CITY OF VANCOUVER

City of Vancouver Greenest City 2020 Action Plan: Create Zero Waste

Centralized Composting and Food Waste Disposer (FWD) Use as Competing Organic Waste Management Strategies in Vancouver Multi-Family Homes

July, 2012

Prepared by:

Alison McKenzie, MSc
UBC-City of Vancouver Greenest City Scholar
alison.mckenzie@alumni.ubc.ca

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

This page is intentionally left blank

EXECUTIVE SUMMARY

The diversion of organics from multi-family homes in the City of Vancouver is a critical component of meeting the Greenest City Action Plan target of reducing the amount of landfilled or incinerated solid waste by 50% compared to 2008 levels. The purpose of this investigation was to evaluate the environmental impacts of a centralized composting program versus the use of garburators (herein referred to as food waste disposers, FWDs) as organic waste management strategies for multi-family residences in the City of Vancouver.

The two organic waste management strategies were critically evaluated according to five major environmental impact categories: diversion potential, global warming potential, water use, useable products, and effluent/emissions. A combination of peer-reviewed and grey literature, including reports and case studies, formed the basis of this evaluation.

The literature presented conflicting results. Diversion potential and eco-toxicity (in the effluent/emissions impact category) presented the strongest evidence in support of a centralized composting program:

1. **DIVERSION POTENTIAL:** In a multi-family setting, it is expected that a centralized composting program can reach a maximum diversion rate of 30% in the initial stages of the program, with the potential of further growth associated with community education. FWD use can account for a maximum of 12% diversion.

2. **ECO-TOXICITY:** Increased FWD use increases organic loading in the sewage stream. If released into surrounding waterways, biological oxygen demand (BOD), total suspended solids (TSS), nitrogen (N) and phosphorus (P) can have widespread ecological impacts. Although acceptable for those municipalities that employ secondary and tertiary sewage treatment, increased organic loading is unacceptable in the City of Vancouver where primary treatment still exists, as does the issue of combined sewer overflows (CSOs).

The strongest evidence in support of FWD use and the municipal sewage system was acidification (in the effluent/emissions impact category):

3. **ACIDIFICATION:** Certain gases react with water molecules in the atmosphere to form acids, which fall in the form of acid rain and can affect both terrestrial and aquatic ecosystems. These gases are not associated with FWD/municipal sewage system emissions in any significant quantity. In a centralized composting program, three gases strongly associated with acidification are emitted: sulphur dioxide (SO_2) and nitrogen oxides (NO_x) and ammonia (NH_3).

Organic waste management studies undertaken by other cities and municipalities have shown conflicting results. Investigations in the UK, Sydney, Wisconsin and New York found that increased use of FWDs is both acceptable and desirable from an organic waste management perspective. Investigations in the Halton region of Ontario and the Ireland Environmental Protection Agency have also evaluated this research question, concluding that FWD use should not be encouraged, or that FWD use should be altogether banned. All of the above evaluations focused on financial, infrastructural, operational and/or environmental impacts associated with FWD use.

Overall, both peer-reviewed and grey literature does not clearly indicate which of these two organic waste management strategies is preferable from an environmental perspective. This is predominantly attributable to the fact that environmental impacts (i.e. global warming potential versus water usage) are extremely difficult to enumerate and qualitatively compare to one another. However, results of this investigation taken in hand with the current conditions in the City of Vancouver and Metro Vancouver suggest that a precautionary approach to increased FWD use would be prudent, prior to advances in municipal sewage infrastructure and upgrades to wastewater treatment plant technology.

A number of recommendations were proposed for further evaluation of these competing organic waste management strategies:

- **ADDITIONAL DATA COLLECTION:** It would be beneficial for the City of Vancouver to collect information on the location, occurrence frequency and effluent organic measurements with respect to combined sewer overflows. Additionally, it would be interesting to evaluate perceptions of multi-family residents about FWD use versus a centralized composting program, as the achievable organics diversion rests largely in the commitment of residents to the program.

- **CITY OF VANCOUVER LIFE-CYCLE ASSESSMENT (LCA):** An LCA specifically conducted for the City of Vancouver would provide quantitative results comparing the environmental, financial, operational and infrastructure-related impacts of a centralized composting system versus FWD use and the municipal sewage system.

- **RE-EVALUATE POST 2050:** The environmental impacts of FWD use and the municipal sewage system should be re-evaluated post 2050, the year that the City of Vancouver will have eliminated a combined sewage system. By this time, it is also possible that upgrades will have been made to wastewater treatment plant technology.

- **PILOT STUDY:** Post 2050, if the City of Vancouver determines that FWDs and the municipal sewage system is a beneficial organic waste management strategy, a pilot study could be conducted to evaluate the environmental, financial, operational and infrastructure-related issues, with results specific to Vancouver.

TABLE OF CONTENTS

ACRONYMS

BOD	–	Biological oxygen demand
CSO	–	Combined sewer overflows
FWD	–	Food waste disposer (also known as food grinder, garburator)
GSAP	–	Greenest City Action Plan
MF	–	Multi-family
SF	–	Single-family
TSS	–	Total suspended solids
WWTP	–	Wastewater treatment plant

1 BACKGROUND: ORGANIC WASTE & THE CITY OF VANCOUVER

1.1 THE GREENEST CITY 2020 ACTION PLAN

The Greenest City Action Plan (GSAP) is a strategy developed by the City of Vancouver to become the greenest city in the world by 2020. Ten unique plans make up the GSAP, all of which fit into the themes of carbon, waste or ecosystems. 'Create Zero Waste' is one of the ten GSAP goals, aiming to reduce the amount of solid waste going to the landfill or incinerator by 50% compared to 2008 levels. The elimination of organics from the waste stream is expected to contribute to approximately half of the 2020 waste reduction target.

1.2 CURRENT ORGANIC WASTE MANAGEMENT STRATEGIES – CENTRALIZED COMPOSTING

All single family residences in the City of Vancouver receiving the yard trimmings collection service can currently dispose of certain organics in the yard trimmings bin, including uncooked fruit and vegetable scraps, coffee grounds and filters, teabags and eggshells, for composting at the Fraser Richmond Soil and Fibre composting facility. A pilot program in the Riley Park and Sunset areas of Vancouver is currently underway, in which all organics scraps can be placed in the yard trimmings cart. This cart is collected weekly, with garbage collection bi-weekly. Approximately 2000 residents are involved in the pilot project. It is expected that a centralized composting system for all single-family homes will be rolled out in the upcoming year.

There is currently no centralized composting system for multi-family residences in the City of Vancouver. A multi-family (MF) residence is defined as a building with five or more units and can include apartments, condominiums and townhouses. Based on data from the Apartment Recycling Program, there are approximately 5,000 multi-family buildings, with a total of about 164,000 units in the City of Vancouver (1). Approximately 50% of individuals in the City of Vancouver live in multi-family housing. Currently 15 privately owned companies offer organics collection services to multi-family buildings, but these are organized and paid for by individual residents.

Approximately 32,400 tonnes of compostable material from Vancouver multi-family homes is disposed of in the landfill each year (2). This represents 44% of the total waste from multi-family homes (please note: tonnage estimate is from 2008, and waste composition estimate is from 2011) (2). The compostable material is predominantly food scraps, but also includes smaller quantities of paper and yard/garden waste (2). This data strongly suggests that the diversion of organics from multi-family homes is a key component of meeting the Greenest City Action Plan Zero Waste Goal.

