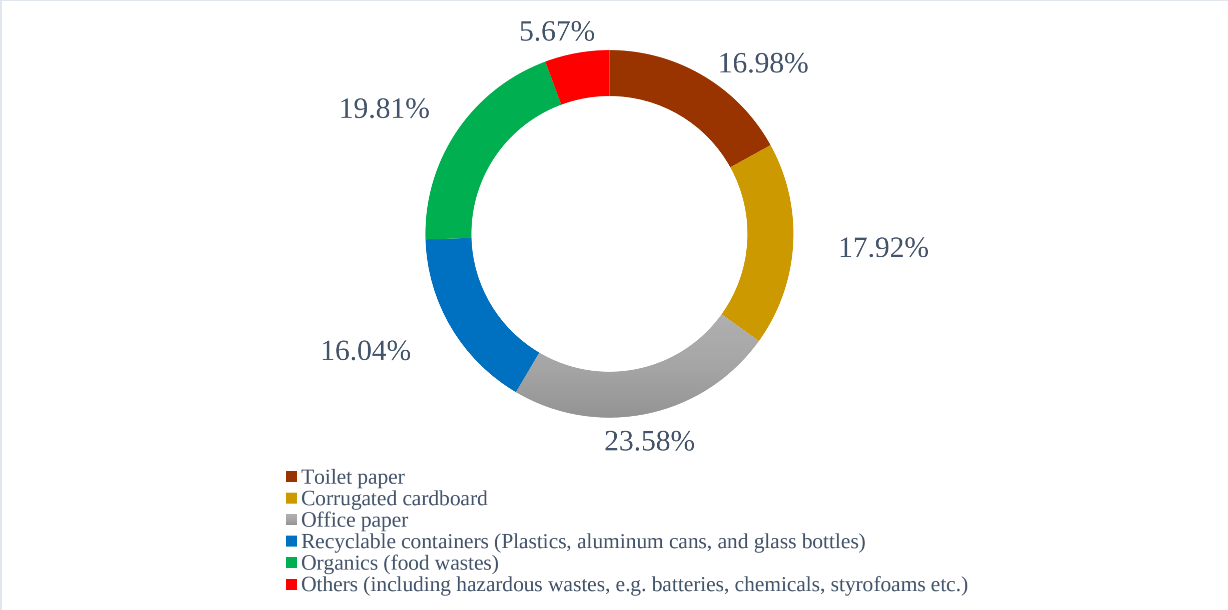

Figure 4.3: Waste composition of George Knott School in Wasagamack First Nation

The high volumes of plastics, rubber and other hazardous materials observed through selected visual audit of household and institutional waste streams in GH and WASS (e.g. Figure

[11] ngTEQ/kg, nano gram Toxic Equivalent per kilogram of soil, is a standard measure for dioxin and furan.

4.3) rendered open air burning and open dumping of wastes to be unhealthy. Plastic materials, for instance, are made from different chemical compounds and additives (Zheng et al., 2005). These plastics emit different toxic fumes when plastics undergo breakdown by burning (Gullet et al., 2007). These toxic compounds, such as polychlorinated biphenyls (PCBs), dioxins and furans, usually require a very high temperature in a controlled incinerator to be partially or completely eliminated from the environment. In the case of open air burning in GH and WASS, the temperatures were relatively low compared to what were required (in controlled incinerator) to destroy the chemical created when plastic burn. Thus, whenever plastic materials are subjected to open air burning in GH and WASS, dangerous chemicals such as sulphur dioxide (SO_2), PAHs, dioxins, furans and heavy metals, as well as particulates (soot and solid ash residues) are released into the environment (UNEP, 2005), as shown in Figure 4.4. These emissions increase the risk of cancer, birth defects and are known to harm the human respiratory and immune systems (Söderström, & Marklund, 2002; Kim et al., 2003). Furthermore, the toxic composition of most waste materials may enter the food chain: affect plant growth, poison fishes and wild games (Raman & Narayanan, 2008). All the aforementioned negative environmental and human health effects of open dumping and open burning threaten the livelihoods of people in GH and WASS.

Figure 4.4: Burning waste at the garbage dumps and yards of homes are common practices in Garden Hill First Nation and Wasagamack First Nation.

4.3.3.2. Risks of forest fires from open burning waste practices.

In GH and WASS, open air burning of garbage took place close to forested areas, thus, the risks of burning waste starting a forest fire was high. Figure 4.5 shows emissions and residual ash from smoldering tires at the community garbage dump in GH. Smoldering waste materials cause unintentional forest fires (Vélez, 2002), which threaten human lives and properties. In addition to pollution from burning waste materials, forest fires have been found to elevate the concentrations of pollutants in soil (Kim et al., 2003). Young residents in the community of WASS, who were volunteer fire fighters, shared experiences of a forest fire incident caused by burning of waste close to forested areas at the garbage dumps. One of the youths described a major occurrence during the summer months when forest plants were dry and highly susceptible to fire:

> *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 and near-misses attributed to open air burning of waste materials have been witnessed on many occasions in the past and in recent times in GH and WASS, according to youths and elders in the communities. Therefore, open dumping and open burning of waste in GH and WASS communities fueled and/or intensified the occurrence of forest fire, in turn, threaten the existence of lives and properties in the communities.

Figure 4.5: Smoldering waste tires, batteries and other hazardous waste on garbage dumps are common sights in Garden Hill First Nation and Wasagamack First Nation

4.3.4 Hazardous and plastics waste in FN waste require better management approaches.

In the past, FN people in GH and WASS had dumped and/or burned their wastes in open pits with limited environmental and human health impacts, due to materials being organic and non-hazardous rather than industrial products that contain hazardous materials (as illustrated in Figure 4.6 below). When asked about how people in GH and WASS communities disposed of solid wastes in the past, many elders disclosed that waste generation was minimal and comprised mainly of food scraps from plants and animals gotten from the land.

> *In those days, we only took from the land what we could consume at a time. There was no room for waste. Even the few wastes that we generated were either buried in the ground, kept for other purposes, or set on fire... food left-overs thrown to the dogs or into the river for the fishes to feed on.*

One of the elders recalled:

> *My parents used to dig holes in the ground and asked us to bury our waste materials, which were mostly plant and animal remains.*

Yet another elder contributed to the discussions on past waste disposal in GH and WASS:

> *In the past, when my father was young, he had said to me that if there were any garbage, they would bury it in the ground, and they didn't have that much garbage because they didn't get much from the stores. They mostly fed from the land. Whenever they killed an animal, they usually knew exactly what to do, they buried the remains and didn't produce much garbage. But nowadays, you see more garbage like cans, plastics, and other materials used for the containment of food and other things that we buy at the northern stores. It is not healthy for our people because it contaminates the earth.*

However, due to changes in consumption patterns in GH and WASS over the years, as well as changes in the types and volumes of wastes generated, traditional disposal practices are no longer safe and effective. To buttress this point of view, the Assembly of FN[12] on the issues of waste

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[12]Assembly of First Nations (AFN) is the umbrella body of all 634 First Nations communities in Canada. The headquarters of the AFN is located in Canada's capital city of Ottawa. (See more at http://www.afn.ca/index.php/en/about-afn/description-of-the-afn)

management in FN communities have recognized the environmental threats posed by changes in the dynamics of waste generation in FN communities from natural materials in the past to industrial products in present days:

> *Historically, waste presented little difficulty for First Nations as they relied on natural materials that were easily disposed of and naturally recycled back into the environment. The nature of waste has changed significantly, however, and now presents many challenges in some First Nations communities* (Assembly of First Nations [AFN], n.d.)

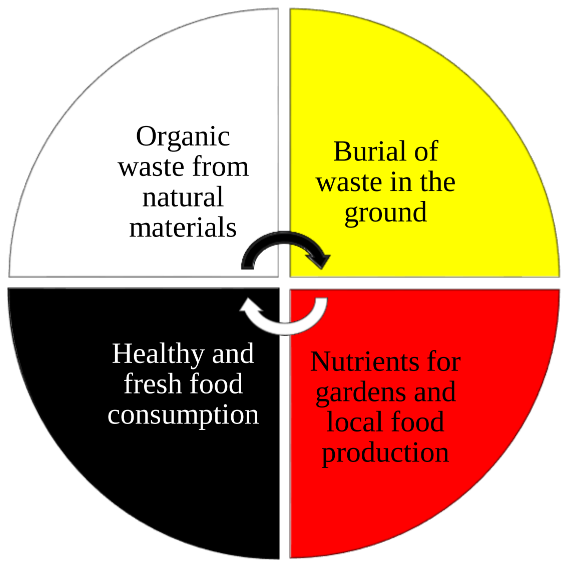

Figure 4.6: Historical cycle of waste material flow in Garden Hill First Nation and Wasagamack First Nation

Many of the solid waste problems in GH and WASS were from burning or open dumping of packaging materials, beverage containers, disposable food containers, plastic bags and hazardous wastes such as e-waste and abandoned vehicles (ELVs). The increased consumption of processed and packaged store-bought (or market) food contributed to a drastic increase in the volume of waste generated over the past few years, community members revealed. Some people in the communities believed that the decline in the consumption of healthy traditional (or country) food and absence of clean running water contributed to high consumption of packaged food materials, such as soft drinks and chips, which in turn increased waste generation in GH and

WASS. This community members' perspective triggers a hypothesis of possible correlation between food insecurity and solid waste generation, as illustrated in Figure 4.7 below.

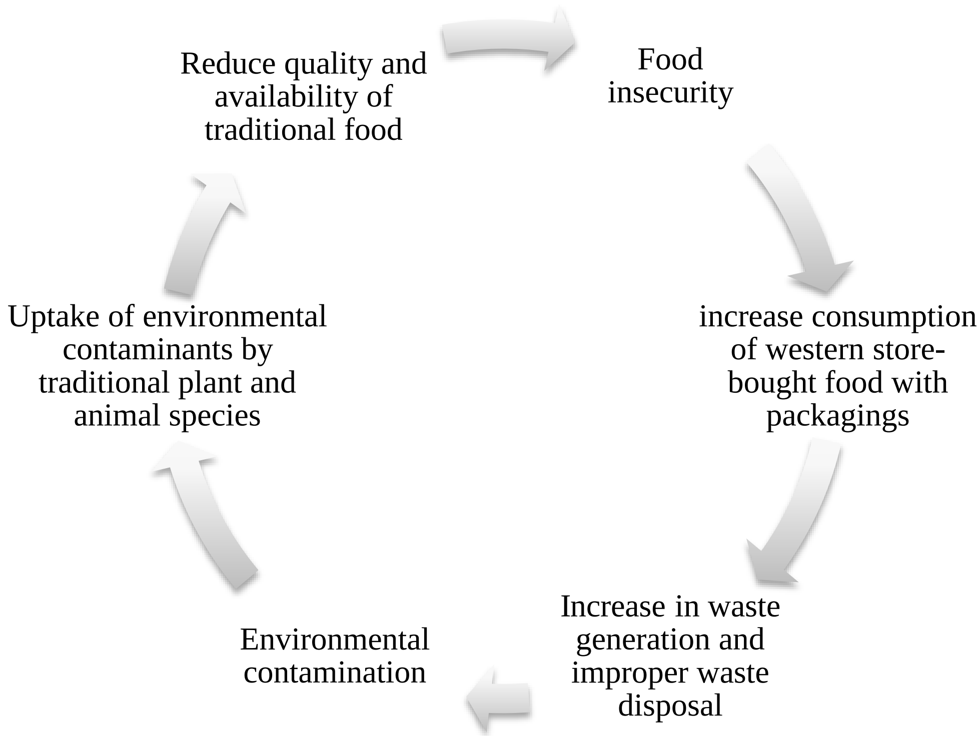

Figure 4.7: Food insecurity as driver of waste generation in Garden Hill First Nation and Wasagamack First Nation

Food insecurity for FN people in GH and WASS depicts a situation where access and availability of socio-culturally and nutritionally appropriate food are limited by social, cultural, economic, environmental, and political constraints (Fieldhouse & Thompson, 2012). In the times past, community members in FN communities, including GH and WASS, depended on traditional (or country) food[13] harvested through gardening, hunting, gathering and fishing for healthy living, but, myriad arrays of factors conjoined with the yoke of colonialism have changed the food consumption pattern to costly, limited choice, low quality and unhealthy store-bought food

[13] Country food (or traditional food) are food from plant or animal sources gathered from local stocks (Fieldhouse & Thompson, 2012)

(Lambden et al., 2006; Fieldhouse & Thompson, 2012). In fact, empirical evidence has demonstrated the relationship between the pattern of food consumption and health outcomes in a Canadian Ojibwa-Cree community (Gittelsohn et al., 1998). Store-bought foods are usually fortified with industrial based ingredients in both the products and packaging, making store-bought foods socially, culturally, nutritionally and even environmentally less beneficial for FN compared to traditional food obtained directly from the land (Lambden et al., 2007). As against store-bought foods, traditional foods are characterized as "natural and fresh, tasty, healthy, inexpensive, and socially and culturally beneficial" (Lambden et al., 2007, p. 308). Privy to the issues of waste generated from packaging materials associated with store-bought foods, one of the community members on two different occasions opined:

> *Back then, we used to go camping out in the bush, fishing, hunting, berry picking, gathering medicinal plants, trapping, rabbit snaring etc. There were no grocery stores around the community. Not much packaging...Nowadays, not many people feed off the land, almost everyone buys food at the store across the lake and brings home plastic packaging and other junks that they throw in the garbage… that's why we have so much garbage around.*

> *For the past 10 years* [or over]*, it's been garbage all over the place especially shopping bags and food packaging. Whenever we go to the store- the northern store- they give out shopping bags that says 'Northern'. In a single day they give away hundreds of those bags to customers. People just throw everything in the garbage.*

As is noted in Figure 4.7 above, improper disposal of packaged store-bought food leftovers may cause environmental contamination, in turn, limits the access, availability and quality of certain traditional food species. Environmental contamination from local and remote sources, including waste dumpsites, have been highlighted in previous research in northern Canadian communities as one of the factors that affects quality and availability of traditional food systems (Lambden et al., 2006; Lambden et al., 2007; Seabert et al., 2014). Effects on traditional food species such as abnormalities in sizes and physical appearances, less animals to harvest, contamination of traditional food ("*animal sicker because of contamination" …. can't be picked due to sewage*") and changes in responses and tastes ("*fishes don't taste the same*") were of significant concerns (Lambden et al., 2007, p. 314). Besides, traditional plant species can uptake metal contamination from soil, in which sources of such contamination are attributed to anthropogenic activities including waste disposal (Cui et al., 2004). A community member from WASS voiced her concern about the negative impacts of waste disposal on the availability of some traditional food in the communities:

> *A long time ago, we used to pick berries and some medicinal plants within and around the community. Nowadays, there is garbage everywhere. So we have to walk very far from the community to go get berries.*

Today, the decline in the consumption of traditional food is one of the causative factors of food insecurity and health complications in northern Manitoba FN communities including GH and WASS (Harvesting Hope Video, 2011). Some community members in GH and WASS suggested that reverting to traditional food systems could be a way for the communities to reduce waste and prevent pollution in the communities. Figure 4.8 below shows the researcher preparing traditional food and learning from elders in WASS.

Figure 4.8: Elders in Wasagamack First Nation shared knowledge about traditional food and waste management

4.3.5 The practices and steps contributing to waste problems in GH and WASS.

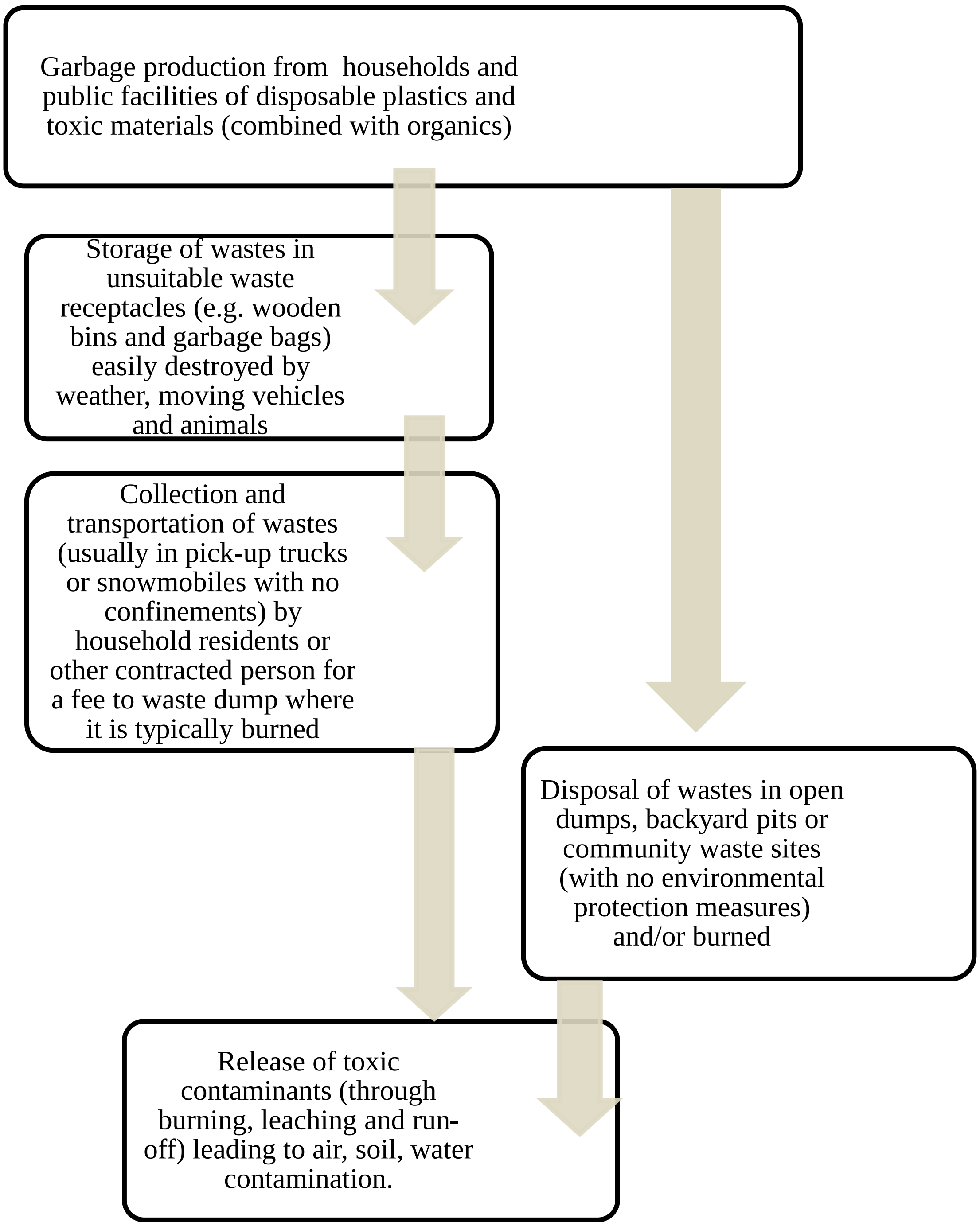

Figure 4.9: Present flow of waste and its contamination in Garden Hill First Nation and Wasagamack First Nation

4.3.5.1 Solid waste storage: lack of adequate waste receptacles for storage of waste generated in the households.

As for waste storage in GH and WASS, most of the garbage storage receptacles found in many community households were locally constructed, low-budget bins made of wood materials. Wooden bins or boxes were the most widely used garbage storage containers especially in WASS. Many households in the community built wooden bins in front of their homes. The size of the wooden bins was relative to the size of the household for which the bins were constructed. However, the situation was different in GH because most of the households did not have containers to store wastes. Rather, wastes were stored in plastic bags, cartons or garbage bags and placed outside the homes.

Figure 4.10: A community member disposing of household waste in a wooden container constructed outside his home

Figure 4.10 shows a community member dumping a bag of garbage into a wooden waste bin fixed outside his home. Proper waste storage containers, combined with pick up service of waste would improve sanitation and waste management in GH and WASS communities. Unlike the regular plastic waste storage containers widely used elsewhere, wooden bins absorb water, which makes them fragile and reduces their longevity. Community members revealed that these wooden bins were often destroyed by moving vehicles and extremely cold weather conditions. Therefore, community members spent extra money to replace the wooden bins. Also, the garbage bags and to a lesser degree the wooden bins were an easy target of stray dogs, bears and other animals in search of food. Domestic and wild animals are attracted to food materials from garbage disposal areas (Rogers et al, 1976; Richardson and Whitney, 1995; Pal, 2003; Klimpel et al, 2010). Stray dogs, for instance, were visible around garbage receptacles and open dumps (see Figure 4.11). In addition, several community members attested to the frequency of bears and wolves in search of food around waste bins and waste disposal areas.

4.3.5.1.1 Wild animals in search of food encroaching the community due to lack of proper garbage storage and disposal, leading to safety concerns

Stray dogs' (or owner-less dogs)[14] populations were said to be on the increase in GH and WASS and fed primarily on human garbage, according to community members. The increase in the population of stray dogs in communities has been associated with the availability of food from human garbage (Klimpel et al., 2010). In addition to open dumping of garbage by people in GH and WASS, stray dogs contributed to the littering of waste materials around the communities. Stray dogs are host to many zoonotic parasites that can easily be transmitted to humans (Klimpel et al., 2010). Human interaction with infected animals can increase the rate of transmission of diseases (Klimpel et al., 2010). Protozoan parasites, such as *Toxoplasma gondii,* can be transmitted to humans through contacts with stray dogs (El Behairy et al., 2013). In addition, diseases vectors

[14] Stray dogs (scientific name *Canis familiaris*), are free ranging or owner-less dogs.

such as ticks, fleas and mosquitoes may also transmit diseases from host animals to humans (Ostfeld & Holt, 2004). An elder from one of the communities commented on the population of stray dogs in the communities and the impact on waste disposal:

> *There are so many stray dogs in our communities, they are always looking for what to eat and following people around. Sometimes they get violent and attack people. Look…the dogs scatter garbage all around the places and create a big mess all over. Also, most people do not store their garbage properly and this makes it easy for the dogs to get to the garbage.*

Wildlife, such as black bears, and vermin, such as rodents, are also attracted by human garbage to places where people live. Black bears (*Ursus americanus*), for instance, travel long distances in search of food (Noyce and Garshelis, 2011) and it is considered normal for bears to pass around human neighborhoods to get nutritious food (Gunther, 1994; Davis et al., 2002). Once a bear gets a taste of human garbage, the tendency of returning to the same area is most likely (Davis et al., 2002). Poorly managed dumping areas and household waste receptacles attract bears like flower nectars attract bees and butterflies. Human-bear conflicts are common in North America as a result of garbage/food attractant mostly in the summer (Spencer et al., 2007). In addition, many of the community members in GH and WASS expressed safety concerns due to the frequency of black bears at the garbage dumps and around households especially during the summer months. For example, a youth in one of the communities stated:

> *In the summer time, when you go to the garbage dump, you will see adult bears roaming around with their cubs. They are probably looking for something to eat after a long rest period. It is dangerous to stay around these areas during those period for fear that they might attack. Although I don't think anyone has ever been attacked but people are frightened by their presence. A bear is a very huge animal and can inflict a huge injury on people.*

There were safety concerns related to bears roaming around community waste sites in GH and WASS. Bears (*Ursus americanus*) are generally non aggressive to humans but when human-bear conflicts occur, the chances of physical injury and or death to either creature are highly probable

(Campbell, 2012). Therefore, managing human-bear conflicts vis-à-vis proper waste management is crucial to ensure human safety and bear conservation in GH and WASS (Gunther, 1994; Spencer et al., 2007).

