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Prepared for Waste Watch Ottawa

Ottawa's Organic Waste Diversion

A Comparative Analysis of Ottawa's Residential Organic Waste Management System

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MSc. Environmental Sustainability Capstone Project

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Acronyms Reference Guide

AD	Anaerobic Digestion
ASP	Aerated Static Pile
CCME	Canadian Council of Ministers of the Environment
EfW	Energy from Waste (Waterloo, Toronto)
EPA	*Environmental Protection Act (Ontario)*
ESC	Environmental Services Committee
GHG	Greenhouse Gas
HRM	Halifax Regional Municipality
IC&I	Industrial, commercial, and institutional
IRMSH	Integrated Resource Management Strategy for Halifax County/Halifax/Dartmouth/Bedford
IWMMP	Integrated Waste Management Master Plan
LYW	Leaf and Yard Waste
NASM	Non-Agricultural Source Material
OM	Organic Matter
RPRA	Resource Productivity & Recovery Authority
SSO	Source Separated Organics
WWMMP	Waterloo Waste Management Master Plan
WWO	Waste Watch Ottawa
WWTP	Wastewater Treatment Plant

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Executive Summary

Waste Watch Ottawa (WWO) has asked our team to research the effectiveness of Ottawa's residential organics waste management system compared to that of other Canadian cities, with a focus on the impact of plastics and dog waste on compost quality. First, in Part 1 background information is provided on the science and benefits of processing organic waste, as well as on implications and consequences of poor organic waste diversion. Organic matter can become compost through two main processes: aerobic or anaerobic digestion. The end-product can enrich soils if it is of good quality or pose environmental and health risks if it is not. Plastics (biodegradable or not) and dog waste are examples of threats to compost quality. Moreover, we explain that properly composting organic waste can reduce Greenhouse Gas (GHG) emissions.

Second, the federal, provincial, and municipal policies that guide the City of Ottawa's residential waste management system are presented in Part 2. Among other important laws and policies, the Ontario Ministry of Environment's Compost Quality Standards which distinguish between AA, A, and B quality are explained. The City of Ottawa's current residential waste management system is described in Part 3, including the 2018 decision to allow plastics and dog wastes in the Green Bin. This section also includes a discussion of statistics regarding Ottawa's organics diversion rate, with a visual representation. The main conclusion is that Ottawa now produces a type of compost called non-agricultural source materials (NASM), which is quality B, and that Ottawa's overall organic diversion rate is lower than the other cities that we researched.

Part 4, presents the waste diversion strategies of five other Canadian cities. For each city under review, qualitative and quantitative data are presented as well as best practices as described in the Data Sources and Methods section of the report. The key findings for each city are as follows: Guelph and Waterloo produce AA compost while allowing compostable plastics and dog waste. Toronto also produces AA and A compost, while allowing any kind of plastic as well as dog waste. Halifax produces A quality compost but does not allow plastics or dog waste. Meanwhile, Metro Vancouver does not accept plastics or dog waste in its organic waste processing facilities, and compost quality varies across that region.

Lastly, conclusions, key gaps, challenges, opportunities, and associated recommendations are presented for Ottawa's residential organic waste management program, in Part 5. The key recommendations are framed in terms of the "zero waste hierarchy" and support WWO's 6 Point Waste Management and Diversion Strategy. Strategies to avoid contaminating compost with plastics and dog waste are presented, as well as incentives to follow regulations, keep organics out of landfills, increase outreach and education initiatives and increase participation in Ottawa's Green Bin Program.

As the City of Ottawa is currently updating its Solid Waste Master Plan, this report comes at a crucial time. The report will contribute to informing the actions of the City on how to divert organic waste effectively to reduce GHG emissions and to extend the expected lifespan of the Trail Road landfill site. With the information from this report, WWO will be better equipped to advocate for evidence-informed improvements to Ottawa's residential organic waste management system.

Introduction

Given the significant problems surrounding participation rates in the current Green Bin program and waste diversion in Ottawa,[1] Waste Watch Ottawa (WWO) and students from the Master of Science Environmental Sustainability program at the University of Ottawa have partnered to assess the City of Ottawa's residential organic waste management system. This capstone project aims to help examine the efficacy of Ottawa's residential organic waste management program compared to that of other Canadian municipalities, based on a project proposal that was developed in collaboration with WWO and which included performance indicators, as described in the Data Sources and Methods section of this report. The results of this report provide our partners at WWO with key evidence and recommendations to assist in advising the City of Ottawa in developing its new solid waste master plan.

This report provides Waste Watch Ottawa with information on Ottawa's organic waste management in comparison with other Canadian cities, which will be used as the substantive basis for their organics report. Data source and methods are presented, followed by a background section detailing the science behind effective composting and the consequences of poor composting in Part 1. Subsequently, an overview of federal (Canadian) provincial (Ontario), and municipal (Ottawa) policies on composting is presented in Part 2, followed by the state of affairs of Ottawa's residential organic waste management program in Part 3. Part 4 shows comparative practices for residential organic waste management in four other Canadian cities and Part 5 provides conclusions and offers recommendations based on best practices found while acknowledging the limitations of this study.

Data Sources and Methods

Three approaches and two methods have been used for the assessment of Ottawa's organics waste program. The three approaches are:

1. A historical overview of Ottawa's organics waste diversion process.
2. An in-depth analysis of Ottawa's current organics waste diversion.
3. Comparing and contrasting the City of Ottawa's organics program with those of select municipalities.

Analyses include quantitative and qualitative examination, as explained in the subsections below.

The historical analysis is based on data provided by our partner, by the City of Ottawa, as well as that collected from city reports, CBC publications, and additional internet research. The in-depth analysis of Ottawa was conducted using information that includes data provided by the partner, information and data requested from the City of Ottawa, and data obtained through secondary source research, such as academic literature. For comparison, our team has juxtaposed the City of Ottawa's organics programs with the cities of Guelph, Waterloo, Toronto, Halifax, and Vancouver using requests for information from officials in those municipalities as well as internet searches and databases. These five cities were identified as strong case studies to compare to the City of

[1] WWO. (2017). "Improving the City of Ottawa's Waste Diversion Performance: Recommendations for Action". Retrieved from https://wastewatchottawa.ca/2017/09/15/waste-watch-ottawa-analysis-finds-citys-lack-of-planning-and-public-education-is-squandering-landfill-capacity/

Ottawa and from which to draw inferences. Each of these cities has implemented a range of strategies to manage organic waste that we have identified in this report.

We included these five cities based on their regulatory regimes, history of organic waste management, population densities, data availability, and their high waste diversion rates, to identify best practices. The municipalities of Toronto, Guelph and Waterloo were chosen to review similar municipalities working under the same policy and regulatory framework within the province of Ontario. We identified the cities of Halifax and Guelph as important comparator cases given their long history of organic waste management. We also included the Region of Waterloo (RoW) whose organic waste collection program is influenced by, and whose organics are processed by the Guelph facility. The cities of Toronto and Vancouver were reviewed because of their large populations and the number of multi-residential housing units. Given the overall scope of the project, resources, data availability and time-constrained the ability to investigate other municipalities in detail. Still, data sought from these municipalities will stimulate a useful comparison of organic waste management in Canada and insights into best practices for the City of Ottawa's organic waste collection and processing. Through all the research steps, the report sought to include the performance indicators identified in the project description by WWO (2019). In order to include these data in our final deliverables, the preparation of a consistent and organized approach to each form of research was indispensable and a consistent research rubric was applied to make effective comparisons when analyzing data sources (see Appendix 1).

Quantitative Analysis

The quantitative assessment has focused on broad performance comparisons of the identified municipalities. Through the comparison of some of the key quantitative variables, as listed below and noted by WWO, recommendations for the City of Ottawa are presented in Part 7. Differences between the city of Ottawa's performance and that of the other municipalities are presented through charts and graphs, representing accomplishments and deficiencies relative to one another. The source of quantitative data has exclusively come from secondary data sources.

The quantitative analysis did not include all original performance indicators as some are more suited to the qualitative analysis. The analysis was also limited by the availability of data with comparable metrics. Most data for Ontario was available through the Resource Productivity & Recovery Authority (RPRA) website. For cities outside the province of Ontario quantified data from reports and policy documents were used. Therefore, the quantitative contrasting of data in the analysis is focused on the following:

Key Quantitative Variables for Comparative Analysis:

- Tonnage of organics collected (2010- 2019)
- Organic waste diversion rate
- Total residential waste generation per capita
- Contrasting residential waste diversion rates for single-family and multi-residential

Based on data acquired from municipal reports, quantitative analyses contrasting Ottawa with other municipalities have been undertaken using MS Excel. Visual analysis using graphs and charts illustrates how each city performs under certain variables. The data sets from major cities across Canada were used for comparative purposes to make inferences based on observed patterns.

The findings from these comparisons provide the 'backbone' for objective evidence that has been presented as figures and graphs in this report.

Qualitative Analysis

The qualitative analysis is equally as important as the quantitative because it underlines real-world constraints and characteristics. The subjective analysis has been used to provide context to each case study by discussing municipal waste management policies for the inclusion of plastics and dog waste, waste diversion practices, and methods, as well as waste diversion promotion and education. In order to gather this qualitative data, reports, policy papers, promotional material, and websites from the cities in question were examined.

Qualitative research included interviews with senior staff members, city officials responsible for municipal waste management programs and selected environmental Civil Society Organizations to ascertain organic waste diversion programs and to understand why certain programs were chosen over others. Information was requested from municipal waste management staff regarding data sources and potential gaps in data. This qualitative evidence has been used to identify municipalities' contextual or political rationale in the determination of their organics recycling programs and is reported in each city's case study.

Key Qualitative Features for Comparative Analysis

- Broad overview of organic waste management
- Policies, standards, and guidelines for the disposal of organic waste
- Compost quality analysis
- End market uses of organic waste
- Technology and innovations employed by cities to dispose of organic waste
- Plastic and dog waste policy for organic disposal

Part 1: Background

1.1 Science and Benefits of Organic Waste Diversion

The organic fraction of municipal solid waste constitutes a large portion of residential waste streams. This makes attaining high diversion rates an important goal for growing municipalities across Canada. Organic waste typically consists of food waste, as well as leaf and yard waste that varies seasonally. Organic matter is a beneficial resource that can be used in soil conservation, for agriculture purposes, erosion control, for carbon cycling and to increase soil fertility.[2] The use of composting technology to dispose of organic waste has increased significantly in recent years due largely to its simple operation, low investment, high value-added, low maintenance cost, and reduced environmental impact.[3]

Anaerobic digesting and composting are two predominantly used processes to breakdown organic waste. Anaerobic digestion and composting could transform organic waste into bioenergy and compost with better environmental and economic benefits than incineration or landfilling.[4] Choosing the right strategy for organic waste management depends on waste quantity and characteristics, cost and financing issues, infrastructure, available land area, collection, and transport as well as regulatory constraints.[5] The benefits of diverting organic waste and the processes for doing so are explored in detail below.

1.1.1 - Benefits of Organic Processing

Many benefits can come from processing organic waste and preventing organic waste from ending up in landfills. In terms of environmental benefits composting can recycle valuable nutrients from food waste back into healthy soil which will improve growing conditions for food and plants.[6] Compost can improve soil structure, enhance soil fertility, promote plant growth by producing high yield and mineral fertilizer retention.[7] The application of high-quality compost increases crop yields, reduces the cost of chemical fertilizer and pesticide applications, and significantly improves the economic benefits of agricultural production.[8] Composting is a sustainable means of improving soil fertility in poor soil areas, increased soil fertility can increase the biomass of plants and size of roots which is why compost can help increase the retention of soil moisture.[9] Additionally, increased soil fertility through compost can help reduce erosion, increases water retention and pH buffer capacity while improving the physical structure of soil and microbial activity in the soil.[10]

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[2] Environment Canada. 2013. *Technical Document on Municipal Solid Waste Organics Processing*. *Environment Canada*

[3] Kumar, Sunil, Zengqiang Zhang, Mukesh, Kumar and Awasthi, Ronghua Li, 2019. Biological Processing of Solid Waste. Biological Processing of Solid Waste. 1st ed. CRC Press. https://doi.org/10.1201/b22333.

[4] ibid.

[5] Bogner, Jean, Riitta Pipatti, Seiji Hashimoto, Cristobal Diaz, Katarina Mareckova, Luis Diaz, Peter Kjeldsen, et al. 2008. "Mitigation of Global Greenhouse Gas Emissions from Waste: Conclusions and Strategies from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. Working Group III (Mitigation)." Waste Management and Research 26 (1): 11–32. https://doi.org/10.1177/0734242X07088433.

[6] Alfred, E.Toronto Environmental Alliance (2016). *Organics First: Setting Toronto on the Zero Waste Path*.

[7] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.

[8] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.

[9] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.

[10] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.

Organic waste processing and its end-products can also help reduce emissions. Adding compost to soil can also increase the soil's ability to absorb carbon.[11] Carbon sequestration is one of the main effects of the long-term use of compost and the repeated applications of compost can help improve the biological function of soil.[12] Diverting organic waste to composting and anaerobic digestion facilities can also help reduce methane emissions from landfills. Organic waste can be turned to biogas that can be captured through anaerobic digestion processes to produce electricity reducing reliance on conventional fossil fuels. Reduced waste generation also produces an indirect reduction of GHG emissions through the conservation of raw materials and fossil fuels, as well as through improved energy and resource efficiency.[13]

Economic benefits of organic waste management include employment benefits, chemical fertilizer replacement, energy production from anaerobic digestion and reduced costs for leachate management in landfills.[14] Compared to other waste management techniques such as incineration, investment in the composting system is less expensive, and selling the final products can lead to greater economic benefit. [15] Most of the costs of composting are upfront with the construction of the composting facility along with the collection and transportation of organic waste. Organic waste management creates local jobs related to the collection and transportation of waste, operation of facilities, and jobs in the private sector to convert digester solids into compost. [16]

Enhancing composting efficiency and increasing the quality of the compost product increases the financial benefit of organic waste processing.[17] Organic waste can often be processed closer to an urban center, unlike some situations where waste is being transported some distance from the point of generation to a more remote landfill.[18] This, for example, is the situation with Toronto which hauls its waste to a site in south-western Ontario and in Vancouver where some waste is trucked to the interior of the province. Ottawa is, however, one of the few big municipalities in Canada which have its own landfill within its own borders. Good organic waste management specifically diversion from landfills can preserve space for waste that cannot be reused or diverted. In the long-term, organic waste management can allow the City of Ottawa to extend the lifespan of the Trail Roads landfill.

Creating green energy through biogas from the waste management process is also good for the economy and can generate revenue for the city.[19] The management and treatment of organic waste can help get the city to reduce GHGs and move closer to achieving a circular economy through the usage of technologies that allow us to turn organic waste into a sustainable resource such as compost or biogas.[20] For example, in the City of Toronto biogas from anaerobic digestion are used to fuel garbage trucks which creates a closed-loop waste management process.[21]

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[11] Alfred, E.Toronto Environmental Alliance (2016). *Organics First: Setting Toronto on the Zero Waste Path*.
[12] ibid.
[13] Bogner, J., Pipatti, R., Hashimoto, S., Diaz, C., Mareckova, K., Diaz, L., … Gregory, R. (2008). Mitigation of global greenhouse gas emissions from waste: Conclusions and strategies from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. Working Group III (Mitigation). *Waste Management and Research*, *26*(1), 11–32.
[14] Environment Canada. 2013. *Technical Document on Municipal Solid Waste Organics Processing*. *Environment Canada*
[15] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.
[16] Alfred, E.Toronto Environmental Alliance (2016). *Organics First: Setting Toronto on the Zero Waste Path*.
[17] ibid.
[18] Alfred, E.Toronto Environmental Alliance (2016). *Organics First: Setting Toronto on the Zero Waste Path*.
[19] Alfred, E.Toronto Environmental Alliance (2016). *Organics First: Setting Toronto on the Zero Waste Path*.
[20] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.
[21] Alfred, E.Toronto Environmental Alliance (2016). *Organics First: Setting Toronto on the Zero Waste Path*.

In terms of social or community-based benefits, participating in composting and organic waste management can have environmental, economic and health benefits. Community education programs to improve organic waste management teaches families how to prevent food waste and save money.[22] Education and programs encouraging organic waste management in communities can help families grow their own food, help with stormwater management, remediate soil, increase community engagement and help divert large quantities of organics from going to landfills.[23] There are many cases and different examples of benefits derived from encouraging community composting and promoting organic waste diversion at a more local level. [24] Compost can also be used to improve the environment in urban communities by replenishing polluted soil. [25] Food is also a valuable resource for communities and using high-quality compost from source-separated organic waste instead of chemical fertilizers can have health benefits. [26] Using organic waste as compost can also replace the cost of chemical fertilizers and enrich crop yields for farmers.[27] Communities can also derive benefits from organic waste management. Compost and other end-products produced by the City can go towards achieving these benefits.

1.1.2 - Aerobic Composting

Compost is a soil amendment that is dark, earthy smelling and high in plant nutrients. Compost improves agriculture production and reduces the loss of topsoil, and there are also economic benefits from organics management.[28] Composting is a process where organic matter is converted into a stable humic substance or decomposed into carbon dioxide by microorganisms.[29] For every tonne of organics composted, approximately half a tonne of compost is produced.[30] To improve compost quality and reduce potential environmental risks, various parameters should be adjusted to optimal conditions and monitored during the composting process. [31]

Composting is an aerobic biological process where organic matter is consumed by thermophilic and mesophilic microorganisms as substrates and converted into stabilized fertilizers or mineralized products.[32] Composting is a monitored and controlled process where aerobic conditions are maintained, and temperatures reach above 55°C to kill harmful pathogens.[33]

The first two steps for composting involve inspecting the organic waste and eliminating non-compostable items such as plastics which are obvious in the delivered material and preparing the organic waste for composting.[34] Active composting involves high levels of biological activity with

[22] Alfred, E.Toronto Environmental Alliance (2016). *Organics First: Setting Toronto on the Zero Waste Path*.
[23] Clark, N. (2015). The Business Of Community Composting. *BioCycle*, *56*(1), 32–38
[24] ibid.
[25] ibid.
[26] Stone, J., Davenport, K., & Ukena, B. (2014). Zero Waste Composting. *BioCycle*, *55*(5)
[27] Bogner, J., Pipatti, R., Hashimoto, S., Diaz, C., Mareckova, K., Diaz, L., … Gregory, R. (2008). Mitigation of global greenhouse gas emissions from waste: Conclusions and strategies from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. Working Group III (Mitigation). *Waste Management and Research*, *26*(1), 11–32.
[28] Environment Canada. 2013. *Technical Document on Municipal Solid Waste Organics Processing*. *Environment Canada*
[29] Bernal, M. P., Sommer, S. G., Chadwick, D., Qing, C., Guoxue, L., & Michel, F. C. (2017). Current Approaches and Future Trends in Compost Quality Criteria for Agronomic, Environmental, and Human Health Benefits. In *Advances in Agronomy* (Vol. 144, pp. 143–233). Academic Press Inc.
[30] Environment Canada. 2013. *Technical Document on Municipal Solid Waste Organics Processing*. *Environment Canada*
[31] ibid.
[32] Mustafa, Muhammad Farooq, Yanjun Liu, Zhenhan Duan, Hanwen Guo, Sai Xu, Hongtao Wang, and Wenjing Lu. 2017. "Volatile Compounds Emission and Health Risk Assessment during Composting of Organic Fraction of Municipal Solid Waste." *Journal of Hazardous Materials* 327 (April): 35–43.
[33] Environment Canada. 2013. *Technical Document on Municipal Solid Waste Organics Processing*. *Environment Canada*.
[34] ibid.

a rapid rise in temperature as microorganisms degrade organic waste.[35] The temperature of the compost piles increases rapidly within the first few days, as mesophilic microorganisms are supplanted by thermophilic microorganisms at rising temperatures. Pathogens and weed seeds are killed as the pile temperature reaches over 55°C. This is followed by a gradual reduction in temperature during the maturation phase.[36] Microorganisms present during the composting process include bacteria, fungi, and actinomycetes all of which are most active during the composting and curing steps.[37] At this point, some facilities will take out bulking agents such as woodchips and begin a curing stage. Microorganisms convert carbon from organic waste into carbon dioxide and humus, nitrogen gas, and complex organic structures are slowly broken down.[38] Composting processes can be made more efficient by enhancing aeration, mitigating feedstock carbon and nitrogen ratios, the addition of chemical agents, and the use of bulking materials which can add costs to processing.[39]

The curing stage is complete when the biological material in the compost material is stable and the maturity of the organic waste is determined.[40] The final screening involves refining the compost so that it may be properly stored prior to being sold. Carbon and nitrogen are the most important elements for composting. Carbon serves as both energy source and the basic structure that accounts for about 50% of microbial cells, whereas nitrogen is a necessary element for cell growth and function.[41] In addition to this, phosphorous and minerals as an important nutrient for plant growth are assessed to determine whether the end-product can be used for agricultural purposes. The application of compost usually improves the physical, biological, and chemical properties of soil.

1.1.3 - Anaerobic Digestion

The second type of organic waste processing is anaerobic digestion (AD) where organic waste is put into high solid or low solid systems and organic waste is broken down in the absence of oxygen-producing digester solids and biogas. AD of organics is a relatively new technology that requires digesters.[42] Anaerobic digestion of composts offers significant benefits including biogas production for energy generation. Digestion without oxygen saves power, can treat heavily polluted organic waste, and the digestate can be used as agricultural fertilizer or compost materials.[43] Depending on the Green Bin program and what waste is accepted along with the design of the processing facility- the AD may require mechanically removing materials from containers or bags.[44] As part of the pre-processing step, water can be added to the feedstocks and mixed so lightweight materials that float to the top such as plastic can be raked out and heavier materials can be removed from the bottom of the tank.[45] Once the feedstock is inspected it gets mixed or shredded to create optimal conditions for digestion.[46]

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[35] ibid.
[36] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.
[37] Environment Canada. (2013). *Technical Document on Municipal Solid Waste Organics Processing*. *Environment Canada*.
[38] ibid.
[39] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.
[40] Environment Canada. (2013). *Technical Document on Municipal Solid Waste Organics Processing*. *Environment Canada*.
[41] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.
[42] Environment Canada. (2013). *Technical Document on Municipal Solid Waste Organics Processing*. *Environment Canada*.
[43] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.
[44] Environment Canada. (2013). *Technical Document on Municipal Solid Waste Organics Processing*. *Environment Canada*.
[45] ibid.
[46] ibid.

In some digestion systems, feedstocks can be mixed with heated water or steam to increase the moisture content and the temperature of the waste to be processed and starter inoculums are added to initiate microbial activity and speed up digestion. [47] There are two major types of AD systems, namely wet low-solids and high solid systems.[48] Both high-solids and wet low-solids systems can have single- or multiple-stage digesters, and operate in either thermophilic or mesophilic temperature ranges– thermophilic digesters typically operate at temperatures of 50 to 60 degrees Celsius (°C) and mesophilic digesters operate at in the 30 to 38°C range. [49]

In two-stage AD systems, the first stage is generally operated at a lower pH level of 5- 6, which is optimal for organisms to break down large organic molecules and in the second stage, the pH increases to between 6.5 and 7.2 which is when biogas forms.[50] Digestion reactions occur faster in the high-energy thermophilic range so this can provide more biogas.[51] Biogas is commonly used within the AD facility itself to heat materials in the digester's vessels and maintain the optimal temperature range.[52] Removing particulate matter and reducing the biogas' moisture content are the only treatment steps required before use and biogas can be purified to create renewable natural gas.[53] Biogas can play an important role in the developing market for renewable energy, and the global use of biogas is estimated to increase in the coming years.[54] One potential issue with biogas from food waste is that it may contain high concentrations of sulphur which can be quite dangerous.[55]

1.1.3 – Other Methods of Organics Processing

Beyond composting and anaerobic digestion, there are also alternative ways to dispose of or use organic waste. Bio-drying is one technique where waste headed to landfills goes through a process of aeration to reduce the moisture and volume of biomass which can then be turned into energy or biogas.[56] A microbial fuel cell is a waste processing technology where a fuel cell is fueled using different sources of organic compounds that can replace fossil fuel.[57] Energy recovery using energy from waste (EfW) technology can help with recovering energy from waste in the form of heat, electricity or fuel using various thermal or biochemical processes.[58]

1.1.4 - Compost Quality Regulation and Guidelines

The provinces and territories are responsible for regulating the production and use of compost.[59] These guidelines apply to compost produced from any organic feedstock but do not apply to compost-based products such as potting soil. [60]

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[47] ibid.
[48] ibid.
[49] Environment Canada. (2013). *Technical Document on Municipal Solid Waste Organics Processing*. *Environment Canada*.
[50] ibid.
[51] ibid.
[52] ibid
[53] ibid.
[54] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.
[55] Environment Canada. (2013). *Technical Document on Municipal Solid Waste Organics Processing*. *Environment Canada*.
[56] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.
[57] ibid.
[58] ibid.
[59] ibid.
[60] ibid.

