A PROVINCE-WIDE COMPARISON OF NON-HAZARDOUS WASTE GENERATION AND RECYCLING RATES

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Abstract: This paper presents a comparison of non-hazardous waste generation and diversion programs between Manitoba (MB) and Saskatchewan (SK) in Canada. Residential and non-residential waste data was compiled from Statistics Canada's waste reports covering biennial years between 1998 and 2010. SK and MB were selected due to their similarities in population, location, and climate. Studies in developing countries show that increased economic growth and population increases waste generation. Population has risen in the Prairie Provinces by 49% within the last 30 years, increasing the need for diversion programs. SK generated 15% more non-residential waste than MB on average, while MB's average residential waste generation was 17.5% higher than SK's. SK and MB's diversion rates were lower than the national average during the study period. Neither SK nor MB operated a publicly-funded curb-side recycling program during the study period, though major cities in both provinces have since implemented these programs. Centralized composting, electronic waste, and various recycling depot programs were implemented in SK and MB during the study period. Combining pay-as-you-throw waste programs with a recycling program has reduced waste disposal in some US communities by 25-45%, which may help increase diversion rates in SK and MB.

Key Words: non-hazardous waste generation, province-wide comparison, diversion programs

1 INTRODUCTION

Part of the reason why efficient solid waste management (SWM) practices have been slow to develop is the heterogeneous nature of waste materials, variable definitions, different policies and standards between jurisdictions, and the large scope of involved parties makes industry measurements difficult to quantify. For instance, only two provinces in Canada, Nova Scotia and Prince Edward Island, have legislated that organic materials are banned from disposal at landfills (Giroux Environmental Consulting 2014). For instance, according to Giroux (2014), the next province planning to introduce this strict policy is Quebec in 2020, and other provinces' plans are unknown. Without reliable values to gauge performance, areas of improvement are difficult to identify, and waste industry efficiency lags behind progress in other industries. Analyzing waste data and measuring trends can also help managers predict required resources to adequately manage materials in the future. With rising waste generation comes the need for increasingly efficient waste management: specifically, this paper will discuss the waste generation and diversion programs in Manitoba (MB) and Saskatchewan (SK), though other strategies exist, such as source reduction.

Western Canadian provinces have experienced a 49% population growth over the past 30 years. In comparison, Atlantic Canada has grown by 4.4% over the same period (Statistics Canada, 2013). Population growth is the driving force behind municipal solid waste (MSW) generation. Socioeconomic factors have been studied and reported by a number of researchers in relation to solid waste. Beede and Bloom (1995) concluded that wealthy countries (about 17% of global population) generate about 25% of all global MSW. Recent studies have suggested that MSW generation is directly related to economic growth and rising living standards (Afroz et al. 2008; Badruddin et al. 2002; Bogner et al. 2007; Jadoon et al. 2013; Jones et al. 2008; Li 2009; Monavari et al. 2011; Sujauddin et al. 2008).

Isa et al (2005) conducted a case study on recycling in Nibond Tebal, Malaysia, and concluded that recycling programs are required for a successful MSW management system. Unfortunately, despite population growth (Table 1) major cities in Saskatchewan and Manitoba were among the last in Canada to implement mandatory curb-side recycling programs. Research in North America (Ashenmiller 2011) shows that publicly-funded curb-side recycling programs increase beverage container recycling rates when compared to drop-off facilities, such as those operated by the Saskatchewan Association on Rehabilitation Centers (SARCAN).