Figure 4.11: A stray dog wandering around a wooden waste container: wooden bins are easy to construct locally but are fragile and easily destroyed by weather and animals in search of food.

On keeping wild animals away from the communities in the past, community members in GH and WASS disclosed the existence of such proper waste disposal practices. One of the elders in the communities stated:

> *My parents used to tell us to put away our food waste or bury them. I think this was done to prevent wild animals, especially bears and wolves, from our homes and camping areas.*

Today, waste generated in the GH and WASS included hazardous materials that may result in harm to animals that forage in the areas. Foraging on strange diet including waste can cause health concerns for animals (Davis et al., 2002; Noyce & Garshelis, 2011). Possible health problems to animals may include dental disorder, bruises and cuts, intestinal damages from consuming sharp objects in the garbage, plastics blocking the intestines, and ingestion of toxic chemicals (Davis et al., 2002). Bears, birds, moose, fishes, beavers, and rabbits were common animals mentioned in GH and WASS communities. These animals (some of which form part of the local traditional food systems) are susceptible to the negative effects of improper solid waste management, a community member disclosed.

4.3.5.2 Solid waste collection and transportation: absence of door-to-door/curbside waste collection services and formal/informal recycling services.

In both GH and WASS, there were no centralized door-to-door or curbside waste collection and disposal systems, which implied that individual households were responsible for waste collection and disposal in whatever convenient manner. Some community members hauled their own garbage with pick-up trucks or snowmobiles (in the winter) to the community garbage dumps. Community members in GH and WASS who had no means of transportation pay as high as $10 to hire private hauler (or taxi) to dispose a bag or full load of garbage, or $100-$200 to haul piles of garbage stored in backyards for disposal during spring clean-up, or rather left to rot in backyard pits due to lack of financial resources to hire a private hauler. Studies have shown that people in disadvantaged areas who had to travel more than 50 metres to access waste collection or temporary disposal facilities are likely to find alternative dumping areas around their households usually in open spaces (Oteng-Ababio, 2010). In fact, the combination of inadequate waste storage containers, door-to-door waste collection systems and a long distance of garbage disposal facilities from households may militate against proper waste disposal (Ampofo et al., 2015) as witnessed in GH and WASS. In GH and WASS, band council administrators from both communities revealed that several attempts to establish centralized waste collection systems had taken a negative toll on their limited finances. Thus, prompted the necessities to scrap such programs amid debts and many pressing social needs in the communities. In general, there were major concerns associated with improper waste storage, collection, transportation and disposal in GH and WASS, in which the impending health risks to children were some of the main areas of discourse.

4.3.5.3 Solid waste disposal: the absence of properly sited, engineered sanitary landfills that meets government standards and non-existence of recycling services.

As aforementioned, solid waste disposal in both communities included backyard pits, open dumps along the roads as well at the community garbage dumpsites. Field visits to the garbage dumpsites in GH and WASS revealed that the sites did not meet standards for siting waste dumps. The garbage dump at GH was less than 100 metres uphill from a creek, and so runoff ends up in the surface water. Similarly, WASS garbage dump was 200 metres uphill from a pond, so that run-off lead directly to it. Source water protection plans were clearly not considered during the siting of the dump and water contamination was inevitable. The siting of the waste dumpsites in GH and WASS broke the following standards according to *Manitoba Waste Disposal Ground Regulations* under the *Manitoba Environment Act 1991*, as highlighted in Table 4.1 below:

Table 4.1: Guideline for siting and operation of waste dumpsite compared to community dumpsites

Manitoba Waste Disposal Ground Regulation	**Garden Hill First Nation**	**Wasagamack First Nation**
1) at least 1000 meters from surface water	Close proximity to nearby creek located less than 100m downhill with runoff from the waste dumpsite, based on slope, ending up in the surface water less than 500m downhill.	Pond located less than 200m downhill with runoff from the landfill, based on slope, ending up in the water
2) at least 100 metres from any public road or railway, excepts the access road to the waste disposal ground	Public road passes through the waste dumpsite	Public road less than 100 metres away from the waste dumpsite
3) at least 400 metres 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 meters in height	No fencing or any barrier at the waste dumpsite 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 15centimeters in thickness and leachate collection	No covering and leachate collection at the waste dumpsite	No cover and leachate collection at the waste dumpsite

In addition, GH waste dump has a major thoroughfare in the middle of the dump with vehicles running in the middle in order to get to the gravel pit, golf course and neighbouring communities. People working at the gravel area ended up driving through the dump at least four times a day and often much more. Thus, there were great concerns for direct human exposure to toxics contaminants. Potentials for surface water pollution from leachates through surface run-offs especially during ice break ups in the spring was also evident. The fencing constructed at the WASS active dumpsites to prevent encroachment of wild animals and uncontrolled public access was dilapidated. In GH, no such barriers existed and thus allowed unrestricted public access and the free movement of wild animals in and around the garbage dumps. As a result, wild animals came in close contact with people, creating safety concerns in the communities. The absence of onsite operations at the garbage dumps in GH and WASS were also evident. There were no trained personnel to monitor waste disposal activities at the garbage dumps to ensure proper disposal and confinement. Thus, people in the communities freely dumped and burned their garbage anywhere within and around the dumping areas. Environmental protection measures were not in place to prevent pollution from the dumpsites. There were no properly engineered liners, leachate collection system or daily cover to minimize environmental contamination from the garbage sites.

4.3.6 More sustainable solid waste management options for the communities.

In order to reduce waste generation and prevent pollution from solid waste disposal, recycling is thought to be one of the most favorable waste management options having less environmental impacts (Pichtel, 2014). However, there are no recycling facilities in the communities of GH and WASS. Even though stewardship programs that support recycling, such as *Recycle Everywhere,* exist in other places across the province of Manitoba, especially off-reserve communities. Oppositely, GH and WASS were described by community members as *Recycle Nowhere*:

> *Anytime I go to Winnipeg, I see these garbage bins with recycle everywhere. In our community, there is nothing like recycling anywhere around.*

This analogy of recycling as being one-sided does not by any means denigrate the efforts of provincial waste management stewards, but calls for a more equitable and altruistic program that involves the participation of each and every communities and across divides. Valdivia (2010) in a thesis on *Organic Waste Management in Manitoba* recognizes that remote communities, such as GH and WASS, may not be able to support certain waste management programs, albeit from an economic point of view. Valdivia (2010) also noted that a community-based strategy may be plausible with immense support from the provincial government.

The key player and main source of garbage in the communities is the local grocery store department known as the Northern Store (owned by The Northwest Company). On this note, one of the band office administrators in WASS blamed the lack of recycling initiatives in the communities on the store owners, for their negligence and lack of corporate responsibilities and environmental stewardship. In this regard, the community member believed that the store owners had a responsibility to take back the wastes generated from the items sold to consumers in the communities, quoted as follows:

> *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.*

Environmental stewardship is one important aspect of corporate responsibility or strategy that firms, such as the Northern Store, operating in GH and WASS communities should normally uphold in pursuant of standard practices (e.g. ISO 14001). ISO 14001 is a certification initiative by International Standard Organization (ISO) that improves the reputation of a company as environmental stewards and respecters, rather than polluters, of the land (Berliner & Prakash, 2013). Solid waste experts have agreed that product distributors have a major role to play in recycling of wastes (Joos et al., 1999). Since the northern stores and many off-reserve contactors working on reserves regularly ship in items to the communities with haulage trucks returning empty, GH and WASS should at least be able to benefit from backhauling to ship out recyclables and hazardous wastes from the communities, albeit many of these waste materials emanate from the activities of these contractors. The Northern Store as the key player in waste generation should be required to have biodegradable bags and do deposit return so that all bottles and cans as well as other recyclable items are returned for recycling. Deposit return is an effective method to boost the collection and recycling of waste materials including toxics (Joos et al., 1999).

Whilst discussion on the solutions to the unsafe disposal of solid wastes in the communities ensued, community members agreed that the introduction of recycling and a ban on burning of garbage would help to reduce pollution in the communities. According to one elder:

> *……. 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. We need to recycle especially cans, plastics and papers 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 centre and proper incinerator for garbage that can be burned.*

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.*

Moving away from current practices where almost all of the waste generated are disposed in open areas or garbage dumps to waste reduction strategies vis-à-vis source reduction, re-use and recycling will help the communities deal with the myriad of problems associated with solid waste management. There is a general willingness amongst community members in GH and WASS to participate in recycling programs, if provided with necessary support and resources, according to the community youths. Figure 4.12 below shows youths in WASS community who voluntarily collected and sorted recyclable materials but lack the necessary incentives to ship out for recycling. Moreover, studies have shown that access to recycling facilities is a major determinant of willingness to participate in recycling programs (Babooram and Wang, 2007).

One of the biggest recycling challenges arises from the disposal of hazardous waste, such as e-waste and end-of-life vehicles, due to the bulkiness and complexity of the waste stream, absence of nearby recycling facilities and the remote nature of GH and WASS. In essence, the cost required to ship these waste out of the communities may outweigh their actual recycling values. But, the arguments for these communities somewhat incline towards environmental benefit more than economic profitability. In the words of the waste coordinator of Peguis FN community located along the southern area of Manitoba and outside the scope of the study area:

> *Recycling is not helping us economically but we are doing it anyways, because it helps the environment, preserves our community values and makes our community cleaner.*

In Manitoba, there exists 13 product stewardship agencies saddled with the responsibilities for the collection and recycling of different end-of-life products and packaging materials including beverage containers, electronic wastes, tires, batteries, mercury switches, etc. throughout the province (Green Manitoba, 2015). These stewarded products, e.g. plastics, glass, electronics, tires, batteries etc., make up a significant proportion of the waste generated in the communities of GH and WASS. However, none of these stewardship agencies have taken adequate initiatives to address the issues of collection and recycling of their designated products in northern communities, even as members equally pay eco-fees charged on some of these products during initial purchase. It is not to be overlooked that many of these products even sells at extravagant prices in these communities compared to off-reserve communities at relative discrepancies in income levels. It is not known whether this situation could be term environmental injustice, however, a more critical outlook suggests that adding up the environmental levies paid on these items over the years may even be enough to start a comprehensive waste management programs in the communities.

Figure 4.12: Youths in Wasagamack voluntarily collected and sorted a truck load of recyclable waste materials but gets no incentives to ship out for recycling

4.3.7 The hazardous and bulky wastes dilemma.

From personal observations, some of the major solid waste management challenges in GH and WASS were related to safe disposal of hazardous waste including healthcare wastes (HCW), construction and demolition debris, end-of-life vehicles (ELVs) and e-waste. Abandoned ELVs, e-wastes and vehicle parts littered every nooks and crannies of the communities. Since vehicles and electronics, for instance, are manufactured with parts containing noxious chemicals, there are severe threats to the environment from improper disposal at their end-of-life.

4.3.7.1 Health care wastes (HCW).

In GH and WASS, Health care waste (HCW) materials, such as syringes, left-over drugs, wound dressings etc. were observed at the garbage dumps. However, it was also observed that the nursing stations had facilities and designated personnel to collect and store biohazards (especially waste sharps) in a safe manner (see Figure 4.13 below). According to the maintenance officers at the nursing stations, biohazards were usually stored and transported off-site for appropriate treatment and disposal. However, other categories of hazardous HCW, such as pharmaceutical wastes, still find their way into the waste streams.

By virtue of the nature of health care facilities located within the communities, HCW encompass all kinds of waste materials, either solid or liquid, generated during the processes of care for persons (in-patient and out-patient) at the nursing station and dialysis center. It is noteworthy that a large fraction of waste generated in healthcare related activities are from administrative and general housekeeping activities and falls in the categories of general wastes (Pruss et al., 1999). These categories of HCW are non-hazardous and normally should end up in municipal solid waste streams to be recycled, re-used or discarded in landfills (Udofia et al., 2015). However, the smaller fraction that are generated from clinical and laboratory procedures are designated as hazardous or special wastes, and may pose significant public health risks if poorly managed (Pruss et al., 1999). In cases where hazardous HCW are not properly segregated from the non-hazardous, as in the cases observed in GH and WASS, the fraction of hazardous HCW generated in healthcare facilities might become greater as a mix of hazardous and non-hazardous (Udofia et al., 2015). Hazardous HCW are classified as sharps, infectious waste, genotoxic, radioactive, pathological, pharmaceutical etc. and possess one or more of the four characteristics of hazardous wastes i.e. toxicity, ignitability, reactivity and corrosivity, which makes them harmful to humans and necessitates special treatment prior to final disposal (Pruss et al., 1999).

Treatment technologies, such as incineration, autoclaving, chemical disinfection, wet thermal treatment, and microwave irradiation, have been developed to eliminate hazards from HCW (Chaerul et al, 2008). None of these technologies existed in GH and WASS, so some hazardous HCW were temporarily stored in refrigerators prior to being transported off-site for treatment and disposal. In the processes of long term storage and off-site transportation of hazardous HCW, health care workers and other staff at the nursing station are exposed to a significant level of health risks.

Several authors have highlighted the risks and danger associated with exposure to improperly managed HCW (Babanyara et al., 2013; Aghapour et al., 2013). These risks include physical injuries from waste sharps and the transmission of diseases through exposure to pathogens (Babanyara et al., 2013). Young citizens in the communities especially children at play, waste handlers and health workers are the most vulnerable to these risks and have higher chances to contact life-threatening diseases such as hepatitis and Human Immune Deficiency Virus (HIV) (Aghapour et al., 2013). Whilst HIV destroys human immune systems, hepatitis viral infections are linked with liver-related illnesses (Minuk & Uhanova, 2001). Severe Acute Respiratory Syndrome (SARS) is another potential terminal disease associated with improper HCW management (Ephraim et al., 2013).

Hepatitis B virus (HBV) can spread through exposure to blood or fluids from an infected person through various methods which includes exposure to waste sharps. HBV is more infectious than HIV and possesses the tendency to remain outside the body --infectious wastes and sharps in the case of HCW-- for a time period up to 7days or more, that an exposed person might be a pierce away from contacting the virus at 30% probability (Center for Disease Control & Prevention, CDC, 2015; Johannessen et. al, 2000). Thus, HBV constitutes an occupational hazard for health workers and waste handlers in GH and WASS. Annually, it is estimated that thousands of people worldwide contact HIV and millions fall victims of hepatitis infections from unsafe injections (Johannessen et. al, 2000). In Canada alone, more than 70, 000 people are living with HIV (Pittman et al., 2014) and according to a report by the Canadian Liver Foundation (CLF), an estimated 300,000 were infected with HBV (CLF, 2012). About 700 new HBV patients are added to the list of infected persons every year, even though undiagnosed cases are prevalent (Pittman et al., 2014). The HBV virus is said to be common among minority groups in Canada, including indigenous people (Minuk & Uhanova, 2001). Multiple evidences from different places around the world have proven the connections between solid waste management and HBV infections (Dounias et al., 2005; Shiferaw et al., 2011; Marinho et al., 2014; Rachiotis et al., 2012; Corrao et al., 2013). Since traditional practices of open dumping and burial were the most favored options in GH and WASS, improper HCW management cannot be ruled out as a threat to community health.

Figure 4.13: Biomedical material storage at the nursing station in Garden Hill

4.3.7.2 End-of-Life vehicles (ELVs) and electronic wastes (e-wastes).

On a different note, there were no systems in place to appropriately handle e-wastes and End-of-life Vehicles (ELVs)[15] in GH and WASS. For many years, no attempts were made by government agencies to remove these hazardous materials from the communities. Therefore, stockpiles of tires and e-waste, scrapyards of ELVs and other hazardous waste materials have continued to build up in these communities and constituted environmental nuisances. Community members lamented on the increase in the use of vehicles in the communities in recent years and the consequent rose in the number of ELVs littering the area, partly due to bad roads (see Figure 4.14):

> *In the past, not many people in the communities moved around in vehicles as most people walked or traveled around using dog teams and sled. Nowadays, people move in cars and we have many junk cars everywhere.*

In the past few decades, the number of vehicles within GH and WASS communities have increased. Owing to their low average income levels, community members mostly purchased used vehicles, paying one or two thousand dollars for a car, often those without ability to pass safety test and so not drivable in the remainder of the province. Vehicles are transported from their point of purchase into the reserve through the winter roads. The winter road networks open around January and close in early April, depending on weather conditions.

The road networks within the communities were constructed with gravel and usually were in bad states, especially when it rains and during ice break ups in the spring. The ice roads can melt and turn to water and still people have to drive on them. Many of the vehicles owned by people in GH and WASS did not undergo safety assessment and many people drove without insurance nor valid driver's license. The vehicular insurance coverages for people in GH and

[15] An end-of-life vehicles (ELV) refers to a vehicle (car, truck, van, etc.) that is no longer useful to its original owner and is to be discarded as waste or abandoned.

WASS were limited. When vehicles break down, there were few options for repairs due to the limited technical abilities of the owners and local repairers and no mechanical shop to get spare parts. These factors limited the life span of vehicles in the communities and resulted in an increasing number of ELVs (or abandoned cars). Community members revealed:

> *When you bring vehicles into the communities, they end up as junks in no time because the roads are bad and we don't have trained technicians to repair 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*

Figure 4.14: Bad roads shorten the lifespans of active vehicles in the communities

Many people in the communities abandoned faulty vehicles on the reserves to purchase another used (mostly unsafetied) but cheap one and the cycle was rapidly repeated. A reconnaissance survey of households revealed an average of two to three ELVs in the yards of every home. There were many locations where ELVs were abandoned near roadside, and dumped in the woods and around surface water features where drinking waters were fetched. In addition to abandoned vehicles, white goods and other electronic wastes were sighted around open dumps and yards of homes in the communities. These scenarios release toxic chemicals into the environment and impacts health and safety in the communities. Community members in both GH and WASS were deeply concerned about the environmental problems posed by hazardous wastes littering the communities (see Figure 4.15 below) and hoped for intervention to remove the toxic burdens from hazardous wastes around the communities.

Figure 4.15: An end-of-life vehicle floating on the lake in Wasagamack First Nation

A community member stated:

> *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.*

Another community member showed concern about the potential impacts of ELVs 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.*

Figures 4.16 below shows young children playing in ELVs abandoned around their homes. Children in the communities are exposed to health and safety hazards from improper waste handling in the communities. Open dumps in their backyard and community expose children and pets to toxic chemicals or biological hazards, which may increase the risk of infections and diseases. Children are likely to be attracted by objects disposed in open dumps and convert them to play materials. Children playing around open dumps come in contact with sharp objects and toxic materials, which may lead to severe injuries. They also face the risk of trip and falls injuries when sliding on abandoned ELV

Figure 4.16: Children at play sliding on end-of-life vehicles abandoned around their homes

Although there are no federal or provincial regulations specified for ELVs management, but some hazardous components of ELVs such as waste tire, anti-freeze, used oil and batteries have been designated under stewardship programs in Manitoba. None of these agencies have established presence in GH and WASS, where the environmental impacts were observed to be devastating. A community member in GH referred to abandoned ELVs lying around every corner of the community as *million dollar junks,* which caused blot of the landscape and concerns over environmental contaminations, but could be recycled for profit (see Figure 4.17). While a vehicle may have reached the end-of-life stage, many parts such as tires, seats, wind screens, batteries and parts can still be recovered for remanufacture or re-use (Harraz & Galal, 2011). In addition, raw materials such as copper, lead, aluminum and steel can be recycled (Harraz & Galal, 2011). Thus, the recovery of ELVs from the communities of GH and WASS will bring about healthy communities and provide economic benefits.

Figure 4.17: One of many on-reserve sites in Garden Hill First Nation with fleets of abandoned vehicles covered in snow. *During spring break up and rainy days, hazardous materials contained in these vehicles can be transported through run-offs and contaminate the nearby water bodies.*

4.4 Comparison of solid waste management practices: Canadian FN and developing nations

First Nations people compared to other Canadians, live in a state of under development of human resources (Cooke & O'Sullivan, 2014; Wong et al., 2012). FN communities have similar levels of poor development as those in low income countries as indicated by disease prevalence (Ospina et al., 2012), drinking water quality and sanitation (Patrick, 2011). Wong (2012) found that the socio-economic status, low human development index and corruption in FN communities are similar to that of poor communities in developing countries.

Poor solid waste management in FN communities relates to the underdevelopment in these communities (Wilson et al., 2012). As in many communities in developing countries, most people in FN live below the poverty line and cannot adequately meet their own needs (Wong, 2012). Solid waste management in FN communities is as bad and possibly worse than that in the third world (or low income countries). A comparison of solid waste management studies in developing countries (Owusu, 2010; Arukwe et al., 2012; Ezeah & Robert, 2012) to studies in FN communities

(Bharadwaj et al., 2006; Bharadwaj et al., 2008; Zagozewksi et al., 2011) indicate similar solid waste management practices.

Solid waste management in developing countries and FN communities are characterized by lack of adequate waste receptacles for storage and segregation, lack of a door-to-door collection system, unsafe disposal practices and absence of material recovery facilities, as illustrated in Table 4.1. Moreover, open dumping and open burning of residential wastes in FN communities, including GH and WASS, are being practiced due to absence of local waste collection, similar to in developing counties. Also common in both instances are the lack of clear legal responsibilities and any regulatory enforcement of municipal solid waste regulations (Bharadwaj et al., 2006; Ezeah & Robert, 2012; Arukwe et al., 2012). More often than not, the onerous responsibilities of collection and disposal of municipal solid waste are assumed by local governments, without adequate means to fulfill these responsibilities (Ogwueleka, 2009). In general, local governments in developing countries (Ogwueleka, 2009) and band councils in FN (Zagozewski et al., 2011) do not have adequate financial resources to effectively manage solid wastes within their jurisdictions.