1.3 CURRENT ORGANIC WASTE MANAGEMENT STRATEGIES – FOOD WASTE DISPOSERS (FWDS)

A food waste disposer (FWD), also referred to as a garburator or food grinder, is a kitchen appliance mounted directly under the kitchen sink and connected to the sewer system. To maintain consistency with the existing literature, the device will be referred to as a food waste disposer (FWD). FWDs allow for the diversion of organic waste from the solid waste stream. They are designed to mechanically break down biodegradable organics such as fruits, vegetables and their peelings, meat scraps, coffee grinds, and small bones. Owing to the fact that typical municipal food waste is approximately 70% water, it has been proposed that treatment of organic waste via the sewage system and wastewater treatment plants is the most efficient and logical organics diversion method (3).

The City of Vancouver currently does not encourage, discourage or prohibit the use of FWDs; however, the City of Port Moody and the Regional District of Nanaimo encourage residents not to use, or even to uninstall their FWDs. The installation and use of FWDs is banned in a number of European countries including Austria, Belgium, Luxembourg, and the Netherlands; their use is actively discouraged in Denmark, France and Germany. On the other hand, some cities and municipalities around the globe encourage the use of FWDs, including areas of the United States, United Kingdom, and Sweden.

The measure of the percentage of households in a city or municipality that have FWDs installed is defined as the 'FWD penetration rate.' The largest market penetration of FWDs is in the United States, with approximately 50% of all households having FWDs installed. The Greater Vancouver Regional District Waste Water Management Report (2000) reported that 33% of GVRD residents own a FWD, and two thirds of these residents actually use their FWDs 'all or most of the time' (4).

2 PURPOSE OF INVESTIGATION

The purpose of this investigation was to evaluate the relative advantages and disadvantages of managing organic material via a centralized composting program versus disposal using FWDs and the municipal sewer system, with specific reference to multi-family residences in the City of Vancouver. This was achieved through two mechanisms. Firstly, the peer-reviewed literature was critically analyzed. Evaluation focussed primarily on environmental impacts, which were subdivided into the following impact categories: diversion potential, global warming potential, water usage, and effluent/emissions. Secondly, existing case reports and studies from other municipalities and cities around the globe were summarized.

3 METHODOLOGY

A combination of peer-reviewed and grey literature formed the basis of this evaluation. Grey literature included reports and case studies. Evaluated reports and case studies included those from the City of Vancouver, Metro Vancouver, consulting companies, and various Canadian, American and European municipalities or cities. The peer-reviewed literature was collated from EBSCO and Web of Science databases. These databases were searched using a variety of keyword combinations. Relevant articles were reviewed, collated, and entered into a spreadsheet for analysis and critical review.

4 RESULTS

4.1 DIVERSION POTENTIAL

Diversion of organic material from the landfill is a complex value to disseminate, as it depends not only on available infrastructure of a waste management system, but also on cooperation levels from residents. Diversion potential is a key factor in assessing waste management options, as it predicts the quantity of organic waste that can be successfully diverted from the landfill.

Please note that all estimates of organic waste composition presented in this report are based the Metro Vancouver Multi-Family Buildings Waste Audit, conducted in 2011 (2), and estimates of quantity are based on the Greenest City Action Plan Administrative Report, which denotes tonnage estimates from 2008 (5).

CENTRALIZED COMPOSTING

Approximately 73,650 tonnes of waste is generated in Vancouver multi-family (MF) residences annually (5). Of this material, approximately 32,400 tonnes is compostable – 44% of the MF waste stream. The largest proportion of compostable material is food waste (36%); the remainder composed of yard and garden waste (6%), and soiled paper products (6%) (2). In aerobic centralized composting methods, all of these materials can be successfully composted.

Organic diversion rates for centralized composting are the product of two variables: participation and capture rates. For MF buildings, participation is measured at the building level; this measure reflects the percentage of buildings that allow residents the opportunity to recycle organics by providing the appropriate bins for collection. Capture rates are measured at the individual level; this measure reflects the percentage of organic waste that individuals place into the appropriate bins and is successfully diverted from the landfill.

To meet the waste reduction target of the Greenest City Action Plan, the incremental diversion rate required from the MF sector has been estimated at 25% organic waste diversion by 2015, and 50% organic waste diversion by 2020 (6). This calculation assumes equal diversion of all materials, including organics and recyclables.

A range of possible organic diversion rates for MF homes in the City of Vancouver was calculated based on possible participation and capture rates (please see Appendix A for calculations). The following assumptions were made for these calculations:

- The participation, capture and diversion rates are based on experiences in other cities and municipalities in North America (see Table 1).
- Capture rates do not exceed 30% following the initial onset of a centralized composting program (as seen in Table 1)
- Participation rates are high (i.e. >70%), as the program would likely be mandatory, owing to the upcoming Metro Vancouver organics disposal ban for MF homes.

TABLE 1. Participation, capture and organic diversion rates that have been evaluated for multi-family homes in other North American municipalities and cities.

Municipality/City	Pilot/ City-Wide	Year	Participation Rate	Capture Rate	Diversion Rate
New Westminster	Pilot	2011	100%	25%	25%
Hamilton	City-Wide	2007	70%	14%	10%
Halifax	City-Wide	1999	100%	[a]	[a]
Toronto	Pilot	2005	100%	25%	25%
Seattle	City-Wide	2011	[b]	28%	[b]

[a] Organics capture rate and diversion rate for multi-family homes is unknown; overall diversion rate for MF homes in Halifax (including recyclables) estimated at 40%
[b] Capture rate of 25% was measured in the buildings serviced by the city, there was no mention of what percentage of buildings participated

Based on the organics diversion rates achieved by other municipalities, it is estimated that organic diversion rates between 11% and 30% can be achieved in multi-family residences through the use of a centralized composting program in the City of Vancouver (see Appendix A for corresponding calculations).

Important to note is that the majority of the evaluated programs in Table 1 are in either pilot or early stages. As the programs develop, it is likely that participation and capture rates will improve. A 30% organics diversion rate in MF homes in the City of Vancouver, the maximum possible diversion rate according to these calculations, suggests that the 25% organics waste diversion target by 2015 is possible to achieve in the MF sector, assuming a program is implemented in a timely manner. Reaching an organics diversion rate of 50% by 2020 in the MF sector, however, would likely require substantial community and education campaigns, as this success rate has not been seen in other municipalities that have evaluated their MF composting programs.

FOOD WASTE DISPOSERS (FWDS) & MUNICIPAL SEWAGE SYSTEMS

An interesting dichotomy exists in the diversion potential for FWDs. On one hand, these devices are considered to be highly convenient and require minimal effort, therefore making FWDs attractive from a participation standpoint. On the other hand, FWDs are not able to dispose of all organic waste, unlike what is achievable through a centralized composting program. Compostable paper and yard and garden waste, which collectively make up 12% of the waste stream in MF residences (2) cannot be disposed of using FWDs. This accounts for approximately 8,800 tonnes of material produced by MF homes in the City of Vancouver (5).

A number of studies have estimated that approximately 50% of food waste can successfully be disposed of using a FWD, yet the average household uses a FWD to dispose of about only 35% of their food waste (7–9). Food waste not suitable for grinding includes bones, fruit pits and fibrous materials like celery, corn husks, artichokes and vegetable peels (10). Penetration rates of FWDs, representing the percentage of households in an area that have FWDs installed, vary between 20% and 33% in Vancouver, according to the GVRD Waste Water Management Report (4). This assumes an equal penetration rate for single-family and multi-family residences.

