

Assessing the Policies and Processes of Waste Management in Four Canadian Cities

Michael Kolasa
Richard Huang
Xiyu Huang
Yutian Xia

Course:

ENVR 400

Community Project in Environmental Science

Research Advisor:

Dr. Tara Ivanochko

April 16, 2019



Executive Summary

Due to the current high levels of consumption globally, management of waste is becoming a growing problem for many metropolitan areas. Canadian cities in particular continue to have large amounts of resource consumption and waste generation. This project presents an assessment of the policies and processes of waste management in Canadian cities from 2012 to 2016. The scope of this assessment includes analysis of waste diversion in four Canadian cities: Metro Vancouver, Toronto, Ottawa, and Edmonton. Metro Vancouver and Ottawa were chosen as comparable metropolitan areas while Ottawa and Edmonton were chosen as comparable smaller scale areas. The waste diversion rate is determined by the amount of waste diverted divided by the total waste which includes the amount of waste diverted in addition to the amount that is sent to a landfill (Mueller, 2013).

Municipal Solid Waste (MSW) management poses a challenge for policymakers, companies and citizens, due to the large volume of waste produced combined with the meticulous planning required to create effective waste treatment infrastructure. This in turn leads to confusion and a lack of transparency in MSW management processes due to the complexity of the system. In order to make the MSW management process more transparent and presentable, this comparative analysis approach will strive to consolidate multiple approaches to the data into a single story. For policymakers, this research will aid them in making environmental regulatory decisions. For waste management companies, this research will assist them in determining customer demand for waste services. Additionally, this research will be presented to SPEC, who will inform the general public with up to date information on municipal waste management, with the goal of motivating individuals to respect and improve the environment. Ultimately, the hope is for the evidence gathered from this research to be useful in planning, implementing and changing waste management systems in Canada.

This project aims to inform the public in major Canadian cities about waste management and how their city's efficiency compares with other cities. It reviews and evaluates the effectiveness of municipal solid waste diversion processes by comparing the policies and processes of waste management in Metro Vancouver, Toronto, Ottawa, and Edmonton. Effectiveness is determined by if a waste management system is on track to achieve the city's waste policy goals.

Data was collected from scientific literature and municipal waste management reports. A comparative analysis was performed, focusing on the waste diversion rates and waste composition data. A comparison of the waste management policies implemented in each city was completed to determine how waste diversion rates are affected by particular policies. Figure E-1 shows an annual snapshot of per capita disposed waste for each city. Since each city has different populations, our study focused on metrics that are less dependent on this factor in order to make comparative analyses of waste management effectiveness between cities possible.

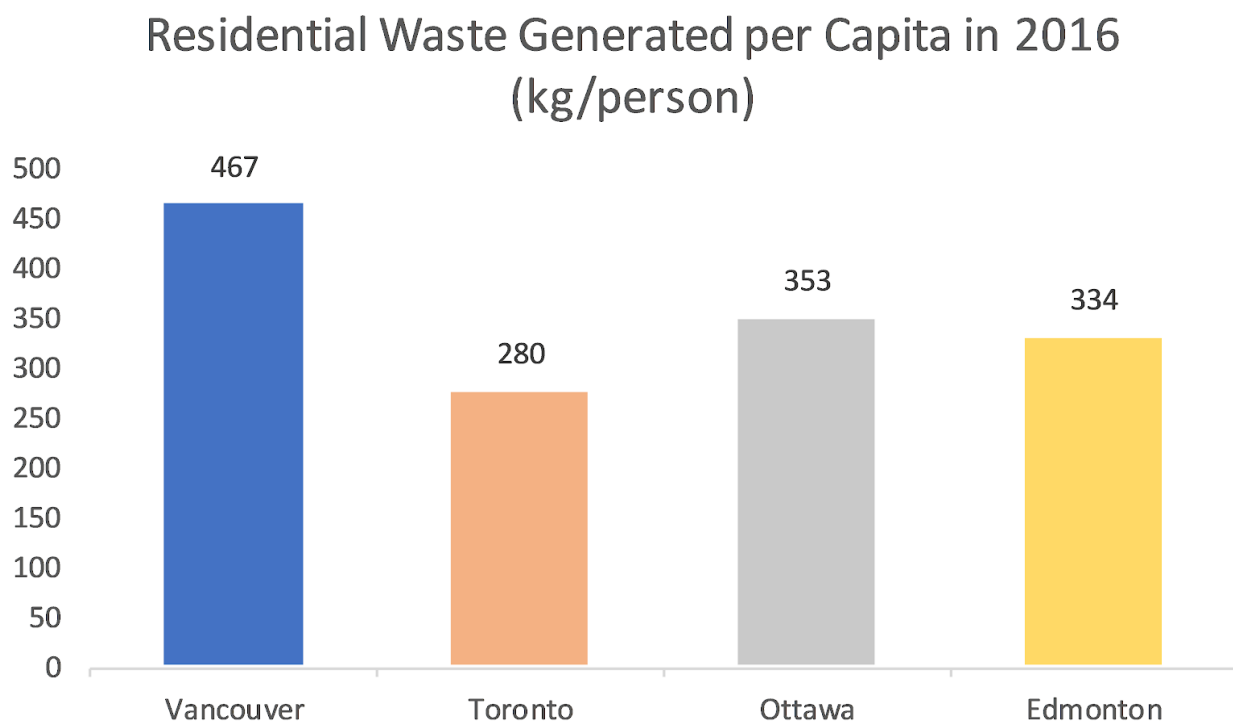


Figure E-1. Comparison of residential waste disposed per capita in Metro Vancouver, Toronto, Ottawa, and Edmonton in 2016.

About the Authors

Michael Kolasa

Michael Kolasa is a fourth-year undergraduate University of British Columbia student in the Integrated Sciences program. His integration topics include Environmental Sciences and Neuroscience to investigate how environmental changes from human interferences may disrupt the function of human neurobiological processes. His interests include the analysis of social and ethical issues in sustainability and exploring challenges when implementing environmental policy.

Richard Huang

Richard Huang is a fourth-year undergraduate student at the University of British Columbia. He is majoring in Environmental Sciences, concentrating on land, ocean, and air systems, and has taken courses discussing environmental policies and waste sustainability. His work experience includes a work placement in a Natural Resources Canada lab and an undergraduate teaching assistant position at UBC.

Xiyu Huang

Xiyu Huang is a fourth-year undergraduate student who is majoring in Environmental Science and focusing on land, air and water area of concentration in the University of British Columbia. She has taken courses investigating how waste causes pollution on soils, river, ocean and relative ecosystems. Her field of interest includes production, reduction and replacement of plastics and impacts of environmental policy implementation on the composition of municipal solid waste and on the waste diversion rate.

Yutian Xia

Yutian Xia is a fourth-year Environmental Science student with a focus of Land, Air, and Water at the University of British Columbia. She has taken courses discussing ecological dimensions of sustainability and waste management.