Table 1. Population comparison between largest cities in MB and SK (Statistics Canada 2012)

	Population (Statistics Canada 2012)	
City, Province	2006	2011
Winnipeg, MB	633, 451	663, 617
Regina, SK	179, 282	193, 100
Saskatoon, SK	202, 408	222, 189

Given their close proximity, SK and MB have common geophysical and socioeconomic characteristics. These characteristics are summarized in Table 2. These common traits make them ideal for comparison. The GDP values in Table 2 were cross referenced with Statistics Canada's reported values for 2012. Statistics Canada (2014) reported that SK's GDP was $78.873 billion, and MB's was $59.126 billion. The percent difference between the two sources is 1.23% for SK, and 1.9% for MB. The reason for the differences may be due to different calculations and/or bases; Statistics Canada's calculation is expenditure-based, and the Canadian Encyclopedia's calculation was not provided. The objectives of this paper are: (i) to examine waste disposal and diversion rates between SK, MB, and Canada's national average; and (ii) to compare diversion practices in SK and MB, and identify a potential strategy to enhance diversion rates.

Table 2. Characteristics in Saskatchewan and Manitoba

	Saskatchewan[1]	Manitoba[2]
Population	1,033, 381	1,208,000
Population Density	1.6/km^2	1.9/km^2
Area	651,036 km^2	647,797km^2
Climate	Continental	Continental
Topography	Prairie, forests, and lakes	Prairie, forests, and lakes
GDP[3]	$77.9 billion	$58 billion
GDP per capita[3]	$75,000 per capita	$48,000 per capita

1. Data from Canadian Encyclopedia article on Saskatchewan, 2015.
2. Data from Canadian Encyclopedia article on Manitoba, 2015.
3. GDP data from 2012.

2 METHODOLOGY

Statistics Canada began releasing biennial "Waste Management Industry Survey: Business Sector" reports in 1998. A pilot survey was conducted in 1989, and again in 1994. The first publicly released survey covered 1995, and was available in 1998 (Statistics Canada 1998). This was followed by the 1996 survey released in 1999. The residential and non-residential waste data in this paper covers years between 1998 and 2010. The surveys were sent to an average of 1320 Canadian waste management companies and local governments, and the average number of returned surveys was 1105. More than 83% of the surveyed waste management companies and regulatory agencies responded to the survey. The surveys typically ranged from one to four hours for completion due to the scope and number of questions; for example, 2002's survey consisted of 14 pages each for business and government recipients. Questions centered around physical quantities, types/sources of MSW and recyclables, finances, and employment in the industry. The reference period for every survey covered the period from April 1st to March 31st the following year.

There are inconsistencies in the waste data. For instance, the 1998 survey quoted a total waste generation of 29,651,154 tonnes, but the 2000 report quoted the 1998 value as 28,112,025 tonnes. This was due to a variety of reasons. First, the scope of recyclable material changed between the 1998 survey and 2000 survey. The recycling scope changed again in 2002, and also added exported waste to the waste disposal figures. Each time a revised definition or subsection is added, the preceding report's values are revised. Revised data was 2.5% lower than the original values on average. Revisions ranged between an increase by 0.88%, and a decrease by 6.6%. For consistency, this paper will use revised values. Selected values from Statistics Canada's reports were cross-referenced in order to check for accuracy. For example, Statistics Canada reported a MSW disposal rate of 798kg/capita for the year 2000 (2004). This differs by 1.5% compared to Werf's (2005) quoted value of 786kg/capita. Possible reasons for the difference may be different sampling groups, different data sources, or different study periods. Manitoba Conservation (2005) used Statistics Canada's values for the years 2000 and 2002 in a sustainability report. The report included values for SK and the national average as well. While SK's value for the year 2000 was matched (840kg/capita), the value for 2002 differed by 1kg/capita. Statistics Canada's value was 798kg/capita, and Manitoba Conservation calculated 799kg/capita. This error could be due to rounding.

These reports only consider non-hazardous MSW and recyclables that were collected, processed, and/or disposed by private or governmental waste management firms. Parties that manage/dispose of their waste at the point of generation, or by transporting them to another of their facilities for processing are not included in the scope of Statistics Canada's surveys. For instance, manufacturers may take waste by-products and re-input them into an early stage in their process. Public citizens operating backyard composting is another example of undocumented waste management. Figure 1 below shows the scope of the surveys. All materials relevant to the white boxes are not included, while the black box describes the materials covered in the surveys.