Recently, waste collection has improved in some developing countries due to increasing participation of the private sectors. However, material recovery and recycling facilities are still not adequate in developing countries (Oteng-Ababio, 2010). In FN communities, on the other hand, responsibilities of the various levels of government and stakeholders on waste management services are unclear, which results in waste management being neglected, without any programming, funding or champions in government working with FN to resolve these issues.

In both FN and developing countries, waste results in health, safety and environmental hazards. Unsafe practices, such as open dumping and open air burning, are the most common waste management practices in developing countries, basically following the false belief that “out of sight, is out of mind" (Arukwe et al., 2012; Ampofo et al., 2015). Similar scenarios exist in FN communities across Canada due to poor funding and other factors (Bharadwaj et al., 2006). In cases where there are designated disposal sites, these dumping areas are often unregulated resulting in dumping of hazardous waste practices like burning. These dumping areas typically do not ensure that contamination and waste remains in place, which results in contamination of land, water, wildlife and people in both FN and developing countries (Zagozewski et al., 2011).

However, developing countries may have better rates of recycling and less burned waste than FN remote communities due to their informal recyclers. In the absence of an organized formal sector, waste in many developing countries are typically collected, disposed, recycled and recovered by self-organized informal recyclers known as scavengers or waste pickers (Solomon, 2009). Scavengers can be found picking up recyclables in different places ranging from streets to open dump sites and landfills (Solomon, 2009). The act of waste scavenging is common among the poor and middle-aged men and women, who resort to menial jobs for income generation and survival in the absence of social welfare packages (Solomon, 2009). Although unregulated, scavenging has provided jobs and income for many people in developing countries and is perceived as a means to alleviate poverty, as well as recycling natural resources to provide an environmental good. Different developing countries governments see their value and have been looking at incorporating them into the formal recycling sector (Medina, 2008). Scavenging is not a common phenomenon in FN communities, where many people are unemployed but resort to social welfare packages rather than scavenging to survive.

In general, the present situation of waste management in both FN communities and many communities in developing countries are unsafe and unsustainable. This situation calls for more research in FN communities to ascertain the possibilities of informal recycling, people's willingness to participate in waste management and to document the probable health and environmental impacts related to unregulated waste disposal activities. There is also an urgent need to explore better management options to minimize human and environmental impacts associated with improper handling of waste as observed in developing countries.

Table 4.2: Characteristics of solid waste management in First Nations and developing countries

Features	Canadian First Nations	Developing Nations
Waste Storage	Waste generated is stored in wooden bin and garbage bags that are easily destroyed by animals, moving vehicles and weather.[1]	Some households have proper waste storage. However, proper waste storage receptacles are absent in many cases.[2,3]
Waste Collection and transportation	No organized waste collection. Residents are responsible for transportation of their own waste in their own vehicles, which are not designed for that purpose to disposal sites. Many people do not own a vehicle and the bad roads to dump require a truck.[1]	Organized informal door-to-door collection or collection by government and private contractors. However, many areas lack adequate waste collection worsened by bad roads and other infrastructural deficiencies.[2,4,5]
Waste disposal	Open dumping, burning in open spaces and burn barrels, dumping of sewage and non-engineered landfill sites.[1, 6]	Open dumping and burning of garbage on roadsides, bushes, and open pits and non-engineered landfill sites [4,5,7]
E-waste management	E-wastes are not collected for recycling. E-waste materials end up in open dumping areas and are typically burned alongside household wastes, releasing toxic chemicals. [1]	Poorly regulated collections and recycling. recycling is usually done by informal recyclers in crude manners with serious health and environmental implications[8]
Waste segregation for recycling	Recycling infrastructure and services exist elsewhere in Canada but lacking in many FN communities.[1]	Recycling are mostly carried out by informal recyclers without safe recycling technologies.[5]
Public health concerns	High levels of dioxins, furans, PAHs and heavy metals have been attributed to open burning of wastes, including e-wastes.[9]	Release of contaminants into the environment have been attributed to poor waste management by open burning and open dumping.[7]
Education and awareness	No public education program on waste management.[1]	Public education programs on waste management are available but inadequate.[10]
Funding of waste	Poor funding to meet requirements or provide pick up and dedicated	Poor funding due to other competing needs in a high poverty situation.

management infrastructures	work. No dedicated funds for waste management so funding shifted to housing or other immediate needs in a high poverty, high need situation. [1, 6]	Corruption also hinders the appropriate disbursement of funds for proper waste management. [5, 10]
Legislative barriers	Dumps rather than landfills constructed and sited without meeting regulations. No requirement for waste management plan. [1]	Dumps rather than landfills constructed without meeting environmental and public health regulations. Requirement exists for waste management but poorly enforced.[2,3,4]
Jurisdiction barriers	Provincial responsibility for product responsibility and federal responsibility for waste on reserve. Other provincial regulations do not apply on FN reserves[11]	Unclear roles and responsibilities of various levels of government and other stakeholder in solid waste management [10, 12]

[1] Field study, [2.] Parrot et al., (2009); [3.] Ampofo et al., (2015); [4] Ogwueleka, 2009; [5] Oteng-Ababio (2012), [6.] Bharadwaj et al., (2006), [7.] Arukwe et al., (2012), [8.] Sullivan et al., (2014). [9.] Bharadwaj et al., (2008). [10.] Ezeah & Robert (2012), [11] Zagozewski et al. (2011), [12] Guerrero et al., (2013)

4.5 Some identified barriers towards implementing proper solid waste management systems in GH and WASS

Solid waste management in GH and WASS suffers from multiple financial, social, institutional, legal, and physical constraints, which include but are not limited to poor funding, weak legislation, poor or non-existent infrastructure (e.g., lack of landfill, waste trucks), lack of trained waste workers or handlers (no worker is paid to be responsible for waste), insufficient environmental awareness program among other factors. These constraints do not provide an enabling environment for proper solid waste management services in these communities.

4.5.1 Inadequate funding and limited capacities.

Waste disposal areas and other waste management services are not well funded and/or managed properly. Environmental pollution through unsafe waste disposal behaviours are likely to occur (Ampofo et al., 2015). There were cases in GH and WASS where community members dumped and burned waste in open areas due to limited budget, no access to a vehicle and lack of resources required to safely dispose of wastes in environmentally friendly and socially acceptable manners. In terms of fiduciaries, the communities receive a larger percentage of their revenues from federal government funds channeled through the AANDC. Funding for critical public services in GH and WASS communities are usually based on a quota system determined by the AANDC (CEO WASS, personal communications, 2015). Literally speaking, FN communities are underfunded and the level of accountability is very poor (Wong, 2012).

Regarding funding for waste management services in FN communities, there is no amount specified for funding being allocated to communities by the AANDC (Bharadwaj et al., 2006). Related funds usually fall under allocations for operations and maintenance (O&M) of community assets and infrastructures, which may include the maintenance of waste collection system and garbage dump sites (Aaron, personal communication, 2015). Considering many pressing and immediate needs, such as housing and medical care, in a high poverty situation, it becomes very difficult or rather impossible for GH and WASS to adequately fund a proper waste management program. Presently, both GH and WASS communities have budget deficits, with community funds falling short of expenditures, without the ability to get loans to service accrued debts (CEO WASS, personal communications, 2015). FN in debt are third party managed, meaning that the federal government requires that they spend a large percentage of their funding to have an outside accounting fund manage their funding.

> *Our* [community] *funding system is not up-to-date; I don't think the federal government* [AANDC] *considers certain factors such as an increase in population to allocate funding to our communities. They still use the old quota system. Every year, we run into debt. There are so many things we need to take care of especially the problems of overcrowding in our houses. Many people in the communities don't have jobs and we need to provide some form of social assistance. So there is nothing or little we can do with regards to our waste management services.*

As a result of poor funding, waste collections services and trained waste experts were lacking in GH and WASS. In that case, waste disposal had to be carried out by community members in any way they could manage, which typically resulted in backyard burning or dumping along road-sides and near water features.

4.5.2 Weak legislative mechanisms.

Significant gaps in environmental protection exist for FN people living on reserves compared to other Canadians living off-reserve (Mackenzie, 2013). The federal government does not take matters concerning the environment as serious in FNs reserves as elsewhere in Canada (OAG, 2009). The Canadian federal laws concerning the protection of FN's reserve lands are insufficient compared to provincial legislations that govern the protection of off-reserve areas (Mackenzie, 2013).

The *Indian Act* is the federal law that regulates activities concerning FN peoples and the legal mechanism that governs the use of FN reserves in Canada (Simeone, 2001). Under the *Indian Act,* the regulations related to waste disposal on FN reserves are the *Indian Reserves Waste Disposal Regulations*[16] (Department of Justice, 2015). Although some FN communities have passed additional bylaws on waste disposal, limited enforcement, occurs under the *Indian Act*. Enforcing bylaws and monitoring illegal dumping is an issue for FNs because most bands do not have the dedicated resources to proceed with regulatory enforcement (personal communications, 2015). Moreover, FNs do not have the full autonomy to enact laws because by-laws are subjected to scrutiny and approval by the minister of the AANDC. Thus, if GH and WASS communities decide to proceed with the process of making a bylaw and the federal government disapproves,

[16] see http://laws-lois.justice.gc.ca/eng/regulations/C.R.C.,_c._960/

such laws may be stalled and one begins to question the options for FN in terms of self-governance capacity and environmental protection. Moreover, the AANDC have not done enough to communicate and enforce existing federal laws and programs in northern communities, including GH and WASS, where access to information is limited due to remoteness and limited bandwidth for internet.

Most people living on the reserves are not aware of the existence of the *Indian Reserves Waste Disposal Regulations* and other legislation related to FN environmental governance. Public opinions among community members in GH and WASS were consistently the lack of awareness and communications about existing laws. One of the community members stated that:

> *I am not aware of any law on garbage disposal and I am sure most of our people are not aware of many government laws except the ones established within the community.*

The practices of open burning of wastes were not considered a serious offence by community members in GH and WASS. Consequently, garbage sites are not confined to licensed landfill sites and there are no systems in place to monitor the impacts on the environment including drinking water sources and air quality in GH and WASS. As well, the domestic waste collection in GH and WASS suffers from the absence of a legal mechanism, which are needed to regulate the storage, collection, transportation and disposal of waste materials. For instance, a community member who disposes of waste indiscriminately by the road-side is only morally indulged to practice otherwise, but not legally controlled. Off-reserve contractors and private firms who worked in GH and WASS reserves have been able to exploit loopholes in environmental legislation to indiscriminately leave behind waste from their operations in GH and WASS without penalties e.g. Arnason, a contactor in GH and WASS, was purported to have dumped waste from an old mining operation at the garbage dump in GH (Community member, personal communication, 2015). While off-reserves laws, such as the *Waste Reduction and Prevention Act* and other regulatory mechanisms may help to improve solid waste management on reserves by providing some funding for programming, programs established under these regulations do not provide waste management set-up and implementation costs, which means they are often not in place on reserve.

4.5.3 Jurisdiction.

There are no waste reduction and pollution prevention policies in GH and WASS and the only options for people are to dump and burn their waste, which imposes grave environmental consequences. FN communities in Canada fall through the cracks between two-tiers of government i.e. provincial and federal jurisdictions. In the case where the use and development of FN lands are officially the responsibility of the federal government and solid waste management falls under provincial responsibilities, there are possibilities of overlap in public service delivery and jurisdictional responsibilities. Whilst some FN have taken full control over activities on their land based on self-government agreements like the *First Nations Land Management Agreements* (Zagozewski et al., 2011), others, including GH and WASS, are not fully autonomous.

As aforementioned, the federal government, through AANDC, is in charge of waste disposal on reserves under the regulations governing FN (Department of Justice, 2015). Many waste management programs are managed under provincial laws, which normally do not fall under FN jurisdictions. Environmental laws enacted within provincial jurisdictions, which governs how people use the land, often have no legal application on FN reserves (personal communications, 2015; CBC News, 1999). In fact, certain difficult-to-meet conditions have to be satisfied for provincial laws to have any legal significance in any sector on FN reserves, except education (Simeone, 2001). Even at the level of education, there have been issues around federal-provincial policy trend not being able to address FN needs (McCue, 2004). Therefore, the dialogue on who is responsible for initiating and funding waste programs on FN reserves ensued during the course of this study. Moreover, FN people on reserves, like other Canadian citizens, pay these eco-fees when they purchase stewarded products such as packaging and electronics etc. under provincial regulations, but do not get any service in return. That they are paying for services they are not receiving provides inequitable services for FN people on reserves in northern Manitoba compared to off-reserve communities.

4.5.4 Absence of community participation, education and awareness.

Community participation in solid waste management influences its level of efficiency and effectiveness. The level of people's awareness affects their willingness to partake in safe waste management practices. Thus, the objectives of environmental education are to enhance people's level of awareness, sensitivity, attitude, skills and participation on critical environmental issues (Hungerford and Volk, 1990). Generally speaking, environmental education creates environmentally responsible citizen. In a previous study on waste disposal in FN communities, the existence of ineffective solid waste management in communities were somewhat attributed to the inadequacy in awareness programs (Bharadwaj et al., 2006). In this present study, however, the absence of adequate environmental awareness programs was also acknowledged by community members in GH and WASS as a contributing factor to unsafe waste disposal behaviors of many people in the communities:

> *Some of our people do not bother about the impact of waste on the environment. Most people do not know what to do with their garbage than to throw it out or burn them because there are no alternatives.*

Whilst a considerable number of community members were aware of the impacts of poor solid waste management, there were no resources, nor funding or incentives and capacities to boost morale towards environmental responsible actions. Education and awareness on health risks of unsafe waste disposal practices and alternatives are the important factors that Zubrugg (2002) argues as necessities for change in people's attitude and behaviour towards waste management. Environmental education enriches people with knowledge that changes their behavior and attitude to make them more sustainable (Pooley & O'Connor, 2000). According to community members from both communities, proper education and awareness programs were opined to be generally low. One of the community participants stressed the need for education and programming on healthy waste management:

> *Our communities need education and awareness on waste especially the hazardous materials. We need someone to go to the schools, health authorities, and the local TV and radio stations. We need a worker and someone who has knowledge about wastes management issues to teach us how to do some things appropriately.*

In addition, inadequate access to information is one of the major community development barriers in these communities. Opportunities to partner and exchange ideas with neighbouring municipalities and communities outside of Island Lake are limited due to isolation and restricted access to information, telecommunication and higher education, without any college education programs on the east-side. Nationwide, about 50% of homes on FN reserves do not have access to the internet (AFN, 2012). The majority of the FN homes with internet services only have access to low-speed internet (National Aboriginal Health Organization, 2008). In Manitoba, the northern communities, including GH and WASS, may perhaps represent some of the most underserved areas in terms of internet services (as well as all other services), which brings about a form of digital divide (Zerehi, 2015). Internet services in GH and WASS are very poor and restrict members of the communities from learning opportunities and networking with experts.

4.5.5 Geographical constraints.

Geographical constraints in many remote places around the globe restrict the options for solid waste management. Waste management options are often limited in remote area, such as islands (Zis et al., 2013). The vulnerability of communities to socio-economic downturn and demographic adversity are directly proportional to its size and geographical isolation (Slack et al., 2003). GH and WASS lack any access to all-weather road and transportation costs are very expensive via airfreight. This transportation impacts the costs of goods and services delivery in the communities. Transportation logistics are usually at the forefront of decision-making on solid waste management challenges in these communities. Without adequate financial support and other supports, the communities cannot offset the cost of sustainable waste management options, most waste treatment and processing facilities are located in the urban centers far away from the communities. In addition, waste collection services in communities may be hindered by the settlement pattern and infrastructural deficiencies. Since the settlement patterns in both communities are scattered, with houses located far from each other, waste collection and transportation within the communities is quite challenging in the face of bad road networks and harsh weather conditions especially during the winter and break-up seasons. On the basis of isolation and poor infrastructures, access to information from outside communities may also be impacted, hence, the opportunities to share knowledge, ideas and resources are limited.

4.6 Summary

Solid waste management activities in GH and WASS were studied to assess their potential environmental and health impacts. Of major concern in the communities were the practices of open dumping and open-air burning of garbage, both of which have been banned in federal regulations. Open dumping and open-air burning as waste disposal methods are considered unsafe and unsustainable (Owusu, 2010). Interviews with community members revealed that GH and WASS problems with waste management included:

i. disposal of packaging and toxic materials (such as e-wastes), many of which should be covered under provincial product stewardship programs but are not covered.

ii. wild animals in search of food encroaching the community due to lack of proper garbage storage and disposal, leading to safety concerns

iii. absence of door-to-door/curbside waste collection services,

iv. non-existence of any formal or informal recycling services;

v. prevalence of open dumping areas and junkyards around the communities:

vi. backyard burning of wastes

vii. the absence of properly sited, engineered sanitary landfills that meet government standards;

viii. water bodies nearby waste dumps, which runoff contaminates;

ix. lack of finances for collection, recycling, landfill operations, education and training or any other integrated solid waste management program; and

x. lack of trained community expert in integrated solid waste management.

Unregulated dumping of waste materials on land and burning in open air expose humans and mother earth to the contaminants in the waste stream and create new contaminants which are detrimental to health and livelihoods in the communities. Uncontrolled disposal and open burning of garbage generate hazardous leachates and toxic gases that pollute the environment, and may also serve as breeding grounds for disease-carrying vectors, such as rats and mosquitoes (United Nations Environmental Programme [UNEP], 2005; Hoornweg & Bhada-Tata, 2012). Children and adults are exposed to physical injuries and infections from sharps and other hazardous materials present in the waste stream. Therefore, solid waste management practices in GH and WASS require urgent attention in order to safeguard community health.

In Canada, a developed country, indigenous communities in the 21st century are challenged with solid waste management problems similar to those in developing countries. FN communities still rely on open dumps and burning as a method of waste disposal due to limited budgets and government neglect. Comprehensive solid waste management approaches are quite rigorous to implement and require adequate technical and financial endowments. The federal government through its agency in charge of FN land management and environmental protections, AANDC and Environment Canada, must act on solid waste management as a critical need of FN communities. AANDC must understand that remote fly-in communities, such as GH and WASS communities, are challenged with geographical constraints and limited resources including lack of institutional, financial, technical and administrative capacities to deal with many of their waste issues. The implementation of a fiscal regime that focuses on waste management as critical services in FN must be upheld. Funds must be made available for the construction and maintenance of a well-engineered landfill that meets environmental standards. A well sustained on-site operation, law enforcement mechanisms and monitoring are required. At the provincial levels, stewardship agency should be compelled to take up responsibilities for marshaling and shipping out their products for recycling in underserved communities. The community leadership, i.e. the band councils, through multi-partnership with AANDC, universities, donors, volunteers, community-based organizations and NGOs should focus on training waste experts from the communities and organizing educational and awareness programs for community members. Overall, programs that support solid waste management in GH and WASS are important to secure community health and the environment, and to protect livelihoods.

CHAPTER 5: ANALYSIS OF THE RISKS ASSOCIATED WITH SOLID WASTE DISPOSAL PRACTICES IN GARDEN HILL AND WASAGAMACK FIRST NATIONS

5.1 Introduction

Open dumping and open air burning are prevalent solid waste disposal practices in First Nations (FN) communities across Canada (Bharadwaj et al., 2006). Inadequate sanitation services and unregulated waste management systems on reserves embolden these practices. Generally, land disposal of waste materials is classified as a point source of contaminant release into the environment (Ritter et al., 2002).

Landfills and incineration involve the controlled burial and burning of waste, respectively. Although landfills and incineration are preferable to open dumps and open burning, both are least favorable in the waste hierarchy, compared to reduction, recycling and reuse, due to their environmental risks. The solid waste management hierarchy ranks waste management options in order of environmental suitability without considering open dumps and open burning. Landfill and incineration occupy the lowest rung of the hierarchy due to the high risk of environmental pollution with open dumping and open air-burning considered unacceptable.

Pollution prevention measures, such as engineered liners, leachate collection systems, cover materials and hydrogeological conditions, are aimed at controlling the impacts of landfills on the environment (UNEP, 2005). Landfills and incinerators have environmental regulatory standards to guide their operations (UNEP, 2005). Open dumps and open air burning have been banned and replaced by sanitary landfills and incinerators in most jurisdictions (Nzeadibe et al., 2012). Government agencies have also established waste reduction strategies to divert waste into more resourceful uses. These waste reduction strategies prolong the life of landfill sites and incinerators, and also reduce the need for construction of more landfill and incinerators, which usually raises social, economic and environmental tensions among citizens, e.g. Not in my backyard (NIMBY) syndrome.

Although not considered acceptable, open dumps and burning are common in some developing countries where many people burn their waste (Nzeadibe et al., 2012), as well as in FN communities (Bharadwaj et al., 2006; Zagozewski et al., 2011). Open dumps are generally characterized by: (1) lack of planning; (2) no on-site operations; (3) no control of human and animal access; (4) no confinement of waste; and, (5) uncontrolled burning (Nzeadibe et al., 2012, p632). Open dumps are common in communities with inadequate garbage collection and disposal systems (UNEP, 2005). These scenarios occur mostly in developing countries and are often attributed to poor socio-economic conditions, poverty, weak legislation and corruption (UNEP, 2005).

Figure 5.1: Open dump near a lake in Garden Hill poses threat to the drinking water sources and recreation in the community

However, open dumping remains a common practice in many FN communities across Canada (Zagozewski et al., 2012), which is a developed country with more than 600 FN communities (AANDC, 2015). Figure 5.1 shows an open dump sited near a water feature in GH. For decades, open dumps and garbage burning have been banned in Canada (pursuant to Clean Environment Regulations) but are often the only option in FN communities (Bharadwaj et al., 2008). Historically, FN communities have suffered from environmental issues due to lax government attention. This section analyses the potential environmental impact of waste disposal on soil and water quality in GH and WASS.

Figure 5.2: Leachates from hazardous waste materials can contaminate soil, ground and surface water

Figure 5.2 shows the discharge of leachates from e-waste at an open dump in GH. Improper solid waste management impacts drinking water sources. In Canada, many cases of drinking water contamination from improper waste disposal have been reported in places like Walkerton, Ontario; Elmira and Smithville, Ontario; Abbotsford, British Columbia.; Squamish, British Columbia.; and Ville Mercier, Quebec (Government of Canada, 2008). Air pollutants, such as fly ash, containing heavy metals, dioxins and furans, and other noxious substances, are typically emitted when waste materials are burned, resulting in human exposure to toxic gases and fumes, contamination of soil, air, water and food sources (Nzeadibe et al., 2012).