Table of contents

Introduction	5
Objectives	6
Waste Diversion Process	7-8
Plan of Action in Canadian Cities	9-10
Methods	11-12
Results	13
Metro Vancouver	14-15
Toronto	15-16
Ottawa	16-18
Edmonton	18-19
Comparison of Four Cities	20-22
Policies	23-24
Discussion	23
Effectiveness of Waste Management Systems	23
Possible Improvements in Waste Management Systems	24-25
Conclusion	25
Acknowledgements	26
References	27-28
Appendices	29
A1. Data for Metro Vancouver	29
A2. Data for Toronto	29
A3. Data for Ottawa	30
A4. Data for Edmonton	30

Introduction

Municipal solid waste (MSW) is composed of items that are used and discarded by the public daily. The provinces and territories regulate waste, and municipal authorities or private waste companies contracted by the city manage it. Canadian cities have seen an increase in the generation of waste over the last decade, where there were 9 million tonnes of waste residential waste disposed of in 2010 (McMillan, 2013). Of this 9 million tonnes, there were 2.9 million tonnes of residential waste diverted (Canadian Council of Ministers of the Environment, 2014). At this rate, there will be a shortage of landfill space for waste in the next few decades (Canadian Council of Ministers of the Environment, 2014).

Though Canadian cities have implemented waste management programs, they still require improvement with their management policies and processes when compared to countries such as Japan (Zhu & Huang, 2017). Japan has introduced technologies that turn waste into resources, where there is a collection, compression, and binding of recyclables to produce items such as yarn, uniforms, and carpets (Ministry of Environment, 2012). When reusing waste is not an option, waste disposal methods include a specialized incineration technique that minimizes the number of dioxins and poisonous gas generated in the atmosphere (Ministry of Environment, 2012). Compared to countries such as Japan, Canada is far behind when it comes to waste management. A goal for the municipal governments in Canada in the years to come is to improve MSW collection, recycling, and disposal, with MSW policies and processes requiring great reform to achieve this goal.

Objectives

There are two main objectives to our report:

- Inform Canadians about the waste management processes occurring in their cities
- Review and evaluate the effectiveness of municipal solid waste diversion processes in Vancouver, Ottawa, Toronto, and Edmonton by comparing their policies and waste diversion rates. Effectiveness is determined by if a waste management system is on track to achieve the city's waste policy goals.

The results from this project will provide the general public with up to date information on municipal waste management, with the goals of motivating individuals to respect and improve the environment and assist companies in determining customer demand for waste services.

Waste Diversion Process

When waste is diverted, it is prevented from going to the landfill. The current waste management process consists of three steps (figure 1). Before waste collection, residences will separate their waste based on the type of material. As table 1 indicates, each city has a different categorization technique for their materials. Generally, blue bins are for general recyclables (containers of different materials, plastics, etc) and green bins for organics. Programs specific to each city include black bins for paper-based items in Ottawa (City of Ottawa, 2012) and yellow and grey bins in Vancouver for paper and glass respectively. Afterwards, in step one, waste is collected from residences, typically every two weeks. In step two, a transfer station receives waste. A transfer station is an intermediate between the residential source, and landfill and recycling (Lakhan, 2015). At the transfer station, the materials are separated once again depending on if they meet the city's requirements for green bins (organics), recyclables (paper, plastic, metal, glass), and landfill material (City of Toronto, 2016b). In step three, the green bin facility, recycling facility, or landfill receive the materials from the transfer station (City of Toronto, 2016b). Some municipalities may have additional steps, where private companies may reuse the waste, or there is a transfer of waste to facilities that produce renewable energy (City of Ottawa, 2016 & City of Toronto, 2016b).

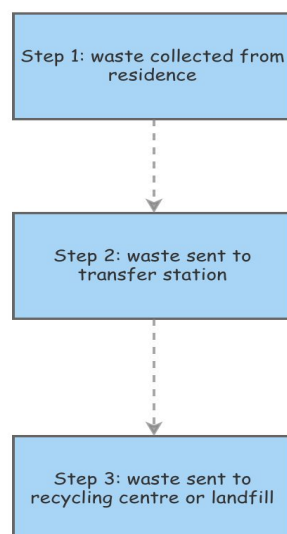


Figure 1. Steps of waste management, with waste collection beginning at the residences and ending up at a recycling facility or the landfill.

Table 1. Summary of the steps for waste management of the four Canadian cities. Column one has the steps, other columns shows what each city does in the step listed. From City of Edmonton (2011a), City of Edmonton (2011b), City of Ottawa (2012), City of Ottawa (2016), City of Toronto (2016b) and Recycle BC (2017).

Step	Metro Vancouver	Toronto	Ottawa	Edmonton
One (residence)	Blue, Yellow, Grey & Green Bin program	Blue & Green Bin program	Blue, Black, Green Box program	Waste pickup present for diverted and undiverted waste, recycling programs unclear
Two (transfer station)	For all cities, materials separated at a station depending on if they are green bin (organics), recyclable (paper, plastic, metal, glass), or landfill			
Three (recycling facility & landfill)	Recycling facility receives the diverted waste, undiverted to landfill	Recycling facility receives the diverted waste, undiverted to landfill	Recycling facility receives the diverted waste, undiverted to landfill	Landfill receives non-recoverable waste, recycling processes for diverted waste unclear
Additional Differences	A Waste-to-Energy facility burns undiverted waste so waste input into the landfill is reduced	Green bin items are turned into compost & biogas that converts to renewable energy	Recyclable materials sold to companies to reuse & create products	Other waste sent to biosolids facility to produce biofuels

Plan of Action in Canadian Cities

There are opportunities in Canadian cities to improve waste management by diverting more waste. A principle of action adopted by the city council defines a policy (Lakhan, 2015). Table 2 summarizes the waste programs implemented in the Canadian cities.

Table 2. Summary of waste programs implemented in the Canadian cities. From City of Edmonton (2011a), City of Ottawa (2011a), City of Ottawa (2011b), City of Toronto (2016a), and Metro Vancouver (2016).

Program	Metro Vancouver	Toronto	Ottawa	Edmonton
Program name	Zero Waste Goal	Zero Waste Future	Ottawa's Waste Plan	The Way We Green
Primary focus	Reduce undiverted waste to zero by reusing & conserving resources	Minimize the amount of waste requiring disposal & shifting towards conserving resources	Improving rates of reducing, reusing, & recycling and managing assets wisely so that there will be room in Ottawa's municipal landfill	Reduce the amount of solid waste generated, while increasing the amount of waste diverted from landfills
Year started	2009	2016	2011	2011
Year set to achieve goal	2040	2046 to 2066	2042	2040

Both Metro Vancouver and Toronto have adopted a Zero Waste policy, which has the goal of minimizing the amount of waste requiring disposal and shifting towards conserving

resources (City of Toronto, 2016a). “Zero waste” policies are based on a circular approach to the economy rather than the current linear approach. The goal of a circular approach is to keep resources in use for as long as possible, whereas the traditional linear approach expects produced items to be discarded after consumer use. In Metro Vancouver, the Zero Waste Goal was enacted in 2009 and aims to reduce landfill waste to zero by 2040 (Metro Metro Vancouver, 2016). The plan to achieve this is to reduce resource consumption (such as the banning of plastic straws by 2019) and to reuse waste whenever possible. In Toronto, the zero waste policy recommends waste reduction, recycling, reuse, and recovery (City of Toronto, 2016a). Waste reduction will occur by diverting 200,000 more tonnes of material from landfill, resulting in a 70% diversion rate (City of Toronto, 2016a). Recycling programs allow residents to leave divertable materials at a drop off depot while reuse events allow residents to trade or swap materials. These have been implemented to reduce the amount of waste requiring management by the city (City of Toronto, 2016a). For recovery, the city is exploring new technologies that recover recyclables from the garbage stream and divert the material from landfill (City of Toronto, 2016a). Achievement of this goal will occur between 2046 and 2066 (City of Toronto, 2016a).