The federal government, through the Canadian Food Inspection Agency (CFIA), regulates compost when it is sold as a soil amendment or product containing plant nutrients, under the *Fertilizers Act*.[61] Most notably, the *Fertilizers Act* allows the federal government to prescribe the form of fertilizers and supplements, the packaging and evaluation of fertilizers and supplements.[62] This *Act* also prohibits the import or export of "fertilizer or supplement that presents a risk of harm to human, animal or plant health or the environment".[63] The Canadian Council of Ministers of the Environment (CCME) established guidelines that are used to determine compost quality and safety. The guidelines determine quality based on the amount of foreign matter in the compost, the maturity, pathogens and trace elements.[64]

Compost quality parameters include pH, carbon to nitrogen ratio, organic matter content, humification ratio, water, cation exchange capacity and such as indicators of the quality of compost. Humus in the soil is an important factor in soil fertility which is why compost that is rich in humic substances is considered a high-quality organic fertilizer. [65] Additionally, compost that is more mature and stable is preferred for agricultural purposes. [66] Maturity is the level of the completeness of composting and implies a stable organic matter (OM) content and low phytotoxicity to plant growth.[67] Stability, on the other hand, refers to the reduced biological activity which occurs when the thermophilic phase of microbial decomposition is complete.[68]

The province has its' own set of guidelines to determine the quality of compost. Ontario's compost quality standards and the *Guidelines for the Production of Compost* can be found under regulation 347 of the Ontario *Environmental Protection Act* (EPA) as well as under Reg. 267/03 of the *Nutrient Management Act*, 2002 (NMA).[69]

The best category of compost quality is AA, followed by A, B, and NASM. Under these guidelines– compost for unrestricted use is category AA or A where the compost can be used for any application such as agricultural lands, residential gardens or horticultural operations with minimal trace elements.[70] Category B is restricted to use compost because of the presence of sharp foreign matter or higher trace element content requiring additional control and precautions for use. [71] The Compost Quality Standards set out by Ontario follows from provincial guidelines and has three categories of compost quality namely AA, A and B. [72] These standards apply to aerobic

[61] ibid.
[62] Fertilizers Act. (1985) Government of Canada. https://lois-laws.justice.gc.ca/eng/acts/F-10/page-1.html#h-222161
[63] ibid.
[64] Canadian Council of Ministers of the Environment. (2005). *Guidelines for Compost Quality*. Canadian Council of Ministers of the Environment.
[65] ibid.
[66] ibid.
[67] Bernal, M. P., Sommer, S. G., Chadwick, D., Qing, C., Guoxue, L., & Michel, F. C. (2017). Current Approaches and Future Trends in Compost Quality Criteria for Agronomic, Environmental, and Human Health Benefits. In *Advances in Agronomy* (Vol. 144, pp. 143–233). Academic Press Inc.
[68] Ontario Ministry of the Environment. (2012). Ontario Compost Quality Standards. Retrieved from https://www.ontario.ca/page/ontario-compost-quality-standards
[69] Bernal, M. P., Sommer, S. G., Chadwick, D., Qing, C., Guoxue, L., & Michel, F. C. (2017). Current Approaches and Future Trends in Compost Quality Criteria for Agronomic, Environmental, and Human Health Benefits. In Advances in Agronomy (Vol. 144, pp. 143–233). Academic Press Inc.
[70] ibid.
[71] Bernal, M. P., Sommer, S. G., Chadwick, D., Qing, C., Guoxue, L., & Michel, F. C. (2017). Current Approaches and Future Trends in Compost Quality Criteria for Agronomic, Environmental, and Human Health Benefits. In Advances in Agronomy (Vol. 144, pp. 143–233). Academic Press Inc.
[72] Ontario Ministry of the Environment. (2012). Ontario Compost Quality Standards. Retrieved from https://www.ontario.ca/page/ontario-compost-quality-standards

composting of non-hazardous organic materials to produce soil conditioner. [73] These standards specify metal limits, the quality of feedstock, pathogens, foreign matter content, compost maturity, and compost labelling.

For category AA compost – sewage biosolids, pulp, and paper biosolids and domestic septage cannot be used in feedstock material whereas in category A compost a maximum of 25% of the feedstock blend can contain the items listed.[74] Category B compost can contain more concentrations of metals, sewage biosolids, pulp, and paper biosolids and domestic septage and allow a small amount of sharp foreign matter.[75] Use of Category B compost typically would not be permitted for areas with regular human contact, such as parks or residential areas but may be used for land reclamation, mining rehabilitation, and reforestation.[76]

In some cases, category B compost may be used on agricultural land to add nutrients as non-agricultural source material (NASM) subject to the requirements of the Nutrient Management Act.[77] NASM is treated and recycled material from non-agricultural sources such as leaf and yard waste, fruit and vegetable peels, food processing waste, pulp, and paper biosolids and sewage biosolids. [78] NASM is classified under one of three categories. The NASM in each of the categories can be applied to agricultural land with category 1 consisting of leaf and yard waste, category 2 consisting of waste matter without meat or fish and food processing from bakeries as well as category 3 which includes pulp, paper, manure, and sewage biosolids. [79] For Category 2 and 3 NASM, land application standards must be documented in a NASM Plan.[80] A summary of compost quality standards and uses of the different categories of compost can be found in the table below.

[73] ibid.
[74] ibid.
[75] Ontario Ministry of the Environment. (2012). Ontario Compost Quality Standards. Retrieved from https://www.ontario.ca/page/ontario-compost-quality-standards
[76] ibid.
[77] ibid.
[78] Ontario Ministry of Agriculture, Food and Rural Affairs (2020). Non-Agricultural Source Materials (NASM).
[79] ibid.
[80] ibid.

Table 1: Describes the various attributes for grades of compost quality. Source: Ontario Compost Quality Standards (2012)[81] and Nutrient Management Act (2002)[82]

ONTARIO COMPOST QUALITY STANDARDS SUMMARY TABLE					
CATEGORIES	**FOREIGN MATTER**	**TRACE ELEMENTS**	**MATURITY/ STABILITY**	**PATHOGENS**	**USES**
AA	Foreign matter greater than 3mm shall not exceed 1% of dry weight and plastics cannot exceed 0.5%. No material that can injure humans or animals. Sewage biosolids, pulp, and paper biosolids and domestic septage are not permitted.	Compost must not contain regulated metals in a concentration exceeding the amounts listed.	Maturity is reached when the compost has cured for a minimum of 21 days, with less than 400mg of oxygen per kilogram of volatile solids per hour or less than 4mg of carbon dioxide per gram of organic material per day.	Must not exceed 1000 colony forming units (CFU) *E. coli* of total solids and must not exceed 3 most probable number of *Salmonella* per 4 grams of total solids.	Highest quality standard. Exempt from transport and use approvals. Can be used on agricultural lands, residential gardens, horticultural operations, and other businesses.
A	Foreign matter greater than 3mm shall not exceed 1% of dry weight and plastics cannot exceed 0.5%. No material that can injure humans or animals. Sewage biosolids, pulp, and paper biosolids and domestic septage are permitted to a maximum of 25% of the feedstock blend.	Similar regulated metal concentrations to AA quality compost except for higher amounts of copper and zinc.	Same minimum standards as above.	Same standards as above.	The second highest quality standard also exempts from transport and use approvals. Must be labelled with maximum application rates and identification of biosolids used in the feedstock.
B	Foreign matter greater than 3 mm shall not exceed 2.0% and plastics cannot exceed 0.5%. A maximum of 3 pieces of sharp foreign matter per 500 ml.	Higher maximum concentration of metals in compost.	Same minimum standards as above.	Same standards as above.	Category B compost is subject to approvals for transportation and management Not permitted for human contact. Uses include organic soil conditioning and restricted agricultural land applications.
NASM	Content of glass, metallic objects, plastic, and other foreign objects cannot exceed 2% of dry weight. Plastic cannot exceed 0.5%.	The concentration of regulated metal content cannot exceed what is listed in Table 2 of CM2 NASM. Higher amounts than the above categories.	Same minimum standards as above.	CP1 NASM must not exceed 1,000 CFU of *E. coli* per 100 ml and 3 CF *Salmonella* per 100ml. CP2 NASM must not exceed 2 million CFU of *E. coli* per 100 ml.	Categories 1, 2 and 3 of NASM. It can be applied to farms but away from sensitive features, such as wells, surface water, and residential spaces. For Category 2 and 3 NASM, land application standards must be documented in a NASM Plan.

[81] Ontario Ministry of the Environment. (2012). Ontario Compost Quality Standards. Retrieved from https://www.ontario.ca/page/ontario-compost-quality-standards.

[82] *Nutrient Management Act*, Ontario (2002). Regulation267/03. Ontario. https://www.ontario.ca/laws/regulation/030267?_ga=2.43061797.1455925739.1587132929-1180316161.1579928712#BK282

1.2 - Implications and Consequences of Poor Organic Waste Diversion Rates

There are also serious public health and environmental consequences of poor organic waste diversion rates over time. Poor organic waste management can lead to the build-up and release of emissions from landfills. Emissions from organic waste including methane and nitrous oxide from the waste sector are microbially produced. The rate at which these emissions are produced can be by temperature, moisture, pH, substrates, microbial competition and such which is why net emissions from organic waste vary temporally and spatially.[83] If organic waste is not managed properly during composting, this process will result in large emissions of ammonia (NH3), nitrous oxide (N2O), and methane (CH4) to the atmosphere and nutrient loss from liquid leaching may also contribute to loss of nutrients. [84]

Organic waste in landfills can contribute to leachate production which causes pollutants to seep into the environment.[85] Methane build-up from organic waste in landfills can cause landfill gas to migrate underground and accumulate in areas close to the landfill causing a risk of explosion.[86] Since landfills function as inefficient anaerobic digesters, significant long-term carbon storage occurs in landfills as well.[87] GHG emissions from waste management will be present decades after waste disposal. When organic waste is sent to landfills anaerobic decay leads to the generation of methane which is then released into the atmosphere.[88] Methane is a GHG that "has a comparative impact… more than 25 times greater than CO2 over a 100-year period" according to the US Environmental Protection Agency.[89] The generation of this gas must be reduced to respond to the climate emergency. In addition to the risk of pollution, poor management of the composting process can also cause emissions of odor, ammonia, GhGs, and nitrate leaching.[90]

Mechanically sorted organic waste in composting facilities also has a significant contribution towards the generation and emission of volatile compounds which can cause public health risks.[91] Efforts should be made to minimize cumulative non-carcinogenic and carcinogenic risk as the public is exposed to a mixture of volatile compounds.[92] Research shows that emissions of volatile compounds from composting facilities environmental pollutants include aromatics, hydrocarbons, sulfur compounds, aldehydes, acids, halogenated compounds, terpenes, benzene, toluene, ethylbenzene, ammonia, hydrogen sulfide, and other intricate volatile compounds are considered to be toxic and hazardous.[93] The emission of volatile compounds is due in large part to the presence

[83] Bogner, Jean, Riitta Pipatti, Seiji Hashimoto, Cristobal Diaz, Katarina Mareckova, Luis Diaz, Peter Kjeldsen, et al. 2008. "Mitigation of Global Greenhouse Gas Emissions from Waste: Conclusions and Strategies from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. Working Group III (Mitigation)." *Waste Management and Research* 26 (1): 11–32.

[84] Bernal, M. P., Sommer, S. G., Chadwick, D., Qing, C., Guoxue, L., & Michel, F. C. (2017). Current Approaches and Future Trends in Compost Quality Criteria for Agronomic, Environmental, and Human Health Benefits. In *Advances in Agronomy* (Vol. 144, pp. 143–233). Academic Press Inc.

[85] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.

[86] Environment Canada. (2013). *Technical Document on Municipal Solid Waste Organics Processing*. *Environment Canada*.

[87] Bogner, J., Pipatti, R., Hashimoto, S., Diaz, C., Mareckova, K., Diaz, L., … Gregory, R. (2008). Mitigation of global greenhouse gas emissions from waste: Conclusions and strategies from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. Working Group III (Mitigation). *Waste Management and Research*, *26*(1), 11–32.

[88] Environment Canada. (2013). *Technical Document on Municipal Solid Waste Organics Processing*. *Environment Canada*.

[89] US Environmental Protection Agency. (n.d.). "Methane Emissions". Retrieved from https://www.epa.gov/ghgemissions/overview-greenhouse-gases#methane

[90] ibid.

[91] Mustafa, Muhammad Farooq, Yanjun Liu, Zhenhan Duan, Hanwen Guo, Sai Xu, Hongtao Wang, and Wenjing Lu. 2017. "Volatile Compounds Emission and Health Risk Assessment during Composting of Organic Fraction of Municipal Solid Waste." *Journal of Hazardous Materials* 327 (April): 35–43.

[92] ibid.

[93] ibid.

of high content of organic matter and moisture and mostly released in the initial active composting stage of organic waste management.[94] Most volatile compounds are released in the early pre-processing stage of organic waste management. [95]

There are also persuasive public health reasons for implementing better waste diversion strategies.[96] There are human health impacts linked to exposure to bioaerosols from composting facilities and pathogens. Epidemiological studies show links between human illnesses in workers and proximity to a waste disposal site. [97] The main pathways of exposure are inhalation of emissions, consumption of contaminated water, and the consumption of pathogens and bacteria through the food chain. [98] Toxic gases and greenhouse gases generated from landfill sites also aggravate the greenhouse effect and harm residents' health. [99] Organic wastes from various sources may contain different kinds of microorganisms that might be infectious to human beings, and health concerns related to airborne particles from composting operations have increased dramatically in recent years due to the potential risks to nearby residents. [100]

In terms of the effects of including municipal solid waste in compost- studies show how this type of compost has the potential to promote negative changes in soil microbial biomass and activity especially if there is high heavy metals content.[101] There is an important need to evaluate the effect of compost on soil microbial biomass as heavy metals such as cadmium, copper, lead and zinc are toxic elements that can enter the food chain through crops.[102] Compost can also affect soil microbial biomass which is the fraction of the soil responsible for the energy and nutrient cycling and regulation of organic matter.[103]

1.2.1 - Pathogens and Dog Waste

With Ottawa's more recent decision to begin accepting pet feces in green bins, it is important to look at the science of treating pet feces with the aerobic composting system that the City uses. Pathogens from source-separated organics (SSO) has the potential to negatively impact human, environmental, vegetal and animal health given the potential for human or animal pathogens to be found in compost feedstock and to ultimately enter the food chain. Waste from dog feces can lead to health and environmental problems, especially in urban areas as these wastes are carriers of a large population of bacteria and pathogens.[104]

[94] ibid.
[95] ibid.
[96] Elving, Josefine, Björn Vinnerås, Ann Albihn, and Jakob R. Ottoson. 2014. "Thermal Treatment for Pathogen Inactivation as a Risk Mitigation Strategy for Safe Recycling of Organic Waste in Agriculture." *Journal of Environmental Science and Health - Part B Pesticides, Food Contaminants, and Agricultural Wastes* 49 (9): 679–89.
[97] Giusti, L. (2009, August). A review of waste management practices and their impact on human health. *Waste Management*. https://doi.org/10.1016/j.wasman.2009.03.028
[98] ibid.
[99] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.
[100] ibid.
[101] Sérgio Ferreira de Araú jo, A., José de Melo, W., & Pratap Singh, R. (2009). Municipal solid waste compost amendment in agricultural soil: changes in soil microbial biomass.
[102] Sérgio Ferreira de Araú jo, A., José de Melo, W., & Pratap Singh, R. (2009). Municipal solid waste compost amendment in agricultural soil: changes in soil microbial biomass.
[103] ibid.
[104] ibid.

Survival of the pathogen within compost is attributed to either the entire pile or pockets within the pile of compost not reaching 55°C.[105] During composting, pathogen destruction occurs through thermal destruction, competitive interactions between microorganisms, nutrient depletion, by-product toxicity, and natural die-off. [106] However, there is a substantial body of literature reporting the survival of bacterial pathogens including E. coli and Salmonella, depending on the interaction of biotic and abiotic factors such as temperature, moisture, ammonia content and pH in composting.[107]

According to previous studies, the pH of composts obtained from dog feces was close to neutral (pH 7) but values of pH between 6.0–8.5 are considered ideal for compost.[108] Additionally, the compost mixed with dog feces showed high contents of nitrogen, phosphorus, potassium, and had a high salinity.[109] The presence of a high concentration of soluble salts in the compost can reduce its quality, especially for agricultural use as compost with high salinity can exacerbate soil salinity, leading to structural breakdown and possibly inhibit plant-growth after repeated applications. [110] With anaerobic digestion dog, fecal waste yielded a biogas production of 229 mL/g TS which when mixed with organic or leaf and yard waste seemed to enhance the richness of biogas. [111]

Examining the case study of how metro Vancouver deals with dog waste present some insights on the effects of dog waste used in compost. According to Kaitlin Lovering of UBC, a dog produces on average 124 kg of excrement per year. In the metropolitan area of Vancouver, dog waste is collected in plastic bags and placed in red bins located in parks. This is picked up by a private contractor who separates the waste from the plastic bags and delivers it to the Iona Island Waste Water Treatment Plant (WWTP) where it is added to the Trucked Liquid Waste (TLW) stream.[112] The treatment process at Iona Island, unlike the historically prominent aerobic process for treating dog waste, is AD, producing biogas. Anaerobic and aerobic processes, along with a combination of the two, are the three prominent processes by which dog waste may be treated.

Since human and animal organic waste may contain pathogenic microorganisms, proper steps must be taken to ensure the prevention of contamination of food or feed and water supplies. [113] Thus, recycling of organic waste may present a health hazard to humans and animals. Where compost products are to be used in the production of livestock and other foodstuffs, it is essential to minimize the risk of pathogens entering the food chain to protect human and livestock health especially with ready-to-eat crops such as salad crops.[114] One study suggests that compost containing dog waste should only be used for flower beds and houseplants.[115]

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[105] Avery, L. M., Booth, P., Campbell, C., Tompkins, D., & Hough, R. L. (2012, August 1). Prevalence and survival of potential pathogens in source-segregated green waste compost. *Science of the Total Environment*. Elsevier.
[106] ibid.
[107] ibid.
[108] ibid.
[109] Martínez-Sabater, E., García-Muñoz, M., Bonete, P., Rodriguez, M., Sánchez-García, F. B., Pérez-Murcia, M. D., … Moral, R. (2019). Comprehensive management of dog feces: Composting versus anaerobic digestion. *Journal of Environmental Management*, *250*, 109437.
[110] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.
[111] Martínez-Sabater, E., García-Muñoz, M., Bonete, P., Rodriguez, M., Sánchez-García, F. B., Pérez-Murcia, M. D., … Moral, R. (2019). Comprehensive management of dog feces: Composting versus anaerobic digestion. *Journal of Environmental Management*, *250*, 109437.
[112] Idem., 8.
[113] ibid.
[114] ibid.
[115] Nemiroff, L., & Patterson, J. (2007). Design, testing, and implementation of a large-scale urban dog waste composting program. *Compost Science and Utilization*, *15*(4), 237–242.

Some studies suggest that anaerobic digestion under thermophilic conditions or high temperatures can result in high sanitation efficiency of pathogens in compost, as dog waste may contain potentially harmful pathogens that can harm people. [116] AD successfully reduces the pathogens in compost while also producing both biogas and compost as an end-product.[117] Large-scale dog waste processing programs seem particularly efficient when employing AD to produce and capture biogas, reducing emissions and increasing diversion. These are important considerations for the City when including dog waste in Green Bins and organic waste processing. Two examples of safety concerns with the aerobic process can be exemplified in two cases: Green Pet Compost in BC and Montreal park composters. Even after a 3-4 month process, ten days of which are spent in-vessel between 60 and 63°C, and regular testing – the owners of Green Pet Compost will not sell their product for garden application likely a precaution in case the process was somehow imperfect.[118] These fears are not unfounded, as Montreal park composters, maintained by trained residents, produced a product from dog feces that was not rendered safe in the composting process.[119] Understanding the varied temperature ranges for AD (mesophilic and thermophilic) and for compost (55°C+ for 3 days in-vessel, 10 days in a window, etc.), we look at one prominent concern when making a product from dog feces.

Although there are testing regulations for pathogens within compost (*Salmonella* and *E. coli*), these two tests along with temperature requirements may not be satisfactory at responding to the dangers present in dog feces. That being said, it ought first to be noted that a temperature of 55 °C as required by Ontario is higher than the conditions in which pathogens including cysts such as Giardia and Cryptosporidium can survive (each deactivated respectively within 18 hours at 37°C and within two days at 55°C).[120] It is higher still than those which might be endured by the eggs of pathogens such as the *Toxocara canis* and *Echniococcus granulosus*, helminths (Roundworm and Hookworm) hosted by dogs and present in their feces. Still, Lovering notes that anaerobic conditions inactivate worm eggs more quickly than aerobic and her analysis demonstrates, in most cases, that AD succeeds at removing pathogens more quickly than composting.[121]In addition to this, anaerobic conditions are also toxic to anaerobic organisms needed for the breakdown of organics. Studies indicate that there is cause for concern when dog feces are included in the organic waste stream. The addition of dog waste lowers the quality of the compost and will likely result in some level of harmful pathogens.

1.2.2 – Plastics in Compost

Plastics in compost can cause detrimental environmental effects due to their low rate of breakdown. Plastics can taint soil ecosystems by releasing toxic substances that have the potential to enter the food chain and affect human health.

Under Ontario's *Compost Quality Guidelines*, it is stated that municipal Green Bin programs that accept plastic or compostable plastic bags must have the proper processing technology to manage

[116] Nemiroff, L., & Patterson, J. (2007). Design, testing, and implementation of a large-scale urban dog waste composting program. *Compost Science and Utilization*, *15*(4), 237–242.
[117] ibid.
[118] Idem., 6.
[119] Nemiroff, L., & Patterson, J. (2007). Design, testing, and implementation of a large-scale urban dog waste composting program. *Compost Science and Utilization*, *15*(4), 237–242.
[120] Idem., 13-14.
[121] Idem., 16. In Lovering's work, Table 1 compares the pathogen removal temperatures for AD and composting.

the addition of plastics. [122] The design of organics processing facilities must accommodate the management of plastics and provide sufficient odour control measures given the higher odour producing potential of feedstock with the inclusion of plastics.[123] Additionally, the use of compostable bags and paper bags are acceptable so long as the facility is equipped to process the materials and allow sufficient time for the bags to decompose.[124] Under Ontario's Compost Quality Standards, in categories AA, A and B the total amount of plastic cannot exceed 0.5% of the total dry weight of compost.[125] Organics processing programs should be designed to minimize the presence of contaminants such as plastics to ensure a clean process and thus a higher quality of compost.

One problem facing the compost industry is contamination from plastic wastes, predominantly from low-density polyethylene (LDPE) - a type of thermoplastic used to make plastic wrapping film and grocery bags. These very stable plastics require a decomposition period of up to 1000 years.[126] Some studies indicate that certain fungal and bacterial species are capable of degrading plastics, though the presence of plastics in compost also affects the interactions within microbial communities in soil.[127] The inclusion of higher amounts of plastic in feedstock which becomes compost may also affect "seed germination, root penetration, nutrient, and water flow, and root uptake of water and nutrients from the soil" when in it applied to land.[128] One study examined the effects of LDPE films in the structure of bacterial and fungal communities in mature compost piles ranging between 2 to 10 years and found that compost had no significant effect on the structure of the microbial community.[129] In terms of the co-occurrence network, the presence of plastics affected interaction patterns within microbial communities. A larger number of niche-specific microbial taxa such as *Firmicutes Bacillaceae* and *Thermoactinomycetaceae* was detected in compost with plastic in it.[130] The long-term effects of plastics in compost can provide insights as to how plastics affect soil quality, ecosystems and relatedly human health.

Biodegradable plastics may present a solution to reducing plastic waste entering organic feedstock while also ensuring that the quality of compost is not impaired. Standards were developed by the American Society for Testing Materials (ASTM) and the International Standards Organization (ISO) to assess the biodegradability of plastics in different environments such as composting and anaerobic digestion.[131] According to ASTM D6400-04, biodegradable plastic is one that degrades due to the actions of naturally occurring microorganisms such as bacteria, fungi, and algae.[132] There are two main types of biodegradable plastics such as those made from bio-based sources like corn, wheat or petroleum known as hydro-biodegradable plastic (HBP) or oxo-biodegradable

[122] Ontario Ministry of the Environment. (2012). Ontario Compost Quality Guidelines. Retrieved from https://www.ontario.ca/page/guideline-production-compost-ontario.
[123] Ibid.
[124] Ibid.
[125] Ontario Ministry of the Environment. (2012). Ontario Compost Quality Standards. Retrieved from https://www.ontario.ca/page/ontario-compost-quality-standards
[126] Ontario Ministry of the Environment. (2012). Ontario Compost Quality Guidelines. Retrieved from https://www.ontario.ca/page/guideline-production-compost-ontario.
[127] Esan, E. O., Abbey, Lord, & Yurgel, S. (2019). Exploring the long-term effect of plastic on compost microbiome. *PLOS ONE*, *14*(3), e0214376. https://doi.org/10.1371/journal.pone.0214376
[128] Esan, E. O., Abbey, Lord, & Yurgel, S. (2019). Exploring the long-term effect of plastic on compost microbiome. *PLOS ONE*, *14*(3), e0214376. https://doi.org/10.1371/journal.pone.0214376
[129] Ibid.
[130] Ibid.
[131] Adamcová, D., Toman, F., Vaverková, M., & Kotovicová, J. (2013). The Effect of Biodegradation/Degradation of Degradable Plastic Material On Compost Quality. Ecological Chemistry and Engineering, 20(4), 783–798.
[132] Ibid.

plastics made with fatty acid compounds.[133] "Biodegradable" plastics can consist of starch plastics blended with linear low-density polyethylene, prooxidant additives, or polyethylene with ultraviolet light-absorbing substituents to initiate photooxidation of the plastic.[134] During the composting process, biodegradable plastics should be converted to carbon dioxide, water, and compost, without leaving any persistent or toxic residue.[135] Studies show that different types of degradable plastics would degrade at different rates and affect compost quality and soil quality in various ways.[136]

Compostable plastics, on the other hand, have a different set of standards. According to ASTM standard D6400, a product is compostable if it can disintegrate, biodegrade, and ecotoxicity which is similar to standards for packaging under ISO (EN 13432).[137] Compostable plastic is plastic that undergoes degradation by biological processes during composting processes. When compostable plastics breakdown they produce carbon dioxide, water, inorganic compounds, and biomass at a rate consistent with other known organic materials and leaves no visual trace or toxic residue behind.[138] In many cases, compostable plastics do not compost within the typical processing times of conventional facilities and are therefore treated as plastics and taken to landfills. One study, which examined whether the quality of compost would change when including compostable or biodegradable bags showed that the compost quality showed no significant influence on compost characteristics such as nutrient content, acidity, salinity, phytotoxicity and ratio of organic to inorganic nutrients which were determined through a series of various tests.[139] To examine the quality of compost, researches used quality parameters to assess the nutrient content of compost and compared composts both without plastic, with degradable plastics and with biodegradable plastics.[140] The nitrogen, potassium and phosphorus values compost with biodegradable plastics were found to be highest and overall researchers determined that different types of plastics degrade at different rates with varying effects on the quality of compost.[141]

The problem with low-quality compost, produced from non-source-separated municipal organic waste, is that it can cause soil pollution from the inclusion of hazardous ingredients such as plastics and biowaste. [142] The inclusion of materials such as plastics, glass, and metals are indicative of low-quality input material for composting, which is typically a problem for non-source-separated municipal solid waste.[143] Plastics need to be removed and taken to the landfill before composting either through preprocessing or source separation.