5.2 Method

Composite soil and water samples were collected from the vicinities of the active garbage dump sites in GH and WASS, as described in Chapter 3. Composite soil samples (GH 1-3, WASS 1-3 and background samples) were analyzed for the presence of heavy metals, while water samples were analyzed for microbial parameters. The values obtained were compared to CCME's different soil quality guidelines for the protection of human health and the environment. Results are reported in milligrams per kilogram (mg/kg), equivalent to ppm, as indicated in the appendix section.

5.2.1 Description of the active waste dumpsites in the communities.

5.2.1.1 WASS active waste dumpsite.

The garbage dumpsite in WASS (53.90862^{0}N, 094.98014^{0}W) was located in the north end of the community. The dumpsite covered a few acres of land and serves the community of WASS for the disposal of household wastes and other categories of waste materials. Truckloads of sewage sludge from the malfunctioning sewage treatment plant, electronic wastes, waste tires, construction and demolition wastes etc. are visible at the garbage dumpsite. According to information provided by community members, the site is about 10 years old and adjacent to their prior dumpsite.

During site visits with band members, I observed that the waste dumpsite in WASS was characterized by:

i. dilapidated barbed wire fencing thereby allowing unrestricted access by the general public and wild animals.

ii. lack of any personnel to monitor waste disposal activities. Hence, uncontrolled waste disposal occurred within and outside the site by community members and contractors (e.g. Arnason Industries, which is the construction company in both FN communities).

iii. absence of engineered clay liner, leachate collection system, landfill gas capture system or a daily cover to prevent environmental contamination and public health problems.

iv. close proximity to surface water features, closer than the minimum distance of 1000 meters stipulated in *Manitoba Waste Disposal Ground Regulation* specific to surface water features.

v. burning of all wastes including toxics occurred regularly, which lead to the release of environmental contaminants. Smoke and fly-ash were visible from distance away from the sites due to burning activities, as shown in the Figure 5.3 below. Nearby residents complained about smoke from burning wastes at the site and possible risks of forest fire due to forested areas being closer than the 30 meters required by guidelines to prevent possible fire (Kent et al., 2003).

Figure 5.3: Burning waste at the site in Wasagamack, smoke and fly-ashes were visible from distance away from the site

5.2.1.2 GH active waste dumpsite

In GH, the waste site is located (53. 53522^{0}N, 940. 40099^{0}W) along a high traffic road in the east end of the community (see Figure 5.4 below). The same road serves as a route to connect the winter-road for travelers in the winter. The site served the community for the disposal of all wastes including toxic wastes. The waste site is characterized by:

i. close proximity to water features; the dump is located near a creek which flows directly into the nearby lake. The lake serves as source of drinking and recreational water source for many community members.

ii. no trained personnel or operations to monitor disposal activities

iii. no pollution prevention measures (i.e. daily cover, liners, leachate collection and gas capture).

iv. absence of fencing allows unrestricted public and wildlife access. Wildlife, e.g. Bear, encroachment was a big safety concern for community members due to lack of fencing.

v. Continuous burning of wastes including e-waste and other toxics leading to the release of environmental contaminants and increased risks of forest fire.

Figure 5.4: Road passes through the garbage dumpsite in Garden Hill. Waste materials are not compacted or covered and can be seen flying around the communities.

5.3 Soil Chemistry

Concentrations of arsenic (As), chromium (Cr), copper (Cu), lead (Pb) and zinc (Zn) in GH and WASS soils were above background levels and the CCME maximum acceptable levels for all land-use categories (i.e. residential and parkland, agriculture, commercial and industrial) (CCME, 2006). Other toxic elements such as antimony (Sb), Nickel (Ni), Silver (Ag), cadmium (Cd), cobalt (Co), niobium (Nb), manganese (Mn), selenium (Se), molybdenum (Mo), tin (Sn) and barium (Ba) were all found to be elevated to varying degrees compared to the background samples.

Arsenic (As) concentration levels detected in GH and WASS soil exceeded the CCME soil quality guideline of 12 mg/kg as well as background concentrations (see Figure 5.5 below). Values obtained ranged from 4.3 to 52 mg/kg for GH soil samples. GH background had the lowest amount of arsenic concentration with a value of 4.3 mg/kg, which is below maximum permissible level. GH2 had the highest amount of contamination (52 mg/kg) of the three samples (GH1, 2, & 3), which is about 4.3 times higher than the maximum permissible levels. GH 1 and GH 3 arsenic concentrations were found to be slightly above background level. For WASS, arsenic values ranged from 4 mg/kg to 56.1 mg/kg. WASS background had the lowest amount of arsenic concentration with a value of 4 mg/kg. WASS1, 2 & 3 had values above 12 mg/kg, indicating arsenic contamination, with WASS 2 having the highest amount of contamination (56.1 mg/kg).

In Canada, the disposal of waste materials is one of the principal sources of arsenic released into the environment (CCME, 1997). A large proportion of arsenic released into the environment remains in the soil (CCME, 1997). Whilst organic arsenic is less problematic, inorganic arsenic is toxic to humans especially children who are at higher risk of exposure (CCME, 1997, Wang & Mulligan, 2006). Studies by Kwon and his colleagues at the University of Alberta have shown the presence of elevated levels of arsenic on the hands of children exposed to playgrounds where arsenic contaminations are present (Kwon et al., 2004). Arsenic is cancer causing. The risk of cancer is probable from ingestion and inhalation of arsenic from a variety of media. Plants hardly uptake arsenic from soil, however, elevated levels of arsenic as low as 10 mg/kg have been found to affect crop yield in some terrestrial plant species (CCME, 1997). Wildlife, such as rabbits and birds, have also been found to be lethally affected by consumption of arsenic contaminated plants (CCME, 1997).

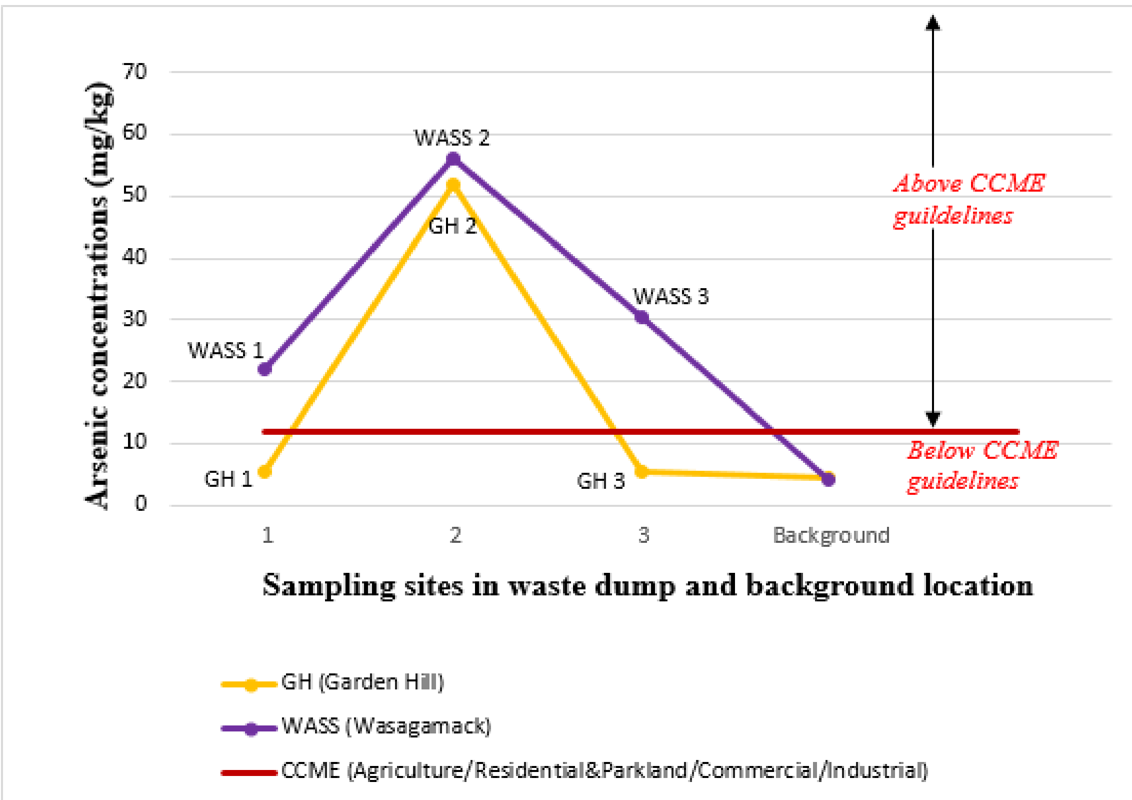

Figure 5.5: Arsenic concentration in Garden Hill First Nation (GH) and Wasagamack First Nation (WASS) soil samples at waste sites and background location

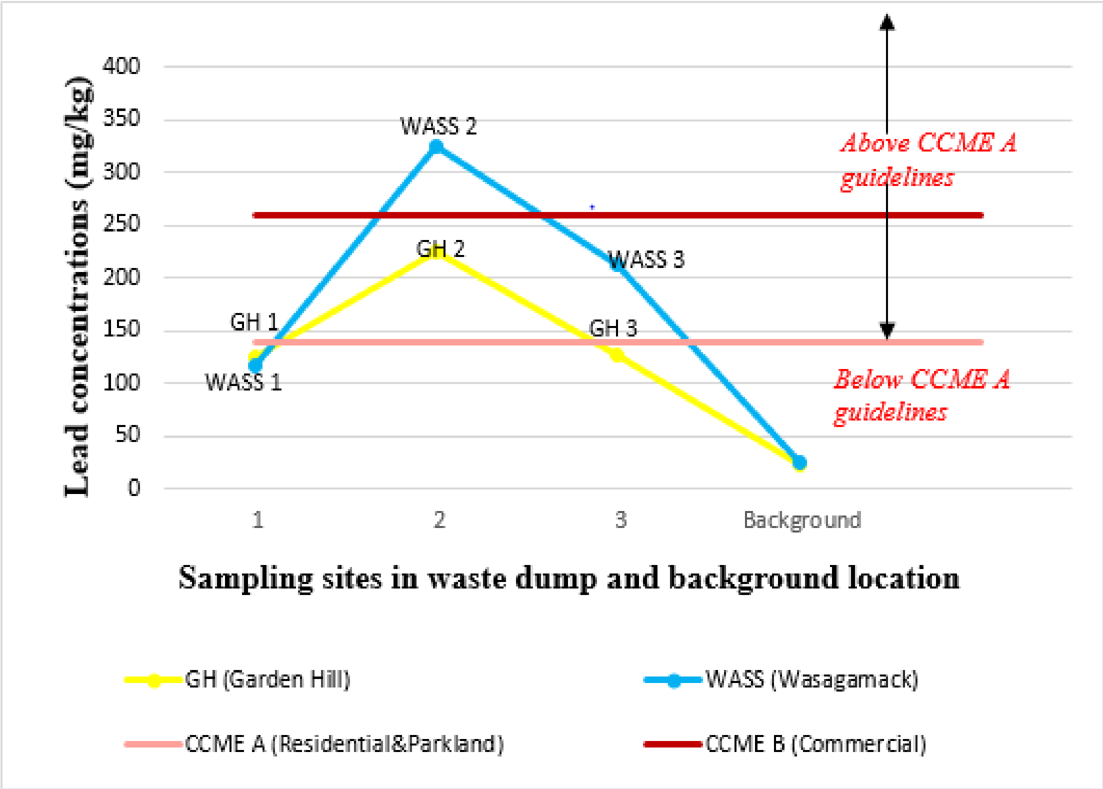

Figure 5.6: Lead concentration in Garden Hill First Nation and Wasagamack First Nation soil samples at waste sites and background location

Figure 5.6 above illustrates the concentration of lead in the samples. Values range from 25.5 mg/kg to 325 mg/kg. WASS background samples had the lowest amount of lead contamination with a value of 25.5 mg/kg. WASS 1-3 have values above 100mg/kg, with WASS 2 having the highest amount of contamination (325 mg/kg). WASS 1 had the lowest of the three samples. Values range from 23.8 mg/kg to 225 mg/kg. GH background had the lowest amount of lead contamination with a value of 23.8 mg/kg. GH 1-3 had values above 100mg/kg, with GH 2 having the highest amount of contamination (225 mg/kg). GH 1 had the lowest of the three samples. Lead finds its application in a range of products such as batteries, lead water pipes and e-wastes. In ambient environment, the concentration of lead is generally low and does not normally exceed 30mg/kg (Brigden et al., 2008). However, the disposal of waste materials containing lead (e.g. Cathode Ray Tube) can cause the introduction of higher lead levels into the environment

(Brigden et al., 2008). At the site in WASS and GH, unregulated dumping and burning of crystal ray tube and lead batteries were observed, thus, the introduction of high lead levels in the soil samples. At high concentration, lead is highly poisonous to living organisms. Humans can be exposed to lead contamination through inhalation of lead dust or ingestion of contaminated food or drinking water. Whether ingested or inhaled, the toxic effects of lead are the same and irreversible (Brigden et al., 2008). Children are highly vulnerable to the effects of lead, in fact, high blood level of lead in correlation with temperament of children exposed to lead have been reported (Nabulo et al., 2006). Some of the effects of lead on human health and the environment are highlighted in Table 4.2, including but not limited to nervous system disorder and cerebral impairment (Verstraeten et al., 2008; Horne & Gertsakis, 2006, Grant et al., 2013).

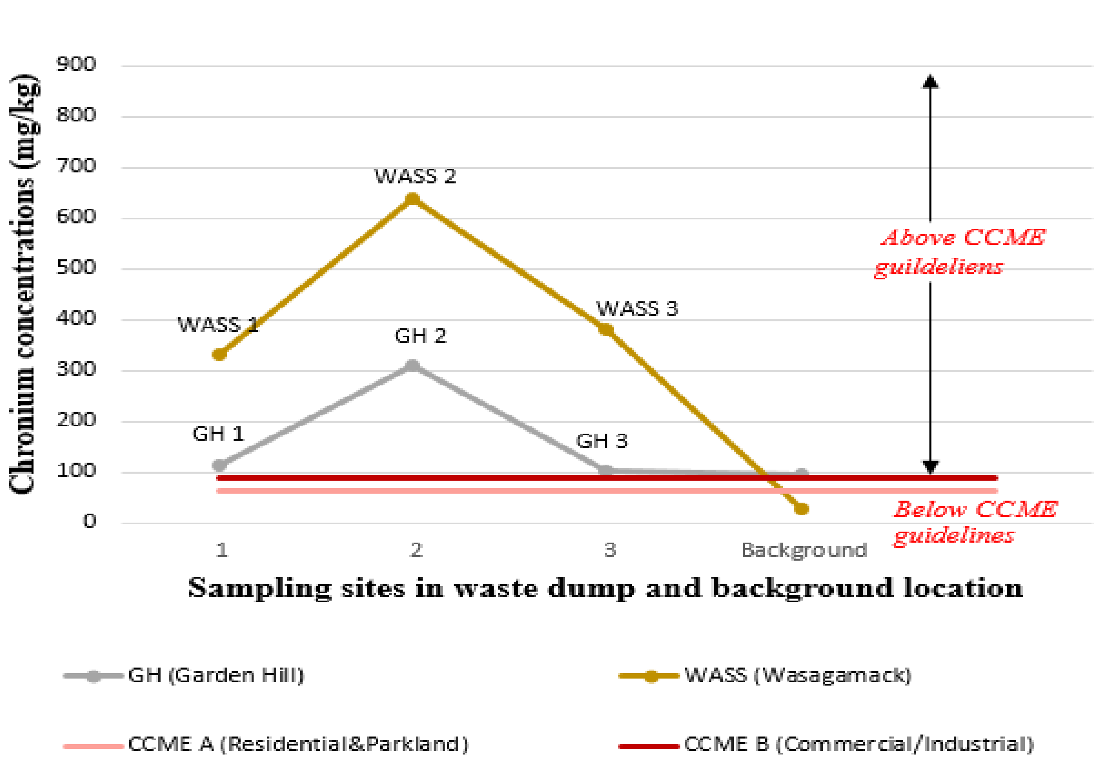

Figure 5.7: Chromium concentration in in Garden Hill First Nation and Wasagamack First Nation soil samples at waste sites and background location

As with lead and arsenic, the CCME soil quality guideline was exceeded for chromium, as indicated in Figure 5.7 above. Maximum acceptable values for chromium according to CCME soil quality guideline are 64 mg/kg for residential and parkland, as well as agriculture and 87 mg/kg for commercial and industrial land uses. However, the values detected in the GH soil samples ranged from 96 to 311 mg/kg. GH background chromium concentration was the lowest at 96 mg/kg. GH 1-3 had values above 100 ppm, with GH2 having the highest amount of contamination (311 mg/kg). GH 3 had the lowest contamination of the three samples. Concentrations ranged from 84.8 to 383 mg/kg. WASS background had the lowest amount of chromium contamination with a value of 84.8 mg/kg. WASS 1-3 had values above 100 mg/kg, with WASS 2 having the highest amount of contamination (383 mg/kg). WASS 1 had the lowest chromium concentration of the three samples (192 mg/kg). Some of the effects of exposure to high levels of chromium are allergies, DNA damage and cancer (Schmidt, 2002).

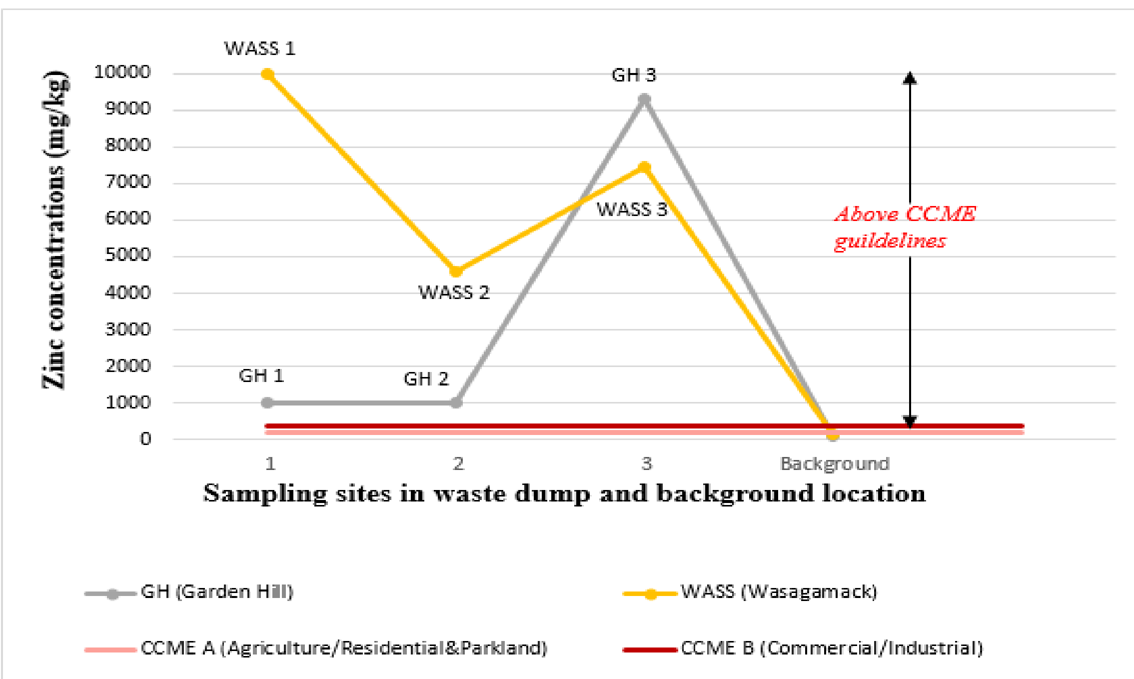

Figure 5.8: Zinc concentrations in Garden Hill First Nation and Wasagamack First Nation soil samples at waste sites and background location

Figure 5.8 above indicates the concentration of zinc in GH and WASS soil samples compared to CCME guidelines and background. Zinc concentration levels in the soil samples were found to be within 5 to above 500 times higher than the acceptable values of 200 mg/kg for residential and parkland and 360 mg/kg for industrial land uses presented in the CCME's soil quality guidelines. For WASS samples, the zinc values for the four samples (including background) ranged from 151 to >10000 mg/kg with the background sample having the lowest zinc concentration (151 mg/kg). WASS 1-3 had values above 1000 mg/kg indicating a high amount of zinc contamination in these samples. WASS 1 sample showed the highest degree of zinc contamination with values greater than 10000 mg/kg. For GH samples, the zinc concentration ranged from 107 to 9290 mg/kg with the background sample having the lowest amount of zinc concentration (107 mg/kg). GH 1-3 had values above background and guideline levels indicating zinc contamination in these samples. GH 3 sample showed the highest degree of zinc contamination with values greater than 9000 mg/kg.