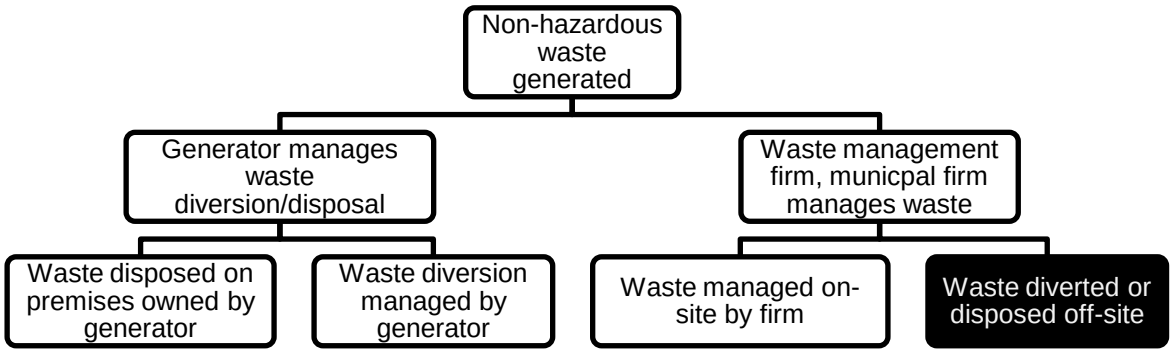

Figure 1. Scope of the Statistics Canada surveys (Adapted from WMIS, 2002)

Throughout this report, residential waste will be the term encompassing waste from all single family and multi-family sites (i.e. houses, cottages, apartment buildings, and condominiums). Non-residential wastes include MSW generated by industrial, commercial, institutional (IC&I), construction, and demolition (C&D) sources.

SWM research is usually conducted in a single city (Afroz et al. 2008; Li 2009; Monavari et al. 2011; Sujauddin et al. 2008), or makes a comparison between two or more cities (Jadoon et al. 2013; Mizpah et al. 2009). This method benefits from the researcher's ability to work with consistent policies within the case study city. Depending on the research objective, this method enables researchers to select cities with similar programs to increase the number of controlled variables. The drawback to this method is that data is limited or unavailable for small cities. Since MB and SK are relatively small provinces in terms of population, it is better to compare the provinces as opposed to comparing individual cities. Provincial data is more reliable since they include a larger sample size, and they are easily accessible via Statistics Canada. The drawback for the provincial comparison method is that municipal policies and cultural practices vary more widely within provinces.

3 DATA AND DISCUSSION

3.1 Total MSW Generation

The average per capita waste generation over the time period was relatively close across Canada. The national average (CA) was 985kg/capita, MB's average was 947kg, and SK's 974kg. The trends are shown in Figure 2. Despite the similar average values, each trend-line is very different. While SK's trend fell to 914kg/capita between 2002 and 2004, it then rose above MB and CA's by 2010. Unlike the other two trends, MB tended to decrease over time, reaching its minimum (893kg/capita) in 2006. CA's average rose to a peak in 2006, then decreased to 965kg/capita in 2010. MSW generation from residential and non-residential sectors will also be discussed separately in sections below.