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[133] Biodegradable Plastic: Types, Properties & Material Table. (2020). Retrieved April 17, 2020, from https://omnexus.specialchem.com/polymer-properties/properties/biodegradable

[134] Gilmore, D. F., Antoun, S., Lenz, R. W., Goodwin, S., Austin, R., & Fuller, R. C. (1992). The fate of "biodegradable" plastics in municipal leaf compost. *Journal of Industrial Microbiology*, *10*(3–4), 199–206. https://doi.org/10.1007/BF01569767

[135] Unmar, G., & Mohee, R. (2008, October 1). Assessing the effect of biodegradable and degradable plastics on the composting of green wastes and compost quality. *Bioresource Technology*. Elsevier. https://doi.org/10.1016/j.biortech.2008.01.016

[136] ibid.

[137] Adamcová, D., Toman, F., Vaverková, M., & Kotovicová, J. (2013). The Effect of Biodegradation/Degradation of Degradable Plastic Material On Compost Quality. Ecological Chemistry and Engineering, 20(4), 783–798.

[138] Ibid.

[139] Unmar, G., & Mohee, R. (2008, October 1). Assessing the effect of biodegradable and degradable plastics on the composting of green wastes and compost quality. Bioresource Technology. Elsevier. https://doi.org/10.1016/j.biortech.2008.01.016

[140] ibid.

[141] ibid.

[142] Bernal, M. P., Sommer, S. G., Chadwick, D., Qing, C., Guoxue, L., & Michel, F. C. (2017). Current Approaches and Future Trends in Compost Quality Criteria for Agronomic, Environmental, and Human Health Benefits. In *Advances in Agronomy* (Vol. 144, pp. 143–233). Academic Press Inc. https://doi.org/10.1016/bs.agron.2017.03.002

[143] Kumar, S., Zhang, Z., Awasthi, M. K., Li, R., Zhang, Z., Awasthi, M. K., & Li, R. (2019). *Biological Processing of Solid Waste*. *Biological Processing of Solid Waste*. CRC Press.

Part 2: Current Policies, Regulations, and Guidelines for Organic Waste Management in Ottawa

The responsibility to manage solid waste is shared between the various levels of government which is why waste reduction strategies entail collaboration or exclusive such as the federal responsibility to regulate transboundary movements of hazardous wastes. Municipalities are responsible for the collection, disposal, and processing of solid wastes while provincial and territorial governments establish the policies and programs to approve and monitor waste management facility operations.

2.1 - Federal Government

In Canada, the federal government provides funding for projects, community activities, preparing reports on waste management and funding infrastructure to help divert waste from landfills.[144] The federal government emphasizes an overarching goal of reducing, reusing and recycling and more recently the importance of a circular economy. The government encourages waste reduction by setting overarching targets and goals as opposed to specific laws and regulations. They are also responsible for controlling international and interprovincial movements of hazardous waste.

The federal government can help cities identify best practices to reduce pollution from waste management practices and often leading policy and program activities through the CCME in conjunction with other provinces and territories. Due to the division of powers between the federal and provincial governments- the federal government will create similar pieces of legislation or mirror laws to fill in any legal gaps and ensure uniformity across provincial laws. This in part explains the need for both a provincial and federal *Environmental Protection Act.*

Concerning food waste and compost, in 1985, the Canadian government enacted the *Fertilizers Act*, which regulates the sale and import of fertilizers. For the most part, the federal government focuses on the international component of waste management working through bodies such as the OECD and the UNEP Basel Convention.

Food waste and the associated carbon emissions are a growing concern for the federal government.[145] In the "Taking Stock" report released in June 2019 by Environment and Climate Change Canada, the government discusses the importance of curbing food waste in accordance with Sustainable Development Goal 12.3 which aims to halve per capita global food waste and losses at the retail and consumer levels by 2030.[146] Additionally, the Pan Canadian Framework on Clean Growth and Climate Change, which outlines how the government aims to meet emissions reductions targets, briefly discusses the municipal waste sector as a key source of cleaner fuels.[147] In terms of organic waste management, Environment Canada produced the 2013 "Technical Document on Municipal Solid Waste Organics Processing" discussing the science behind organic waste management and processing technologies being employed in various cities across the country. In addition to this guidance, documents by the Canadian Council of Ministers of the Environment (CCME), an intergovernmental panel, provide municipalities with guidelines for

[144] Environment Canada. 2013. *Technical Document on Municipal Solid Waste Organics Processing*. *Environment Canada*.
[145] Ibid.
[146] Ministry of Environment and Climate Change. 2019. *Taking Stock Reducing Food Loss and Waste in Canada*.
[147] Government of Canada. 2016. *Pan-Canadian Framework on Clean Growth and Climate Change*. *Government of Canada Canada*.

compost quality and treatment of biosolids which are adhered to by many major municipalities.[148] The compost quality standards outlined by the federal government are detailed at length in the section above.

2.2 - Provincial Government

The province has an important role in managing and diverting organic waste. Ottawa is a city within the province of Ontario and, as such, must adhere to laws enacted by the provincial government. Ontario residents generate about 3.5 million tonnes of food waste every year and around 4% of Ontario's GHG emissions come from waste. [149] The province is responsible for monitoring, approving and licensing waste management operations. The province can also play a strong role in assisting cities with achieving waste reduction targets and driving waste reduction and recycling and composting agendas.

Part of the province's goal for improved waste is to achieve a circular economy whereby a resource is recovered and used as many times as possible before it ends up as waste. A circular economy moves us towards a more sustainable economic system but requires significant innovation and regulation to eliminate a large amount of food waste going into landfills - a common trend among developed and affluent countries.[150] In 2016, the province adopted legislation and issued statements with the goal of creating a circular economy. A circular economy focuses on changing production systems from seeing organic waste as "waste" to other useful products such as compost, food or biofuels.[151]

In line with this goal, the province passed the *Waste-Free Ontario Act* (2016), that includes the *Resource Recovery and Circular Economy Act* (2016) and the *Waste Diversion Transition Act* (2016) to move the province towards achieving waste reduction targets and a circular economy[152]. In 2018, the province of Ontario issued a "Food and Organic Waste Policy Statement" under section 11 of the *Resource Recovery and Circular Economy Act* (2016) to encourage ministries, municipalities, businesses and the waste management sector to increase waste reduction and recovery of food waste to reduce greenhouse gas emissions and meet the province's Climate Change Action Plan targets.[153]

For the City of Ottawa, this means aiming to achieve 70% waste reduction and resource recovery of food and organic waste by 2023 and 50% diversion in multi-residential buildings by 2025.[154] In this policy statement, the province encourages municipalities to work with municipal associations to develop education campaigns that will encourage residents to increase their participation in resource recovery efforts available to residents of the community. The province also encourages municipalities to improve existing policies or procedures to encourage the use of compost, digestate, and other soil amendments.[155] The Ontario Food Recovery Hierarchy, similar to that proposed by the federal government, suggests the following steps: reduce or prevent food and

[148] Ministry of Environment and Climate Change. 2019. *Taking Stock Reducing Food Loss and Waste in Canada*.
[149] "Waste Management Ontario." https://www.ontario.ca/page/waste-management.
[150] Borrello, Caracciolo, Lombardi, Pascucci, & Cembalo, 2017
[151] Ministry of Environment Conservation and Parks Ontario. n.d. "Strategy for a Waste-Free Ontario: Building the Circular Economy." 2016.
[152] Ministry of Environment Conservation and Parks Ontario. n.d. "Strategy for a Waste-Free Ontario: Building the Circular Economy." 2016.
[153] ibid.
[154] Ministry of Environment Conservation and Parks Ontario. n.d. "Strategy for a Waste-Free Ontario: Building the Circular Economy." 2016.
[155] ibid.

organic waste; feed people by redirecting surplus food and recover food waste to create beneficial end products.

Note that these policies represent minimum standards and direction to prevent and reduce food and organic waste. In this policy statement, Ontario emphasizes the goal of building a circular economy for food and organic waste. This policy statement is intended to be used as an educational tool, to encourage the expansion of the Green Bin program in Ontario, set sector and municipality specific organic waste reduction and recovery targets and provide directives for businesses and multi-residential buildings on how to increase diversion rates and recover resources.[156] The province aims to support existing resource recovery systems and develop additional capacity to process food and organic waste through strategic infrastructure planning. Supporting the development and operation of resource recovery systems will be an important part of Ontario's work towards achieving zero waste and getting to net-zero emissions.

A range of legislation in Ontario governs licensing, approval and monitoring of waste management in cities. The *Resource Recovery and Circular Economy Act* (2016) establishes a producer responsibility regime by making producers accountable and financially responsible for recovering resources and reducing waste associated with their products. This *Act* also established the Resource Productivity and Recovery Authority which collects data about the waste tonnage from cities and oversees producer performance. *Waste Diversion Transition Act* (2016) will guide the transition from current waste diversion programs to the producer responsibility framework by allowing for existing waste diversion programs to continue until more categories of waste come under the *Resource Recovery and Circular Economy Act*.[157] The *Environmental Assessment Act* regulates municipal waste disposal and facilities. The *Nutrient Management Act* establishes standards for managing materials with nutrients on agricultural land, which is an important consideration for compost quality. The *Ontario Environmental Protection Act (EPA)* regulates waste disposal sites, the transport of waste, hazardous waste, waste treatment methods, and environmental approvals. Regulation 347 applies to Waste Management and includes *Ontario's Compost Quality Standards* and *Guidelines for the Production of Compost*. Quality standards range from B to A, to AA, with AA being the best.

In 2018, the Minister of the Environment released Preserving and Protecting our Environment for Future Generations: A Made-in-Ontario Environment Plan to guide the development of new environmental policies in Ontario. With plans to protect air, land, water, and communities and to reduce waste while lowering greenhouse gas emissions. Section 6 of the Plan focuses on reducing litter and waste in communities.[158] The Province aims to reduce the amount of waste going to landfills, increase opportunities for Ontarians to participate in waste reduction efforts, increase the use of technologies to recover resources in waste and consider producer responsibility for the end of life management of products.[159] This plan echoes a lot of what was mentioned in previous laws and regulations surrounding waste management. Specific to organic waste, the Province would like to expand the green bin program to large cities and relevant businesses, possibly ban food waste from landfills, improve public education about diverting organic waste, develop

[156] "Waste Management Ontario." https://www.ontario.ca/page/waste-management.
[157] Strategy for a Waste-Free Ontario: Building the Circular Economy
[158] Ministry of the Environment, C., and P. (2018). A Made-in-Ontario Environment Plan. Retrieved April 1, 2020, from https://www.ontario.ca/page/made-in-ontario-environment-plan
[159] ibid.

requirements for compostable packaging or plastics and develop best practices for safe food donation.[160] These are key considerations for the City of Ottawa when developing its new *Solid Waste Master Plan*.

2.3 - Municipal Government

Arguably, cities have the largest role in reducing organic waste diversion. The City of Ottawa is largely responsible for the collection, processing, and disposal of household waste. As "creatures of the province," municipalities have the authority to pass by-laws for the environmental well-being of the municipality including the management and collection of waste. By-laws created by the city must adhere to federal and provincial waste management legislation.

Organic processing facilities are subject to the development and redevelopment requirements and bylaws enacted by the municipality in which they are located, even if they are privately owned facilities.[161] Municipal By-laws are normally developed to cover issues that are common to residential, commercial, and industrial developments and some Canadian municipalities have enacted specific bylaws regulating organic waste processing facilities or solid waste management facilities in general.[162] Many of these municipalities also require that these facilities gain specific licensing in addition to provincial permits and requirements such as environmental compliance approvals under the *Ontario EPA*.[163]

Cities can create their own Solid Waste Master Plans, as Ottawa is doing currently, to establish long term waste management targets and goals. Cities can also create policies and programs to help meet these targets and determine where and how waste will be processed. Municipalities are the front-line governments responsible for waste in Canada. They are responsible for the bulk of residential waste management services. This could include, for example, curbside collection of organics, waste, and recyclables and providing depot drop-off locations."[164] The City of Ottawa uses a mixed model with the bulk of the curbside collections being done through in-house contracting. The efficiency of this approach is reviewed by annual reports prepared for Councilors. The City of Toronto also uses a similar "mixed" approach for curbside collection.

All municipalities in Ontario can carry out their responsibilities directly, through partnership arrangements or by simply contracting out to arms-length commercial entities. It is beyond the scope of this study to describe the costs and benefits of all these options. A cursory review, however, suggests that Ottawa has generally opted for almost complete arm's length arrangements with third parties for the post-collection processing of green bin materials. There is again a similar approach in Toronto for green bin material processing, using the same company as Ottawa but at a different location. In the case of Ottawa, having a third-party contractor to process organic waste has had both benefits and costs.

The City of Ottawa also plays a role in influencing better management of waste in commercial properties and businesses, by requiring that waste diversion plans be in place before the business

[160] ibid.
[161] Environment Canada. (2013). *Technical Document on Municipal Solid Waste Organics Processing*. *Environment Canada*.
[162] ibid
[163] ibid.
[164] City of Ottawa. 2020. "The Role of the Federal, Provincial and Municipal Governments | Solid Waste Master Plan | Engage Ottawa." 2020.

can be licensed in the city. The City of Ottawa can make changes to policies and programs to help meet targets and goals set by the Solid Waste Master Plan. Depending on the direction taken by the Solid Waste Master Plan, this legislation could be used to help achieve certain goals.[165] Currently, the City's Solid Waste Management By-law provides a framework for the collection of garbage and recyclable material from residential buildings and some Industrial, Commercial and Institutional (IC&I) establishments. The Solid Waste Management By-law can be amended to widen its scope by setting limits on the amount of waste that may be generated by residents, fees for waste collection, and diversion or source separation requirements.[166] Solid Waste Management (By-law No. 2012-370) Schedule L details what materials are accepted in organic waste bins. Amendments were made in 2018 to add dog feces and plastic bags containing organic materials to Schedule L.

[165] ibid.
[166] ibid.

Part 3: Organic Waste and Ottawa

N.B. Attempts to contact Renewi (the company in charge of processing Ottawa's residential organic waste) were made by phone and e-mail, first for an interview and then for a compost sample, but no information was obtained. Renewi first agreed to an interview and then did not specify a time, and the company did not reply to the request for the compost sample at all.

3.1 How composting works in Ottawa

Along with Blue Bin, Black Bin, and the Hazardous Waste Depots, Ottawa's Green Bin program demands that residents, primarily those of single-family residences, separate their waste and reduce the total amount of material sent to the Trail Road Waste Facility. As declared by the City of Ottawa, the purpose of establishing its Green Bin program in 2007 was "to divert organic and food waste from the City's landfill at Trail Road and put it to use as compost and other beneficial products."[167] Originally, the City contracted a company named OrgaWorld to process its residential organic waste but in 2017, OrgaWorld was bought by Renewi,[168] after "a 2014 Audit of the Source-Separated Organics program determined there were serious flaws with the City's contract with Orgaworld."[169] In 2019, the facility operated by Renewi was sold again to "Convent Capital ("Convent"), a self-described independent, sustainability-focused, Dutch investment firm based in Amsterdam".[170] This new ownership could create more challenges for the City.

The City of Ottawa includes 3 categories of organic waste items accepted for residential curbside pick-up. These are food waste, yard waste and other (including animal bedding, "food-soiled pizza boxes" and, more recently, pet feces).[171] Although, in the composting industry's peak season, LYW - which was formerly composted in open windrows at Trail Road[172] - is processed at an outdoor facility on Barnsdale Road to respect the Renewi facility capacity.[173] Diapers and sanitary products are not permitted in the Green Bin, though recent developments allow for the use of plastic bags for the disposal of organic waste. Thus, all those living in single-family residential units can dispose of their food, yard and a limited number of miscellaneous organic materials in their Green Bin by leaving it at the curbside for weekly collection.

On the other hand, those living in multi-residential buildings do not always have the same privilege. The City does not automatically provide green bin service to multi-residential buildings, although it is possible, as a property owner or manager, to have green bins delivered free of charge. Diversion rates for waste disposed at multi-residential buildings are much lower than rates for single-family homes.[174] This means that most of the waste, including organics, is sent from multi-residential buildings directly to the landfill. A 2003 report to the Environmental Services

[167] City of Ottawa. (2018). "Report to the Environment and Climate Protection Committee, Source Separated Organics Program." Retrieved from WWO.
[168] Porter, Kate. "Ever Wonder Where All Your Green Bin Slop Goes? | CBC News." CBCnews. CBC/Radio Canada, October 18, 2019. https://www.cbc.ca/news/canada/ottawa/ottawa-green-bin-compost-facility-tour-photos-1.5324407.
[169] City of Ottawa, 2018
[170] Griffin-Smith, Philip. "Sale of Renewi Canada." Renewi, June 17, 2019. https://www.renewi.com/en/investors/newsroom/sale-of-renewi-canada.
[171] Public Works and Environmental Services Dept. "Green Bin and Leaf and Yard Waste." City of Ottawa, January 16, 2020. https://ottawa.ca/en/garbage-and-recycling/green-bin-and-leaf-and-yard-waste.
[172] Ibid.
[173] City of Ottawa, 2019 report to Standing Committee on Environmental Protections: Solid Waste Master Plan Roadmap, 6.
[174] Public Works and Environmental Services Dept. "Green Bin and Leaf and Yard Waste."

Committee (ESC) on Phase two of the Integrated Waste Management Master Plan (IWMMP) reports that multi-residential waste included, at that time, 28% paper, 8% plastic, 6% glass and 5% metal.[175] These are all recyclable which could have been kept out of the landfill, even in the early 2000s, as is the situation now with compostable organic waste in multi-residential buildings.

The Organic waste collected from single-family residential units, along with the smaller amount collected from multi-residential buildings is sent to the composting facility at 5123 Hawthorne Rd. in Gloucester, which is currently managed with three other organic waste processing facilities in Canada by Convertus under Convent Capital.[176] Renewi Canada will continue to process organic materials as specified in their contract which expires in 2030. The facility uses 6 tunnels, or enclosed Aerated Static Piles (ASPs), to compost organic material and has a capacity of 100,000 tonnes per annum. Before the feedstock can begin decomposition in these ASPs, however, plastic and compostable bags are ripped open by a shredder - equipment that was newly installed in 2019.[177] The tunnels are fed air through the floor and water is misted from the roof to maintain the most ideal moisture and temperature conditions. Reaching a minimum temperature of 55 degrees Celsius within these tunnels helps to eliminate dangerous pathogens - especially useful when processing pet feces.[178]After over a week in the tunnels, the organic material is screened, stored and cured to meet quality standards and is inspected after another 21 days. Mike Leopold, at the time GM of Renewi, noted that it is during the screening process that plastics are removed.[179] Post-screening, compost is matured and tested, only processing about 4 weeks before being sold to be further cured by third parties or to be applied as NASM. With the offers of organic waste diversion and quick production of "NASM," the Renewi Facility's most impressive quality is found in its efficient odour abatement technology, for which Orgaworld had originally invested almost 4 million dollars.[180]

The relatively quick process of organic decomposition which begins at Renewi is efficient, although it is certainly not perfect. Though processing at Renewi has reached completion in about 28 days, the compost is not of high enough quality to send to the City of Ottawa residents. Kate Porter of CBC News wrote, "Renewi ends up with a product it calls NASM, or non-agricultural sourced material, that it sells to farms to boost the nitrogen and phosphorus in soil. Its compost would need to be screened several more times to be suitable for residents to use".[181] NASM is equivalent to B compost quality. As explained by Ontario's Ministry of Agriculture, Food, and Rural Affairs, NASM "has been applied to Ontario farmland for more than 30 years".[182]

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[175] City of Ottawa. (2003). "Report to the Environmental Services Committee, "SOLID WASTE – INTEGRATED WASTE MANAGEMENT MASTER PLAN STRATEGIC DIRECTIONS AND PHASE TWO NEXT STEPS", Section 2.

[176]"Purchase of Renewi Canada," Convent Capital, Accessed March 16, 2020, https://conventcapital.nl/en/purchase-of-renewi-canada-2/.; "Convertus." Accessed March 16, 2020, https://conventcapital.nl/en/convertus-us/

[177] "How Plastic Bags Are Separated from Your Compost." CBCnews. CBC/Radio Canada, October 2019. https://www.cbc.ca/player/play/1625520195788.

[178] Newman, Larry. "How Orgaworld Composts Our Plastics." IMAGE. Sandy Hill Community News, September 23, 2018. http://home.imagesandyhill.org/2018/09/how-orgaworld-composts-our-plastics/.

[179] ibid.

[180] City of Ottawa. (2018). "Report to the Environment and Climate Protection Committee, Source Separated Organics Program." Retrieved from WWO.

[181] Kate Porter, "Ever Wonder Where All Your Green Bin Slop Goes? | CBC News," CBCnews (CBC/Radio Canada, October 18, 2019), https://www.cbc.ca/news/canada/ottawa/ottawa-green-bin-compost-facility-tour-photos-1.5324407

[182] Ministry of Agriculture, Food and Rural Affairs. "Non-Agricultural Source Materials (NASM)." Ontario, January 22, 2020. http://www.omafra.gov.on.ca/english/nm/nasm.html?fbclid=IwAR1b9gCVRaMbCXBgm3LXsSQ5EsPevA5OS4m3ItUHyz5agrPzcnMEMmsukSg

Application of NASM allows the restoration of nitrogen, phosphorus and other nutrients to agricultural soil, yet this application which returns nutrients to farmland also embeds small plastic particles, as well as other foreign and incompletely decomposed matter into the completed compost which can cause problems caused by land application. This NASM, processed from a feedstock that contains both pet feces and plastics, contains particulate matter too great in size, and thus fails to meet other requirements set out in Part II of Ontario Compost Quality Standards, to be considered either Category AA or Category A compost.[183] Knowing that the composting process carried out at Renewi does not meet the same quality standards as some other municipal composting processes will be discussed in Part 4.

3.2 Decision to allow plastic bags and dog waste

Through the City's Green Bin program, residents of Ottawa have had access to weekly pick up of their organic waste since 2010, yet the City reports that residential participation in the City's Green Bin program is currently 51%.[184] Waste Watch Ottawa argues that low participation can, among other things be attributed to the City spending less per household on waste diversion education and promotion than 14 other regions and large municipalities in Ontario.[185] In July 2019, the City began allowing residents to use non-compostable plastic bags to dispose of their household organic waste, including dog waste, with the goal of making it easier and less repugnant for people to use the service.[186]

This decision was made in March 2018 without significant evidence that the change in policy to accept plastics and dog waste in the Green Bin would substantially increase diversion. Reasons, why people were not using the Green Bin, were not cited other than claims that people did not use the green bin because of the so-called "yuck factor," which implied that residents found managing kitchen waste messy and unpleasant. The feasibility of separating non-compostable plastic from organic waste was not established, and the potential health and environmental concerns associated with mixing dog waste and plastics with other household organics in an aerobic composting system were not addressed. There was also no clear plan for disposing of the plastic that is to be separated from the organics, though a report did say that the plastics would be sent to landfill, to be used as fuel for kilns when the regulatory and technical circumstances make this possible.[187] There are no available details at present on the weight of plastics that are extracted or the final disposition of the materials since the responsibility for this according to the City claims lays with Renewi and not the City of Ottawa.