Ottawa’s Waste Plan was approved by council in 2011 and expected to be achieved by 2042. The plan aims to have enough space in its municipal landfill by 2042 by encouraging the community to improve rates of reusing, reducing, recycling, and to manage assets wisely (City of Ottawa, 2011a). The primary goals for this plan are to generate less waste and to optimize waste diversion by simplifying product packaging and introducing consistent diversion programs into every household and workplace (City of Ottawa, 2011b). The City of Ottawa also targets to increase the capture rates for different material types to 90+% (City of Ottawa, 2011b).

Edmonton’s 30-year environmental plan, *The Way We Green*, focuses on resilience and sustainability (City of Edmonton, 2011a). The challenge is to reduce the amount of solid waste generated while increasing the amount of waste diverted from landfills through recycling and other initiatives in an economically feasible way. Twelve goals, such as “Edmonton generates Zero Waste,” need to be reached by 2040. Edmonton’s integrated and sustainable waste management system currently diverts over 50% of household waste through recycling and composting (City of Edmonton, 2011a).

Methods

Primary information about waste management was reviewed using sources such as municipal government reports and outlines of policies related to waste management. We compiled and interpreted the data to compare the waste management practices of our chosen Canadian cities. Our data allowed us to observe trends of waste generated over time and to compare the waste habits of different cities. The review of official websites and literature provided an overview of factors affecting waste management systems by looking at previous data collection (Guerrero, Maas & Hogland, 2013). We examined each city's waste policies and assessed the efficacy of these policies by comparing the city's waste generation data with other cities. By doing so, we can objectively determine how effective waste management policies are in different cities, and understand the mechanics of how they handle waste. The selected study period for the comparative in-depth waste breakdown analysis was from 2012 to 2016 and the study period for the general diversion rate analysis was from 2012 to 2017 due to the availability of the data. For Metro Vancouver, the data was collected from Solid Waste Management Annual Summary reports, which were published yearly from 2012 to 2016 on the Metro Vancouver Services website. Data was also collected from the Biennial / 5 Year Progress Report: Integrated Solid Waste and Resource Management Plan, which was published in November 2017 by Metro Vancouver. For Toronto and Ottawa, the data was collected from Resource Productivity & Recovery Authority datacall reports. The official website of city of Edmonton has a dataset about residential waste diversion since 2009. In addition, by contacting Edmonton Waste Management Centre, we received the data of EWMC waste sent to landfills from 2012 to 2016.

For each city, yearly municipal diversion rates were found by dividing the amount of waste diverted by the amount of waste generated each year. Diversion rate trends were coupled with waste policy implementation dates for each city, in order to gauge the effectiveness of certain policies by correlating policy implementation with significant changes in diversion rates. Further analysis categorized diverted waste into six major recycled materials (organic, paper, plastic, metal, glass and other). These materials were chosen due to their significant proportions in household waste. Differences in the amount of materials recycled and the amount of waste diverted presented in the reports was reconciled and was

assumed to be due to generation of Extended Producer Responsibility (EPR) waste. EPR waste is defined as diverted waste that has management responsibility shifted from municipal governments to producers and consumers. For example, this could mean instead of paying a flat municipal tax for waste treatment, the cost of residential waste for individuals would be based on the waste they generate. In our analysis, the amount of EPR waste generated annually in each city was found by subtracting diverted waste by recycled materials waste. EPR waste can be asserted to be present in all observed cities with the exception of Edmonton, which is due to a lack of data transparency rather than an explicit statement by Edmonton reports. The amount of each material and EPR waste generated from 2012 to 2016 was accumulated and their proportions relative to each other was found. This data was also coupled with policy implementations in order to evaluate the effect different policies had on the overall recycling of specific materials.

Results

Our analysis of single family and multi-family residential waste management in each city shows Metro Vancouver, Toronto, Ottawa, and Edmonton do differ in waste management effectiveness . One instance of this can be seen in Figure 2, which shows an annual snapshot of per capita disposed waste for each city and each city can be ranked by their average individuals' waste disposed. The following section looks at the 2012 to 2016 breakdown of materials cumulatively recycled by each city along with the cumulative EPR waste produced, though a lack of data for Edmonton has resulted in a lower resolution analysis.

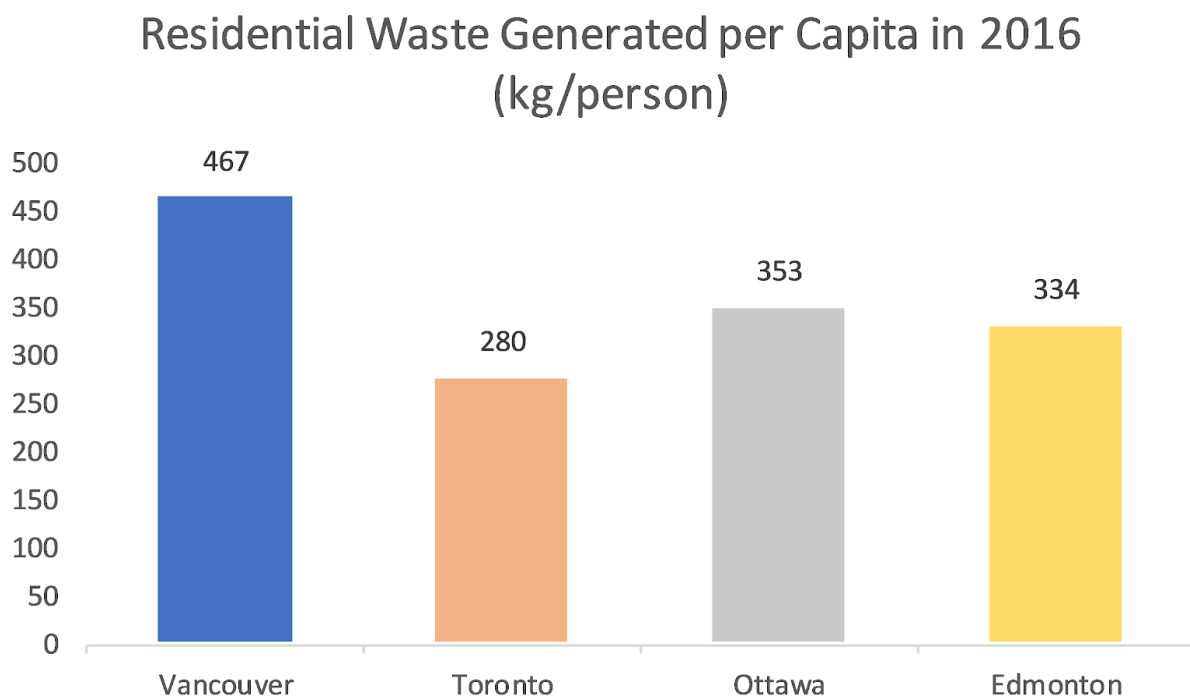


Figure 2. Comparison of waste disposed per capita in Metro Vancouver, Toronto, Ottawa, and Edmonton in 2016.

Metro Vancouver

Metro Vancouver's residential diversion rate has increased from 48 percent in 2012 to 58 percent in 2016 (Metro Vancouver recycling and Solid Waste Management Report, 2012-2016), and the absolute numbers of diverted waste each year can be seen in Figure 3. Large increases in organics recycling after 2013 coincides with new policies implemented in 2013, where green bin recycling would be picked up more frequently than garbage, and 2015, where a ban on food scraps to landfills was introduced. An increase to recycling overall was also found in 2015, which coincides Metro Vancouver joining the Recycle BC program in 2014 and financial incentives to manage its own recycling program was given. Figure 4 shows Metro Vancouver's cumulative residential recycling and EPR waste from 2012-2016. The cumulative recycled portion was then broken down to its recycled material proportions. The large fraction of organics recycled shows the green bin recycling program has been more successful in reducing undiverted waste when compared to other Metro Vancouver recycling programs, such as blue bin container recycling and paper recycling.