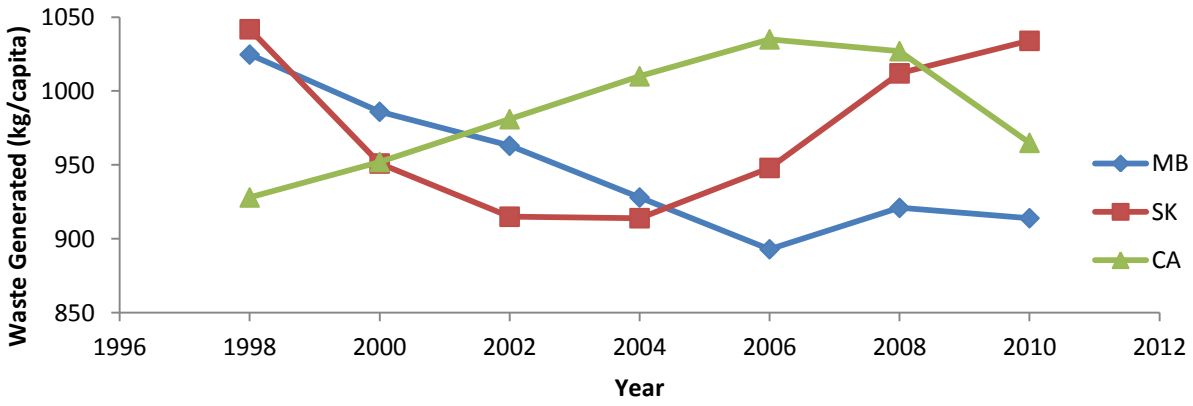

Figure 2. Annual per capita MSW generation rate in SK, MB, and CA (data from Statistics Canada, 2000-2013)

3.2 Residential Waste Generation

Between 1998 and 2006, CA's average residential waste generation was in between those in SK and MB, as shown in Figure 3. MB's generation rate was above SK's for each year except 1998, when MB's rate was lowest. SK was consistently the lowest residential waste generator of the three trend-lines. MB's average generation rate was 401kg/capita, SK's was 327kg, and CA's was 379kg.

On average, MB generated 18.3% more residential waste than SK, and 5.5% more than CA. Comparing MB's trend-line in Figure **2** and Figure **3**, the residential waste increases between 1998 and 2000, yet the total waste generation decreases. Thus the non-residential waste has a greater effect on the total waste generation in MB as well.

Comparing SK's trend-lines between 2004 and 2010 (Figures 2 & 3), it appears that the sharp increase in total waste generation was due to non-residential waste sources. This is supported by SK's small range of values in Figure 3 (minimum value of 300kg/capita, and maximum value of 350kg/capita).

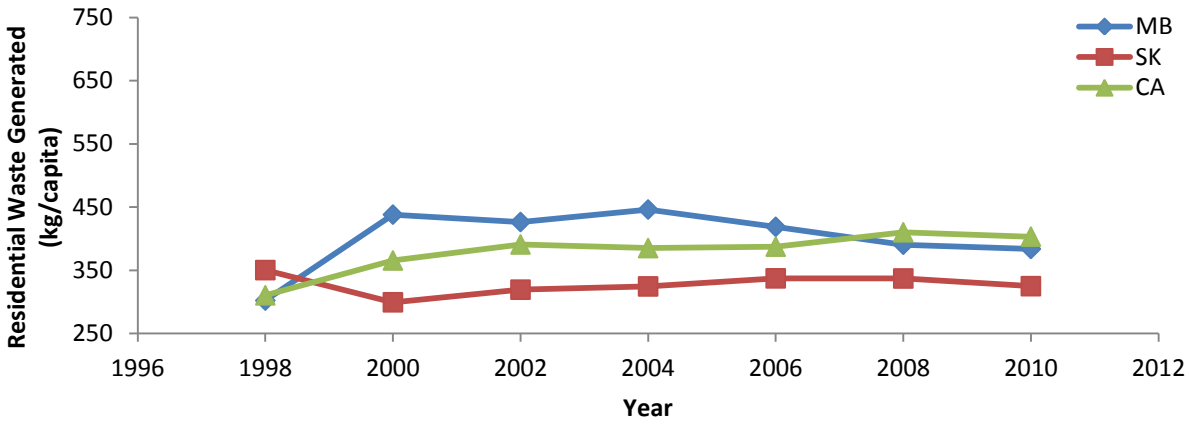

Figure 3. Annual per capita Residential waste generation rate in SK, MB, and Canada (data from Statistics Canada, 2000-2013)

3.3 Non-residential Waste Generation

Aside from 1998, MB's generation rate was consistently the lowest. SK tended to have the highest rate of the three as show in Figure 4. SK and MB reached their lowest points at around the same time (2004 for SK, and 2006 for MB). Contrarily, CA's average was high whenever SK and MB's were low, and decreased in 2008 when both provincial averages increased.