As a result, the City of Ottawa is risking a reduction in compost quality which could have adverse effects on human and environmental health as well as the use and marketing of the completed compost, and there is no guarantee that the City's goal of increasing participation in its Green Bin

Ibid.
[184] City of Ottawa. (2019). "Solid Waste – Data and Reports." Retrieved from: https://ottawa.ca/en/garbage-and-recycling/solid-waste-data-and-reports.
[185] WWO. (2017). "Improving the City of Ottawa's Waste Diversion Performance: Recommendations for Action". Retrieved from https://wastewatchottawa.ca/2017/09/15/waste-watch-ottawa-analysis-finds-citys-lack-of-planning-and-public-education-is-squandering-landfill-capacity/
[186] City of Ottawa. (2018). "Report to the Environment and Climate Protection Committee, Source Separated Organics Program." Retrieved from WWO.
[187] City of Ottawa. (2018). "Report to the Environment and Climate Protection Committee, Source Separated Organics Program." Retrieved from WWO.

program will be met with these changes.[188] Indeed, a 2018 City of Ottawa Report to the Environment and Climate Protection Committee stated that "the addition of plastic bags and dog waste, the renegotiated contract will, if approved, change the finished material from AA (unrestricted use) compost to beneficial use products, such as compost and non-agricultural source material." To address these concerns, WWO presented their 6-point waste management and diversion strategy to the City of Ottawa in 2018 and recommended that plastic bags and dog waste not be allowed.[189]

Data showing how the decision to allow plastic bags and dog waste in the Green Bin has impacted organic waste diversion rates and compost quality in Ottawa will not be available until April 2020, but as mentioned, Renewi already reports that the compost quality is now NASM. In the winter, organic waste diversion includes little yard waste. Therefore, at the end of the first winter since their implementation, it will become clear whether or not the new rules have increased green bin usage in Ottawa, without the influence of yard waste, and better analysis of the change in compost quality will become possible.

Ottawa's City Council is currently working on releasing its next Solid Waste Master Plan. This will be a "30-year plan to set a strategic direction for how waste is managed in Ottawa" which will "consider current regional, national and global waste contexts – such as the move toward individual producer responsibility and single-use plastics." The new *Solid Waste Master Plan* "will consider GHG impacts, and opportunities will be explored to minimize Solid Waste's carbon footprint."[190]

3.3 Updated Waste Diversion Rates and Statistics

While the Ottawa single-family residential diversion rate reached 44%,[191] solid waste sent to the Trail Road Waste Facility in 2018 would have been just above 350 Kg per capita (making Ottawa neither the best nor the worst waste producer of the researched municipalities).[192] This weight consists of primarily residential as well as small quantities of IC&I waste. In 2014 and 2015, the city conducted studies on the composition of waste sent to landfill. The results showed that over a third of the waste sent to landfill consisted of organic material that could be composted and that under half of the waste was garbage that might not be diverted under the municipality's current diversion programs.[193] Although the residential diversion rate was found to be improving, the City still has significant room for improvements. Without more recent landfill waste composition data, a similar result would be expected.[194]

Looking at these weights and diversion rates of up to 50% for single-family homes,[195] it seems odd that we still send such a great amount of organic waste to the landfill. Understanding the

[188] WWO. 2019. "WWO Capstone Organics Project Description." Retrieved from WWO.
[189] WWO. (2018). "Waste Watch Ottawa Releases a Waste Management Action Plan for the New Ottawa Council." Retrieved from https://wastewatchottawa901191586.files.wordpress.com/2018/08/wwo-aug-29-waste-mgmt-news-release.pdf
[190] CITY OF OTTAWA KEY CLIMATE CHANGE INITIATIVES Originally released on April 23, 2019; Last updated on December 2, 2019, 7, Retrieved from WWO.
[191] Public Works and Environmental Services Dept. "Solid Waste – Data and Reports." City of Ottawa, September 9, 2019. https://ottawa.ca/en/garbage-and-recycling/solid-waste-data-and-reports.
[192] See figure 17.
[193] Public Works and Environmental Services Dept. "Solid Waste – Data and Reports." City of Ottawa, September 9, 2019. https://ottawa.ca/en/garbage-and-recycling/solid-waste-data-and-reports.
[194] See Figure 2
[195] See Figure 3

difference between collection at single and multi-family residential buildings, where waste diversion only reaches a rate of 17%,[196] allows us to understand the high percentage of organic matter still arriving at Trail Road. Unfortunately, nearing the capacity of our aerobic processing facility with less than a 50 percent total diversion rate (see **Figure 2**), it seems Ottawa has to draft new plans in order to respond to the need to divert and process well over 100,000 tonnes of organic waste per year. Organic waste diverted to the Orgaworld/Renewi facility in 2017 was just under 80,000 tonnes while the tonnage of NASM produced at the facility was around or just above half of that number (weight loss likely attributed to moisture content and screening of contaminants).[197] If Ottawa reaches its original target of 70% diversion for green bin organics, it will certainly need to find a means of increasing the facility's capacity or of finding a new solution. This capacity increase is necessary to begin diverting more organics from the landfill to increase its life expectancy in the order of 20 years, at the current population level.[198]

3.4 - Quantitative Assessment

The City of Ottawa has had success in mitigating growth in residential waste, despite the city's growth in population. It appears clear, however, that efforts to increase waste reduction and diversion have mostly stagnated over the studied period. Organics diversion too has remained relatively stable around 25% of total residential waste. As noted in section 3.2, Ottawa did not accept dog waste or plastics from 2014-2018. Given this, Ottawa's organics diversion rate is in line with those of the other municipalities that do not accept plastics and dog waste - Halifax and Vancouver. To understand the reasoning and other measures used in Halifax and Vancouver, see Part 4.

Based on the information analyzed, Ottawa has the most room to improve through increasing the participation of its multi-family residences (see Appendix 4: Figure 21). It is understood that there is no provincial legislation requiring organics diversion for private businesses in Ontario, although the province is aiming for 50% of organics to be diverted from multi-residential buildings by 2025;[199] however, the city should consider taking steps that will immediately encourage participation, nonetheless. This could be addressed by, banning organics from landfills, and mandating green bin organics collection in multi-residential buildings once clear and practical solutions are provided to multi-residential property owners on how to manage organic waste.

[196] Ibid.
[197] Newman, Larry. "How Orgaworld Composts Our Plastics." IMAGE. Sandy Hill Community News, September 23, 2018. http://home.imagesandyhill.org/2018/09/how-orgaworld-composts-our-plastics/.
[198] WWO. (2017). "Improving the City of Ottawa's Waste Diversion Performance: Recommendations for Action". Retrieved from https://wastewatchottawa.ca/2017/09/15/waste-watch-ottawa-analysis-finds-citys-lack-of-planning-and-public-education-is-squandering-landfill-capacity/
[199] "Food and Organic Waste Policy Statement | Ontario.Ca." n.d. Accessed March 16, 2020. https://www.ontario.ca/page/food-and-organic-waste-policy-statement.

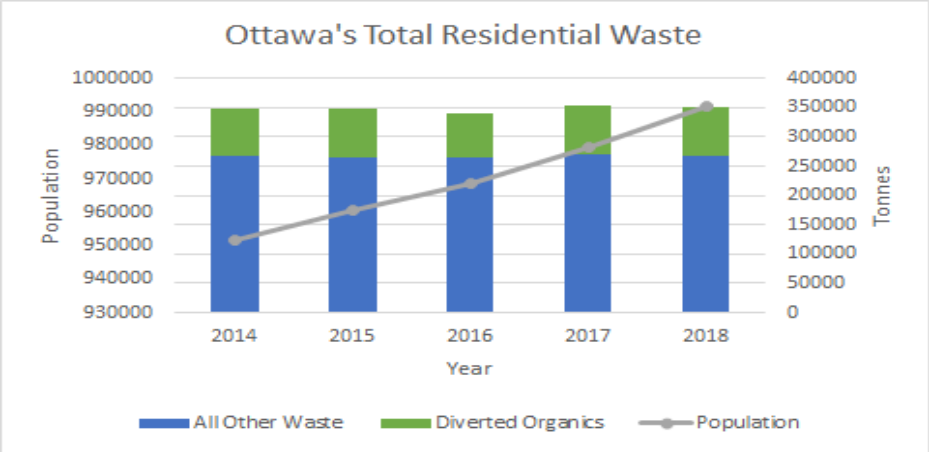


Figure 1: (Ottawa) Population growth and residential waste collection. Waste collection includes multi-residential and single-residential amounts. 'All Other Waste' is all non-organic waste including diverted recycling. This highlights the changes in organic diversion over total waste. Note that the population scale differs significantly from waste tonnages, producing the appearance of large population growth over the study period. In this graph, the population grew 3.6% over the studied period, while total waste remained relatively constant. Data sourced from: https://rpra.ca/programs/about-the-datacall/

The following chart illustrates the necessary capacity for Ottawa to capture up to 100% of organic waste from household collection, up to the year 2030. Using a linear population growth prediction for Ottawa (see Appendix 4: Figure 20), the chart captures increases in household organic waste. Linear population extrapolation fits well, given the short prediction period, being only slightly more conservative than an exponential extrapolation. The 'Predicted Organics Collected' assumed that organic waste remains at the 2018 rate of 24% going forward (see Appendix 4: Figure 22**)** and a per capita waste generation of 355Kg/cap. - consistent with the 2018 rate. [200] The 'Organics to Landfill' illustrates the amount of organic waste going to landfills, at a rate of 48% of garbage sent to landfills.[201] Actual waste tonnage was drawn from Resource Productivity and Recovery Authority (RPRA) figures.

As the chart shows, should Ottawa converge on near-100% diversion of household organic waste, the city will require the capacity to compost approximately 250,000 tonnes, by 2030. Even a relatively small increase above the current rates of collection and the diversion rate of 24% means that there is not enough capacity at the current Renewi facility.

[200] "RPRA - The Resource Productivity and Recovery Authority." n.d. Accessed March 19, 2020. https://rpra.ca.
[201] City of Ottawa. n.d. "Solid Waste Master Plan | Engage Ottawa: Current Waste Management System." Accessed March 19, 2020. https://engage.ottawa.ca/solid-waste-master-plan.

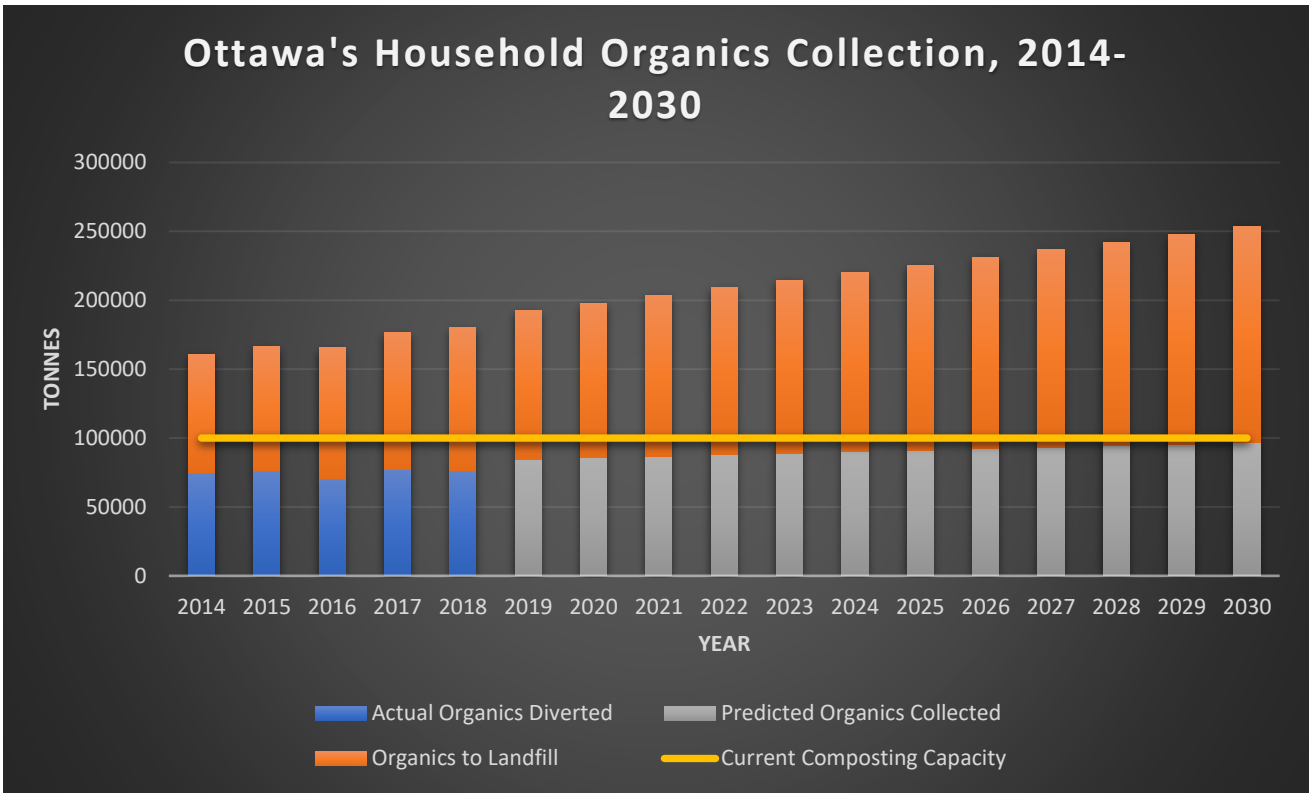


Figure 2: Graph representing Ottawa's future household organics composting needs. Data acquired from StatsCan (see Appendix 4: Figure 21), RPRA, and Ottawa's Solid Waste Master Plan.

Part 4: Best Practices for Organic Waste Diversion in Canadian Municipalities

Table 2: Overview of three main policies in the six municipalities that were studied

	Are plastics Accepted?	Are dog feces Accepted?	Compost Quality
Ottawa	Yes	Yes	NASM(B)/Potting soil
Guelph	Only compostable ones	Yes	AA
Waterloo	Only compostable ones	Yes	AA (Handled by Guelph)
Toronto	Yes	Yes	A or AA
Vancouver	No	No	Varied
Halifax	No	No	A

N.B. We were not able to obtain a specific answer for Vancouver's compost quality given the many jurisdictions that are included in Metro-Vancouver.

4.1 - Guelph

The City of Guelph, Ontario, boasts the oldest residential organics waste management system in the province, which has been operating since the late 1990s. It was established to divert waste from the landfill because the City of Guelph does not own its landfill and the residents wanted to take responsibility for their own waste.[202] Since 2008, a zero-waste philosophy has guided the City of Guelph's approach to waste diversion.[203]

Guelph's current Solid Waste Management Master Plan (SWMMP) is a "25-year strategy approved by Council in 2008" that sets "a path to achieve new waste minimization, diversion and disposal targets, and identif[ies] short and long term programs designed to achieve the targets."[204] Following these objectives, in 2012 the City of Guelph achieved the highest percentage of residential organic waste diversion in Ontario at 32%.[205] In 2014, a review of the SWMMP was undertaken and "community engagement was an important and integral part of the review process"[206] including "feedback from over 680 residents and stakeholders" that "was obtained through various engagement opportunities, including open houses, focus groups, and surveys."[207]

Starting in 2019, Guelph began expanding its residential organic waste management program to include multi-residential buildings. This program uses front-end loading garbage trucks and helps the City "serve a greater proportion of the existing multi-residential community, provide waste services for new multi-residential properties that were inaccessible by automated [side-loading]

[202] Personal Communication
[203] City of Guelph. (2014). "Solid Waste Management Master Plan Review Final Report". Retrieved from: https://guelph.ca/wp-content/uploads/2014SWMMPFinalReport.pdf
[204] Ibid.
[205] Ibid.
[206] Ibid.
[207] Ibid.

trucks, capture more recyclables and organics, reduce the amount of waste going to landfills, and educate the multi-residential community about correct waste sorting".[208]

Materials that are accepted in Guelph's green cart include food items, tea bags, coffee (grounds and filters), paper towels and tissues, household plants, and pet waste.[209] No plastic bags are accepted in Guelph's green cart program. As stated on the City's website, Guelph has provided carts to its residents for disposal of their organic waste because "using carts [instead of disposable bags] reduces the amount of waste [that Guelph] send[s] to landfill, lowers the City's operating costs and decreases Guelph's carbon footprint."[210] Still, residents can use paper bags, certified compostable bags, or nothing to line their cart.[211] Other "acceptable liners include shredded paper, newspaper, flour/sugar/fast food bags, [and] a cereal box."[212]

The facility that processes Guelph's residential organic waste is operated by AIM Environmental Group but owned by the City of Guelph. Interestingly, Guelph receives compensation from the Region of Waterloo (RoW) because Waterloo uses Guelph's facility. This reduces costs to taxpayers in Guelph.[213] Using an aerobic tunnel process, the City produces AA quality compost that goes to farmers in the region.[214] The rationale for including dog waste and compostable plastic bags but not regular plastic bags in Guelph's green cart is unclear, but given the quality of the compost that Guelph produces, it is inferred that the City does not have a significant contamination problem.

4.1.1 – Quantitative Assessment

As shown in **Figure 3**, residential waste has increased slightly in Guelph, over the studied period. Given there was not a major shift in population, although there have been new housing and apartment building developments, it is challenging to make inferences from the graphs alone. Residential organics diversion was consistent with Toronto and the Region of Waterloo, at 32%.

[208] City of Guelph. "Multi-Residential Waste Collection." City of Guelph, September 26, 2019. https://guelph.ca/living/garbage-and-recycling/curbside-collection/multi-residential/.
[209] City of Guelph. "Cart Program." City of Guelph, August 13, 2018. https://guelph.ca/living/garbage-and-recycling/curbside-collection/cart-program/.
[210] Ibid.
[211] Personal Communication
[212] City of Guelph. "Cart Program." City of Guelph, August 13, 2018. https://guelph.ca/living/garbage-and-recycling/curbside-collection/cart-program/.
[213] City of Guelph. "Organic Waste Processing Facility." City of Guelph, January 15, 2019. https://guelph.ca/living/garbage-and-recycling/waste-resource-innovation-centre/owpf/.
[214] Personal Communication

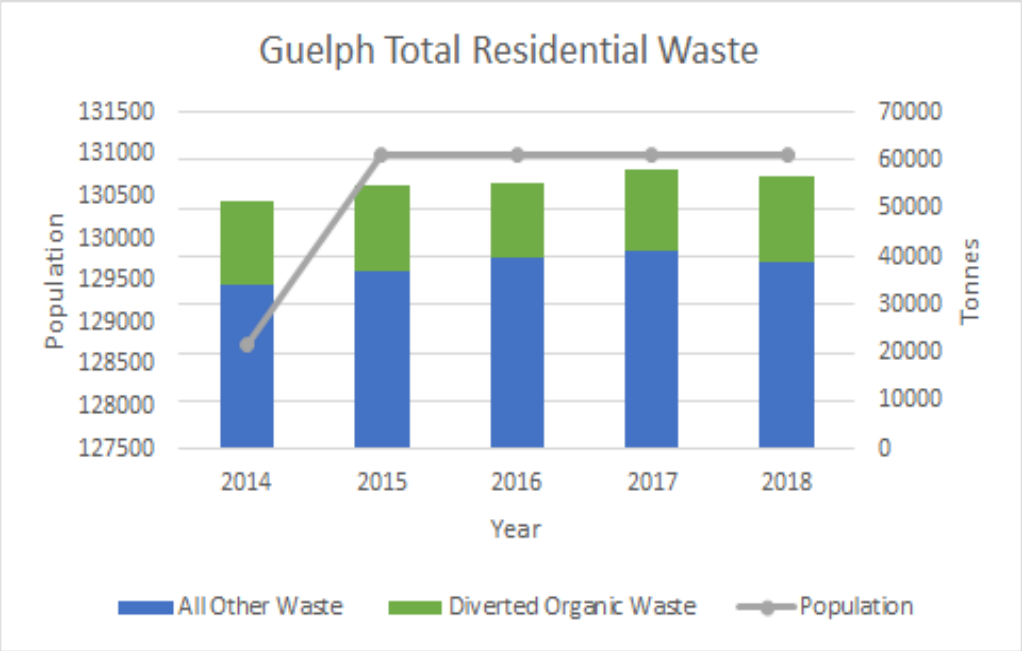


Figure 3: (Guelph) Population growth and residential waste collection. Waste collection includes multi-residential and single-residential amounts. 'All Other Waste' is all non-organic waste including diverted recycling. This highlights the changes in organic diversion over total waste. Note that the population scale differs significantly from waste tonnages, producing the appearance of large population growth over the study period. Data sourced from: https://rpra.ca/programs/about-the-datacall/

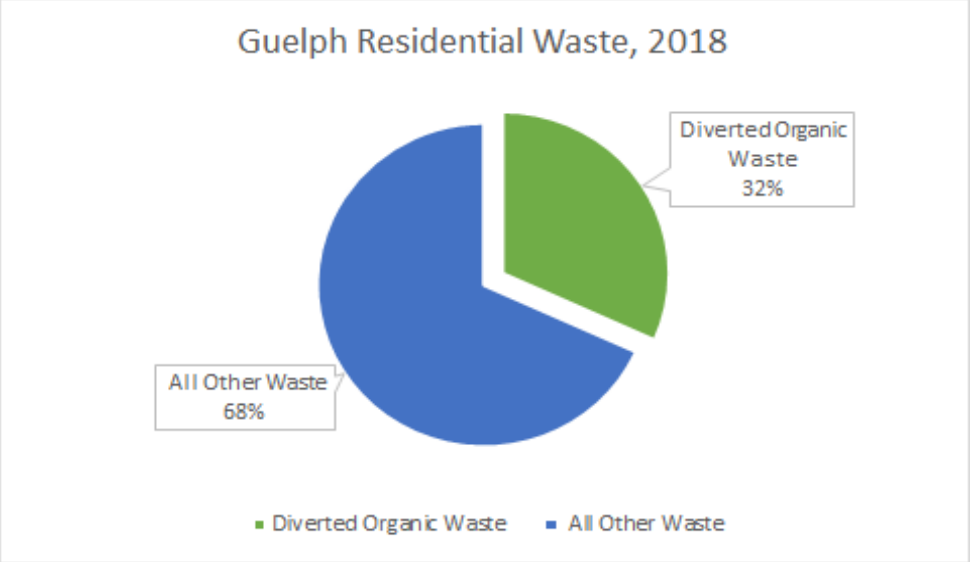


Figure 4: (Guelph) Residential organics diversion as a percentage of total residential waste collected in 2018.

4.2 – Region of Waterloo

Inspired by Guelph`s early erection of a municipal composting facility, the Region decided to rely on Guelph's processing facility for the composting of food waste. Waterloo Region took charge of collection, as well as some LYW processing, along with recycling programs, transfer facilities, and its one landfill. The Waterloo Waste Management Centre at 925 Erb Street West is Waterloo`s only landfill, replacing 5 landfills now closed which served the region in the past. Another Waste

Management site, sitting atop a closed [215] at 201 Savage Dr. in Cambridge serves the region offering services such as processing and transfer of LYW.[OBJ] The Waterloo Waste Management Master Plan (WWMMP) notes that the Region and partnered municipalities provide a variety of services to "the cities of Cambridge, Kitchener, and Waterloo, as well as the townships of North Dumfries, Wellesley, Wilmot, and Woolwich […] roughly 1,300 square with a population of about 590,000 people."[216]

The goal of the WWMMP is to increase diversion, focusing on observing development in EfW technologies while odour abatement and gas collection at the landfill remained the highest priority and landfill cell expansion was pursued.[217] After the 2017 and 2018 changes to Waterloo's waste collection, reducing the frequency of garbage pick-ups to every second week while collecting organics weekly, the Region saw a 4,000-tonne increase in collected organic waste with the annual total reaching nearly 25,000 tonnes.[218] The same year, a residential diversion rate of 65% was achieved by the Region.[219] All of this effort to divert waste outlined in the WWMMP would likely be nowhere near as efficient as it is currently were it not for the Region`s public engagement and education campaigns. "In 2018, a total of $71.2 million was spent on program and service delivery by the Region's Waste Management Division […] Waterloo's biggest expense was the curbside collection, which accounted for 28% of our total costs."[220] Although the Region sets no specific funding aside for the Green Bin program and the focus has been on the promotion of the Blue Box,[221] an App developed by the Region promotes proper sorting of waste, an on-site education program at the Erb Street site, and a 24/7 call center offers the public the information needed to positively impact diversion rates.[222]

In 2015, Waterloo wrote that the landfill would reach capacity at "15 million cubic meters of waste" in 2030 or later.[223] Yet, in 2018 a landfill cell expansion (SE-4B) and the improvement of landfill gas collection system in the south-east cells` allowed Toromont Energy, operator of the landfill gas to an energy power plant, to begin running a 5th generator and extended the lifespan of the landfill to an estimated 20-year capacity.[224] In an earlier and ongoing attempt to extend the lifespan of the landfill, a contract was drawn with AIM Environmental Group who manages the Guelph organic waste facility. According to the Guelph website, "The Region will pay AIM to process its organics and the City of Guelph receives compensation from AIM for the use of its facility by the Region of Waterloo, reducing costs to Guelph taxpayers."[225] Thus, the Region contracts Miller Waste,[226] as do some other municipalities and regions in Ontario, as well as

[215] "Landfill and Recycling Centre," Region of Waterloo, accessed March 16, 2020, https://www.regionofwaterloo.ca/en/living-here/landfill-and-recycling-centre.aspx
[216] Region of Waterloo (2013), "Region of Waterloo Waste Management Master Plan: Final Master Plan Report," WWMMP, 1.
[217] Idem., 5
[218] Region of Waterloo, "Waste Management Annual Report 2018," 4. Accessed March 16, 2020. https://www.regionofwaterloo.ca/en/living-here/resources/Documents/Waste/DOCS_ADMIN-3122859-v1-2018_Waste_Management_Annual_Report_Accessible_version-2.pdf
[219] ibid.
[220] Region of Waterloo (2013), "Region of Waterloo Waste Management Master Plan: Final Master Plan Report," 7.
[221] Personal Communication
[222] Region of Waterloo, "Education and Events." Accessed March 12, 2020. https://www.regionofwaterloo.ca/en/living-here/environmental-education-and-resources.aspx
[223] (Waterloo, Environmental controls and programs, 1)
[224] "Landfill and Recycling Centre," Region of Waterloo, accessed March 16, 2020, https://www.regionofwaterloo.ca/en/living-here/landfill-and-recycling-centre.aspx
[225] City of Guelph. "Organic Waste Processing Facility." City of Guelph, January 15, 2019. https://guelph.ca/living/garbage-and-recycling/waste-resource-innovation-centre/owpf/
[226] "Southwestern Ontario." Miller Waste. Accessed March 26, 2020. https://millerwaste.ca/services/waste-services/municipal-collection/sw-ontario/

outside the province, to collect its residents' organic waste, along with garbage disposal and recycling.