Figure 3. The amount of diverted residential waste generated in Metro Vancouver from 2012 to 2016.

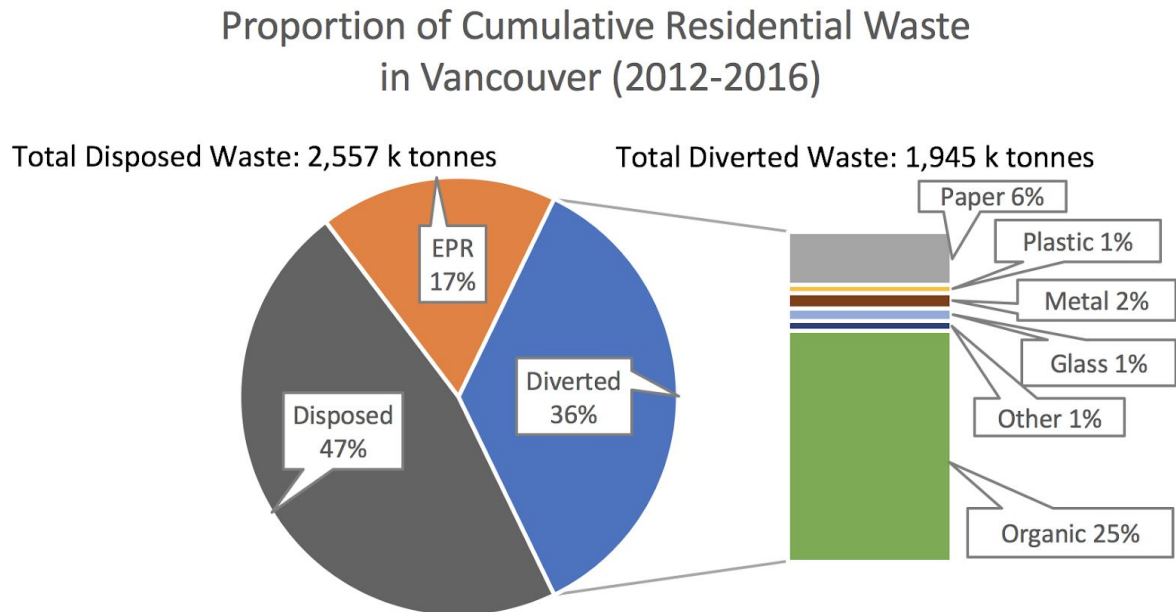


Figure 4. The proportion of recycled and the proportion of disposed for cumulative total residential waste in Metro Vancouver from 2012 to 2016.

Toronto

Toronto's residential diversion rate has not changed much from 2012 to 2016, with diversion rates close to 52 percent. However, the amount of total waste generated each year has declined and the absolute numbers of diverted waste each year can be seen in Figure 5. Toronto has used the Pay as You Throw program since 2008, where a household is charged for the amount of waste they put out for collection rather than the traditional mechanism of paying fixed fees for waste collection services (Lakhan, 2015). The Zero Waste Future plan was implemented in 2016, with the goal of reducing landfill waste input by 70 percent by 2026 and to achieve zero waste by 2066. Figure 6 shows Toronto's cumulative residential recycling materials breakdown and EPR waste from 2012-2016. The majority of recycled materials is organics, similar to Metro Vancouver, though paper recycling has a larger proportion in Toronto.

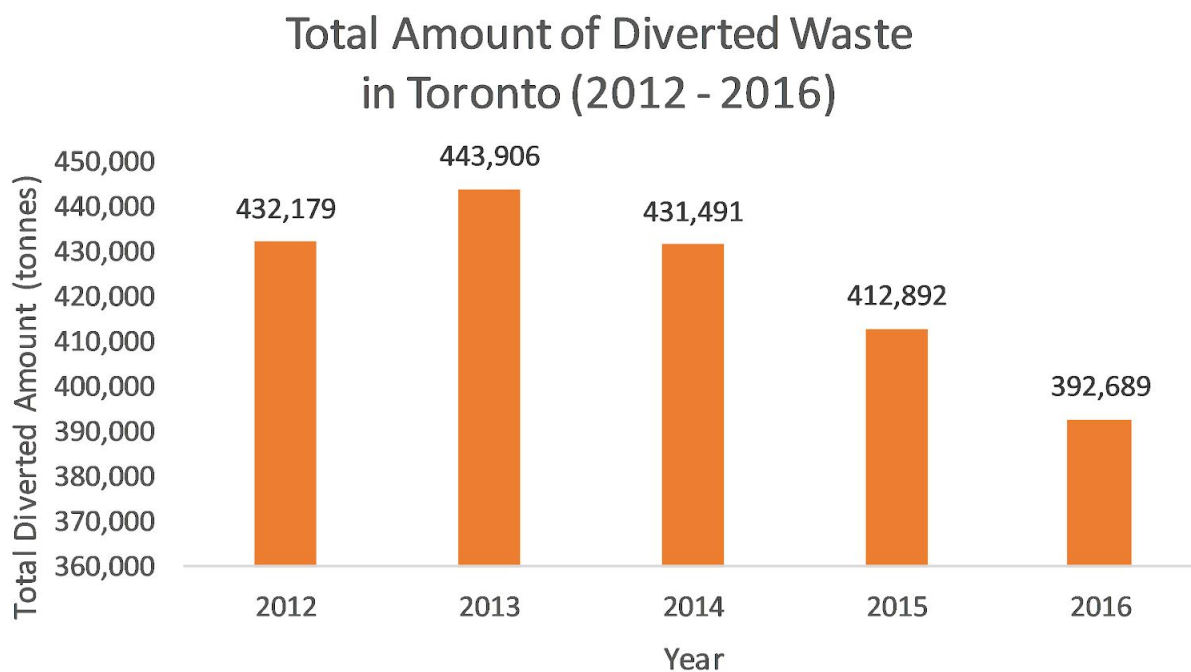


Figure 5. The amount of diverted residential waste generated in Toronto from 2012 to 2016.