Based on the percentage of food waste that is disposed of using FWDs, and the percentage of Vancouver residences that have FWDs installed, a range of possible diversion rates for MF homes was estimated for the City of Vancouver. Please see Appendix B for the relevant calculations. This range corresponds with existing estimates of diversion rates for FWDs calculated by consulting companies and other municipalities (7).

For the City of Vancouver, it is estimated that diversion rates between 5% and 12% can be achieved for multi-family residences through the use of FWDs and the municipal sewer system.

SUMMARY

These results indicate that a centralized composting system for multi-family homes in the City of Vancouver can achieve diversion rates between 11% and 30% in the initial stages of the program. The use of FWDs and the municipal sewage system can yield diversion rates between 5% and 12%. Overall, a centralized composting program may allow for greater diversion of organic material from the landfill when compared to FWDs, and also shows potential to continually grow in terms of diversion rate. Undoubtedly, barriers to participation and capture efficiency exist for curbside pickup of compost in multi-family buildings, however the literature indicates that educational programs can have a significant impact on participation (11)**.**

QUICK FACTS:
Centralized Composting vs. Food Waste Disposers

Diversion of Organics

Background

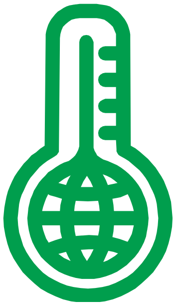
- To achieve the Greenest City Action Plan waste reduction target, organic diversion rates from the multi-family sector must reach approximately 25% by 2015, and 50% by 2020 (6)

Centralized Composting

- 100% of food scraps, compostable paper and yard/garden trimmings can be composted in a centralized composting program
- Capture rates, reflecting participation at the individual level, tend to be substantially lower than building participation rates
- Existing multi-family centralized composting programs show that progress in organic diversion rates comes with time, as educational programs can have a significant impact on participation and issues of contamination
- Based on the participation and capture rates in multi-family buildings in other municipalities, a maximum organic diversion rate of 30% is estimated for multi-family residences in the City of Vancouver through the use of a centralized composting system
- This estimate indicates that a target of 25% organic diversion by 2015 is achievable; however reaching the 50% organic diversion target by 2020 will require substantial educational campaigns and community involvement

Food Waste Disposers (FWDs)

- Disposing of organics using a FWD does not account for compostable paper and yard/garden trimmings, which constitute 12% of organic waste in multi-family residences in the City of Vancouver
- The maximum percentage of household food waste that can be disposed of using a FWD is approximately 50%; individuals report grinding an average of 35% of their food waste
- The maximum penetration rates – i.e. those multi-family residences that have and use a FWD – is estimated to be 33% in the Greater Vancouver Regional District
- Based on a 33% penetration rate, the maximum amount of organic waste that could be successfully diverted from the landfill is approximately 12% of the total organic waste produced in Vancouver multi-family residences



4.2 GLOBAL WARMING POTENTIAL (GWP)

4.2.1 BACKGROUND

In addition to the 2020 waste reduction target, the Greenest City Action Plan includes an initiative to reduce community-based greenhouse gas emissions by 33% from 2007 levels through climate leadership and eliminating dependence on fossil fuels.

Global Warming Potential (GWP) is a commonly used metric to compare the ability of different greenhouses gases (GHGs) to trap heat in the atmosphere (12). In this section of the report, GWP will represent both direct and indirect GHG emissions. Direct emissions occur when pollutants are released directly into the air – for example, due to diesel combustion. Indirect GHG emissions are reflective of energy consumption, where the actual emissions are produced upstream at a power plant (13).

GHG emissions occur throughout the full life cycle of a waste management system, from the inception – including construction of infrastructure – throughout the operation, maintenance, disposal and treatment stages. To evaluate GHG emissions, a commonly used tool in the literature is a Life Cycle Assessment (LCA). An LCA is a method for examining environmental impacts associated with a particular process or product, and is useful for comparing two waste management options from a cradle-to-grave perspective (14).

A number of LCA studies have evaluated the GWP associated with organic waste management techniques. Results consistently show that backyard, home or vermicomposting contribute the least to GWP of all the waste management strategies. Although not the focus of this evaluation, the consistent conclusions of these studies suggest that the use of these low-impact composting technologies should be explored in the future.

CENTRALIZED COMPOSTING

Conflicting results exist in the literature regarding the GHG emissions from centralized composting systems. The main GHG emissions are in the form of carbon dioxide (CO_2) associated with heavy machinery required for the pickup, transport, and processing of organics. GHGs can also be emitted from organic material during the composting process in the form of methane (CH_4) and nitrous oxide (N_2O). These emissions vary substantially depending on the management and employed technologies of a composting facility.

Some sources indicate that curbside pickup and transportation of compost is the major energy consumer and GHG emitter. Lundie (2005) found that the pickup and transport of organics accounted for 74% of all centralized composting process GHG emissions (14). Other studies have found conflicting results, indicating that pickup and transportation of organics contribute a minimal amount to the overall GHG emissions when compared to the processing and disposal stages (15–17).

There are a number of limitations associated with LCAs when evaluating centralized composting systems. There is a large amount of variability in GHG emissions associated with different composting technologies, and the literature is not consistent with the type of technologies they investigate (i.e. windrow, aerated static piles, in-vessel, enclosed channel). Similarly, LCAs account for GHG emissions associated with the transportation and application of compost to land – information that is highly dependent on distance travelled and on the land application method. Finally, LCAs rarely account for the indirect beneficial effects of the compost from a GWP perspective. Soil enriched with compost enables the soil to retain more water and reduces the need for fertilizers, herbicides and fungicides; this has implications for decreased use of these substances in the future, and subsequently decreased emissions associated with their production (18).

Despite these limitations, a rough comparison is nevertheless useful in comparing the environmental impact of a centralized composting program and FWDs/the municipal sewage system. When taking both direct and indirect GHG emissions into consideration, the majority of studies show that the use of FWD/wastewater treatment system is preferable to the use of a centralized composting system.

FOOD WASTE DISPOSERS (FWDS) & MUNICIPAL SEWAGE SYSTEMS

The vast majority of research regarding FWDs has examined the energy consumption associated with in-home FWD usage. In North America, a FWD typically runs on a 350-750 watt motor, and is used approximately 2.4 times per day for 16 seconds; this equates to an annual electricity consumption of 2-3kWh/household/year (19). In BC, this equates to less than 1% of a household's energy consumption (20). Emissions throughout the life cycle of FWD use and the sewage system are not well characterized in the literature. Lundie (2005) found that 26% of the energy required in the lifecycle of liquid waste was attributed to the FWP device; 39% to transport in the sewage system, and 29% from the production of electrical energy (14).

There is one very important feature of FWDs and the wastewater treatment system with respect to GHG emissions: the production of energy from the anaerobic digestion of sewage sludge. Sludge removed from the secondary wastewater treatment process is heated in a digester; methane gas is produced which then is used to create heat and electricity. In LCA analyses, the ability of a treatment plant to create energy factors in as a 'credit' in the LCA equation. In other words, this process is creating usable energy and is avoiding the GHG emissions associated with producing energy by other means. This energy production is the only consistent piece of evidence that shows that FWD installation and use is preferable over a centralized composting system.

It is pertinent to evaluate how these results apply to the City of Vancouver and Metro Vancouver. Five wastewater treatment plants service the Metro Vancouver region. Of these, two are able to convert methane into usable electricity, and four are able to convert methane into usable heat for surrounding facilities (Table 2). We must therefore consider that Metro Vancouver does not currently possess the ability to create usable electricity and heat from all wastewater treatment facilities, unlike what is evaluated in the literature.