MB's average generation rate was 547kg/capita, SK's was 646kg/capita, and CA's was 604kg/capita. On average, SK generated 15.4% more residential waste than MB, and 6.4% more than CA. Comparing Figure 2 and Figure 4, it appears that SK's total generation rate follows the same trend as its non-residential rate. In Figure **4**, Canada's total generation rate is affected more by its non-residential generation rate than its residential rate.

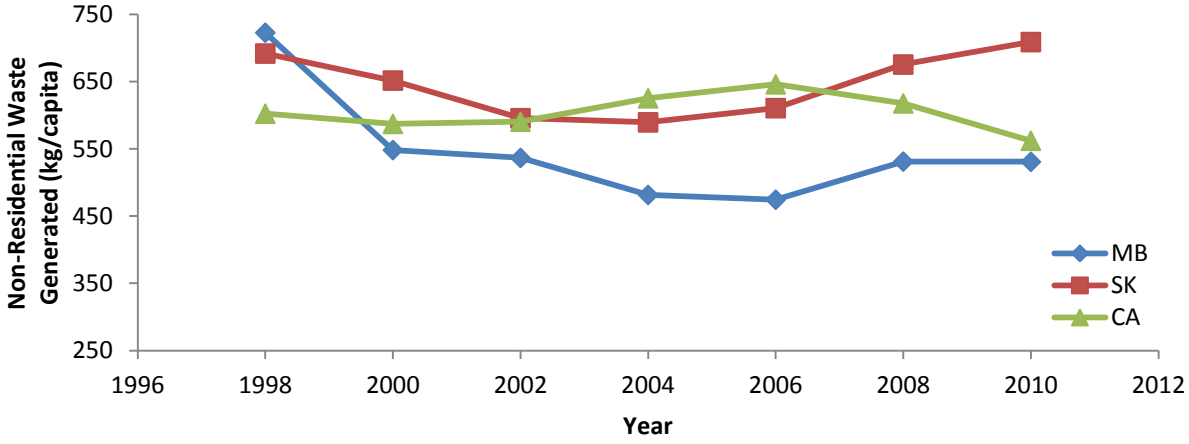

Figure 4. Annual per capita Non-residential waste generation rate in MB, SK, and Canada (Statistics Canada, 2000-2013)

Nationally, an average 61.5% of annual total waste generated comes from non-residential sources. MB's average non-residential waste generation accounts for 57.7% of the average total waste generated in MB, and SK's average is 66.4%. The biennial proportions of residential and non-residential waste are given in Figure 5. In the figure, "R" denotes residential waste, and "NR" denotes non-residential waste.

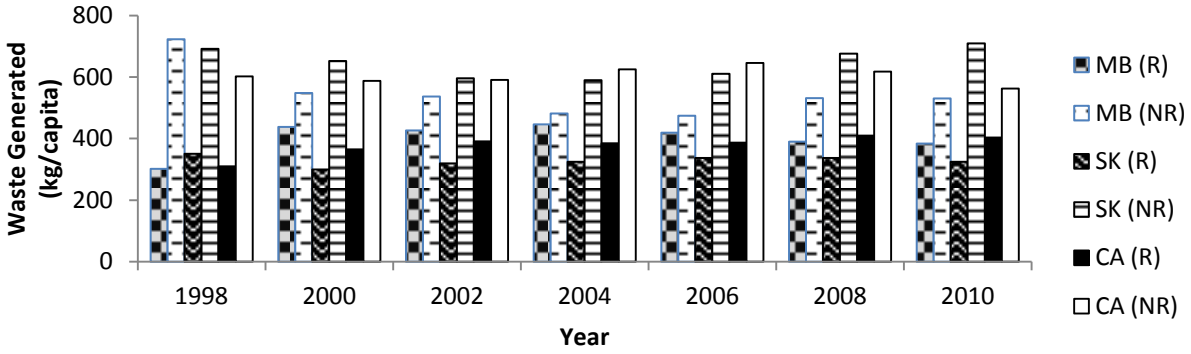

Figure 5. Residential and Non-residential waste generation in MB, SK, and Canada (data from Statistics Canada, 2000-2013)