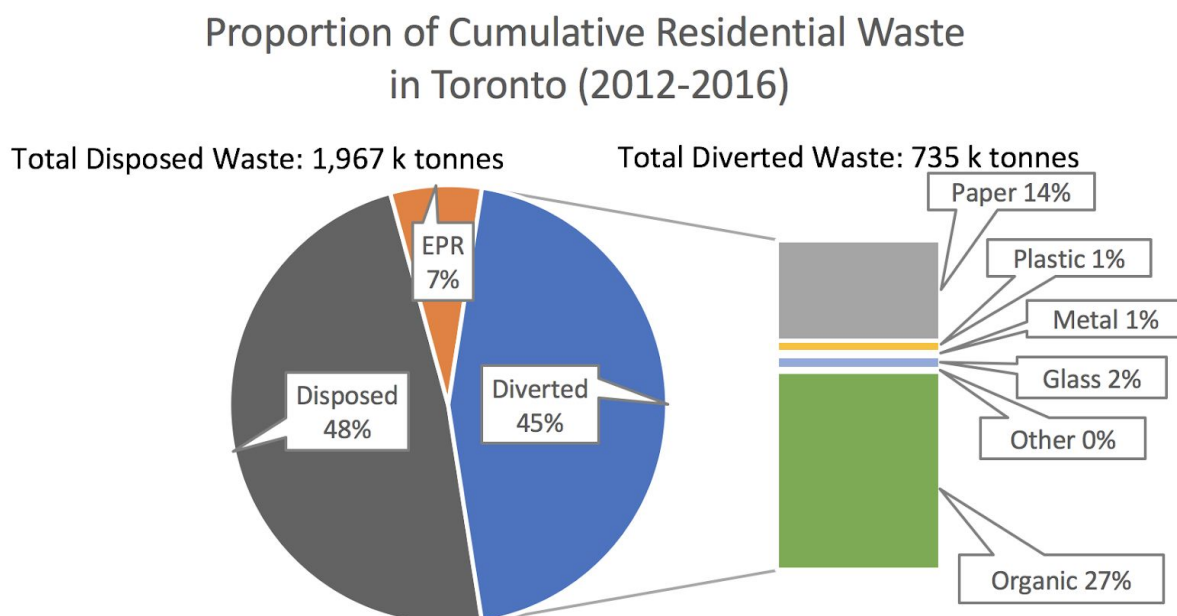


Figure 6. The proportion of recycled and the proportion of disposed for cumulative total residential waste in Toronto from 2012 to 2016.

Ottawa

Ottawa's residential diversion rates have fluctuated 2012 to 2016, with a diversion rate low of 43 percent in 2015 and a diversion rate high of 47 percent in 2013. Like Toronto however, Ottawa appears to be declining in total waste generated with time and the absolute numbers of diverted waste each year can be seen in Figure 7. Ottawa's green bin program implemented bi-weekly residential garbage collection in 2012, similar to Metro Vancouver's organics collection model, though the expected outcome of 53 percent diversion was not achieved. In 2014, blue, green, and black bin programs were installed in all city buildings. Ottawa also has more landfills than the other cities, despite having a lower population than metropolitan areas such as Toronto and Metro Vancouver. Over the past 5 years, operations have expanded landfill intake rather than reduce intake, such as the expansion of the Springhill landfill in 2014. Figure 8 shows Ottawa's cumulative residential recycling materials breakdown and EPR waste from 2012-2016. The majority material recycled is again organics, though at a lower proportion compared to Metro Vancouver and Toronto, though paper recycled is greater than Metro Vancouver.

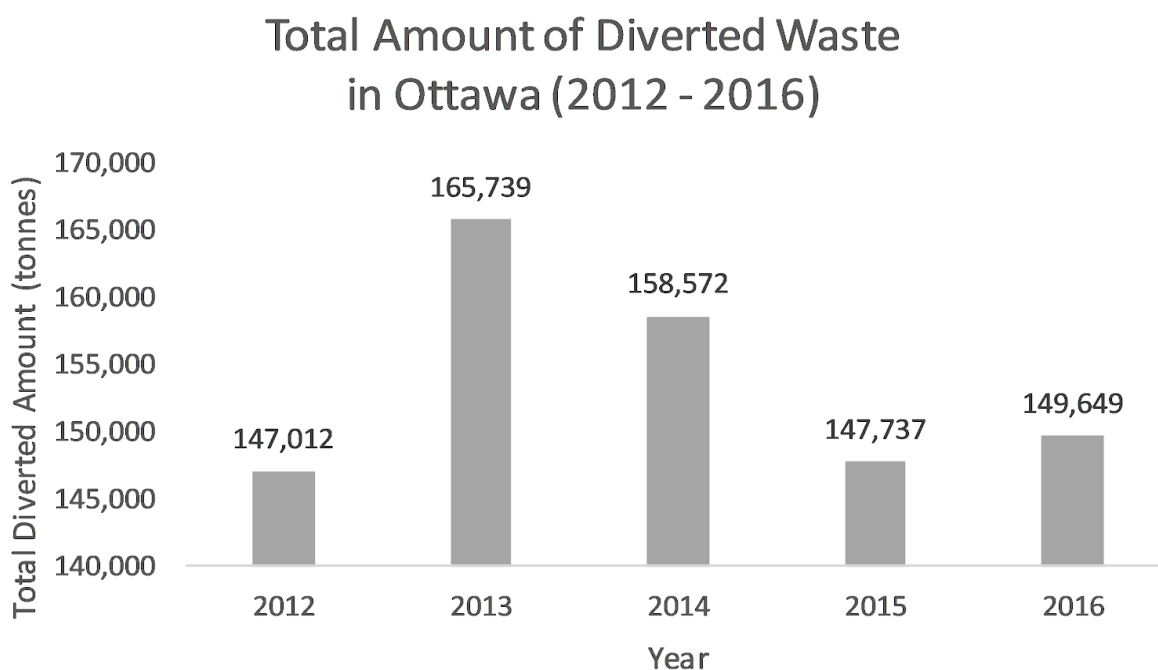


Figure 7. The amount of diverted residential waste generated in Ottawa from 2012 to 2016.

Proportion of Cumulative Residential Waste in Ottawa (2012-2016)

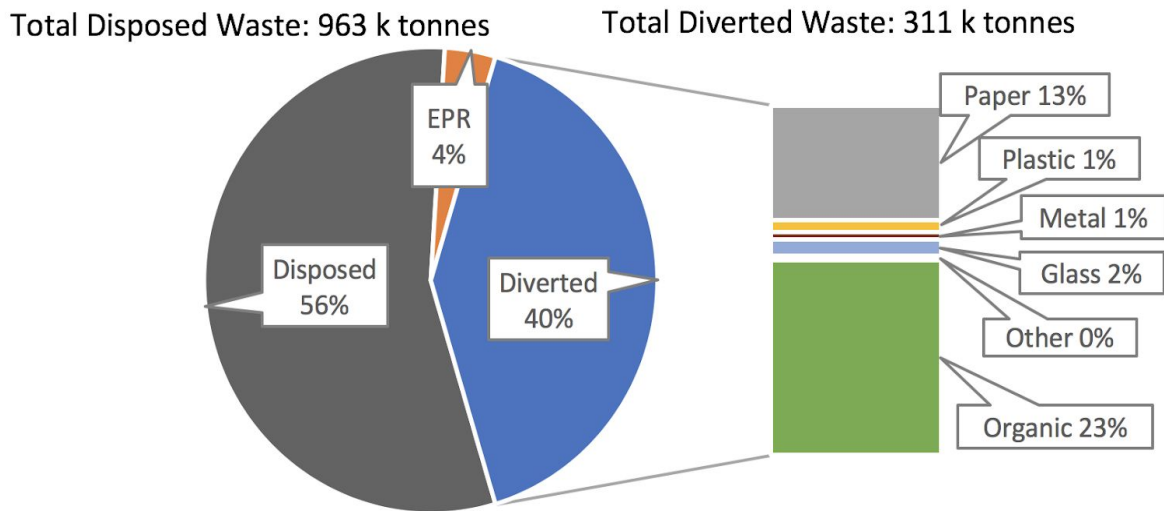


Figure 8. The proportion of recycled and the proportion of disposed for cumulative total residential waste in Ottawa from 2012 to 2016.