TABLE 2. Metro Vancouver wastewater treatment plants and electricity/heat generation ability.

Plant	Methane production	For Electricity	For Heat
Annacis Island WWTP	Y	Y	Y
Iona Island WWTP	Y	Y	Y
Lions Gate WWTP	Y	N	Y
Lulu Island WWTP	Y	N	Y
North West Langley WWTP	N	N	N

SUMMARY

The literature consistently indicates that use of FWDs/municipal sewage system is a preferable organic waste management strategy to a centralized composting program from the perspective of global warming potential. This is due to (1) the greenhouse gas emissions associated with the pickup, transport and processing of organic waste in a centralized composting process and (2) the ability of wastewater treatment plants to create usable energy from sewage sludge. These results cannot be generalized to all of Vancouver, however, as not all wastewater treatment plants have the ability to convert methane into usable energy. It must also be noted that these results will be subject to change if composting facilities also have the ability to create usable energy through the use of anaerobic digestion. In fact, this technology has been developed for use at the Fraser Richmond Soil & Fibre composting facility.

QUICK FACTS:
Centralized Composting vs. Food Waste Disposers

Global Warming Potential (GWP)

Background

- The Greenest City Action Plan includes initiatives to reduce community-based greenhouse gas emissions by 33% from 2007 levels through climate leadership and eliminating dependence on fossil fuels

- Greenhouse Gas (GHG) emissions can be direct (i.e. combusting fuel in diesel trucks) or indirect (a device requires electricity, and emissions occur upstream at the power plant that creates the electricity)

Centralized Composting

- Direct GHG emissions occur during pickup, transportation and processing of organic waste, in addition to GHG emissions from organic material during the composting process

- Diligent management of composting processes is critical in the prevention of GHG emissions

- Anaerobic digestion and the creation of useable energy at composting facilities is not taken into account in the literature, but this technology – if adopted in the future – will have a significant impact on the GWP of centralized composting

Food Waste Disposers (FWDs)

- The source of GHG emissions throughout the life cycle of FWD use and wastewater treatment is not well understood; the majority of research has only investigated the at-home energy requirements of the FWD, which account for less than 1% of energy consumption in BC homes

- The most beneficial aspect of FWDs and wastewater treatment is the digestion process, where methane is captured to produce usable energy and heat; this can offset emissions associated with the wastewater treatment process

- Most life cycle analyses (LCAs) show that because of the creation of usable energy, use of FWDs is preferable to centralized composting from a GWP perspective

- The appropriate infrastructure must be in place for FWDs and the wastewater treatment process to rank above a centralized composting system in terms of GHG emissions – it should be noted that only two of the five wastewater treatment plants in Vancouver have this capability

4.3 WATER USAGE

The most common criticism of FWDs in the public domain is the potable water required for their use. There are two conflicting schools of thought in reference to this issue. One, as presented by the FWD industry, is that organic food waste is 70% water, thus it should be treated using the sewer system and not treated as a 'solid' in a the composting process (21). The competing viewpoint is best summed up in a report to the City of Peel, where it was stated that "it is environmentally inefficient to mix food waste with water, transport it to the plant, and then expend resources to separate the solids from the water through an expensive dewatering process" (22).

CENTRALIZED COMPOSTING

Few details are provided in the literature regarding what water is used for, in what stages, and in what quantities throughout the life cycle of a centralized composting process. Lundie (2005) determined through the use of an LCA that centralized composting is associated with 19 kL of water per functional unit. A function unit is described as the management of the average amount of food waste produced by a household in 1 year. This can be compared with 2335 kL of water per functional unit required for a FWD and sewage treatment.

FOOD WASTE DISPOSERS (FWDS) & MUNICIPAL SEWAGE SYSTEMS

Calculations of water consumption associated with FWD use in the literature tend to use a value of approximately 12 liters of water required for every kilogram of food waste. Based on this water usage per kilogram of food waste, estimates of water consumption from FWD operation range from 2.2 to 4.3 L/day, which corresponds to between 0.7 to 3.0% of total household water use (3,19). To put this water usage into context, the water consumed from one flush of a toilet varies between 6 and 18 litres.

These estimates from the literature hold true for the City of Vancouver. It is estimated that an average of 2.6 liters of water per multi-family household per day is required to dispose of organics through the use of a FWD. Calculations and assumptions for this value can be seen in Appendix C.

The literature indicates that water consumption associated with the operation of wastewater treatment plants is minimal compared to the water used during FWD operation. The study by Lundie (2005) mentioned above demonstrated that 2335 kL of water per functional unit was required for FWD and sewage treatment. 97% of that water is consumed during the operation of the FWP.

SUMMARY

Evidence from the literature contradicts the common public opinion that a significant amount of water is consumed during FWD operation; daily FWD use in an average City of Vancouver multi-family home corresponds with less than 1 flush of a toilet. The fact remains, however, that the water usage associated with FWD operation far exceeds the water required during a centralized composting system, when examined from a life cycle perspective.

QUICK FACTS:
Centralized Composting vs. Food Waste Disposers

Water Usage

Background

- Supporting sustainable use of water resources for future generations is an important goal for the City of Vancouver
- The largest public criticism of food waste disposers (FWDs) from an environmental perspective is the amount of potable water required for their operation

Centralized Composting

- Water usage is not well characterized in the literature; the literature does not review what water is used for, in what quantities is it used, and in water stages of the process it is required

Food Waste Disposers (FWDs)

- FWDs require approximately 12 liters of water for every kilogram of food waste
- Estimates of water usage correspond to 0.7-3.0% of total household water use
- Calculations specific to the organic waste produced in multi-family residences in the City of Vancouver indicate that residences with a FWD use approximately 2.6 L per multi-family household per day (equivalent to less than 1 flush of a toilet)
- Approximately 97% of the water consumed during the life cycle of the FWD/municipal sewage system is associated with household water consumption required for FWD operation
- Despite the fact that daily FWD use corresponds with a small percentage of total household water use, amount of water consumed from the use of a FWD significantly exceeds that used in a centralized composting process
- The above point is enumerated in one study, where the life cycle analysis of water usage for a centralized composting system was 19kL per functional unit (a unit indicating the management of food waste produced by a household in one year), versus that of a FWD and sewage treatment, at 2335 kL per functional unit

4.4 USABLE PRODUCTS

Both composting and the wastewater treatment process result in useful outputs. Compost acts as a mechanism to return valuable nutrients to the soil and can be donated or sold back to the community. The wastewater treatment process has two beneficial products: energy generation from anaerobic digesters (where facilities exist), and usable soil amendment or fertilizer from biosolids. This section will not evaluate energy generation, as this is addressed in the global warming potential section of the report. Upon assessing environmental benefits of these products, their quality, usability and risks must also be evaluated.

CENTRALIZED COMPOSTING

The BC Organic Matter Recycling Regulation (OMRR) regulates the production, distribution, sale, storage, use and land application of compost. Compost is classified as either Class A or Class B based on the biological, metal and nutrient composition. Class A compost, otherwise known as 'retail-grade organic matter' can be distributed and applied without restriction. Class B compost, known as 'managed organic matter' is subject to restrictions, including buffer distances for applications near surface water, grazing and food crop restrictions, and signage requirements if contamination levels exceed the designated threshold (23).

Compost contamination has been widely evaluated in the literature. However, results are difficult to generalize owing to differences in feedstock, composting processes, temperature, pH, etc. One consistent piece of evidence is that source segregation of organics (i.e. the separation of organics from the rest of the garbage stream at the residential level) decreases contamination dramatically compared to mixed refuse compost that is mechanically separated. This suggests that compost from a centralized composting system does not have a high risk of contamination.