As the Green Bin waste is collected by the Region and transferred to the facility in Guelph, please refer to section 4.1 which expands on Guelph's policies, procedures and technologies applied to produce its high-quality compost and for information concerning the end market uses.

4.2.1 – Quantitative Assessment

With the population growing 5% over five years, the Region of Waterloo managed to keep residential waste collection amounts stable. It should be noted that this assessment is a review of figures for the region, Kitchener, Waterloo, Cambridge, and some outlying rural communities inclusive. The Waterloo region also increased the diversion rate of its organics by 2% between 2014-2018, bringing its organics diversion on-par with Toronto and Guelph.

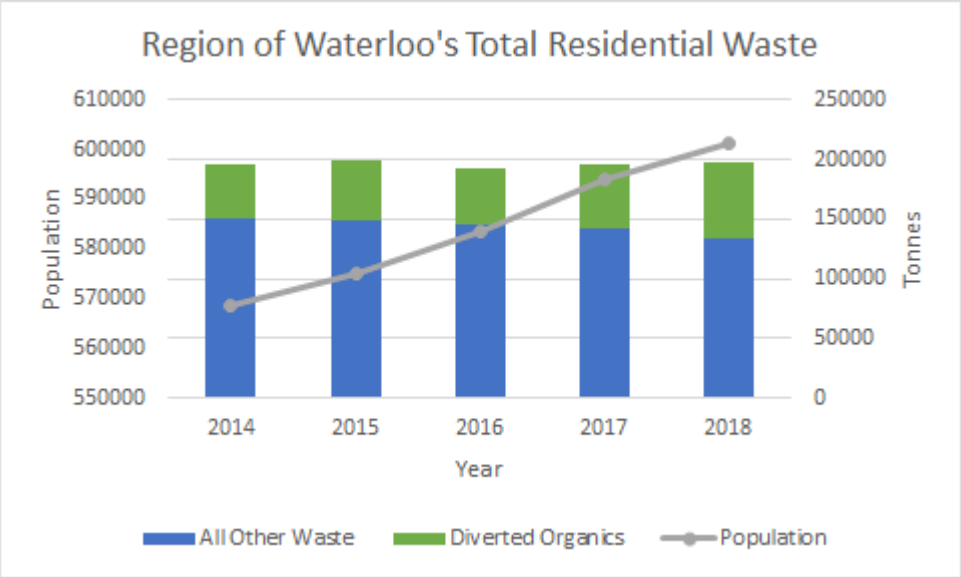


Figure 5: (Waterloo) Population growth and residential waste collection. Waste collection includes multi-residential and single-residential amounts. 'All Other Waste' is all non-organic waste including diverted recycling. This highlights the changes in organic diversion over total waste. Note that the population scale differs significantly from waste tonnages, producing the appearance of large population growth over the study period. Data taken from RPRA: https://rpra.ca/programs/about-the-datacall/

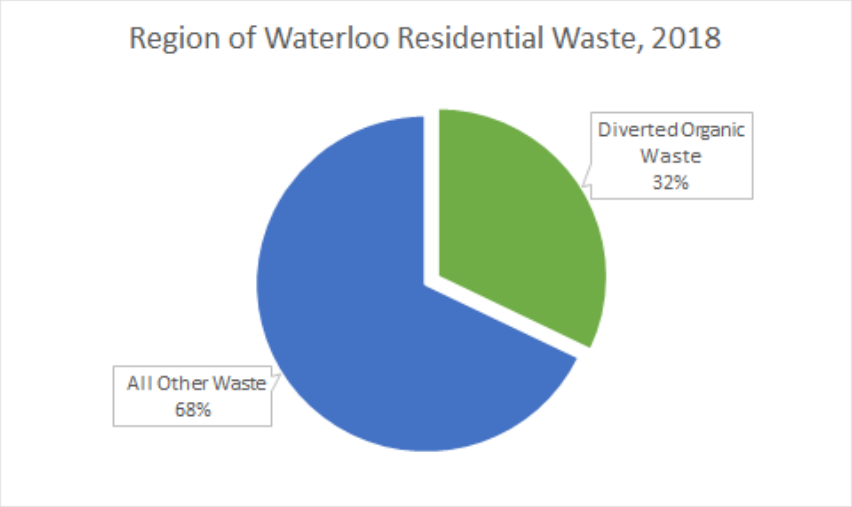


Figure 6: (Waterloo) Residential organics diversion as a percentage of total residential waste collected in 2018.

4.3 – Toronto

The City of Toronto has a growing population and limited landfill space, and as such having a good waste management plan focused on increasing organics diversion will help the city meet targeted diversion rates. Almost 40% of the half a million tonnes of residential garbage sent to landfills by the city every year is organic material that could be composted in the Green Bin.[227] The main landfill for the City of Toronto is the Green Lane site in south-western Ontario and the lifespan of this landfill is dependent on the waste diversion rate. In 2002, the City of Toronto rolled out its Green Bin program for residential homes, this was the first Green Bin program in a large metropolitan city in North America.[228]

The primary driver for the Green Bin program was the closing of the City's Keele Valley landfill which left the City scrambling to find a replacement landfill and signaled that the City needed to aggressively reduce the amount of waste produced.[229] When planning the Green Bin program, the City considered the "yuck factor" associated with organics and worked to design a program that would encourage participation and increase waste diversion. [230] This led to the decision to allow residents to put organics in plastic bags and accept items beyond just food waste and napkins. The Green Bin program also accepts animal waste, cat litter, house plants, diapers, and sanitary products.[231] The City has allowed pet waste and organics in plastic bags since the inception of Toronto's Green Bin program. In 2011, according to a survey taken by Statistics Canada, 76% of households in Toronto composted and 89% of leaf and yard waste was composted.[232] The Green bin program for all single-family residences has a high participation rate and bins for organics

[227] Toronto Environmental Alliance. TEA Organics Report, 2016. https://d3n8a8pro7vhmx.cloudfront.net/toenviro/pages/1775/attachments/original/1465851365/Organics_First_-_TEA_Report_-_June_2016.pdf?14658513659

[228] Cushman, J. (2016). Looking Back at the City's Green Bin Program. Retrieved March 29, 2020, from https://www.torontoenvironment.org/looking_back_green_bin_program

[229] Doyle, Angela. City of Toronto, Solid Waste Management Service. 2020.

[230] ibid.

[231] Doyle, Angela. City of Toronto, Solid Waste Management Service. 2020.

[232] Mustapha, I. (2013). Composting by households in Canada. Statistics Canada. Retrieved from https://www150.statcan.gc.ca/n1/pub/16-002-x/2013001/article/11848-eng.pdf

collection are provided to homes and high-rise buildings at no cost, along with in-unit kitchen catchers to encourage participation.[233]

The City of Toronto collects organic wastes in the Green Bin from all houses and most multi-residential buildings as well as city buildings, schools, and small businesses on major streets. [234] However, a substantial portion of high-rise apartments and private businesses in Toronto pay for waste collection from private waste companies that are not required to have Green Bins and so much of the organic waste from these buildings ends up in the landfill.[235]

Organics are collected curbside and sent to one of two organics processing facilities, Disco or Dufferin which are City-owned anaerobic digesters located in Toronto. The City uses anaerobic digestion to process organics because it allows them to produce high-quality compost, reduce emissions by capturing biogas from organics waste processing, and minimize odours so organics can be processed within the city limits.[236] The Dufferin facility opened as a prototype to demonstrate organics processing would work when the City rolled out its residential Green Bin organics program.[237]

Later in 2014, a second digester, the Disco Road Organics Processing Facility that can process 83,000 tonnes per year went into operation. [238] Currently, the Disco Road facility processes 75,000 tonnes of organics per year and the Dufferin Organics Processing Facility is just finishing an expansion that will increase its processing capacity from 25,000 to 55,000 tonnes of organic material per year.[239] During the opening of the Disco Road facility, the Dufferin facility was shut down to add Anaergia's BIOREX pre-treatment equipment, which features an extrusion system for the pre-processing phase to filter non-organics and shred bags.[240] Organic waste gets pre-processed to remove plastic bags and contaminant materials, during this phase anything that behaves like plastic, even bio-based plastics including compostable plastic bags and cutlery, is removed and sent to landfills.[241] At the Disco road facility, organics waste is processed in a hydro-pulper to remove non-organic materials. It is then sent to anaerobic digesters where bacteria break down the organics to produce biogas and digester solids.[242]

The digester solids from the anaerobic process are then sent to contractors who turn it into high-quality compost for parks and gardens.[243] The city receives some of this compost back to give out for free to the public on Community Environment Days.[244] Digester Solids from the Disco and Dufferin facilities are turned into high-quality compost meeting Category A and AA standards.[245] Anaerobic digestion also produces biogas which gets turned into renewable natural gas. In 2019,

[233] Gorrie, P. (2015). Toronto Expands Anaerobic Digestion Of Source Separated Organics - ProQuest. *Biocycle*, *56*(2), 40–43.
[234] Toronto Environmental Alliance. TEA Organics Report, 2016.
[235] ibid.
[236] Doyle, Angela. City of Toronto, Solid Waste Management Service. 2020.
[237] Gorrie, P. (2016). Toronto Moves Ahead With AD Plant Upgrade. *Biocycle*, *57*(6), 33–34.
[238] ibid.
[239] Doyle, Angela. City of Toronto, Solid Waste Management Service. 2020.
[240] ibid.
[241] City of Toronto. (2020). What Goes in the Green Bin? . Retrieved March 29, 2020, from https://www.toronto.ca/services-payments/recycling-organics-garbage/houses/what-goes-in-my-green-bin/
[242] City of Toronto. (2020). What Happens to Organics? .Retrieved March 29, 2020, from https://www.toronto.ca/services-payments/recycling-organics-garbage/houses/what-happens-to-organics/
[243] City of Toronto. (n.d.). What Happens to Organics? . Retrieved March 29, 2020, from https://www.toronto.ca/services-payments/recycling-organics-garbage/houses/what-happens-to-organics/
[244] ibid.
[245] Doyle, Angela. City of Toronto, Solid Waste Management Service. 2020.

the City partnered with Enbridge Gas Distribution to outfit the Dufferin Facility with equipment to turn biogas into renewable natural gas that can be used to fuel the City's garbage trucks.[246] This is a closed-loop approach that allows the City to harness the green energy potential of this waste by-product and reduce its carbon footprint.[247] "Toronto's green bin processing facilities are a source of green energy: biogas created during the process can be converted into renewable natural gas - a fuel with 93% less greenhouse gas emissions than diesel".[248] The Green Bin Program contributes to the diversion rate by collecting approximately 34% of the total tonnes of material diverted from landfills.[249]

The City of Toronto's Long-Term Waste Management Strategy is currently a major influence on the Green Bin Program. The City's Long-Term Waste Management Strategy sets a goal of diverting 70 percent of the waste generated in Toronto away from landfill by 2026 and prioritizes waste reduction. [250] As part of the long-term waste strategy, the City is moving towards a circular economy and zero-waste future.[251] Toronto has the tools in place to get to zero waste and meet diversion targets as per its long-term waste management strategy by giving extra food to local food programs, by diverting organics to compost facilities or through the creation of renewable natural gas.

To reduce food waste, the City of Toronto, in partnership with the National Zero Waste Council, other cities, and retailers, is working to reduce food waste through the campaign "Love Food Hate Waste," focusing on information and outreach programs to educate residents.[252]Another innovative strategy employed by the City is to give out Waste Reduction Community Grants of up to $25,000 to support innovative community-based efforts to reduce waste and increase diversion.[253] The City is actively working towards achieving the diversion target by reviewing current processes and infrastructure to increases efficiencies and by research innovative technologies and programs from around the world.[254]

4.3.1 – Quantitative Assessment

The City of Toronto has the highest diversion rates across our study group of municipalities; however, this may be attributed to the City's single-stream pickup for recyclables, which comes with a cost of increased contamination. Mixed recyclables require increased processing costs, and send more recyclables to landfills, due to contamination.[255]. For organics processing in Toronto, it differs from other cities' (see **Appendix 3**), which allows Toronto to divert more types of organic

[246] City of Toronto. (2020b). What Goes in the Green Bin? . Retrieved March 29, 2020, from https://www.toronto.ca/services-payments/recycling-organics-garbage/houses/what-goes-in-my-green-bin/
[247] Doyle, Angela. City of Toronto, Solid Waste Management Service. 2020.
[248] Toronto Environmental Alliance. TEA Organics Report, 2016. https://d3n8a8pro7vhmx.cloudfront.net/toenviro/pages/1775/attachments/original/1465851365/Organics_First_-_TEA_Report_-_June_2016.pdf?14658513659
[249] Doyle, Angela. City of Toronto, Solid Waste Management Service. 2020.
[250] City of Toronto. (2020a). Waste Strategy Programs & Initiatives. Retrieved March 29, 2020, from https://www.toronto.ca/services-payments/recycling-organics-garbage/long-term-waste-strategy/why-do-we-need-a-waste-strategy/
[251] Doyle, Angela. City of Toronto, Solid Waste Management Service. 2020.
[252] City of Toronto. (2020a). Waste Strategy Programs & Initiatives. Retrieved March 29, 2020, from https://www.toronto.ca/services-payments/recycling-organics-garbage/long-term-waste-strategy/why-do-we-need-a-waste-strategy/
[253] ibid.
[254] Doyle, Angela. City of Toronto, Solid Waste Management Service. 2020.
[255] "Why Is Single Stream Recycling Such a Problem for Toronto – Here's Our Take." n.d. Accessed April 10, 2020. https://www.garbagebinrentals.ca/waste-collection-removal-disposal-blog/682-why-is-single-stream-recycling-such-a-problem-for-toronto-here-s-our-take.html.

and inorganic materials, including items such as diapers. See the comparisons section for details on the ways other municipalities waste management processes compare.

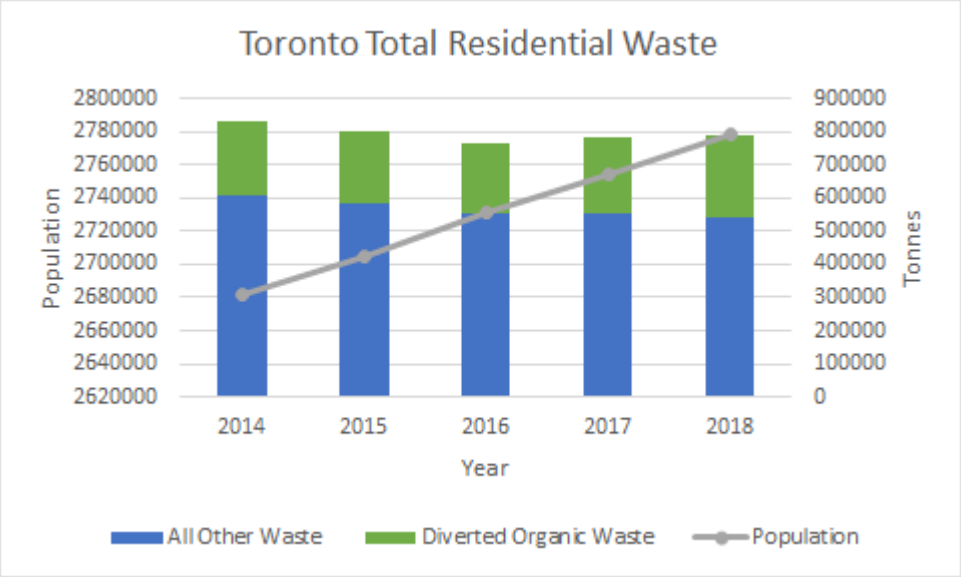


Figure 7: (Toronto) Population growth and residential waste collection. Waste collection includes multi-residential and single-residential amounts. 'All Other Waste' is all non-organic waste including diverted recycling. This highlights the changes in organic diversion over total waste. Note that the population scale differs significantly from waste tonnages, producing the appearance of large population growth over the study period. Data from RPRA: https://rpra.ca/programs/about-the-datacall/

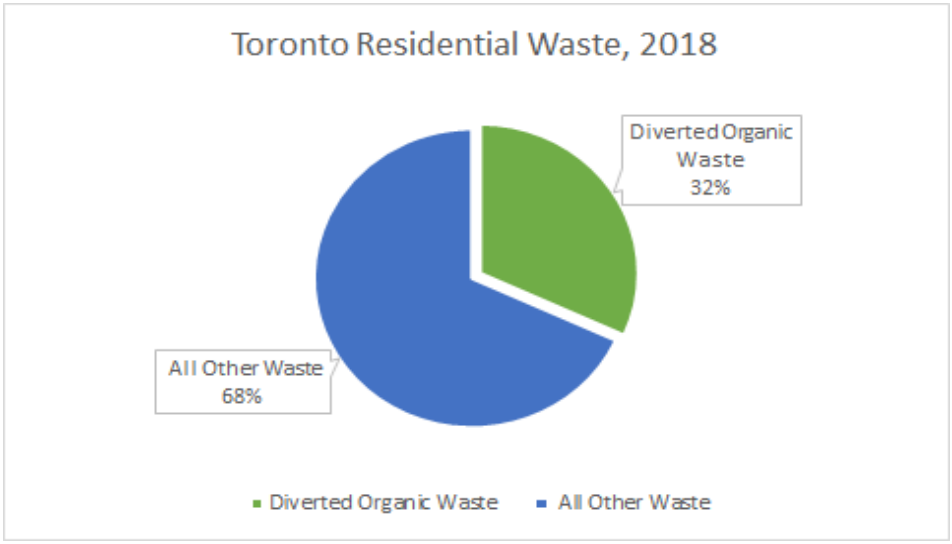


Figure 8: (Toronto) Illustrates residential organics diversion as a percentage of total residential waste collected in 2018.

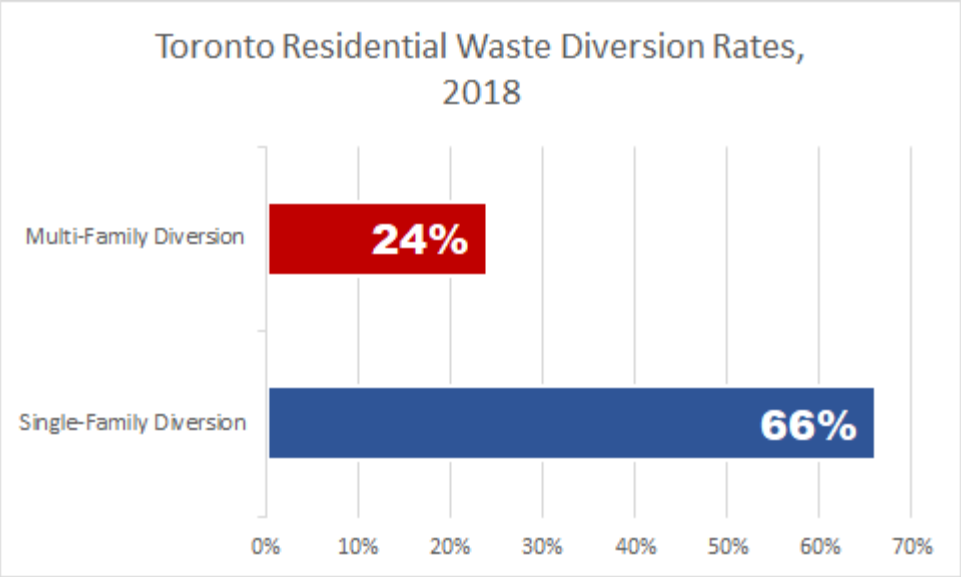


Figure 9: (Toronto) Single- v Multi-residential diversion rates in 2018. Data from: https://www.toronto.ca/services-payments/recycling-organics-garbage/solid-waste-reports/

4.4 - Vancouver

West Vancouver is a member municipality of Metro Vancouver that acknowledges composting "takes waste out of our landfills, reduces [West Vancouver's] methane contributions, and creates compost and bioenergy."[256] "Organics, which includes food scraps and yard trimmings, are banned from being disposed of as garbage and should be placed in [the] Green Can, yard trimmings container or backyard compost.[257] All municipalities in Metro Vancouver take the same approach.[258]

West Vancouver's current residential organics waste management program is based on a similar approach by the Regional District of Nanaimo and a pilot project that ran in West Vancouver between 2009 and 2010. Some challenges to managing this program that the District faces are: Economic barriers to purchasing the space necessary to process organic waste, unwelcome odor and leachate issues, and the presence of wildlife that are attracted to food scraps, including bears. As a result, West Vancouver and Metro Vancouver collaborate to fund and manage West Vancouver's residential organic waste management program as part of North Shore Transfer Station operations.[259]

Sea to Sky Soils is one of the companies that currently processes West Vancouver's organic materials,[260] but they only accept yard waste, wood, and manure. [261] Sea to Sky Soils directs people

[256] Metro Vancouver. "About Food Scraps Recycling." Metro Vancouver, 2019. http://www.metrovancouver.org/services/solid-waste/recycling-programs/food-scraps-recycling/about/Pages/default.aspx.
[257] West Vancouver. "Green Can, Yard Trimmings & Compost: District of West Vancouver." District of West Vancouver. Accessed March 16, 2020. https://westvancouver.ca/home-building-property/green-can-yard-trimmings-and-compost.
[258] Metro Vancouver. "About Food Scraps Recycling." Metro Vancouver, 2019. http://www.metrovancouver.org/services/solid-waste/recycling-programs/food-scraps-recycling/about/Pages/default.aspx.
[259] Personal Communication - Emily Willobee MPP Policy & Programs Planner | Engineering Services | District of West Vancouver
[260] Ibid.
[261] "Organics Disposal." *Sea to Sky Soils*, n.d. www.seatoskysoils.com/projects.

to the Pemberton Transfer Station and the Whistler Transfer Stations for food waste processing.[262] Sea to Sky Soils "uses traditional aerobic compost processing methods with Gore cover technology" - semi-permeable membranes that create the necessary conditions for aerobic composting to take place while trapping odors and other emissions at a lower cost than other composting systems.[263] They are "located in an agricultural area", so they "sell some finished product locally in Pemberton and up/down the Sea to Sky corridor".[264]

Instead of combining food scraps with other residential organic materials such as yard waste, West Vancouver asks residents to use a smaller, dedicated 46L green can for their food scraps. Three main reasons lead to this decision:

1) "The dedicated green bin can be found to be an effective tool at encouraging participation in the green can program during [West Vancouver's] year pilot phase in 2009-2010. Pilot participants who were given a 46L cart were more likely to separate their food scraps. It helped to reduce the "ick" factor and to manage concerns about wildlife attractants. Pilot participants who were NOT given a small bin for their food scraps often came up with their small bin solution (e.g. large cat litter boxes or other containers as totes)."[265]

2) "West Vancouver is bear country and food scraps are a well-known wildlife attractant. The small dedicated green can enable residents to more easily store food waste in a shed or garage, away from bears and in compliance with the local bylaw. There are also wildlife by-law enforcement benefits related to having dedicated food scraps can instead of a co-mingled option. It's easy to spot an unsecured green can and follow up with education about how to properly store garbage and food waste until the morning of collection day."[266]

3) "The use of a dedicated green can encourage early adoption of organics separation. The smaller cart provides a prompt that the new service was available when the program launched in 2012 and made it obvious who on each block was committed to reducing their waste by participating in the program. Thanks to high rates of resident participation in [their] green can program, West Vancouver was able to reduce garbage collection frequency to every second week just one year after launching. This transition happened more quickly for [them] than it did for many of our neighboring municipalities."[267]

West Vancouver does not accept plastics or dog waste in its residential green can program. These materials, including "biodegradable" and "compostable" plastics, are considered contamination that negatively impacts finished compost products. Instead, plastics and dog waste can be put in the garbage, though they do offer specialized dog waste collection in certain areas such as dog parks with the red bin program. To use that service, visitors can place their dog waste in any type of bag and put it in the dedicated bin. Then, the waste is separated from the bag and is processed through regional wastewater treatment processes, while the bag goes to the incinerator.[268] These

[262] "Organics Disposal." *Sea to Sky Soils*, n.d. www.seatoskysoils.com/projects.
[263] "GORE® Cover For Organic Waste Treatment." Gore, n.d. https://www.gore.com/products/gore-cover-for-organic-waste-treatment.
[264] Personal Communication - Emily Willobee MPP Policy & Programs Planner | Engineering Services | District of West Vancouver
[265] Personal Communication - Emily Willobee MPP Policy & Programs Planner | Engineering Services | District of West Vancouver
[266] Ibid.
[267] Ibid.
[268] Lovering, Kaitlin. *Comparative Analysis of Dog Waste Processing Methods for Metro Vancouver*. PDF File. August, 2018. https://sustain.ubc.ca/sites/sustain.ubc.ca/files/Sustainability%20Scholars/2018_Sustainability_Scholars/Reports/2018-

approaches are "consistent with other municipal collection programs in the Metro Vancouver region."[269]

The City of Burnaby is also a member municipality of Metro Vancouver. In addition to complying with Metro Vancouver's landfill ban on organics, the City of Burnaby does not accept any kind of plastic or animal waste in its residential organics program. The organics that are picked up by the City are processed using aerobic digestion at GFL's Enviro-Smart Organics/West Coast Instant Farms in Delta, BC, and the City buys back the finished compost product (which is blended with sand) for operational use. Most notably, the compost is used in the City's Parks operations and is sometimes also sold to Burnaby residents at special events such as the Eco-Centre Open House.[270]

4.4.1 – Quantitative Assessment

Metro-Vancouver has been struggling to reach its 2015 goal of a 70% diversion rate.[271] This municipality has a very diverse strategy to mitigate and divert waste, with many different programs to manage different types of materials. Therefore, it is important to consider that it is not simply a matter of how much waste is diverted, but also how diverted materials are processed. It should also be noted that figures separating organics between residential and total were no longer available in reports after 2016.