Edmonton

Edmonton's diversion rate has been steady between 2016 and 2016, with a diversion rate low of 51% in 2013 and 2014, and a diversion rate high of 52% in 2012, 2015, and 2016. However, Figure 9 shows that instead of decreasing the amount of waste generated like Toronto and Ottawa, Edmonton is increasing their waste generation with time. Also, due to a lack of transparency in Edmonton's waste data reporting, a recycled materials breakdown analysis could not be done and Figure 10 is the highest resolution analysis on diverted waste that could be done.

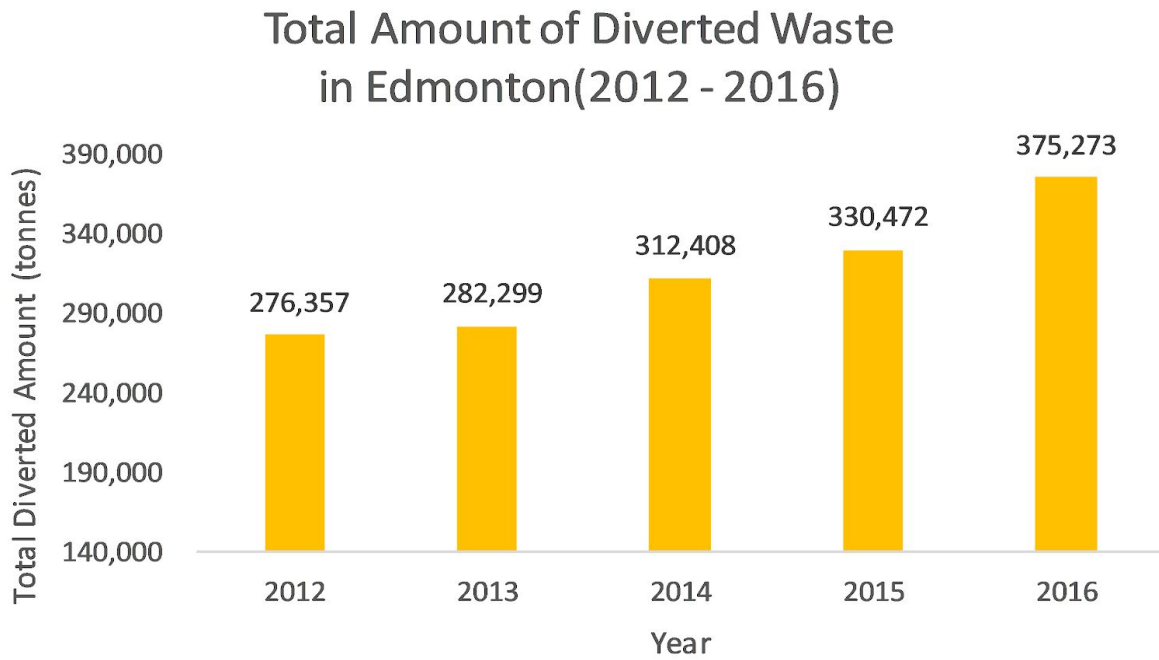


Figure 9. The amount of diverted residential waste generated in Edmonton from 2012 to 2016.

Average Disposed/Diversion Rates in Edmonton (2012-2016)

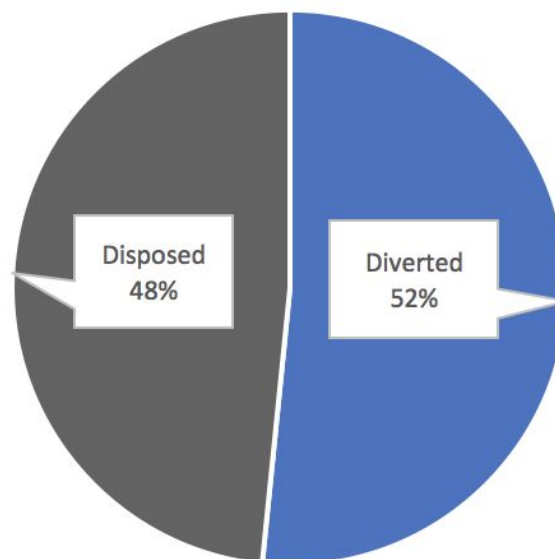


Figure 10. The Average Waste Disposed/Diversion Rates in Edmonton from 2012 to 2016.

Comparison of Four Cities

Figure 11 compares the waste diversion trends of four cities from 2012 to 2017. In Metro Vancouver, there is a steady increase until 2017, which shows that the amount of waste diverted is increasing. The decline in 2017 was correlated with the implementation of a waste policy that shifted responsibility of residential recycling collection from the government to the organization Multi Material BC (Solid Waste Utility report, 2017). Toronto and Edmonton have minimal changes over the years, which shows that the rates of the amount of waste diverted and the amount of waste disposed are similar to each other. In Ottawa, there is a sharp decrease of diversion rate in 2013 followed by some stabilization in 2015. The stabilization can be correlated with the implementation of more recycling programs in city buildings in 2014. From this, Metro Vancouver has the most effective system for processing waste diversion, followed by Toronto and Edmonton, and Ottawa.

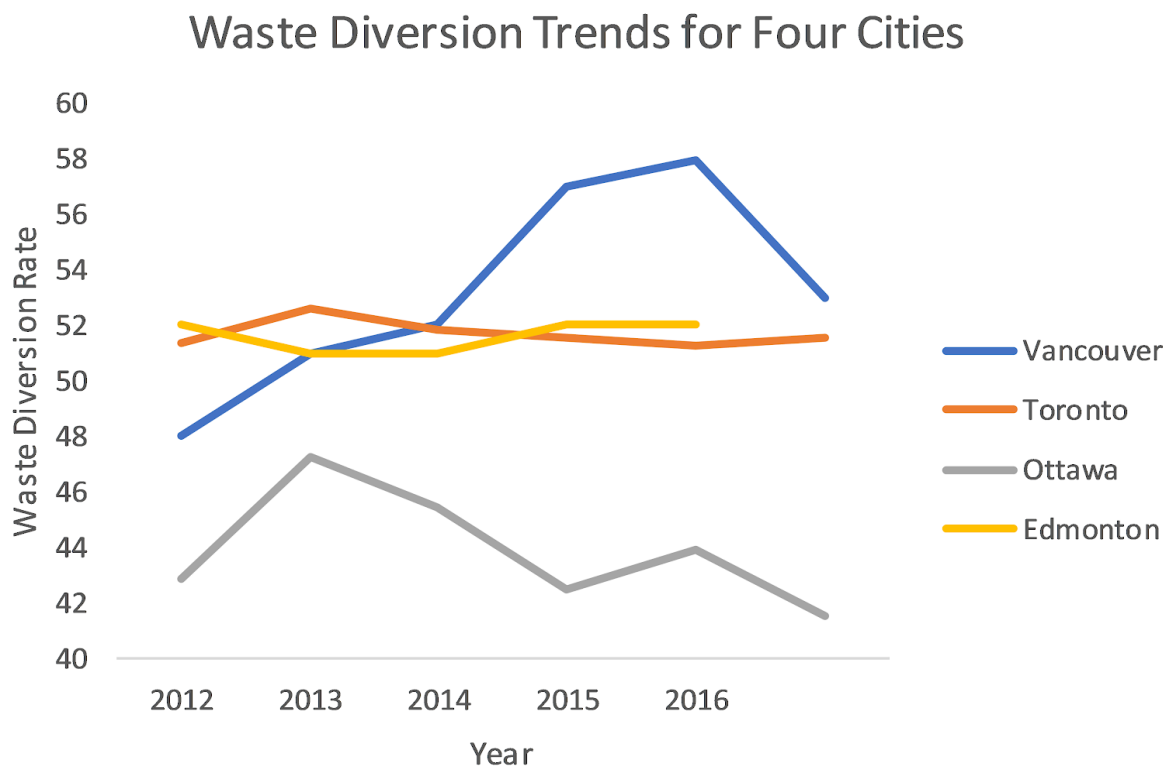


Figure 11. Comparison of waste diversion rates in Metro Vancouver, Toronto, Ottawa, and Edmonton from 2012-2017. Information of Edmonton was not available past 2016.