FOOD WASTE DISPOSERS (FWDS) & MUNICIPAL SEWAGE SYSTEMS

Following treatment at a wastewater treatment plant, the remaining solid fraction, known as 'biosolids,' requires disposal. Disposal options for biosolids include incineration, landfill and land application. Owing to the high nutrient load of biosolids, the preferred option is using the material as a soil amendment or fertilizer. Applications include land reclamation, agricultural land and forest fertilization, erosion control and slope stabilization. The literature indicates that increased use of FWDs does in fact increase biosolids production, however incrementally the change is very small. This is due to the fact that material passing into a WWTP is reduced by about 90% during the digestion process (24).

Also regulated by the BC OMRR, biosolids are classified as either Class A or Class B, based on the biological, metal and nutrient composition. Both Class A and B biosolids are restricted in their use based on land type (agricultural, silvicultural or land reclamation, for example) and quantities applied (23). Stringent restrictions are assigned for biosolids owing to the fact that sewage sludge can contain high concentrations of potentially toxic elements such as heavy metals, organic pollutants (like PCBs and brominated flame retardants) and a diverse array of chemicals contained in personal care products and pharmaceuticals (25,26).

SUMMARY

There has been much concern, in both community and academic audiences, regarding the use of biosolids as soil amendments and fertilizers. The majority of concern stems from the heavy metals, hormones and chemicals that may be present in biosolids. The literature indicates that increased use of FWDs does not significantly increase WWTP biosolid quantity. This, taken in hand with the regulations in place regarding biosolids application, does not suggest that increased use of FWDs would be environmentally detrimental from the perspective of biosolids production and usage. There is no evidence that either biosolids or compost is more beneficial, as each are used independently and the benefits have not been evaluated or compared quantitatively.

QUICK FACTS:
Centralized Composting vs. Food Waste Disposers

Useable Products

Background

- Both composting and digestion of sewage sludge result in usable products that can be environmentally and economically beneficial
- Regulating bodies set limits on quantities of heavy metals, biological organisms and chemicals present in compost and biosolids; the products are then classified accordingly. Classifications designate how, where and in what quantities these products can be applied. In British Columbia, these limits are imposed under the Organic Material Recycling Regulation (OMRR)

Centralized Composting

- Source segregation of organics (i.e. the separation of organics from the rest of the garbage stream) results in high-quality compost which typically has little contamination in terms of heavy metals and chemicals
- Compost produced from a centralized composting system can be used by landscapers, lawn care companies, golf courses, nurseries, retail garden centres and in agriculture

Food Waste Disposers (FWDs)

- Biosolids are the nutrient-rich solids remaining from the anaerobic digestion process
- Biosolids can be used for land reclamation, agricultural land and forest fertilization, erosion control, slope stabilization and as a component of compost
- The literature indicates that increase in FWD usage does not correspond with the production of significantly higher amounts of biosolids, as material passing through a wastewater treatment plant is reduced by about 90% during the digestion process
- Biosolids can contain high concentrations of potentially toxic elements, including heavy metals, organic pollutants and chemicals from personal care products and pharmaceuticals. Because this issue has been well characterized in the literature, British Columbia has imposed strict restrictions on the use and application of different classes of biosolids
- There is no evidence that either biosolids or compost is more beneficial, as each are used independently and the benefits have not been evaluated or compared quantitatively.

4.5 Effluent & Emissions

4.5.1 Aquatic & Terrestrial Eco-Toxicity

Centralized Composting

Evaluating emissions associated with a centralized composting program is challenging for a number of reasons. Types and quantities of emissions vary according to specific composting methods. Other features which impact emissions from a composting facility include feedstock, moisture, aeration, temperature, humidity, pH and age of the pile (27,28). Common emissions and their associated environmental impact can be seen in Table 3.

Table 3. Common emissions from composting facilities and their associated environmental impacts.

Emission	Description
Bioaerosols	▪ Includes bacteria, fungi, viruses ▪ Potential health implications for individuals in the surrounding environment
Volatile Organic Compounds (VOCs)	▪ Concern from an environmental and health perspective ▪ Contribute to the formation of ground-level ozone when combined with oxides of nitrogen (NO_x). Ground-level ozone can elicit harmful effects on ecosystems, as well as contribute to respiratory-related issues in humans
Heavy Metals	▪ Elements of concern include zinc, copper, nickel, cadmium, lead, chromium and mercury ▪ Long-term accumulation of metals has consequences for plant toxicity, the human and animal food chain, and soil microbial processes
Leachate	▪ Leachate is defined as the product of water percolating through refuse ▪ Can contain any number of substances present in a compost pile – biological oxygen demand (BOD), nitrogen-containing compounds, phenols, pesticide residues and heavy metals ▪ Can seep through soil or runoff to surrounding surface water, with implications for both the local ecology and drinking water
Greenhouse Gases	▪ Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) can be emitted from both composting machinery and the organic material being processed

These potential environmental effects cannot be directly compared to FWDs and the sewage system; nor can they be enumerated specifically for Vancouver composting facilities. Composting air emission monitoring and diligent composting facility management are methods that must be employed to ensure these variables do not contribute negatively to the ecological footprint of a composting facility. Precautionary measures that can be taken that account for these emissions are outlined in the BC Organic Matter Recycling Regulation, 2007 (29).

FOOD WASTE DISPOSERS (FWDS) & MUNICIPAL SEWAGE SYSTEMS

Municipal wastewater effluent represents one of the largest single effluent emissions in Canada (30). The impacts of these emissions are far reaching, ranging from environmental effects like marine ecosystem contamination and destruction, to anthropogenic effects such as restrictions on drinking water, fish and shellfish consumption, and outbreaks of water-borne diseases.

There are currently five wastewater treatment plants that serve the Greater Vancouver Regional District: Iona Island, Lions Gate, Annacis Island, Lulu Island, and Northwest Langley. Of these, Iona and Lions Gate are primary treatment plants; the remaining three are secondary treatment plants. Primary and secondary plants differ in their treatment processes, and therefore also differ in the amount of organic materials released into surrounding water bodies.

The literature consistently demonstrates that a number of different nutrients and chemicals are contained in sewage discharge; however, the effluent parameters that are relevant from the perspective of increased FWD use are biological oxygen demand (BOD), total suspended solids (TSS), nitrogen (N) and phosphorus (P). See Table 4 for a brief description of these measures and their associated environmental impacts.

TABLE 4. Organic measures resulting from sewage discharge and associated implications for aquatic ecosystems.

Measure	Description
BOD	▪ Indicates degree of organic pollution in a water body ▪ Refers to the amount of dissolved oxygen (O_2) consumed by biological organisms during the breakdown of organic matter ▪ High BOD levels result in low levels of dissolved O_2 ▪ Low dissolved O_2 result in a disruption of aquatic ecosystems
TSS	▪ Solid materials suspended in water that can be trapped by a filter ▪ TSS can block light from reaching submerged aquatic vegetation, thereby decreasing oxygen levels due to a decrease in photosynthesis ▪ TSS can also absorb heat, increasing surface water temperature and disrupting optimal temperatures for aquatic ecosystems
Eutrophication Potential (N and P)	▪ In aquatic environments, excessive aquatic plant growth results from the release of large amounts of nutrients (particularly nitrogen and phosphorus) ▪ In terrestrial ecosystems, the contribution of nitrogen oxides (NO_x) and ammonia (NH_3) to the soil can change the nutrient content and affect survival and growth of plant species ▪ As the plant life is broken down by bacteria, bacteria also consume the dissolved O_2, affecting the surrounding aquatic ecosystem

Studies that have investigated changes in sewage composition corresponding with increased installation and use of FWDs show consistent results. These confirm the logical assumption that increased organic matter in the sewage stream results in a corresponding increase in nutrient loading in wastewater treatment plant influent. This has been demonstrated for nitrogen and phosphorus (14,15), TSS and BOD (3,31).