Vancouver has had success in increasing its multi-residential diversion participation. Although figures for organics were unavailable, it is suspected that the landfill organics ban implemented in 2015[272] assisted in more participation and diversion. For our study, 2018 shows Vancouver as having the highest multi-family diversion rate among the cities reviewed.

31%20Comparative%20Analysis%20of%20Dog%20Waste%20Processing%20Methods%20for%20Metro%20Vancouver_Lovering.pdf?fbclid=IwAR25oA4sWnPJbbXqukye_NjQsOGZg2lf0iyp4EhCqyiG4cMIXKNEKGRAIdc

[269] Ibid.

[270] Personal Communication.

[271] Saltman, Jennifer. "By The Numbers: Metro Vancouver Winning War on Waste." By the Numbers: Metro Vancouver waste diversion and disposal rates | Vancouver Sun. Vancouver Sun, January 21, 2017. https://vancouversun.com/news/local-news/by-the-numbers-metro-vancouver-winning-war-on-waste.

[272] RCBC. "Metro Vancouver Organics Ban." Recycling Council of British Columbia, January 23, 2020. https://www.rcbc.ca/metrovan-organics-ban.

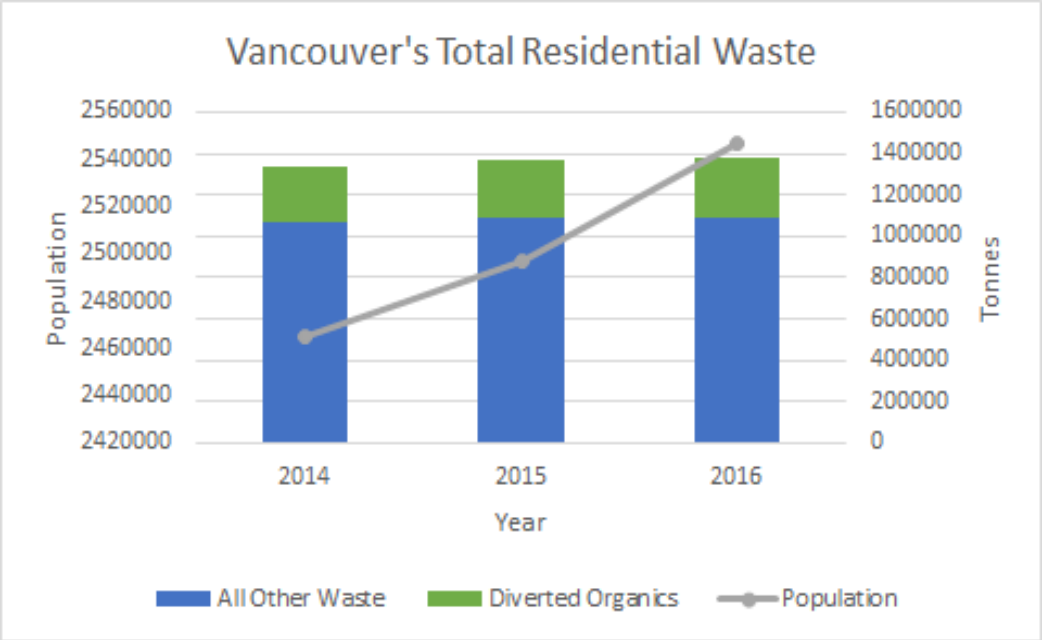


Figure 10: (Metro Vancouver) Population growth and residential waste collection. Waste collection includes multi-residential and single-residential amounts. 'All Other Waste' is all non-organic waste including diverted recycling. This highlights the changes in organic diversion over total waste. Note that the population scale differs significantly from waste tonnages, producing the appearance of large population growth over the studied period. The data separation required for our comparison was unavailable for 2017 and 2018. Data Sourced from Metro Vancouver annual waste reports: http://www.metrovancouver.org/services/solid-waste/about/reports-resources/Pages/default.aspx

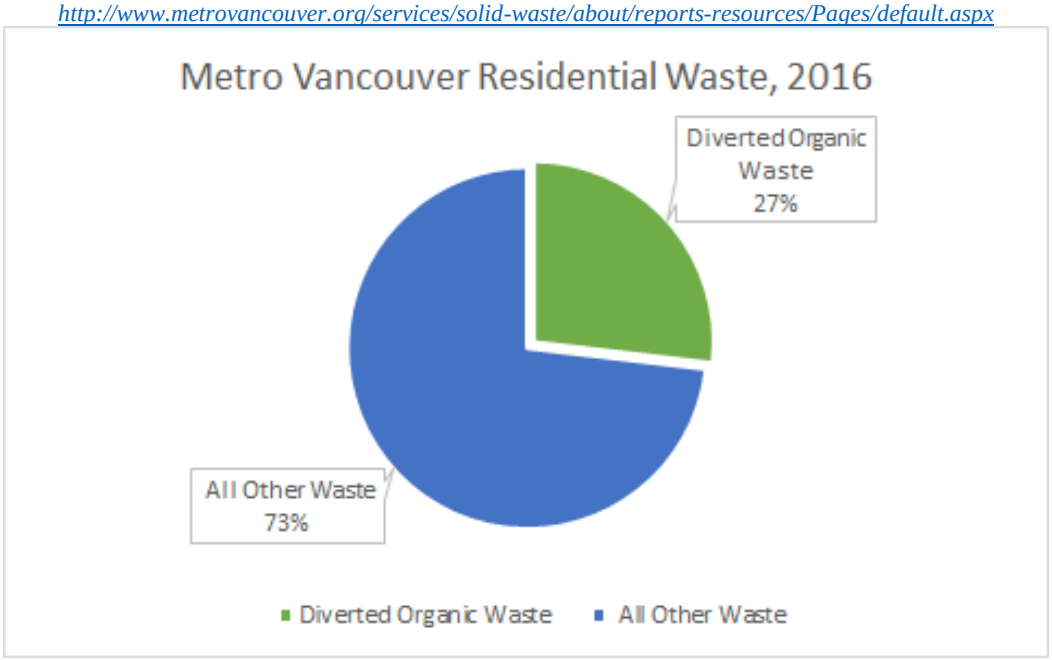


Figure 11: (Metro Vancouver) Illustrates residential organics diversion as a percentage of total residential waste collected in 2016.

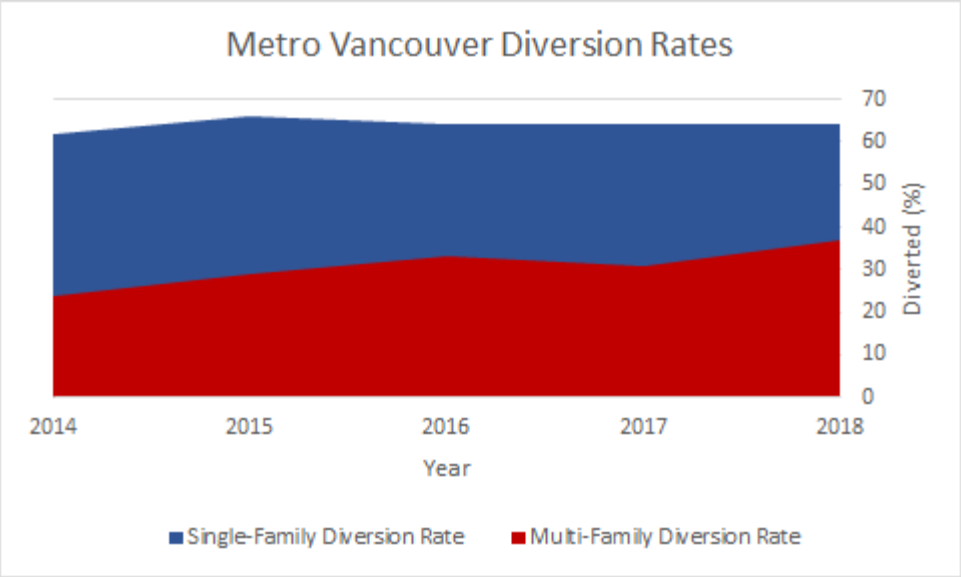


Figure 12: (Metro Vancouver) Shows the improvement of multi-residential waste diversion from 2014-2018. Data from Metro-Vancouver annual reports (http://www.metrovancouver.org/services/solid-waste/about/reports-resources/Pages/default.aspx).

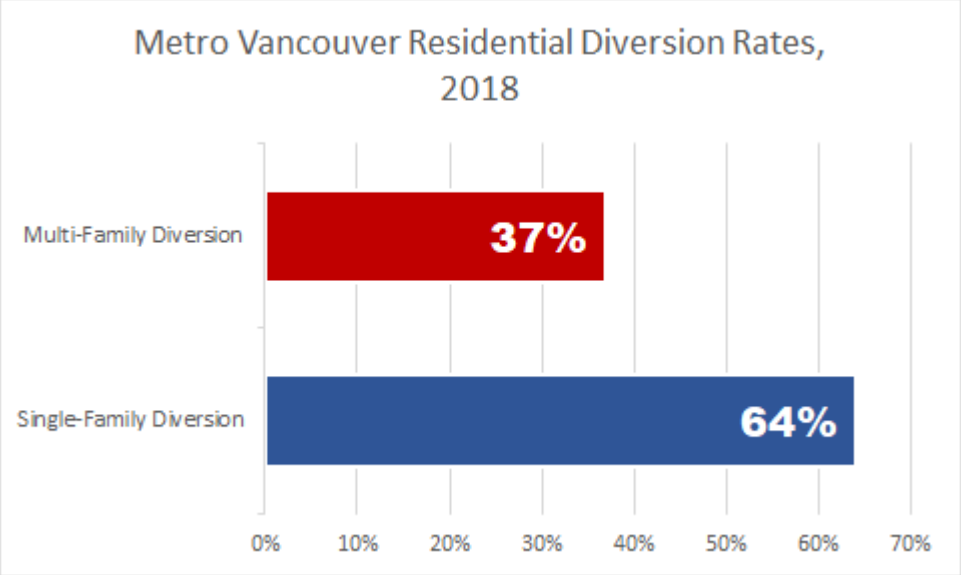


Figure 13: (Metro Vancouver) Shows the difference in diversion rates between single- and multi-family residences in 2018. Data from Metro Vancouver annual reports: (http://www.metrovancouver.org/services/solid-waste/about/reports-resources/Pages/default.aspx)

4.5 - Halifax

The city of Halifax prides itself on its early adoption of the Green Cart program, collecting SSO since 1998.[273] With the closure of the Sackville Landfill occurring in 1996, a consequence of the environmental damage the landfill had been causing, Halifax Regional Municipality (HRM) opened the new Otter Lake landfill with improved environmental security. In a report to Mayor Savage and Members of Halifax Regional Council entitled, *Community Integration Fund – Otter Lake Landfill*, the HRM Council notes the problems with the Sackville Landfill included lack of

[273] "FAQs." Shape Your City Halifax. Accessed March 16, 2020. https://www.shapeyourcityhalifax.ca/compost-matters/faqs.

source separation, pre-processing, odour, vector (organisms transmitting disease) and leachate which - although treated - "was and continues to be discharged into the Sackville River."[274] The opening of Otter Lake marked a new era of landfill use for the Halifax area and comes around the same time as the implementation of new provincial Solid Waste policies including a landfill ban on organic waste. Released in 1995 - considering the Sackville landfill's failures, "An Integrated Resource Management Strategy" (IRMSH) was prepared by the Community Stakeholder Committee (CSC) to promote environmental responsibility in attacking the task of waste diversion. As of 2017, the remaining 3 landfill cells had another estimated 2.5 million tonnes of waste capacity but estimates for lifespan range from 17 to 54 years from that point.[275] The possibility of diverted commercial waste to private waste companies driven by higher tip fees at Otter Lake is cited as one reason for these more hopeful lifespan estimates.[276]

According to the Solid Waste Strategy Review - Otter Lake Analysis, submitted to Mayor Savage and Members of Halifax Regional Council, "Since the adoption of the Strategy in 1997, HRM has achieved an overall blended diversion rate of 62%"[277] - based on figures from 2012.

Diverting organic waste in HRM - whose municipal composting facilities have a combined capacity of only 50,000 tonnes per year - often calls for reliance on smaller private composting facilities, such as Fundy Compost to handle its excess organic waste. The two municipally operated compost plants are "located within a 10 km radius of the center of where the majority of organics are generated."[278] This proximity allows for trucks to bring collected organic wastes right to the closest facility, either the Ragged Lake Waste Composting facility in Goodwood or the Miller Waste Systems Material Recovery Facility, located in Halifax. It ought to be noted that AIM Environmental Group, who manages the Guelph Facility, is also in charge of the management of the Ragged Lake facility,[279] while Miller Waste Systems serves numerous municipalities across Canada with waste collection and other important services.

The IRMSH, released on March 25, 1995, states Halifax's primary environmental objectives are to "maximize the 3Rs," "maximize environmental sustainability and minimize costs," and to foster stewardship and conserver society values."[280] Citing Section 93(1) of part IX within the Nova Scotia Environment Act, the strategy reads, "There is hereby adopted the Canadian target of a fifty per cent solid waste diversion goal for the year 2000" a diversion target which, quite incredibly at that time, was met according to plan.[281,282] Inevitably, such great diversion rates, even in a smaller municipality (relative to the other cities compared here), will create the need for increased waste processing capacity. According to the 2016 Report to Chair and Members of Environment &

[274] City of Halifax (2017), "Report to Mayor Savage and Members of Halifax Regional Council, Community Integration Fund -Otter Lake Landfill," 3. https://www.halifax.ca/sites/default/files/documents/city-hall/regional-council/170905rc1414.pdf
[275] Ibid.
[276] Ibid.
[277] City of Halifax (2013), "Report to Mayor Savage and Members of Halifax Regional Council, Solid Waste Strategy Review - Otter Lake Analysis," 4.Accessed March 19, 2020. https://www.shapeyourcityhalifax.ca/301/widgets/2403/documents/468

[278] "FAQs." Shape Your City Halifax. Accessed March 16, 2020. https://www.shapeyourcityhalifax.ca/compost-matters/faqs.
[279] "Halifax Ragged Lake Compost Facility," AIM Environmental Group (AIM Environmental Group), accessed March 2, 2020, https://aimgroup.ca/halifax-ragged-lake-compost-facility/
[280] City of Halifax (1995), "An Integrated Resource Management Strategy for Halifax County/Halifax/Dartmouth/Bedford" (IRMSH), 4.
[281] Ibid.
[282] Nova Scotia Environment and Labour (2004), "Status Report 2004 of Solid Waste-Resource Management in Nova Scotia," 11. Accessed March 16, 2020, https://www.novascotia.ca/nse/waste/docs/WasteResourceStatus2004.pdf

Sustainability Standing Committee on Organics Processing Management, there are 3 options, each with their own pair of sub-options, for how HRM might respond to the lack of capacity at its organic waste processing facilities. These options consider the possibilities of keeping one or both extant facilities while raising the total processing capacity, the erection of new Aerobic facilities, and/or a new On-Farm Anaerobic Digestor.[283]

Only a few years prior to this report, Stantec had made suggestions to HRM on opportunities to reduce cost, including the possibility of "an extension of approximately 17-23 years to the life of the landfill [which] can be achieved by a 10-15 meter increase in the finished grade of the site," as well as the need to increase organics capacity, and control curing as well as the sale of compost.[284] HRM is also very active in consulting the public on new developments, as well as educating the public and promoting environmental stewardship along with proper waste diversion and composting techniques. Evidence of this ongoing dialogue with residents of Halifax can be shown in reports such as the 2013 Recommendation Report to Mayor Savage and Members of Halifax Regional Council on the Waste Strategy Public Consultation Process. This report outlines Standing Committee meetings already held in public as well as direct consultation with the public to be carried out as town hall meetings.[285] HRM succeeds at instilling conserver society values in all willing residents through these consultations as well as its many education initiatives including training sessions, the Beyond 3Rs" program, community events, online info and a four week "Master Composter Recycler" course.[286]

It is likely that these consultation and education initiatives have had a positive impact on the source separation of organic feedstock and therefore has helped HRM's composting facilities to achieve a high compost quality. In Halifax, the refusal to accept pet feces as well as plastics, including "compostable" plastic bags[287] likely facilitates the efficient screening of foreign matter from and the reduction of pathogens within the compost. According to information provided by Shannon Betts of HRM in an interview on Halifax's Green Cart program, Halifax produces a Category A compost, according to CCME guidelines, although the product requires further curing, which is often carried out by landscaping companies who apply the compost commercially.[288]

At the Miller Waste facility, feedstocks are dumped onto the tipping floor from a municipal compost truck and are pushed up a conveyor belt to be sorted of non-organic material. A magnet removes metal from the feedstock and in an aerobic digester vessel "75 feet wide, 270 feet long, and over eight feet deep," matter is agitated by a metal blade.[289] After a month in the first part of this vessel, compost is aged at the rear portion of the vessel for another two months before it is screened again and sent to companies such as Elmsdale Landscaping for another year or more of curing.[290] From the 2016 annual report notes that Ragged Lake also produces a Category A quality

[283] City of Halifax, (Jan 6, 2015), "Report to Chair and Members of Environment & Sustainability Standing Committee on Organics Processing and Management," 21.
[284] Stantec (2013), "Waste Resource Strategy Update: Halifax Regional Municipality," iv-v.
[285] City of Halifax (2013), "Report to Mayor Savage and members of Halifax Regional Council on Waste Strategy Public Consultation Process", P.1-3.
[286]"Garbage, recycling, & green cart: Education and Outreach," Halifax. Accessed March 16, 2020,
[287] "FAQs," Shape Your City Halifax, accessed March 16, 2020, https://www.halifax.ca/home-property/garbage-recycling-green-cart/green-carts-leaf-yard-material
[288] Personal Communication
[289] Ibid.
[290] Walton, Victoria, "How Halifax Composts 50,000 tonnes of material a year," The Coast, accessed March 16, 2020, https://www.thecoast.ca/halifax/how-halifax-composts-50000-tonnes-of-material-a-year/Content?oid=22662995

compost by employing 24 ~25-tonne vessels, after spending up to ten days in these, the waste is cured in a Portable Static Pile process with Aerated Curing for up to three months before being screened prior to sale.[291,292]

It is noted that with both facility processes that the compost stays at the facility longer than organic waste is kept at the facility in Ottawa - by at least a month and up to two and a half months longer. Even being cured this long, HRM still sells their compost as unfinished and has other companies cure it over a year before use.[293] This is very different from the application of NASM so common in Ontario municipalities like Ottawa.

4.5.1 - Quantitative Assessment

It is clear in Halifax that despite a growing population the city has been able to successfully mitigate and divert a substantial amount of waste. Although the province of Nova Scotia is facing criticism for the cost and extent of its waste management systems, waste management in the province has been regarded as the most effective in Canada.[294] Waste figures from the following graphs differ from the remainder of the comparisons, in that the figures do not include waste collection estimates for multi-family residences.

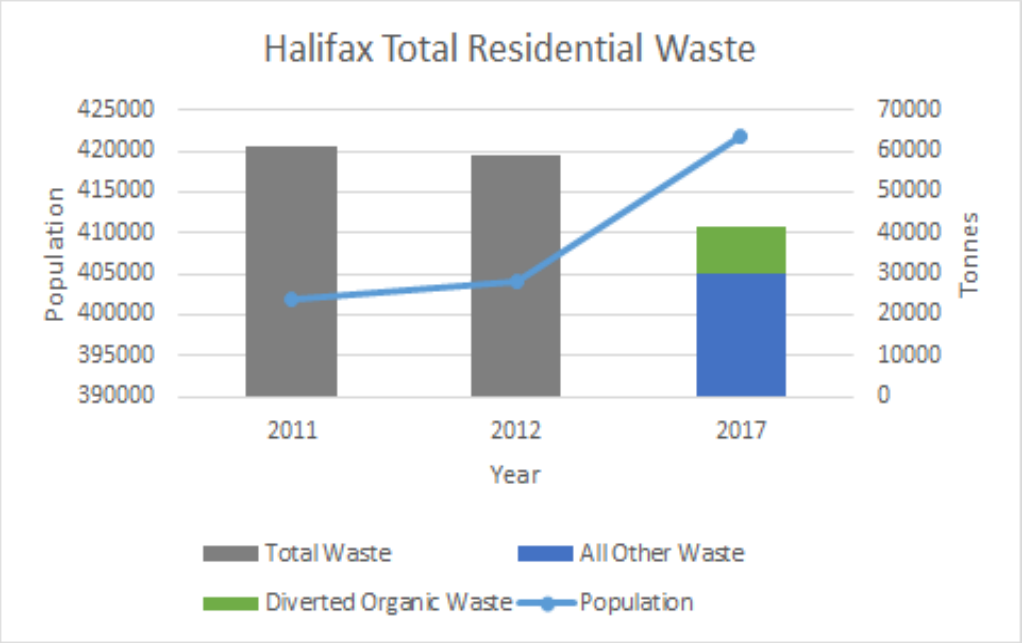


Figure 14: (Halifax) Changes in waste produced and population. Available data consisted of only the years shown, and only 2017 gave figures that outlined specific diversion tonnages. Data taken from Divert NS 2017 Waste Audit Report: https://divertns.ca/assets/files/WasteAudit2017.pdf

[291] City of Halifax (October 25, 2017), "Ragged Lake Composting Facility Annual Report – 2016|Western Common Advisory Committee special meeting,"

[292] AIM Environmental Group (Nov 23, 2017), "Halifax Regional Municipality Ragged Lake Source Separated Organics Composting Facility: Community Liaison Committee Meeting," Accessed March 16, 2020. https://aimgroup.ca/wp-content/uploads/2019/10/Final-as-presented-November-23-17-Ragged-Lake-CLC-Meeting-1-Presentation.pdf

[293] "Halifax Seeks to Contain Organic Waste Cost with Long-Term Deal | CBC News," CBCnews (CBC/Radio Canada, January 8, 2018), https://www.cbc.ca/news/canada/nova-scotia/halifax-organic-waste-compost-deal-1.4475913

[294] Richter, Amy, Nathan Bruce, Kelvin T. W. Ng, Asma Chowdhury, and Hoang Lan Vu. 2017. "Comparison between Canadian and Nova Scotian Waste Management and Diversion Models—A Canadian Case Study." *Sustainable Cities and Society* 30 (April): 139–49. https://doi.org/10.1016/j.scs.2017.01.013.

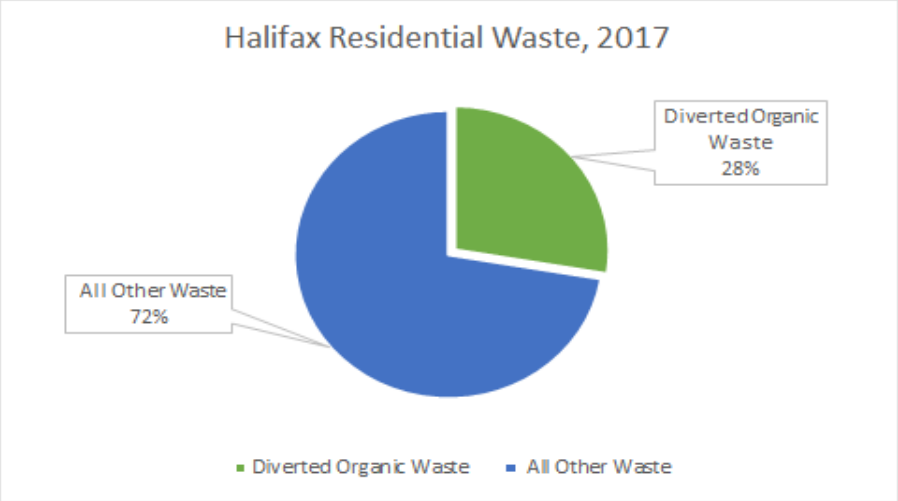


Figure 15: (Halifax) Residential organics diversion as a percentage of total residential waste collected in 2017.

4.6 – Contrasting Quantitative Results

The following graphs depict the comparisons drawn from Resource Productivity & Recovery Authority (RPRA) and municipal tables and reports from 2014-2018. RPRA data was consistently formatted for Ontario jurisdictions, with the addition of available data for Metro Vancouver for direct comparison. For Ontario and Metro Vancouver, factual figures for single-family residential waste pickup and estimates for multi-family residences are included in reports. It was not clear if Halifax residential waste figures included multi-residential, which is privately collected as is the case with the other cities studied. Therefore, it is important when referencing Halifax to understand these representations likely only demonstrate the city's public collection from single-family residences. It is noted that the city of Halifax and the province of Nova Scotia remain leaders in waste reduction and diversion in Canada.[295]

Figure 16 shows the amount of residential waste produced per capita for the studied municipalities. As was discussed previously, Halifax may reflect an unfair comparison and was therefore excluded from the graph. However, it can be noted that in 2016 Nova Scotians produced 398kg/capita of waste, inclusive of residential, commercial, and industrial sources[296]. As can be seen in **Figure 16**, Ottawa lies in the middle of the studied municipalities. Although there remains an opportunity to reduce waste generated by residents, Ottawa is not falling behind relative to its studied counterparts.