Linear equations were developed based on Figures 2-4, and Figure 6. These equations are listed in Table **3** along with their corresponding R^2 values. The "y" term represents the waste generated or diverted, while "x" refers to each year following 1998. Only three of the equations have R^2 values over 0.70, and only one has an R^2 value above 0.90. As such, most of the equations are not significantly useful for forecasting future generation and diversion rates. 94.2% of Canada's residential waste diverted data can be related to the equation given in Table **3**. This supports the hypothesis that Canada's residential waste diversion rate will continue to increase each year, and provides evidence that MB and SK's waste diversion strategies are behind the rest of the nation.

Table 3. Linear Equations and R^2 for Figures 2-4, and 6

	Waste Category	Linear Equation (kg/capita)	R^2
CAN	Total Generated	y = 6.454x - 944	0.401
	NR Generated	y = -0.0715x + 605	0.0001
	R Generated	y = 6.507x + 340	0.708
	R Diverted	y = 5.4699x + 70	0.9422
MB	Total Generated	y = -9.501x+1004	0.786
	NR Generated	y = -12.003x + 618	0.3931
	R Generated	y = 2.5362x + 385	0.0495
	R Diverted	y = 0.9402x + 54	0.229
SK	Total Generated	y = 2.348x + 960	0.034
	NR Generated	y = 2.033x + 634	0.033
	R Generated	y = 0.3079x + 326	0.0067
	R Diverted	y = -0.3041x + 48	0.011

There have been some studies which suggest that GDP is related to non-residential waste generation (Ko et al. 2009; Xiao et al. 2006). Given the GDP data in Table 2. Characteristics in Saskatchewan and Manitoba Statistics Canada's 2012 waste report will probably show that SK generated more MSW than MB that year. This is supported by the final values in Figure 2: SK generated 1034kg/capita in 2010, and MB generated 914kg/capita. If 2010's trend continues, SK will generate more waste in 2012 as well. More than half of the waste generated in MB and SK are from non-residential sources. This supports the hypothesis that their relative GDPs will be similar to their total waste generation values. Further economic analysis with GDP and waste data is required in order to test this hypothesis.

3.4 Residential Waste Diverted

Trend-lines for residential waste diverted between 1998 and 2010 are shown in Figure 6. CA's average residential diversion rate was 102kg/capita, and increased over time from 70kg/capita in 2000 to 132kg/capita in 2010. MB's average was 60kg/capita, and SK's was 47kg/capita, making MB's average 21% higher than SK's. CA's average was 41.6% higher than MB's, and 54% higher than SK's. This indicates a definite lack in recycling practices in these two provinces compared to the rest of Canada. During the study period, MB's range was between 44kg/capita and 69kg/capita (25kg difference), while SK's was between 33kg/capita and 71kg/capita (38kg difference). Interestingly, all three trend-lines dropped between 1998 and 2000, and then ended at higher values than those in 2000. Unfortunately, the data for 2012 has not been released as of February, 2015.