Zinc is ubiquitous and naturally occurs in trace amounts in soil; however, elevated levels of zinc have been shown to disrupt soil microbial populations (Walker, 2008) especially in terms of diversity and evenness (Moffett et al., 2003). Even though zinc is highly beneficial to plants, elevated concentrations may result in phytotoxicity and stunted growth (Nabulo et al., 2006). Humans can be exposed to zinc poisoning through accidental consumption of contaminated soil or through dietary intake of zinc-contaminated plant. Human traffic around the sites and the consumption of traditional plants near the contaminated area may increase the possibility of zinc exposure in GH and WASS. Zinc is present in tires and may be released to the environment as tires disintegrate (Nabulo et al., 2006). Thus, the presence of elevated levels of zinc compared to background samples can be attributed partly to the dumping and burning of tires at the sites. More so, vehicular traffic along the sites cannot be ruled out as a source of zinc contamination (Nabulo et al., 2006; Lagerwerff & Specht, 1970)

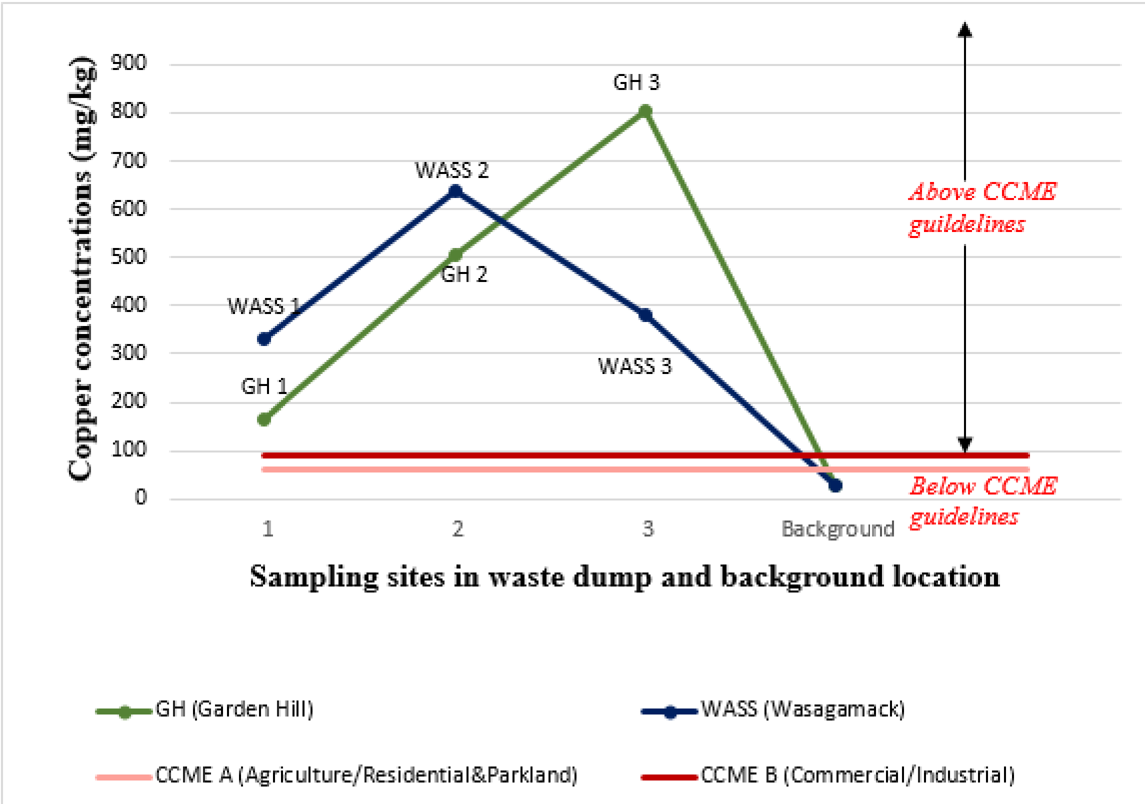

Figure 5.9: Copper concentration in in Garden Hill and Wasagamack First Nations soil samples at waste sites and background location

The concentrations of copper ranged from 26.5 to 804 mg/kg for GH soil and 28.3 mg/kg to 638 mg/kg for WASS soil (See Figure 5.9 above). Both values exceeded permissible copper levels of 63 mg/kg and 91 mg/kg for agriculture and residential and parkland, and industrial and commercial land uses respectively, as presented in CCME guidelines (CCME, 1999). GH background had the lowest copper concentration with a value of 26.5 mg/kg. GH 1-3 had values above 100 mg/kg, with GH 3 having the highest amount of contamination (804 mg/kg). GH 1 (165mg/kg) was the lowest of the three samples, which was still 2.6 times higher than the maximum permissible level for residential and parkland. On the other hand, WASS background had the lowest amount of copper contamination with a value of 28.3 mg/kg. WASS 1-3 had concentrations above 300 mg/kg, with WASS 2 having the highest amount of contamination (638 mg/kg). WASS 1 has the lowest of the three samples as shown in Figure 4.22 below. Burning of waste materials (e.g. Printed Circuit Board) may be the reason for high concentrations of copper in the samples as reported in previous studies (Leung et al., 2008). Copper, at high concentration, is toxic to human and capable of causing severe health complications such as stomach infections, lungs and kidney diseases (ATSDR, 2004).

Overall, from the three samples (WASS1, 2 &3), WASS 2 showed the highest amount of contamination of arsenic, chromium, lead and copper while WASS 1 had the highest amount of zinc metal contamination. Comparing the degree of metal contamination in the various samples to the soil quality guideline, the WASS background generally had values (zinc, lead, chromium, arsenic, copper) lower than the soil quality guideline. WASS 1, 2 and 3 had values of zinc, chromium, arsenic, lead and copper metal contamination greater than the guidelines for all land use categories. For the three GH samples (GH 1, 2 &3), GH 2 shows the highest amount of contamination of arsenic, chromium, and lead metals while GH 3 had the highest amount of Zn and lead metal contamination. Comparing the degree of metal contamination in the various samples to the soil quality guidelines, the GH background generally had values (zinc, lead, arsenic, copper) lower than the soil quality guidelines except for chromium metal, which had a higher value than the soil quality guideline. GH 1, 2 and 3 had values of zinc, chromium, and copper contamination greater than the soil quality guideline (agricultural, residential and parkland, commercial, and Industrial).

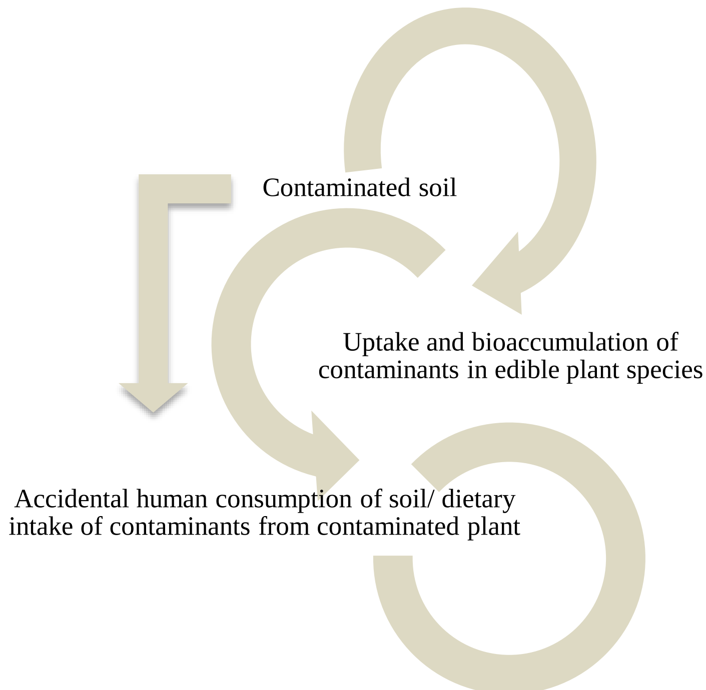

Figure 5.10: Pathway for human exposure to soil contaminants (Adapted from Cui et al., 2004)

The presence of heavy metal contamination (especially zinc, copper, lead, chromium and arsenic) may be attributed to dumping and burning of e-waste and other hazardous waste materials at the waste sites (Tang et al., 2010). Moreover, metal contamination of similar trends has been found in e-waste disposal sites in Ghana (Brigden et al., 2008). In linkages, plant species uptake of zinc, lead, copper and other metals from contaminated soil have also been identified in previous studies (Cui et al., 2004; Luo et al., 2011). Humans can be exposed to soil contaminants through accidental ingestion or consumption of contaminated plant or animal species, as illustrated in Figure 5.10 (Cui et al., 2004). The risk of toxicity to humans can range from moderate to severe depending on a myriad number of factors including nature of contaminants and the level, route or frequency of exposure (see Table 5.1 below).

Table 5.1: Chemical parameters found above background and guideline levels and their potential human health and environmental effects

Substance	Uses/location	Environmental and health implications	Routes of exposure
Arsenic	Used as doping agent in transistors and printed wiring board (PWB). Used in small quantity as gallium arsenide in Light Emitting Diode (LED) [1,2,3]	Sore throat; tissue damage, irritated lungs; vascular & heart disease; increase the risk of lung, skin and urinary tract cancer [2, 3]	Ingestion of contaminated water or food; inhalation of dust particles and fumes [3, 4]
Chromium	Used to prevent corrosion; decorative for steel housing, Data tapes and floppy disks [2,5]	Allergic reactions; stomach ulcer; damage to pulmonary and renal system; DNA damage, increase risk of cancer. [2, 5]	Ingestion through chromium contained in water, food or soil, Inhalation and dermal absorption.[2]
Copper	Printed circuit board conductivity/Cathode Ray Tube (CRT), PWB, connectors, Lithium batteries [6]	Hepatic and renal diseases, irritation of the nose, mouth and eyes, headaches, stomach problems, dizziness, vomiting and diarrhea. Chronic exposure can result in Wilson's disease [6]	Inhalation, oral, dermal [6]
Lead	Used as glass panel gasket in CRT; Soldering; found in batteries and light bulb [3]	Damage to hematopoietic, hepatic, renal and skeletal systems; Central Nervous System damage. Lead accumulates in the environment; toxic to plant, soil and microorganism [3]	Ingestion of contaminated water or food; inhalation of lead containing dust particles; skin contact [7,8]
Zinc	Battery, PWB, Phosphor emitter CRT and metal coatings [8,9]	metal fume fever [8]	Ingestion and inhalation [8]

[1] Frumkin & Thun, (2001), [2] Schmidt (2002), [3] Horne & Gertsakis (2006), [4] Abernathy et al. (1999), [5] Dashkova (2012), [6] ATSDR (2004), [7] Verstraeten et al. (2008), [8] Grant et al. (2013), [9] Bandyopadhyay (2008)

Due to the many hazardous components of e-waste, adverse health and environmental effects result from improper handling and disposal such as open dumping and open air burning (Pinto, 2008). Some major case studies related to the health and environmental concerns of unregulated and unsafe e-waste recycling and disposal activities have been highlighted in Chapter 2. A typical outlined example of environmental and health hazards associated with unsafe management of e-waste are evident in residential towns in developing countries e.g. Guiyu town in China (Wong et al., 2007) and Alaba in Lagos, Nigeria (Alabi et al., 2012). Since waste disposal practices in GH and WASS are similar to developing countries, effects on human health and environments are likely to occur. Guiyu is considered as one of the largest informal e-waste recycling centers in the world (Xu et al. 2014). Comparable to the study areas under investigation, many people in Guiyu including women and children were exposed to hazards from unregulated handling of e-wastes (Leung et al., 2008). In addition, crude methods of dissembling e-waste, such as open air burning, to recover valuable materials are the main practices in Guiyu (Osibanjo & Nnorom, 2007). Workers in Guiyu conducted their dismantling activities without the use of Personal Protective Equipment (PPE) to prevent them from exposure to chemicals embedded in e-waste or emitted through open air burning (Leung et al., 2008). Table 2.5 in Chapter 2 highlights the many risks and hazards associated with e-waste components, categorized based on their chemical composition, health effects and route of exposure.

Reported adverse effects on residents around e-waste disposal sites include but are not limited to birth defects (Xu et al., 2012) and drinking water contamination (Wong et al., 2007). Studies have also found a correlation between blood level lead, temperament and mental imbalance in children exposed to e-waste sites (Liu et al., 2011). Similarly, analyses of soil and plant samples at major e-waste sites have revealed elevated concentrations of PAHs, PCBs and heavy metals (Alabi et al., 2012).

PAHs have been shown to be genotoxic (cause DNA damage) to humans (Gamboa et al., 2008), and are potential carcinogens, i.e. increases the risk of cancer (Ruíz-Godoy et al., 2007).

PCBs have also been linked with toxicity problems during the development of mammalian embryos and early life (Jacobson et. al., 1990; Longernecker et al., 2003), birth defects (Safe, 1994) and cancer (Silberhorn et al., 1990, Cogliano et. al, 2011). The release of mutagens, carcinogens and genotoxic compounds, such as PAHs, into the environment is sometimes attributed to the act of open air burning of e-waste (Alabi et al., 2012; Feldt et al., 2014). Burning of e-wastes along with other materials in the waste stream are common practices at the sites under investigation.

In addition, high concentration of heavy metals such as cadmium, chromium, mercury, nickel, manganese, copper and lead have been discovered in soil samples collected at e-waste dumping grounds (Alabi et al., 2012). Most of these metals are either mutagenic or carcinogenic, or both (Alabi et al., 2012), and some have the tendency to bio-accumulate in the environment (Chatterjee et al. 2013). Studies in the field of epidemiology consider lead, a major constituent of e-waste, as both genotoxic (Pasha Shaik et al., 2006) and carcinogenic (Fowler et al., 1994). Exposure to zinc, nickel, lead and copper can be highly detrimental to human health (Leung et al, 2008). Lastly, pollutants from e-wastes dumpsites could find passageway into water systems through leaching and surface run-off (Amfo-otu et al., 2013), causes water pollution and spread of diseases. E-wastes disposed in drainage channel could also impede flow of water, leading to flooding (Murali, 2009). When released into the atmosphere, some refrigerants, such as chlorofluorocarbons (CFCs), used in the cooling system are ozone-depleting substances (ODS) which results in unhealthy exposures of humans and other species to ultraviolet radiation from sunlight (MOPIA, 2014). The issues with the use of ODS in e-wastes especially white goods have been addressed in the Montreal Protocol and monitored in Manitoba through the ODS and halocarbon regulation (MOPIA, 2014).

5.4 Water Microbiology

Two different water samples (labeled GH Water and WASS Water) were collected from areas within and outside the sites and analysed for microbiological parameters. The pH value for all the samples were detected within the permissible range, albeit slightly alkaline (Health Canada 2012a, Health Canada 2012b). However, the microbial parameters related to the presence of *Escherichia coli (E. coli) and total coliform* for all the samples were elevated above Health Canada's GCDWQ and GCRWQ. Microbial parametric values for samples, GH Water (411 MPN/100ml) and WASS Water (1900 MPN/100ml), analysed for *E. coli* were far above Health Canada's GCRWQ maximum acceptable level (MAC) of non-detectable per 100mL. The huge discrepancies in the figures obtained for GH water and WASS water might be due to the discharge of truckloads of raw sewage into the water system around the site. The values for total coliform were found to be elevated at >2420 MPN/100 ml for all the samples. The MAC for total coliforms in water discharged into the environment is presented as none detectable per 100 mL (Health Canada, 2013). All values obtained for E. coli and Total coliform also exceeded Manitoba's standard for effluent discharge into water body (MWS, 2011).

Table 5.2: 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)	-	≤ 400	N/A
Manitoba effluent discharge	-	200	200
*MPN: stands for most probable number			

The presence of total coliform often indicates the deterioration of water quality and a measure of vulnerability of water sources to contaminations by pathogenic microbes such as *E.coli* (Health Canada, 2012a). *E.coli* is used to analyze microbial safety in drinking and recreational water (Health Canada 2012a, Health Canada 2012b). This implies that water bodies around the sites might be exposed to microbial parameters from on-site activities. The high value of *E.coli* in the samples may be related to the disposal of sewage and diapers containing human feces at the sites. *E.coli* is one of many pathogens described as relevant to drinking water due to 'high' health significance rating according to World Health Organization (WHO) guidelines (WHO, 2011). Infectious diseases caused by pathogenic microbes are the most prevalent human health complications associated with drinking water (WHO, 2011). However, for pathogens such as *E.coli* transmitted by faecal and oral route, other routes of contamination such as food, hand, equipment and clothing are applicable especially when proper sanitation and hygiene are not observed (WHO, 2011). The unrestricted public access to the sites and close proximity of the site to water features may expose community members to microbial contaminations.

5.5 Limitations

This study was constrained by limited funding to adequately assess the impacts of solid waste disposal practices on soil and water quality at the sites. Important parameters such as dissolved metal, dioxin and furan, and polyaromatic hydrocarbons are expensive tests, and thus were excluded from the test parameters. More comprehensive studies and precautionary measures are recommended to adequately test for other parameters related to human health and environmental concern from the sites.

5.6 Summary

This environmental field investigation revealed the presence of human health and environmental risks due to waste disposal practices at the sites. The fact that the sites are located nearby to work places and residents and near stream and other surface water features increases risks to humans and wildlife. The unrestricted access to these sites by the general public poses health hazards including physical risks and inoculation from waste sharps, as well as risks of exposure to contaminants present on the sites. People moving in and out of the sites to dump their wastes are exposed to chemical and microbial contaminants by soil and leachates adhering to people and their shoes, clothing and cars, and inhalation of toxic fumes from open air burning of waste at the sites. Contamination of shoes with landfill mud containing lead and other toxics may result in the contamination of home environments. Transfer of heavy metals from contaminated soil to edible plant or biomagnification and bioaccumulation through animals or fish is another way in which community members can be exposed to health risks (Cui et al., 2004).

Restriction of people and vehicular movement, as well as wildlife, through proper fencing and presence of on-site operation and personnel around the site is highly recommended to reduce exposures to health risks from the sites. Dumping of sewage should also be restricted at the sites to avoid exposure to pathogens. Due to close proximity to water features, the waste site at GH, in particular, should be closed and replaced with a sanitary landfill, which only accepts non-hazardous waste. In addition, transfer stations should be built to allow people to drop off their recyclable and hazardous wastes to be sent to recycling facilities. These transfer stations should serve the purpose of separation of recyclables and hazardous waste from the general wastes to be disposed at the sites. The lack of support for proper solid waste management from AANDC and the absence of provincial initiatives in GH and WASS have resulted in the presence of batteries, tires, electronic appliances and other toxic and flammable compounds at the site and littered around the communities. Developing solid waste management programs and partnering with the province's product stewardship programs for tires, oil, computers and other programs for appliances are recommended to keep hazardous materials out of the sites. In order to gain more insights into the health risks and potential exposure to contaminants, testing of dioxin, furans and PAHs should occur.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

We urgently need to clean up our communities and introduce recycling…what we have here are million dollar junks– Community member (Garden Hill First Nation)

Both the unsafe siting of waste dumps and the open dumping and burning of waste, including e-waste and other toxic wastes is unsafe and unhealthy. At this point there is no route for safe disposal of waste in Garden Hill First Nation (GH) and Wasagamack First Nation (WASS) communities. Clearly something has to be done.

The criteria for siting a waste dumpsites were not met for distance to surface water, public roads and dwellings. Environmental protection measures, such as leachate collection, clay liners and cover, required for safe operation of waste dumpsite were also absent. With surface features at GH only about 30 meters away and WASS only about 200 meters away – surface water is at high risk. This means a high likelihood of water contamination from runoff and higher exposure rates for people in their homes and driving through the waste dumps.

Many community members rely on open dumping and open burning to get rid of their waste materials. The indiscriminate dumping of waste by the road and backyards of homes and the continuous practices of open burning of waste in GH and WASS are environmentally unsafe and unsustainable. Participatory documentary video revealed the extent of the waste problems in GH and WASS and captured reactions by community members (see https://youtu.be/EQ1YrQDjvB8). In this video, the conditions of waste disposal sites in the communities and emission from open burning of waste are showcased.

In general, community members are concerned about health and safety problems from their waste disposal. Abandoned vehicles and e-wastes litter the communities and pose risks to children from exposure to toxic materials and sharps. A lack of comprehensive solid waste management program contributed to the habit of open dumping and backyard burning due to the lack of any other alternatives. As aforementioned, the active wastes dumpsites in the communities lack adequate environmental protection measures and are not monitored for pollution. Elevated concentration of toxic metals and microbial contaminations were detected in and around the garbage dumps. Pollutions from the garbage dump in the GH and WASS place community health and safety at risk. The findings of this study corroborate previous research on solid waste management practices in FN communities (Bharadwaj et al., 2006; Bharadwaj et al., 2008; Zagozewksi et al, 2011) showing elevated levels of toxins due to improper waste disposal operations and unsafe conditions of solid waste management on FN reserves across Canada.

Historically, people in the communities relied mostly on traditional food and other activities, which generated mostly organic waste. Today, the high consumption of packaged store-bought food, with the lack of clean running water and food insecurity in northern communities, have led to an increase in generation of inorganic and toxic waste (such as plastic bottles and cans) in GH and WASS. However, the communities are yet to develop a comprehensive solid waste management plan to reduce waste and prevent pollution. Factors such as poor funding and absence of community trained waste experts limit the development of a solid waste management plan for the communities.

Comprehensive and integrated solid waste management planning in FNs is required to deal with the health and environmental hazards of open air burning and dumping. Developing a solid waste management program and/or an operational plan can reduce environmental, health and safety risks in communities. A comprehensive solid waste management plan is a major prerequisite for an integrated solid waste management (ISWM) (O'Leary & Walsh, 1995).

Funding from AANDC is not enough for proper solid waste management planning or even for meeting basic needs of community members for housing, education, employment and water supply. As well, the communities do not have the technical capacities to develop a comprehensive solid waste program. Due to remoteness and other logistic constraints, opportunities to partner with municipalities are limited. However, this research is a call for action for federal government and provincial producers' responsibility organizations (PROs) to provide the required resources and support. Considering the level of unemployment in the communities, a comprehensive waste management program will serve as an avenue to create jobs for people in the communities if funding from government is provided for community solid waste management planning and implementation.

Communities are major stakeholders in the integrated solid waste management scheme and their level of participation has both practical and policy influences (Muller et al., 2002). That the land is their livelihood and sacred and that they are remote islands mean that solid waste management has to be better not worse than elsewhere to protect culture, health and environment. Solid waste management congruent with community traditions will help to instill community ownership and control of the solid waste program and help GH and WASS to make their own decision with respect to community-based solid waste management (Muller et al., 2002). Both GH and WASS share the view on sustainable development that human activities within a community must meet the needs and aspirations of the present and future generations (Turner et al., 2000).

Community participation is crucial to any solid waste management programs that will be adopted in future. Proper environmental education and awareness should be the principal focus to improve solid waste management in GH and WASS. Band councils in collaboration with AANDC should provide adequate laws and enforcement tools that control illegal dumping of waste in the communities. Citizens in the communities participate in product stewardship by paying eco-fees for stewarded products but do not get any service in return. There are no formal waste collection and recycling in the communities. Governments, stewards and steward agencies should provide adequate support for the communities to provide training and community education, introduce composting programs for schools, build transfer station for marshaling and ship out hazardous waste from the communities. In the short and long term, solid waste management programs in GH and WASS will provide economic, social and environmental benefits to the communities.

6.1 RECOMMENDATIONS

The recommendations below apply specifically to GH and WASS as steps toward a comprehensive solid waste management regime and may offer some solutions to other FN communities with similar situations.