[295] Richter, Amy, Nathan Bruce, Kelvin T. W. Ng, Asma Chowdhury, and Hoang Lan Vu. 2017. "Comparison between Canadian and Nova Scotian Waste Management and Diversion Models—A Canadian Case Study." *Sustainable Cities and Society* 30 (April): 139–49. https://doi.org/10.1016/j.scs.2017.01.013.

[296] Avery, Bruce, Ashley David, Joe Hruska, Bob Kenney, Laurie Lewis, Dale Lyon, and Alanna McPhee. 2017. "Divert NS: 2017 Waste Audit Report" 58.

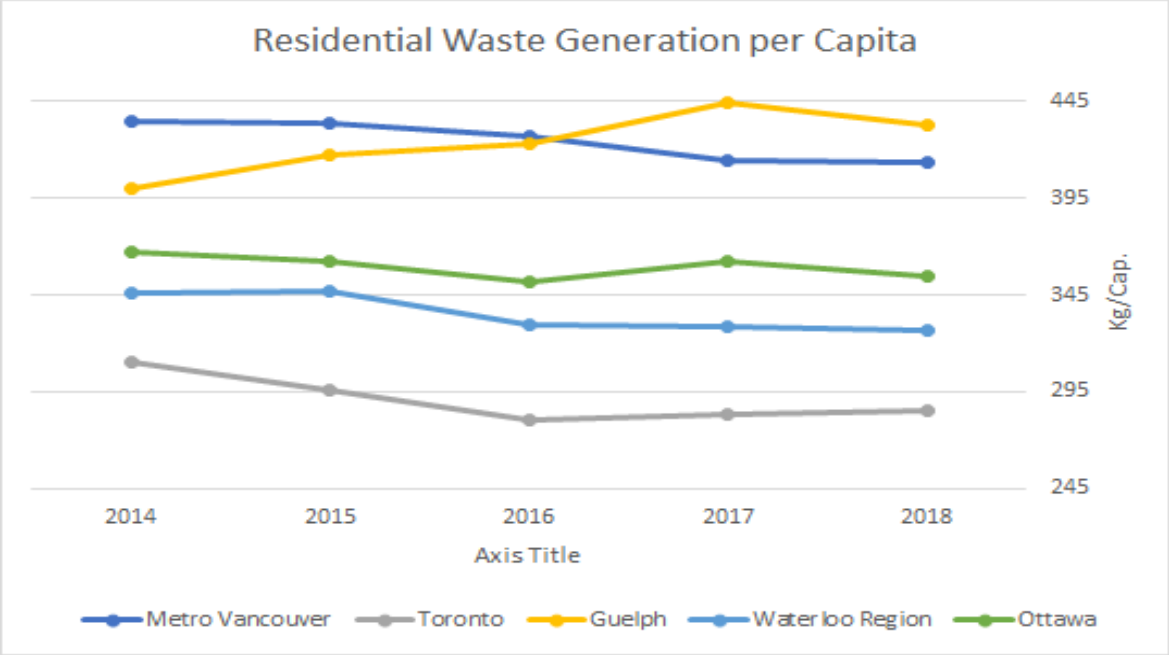


Figure 16: Comparing the waste per capita from the city selection. Halifax data was incapable of forming a fair comparison.

Ottawa, Toronto, and Metro-Vancouver were the only cities with available diversion data that differentiated between single-family and multi-residential. These figures represent the amount of waste diverted to recycling and composting from landfills. When examining such diversion rate differences, we begin to see a gap between Ottawa's performance versus Toronto and Vancouver. As **Figure 17** illustrates, Ottawa's single-family residential diversion rate trails by up to 22%.

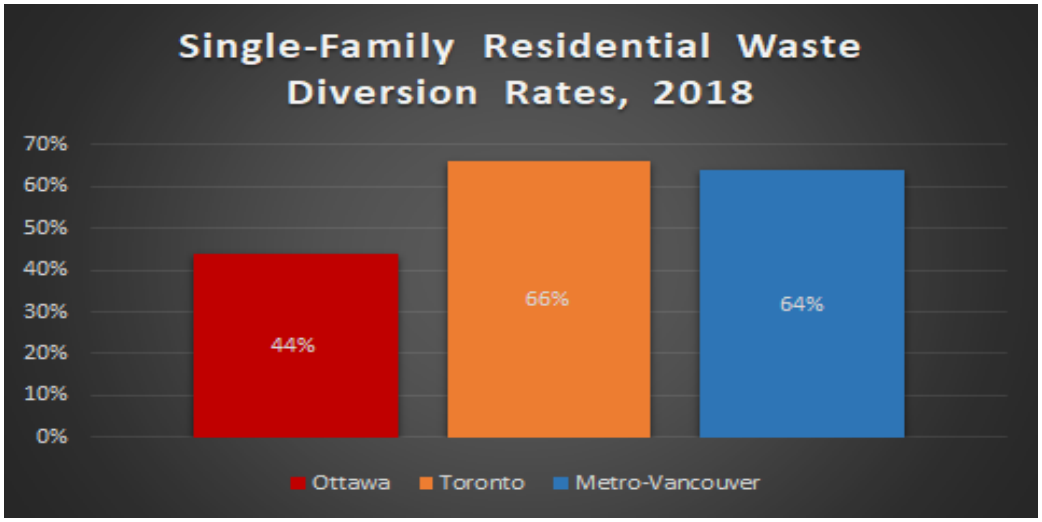


Figure 17: Comparing the single-family diversion rates from cities with available data.

Figure 18 illustrates an even greater opportunity for the city of Ottawa to improve waste diversion. Multi-family residential diversion is most frequently left to property owners to manage. In Ontario, there is no requirement for landlords to participate in organics programs, which contributes significantly to the low rates of waste diversion. Metro Vancouver has implemented a ban on

organics from entering landfills to assist in improving the overall rates of organic diversion.[297] Ontario is expected to follow with a similar ban, to be implemented by 2022.[298]

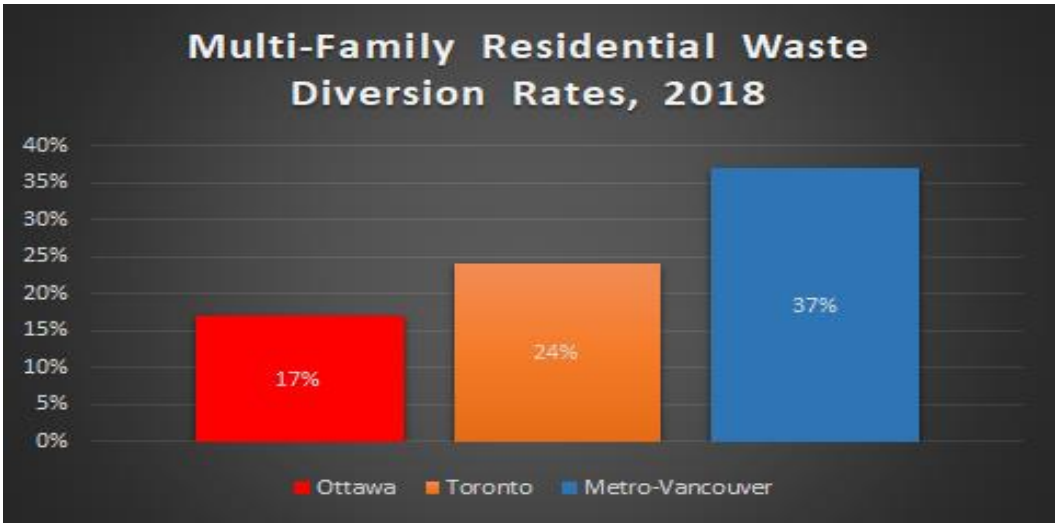


Figure 18: Comparing the multi-family diversion rates across available cities.

Figure 19 illustrates how Ottawa is underperforming across all studied municipalities, in organics diversion. Other sections discuss the steps and reasoning Ottawa is taking to improve its residential waste management.

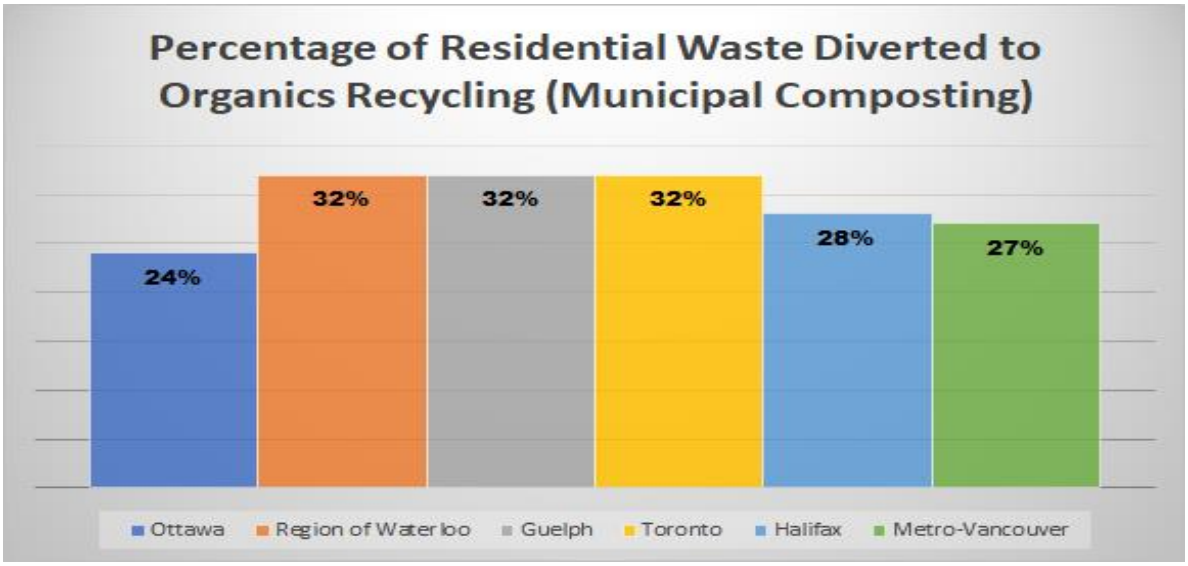


Figure 19: Comparing how much of each city's residential waste was diverted to organics recycling.

Ottawa should be commended for its efforts to achieve sustainable waste development; however, there remains significant room for improvement. Ottawa's multi-residential participation in diverting recyclables and especially organic waste has the most room for improvement. There is

[297] Vancouver, Metro. n.d. "About Food Scraps Recycling." Accessed March 16, 2020. Retrieved from: http://www.metrovancouver.org:80/services/solid-waste/recycling-programs/food-scraps-recycling/about/Pages/default.aspx.

[298] "Food and Organic Waste Framework | Ontario.Ca." n.d. Accessed March 16, 2020. Retrieved from: https://www.ontario.ca/page/food-and-organic-waste-framework.

insufficient incentive for landlords to participate in organics recycling. Matching strategies from more successful jurisdictions could help improve Ottawa's waste diversion.

It should be noted that 'All Other Waste' denotes landfill waste and diverted non-organics recycling, such as plastics and metals. The graphs are designed to highlight the effectiveness of organics diversion for each of the selected municipalities. There was no data available to graph multi-residential organics diversion rates, However, for Ottawa, Toronto, and Vancouver there was information available to compare overall diversion rates between single-residential and multi-residential waste collection. Numbers also do not expose the wide range of waste management practices. Municipalities rely on a dynamic range of policies and measures to manage waste, which are not completely captured by waste tonnage figures. However, the waste tonnage does ultimately highlight the overall performance of waste management policy.

Part 5: Key Challenges and Gaps

Moving forward, Ottawa has numerous challenges to face in terms of responding to recent changes in accepted SSO and to increasing collected SSO, influenced by a rise in population and progress towards a higher organic waste diversion rate (see Table 2). The first of these challenges - a key to responding to the other challenges to be faced, and what ought to be a priority when examining diversion rates from 2019 and 2020 - is responsible reporting on the successes (or failures) of accepting plastics and dog waste in the Ottawa Green Bin program. This should include analysis methods that go beyond the scope of provincial regulation on the maximum diameter of foreign matter, temperature, and pathogen requirements. Although this evaluation is a challenge, it serves a great purpose in providing information necessary to respond to numerous other key challenges, some of which are listed in the following **Table 3.**

Table 3: Key Gaps, Challenges and/or Opportunities for Ottawa's Residential Waste Management as Identified in this Report

Challenges and Gaps	Summary
Responsible analysis and reporting	Change in procedures at the Renewi organic waste facility demands rigorous analysis and evaluation of feedstock, facility procedures, products, and emissions. Furthermore, the City must be accountable to its residents and update public records pertaining to waste diversion in a timely manner.
Waste Reduction and Reuse	Opportunity to work towards building a circular economy and follow the zero-waste hierarchy. Arguing that plastic bags eliminate the "yuck" factor can be grounds to push for a landfill ban on residential organics.
Multi-residential buildings	With only a 17% multi-residential organics diversion rate,[299] Ottawa has significant room for improvement by collecting organic waste from larger residences.
Capacity to Process Organics	With a growing population, increasing diversion to a realistic target will require Ottawa to expand its capacity to process organics. Whether this entails investing in the extant facility or funding a new facility.
Compost Quality	This report demonstrates that Ottawa is behind these other municipalities in terms of product quality. Methods by which the current feedstock might be made a high-quality compost ought to be considered. These may include controlling the curing process, manual plastics separation, backyard or community composting and AD depending on the forecasted needs of the City.
Participation and engagement	Ottawa is trailing behind larger Canadian municipalities in terms of organic waste diversion. The challenge to meet its targeted 70% residential organic waste diversion rate[300] is an opportunity for Ottawa to strengthen its educational programming and explore new avenues by which they might increase participation.

[299] Figure 3
[300] Ministry of Environment Conservation and Parks Ontario. "Strategy for a Waste-Free Ontario: Building the Circular Economy." 2016.

Part 6: Limitations

The scope was constrained by access to data. One of the main goals of the project was to assess the impact of plastics and dog waste on the quality of Ottawa's compost, but data for that was not yet available for analysis. In addition, officials were often unwilling to share raw data that was not already published in reports.

Another challenge relating to access to information was finding the right people to contact for interviews. We thank our partners for their invaluable help in connecting us, but we note that not having consistent contact with them at the start of our project was a limitation. Furthermore, our contacts were not always able or willing to answer all our questions.

A final factor to consider is that the data used in this report is based on municipal reports and secondary sources, as we were not able to obtain raw data from municipalities. For this reason, there is potential for bias in the way that data is presented. Moreover, waste data has inherent errors due to sampling errors and estimates. As a result of these limitations, this report is not as thorough as was initially intended.

6.1 - Recommendations for Further Assessment

Table 3 shows a list of variables that remain unaddressed, with comments as to the data that would be required to address them. Official access to information requests could be considered for future capstone projects, but it would have to be completed much in advance of the start of the project so that it be successful.

Table 3: Outstanding variables and data collection

Variable	Data required
Quantitative measure of GHG emissions reductions due to diverting organic waste from landfills	GHG emissions from landfills before and after organic waste diversion
Correlation between program cost and diversion rate for organics	Municipal spending on residential organic waste programs; organic waste diversion rate for each city under review
Correlation between spending on educational programming and diversion rate for organics	Municipal spending on educational programming about residential organic waste diversion; organic waste diversion rate for each city under review
Analysis of a compost sample	Access to a compost sample
Promotion of backyard composting	StatsCan data on backyard composting
Alternatives to the put-or-pay system	Composting contracts for municipalities under review

Part 7: Recommendations & Conclusion

7.1 - Recommendations

The recommendations listed below emphasize actions, goals, and strategies that the City of Ottawa could undertake in order to achieve emissions reduction targets. These recommendations also provide some considerations that should be included in the development of the Solid Waste Master Plan for the City of Ottawa. Given that the City should aim to meet a 70% waste reduction target by 2023, according to Provincial guidelines it is imperative for the City to make improvements to waste management particularly organic waste management. Good organic waste management entails many benefits and can mitigate environmental harm as well.

Summary of Recommendations

7.1.1 – Ottawa Should Implement the Zero-Waste Hierarchy

Ottawa should emphasize the zero-waste hierarchy throughout its new Solid Waste Master Plan which encourages the reduction and reuse of waste. We recommend that the City enact a by-law to ban organic waste from landfills and encourage the use of clear bags. The City should implement a food waste reduction strategy, work with local partners, and employ technology to reduce food waste.

7.1.2 – Ottawa Should Increase Community Outreach and Education Encouraging Waste Diversion

Ottawa should develop a comprehensive and targeted campaign to encourage organic waste diversion in single-family homes and multi-residential buildings. Ottawa needs to invest in waste diversion campaigns, community outreach and local waste diversion initiatives such as community composting.

7.1.3 – Ottawa Should Adopt Best Practices Employed by Other Cities

In order to deal with issues surrounding diminishing landfill capacity and reduced compost quality, Ottawa should adopt some best practices as noted in the case studies. We recommend investments in new organic processing technologies, education, reduction strategies and infrastructure for organic waste processing to improve compost quality and reap other economic benefits for the City.

7.1.4 – Ottawa Needs to Improve Regulations, Performance Measures, and Transparency

The City of Ottawa ought to conduct yearly performance reviews to highlight the potential of the programs, services, and infrastructure they have in place while evaluating what works for the City. We recommend encouraging residents to separate their organics out of the garbage bin through incentives and fees. We also recommend that Ottawa should publish reports on waste management every year basis and develop performance indicators to increase accountability.

7.1.5 – Ottawa Should Improve Waste Management for Multi-Residential Buildings

Ottawa's best option is to mandate the diversion of organics from multi-residential buildings and provide Green Bin services to multi-residential buildings. Consideration and research should be given to a landfill ban for organics, specific to Ottawa, to understand the best methods for implementing a landfill organics ban, which would further encourage multi-residential organics diversion.

7.2.6 – Ottawa Needs to Consider Capacity to Process Organic Waste in the Long-term

We recommend three main considerations for the long-term: reduction of food waste, investment in waste processing technologies and improvements in compost quality. We recommend that the city work support or incentivize startup or tech-based organizations to limit food waste from local grocers, farmers, and restaurants. The City may want to explore investing in technologies that recover energy from organic waste and employ strategies to improve compost quality.

7.2 - Recommendation Reasoning

The following subsections are overviews of the reasoning for the suggested recommendations.

7.2.1 - The Zero-Waste Hierarchy: Recovering and Reducing Organic Food Waste

Given what is known about Ottawa's organic waste diversion rates it is important to place a strong emphasis on the zero-waste hierarchy in the City's new solid waste master plan. Emphasizing the importance of reducing and recovering food and organic waste ensures that future policies and guidelines will aim to do so. A Zero Waste strategy would prioritize waste prevention to minimize the amount of waste going to landfills while also conserving precious resources. The zero-waste hierarchy is in line with building a circular economy where changes are made in how organic waste is viewed and valued, how products and packaging are designed to maximize resource recovery. This can help the City achieve its' goal of waste reduction while encouraging reuse and upcycling of waste. With this in mind, we recommend that the City of Ottawa move forward in enacting a by-law that bans organic waste from landfills. Both Halifax and Vancouver have enacted a ban on organics in landfills. In support of this ban, we recommend that garbage bags must be clear in order to better enforce this ban.

In terms of recovering food and organic waste, we recommend that the City of Ottawa explore technologies or upgrades that would facilitate the production of energy from organic waste. Alternatively, perhaps the city could also commission consultation to determine how waste can be transformed or traded in to create other valuable goods. This can be done by forming a partnership with private sector businesses and community associations. Additionally, the City should encourage, and support community initiatives aimed at community gardening and composting to further reduce the amount of waste being sent to landfills. The final compost could be used in community gardens or to address local landscaping needs. As part of a circular economy, it will be important to establish ambitious diversion targets with concrete actions that will help achieve

these targets. It will also be important to implement a food waste reduction strategy and employ technology to reduce food waste.

Figure 20: Zero Waste Hierarchy of Highest and Best Use 7.0[301]

7.2.2 - Increase Community Outreach and Education Encouraging Waste Diversion

Outreach and education help to communicate effectively to the City's residents how to participate in the City's waste management programs and to encourage reduction, reuse, and recycling of waste. Ottawa should develop a comprehensive and targeted campaign to encourage organic waste diversion in single-family homes and multi-residential buildings. The use of promotional and educations tools such as multimedia, collection calendars, applications, online modules, community events, advertising, and printed resources including stickers, posters, and guides will be an important part of this strategy. Organic waste diversion campaigns should advertise what goes in the green bins regularly, how people could benefit from organic waste end-products and community initiatives to utilize organic waste resources. It would also be important to target children and adolescents in this campaign as they are the future homeowners, residents and business owners. Participation can be encouraged by making composting and green bin usage a pro-social behavior or norm overtime.

The City should aim to support Community Composting, which reduces organic waste, teaches communities the value of food and localizes organics processing while maintaining high qualities of compost. The City of Toronto provides grants for community initiatives aimed at reducing or reusing waste. Community composting can have many benefits, which should be encouraged by the City of Ottawa as it can also bring attention to issues surrounding food security and sustainability. Outreach and education can encourage participation and engagement which was noted as a challenge for the City of Ottawa. Proactively reaching out to communities through

[301] "The International Zero Waste Definition & Hierarchy." Zero Waste Canada. Accessed April 19, 2020. https://zerowastecanada.ca/zero-waste-hierarchy/.

education campaigns and programs is the first step in garnering engagement as it informs residents about the importance of separating their waste. Ottawa needs to invest in waste diversion campaigns, community outreach, and local waste diversion initiatives.

7.2.3 - Adopt Best Practices Employed by Other Cities

Despite also accepting plastics and dog waste, the cities of Guelph, Waterloo, and Toronto produce high quality, grade A or AA, compost. This makes these cities important case studies for Ottawa to learn from, should Ottawa continue to accept plastics and dog waste in the organic stream. The City may also wish to reconsider its policy surrounding dog waste and plastics. In Halifax, the refusal to accept pet waste and plastic bags allows for more efficient screening of compost and thus higher quality compost due to better source-separation. A challenge the City will soon be facing is diminishing landfill disposal capacity at Trail Road landfill which is why alternative processing technologies and the employment of best practices could help enhance organic waste processing capacity. Adopting best practices will allow the City to derive the benefits of efficient organics waste management while mitigating the environmental harms.

To encourage multi-residential diversion of organic waste the city of Guelph began expanding its residential organic waste management program to include multi-residential buildings through the use of front-end loading garbage trucks. West Vancouver adopted a novel solution by asking residents to use a smaller dedicated 46L green can for their food scrap and through buying back compost produced for city operations like park management. The City of Waterloo increased its diversion rates through investments in public engagement and education campaigns while also investing in EfW technologies. The City of Toronto has a closed-loop organic waste management process by using anaerobic digestion to produce high-quality compost and capture biogas which fuels waste-collection trucks. These cities are all able to produce AA quality compost in large part due to their investment in technologies and waste management processes. The City must evaluate their options and adopt best practices to improve the compost quality being produced. It is noted that with both facility processes, compost that stays at the facility longer is of better quality. If compost is kept at the facility in Ottawa - by at least a month and up to two and a half months longer the quality could be improved. Even being cured this long, HRM still sells their compost as unfinished and has other companies cure it over a year before use! This is very different from the application of NASM so common in Ontario municipalities like Ottawa.

The City of Ottawa should consider making use of organic waste for its operations and giving organic waste back to residents to reap the benefits of good waste management. The City of Ottawa despite its problematic history with Orgaworld should invest in organics waste processing and draft agreements to ensure mutual benefits for both taxpayers and the company. Agreements to upgrade the facility can support local jobs and purchasing agreements can be made in order for the City of Ottawa and residents to easily access and use the end-products of the composting process. Investments in new organic processing technologies, education, reduction strategies and infrastructure for organic waste processing will result in improvements to the compost quality and other benefits for the City.

7.2.4 - Improve Regulatory Control, Performance Measures and Transparency

The City of Ottawa should also include strategies aimed at improving regulatory control, over the disposal of food waste which can be an important step forward in establishing a successful organics

diversion program. The City is responsible for the collection, processing, and disposal of waste and as such should take steps to ensure that food waste is source-separated and processed without deteriorating the quality of compost. In Vancouver, food waste regulations and a comprehensive food waste collection program have led to significant growth in diversion efforts in the region. Regulations should be aimed at reducing the amount of non-organic waste ending up at the Renewi facility, while also encouraging residents to keep organic waste away from landfills. A large part of this will include encouraging residents to separate their organics out of the garbage bin through incentives and fees.

The City of Ottawa ought to conduct yearly performance reviews to highlight the potential of the programs, services, and infrastructure they have in place while evaluating what works for the City and what does not. As part of the new waste management plan, the City should strive to develop performance indicators to show how far along the City has come in achieving waste diversion rates. Some indicators we suggest include organic waste diversion rates, greenhouse gas reduction benefits, potential avoided greenhouse gas emissions, compost quality and perhaps in the future waste-based energy benefits. This is an opportunity for the City is to develop updated and robust performance metrics to accurately measure the success of waste management services in the City while accounting for changing waste composition and populations. Improved understanding of waste management and resource recovery can help improve decision-making and encourage the City to maximize the efficient use of its current programs, services, and infrastructure.