The potential for increased organic loading in Vancouver sewers and WWTPs is a concern for two reasons. Firstly, there is inevitable discharge of effluent into water bodies, particularly with primary wastewater treatment plants. The Greater Vancouver Sewerage and Drainage District Quality Control Annual Report (32) provided estimates of the reduction of BOD and TSS in each of the WWTPs. Table 5 depicts these results, and demonstrates the substantial difference in the ability of each treatment plant to decrease the percentage of BOD and TSS before it is disposed of into surrounding waterways.

Interestingly, the majority of the life cycle assessments in the literature have concluded that the environmental impact associated with increased organic loading in the sewers and WWTPs is not a problem from an environmental perspective. It is crucial that this evidence be critically evaluated: the evaluated wastewater treatment plants in these studies tend to utilize tertiary treatment of sewage. This level of treatment is not available in Vancouver, meaning that we experience significantly more direct discharge into water bodies than those plants evaluated in the literature.

TABLE 5. Percent BOD and TSS reduction from the five Metro Vancouver wastewater treatment plants (32).

Wastewater Treatment Plant	% BOD Reduction	% TSS Reduction
Iona Island *	36	55
Lions Gate*	35	64
Annacis Island **	96	92
Lulu Island **	98	97
Northwest Langley**	97	91

* Reduction for primary plants expected to be 30% for BOD and 60% for TSS.
** Reduction for secondary plants expected to be 90% for both TSS and BOD.

The second, and most crucial issue for the City of Vancouver, is the environmental implications of increased organic material in the sewage stream resulting from increased FWD use, and the issue of combined sewer overflows (CSOs). Combined sewer systems utilize the same pipe to collect and transport stormwater runoff and domestic sewage to a WWTP. During periods of heavy rain, the volume in the combined sewer system can exceed the capacity of the WWTP, discharging or ‘overflowing’ directly into surrounding water bodies. This phenomenon is known as a CSO.

As described above, increased FWD use increases the organic loading in a municipal sewage stream. Direct discharge of this sewage stream into coastal aquatic areas of Vancouver is extremely concerning from an environmental perspective, for the reasons described in Table 4. As further evidence to this issue, under the Sewer Use Bylaw (Municipal Code, Chapter 681-10, Section E), the City of Toronto has banned FWD usage in areas of the city served by combined sewers (33).

Currently, the City of Vancouver is transitioning from a combined sewer system to a separate sewer system, which will eventually eliminate the issue of CSOs. Although the transition has been underway for a number of years, the project will not be completed until 2050. The possibility of continued CSOs is a major discouraging factor for the increased use of FWDs.

SUMMARY

Both composting and FWD/municipal sewer systems are associated with emissions and effluent that can result in terrestrial and aquatic eco-toxicity. For composting, this can include bioaerosols, volatile organic compounds (VOCs), heavy metals, leachate and greenhouse gases. Air emission monitoring and proper facility management act to minimize these emissions; guidelines for which are designated under the BC Organic Matter Recycling Regulation. It has been consistently demonstrated that increased FWD use increases the organic material in a sewage stream, which in turn increased the biological oxygen demand (BOD), total suspended solids (TSS), nitrogen and phosphorus levels, all of which are harmful for aquatic environments. In Vancouver, two factors indicate that increased organic loading in the sewage stream is concerning: two primary wastewater treatment plants, which discharge between 50-60% of BOD and TSS into surrounding water bodies (Table 5), and combined sewer overflows (CSOs), which discharge all stormwater and sewage directly into surrounding water bodies. The presence of primary WWTPs and the ongoing issue of CSOs is a major discouraging factor for the increased use of FWDs.

4.5.2 ACIDIFICATION

Acidification is an environmental issue that affects both terrestrial and aquatic ecosystems. Acidification occurs when gases in the atmosphere react with water molecules to form acids, which then fall in the form of acid rain and enter the soil and water bodies. The most common gases associated with acidification are sulphur dioxide (SO_2), nitrogen oxides (NO_x) and ammonia (NH_3) (34). On land, acidification is associated with soil nutrient depletion, harmful effects on plant life, and enhancing the release of particular toxic chemicals. In the water, changes in pH have particularly damaging effects for coral reefs, which play a crucial role in the functioning of ecosystems.

CENTRALIZED COMPOSTING

The production of gases associated with acidification occurs through multiple stages of the life cycle of a centralized composting process. SO_2 and NO_x emissions occur during the transportation of organic waste and during operation of machinery at the composting facility. These emissions are associated with the combustion of diesel fuel. The largest contribution to acidification potential, however, is the NH_3 emissions from the aerobic composting process itself (35).

The literature presents consistent evidence that a centralized composting process emits significantly larger quantities of SO_2, NO_x and NH_3 than the use of FWDs and treatment via the municipal sewer system (14,36,37).

FOOD WASTE DISPOSERS (FWDS) & MUNICIPAL SEWAGE SYSTEMS

It is not clearly defined and quantified in the literature what aspects of the FWD/municipal sewer system life cycle emit gases that contribute to acidification. As stated above, when compared and ranked in terms of acidification potential, the use of FWDs and the municipal sewer system consistently rank as more favourable when compared to a centralized composting system (14,36,37).

SUMMARY

In life cycle analyses of a centralized composting program, acidification potential consistently emerges as the most detrimental of all associated environmental impacts. Sulphur dioxide (SO_2) and nitrogen oxides (NO_x) are released during transportation and on-site processing of organics via the combustion of diesel fuel. The greatest contribution to acidification potential is the release of ammonia (NH_3) from the aerobic composting process itself. Measures can be taken to decrease the emission of ammonia from composting facilities, such as the use of gas collection mechanisms and biofilters.

4.5.3 Fats, Oils & Grease (FOG)

Centralized Composting

Environmental issues associated with fats, oils and grease (FOG) in a centralized composting program have not been evaluated in the literature.

Food Waste Disposers (FWDs) & Municipal Sewage Systems

FOG is an environmental, infrastructural and financial concern with respect to municipal sewage systems. Environmentally, untreated FOG reaching aquatic ecosystems is associated with depletion of oxygen in aquatic environments and pollution of aquatic habitat. In terms of infrastructure, FOG can block and damage sewage pipes, bind screens, and is often associated with overflows and odour problems at wastewater treatment plants – all issues with financial implications.

There is conflicting evidence in the literature regarding increased FWD use and corresponding levels of FOG in the municipal sewage system. Two studies found that increased FWD use was not associated with increases in FOG or sewage blockages (19,38). Other studies have indicated that increase FWD use will likely increase FOG levels and sewage blockages (9,10).

Not only does the literature provide conflicting results, but evaluating the issue of FOG in relation to FWD use relies on (1) a pilot study to compare FOG levels before and after FWD installation and use and (2) assumptions about a city's municipal sewage system and infrastructure. It is therefore difficult to make a definitive conclusion about this issue with relevance to the City of Vancouver.