6.1.1 Initiate community clean-up programs and closure of open dumps

Cleaning up the communities' open dumps will ensure that environmental and safety risks from improper solid waste disposal in the communities are reduced. Whilst the active garbage dumps in the communities might not be ideal, eliminating open dumping areas present in all sections of the communities and the restriction of solid waste disposal to a single site will go a long way to reduce environmental impacts. Many valuable resources may be recovered during cleanup activities and community participation may present an opportunity for environmental education and awareness among community members. Lessons can be drawn from other FNs, such as Peguis First Nation in Manitoba, Akisqnuk First Nation in southeast British Columbia, Atikameksheng Anishnawbek in Ontario and Pictou Landing First Nation in Nova Scotia among others that organize routine community cleanup programs and engage volunteers within the communities.

6.1.2 Replace existing garbage dumps with sanitary landfills

Bring waste dumps up to the standard for a landfill by proper siting that meets requirements for proper distance from water features, roads, houses, etc. Without engineering liner, leachates collection system or a daily cover and due to close proximity to water features it is necessary to clean up the active dump sites in the communities and replace them with sanitary landfills. A procedural approach to migrate from open dumps to a well-engineered landfill have been outlined by Ball and Rodic (2010). GH has requested proper waste management facilities from the government without AANDC and Environment Canada meeting this request. Thus, the federal and provincial government must provide long term stable funding for the construction and maintenance of a well-engineered landfill with adequate environmental protection measures. The people of GH and WASS, like many other citizens, are entitled to descent wellbeing and a healthy environment, which is particularly important for FNs as the land is sacred to the FN people and provide their means of livelihood.

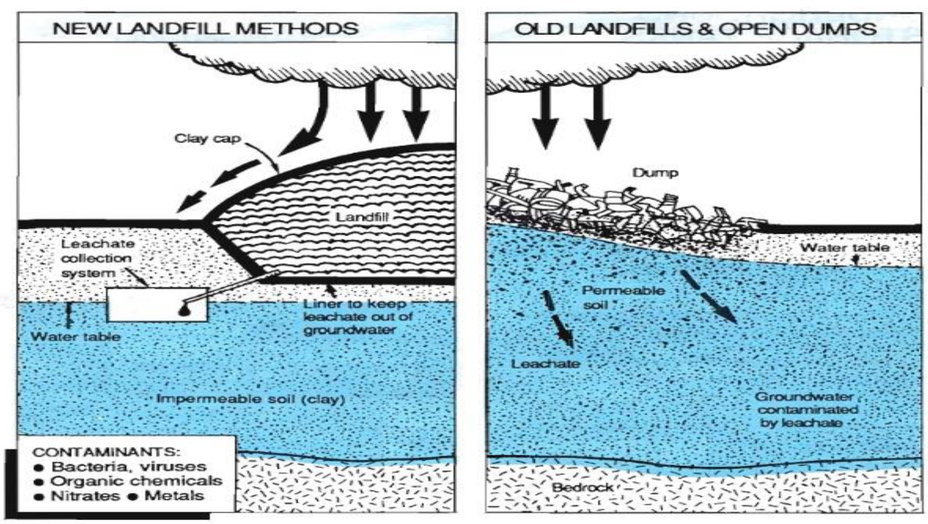

Figure 6.1: Landfill vs Open dump: impact and prevention (Raymond, 1998)

6.1.3 Train community experts on waste to ensure environmental protection

To ensure the success of solid waste management in GH and WASS, adequate trained manpower from within the community should be provided to monitor waste operations and ensure service delivery. According to Furedy (1991) and Muller et al. (2002), waste services should include:

i. proper management of wastes generated within the household;
ii. routine action of handing waste by waste collectors;
iii. payment of user fees or service charges, if applicable;
iv. planning and managing waste programs;
v. reducing waste generation and facilitating material recovery for recycling (through waste segregation at source);
vi. keeping public areas of the community clean;
vii. supporting community waste projects and efforts for improvement;
viii. supplying **"watchdogs**" for the community;
ix. allowing rational decisions on appropriate waste management methods; and
x. supporting value changes among stakeholders (industry, government and community members) that impact on solid waste problems.

All these services can only be provided and sustained in GH and WASS with the presence of community trained experts who understand community waste needs and possesses the technical-know-how to deal with future challenges.

6.1.4 Introduce waste collection system

Appropriate solid waste management begins with proper planning and implementation of waste collection services (Pichtel, 2014). Waste collection is the most crucial element of any sustainable waste management program (Muller et al, 2002). One of the barriers to proper disposal of solid waste in GH and WASS were associated with a lack of centralized waste collection facilities. Each of the communities occupies a large area of land with low population densities and a scattered settlement pattern, so that it is not so convenient for some members especially those without personal vehicles, to reach the garbage dump especially during severe weather conditions. Thus, many people converted places on the streets and the backyards of their housing units to waste disposal grounds. On the other hand, community members who had the means to transport waste materials from their houses to the garbage dump for disposal normally did so with pick up vans. These vans lacked proper confinement to contain the waste during transportation, often encountered were waste material flying off vehicles into nearby water features and sometimes created nuisances along roadsides. Clearly, the introduction of a centralized waste collection system will ensure a regulated door-to-door collection of waste, proper separation for recovery and recycling, and safe disposal by a trained waste collector. This will also provide employment opportunities for community members. It is noteworthy that waste collection can be very costly, therefore, the communities must formulate a funding plan to generate enough money to sustain collection services.

6.1.5 Build transfer stations

Transfer stations serve as places where wastes are stored temporarily in the event that landfill are far away from waste generation and collection points. In addition, transfer station will help GH and WASS to locate a safe point for the separation and collection of recyclables and hazardous wastes generated within the communities This separation of all non-organic matter can allow for the composting of organic to build the poor soil in the area for local food production purposes. Wastes at transfer stations are then marshaled onto appropriate haulage vehicle to places where they are recycled or properly disposed. Related facilities existed in other FNs communities, such as Hollow Water and Peguis FNs, where hazardous wastes are being successfully collected and taken out of landfills. Transfer station can be sited close to garbage dump or at a central location determined by the band. In GH and WASS, it might be appropriate to have mini transfer station in all the zones or divisions (north, south, east and west ends) of the reserves for convenience. Access and environmental factors should be considered when sitting a transfer station, and appropriate procedures must be followed regularly to ensure proper containment of wastes prior to when they are shipped out for proper disposal.

6.1.6 Need for composting programs in the communities

It is highly recommended that the schools, band offices, nursing stations and other facilities and gardens separate organic materials for composting. Organic matter from fruits and vegetables builds soils and meat and other material is good fodder for chicken and other birds in poultry farms. It is well known that the boreal soil is typically lacking in nutrients and that these composting programs will reduce the cost of fertilizer and chicken feed (Thompson et al, 2015). Compost binds soil particles to create good soil structure. Compost in boreal clay soil loosens tightly bound particles in clay or silt soil so roots have space, air penetrate, supply nutrients as well as bacteria and retain moisture (Thompson et al, 2015). The availability of compost will help enrich the soil in GH and WASS and boost local food production through community gardening. Community gardening in turn reduces food insecurity and provides community development and youth empowerment (Fulford & Thompson, 2013). The combination of community gardens and composting facilities trigger environmental responsible behaviour among youths (Fulford & Thompson, 2013). A local farm, Meechim Inc., was put in place in GH in 2015 and would benefit greatly from these inputs to build soil for improved crop yield and food for poultry farming. As well, WASS and other northern communities are starting farms in the near future, which already use fish from the fisheries (Thompson et al, 2014). These composting of organics are preferable to organics being wasted and turning into methane in a landfill (Thompson et al., 2009).

6.1.7 Embrace community environmental education and awareness to enhance community participation and capacity building.

Improper solid waste management activities that lead to environmental contamination can often result from either insufficient resources or lack of understanding of potential risks of contamination, or negligence. The absence of understanding of potential risks of contamination may stem from lack of environmental education, which provides necessary information to change people's attitude. Hence, environmental education- when adapted to meet community needs- is a pillar of change that is crucial to environmental protection and unraveling the causes of environmental issues including waste management (Hudson, 2001).

St. Regis Mohawk Tribal Community in the United States, have successfully utilized community environmental education and awareness to achieve the goal of a clean and healthy environment (USEPA, n.d.). Media campaigns i.e. radio and T.V presentations, community gatherings, printed materials and art are effective tools within communities' capacity that can be employed to develop understanding among community members about the critical environmental issues associated with solid waste management and how their actions impact the problems (Muller et al., 2002). In GH and WASS, access to information were through the local T.V and radio stations and social media platforms. Community members who had access to the internet (albeit low bandwidth) were availed the opportunities to share information through various social media groups and live chat. Previous research has suggested that promoting the use of the internet and social networking sites for communication and cultural exchanges in FN communities could strengthen community resilience (Molyneaux et al, 2014). Over the last few years, social media have evolved from a mere platform of information to a powerful platform of influence (Hanna et al., 2011). Whilst all of these media may serve as tools for environmental education, it is imperative to examine all methods in order to determine the most effective and less costly.

6.1.8 Enact band by-laws on solid waste disposal

Pursuant to section 81 of the *Indian Act*, band councils of FN communities hold the right to make special laws (i.e. by-laws) to monitor activities on reserve land (AANDC, 2008). Although, AANDC may provide assistance with by-laws, band councils are acclaimed to have *jurisdictional independence* to make decrees on matters that affect well-beings in the communities (AANDC, 2008). Some FN have enacted by-laws on solid waste disposal, for example, White Bear FN[17] and The Chippewas of Georgina Island FN[18] have by-laws respecting garbage disposal. By-laws are recommended as an effective way of achieving community objectives on reserves (AANDC, 2010). As such, by-laws on waste disposal should be considered by the communities of GH and WASS to address the needs and aspirations for a better waste management regime and to maintain a cleaner and healthier community. By-laws act as guiding principles for community members to actively participate in environmental protection and behave in environmentally responsible manners. Regulatory provisions, such as ban on open burning and use of plastic bags, should be upheld and adequate enforcement mechanism should be mobilized within community capacity. O'Leary and Walsh (1995) agree that by-laws and other regulatory codes are only suitable if they are enforced in consistent and effective manner. Thus, probation officers within the band council administration may be tasked with enforcement in conjunction with the local law enforcement agencies and environmental officers. The need for the adoption of proper waste

[17] http://whitebearfirstnation.ca/+pub/document/bylaws/Whitebear%20Lake%20Resort%20-%20By-Law%2098-2.pdf (see page by-law 98-5)
[18] http://sp.fng.ca/fngweb/138_waste_mgmt_by-law_19-B-04.pdf

management strategies that are consistent with traditional values of the communities should be acknowledged in the proposed by-law, and community participation as a vital success mechanism should be well emphasized. The band councils in GH and WASS may also consider the establishment of an environmental department within public works offices to adequately respond to environmental issues within the communities.

6.1.9 Conduct waste audit and develop waste reduction plan

A waste audit analyzes the waste stream in order to examine the amount and types of recyclables and other kinds of waste materials generated in GH and WASS communities. A waste audit will neither directly nor exclusively reduce waste in the communities. Rather, the outcome of a waste audit will help to understand current waste management practices and how they can be further developed to minimize waste generation and prevent pollution (Pichtel, 2014). The communities of GH and WASS currently have no baseline audit data from which improvements to present waste management can be made. Therefore, conducting waste audits will assist the communities to better mobilize appropriate facilities for waste reduction, re-use and recycling as well as collection, transportation and final disposal. In general, the communities will benefit from waste audit in the following ways:

1) define types, sources (residential and commercial) and volume of waste generated
2) Identify gaps in waste generation, collection, transportation, treatment and disposal
3) Determine the areas of waste management that requires intervention and improvements
4) Assist the communities to set objectives and targets for waste minimization
5) Provide useful information to focus community environmental education and awareness campaign.

Waste audits are generally of two types; 1) Weight based, (2) Volume based. Whilst the weight based waste audits deal with the weight of different categories of waste collected, volume based audits is a physical exercise which provides information about volume occupied by a waste category. A waste audit may follow the Plan-Do-Review procedures designed for small remote communities by Australian Local Government Association of the Northern Territory [LGNAT] (LGNAT, n.d.).

6.1.10 Understand the roles of the communities and the concept of shared responsibilities

Generally, solid waste management in Canada is the responsibility of the municipal governments, and governed by regulations of the provincial or territorial governments (McKerlie et al., 2006). Waste management services are either handled directly by municipal government or contracted to private firms (Statistics Canada, 2012). FN are governed by federal laws under the Indian Act. However, there are no comprehensive federal laws regarding the collection, treatment and disposal of solid wastes on FN. Most regulations, guidelines and programs related to solid waste management have been enacted at the regional levels (Van de Merwe, 2009).

Many provinces have already adopted the Product Stewardship (PS) approach proposed by the CCME as a policy tool for their waste management programs. In Manitoba, the PS programs have evolved through various stages over the years, under regulatory provisions of the *Waste Reduction and Prevention (WRAP)* Act. Under the PS programs, producers, importers or brand owners (called stewards) are mandated to register with an industry-led organization and pay fees for the collection and recycling of their product at end-of-life (Government of Manitoba, 2014; Green Manitoba, 2015).

The shared responsibilities model stems from the fact that all stakeholders including stewards, local governments and consumers should share the responsibilities for the stewardship of designated products for effective end-of-life management (McKerlie et al., 2006). The table below indicates the role and responsibilities of the various parties in a typical PS program in Manitoba.

Table 6.1: Future responsibilities and roles of stakeholders for stewarded products

Responsible Party	**Responsibility Starts**	**Responsibility Ends**	**Role**
Steward (producers, retailers, brand owners) or producer responsibility organizations (PROs)	Pre-consumer: offer designated product for sale in jurisdiction	Remittance of funds to stewardship agency	Transfer funds to the stewardship agency for post-consumer, i.e. end-of-life, management
Community members in Garden Hill and Wasagamack (as product consumers)	Consumption or point of sale	Designated collection/recycling point	Pay eco-fee and take end-of-life designated products to a designated collection/recycling point
Stewardship Agency	Post-consumer: any recycling point for designated post-consumer products	Sale of commodities or legal disposal of residuals	Legally recycle designated post-consumer products brought to any designated collection/recycling point

Although the responsibilities for non-stewarded products and residuals (i.e. no eco-fees) are shared between the residents and local government (Colin, personal communication, 2015), if the community cannot meet its obligations due to poverty and lack of capacity it should then fall on the capable party. Falling through the cracks should not be an option when there are two responsible parties. At this point PROs are not assisting but pointing at FN to do all the upfront work as FN communities on reserves, AANDC and/or band councils assume the roles and responsibilities of local government. However, the PROs created the product and need to take responsibility for it if there is no other party capable of doing so.

Table 6.2: Future responsibilities and roles of stakeholders for residual wastes

Responsible Party	**Responsibility Starts**	**Responsibility Ends**	**Role**
Community members	Point of waste generation	Collection point of non-stewarded products and residuals in resident's jurisdiction	Pay taxes and take residuals to designated collection points in jurisdiction
Municipal or local government	Collection point of non-stewarded products and residuals in local government jurisdiction	Sale of commodities or safe disposal of waste residuals in a manner that accords with legal requirements	Manage non-stewarded products & residuals brought to jurisdiction's collection points when capable of doing so.

To ensure successful programs are delivered to the citizens, the areas of common interest for stewardship agencies and local government are to:

i. Promote waste reduction through education and awareness;
ii. Establish convenient collection points in communities
iii. Work out logistic challenges related to the transportation of recyclables from rural locations to urban recycling facilities
iv. Create green job opportunities for community members
v. Develop suitable and unique solutions for small and remote communities.

In practice, community members will be responsible for bringing the stewarded and non-stewarded products to the designated points for management by stewardship agencies and local governments respectively. For GH and WASS and other remote northern communities, the stewardship agencies' and local governments' (band council) responsibilities starts when the designated products are brought to a collection point or a marshalling area by communities. At present, there are no designated collection point or efforts in GH and WASS and many other remote communities even though the citizens in these communities equally pay eco-fees.

6.1.11 Multi-Stakeholder partnership & social enterprise: collaborate to develop regional waste management approach.

Through partnership with numerous stakeholders such as neighboring communities, donor agencies, private companies, government agencies, NGOs, stewards etc., communities are presented with opportunities to develop sustainable waste management and initiate regional waste management strategies. Multi-stakeholder partnership will bring about the sharing of ideas, knowledge and resources to ameliorate the logistics barriers of dealing with wastes in a single remote community. More so, a working relationship between FN communities, local businesses and stewards, for instance, may provide opportunities for resource recovery, corporate social responsibilities and community economic development. A recommended approach towards minimizing the benefits to the communities from a multi-stakeholder partnership is to work within the framework of a *social enterprise*[19]. Social enterprises provide means to meet the need of underserved communities and activate community participation in the delivery of public services (Munoz et al., 2014). According to the Organization for Economic Co-operation and Development (OECD), a social enterprise is:

> Any private activity conducted in the public interest, organized with an entrepreneurial strategy but whose main purpose is not the maximization of profit but the attainment of certain economic and social goals, and which has a capacity of bringing innovative solutions to the problems of social exclusion and unemployment (OECD, 1999, p. 10)

Generally, social enterprises focus on building a social economy through the re-investment of proceeds from a business entity into capacity building and community development (Munoz et al.,

[19] A comprehensive guide towards building a social enterprise in Canada can be found in *The Canadian Social Enterprise Guide* published by enterprise non-profit (enp). http://www.socialenterprisecanada.ca/

2014). Since solid waste management vis-à-vis resources recovery may yield financial incentives, there are possibilities for application of a social enterprise model for the common good of people in GH and WASS. Social enterprise has been successfully utilized to solve energy and food production in Manitoba FNs communities (Aki Energy, 2015). Studies have highlighted the benefits of a social enterprise model in waste management: as an effective way of building capacity, ensuring environmental sustainability as well as creating economic benefits for the purpose of poverty alleviation and community economic development (Jessen, 2004; Tremblay et al., 2010). A successful social enterprise may produce a new generation of social enviro-preneur or *individual socially entrepreneurial leader* in the communities (Munoz et al., 2014, p. 480). Social enterprise is not a new concept in GH as it has been successfully utilized to ameliorate the problem of food insecurity through local food production initiatives called Meechim Inc. Lessons from a social enterprise in waste management such as *United We Can* in Vancouver, British Columbia (Tremblay et al., 2010) and community-based projects conducted in Bago, Philippine (City of Bago, 2009) as well as remote communities in Australia (Regional and Remote Australia Working Group, n.d.) prove the effectiveness of social enterprise in the establishment of a self-sustained solid waste management programs. Government support towards social enterprises have been in the form of financial incentives, support for business and patronage (Munoz et al., 2014). Social enterprise is a win-win approach whereby communities will have the opportunities to reap social, economic and environmental benefits. As well, other stakeholders may improve reputation through corporate responsibilities and environmental sustainability.

6.7.12 Develop waste management option and compute financial implications.

Based on information derived from waste stream analysis, the GH and WASS may decide on other approaches based on the waste hierarchy. These options should be compared to assess the most feasible within community technical, logistics and financial capabilities. The USEPA establishes the following as the common criteria to compare solid waste management options:

1) Environmental impacts
2) Financial implications
3) Prospects to create employment opportunities
4) Logistics
5) Legal implications
6) Level of community ownership and control

The assessment of financial implication (or cost estimation) of any solid waste management options should include both cost for procurement, daily-to-day running and maintenance, which falls under capital and recurrent spending respectively (Parthan et al., 2012). Basically, cost estimation keeps solid waste planners informed about resources requirement and eventualities. Several models have been developed to effectively estimate cost of solid waste management (Parthan et al., 2012). Methods that can be utilized to estimate costs of solid waste management and recycling including the unit cost model (UCM), benchmarking, and cost modelling (Parthan et al., 2012). Perhaps, one of the challenges for both communities is to achieve the most with limited financial resources. The communities have many issues at hand including lack of infrastructures, open dumps, isolation and other environmental problems related to poor sanitation and housing. However, appropriate cost planning may enable the communities to attract government and funding agencies to patronize their solid waste management plan.

In conclusion, government agencies, such as AANDC, should provide dedicated funding for the communities to deal with the critical problems associated with poor solid waste management. Manitoba product stewardship agencies should also be mandated to spend from proceeds recovered from charging eco-fees on consumer products to develop appropriate waste collection and recycling in northern remote communities including GH and WASS. Appropriate funding is needed in GH and WASS to develop waste infrastructures (such as engineered landfill, waste compactor trucks and waste bins) and to train community members to manage, operate and monitor environmentally sound waste management programs in their communities.

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APPENDIX A: ETHICS PROTOCOL APPROVAL

Human Ethics
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UNIVERSITY OF MANITOBA | Research Ethics and Compliance
Office of the Vice-President (Research and International)

APPROVAL CERTIFICATE

September 17, 2014

TO: **Ahmed Oyegunle** (Advisor S. Thompson)
Principal Investigator

FROM: **Susan Frohlick, Chair** [redacted]
Joint-Faculty Research Ethics Board (JFREB)

Re: **Protocol #J2014:127**
"Solid Waste Disposal Practices in Two Northern Manitoba First Nations Communities: A Paradigm Shift towards a Community-based integrated Waste System"

Please be advised that your above-referenced protocol has received human ethics approval by the **Joint-Faculty Research Ethics Board**, which is organized and operates according to the Tri-Council Policy Statement (2). **This approval is valid for one year only**.

Any significant changes of the protocol and/or informed consent form should be reported to the Human Ethics Secretariat in advance of implementation of such changes.