Policies

There are similarities and differences in the policies implemented in each city. Table 3 provides a comparison of the policies and their elements implemented in each city. All cities have created a policy which includes detailed information about its goal and process to achieve the goals by working towards a target diversion rate. However, only Ottawa provides a limit for waste disposal because their policy aims to manage assets wisely so that there will be room in Ottawa's municipal landfill (City of Ottawa, 2011a). All cities have not evaluated the effectiveness of their policy since implementation. Furthermore, all cities except Edmonton provide yearly reports on the progress to achieve the goal. Curbside recycling, where recyclables and waste are picked up by garbage trucks, is present in all cities. Also, all cities except Edmonton have a green bin program, where food scraps are organized separately from the rest of the waste. Weekly waste pickups occur in Edmonton while bi-weekly waste pickups occur in Metro Vancouver, Toronto, and Ottawa.

Table 3. Comparison of the policies between the four cities. Green/✓ signifies a yes response to the question in the policy element column while red/X signifies a no response. Adapted from Canadian Council of Ministers of the Environment (2014).

Policy element	Metro Vancouver	Toronto	Ottawa	Edmonton
Overarching policy for waste created?	✓	✓	✓	✓
Is a vision for waste reduction included in policy?	✓	✓	✓	✓
Is there a numerical target for waste diversion?	✓	✓	✓	✓
Is there a numerical upper limit for waste disposal?	X	X	✓	X
Is there monitoring or evaluation for the policy?	X	X	X	X
Are there progress reports for the policy?	✓	✓	✓	X
Are there specific strategies for residential waste?	✓	✓	✓	✓
Is there curbside recycling present?	✓	✓	✓	✓
Is there a Green Bin program present?	✓	✓	✓	X
Are there weekly pickups for residential waste?	X	X	X	✓
Are there bi-weekly pickups for residential waste?	✓	✓	✓	X

Discussion

Effectiveness of Waste Management Systems

Through analysis of our data, it is apparent that the policies of each city affect the effectiveness of their waste reduction. Despite similar statements on the effectiveness of waste management systems for each city, looking closer at specific policy implementations and their effect on objective waste disposal data has allowed us to evaluate the true efficacy of each waste system. For example, in the Metro Vancouver waste reports, the implicit inclusion of EPR recycling into residential diversion numbers skewed residential diversion rates to appear higher in the reports if the reader only considered government responsibility. Also, though some cities are presenting zero waste as an achievable goal in the future, current diversion rates do not seem to reflect it. Ottawa and Toronto's diversion rates have kept relatively constant over the past five years and though Metro Vancouver's diversion trend increased from 2012 to 2016, new waste disposal data from 2017 showed a sharp decline in waste diversion. However, decreased total waste generation in Toronto and Ottawa and the still relatively high diversion rate in Metro Vancouver show overall waste management has improved in these cities when compared to their earliest years.

In terms of comparisons of specific policies between the cities, common programs observed included green bin recycling for organics and blue bin recycling for paper and plastic, as well as weekly or biweekly curbside pickup. Even with the consideration that the generation of these types of waste occurs in relatively larger amounts in residential homes, the amount recycled does show the green and blue bin programs in the cities' are largely successful. Metro Vancouver, Toronto, and Ottawa are also fairly transparent with the release of annual waste reports to the public. For waste management infrastructure, each city has similar numbers of recycling stations and transfer facilities. Differences include more landfill facilities in Ottawa and the operation of a waste-to-energy facility in Metro Vancouver, which reduces input to the landfill. Each city also has education programs that aim to inform the public on disposal behaviours, such as Metro Vancouver's "Return-it" container recycling campaign, though they were not observed to have had significant effects on recycling metrics.

Possible Improvements in Waste Management Systems

One of the main problems with the waste management systems in Canada is that the cities have lacked a big push to drive forward a significant increase in the waste diversion rate over the years. Politicians provide a possibility to improve waste diversion by implementing policy to increase recycling and reduce waste consumption. For example, in 2013, the Ontario government proposed the Waste Reduction Act which requires producers to be responsible for recycling the products they sell (Environmental Registry, 2013). The Waste Reduction Act would require producers to reimburse a municipality for the municipality's handling costs and collection of waste by including recycling costs in the cost of the product (Environmental Registry, 2013). Consequently, the money would go towards an increase in funding for the existing Blue Box program (Environmental Registry, 2013). With increased funding for recycling programs, the government could promote the reuse, reduction, and recycling of designated waste which could encourage the public to recycle more frequently. However, there was no implementation of the Waste Reduction Act because the Ontario government could not come to a consensus on it. By explicitly stating the responsibilities of the consumers, producers, and municipal governments, cities could adopt similar policies that improve waste diversion accountability.

There is a need to improve the waste tracking and monitoring system in all four cities. Currently, all four cities do not monitor their policies. An effective waste management system should track the movement of waste to monitor the progress towards achieving the city's policy vision and goals. Also, it should assess the influence of policy on helping accomplish those goals. The requirements for an effective system include: promote accountability, adaptability, and easily understandable (Canadian Council of Ministers of the Environment, 2014). As previously mentioned, the system requires monitoring of progress over time with clear goals. All four cities somewhat provide this, but they do not provide clear roles for accountability when attempting to meet the established goals. Secondly, some of the systems have remained unchanged over time, though the current needs of the municipality have changed. As the population in each city continues to increase, there will be a greater amount of waste requiring diversion. The majority of these systems have been implemented for over six to ten years, and will need updating to handle the increased amount of waste. It is important to continually reevaluate the system over time so that the system can meet the needs of the general public and policymakers.

Lastly, the system should be easily understandable for both the general public and local government. In Edmonton, there is difficulty finding detailed information on the waste management system and there is little data readily available. Moreover, in Ottawa, there is data available but it is very little when compared to Metro Vancouver or Toronto. Cities should update their websites with the newest waste management information, so the general public and policymakers can facilitate discussion and decisions based on current and past results.

Conclusion

An assessment of the policies and processes of waste management in the four Canadian cities allows us to determine the effectiveness of Metro Vancouver, Toronto, Ottawa, and Edmonton's waste management system. Within each city, there was a recent implementation of a waste management program that has a goal to reach in the next 20 to 40 years. These programs were assessed to determine if they are following their trajectory to meet their goal waste diversion rate.

Based on the criteria that were developed to compare the policies in each city plus a data analysis on the effectiveness of the processes, Metro Vancouver has the most effective system for processing waste diversion, followed by Toronto and Edmonton, and Ottawa. The results from this project may be useful in three areas: as a facts sheet for policymakers to base their environmental regulatory decisions, to motivate the general public to respect their environment, and to assist waste management companies in determining customer demand for waste services.

Acknowledgements

We would like to express our appreciation to all those who provided us the possibility to complete this report. A special gratitude to our project partner, Daniel Rotman (Society Promoting Environmental Conservation), whose contribution in encouragement, and providing constructive and valuable suggestions helped us plan and develop this project. We would also like to extend our thanks to Dr. Tara Ivanochko for her advice and assistance throughout the school year.