It is also important to be accountable to the residents of this City by increasing the amount of publicly available data about waste diversion and management in a timely manner. The data should be reported on every year and to include performance indicators for both City residents and decision-makers. Publicly available performance indicators and reports can help educate the general public, shape waste management, and promote continued efforts in improving waste management systems. Furthermore, as part of being accountable, it is important to report back to City residents about the successes of waste diversion to sustain and improve efforts.

7.2.5 - Improve Waste Management in Multi-Residential Buildings

As identified in the qualitative assessment, Ottawa could stand to make large improvements in organics diversion by reaching more multi-residential households. To accomplish this, several strategies could assist in increasing waste diversion in multi-unit residences. These strategies could include providing convenient on-site access to green bins, banning organics from landfills, and retrofitting multi-residential buildings with garbage disposals. Each of these diversion strategies come with a series of implications, and a mixture of solutions may be the soundest approach.

Metro-Vancouver has opted for the first two solutions – utilization of private collection and landfill banning of organics.[302] Metro Vancouver advises landlords to educate and inform residents of how to handle food waste properly. This involves residents using a kitchen food scrap bin, which is to be emptied into large organic waste bins located on the property. The building's organic waste is then privately collected and transported to a waste transfer station for composting. In this case, the onus is placed heavily on multi-residential property owners to appoint an organic waste liaison to generate a tenant education plan for green bin waste diversion. Guidance and informational

[302] "Food Scraps Recycling: How-to Guide for Apartments and Condos." n.d. Metro Vancouver. Accessed March 29, 2020. http://www.metrovancouver.org/services/solid-waste/SolidWastePublications/HowToApartmentsCondos.pdf.

materials for multi-residential liaisons are provided by the region.[303, 304] This, in conjunction with an organic waste ban in landfills, strongly promotes the diversion of organics at multi-residential buildings. We recommend that the City provide Green Bin services in multi-residential buildings, as in the case of Toronto, in order to encourage greater organic waste diversion rates.

An Ontario example of a similar plan is the City of Barrie's pilot of an organic waste diversion program for multi-residential buildings. Barrie advises the same method as Metro Vancouver, by asking residents to use a kitchen food scraps bin to be emptied into a larger organics bin, located on the building property; however, Barrie incentivizes the program differently. This municipality offers waste collection services for multi-residential buildings, on the condition that all residents participate in waste diversion practices. Furthermore, the city provides the building's container as well as the individual units' kitchen containers for participating buildings. This program diverted 220,800 kg (221 Tonnes) of organic waste from 128 multi-residential buildings, in 2018.[305]

The alternative to using bin collection is the use of kitchen garburators. This is perhaps the least advisable approach, as there are many considerations with using garburators as a method of organics diversion. The first consideration is how the municipality treats and dispenses its biosolids. Landfilling, incineration, and dumping in waterways are not ecologically sound practices for disposal of food scraps via wastewater; however, some municipalities treat sewage for use in agricultural land application.[306] Another issue with garburators is not only the cost associated with treating sewage, but also the cleaning of sewage systems that suffer from the improper use of garburators – such as grease and non-organics disposed of through garburators. The cost to clean sewage systems from garburator usage in 2014, mostly from multi-residential units, was approximately $2 million for Metro Vancouver.[307] The major benefit to garburators is that residents find them extremely convenient and are willing to use them often; so often, that buildings equipped with garburators may participate less in organic bin collection programs, compared to those without.[308] This is a consideration for cities that determine garburators are detrimental to their waste infrastructure, as they do not have the authority to ban this technology.[309] Ottawa may wish to strongly encourage or incentivize green bin participation to discourage the adoption of garburators.

7.2.6 - Long-term considerations

In terms of long-term considerations, the data from this report shows us how as Ottawa's population increases, and more efforts are made towards achieving organic waste diversion targets the city will not have the capacity to process it. It is important to increase organics processing

[303] "Food Scraps Recycling: How-to Guide for Apartments and Condos." n.d. Metro Vancouver. Accessed March 29, 2020. http://www.metrovancouver.org/services/solid-waste/SolidWastePublications/HowToApartmentsCondos.pdf.

[304] Vancouver, Metro. n.d. "Multi-Family Composting." Accessed April 14, 2020. , http://www.metrovancouver.org:80/services/solid-waste/recycling-programs/food-scraps-recycling/apartments-condos/multi-family-composting/Pages/default.aspx.

[305] "Multi-Residential Diversion Programs." n.d. Accessed March 30, 2020. https://www.barrie.ca:443/Living/GarbageAndRecycling/Pages/Multi-Residential-Collection.aspx.

[306] "Health and Environment." n.d. Accessed March 30, 2020. http://www.metrovancouver.org/services/liquid-waste/innovation-wasterwater-reuse/biosolids/quality-control/Pages/default.aspx.

[307] Jun 26, CBC News · CBC News · Posted:, 2015 7:29 AM PT | Last Updated: June 26, and 2015. 2015. "Metro Vancouver's Underground Arteries Clogged with Garburator Grease | CBC News." CBC. June 26, 2015. https://www.cbc.ca/news/canada/british-columbia/garburators-cost-metro-vancouver-2m-a-year-in-clogged-up-sewers-1.3128519.

[308] David Hendrickson. 2011. "The Belly of the Beast: Post-Occupancy Assessment of Sustainable Consumption in Multi-Unit Residential Buildings." Doctoral Thesis, Vancouver: Simon Fraser University.

[309] Jun 26, CBC News · CBC News · Posted:, 2015 7:29 AM PT | Last Updated: June 26, and 2015. 2015. "Metro Vancouver's Underground Arteries Clogged with Garburator Grease | CBC News." CBC. June 26, 2015. https://www.cbc.ca/news/canada/british-columbia/garburators-cost-metro-vancouver-2m-a-year-in-clogged-up-sewers-1.3128519.

capacity according to population and waste diversion projections to ensure that compostable waste does not end up at the Trail Road landfill. We recommend three main considerations for the long-term: reduction of food waste, investment in waste processing technologies and improvements in compost quality. These three recommendations encapsulate some of the main findings of our report and broadly emphasize what needs to be taken into consideration in Ottawa's' new Solid Waste Master Plan.

As part of their long-term goal and considering the climate emergency, the City should focus on policy efforts and spending on reducing waste and upcycling. In the case of organic waste, apps have allowed grocery stores to sell food that is about to expire for deeply discounted prices. The City could help establish programs with local farmers, grocers, and restaurants to send their food to programs that feed the most vulnerable populations in the City. Building partnerships with residents and businesses in the City of Ottawa through outreach and education can help reduce food waste. The City alternatively could help support or incentivize startup or tech-based organizations that could deliver such programs aimed at reducing food waste.

It would be worth considering investments in, or upgrades to, the Renewi organics facility (or investments in a new facility) as well as technology that can effectively remove most plastic from feedstocks. The City may want to explore investing in technologies that recover energy from organic waste to create a closed-loop process as in the case of Toronto. It would be worth exploring how biogas could be captured at the Renewi facility as well as bio-drying or creating microbial fuel cells to reduce the usage of conventional fossil fuels.

Improving the compost quality should be a goal enshrined in the waste management strategy. As in the case of Halifax, it is worth considering storing compost for longer at the Renewi or another specified site for a longer period to improve the overall quality of compost. Despite the costs associated with the added time for storage the environmental and economic benefits associated with improved compost quality will make it worth it. Investing in organics waste processing will have economic benefits for the City in the long-term, however, it is important to note that the right steps must be taken to simultaneously preserve compost quality and increase organic waste diversion rates. Some scientific evidence suggests that biodegradable plastics can breakdown in composting processes without affecting soil quality which upon further research can offer an alternative to the usage of plastic bags. As part of the long-term waste management strategy the City should explore how to provide residents with biodegradable compost bags or subsidies for people to purchase biodegradable compost bags. As in the case of Vancouver with its red bin, the city may want to consider alternative means of disposing dog waste to improve its compost quality. It would also be worth encouraging residents to flush dog waste, place it in the backyard or specialized bins for collection. Overall, the improvement of compost quality should be of utmost importance to the City of Ottawa to reap the environmental and economic benefits of producing high-quality compost.

7.3 - Concluding Remarks

Working closely with WWO, the project team assisted in the provision of usable data, graphics, and results that could help inform decision-makers and the public about how the City of Ottawa's residential organic waste management system could be improved. Using qualitative and

quantitative methods, the report analyzed multiple variables including policies, compost quality, end-market uses, processing technologies, and the impact of including plastics and dog wastes on organic waste diversion rate. This approach was applied to the study of Ottawa, Guelph, Waterloo, Toronto, Halifax, and Vancouver's residential organic waste management systems. In this way, the report highlighted gaps, challenges, and opportunities for Ottawa based on best practices from the other cities under review, culminating in recommendations for the City of Ottawa. As such, independent findings of this uOttawa project include: Ottawa should implement the Zero-Waste Hierarchy, Ottawa should increase community outreach and education encouraging waste diversion, Ottawa should adopt best practices employed by other cities, Ottawa needs to improve regulations, performance measures, and transparency, Ottawa should improve waste management for multi-residential buildings, and Ottawa needs to consider the capacity to process organic waste in the long-term.

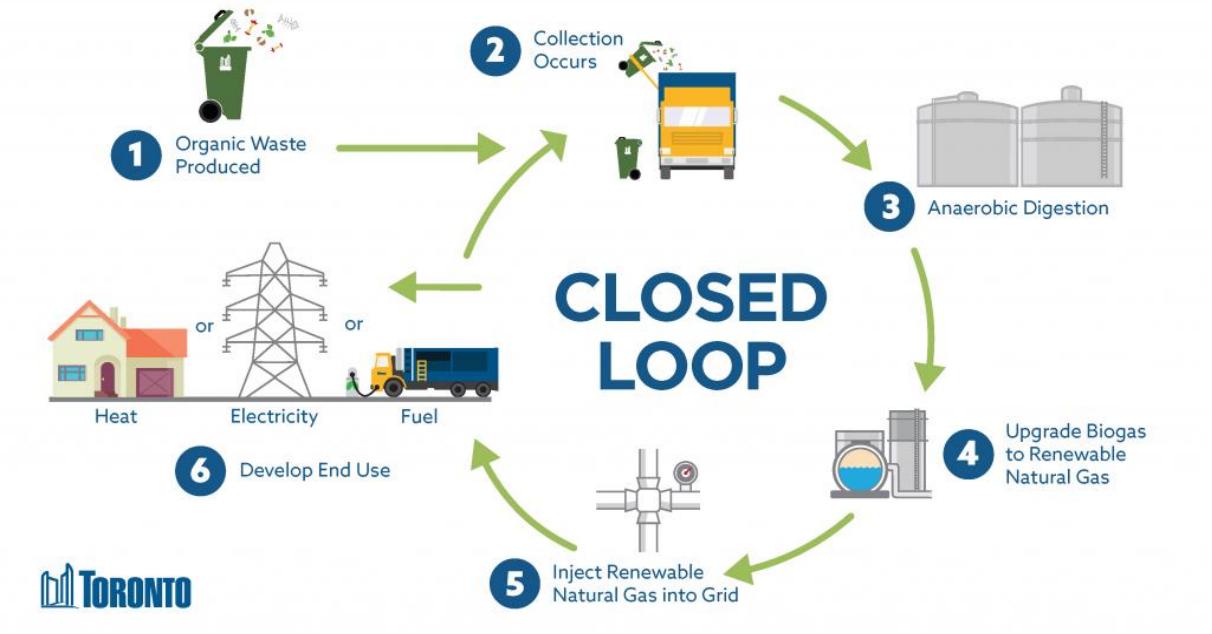
The project team thanks WWO for assisting with identifying information sources and hopes that this report will support WWO’s 6 Point Waste Management and Diversion Strategy as WWO continues to work with the City of Ottawa on the City’s new Solid Waste Management Plan.

Appendix 1 - Research Rubric for Comparing Cities

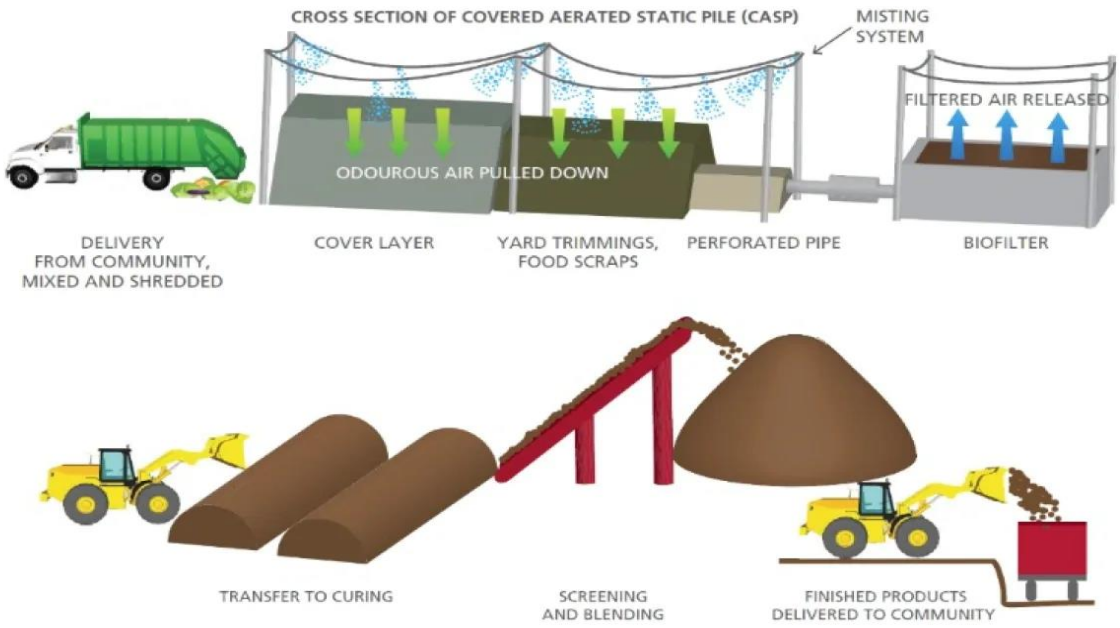
Case Study (City)- Organic Waste Diversion	
	Questions
Program Description	
	Provide a broad overview and history of the waste collection program in the city (all types with more details on the organics program)
	The name of the landfill(s) the city sends its garbage to and expected lifespan
	How is organic waste collected and disposed of in the city? (curbside to disposal facility)
	Summary of the cities' long-term waste strategies, targets and goals (include emissions reductions goals and how waste reduction factors in)
	Summary of progress being made to reach those targets (if that information is available)
	Describe public engagement, programs and educational campaigns related to waste diversion
	Difference between multi-residential and household organic waste collection
Policies and Guidelines	
	City's policy on organic waste collection and overarching principles (ex. circular economy, waste reduction for climate change etc.)
	Provincial policy on organic waste collection
	What is included/excluded as part of organic waste?
	Policy on dog waste and plastics in compost?
	Compost quality standards being employed by the city?
End Market Uses of Organic Waste	
	What are the end uses of organic waste in the city?

	The facilities/companies responsible for disposing of organic waste? What does the facility do with organic waste?
	How is the organic waste processed (specifics on anaerobic/composting)?
	Is the city able to use the end product of organic waste or make money from organic waste?
Technology and Innovations	
	Technologies being employed by the city to convert organic waste?
	Innovative solution to divert organic waste?
	Novel strategies or solutions being employed by the city?
	Technology being used to deal with plastics and dog waste in compost?
Quantitative Data (Secondary Sources)	
	Collected organics tonnage per household (2010-2019)
	Organic diversion from disposal rate (percentage)
	Compost tonnage produced
	Program cost
	Promotion or education spending
	Greenhouse gas emissions from waste management
	Participation rates
	Compost Quality (if listed)
	Net GHG impacts (if listed)

Appendix 2 - Organics Recycling Diagrams



Source: https://www.cbc.ca/news/canada/toronto/compost-waste-food-carbon-methane-atmosphere-environment-sustainable-1.5329519



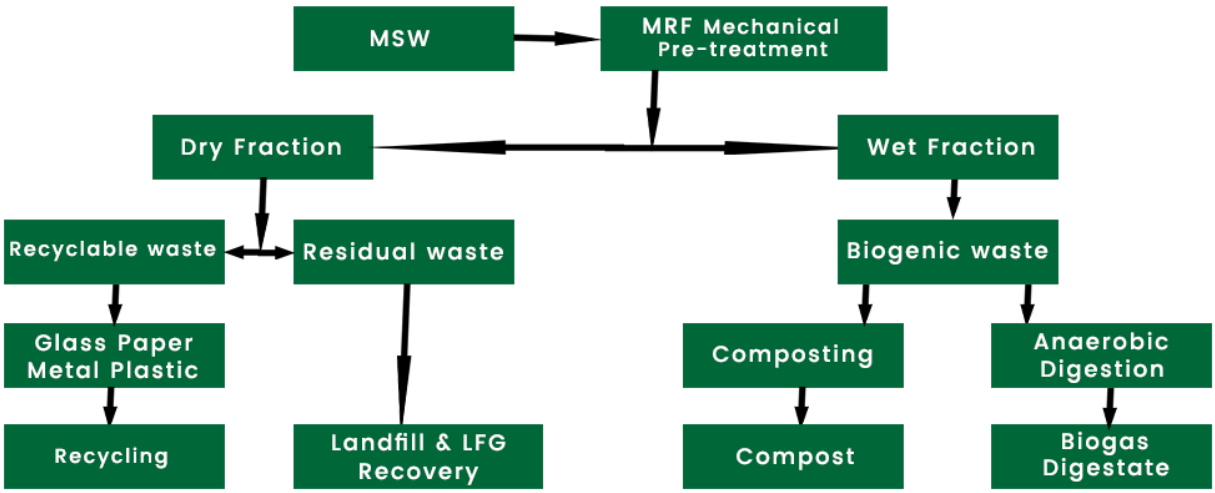
Harvest Power organics processing, Richmond, BC
Source: https://www.cbc.ca/news/canada/british-columbia/organics-ban-update-metro-vancouver-2017-1.3957186

Orgaworld organics recycling (Ottawa)

Source: http://home.imagesandyhill.org/2018/09/how-orgaworld-composts-our-plastics/

Appendix 3– Municipal Waste Management Diagram

General waste management flow:



Source: https://protorelief.ro/en/types-waste/

Appendix 4 – Additional Graphs and Charts

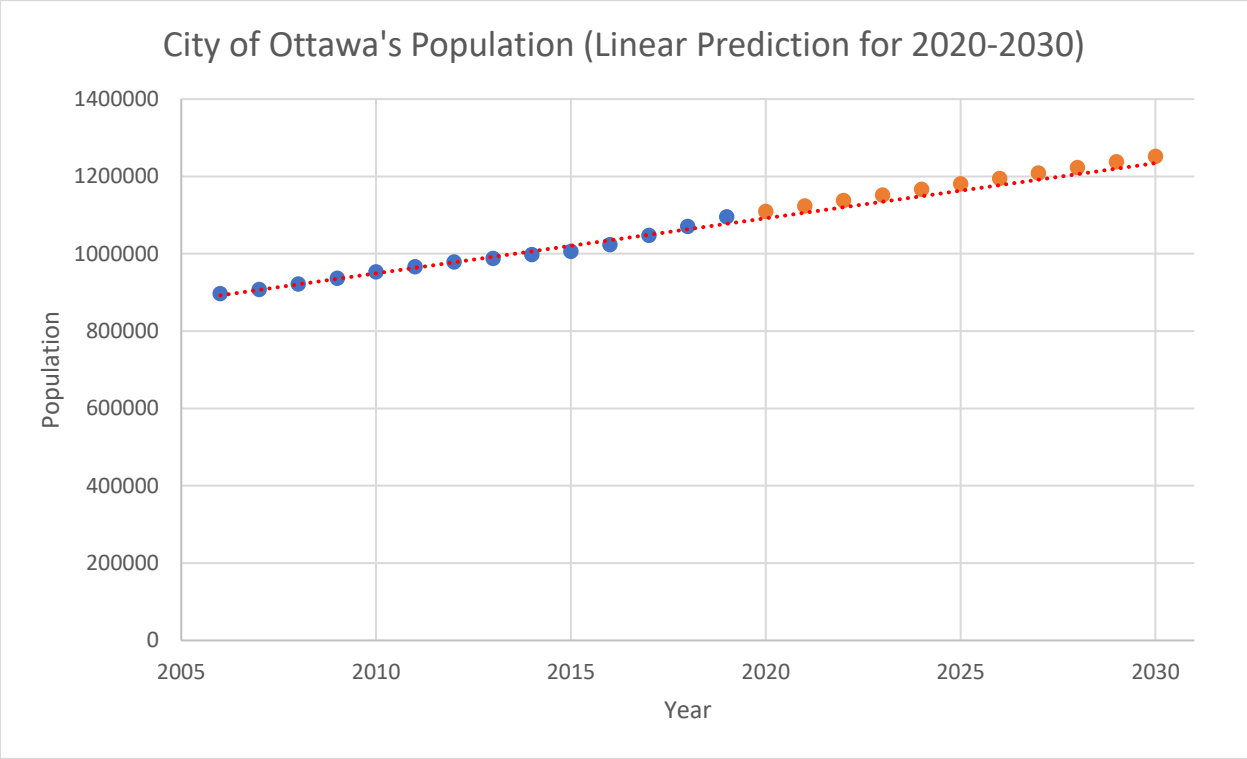


Figure 21: Graph of Ottawa's population from 2006 – 2030. The prediction was made via linear extrapolation of StatsCan population data from 2006-2019.[310]

[310] "Add/Remove Data - Population Estimates, July 1, by Census Metropolitan Area and Census Agglomeration, 2016 Boundaries." n.d. Accessed March 18, 2020. http://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1710013501.

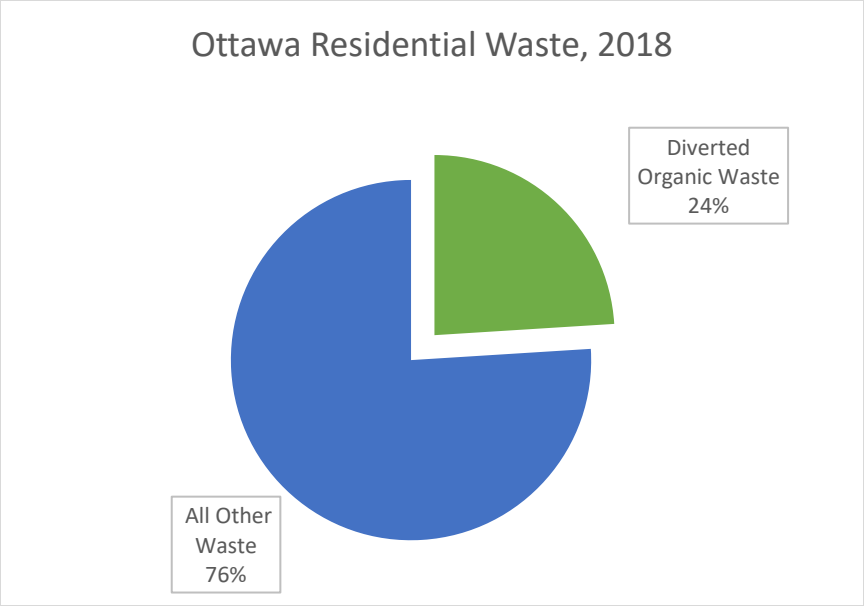


Figure 22: (Ottawa) Illustrates residential organics diversion as a percentage of total residential waste collected in 2018.

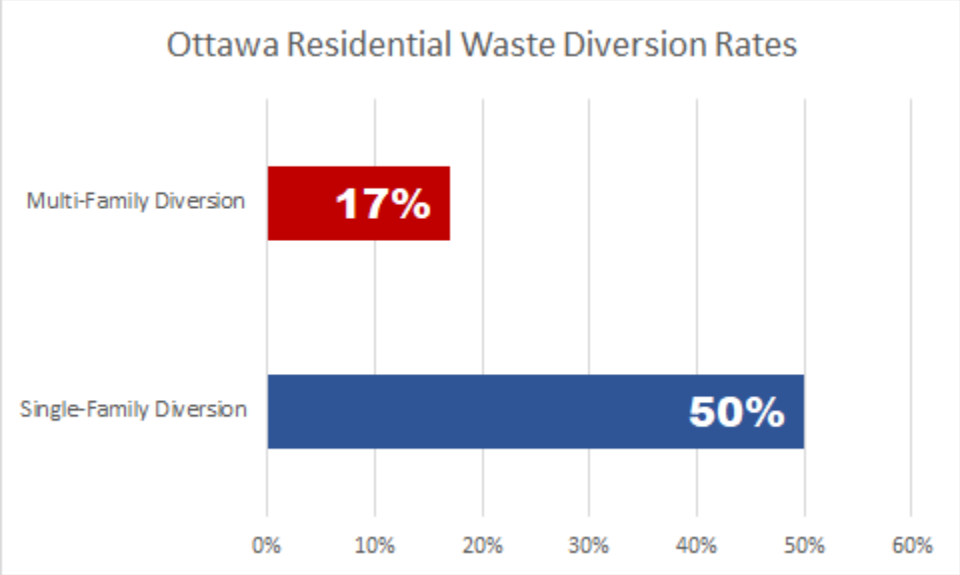


Figure 23: (Ottawa) The amount of total waste diverted from landfills, contrasting multi-residences and single-family residences. Data sourced from: Recycling and Waste Handbook (https://documents.ottawa.ca/sites/documents/files/documents/recycling_handbook_en.pdf) and RPRA (https://rpra.ca/programs/about-the-datacall/).