Please note:

- **If you have funds pending human ethics approval, please mail/e-mail/fax (261-0325) a copy of this Approval (identifying the related UM Project Number) to the Research Grants Officer in ORS in order to initiate fund setup. (How to find your UM Project Number: http://umanitoba.ca/research/ors/mrt-faq.html#pr0)**

- **if you have received multi-year funding for this research, responsibility lies with you to apply for and obtain Renewal Approval at the expiry of the initial one-year approval; otherwise the account will be locked.**

The Research Quality Management Office may request to review research documentation from this project to demonstrate compliance with this approved protocol and the University of Manitoba *Ethics of Research Involving Humans.*

The Research Ethics Board requests a final report for your study (available at: http://umanitoba.ca/research/orec/ethics/human_ethics_REB_forms_guidelines.html) **in order to be in compliance with Tri-Council Guidelines.**

umanitoba.ca/research

APPENDIX B: CONSENT FORMS

Consent form for interviews: community members and waste experts

UNIVERSITY OF MANITOBA

Natural Resources Institute

70 Dysart Rd,
Winnipeg, Manitoba
Canada R3T 2N2
General Office
Fax:
http://www.umanitoba.ca/academic/institutes/natural_resources

CONSENT FORM

Project Title: Solid Waste Disposal Practices in Two Northern Manitoba First Nations Communities

Principal Investigator: Ahmed Oyegunle, Master of Natural Resources Management Candidate, Natural Resources Institute, Clayton H. Riddell Faculty of Environment, Earth and Resources, University of Manitoba,

Research Advisor: Dr. Shirley Thompson, Associate Professor, Natural Resources Institute Clayton H. Riddell Faculty of Environment, Earth and Resources, University of Manitoba,

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

1) **Project Description:** This study form part of the requirements for my Masters of Natural Resources Management degree at the University of Manitoba, under the supervision of Dr. Shirley Thompson at the Natural Resources Institute. The overall objective of this research is to develop a sustainable waste management plan for Garden Hill and Wasagamack First Nations communities.
2) **Procedure:** Should you agree to participate in this study, you will be interviewed on waste disposal practices in Garden Hill and Wasagamack, and integrated solid waste management planning.
3) **Location and Time Requirements:** The interview will hold for about 30 minutes, during regular working hours (8:30am – 4:30pm). The interview may be recorded using an audio device to ensure that I do not miss any of the point in the discussion. I will also be taking note by hand.
4) **Voluntary Participation/Withdrawal:** Participation in this study is strictly voluntary. You may choose not to participate or may end the interview session at any time without dire consequences. You may also decline to answer question(s) during the interview.

5) **Confidentiality:** Information gathered during the course of the interview will be kept confidential. All collected data will be coded and kept in a safe lock at the University Office. Only the principal investigator and the research advisor will have access to the data. Your personal information will be withheld in any report published from the study. Upon completion of the purpose for which this study is being conducted, at approximately September 2015, information containing personal data will be discarded. Interview note and audio recordings will be destroyed.
6) **Compensation:** No compensation will be paid to you as a result of participation in this study.
7) **Result Dissemination:** Information provided by you may be published in my thesis report at the University of Manitoba and academic journal. Any publication resulting from this research will be shared with the communities under investigation, regional government agencies, as well as other participants requesting these materials.
8) **Risks and Benefits**: There are no risks to you from participating in this research. However, the communities under investigation may benefit if the outcomes of this study results in a sustainable waste management plan.
9) **Feedback:** Should you require a copy of the notes and recording that I took during the interview, I will be willing to provide it to you via email. An overview of the study will be communicated to you upon request either by email or post after 09/15.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.
This research has been approved by the Joint- Faculty Research Ethics Board. If you have any concerns or complaints about this project, you may contact any of the above named persons or the Human Ethics Coordinator (HEC) at or email
copy of this consent form has been given to you to keep for your records and reference.

____

Signature of Participant Date

____

Signature of Principal Investigator Date

Consent form for participatory documentary video

UNIVERSITY OF MANITOBA

CONSENT FORM

Natural Resources Institute

70 Dysart Rd,
Winnipeg, Manitoba
Canada R3T 2N2
General Office

http://www.umanitoba.ca/academic/institutes/natural_resources

Project Title: Solid Waste Disposal Practices in Two Northern Manitoba First Nations Communities

Principal Investigator: Ahmed Oyegunle, Master of Natural Resources Management Candidate, Natural Resources Institute, Clayton H. Riddell Faculty of Environment, Earth and Resources, University of Manitoba,

Research Advisor: Dr. Shirley Thompson, Associate Professor, Natural Resources Institute, Clayton H. Riddell Faculty of Environment, Earth and Resources, University of Manitoba,

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

INTRODUCTION: You are being asked to take part in a research study regarding solid waste management in Garden Hill and Wasagamack First Nations communities. Before you give your consent to be a participant, it is important that you understand what your participation would involve. Please ask questions if there is anything you do not understand.

PURPOSE: The purpose of this research study is to develop a solid waste management plan for Garden Hill and Wasagamack First Nations communities. The video may also be used for educational purposes Upon your consent, I hope to use your name to accompany your presentation. In the case that you want anonymity all personal information such as names will be changed to keep your confidentiality, however, because your face will be on camera, there is the chance that someone watching the video may recognize you. Alternatively, we could use your audio only with other images showing on the screen.

STUDY PROCEDURES: If you choose to participate in this study, you will be asked to answer some questions related to solid waste management on First Nations reserves. The interview will be participant led – but the theme will be discussed beforehand. Your story and answer to questions will be videotaped and notes will be taken. If a videotape recorder is used sections of your story or answer to questions may be spliced with other images (B-roll) to create a video on solid waste management. Images with your voice over may be used, such as a picture of waste dumps that you are discussing. The anticipated time required for your interview session will be approximately 30-60 minutes but may take further time or future interview, with your consent.

RISKS: There is the potential risk that your face or voice may allow someone to identify you. This video may be uploaded to YouTube and/or used for educational purposes.

BENEFITS: You will be helping to create a participatory video on current solid waste management in Garden Hill and Wasagamack First Nations. Your opinion will also help in creating public awareness on the environmental and human health risks of unsafe waste management practices in First Nations communities.

CONFIDENTIALITY: Information gathered is non-invasive. Access to the information will be through the principal investigator as directed by the chief and council. The video will be edited to tell a short story about the waste disposal in the communities. Copies of the video will be provided to the communities and potentially shown on You-tube.

FEEDBACK: You will have the opportunity to review the video and provide feedbacks before it is released prior to end of 09/15.

WHO TO CONTACT: If you have any questions about this study, contact Dr. Shirley Thompson, (thesis advisor) at or during business hours (M-F, 9:00 A.M. - 5:30 P.M.) In addition, if you have any questions as to your rights as a research participant, please contact the Human Ethics Secretariat at at the University of Manitoba.

VOLUNTARY PARTICIPATION/WITHDRAWAL: Your participation in this research study is strictly voluntary. You may refuse to participate or may choose to not have video recordings. However, you may be unable to withdraw your participation at the time the video production is underway which is approximately on or before June, 2015. By providing your signature below, you agree to have the researcher videotape your responses for the purposes of making a video. If you agree to participate in this study, you are also agreeing to provide information and allowing the band to use it for the best interest of the community.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.

This research has been approved by the Joint- Faculty Research Ethics Board. If you have any concerns or complaints about this project, you may contact any of the above named persons or the Human Ethics Coordinator (HEC) at or email
A copy of this consent form has been given to you to keep for your records and reference.

Participant's Name Printed: First Name Initial Last Name

Participant's Signature Date

Signature of Person Conducting Consent Discussion Date

☐ Consent for video use

☐ Consent for your information attributed to your name.

Please provide your contact l address and contact information below if you would like to receive a summary of the interview findings and a copy of the video.

APPENDIX C: SUMMARY REPORTS

SUMMARY REPORT ON SOLID WASTE MANAGEMENT IN WASAGAMACK FIRST NATION

REPORT BY:
AHMED OYEGUNLE
NATURAL RESOURCES INSTITUTE
UNIVERSITY OF MANITOBA
SUPERVISED BY: DR SHIRLEY THOMPSON

Abstract

For many First Nations in Northern Manitoba, solid waste management remains a serious, albeit under-researched, problem. Wasagamack First Nation waste sites and activities were studied in 2014-2015 to assess their potential environmental and health impacts. Solid waste management practices were investigated through personal observations, interviews with band members and laboratory analysis. Findings indicated that poor funding, lack of adequate waste receptacles for storage of waste generated in the households, absence of recycling and door-to-door garbage pick-up services etc., were the causes of waste, including toxics being disposed and/or burned in backyards of homes and public places. Laboratory analyses revealed the presence of toxic contaminants (such as Zinc, Arsenic, Copper, Chromium and Lead) above all existing guidelines and background levels in soil samples collected from dumpsites in the communities. Overall, this study calls for the urgent implementation of environmentally sound waste management programs in the communities to safeguard community health and the environment.

Table of Contents

1) Introduction

Waste management activities in Wasagamack First Nation (WASS) were studied in 2014-2015 to assess their potential environmental and health impacts. Of major concern are the practices of open dumping and open-air burning of garbage, both of which have been banned in federal regulations. Open dumping and open-air burning as waste disposal methods are considered unsafe and unsustainable (Owusu, 2010).

Interviews with band members revealed that WASS problems with waste management started with the:

i. use and disposal of packaging and toxic materials (such as e-wastes, tires, lead batteries, etc.), many of which should be covered under provincial product stewardship programs but aren't.
ii. lack of adequate waste receptacles for storage of waste generated in the households,
iii. absence of door-to-door/curbside waste collection services,
iv. non-existence of any formal and informal recycling services;
v. prevalence of open dumping areas and junkyards around the communities:
vi. backyard burning of wastes
vii. the absence of properly sited, engineered sanitary landfills that meet government standards;
viii. lack of finances for collection, recycling, landfill operations, education and training or any other integrated solid waste management program; and
ix. lack of trained community expert in integrated solid waste management.

Unregulated dumping of waste materials on land and burning in open air expose humans and mother earth to the contaminants in the waste stream and create new contaminants which are detrimental to health and livelihoods in the communities. Uncontrolled disposal and open burning of garbage generate hazardous leachates and toxic gases that pollute the environment, and may also serve as breeding grounds for disease-carrying vectors, such as rats and mosquitoes (United Nations Environmental Programme [UNEP], 2005; Hoornweg & Bhada-Tata, 2012). Children at play and adults are exposed to physical injuries and infections from sharps and other hazardous materials present in the waste stream. Therefore, the safety of solid waste management practices in WFN communities require urgent attentions in order to safeguard community health.

2) Description of the active garbage dumpsite

The garbage dumpsite in WASS (53.90862^{0}N, 094.98014^{0}W) is located in the north end of the community. The dumpsite covered a few acre of land and serves the community of WASS for the disposal of household wastes and other categories of waste materials. Trucks of sewage sludge from the malfunctioning sewage treatment plant, electronic wastes, waste tires, construction and demolition wastes etc. were observed at the garbage dumpsite. According to information provided by community members, the age of the site was about 10 years old with prior site being adjacent.

During site visits with band members, it was observed that the waste site in WASS was characterized by:

i. dilapidated barb wired fencing thereby allowing unrestricted access by the general public and wild animals.

ii. lack of trained personnel to monitor waste disposal activities. Hence, uncontrolled waste disposal occurred within and outside the site by community members and contractors (e.g. Arnason).

iii. absence of engineered clay liner, leachate collection system, landfill gas capture system or a daily cover to prevent environmental contamination and public health problems.

iv. close proximity to water features, closer than recommended guideline for surface water features.

v. Burning of all wastes including toxics occurred regularly which lead to the release of environmental contaminants. Smoke and fly-ash were visible from distance away from the sites due to burning activities, as shown in the Figure 1 below. Nearby residents complained about smoke from burning wastes at the site and possible risks of forest fire due to treelines closer than the 30meters required guideline to prevent fire.

Figure 1: Picture of the garbage dump in WASS

3) Sampling and laboratory analyses

During environmental field investigations in the summer of 2015, composite soil samples (WASS soil sample) were collected at random from different areas within the garbage dumpsites and from other areas within the communities (background samples). The collected samples were preserved and sent to the laboratory to analyse for the presence of heavy metal contaminations. The aim of the analyses was to detect the presence of environmental contamination at the site due to the observed site characteristics listed above. The analyses were carried out using a scientific method called inductively coupled plasma mass spectrometry (ICP-MS) techniques. The values obtained were compared to Canadian Council of Ministers of Environment (CCME) soil quality guideline for the protection of human health and the environment. Results are reported in milligram per kilogram (mg/kg), equivalent to ppm, as indicated in the appendix section.

From results of the analyses, values for the concentrations of heavy metals such as Arsenic, Chromium, Copper, Lead and Zinc in WASS soil were detected above CCME maximum acceptable levels for all land-use categories (i.e. Agriculture and residential and parkland [CCME A], and commercial and industrial [CCME B]). Antimony, Nickel, Silver, Cadmium, Cobalt, Niobium, Manganese, Selenium, Molybdenum, Tin and Barium were also found to be higher when compared to the background levels. The results are summarized as follows:

i. Zinc concentration levels in the soil samples were found to be up to 500 times higher than the acceptable values presented in the CCME's soil quality guideline (e.g. 200mg/kg for residential and parkland). For all the WASS samples including background, the Zinc values range from 151mg/kg to >10000mg/kg, with the background sample having the lowest amount of Zinc concentration. WASS 1-3 have values above 1000mg/kg indicating a high amount of Zinc contamination. WASS 1 sample has the highest degree of Zinc contamination with a value greater than 10000mg/kg, as indicated in Figure 2.1.

ii. Figure 2.2 indicates the concentration of Arsenic in WASS soil samples compared to CCME's guideline and background levels. Arsenic concentration levels detected in WASS soil (22mg/kg-56.1mg/kg) exceeded the CCME soil quality guideline (12mg/kg) for all land use categories, as well as background concentrations (4.0mg/kg).

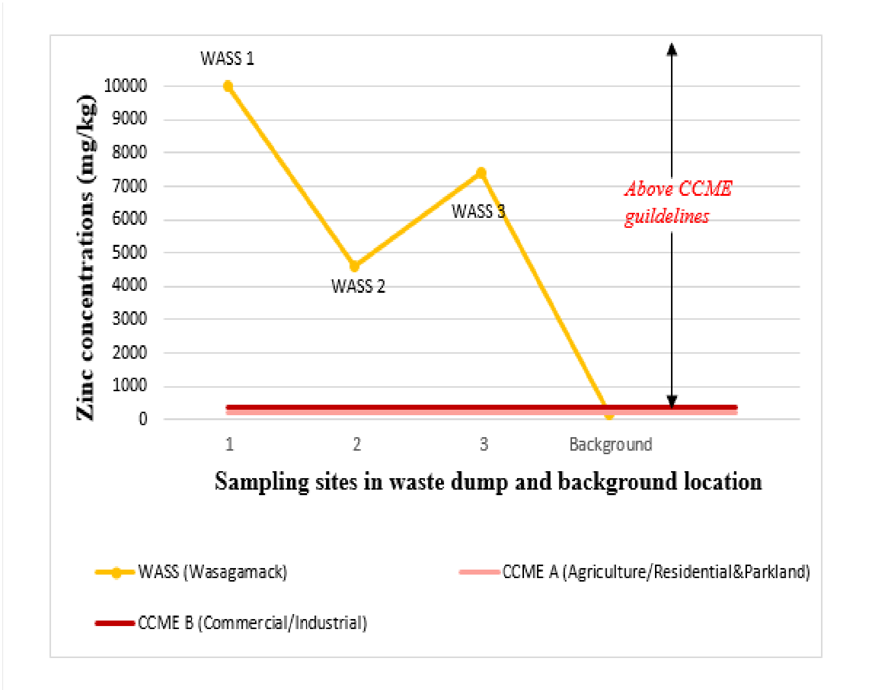

Figure 2.1: **Zinc concentration in Wasagamack waste dumpsite and background soil samples**

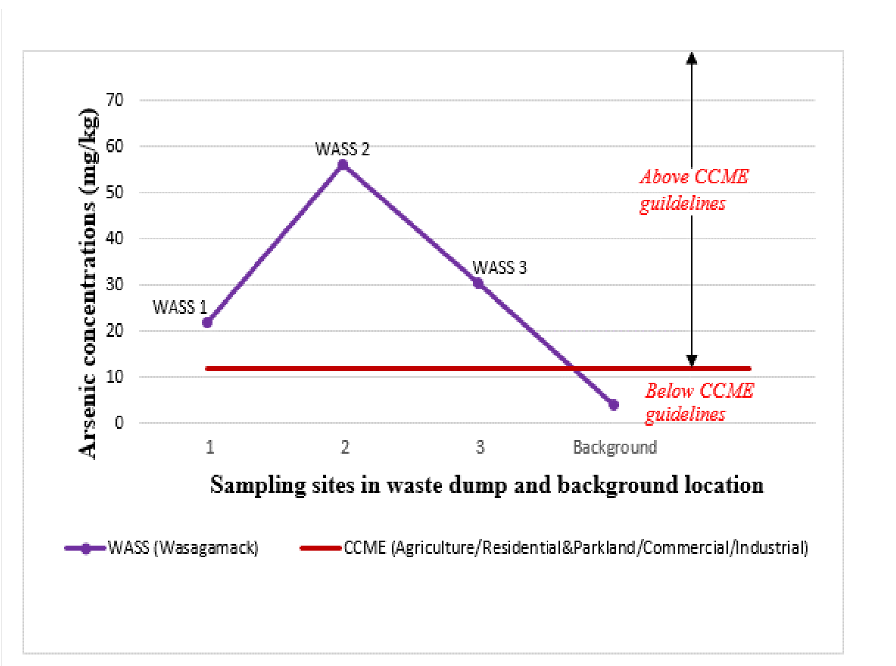

Figure 2.2: **Arsenic concentration in Wasagamack waste dumpsite and background soil samples**

iii. The concentrations of Copper were recorded at values range from 28.3mg/kg to 638mg/kg for WASS soil. Background sample has the lowest concentration of Copper at 28.3mg/mg. Therefore, the highest concentration of Copper in WASS sample (638mg/kg) exceeded permissible Copper levels of 63mg/kg (residential and parkland [CCME A]) and 91mg/kg (industrial [CCME B]) presented in CCME soil quality guidelines. This elevated copper concentration indicates that the site is contaminated with copper.

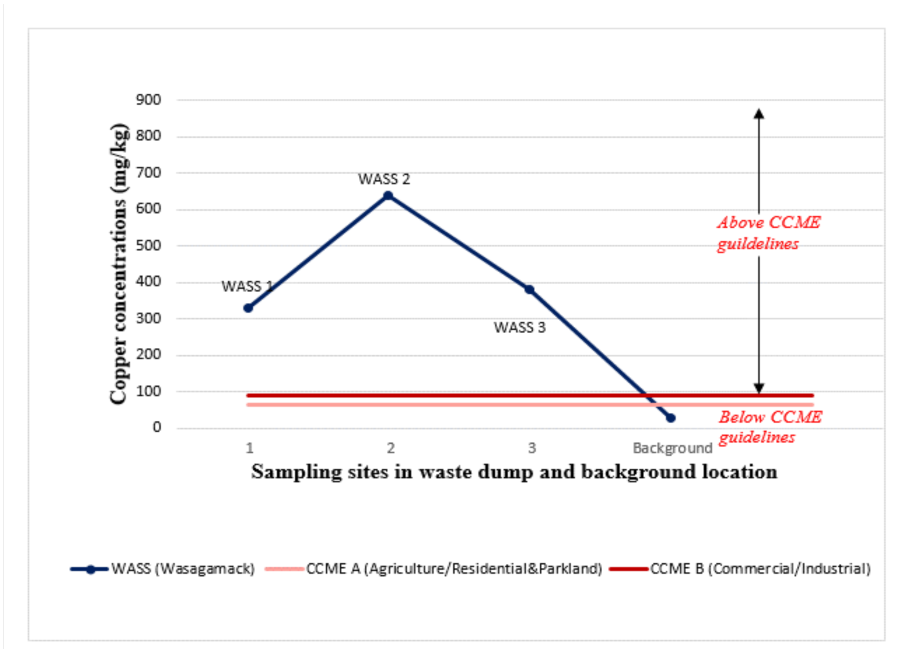

Figure 2.3: **Copper concentration in Wasagamack waste dumpsite and background soil samples**

iv. Figure 2.4 illustrates the concentration of Lead in the samples. Values range from 25.5mg/kg to 325mg/kg. WASS background have the lowest amount of Lead contamination with a value of 25.5mg/kg. WASS 1-3 have values above 100mg/kg, with WASS 2 having the highest amount of contamination (325mg/kg). WASS 1 have the lowest of the three samples.

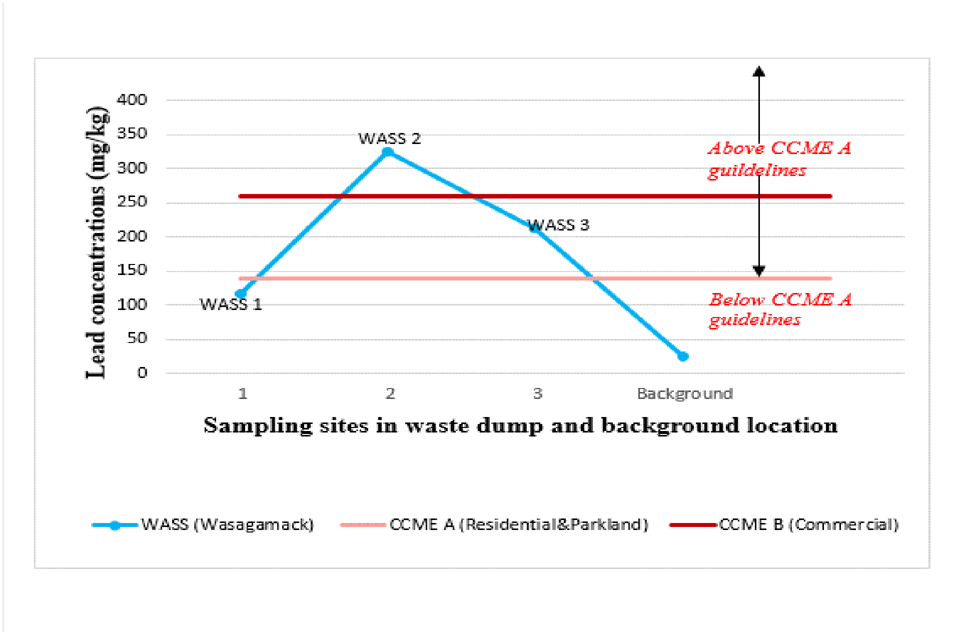

Figure 2.4: **Lead concentration in Wasagamack waste dumpsite and background soil samples**

v. CCME soil quality guidelines and background levels were exceeded for Chromium, indicating Chromium contamination at the site. Values range from 96mg/kg to 311mg/kg. WASS background have the lowest amount of Chromium contamination with a value of 84.8mg/kg. WASS 1-3 have values above 100mg/kg, with WASS 2 having the highest amount of contamination (383mg/kg). WASS 1 have the lowest of the three samples (192mg/kg).