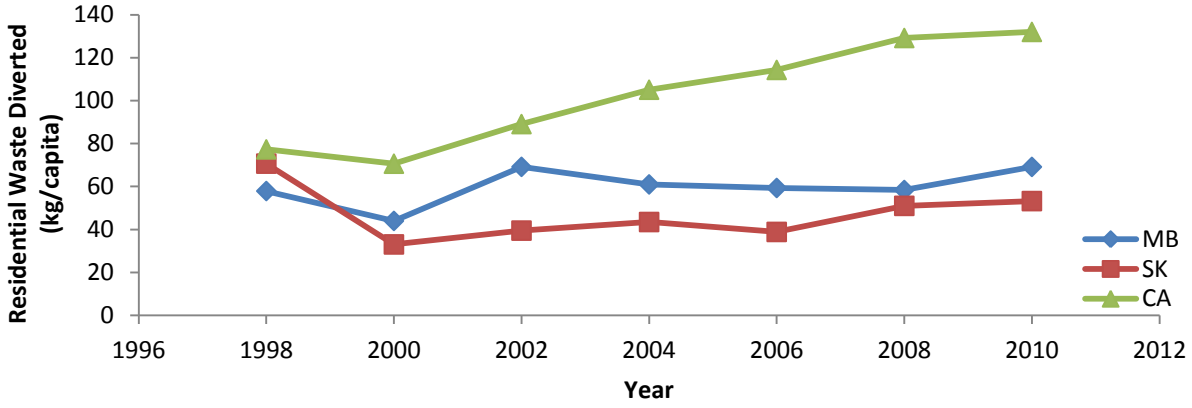

Figure 6. Annual per capita Residential Waste Diverted in MB, SK, and Canada (data from Statistics Canada, 2000-2013)

MB and SK diverted less than half as much residential waste as the CA in 2010. It is important to note that neither MB nor SK operated a publicly-funded curbside recycling program during the study period. As mentioned in the introduction, major cities in SK and MB were among the last to implement curbside recycling programs.

3.5 Recycling Practices and Programs

Winnipeg's city-wide curbside recycling program began in October 2012. Saskatoon's city-wide curbside recycling program began in January 2013, and Regina's program began later that year in July. As such, the full effect of these programs will not be reported by Statistics Canada until 2014's report is published. Saskatoon's data will affect SK's diversion rate for 2012 because of the April 1st to March 31st period used by the survey. Winnipeg will also produce affected data for MB's diversion rate. These programs accept multiple materials and are mandatory; some private, optional recycling companies have operated in these cities in the past with variable material collection (i.e. paper only, plastics, etc.). For example, Crown Shred & Recycling was established in Regina in 1988 for paper recycling and shredding (Crown Enterprises Ltd., 2011). The main characteristic that enables curbside recycling to affect diversion rates is its convenience (Wagner 2013). It is possible that if residential MSW collection was as inconvenient/inaccessible as previous iterations of recycling programs, source reduction would have minimized disposal rates and maximized diversion rates. However, MSW represents a greater threat to health and safety, so there was a greater incentive to develop MSW collection programs early.

Table 4 below presents a sample of MSW diversion programs implemented in SK and MB before and during the study period of 1998-2010. SK and MB have provincial government-run websites dedicated to providing drop-off location information to the public. There are a wide variety of supported materials. Neither SK nor MB have implemented mandatory composting programs, and have been slow to develop

comprehensive centralized composting. Saskatoon has opened two compost depots, the first of which was in 2001. The depots only accept certain yard wastes as of 2015 (City of Saskatoon, 2015). Swift Current (SK) yard waste has had biweekly curbside collection since 2001, and is composted by Delta Rock & Sand (Werf, 2006). As of 2015, Brandon's (MB) organic depots accept both kitchen and yard waste (City of Brandon, 2015), although yard waste depots date back to 1993 when Brandon's landfill started a yard waste diversion program (City of Brandon, 2007).