Summary

Fats, oil and grease (FOG) have no known environmental issues in the context of a centralized composting program. FOG is associated with environmental, infrastructure and financial costs for the municipal sewage system. However, the literature provides inconsistent results with respect to the impact of increased FWD use on FOG levels and associated blockages.

QUICK FACTS:
Centralized Composting vs. Food Waste Disposers

Effluent & Emissions

Background

- Both centralized composting processes and FWDs/municipal sewer system produce effluent and emissions that can detrimentally affect the surrounding environment.

Centralized Composting

- Composting facilities have the potential to release a number of pollutants into the air, water and soil, including bioaerosols, volatile organic compounds (VOCs), heavy metals, leachate, and greenhouse gases. The BC Organic Matter Recycling Regulation (2007) provides management strategies to minimize these emissions.

- The most common gases associated with acidification are sulphur dioxide (SO_2), nitrogen oxides (NO_x) and ammonia (NH_3). The literature consistently indicates that centralized composting facilities contribute more to acidification than FWD use and the municipal sewer system, owing to emissions of SO_2 and NO_x from heavy machinery usage, and NH_3 from the organic material during the composting process.

Food Waste Disposers (FWDs)

- Increased use of FWDs results in increased organic loading in sewers, which includes increased biological oxygen demand (BOD), total suspended solids (TSS), nitrogen and phosphorus. These substances have a number of detrimental effects on aquatic ecosystems.

- In Vancouver, two of the five wastewater treatment plants use primary treatment; this results in between 50-60% of the organic loading in sewage being discharged into aquatic environments. Increased FWD use would contribute to the organic load reaching local waterways.

- Combined sewer overflows (CSOs) result in the direct discharge of the sewage stream into aquatic environments. Increased FWD use would contribute to the organic load reaching local waterways.

- Literature evaluations typically conclude that increased FWD use does not result in harmful emissions into aquatic environments. These results are not applicable to the City of Vancouver, owing to differences in sewer systems and treatment technologies in Vancouver wastewater treatment plants.

4.6 Reports and Case Studies

Various cities and municipalities have commissioned investigations to determine the advantages and disadvantages of FWDs as an organic waste management strategy. A summary of the reports, year of publication, subject of investigation, and overall conclusions and recommendations are presented in Table 6. The impact categories that were assessed in these investigations varied, and included financial (F), infrastructure (I), environmental (E), and health (H). These are indicated in the subject line of Table 6. Also noted is the presence of bias in the study, owing to industry sponsorship.

Table 6. Report and case study results from cities and municipalities regarding FWD use.

Investigator	Year	Subject	Conclusions	Bias Present
New York City (9)	1999	FWDs (F,I)	• Lift ban on FWDs • Positives > negatives, but only for a FWD growth rate of <1%/year	No
In-Sink-Erator, based on report from University of Wisconsin-Madison (21)	1998	FWDs (E, F, I)	• FWD use should be encouraged over all of MSW organics management systems	Yes
Herefordshire Council/Worcestershire Council, UK (38)	2007	FWDs versus CC[a] (E, F, H)	• FWD use should be encouraged over centralized composting • Based on odour, convenience and global warming potential (GWP was the only environment impact evaluated)	No
Sydney, Australia: Report Prepared for In-Sink-Erator (39)	2000	FWDs (E, F, I)	• Should promote FWD use • Conclusions do not hold for penetration >15%	Yes
Halton Region, Ontario (8)	2005	FWD versus CC[a] (E, F, I)	• Centralized composting program preferable over the use of FWDs • Due to low diversion rate (estimated 2-5%) using FWDs	No
Ireland Environmental Protection Agency (10)	2008	FWDs (E, F, I)	• Do not promote FWD use • Due to prevalence of sewer blockages, CSOs and insufficient capacity of WWTPs	No

[a] CC = Centralized Composting Program

The study conducted in New York City in 1999 is a widely referenced investigation in the FWD research realm. New York City had banned the use of FWDs since the 1970's, due to concern of sewer blockages and increased operational and maintenance costs (7). Following a 21-month period of FWD use in certain areas of the city, the environmental, financial and operations impacts were evaluated. The study showed that the introduction of FWDs did not result in a large increase in water use. Evaluation of contaminant levels in open water and tributaries showed that a minimal increase in biological oxygen demand occurred due to FWD use and wastewater treatment plant discharge. In terms of the sewer system, an increase in suspended solids, oil and grease was seen, which was reflected in increased maintenance costs to the city. Overall, however, it was determined that the benefits – namely landfill diversion – outweighed the negatives of FWD use, and the ban on FWD installation and use was lifted. An important caveat was that the favourable conclusion of FWD use only held if the growth rate of FWD installation did not exceed one percent per year.

Three reports concluded that FWD installation and use is a highly favourable method of organic waste management: a report produced by the University of Wisconsin-Madison (21); a case study produced by the Cooperative Research Centre for Waste Management and Pollution Control evaluating areas of Sydney, Australia (39); and a report produced for the Herefordshire Council and Worcestershire Council in the UK . Common findings in these evaluations were that FWD use is favourable owing to generation of energy from digestion of biosolids. Of course, all facilities treating biosolids must be equipped with digesters for this conclusion to be applicable. All three studies determined that the increased loading to sewer systems and wastewater treatment plants would be minimal. The one study that evaluated environmental effects other than global warming potential found that FWD use contributed more to aquatic and terrestrial eco-toxicity and eutrophication than any other organic waste management strategy. Similar to the New York City study, two of these reports explicitly stipulated that favourable use of FWD would only hold up to 15% market penetration of FWDs.

Reports from the Halton Region of Ontario (7), and the Environmental Protection Agency of Ireland (10) determined that FWD installation and use should not be encouraged over other methods of organic waste management. The take-home message from the Halton Region report was in reference to waste diversion: it was estimated that the use of FWDs could achieve a 2-5% increase in organics diversion over a 20-year timeframe for approximately $177 million, versus a centralized organics composting program which could achieve 15-20% organics diversion for approximately $91 million. The Ireland EPA report concluded that owing to the prevalence of sewer blockages, combined sewer overflows and insufficient capacity of wastewater treatment plants, increased FWD installation and use would be costly and inefficient.

Interestingly, of the four reports or case studies that recommended the use of FWDs for the management of organic waste, two had major sources of bias. These reports were prepared for, or prepared by, In-Sink-Erator – the industry leader in FWD production and installation.

5 DISCUSSION

5.1 SUMMARY

This report qualitatively evaluated the environmental impacts associated with two organic waste management strategies for multi-family homes in the City of Vancouver: a centralized composting program and the use of food waste disposers (FWDs) and the municipal sewage system. Environmental impacts were assessed using both peer-reviewed literature and grey literature, which included reports and case studies. Evaluation focussed on five main environmental categories: diversion potential, global warming potential, water use, useable products, and effluent/emissions.

The literature presented conflicting results. The strongest evidence in support of a centralized composting program was in terms of diversion potential and the eco-toxicity. The strongest evidence in support of FWD use and the municipal sewage system was the issue of acidification. The environmental impact categories of global warming potential (GWP), water usage and useable products did not provide as consistent or as clearly defined results.

Studies undertaken by other cities and municipalities around the globe also demonstrate conflicting results. Investigations in the UK, Sydney, Wisconsin and New York determined that increased use of FWDs is both acceptable and desirable from an organic waste management perspective. Investigations conducted for the Halton region of Ontario and the Ireland Environmental Protection Agency concluded that FWD use should not be encouraged, or FWD use should be altogether banned. All of the above evaluations focused on financial, infrastructural, operational and/or environmental impacts associated with FWD use.