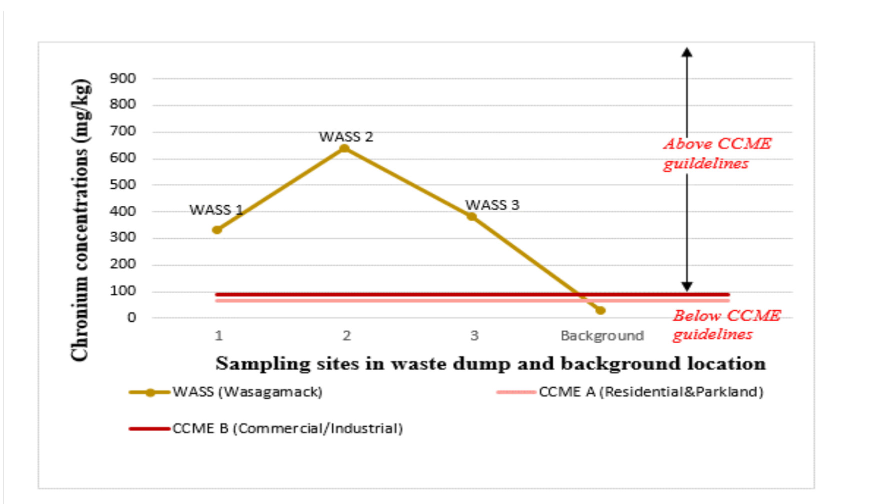

Figure 2.5: **Chromium concentration in Wasagamack waste dumpsite and background soil samples**

In general, the presence of high concentrations of Arsenic, Chromium, Copper, Lead and Zinc may be associated with the dumping and open air burning of e-waste, construction and demolition wastes and other chemical containing materials at the sites. Arsenic, Chromium, Copper, Lead and Zinc are constituents of crystal ray tube (CRT) and liquid crystal display (LCD) display and printed wiring boards in electronics appliances.

4) Potential impacts of elevated heavy metal concentrations on environmental and community health

Table 1 below highlights the potential impacts of heavy metal contaminations detected above background and guideline levels on environmental and human health.

Table 1: Chemical parameters found above background and guideline levels and their potential human health and environmental effects

Substance	Uses/location	Environmental and health implications	Routes of exposure	Sources
Arsenic (As)	Used as doping agent in transistors and PWB. Used in small quantity as gallium arsenide in Light Emitting Diode (LED)	Sore throat; tissue damage, irritated lungs; vascular & heart disease; increase the risk of lung, skin and urinary tract cancer	Ingestion of contaminated water or food; inhalation of dust particles and fumes	Frumkin & Thun, (2001), Schmidt (2002), Horne & Gertsakis (2006), Abernathy et al. (1999).
Chromium (Cr)	Used to prevent corrosion; decorative for steel housing, Data tapes and floppy disks	Allergic reactions; stomach ulcer; damage to pulmonary and renal system; DNA damage, increase risk of cancer.	Ingestion through chromium contained in water, food or soil, Inhalation and dermal absorption.	Schmidt (2002); Dashkova (2012)
Copper (Cu)	Printed circuit board conductivity/CRT, PWB, connectors, Lithium batteries	Hepatic and renal diseases, irritation of the nose, mouth and eyes, headaches, stomach problems, dizziness, vomiting and diarrhea. Chronic exposure can result in Wilson's disease	Inhalation, oral, dermal	ATSDR (2004)
Lead (Pb)	Used as glass panel gasket in CRT; Soldering; found in batteries and light bulb	Damage to hematopoietic, hepatic, renal and skeletal systems; Central Nervous System damage. Lead accumulates in the environment; toxic to plant, soil and microorganism	Ingestion of contaminated water or food; inhalation of lead containing dust particles; skin contact	Verstraeten et al. (2008) Horne & Gertsakis (2006), Grant et al. (2013)

Zinc (Zn)	Battery, PWB, Phosphor emitter CRT and metal coatings	metal fume fever	Ingestion and inhalation	Grant et al. (2013), Bandyopadhyay (2008)

5) Recommendations

In order to protect the community from health and environmental impacts associated with improper waste disposal activities in the communities, the following immediate actions are recommended:

1) Upgrade the WASS dumpsite to a better landfill with appropriate environmental protection measures. On-going funding to maintain should come from Aboriginal Affairs and Northern Development Canada (AANDC)
2) Build transfer station to separate, sort and collect recyclables and hazardous wastes to ship out of the communities working with producer responsibility organizations and Province for funding.
3) Apply for funding for the provisions of garbage collection trucks and curbside collection containers for door-to-door and curbside collection of garbage and recycling.
4) Train at least community member to specialize in waste management including siting landfill and recycling as well as providing education in schools and to band members through radio and programming.
5) Obtain education materials for schools and engage school in composting and recycling.

A SUMMARY REPORT ON SOLID WASTE MANAGEMENT IN GARDEN HILL FIRST NATION

REPORT BY:
AHMED, OYEGUNLE
NATURAL RESOURCES INSTITUTE
UNIVERSITY OF MANITOBA
SUPERVISED BY: DR. SHIRLEY THOMPSON

ABSTRACT

For many First Nations in Northern Manitoba, solid waste management remains a serious, albeit under-researched, problem. Garden Hill First Nation waste sites and activities were studied in 2014-2015 to assess their potential environmental and health impacts. Solid waste management practices were investigated through personal observations, interviews with band members and laboratory analysis. Findings indicated that poor funding, lack of adequate waste receptacles for storage of waste generated in the households, absence of recycling and door-to-door garbage pick-up services etc., were the causes of waste, including toxics being disposed and/or burned in backyards of homes and public places. Laboratory analyses revealed the presence of toxic contaminants (such as Zinc, Arsenic, Copper, Chromium and Lead) above all existing guidelines and background levels in soil samples collected from dumpsites in the communities. Overall, this study calls for the urgent implementation of environmentally sound waste management programs in the communities to safeguard community health and the environment

TABLE OF CONTENTS

1) Introduction

Waste management activities in Garden Hill First Nation (GHFN) were studied in 2014-2015 to assess their potential environmental and health impacts. Of major concern are the practices of open dumping and open-air burning of garbage, both of which have been banned in federal regulations. Open dumping and open-air burning as waste disposal methods are considered unsafe and unsustainable (Owusu, 2010).

Interviews with band members revealed that GHFN problems with waste management started with:

i. use and disposal of packaging and toxic materials (such as e-wastes, tires, lead batteries, etc.), many of which should be covered under provincial product stewardship programs but aren't.
ii. lack of adequate waste receptacles for storage of waste generated in the households,
iii. wild animals in search of food encroaching the community due to lack of proper garbage storage and disposal, leading to safety concerns
iv. absence of door-to-door/curbside waste collection services,
v. non-existence of any formal and informal recycling services;
vi. prevalence of open dumping areas and junkyards around the communities:
vii. backyard burning of wastes
viii. the absence of properly sited, engineered sanitary landfills that meet government standards;
ix. lack of finances for collection, recycling, landfill operations, education and training or any other integrated solid waste management program; and
x. lack of trained community expert in integrated solid waste management.

Unregulated dumping of waste materials on land and burning in open air expose humans and mother earth to the contaminants in the waste stream and create new contaminants which are detrimental to health and livelihoods in the communities. Uncontrolled disposal and open burning of garbage generate hazardous leachates and toxic gases that pollute the environment, and may also serve as breeding grounds for disease-carrying vectors, such as rats and mosquitoes (United Nations Environmental Programme [UNEP], 2005; Hoornweg & Bhada-Tata, 2012). Children at play and adults are exposed to physical injuries and infections from sharps and other hazardous materials present in the waste stream. Therefore, the safety of solid waste management practices in GHFN require urgent attentions in order to safeguard community health.

2) Description of the active garbage dumpsite in GHFN

In GHFN, the waste site is located (53 53.522^{0}N, 0940 40.099^{0}W) along a high traffic road side in the east end of the community (see figure 2 below). The same road serves as route to connect the ice-road for travellers in the winter. The site served the community for the disposal of all wastes including toxic wastes. The waste site is characterized by:

i. close proximity to water features; the dump is located on a creek which flows directly into the nearby lake.
ii. no trained personnel or operations to monitor disposal activities
iii. no pollution prevention measures (i.e. daily cover, liners, leachate collection and gas capture).
iv. absence of fencing allows unrestricted public and wildlife access. Wildlife, e.g. Bear, encroachment was a big safety concern for community members due to lack of fencing.
v. Continuous burning of wastes including e-waste and other toxics leading to the release of environmental contaminants and increase risks of forest fire.

Figure 2: Road passes on top of garbage dump where community members typically dumped wastes. Waste materials were not compacted and can be seen flying around the communities.

3) Sampling and laboratory analyses

During environmental field investigations in the summer of 2015, composite soil samples (GHFN soil) were collected from different areas within the garbage dumpsites (GH1, GH2 and GH3) and background samples as control (GH BG). The collected samples were preserved and sent to the laboratory to analyse for the presence of heavy metal contaminations. The aim of the analyses was to detect the presence of environmental contamination at the site due to the observed site characteristics listed above. The analyses were carried out using a scientific method called inductively coupled plasma mass spectrometry (ICP-MS) techniques. The values obtained were compared to Canadian Council of

Ministers of Environment (CCME) soil quality guideline for the protection of human health and the environment. Results are reported in milligram per kilogram (mg/kg), equivalent to ppm, as indicated in the appendix section.

From results of the analyses, values for the concentrations of heavy metals such as Arsenic, Chromium, Copper, Lead and Zinc in GHFN soil were detected above CCME maximum acceptable levels for all land-use categories (i.e. residential and parkland, agriculture, commercial and industrial). Antimony, Nickel, Silver, Cadmium, Cobalt, Niobium, Manganese, Selenium, Molybdenum, Tin and Barium were also found to be higher when compared to the background levels. The results are summarized as follows:

i. Zinc concentration levels in the GHFN soil samples were found to be within 5 to above 50 times higher than the acceptable values presented in the CCME's soil quality guideline for residential and parkland (CCME A) and industrial land use categories (CCME B): For GHFN soil samples, the Zinc concentration values for the four samples analysed ranges from 107mg/kg to 9290mg/kg with the background sample having the lowest amount of Zinc concentration (107mg/kg). GH 1-3 have values above 1000mg/kg indicating a high amount of contamination in these samples. GH 3 sample shows the highest degree of Zinc contamination with a value greater than 9000mg/kg, as indicated in Figure 2.1.

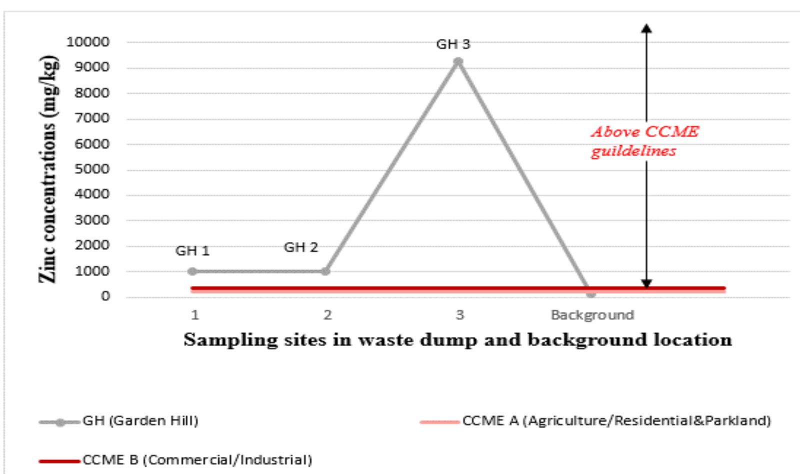

Figure 2.1: **Zinc concentration in Garden Hill (GH) waste dumpsite and background soil samples**

ii. Arsenic concentration levels detected in GHFN soil (5.4mg/kg - 53mg/kg) exceeded the CCME soil quality guideline of 12mg/kg as well as background concentrations 4.3mg/kg (see Figure 2.2). The highest detected contamination in GHFN soil was found to be 4.4 times higher than CCME guideline for all land use categories and 12.3 times higher than background level.

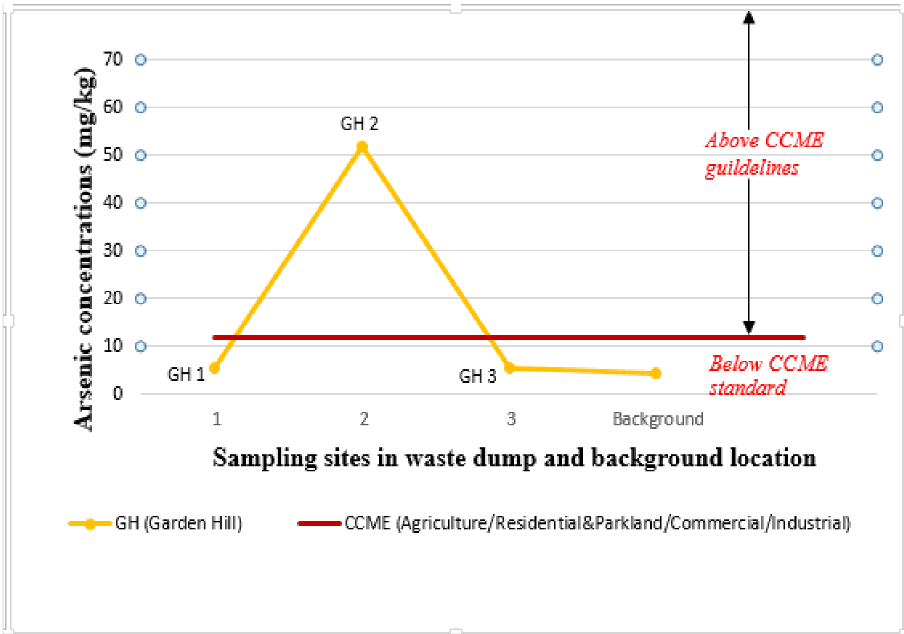

Figure 2.2: **Arsenic concentration in Garden Hill waste dumpsite and background soil samples**

iii. The concentrations of Copper were recorded at values from 165mg/kg to 804mg/kg for GHFN. These values exceeded permissible levels for Copper (63mg/kg) in residential and parkland presented in CCME guidelines. GH background have the lowest amount of Copper concentration with a value of 26.5mg/kg. Figure 2.3 indicates the concentration of copper in the GHFN soil samples compared to CCME guidelines.

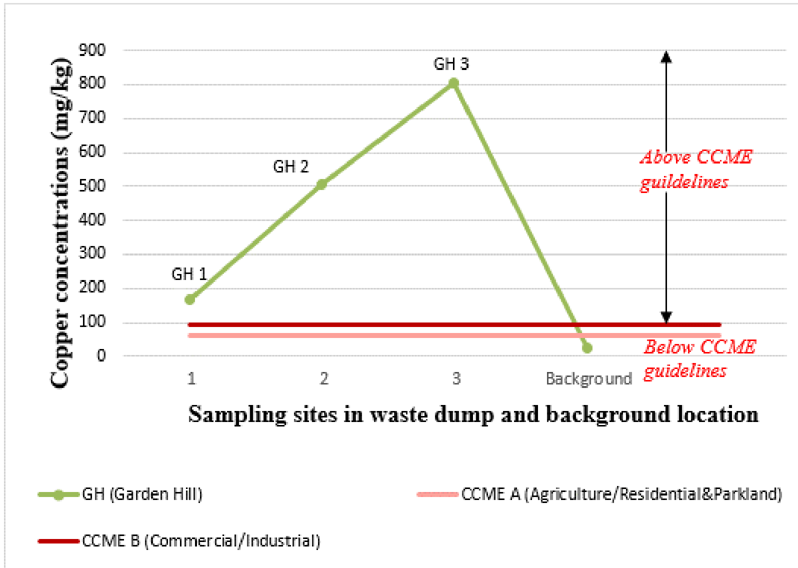

Figure 2.3: **Copper concentration in Garden Hill waste dumpsite and background soil samples**

iv. Figure 2.4 illustrates the concentration of Lead in the samples. GH background has lead concentration of 23.8mg/kg. However, GH 1-3 have values above guidelines and background levels, indicating lead contamination. GH 2 has the highest amount of contamination of 225mg/kg.

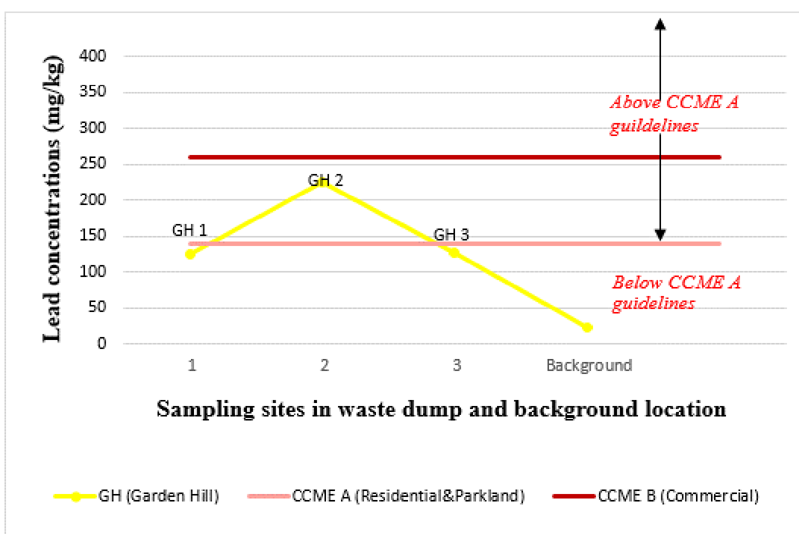

Figure 2.4: **Lead concentration in Garden Hill waste dumpsite and background soil samples**

v. CCME soil quality guidelines were exceeded for Chromium (see Figure 2.5). Values range from 101mg/kg to 311mg/kg. GH background have the lowest amount of Chromium contamination with a value of 96mg/kg. GH 1-3 have values above 100mg/kg. GH 2 having the highest amount of contamination (311mg/kg) compared to chromium guideline values of 64mg/kg and 87mg/kg for residential and parkland and industrial respectively.

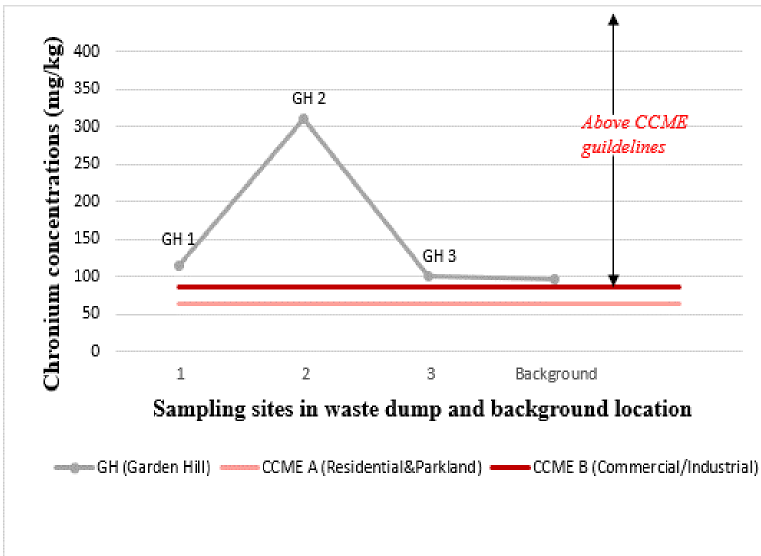

Figure 2.5: **Chromium concentration in Garden Hill waste dumpsite and background soil samples**

In general, the presence of high concentrations of Arsenic, Chromium, Copper, Lead and Zinc may be associated with the dumping and open air burning of e-waste, waste tires, construction and demolition wastes and other toxic materials at the sites. Arsenic, Chromium, Copper, Lead and Zinc are constituents of crystal ray tube (CRT) and liquid crystal display (LCD) display and printed wiring boards in electronics appliances. The close proximity of the site to water features increases the risks of surface water contamination from the site. Since the site is located on a road, there is also increase chances of human exposure to these contaminants through contaminant sticking to vehicle tires, shoes and clothes.

4) Potential impacts of elevated heavy metal concentrations on environmental and community health

Table 1 below shows the potential impacts of heavy metal contaminations detected above background and guideline levels on environmental and human health. For example,

Table 1: Chemical parameters found above background and guideline levels and their potential human health and environmental effects

Substance	Uses/location	Environmental and health implications	Routes of exposure	Sources
Arsenic (As)	Used as doping agent in transistors and PWB. Used in small quantity as gallium arsenide in Light Emitting Diode (LED)	Sore throat; tissue damage, irritated lungs; vascular & heart disease; increase the risk of lung, skin and urinary tract cancer	Ingestion of contaminated water or food; inhalation of dust particles and fumes	Frumkin & Thun, (2001), Schmidt (2002), Horne & Gertsakis (2006), Abernathy et al. (1999).
Chromium (Cr)	Used to prevent corrosion; decorative for steel housing, Data tapes and floppy disks	Allergic reactions; stomach ulcer; damage to pulmonary and renal system; DNA damage, increase risk of cancer.	Ingestion through chromium contained in water, food or soil, Inhalation and dermal absorption.	Schmidt (2002); Dashkova (2012)
Copper (Cu)	Printed circuit board conductivity/CRT, PWB, connectors, Lithium batteries	Hepatic and renal diseases, irritation of the nose, mouth and eyes, headaches, stomach problems, dizziness, vomiting and diarrhea. Chronic exposure can result in Wilson's disease	Inhalation, oral, dermal	Agency for Toxic Substances and Disease Registry (2004)
Lead (Pb)	Used as glass panel gasket in CRT; Soldering; found in batteries and light bulb	Damage to hematopoietic, hepatic, renal and skeletal systems; Central Nervous System damage. Lead accumulates in the environment; toxic to plant, soil and microorganism	Ingestion of contaminated water or food; inhalation of lead containing dust particles; skin contact	Verstraeten et al. (2008) Horne & Gertsakis (2006), Grant et al. (2013)
Zinc (Zn)	Battery, PWB, Phosphor emitter CRT and metal coatings	metal fume fever	Ingestion and inhalation	Grant et al. (2013), Bandyopadhyay (2008)

5) Recommendations

In order to protect the community from health and environmental impacts associated with improper waste disposal activities in the communities, the following immediate actions are recommended:

i. closure of the garbage dump in GHFN with the requirement to build a landfill with appropriate environmental measures and hydrogeological consideration. On-going funding to maintain should come from Aboriginal Affairs and Northern Development Canada (AANDC)
ii. Build transfer station to separate, sort and collect recyclables and hazardous wastes to ship out of the communities working with PROS and Province for funding.
iii. Apply for funding for the provisions of garbage collection trucks and curbside collection containers for door-to-door and curbside collection of garbage and recycling.
iv. Train at least community member to specialize in waste management including siting landfill and recycling as well as providing education in schools and to band members through radio and programming.
v. Obtain education materials for schools and engage school in composting and recycling.