Table 4. Sample of MSW Diversion programs in Saskatchewan and Manitoba

Saskatchewan[1]		Manitoba[2]	
Program (initial year)	Collection method	Program (initial year)	Collection method
Beverage container collection & recycling program (1988)	Drop-off at SARCAN Depot	Tire stewardship program (1995)	Drop-off at various tire retailers
Scrap tire program (1996)	Consumers contact SSTC to arrange for disposal	Beverage container recycling program (2010)	Drop-off at various locations
Post-consumer Paint stewardship program (2006)	Drop-off at SARCAN Depot	Multi-material recycling (2010)	Public/private-run collection
Sask. waste electronic equipment program (SWEEP) (2007)	Drop-off at SARCAN Depot	Waste electronic equipment program (2010)	Drop-off at various locations

1. From City of Regina's Waste Management Report, 2009
2. From City of Brandon's Waste Management Plan, 2010

Pay-as-you-throw (PAYT) programs require waste generators to pay for waste collection. For instance, one version of PAYT requires residential waste generators to purchase bag tags; waste collectors only collect tagged bags. The idea is that citizens will reduce their waste generation in order to avoid the financial penalty; however, this system is vulnerable to illegal tipping practices, such as dumping waste in IC&I and C&D bins. Some studies (Robins & Kelleher 2005; Linderhof et al. 2001) have shown that combining mandatory curbside recycling programs with PAYT programs reduces waste disposal. One such study concluded that various American municipalities reduced waste disposal between 25 and 45% (Skumatz, 1995). Linderhof et al. (2001) conducted a case study in the municipality of Oostzaan, in The Netherlands, and concluded that annual total waste decreased by 42% within three years of implementing a weight-based PAYT program. Furthermore, non-recyclable waste collection decreased by 56%.

Once data is published regarding SK and MB's diversion rate with curbside recycling, it would be ideal to review the possibility of adding a PAYT program to diversion practices. However, Winnipeg has previously received public opposition to a PAYT program in 2004 (Robins & Kelleher 2005). Linderhof et al. (2001) also observed "extensive public debate that preceded" the PAYT program, yet the program successfully reduced waste collection and disposal at residential waste sources. However, Oostzaan is a municipality with a population under 10,000, whereas Winnipeg's population was 663, 617 as of 2011 (Statistics Canada 2012). A possible strategy to garner public opinion in Winnipeg is to implement PAYT pilot projects in towns near Winnipeg, or in Brandon, which has preceded Winnipeg in waste management programs in the past. If the pilot projects prove successful, as in the small town of Oostzaan, Winnipeg officials will have proof of the efficacy of PAYT programs in the province. There is also the possibility that citizens involved in the pilot projects will share their experiences with Winnipeg citizens, which could be positive or negative. If public opinion remains opposed to the program, then the city at least avoided the cost of overhauling their system. Given that over half the population of Manitoba resides in Winnipeg, running a pilot project in the city would be financially risky; running a pilot project in smaller towns or cities presents much less risk due to the decreased scale. It would be difficult to trust results from a pilot project within a small area of Winnipeg because the distribution of socioeconomic factors (i.e. income, education, culture) would be skewed. It is preferable to run a pilot project in a small city in order to ensure a fair distribution between varying socioeconomic factors. A similar process is recommended for SK; however, further study is recommended in order to determine the ideal population size to run a PAYT pilot project, since SK has more cities than MB.

4 CONCLUSIONS

Despite geographical similarities, MB and SK have different, non-hazardous MSW generation trends. SK's waste generation rate is strongly affected by its non-residential waste streams, while MB's Residential waste stream is almost on-par with its non-residential waste stream. The average total MSW generation rate is similar between MB, SK, and Canada; however, their per capita trend-lines are different: SK started high, fell, then rose again; MB started high, and steadily declined; the national trend started low, steadily increased, and then fell at the end of the study period. Some existing diversion programs in SK and MB were discussed. MB and SK did not have publicly-funded curbside recycling programs during the study period, but have since implemented them. Organic waste depots exist in both provinces, but are voluntary, and mostly accept only yard wastes. Results from other studies have shown that PAYT services can be used to further optimize MSW systems by decreasing disposal rates between 25 and 45%. PAYT pilot projects were recommended in SK and MB in order to gauge efficacy and public opinion/co-operation in the provinces.

5 ACKNOWLEDGEMENTS

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