References

- Canadian Council of Ministers of the Environment. (2014). *State of Waste Management in Canada*. Giroux Environmental Consulting: Author.
- City of Edmonton, Solid Waste Management Division. (2011a). *The Way We Green: Environmental Strategic Plan*. Edmonton: Author.
- City of Edmonton, Solid Waste Management Division. (2011b). *Garbage & Recycling*. Edmonton: Author.
- City of Ottawa, Infrastructure Services and Community Sustainability. (2011a). *Ottawa's Waste Plan*. (Ref Number:ACS2011-ICS-ESD-0036). Ottawa: Author.
- City of Ottawa, Infrastructure Services and Community Sustainability. (2011b). *Goals and Target Setting for Ottawa's 30-Year Waste Plan*. Ottawa: Author.
- City of Ottawa, Infrastructure Services and Community Sustainability. (2012a). *Solid Waste Collection Design Guidelines for Multi-Unit Residential Development*. Ottawa: Author.
- City of Ottawa, Public Works & Environmental Services Dept.. (2016). *recycling*. Retrieved from <https://ottawa.ca/en/residents/garbage-and-recycling/recycling#what-goes-your-black-bin>
- City of Toronto, Solid Waste Management Division. (2016a). *Long Term Waste Management Strategy*. Toronto: Author.
- City of Toronto, Solid Waste Management Division. (2016b). *Final Long Term Waste Management Strategy*. Toronto: Author.
- Environmental Registry. (2013). *Waste Reduction Act*. Ministry of Environment: Author
- Guerrero, L. A., Maas, G., Hogland, W., Linnéuniversitetet, Institutionen för biologi och miljö (BOM), & Fakulteten för Hälso- och livsvetenskap (FHL). (2013). Solid waste management challenges for cities in developing countries. *Waste Management*, 33(1), 220-232. Doi: 10.1016/j.wasman.2012.09.008
- Lakhan, C. (2015). Evaluating the effects of unit based waste disposal schemes on the collection of household recyclables in ontario, canada. *Resources, Conservation & Recycling*, 95, 38-45. Doi: 10.1016/j.resconrec.2014.12.005
- Maystre, L. (1995). A goal-oriented characterization of urban waste. *Waste Management & Research*, 13(3), 207-218. Doi: 10.1016/s0734-242x(95)90040-3

McMillan, M. (2013). *Waste Management Industry Survey*. (Issue No. 2013001). Retrieved from the Statistics Canada website:
<https://www150.statcan.gc.ca/n1/en/catalogue/16F0023X2013001>

Metro Vancouver, Biennial/5 Year Progress Report (2016). *Integrated Solid Waste and Resource Management Plan*. Vancouver: Author.

Ministry of Environment. (2012). *Solid Waste Management and Recycling Technology of Japan*. Japan Environmental Sanitation Center: Author.

Mueller, W. (2013). The effectiveness of recycling policy options: Waste diversion or just diversions? *Waste Management*, 33(3), 508-518. Doi: 10.1016/j.wasman.2012.12.007

Recycling Council of BC, What Happens to my Recycling? (2017). *Recycling BC*. BC: Author.

Zhu, J., & Huang, G. (2017). Contract-out planning of solid waste management system under uncertainty: Case study on toronto, ontario, canada. *Journal of Cleaner Production*, 168, 1370-1380. Doi: 10.1016/j.jclepro.2017.09.084

Metro Vancouver (2017). *2017 Solid Waste Utility (SWU) Fees & By-Law Changes – RTS 11614*. Vancouver: Author.

Appendices

A1. Data for Vancouver

Year	2012 and before	2012	2013	2014	2015	2016	2017
Vancouver							
Residential (tonnes)							
Waste generated		1,077,776	1,061,571	1,070,600	1,083,639	1166405	1103329
Waste diverted		519,148	539,720	553,409	613,217	677149	581081
Paper		106,173	92,862	28,944	50,633	36677	
Plastic		8,348	7,508	15,658	7,403	4583	
Metal		22,193	18,981	22,498	14,278	17975	
Glass		11,537	9,823	24,399	18,598	9033	
Total		164,419	145,625	100,867	101,295	74412	
Waste disposed		558,628	521,851	517,191	470,422	489256	522,248
Waste diversion rate		48%	51%	52%	57%	58%	52%
Per Capita Disposal		0.23	0.21	0.21	0.19	0.19	0.2
Per Capita Diverted							
Per Capita Generated (calculated) (kg/cap)		447.4777024	436.8056684	434.3148487	433.9675081	467.1130065	
Policy Implementation	Zero Waste 2040		Green Bin Expar	Joined Recycled	Landfill ban of food scraps		
Population (SF+MF)		2408558	2430305	2465032	2497051	2497051	

A2. Data for Toronto

Year	2012 and before	2012	2013	2014	2015	2016	2017
Toronto							
Residential (tonnes)							
Waste generated		840,851	843,503	831,273	799,479	765,362	780,564
Waste diverted		432,179	443,906	431,491	412,892	392,689	403,053
Paper		127,786	118,077	115,427	103,932	93,549	92,192
Plastic		7,500	10,460	14,325	15,678	15,200	13,229
Metal		5,108	5,606	5,984	5,407	5,597	5,414
Glass		16,072	16,599	13,970	11,442	10,796	9,856
Total		156,465	150,742	149,706	136,459	125,140	120,692
Waste disposed		408,671	399,596	399,781	386,588	372,673	377,511
Waste diversion rate		51.40%	52.63%	51.90%	51.60%	51.30%	51.60%
Per Capita Disposal (kg/cap)		155	150	149	143	136	137
Per Capita Diverted (kg/cap)		164	167	161	153	144	146
Per Capita Generated (kg/cap)		319	317	310	296	280	283
Policy Implementation	Pay As You Throw, Parks & Public Space Recycling					Zero Waste Future	

A3. Data for Ottawa

Year	2012 and before	2012	2013	2014	2015	2016	2017
Ottawa							
Residential (tonnes)							
Waste generated		342,612	350,657	348,862	347,871	341,228	354,217
Waste diverted		147,012	165,739	158,572	147,737	149,649	146,821
Paper		47,798	48,122	47,445	44,146	43,066	28,031
Plastic		4,128	4,645	4,752	4,729	6,258	3,477
Metal		2,989	3,228	3,174	3,151	3,404	2,638
Glass		5,971	6,872	6,430	6,872	7,375	6,046
Total		60,886	62,866	61,801	58,898	60,103	40,192
Waste disposed		195,600	184,918	190,290	200,134	191,579	207,396
Waste diversion rate		42.91%	47.27%	45.50%	42.50%	43.90%	41.40%
Per Capita Disposal (kg/cap)		209	196	200	208	198	212
Per Capita Diverted (kg/cap)		157	176	167	154	155	150
Per Capita Generated (kg/cap)		366	372	367	362	353	362
Policy Implementation		Ottawa's Waste Plan approved in 2011					
Population		935,145	943,319	951,738	960,765	968,591	979,184

A4. Data for Edmonton

Year	2012 and before	2012	2013	2014	2015	2016	2017
Edmonton							
Residential (tonnes)							
Waste generated							
Waste diverted							
Waste disposed		255099	271228	300157	305051	346406	
Waste diversion rate		52%	51%	51%	52%	52%	
Per capita waste		345		340	340	334	310
Policy Implementation		The way we green					
Population		817498		928182		932550	