The available evidence regarding environmental impacts of a centralized composting program versus increased FWD use and the municipal sewage system does not present a straightforward conclusion. However, with specific reference to the City of Vancouver and Metro Vancouver, it appears that a precautionary approach to increased FWD use would be prudent, prior to advances in municipal sewage infrastructure and wastewater treatment plant upgrades in technology.

5.2 LIMITATIONS

5.2.1 LIMITATIONS TO THE LCA APPROACH

The majority of the peer-reviewed literature used the Life-Cycle Analysis (LCA) approach to evaluate the environmental impacts of centralized composting programs and the use of FWDs. Some inherent limitations exist with the use of LCAs. Firstly, all calculations are based on assumptions regarding quantities of waste, transportation distances, energy consumption, sources of energy, among numerous others. In some LCAs, these assumptions are explicitly stated, allowing the reader to draw his or her own conclusions about the generalizability of the study results. Some, on the other hand, do not state these assumptions. It is therefore critical when applying the results of LCAs that the investigators take into account how applicable the LCA results are to the municipality or city in question.

5.2.2 Biases of Available Literature

A pronounced and concerning issue emerged in relation to the biases of the available literature. In both the grey literature (reports and case-studies) and peer-reviewed literature, it became apparent that In-Sink-Erator, the industry leader in FWD technology and installation, plays an active role in this research area. It was particularly unnerving that some peer-reviewed journal articles comparing the environmental impacts of waste management strategies were openly sponsored by In-Sink-Erator, and some even discussed In-Sink-Erator by name when discussing general information about FWDs. This biased trend in the literature has been noted by other authors (10). For future research efforts, it is crucial that In-Sink-Erator sponsored LCAs, reports and case studies be critically analyzed in terms of methodology, results, conclusions, and consistency with the existing literature.

6 RECOMMENDATIONS

A number of recommendations were proposed for further evaluation of these competing organic waste management strategies.

6.1 Additional Data Collection

An interesting and pertinent avenue to explore in this evaluation would have been the analysis of City of Vancouver and Metro Vancouver data in terms of sewage composition, measurement of BOD, TSS, N and P in the water bodies surrounding wastewater treatment plants, and statistics regarding the timing, location and frequency of combined sewer overflow occurrences. This data would provide quantitative evidence to either support or refute the conclusion that increased use of FWDs would not be environmentally beneficial for the City of Vancouver. Because these measures are currently unavailable, it is recommended that such monitoring take place to produce some data relevant to Vancouver that can be compared with the literature.

It would also be valuable to conduct an assessment of public perceptions and opinions of the two organic waste management strategies. As elucidated in the evaluation of diversion potential, the participation level of residents plays a significant role in the success of an organics program.

6.2 City of Vancouver Life-Cycle Assessment (LCA)

If the City of Vancouver desires quantitative results in addition to the qualitative assessment provided in this report, a Life-Cycle Assessment (LCA) conducted specifically for the City of Vancouver would be highly beneficial. This LCA would provide quantitative results comparing the environmental, financial, operational and infrastructure-related impacts of a centralized composting system versus FWD use and the municipal sewage system, and not rely on the assumptions made by other LCAs in the literature.

6.3 Re-Evaluation Post 2050

Assuming the precautionary approach is taken prior to 2050 with reference to FWD use, the environmental impacts of FWD use and the municipal sewage system should be re-evaluated post 2050. By 2050, the City of Vancouver will have eliminated a combined sewage system, and therefore the issue of combined sewer overflows (CSOs). By this time, it is also possible that upgrades will have been made to wastewater treatment plant technology. This may affect not only the eco-toxicity implications of FWDs and the municipal sewage system, but also global warming potential as composting facilities are now beginning to generate usable energy through the use of anaerobic digesters.

6.4 PILOT STUDY

Post 2050, if the City of Vancouver determines that FWDs and the municipal sewage system is a beneficial organic waste management strategy, a pilot study could be conducted. This is an effective means to evaluate the environmental, financial, operational and infrastructure-related issues, with results specific to Vancouver.

7 ACKNOWLEDGEMENTS

I would like to thank the University of British Columbia/City of Vancouver Greenest City Scholar Program, for providing me with the opportunity to undertake this investigation.

Thank you to Jonathan McDermott and Simone Rousseau at the City of Vancouver for acting as mentors and contributing their knowledge, assistance and support. In the Solid Waste Management Branch, thank you to Monica Kosmak, Bob McLennan and Michelle Harris for helping me to understand the intricacies of the solid waste management world. In the Sustainability Office, thank you to Amy Fournier for her continuing support, information and ideas.

8 APPENDICES

APPENDIX A:

Calculation of multi-family organics diversion rates in the City of Vancouver based on the success of multi-family centralized composting systems in other cities and municipalities.

Participation Rate	Capture Rate	% Diversion	Amount (tonnes) Diverted from Landfill
100%	30%	30%	9720
100%	15%	15%	4860
90%	30%	27%	8748
90%	15%	14%	4374
70%	30%	21%	6804
70%	15%	11%	3402

APPENDIX B:

Calculation of food waste diversion for all multifamily homes in the City of Vancouver based on the use of FWDs.

Scenario 1:

- **FWD grinding 50% of food waste**
- **FWDs installed and used in 33% of Vancouver MF Homes**

Category	Description/Assumption	Amount (tonnes)
Total organics	Including food waste + compostable paper + food/garden waste	**32,400**
Food waste only	Total organics – (compostable paper + food/garden waste)	32,400 – 8,800 = **23,600**
Capture Rate	FWD grinding 50% of food waste	23,600 x 50% = **11,800**
Participation	FWD in 33% of Vancouver MF homes	11,800 x 33% = **3,894**
Percent Diversion	% of total organic waste in MF homes to be disposed of by FWDs	(3,540 / 32,400)*100 = **12%**

Scenario 2:

- **FWDs grinding 35% of food waste**
- **FWDs installed and used in 20% of Vancouver MF homes**

Category	Description/Assumption	Amount (tonnes)
Total organics	Including food waste + compostable paper + food/garden waste	**32,400**
Food waste only	Total organics – (compostable paper + food/garden waste)	32,400 – 8,800 = **23,600**
Capture Rate	FWD grinding 35% of food waste	23,600 x 35% = **8,260**
Participation	FWD in 20% of Vancouver MF homes	8,260 x 20% = **1,652**
Percent Diversion	% of total organic waste in MF homes to be disposed of by FWDs	(1,652 / 32,400)*100 = **5%**

APPENDIX C:

Calculation of the water requirements for operating a FWD in MF homes in the City of Vancouver (based on statistics from the Metro Vancouver MF building waste audit)

- Waste quantity based on estimates from Metro Vancouver Multi-Family Building Waste Audit (2)
- Waste composition estimates from the Metro Vancouver Multi-Family Building Waste Audit (2)
- Estimate of water usage based on commonly used value of 12 liters of water required for every kilogram of food waste

Average organics disposed of by MF residence in City of Vancouver per year	180 kg/year
Average organics – yard/garden/paper waste	180 kg/year – 12% = 158 kg/year
Average organics that can be disposed of using a FWD per year	158 kg/year – 50% = 79 kg/year
Average organics that can be disposed of using a FWD per day	79 kg/year x (1year/365 days) = 0.22 kg/day
Average water use per kg waste per day	12L/kg food waste x 0.22 kg/day = **2.6 L/day**

9 REFERENCES

1. City of Vancouver. Solid Waste Division Report [Internet]. 2010. Available from: http://vancouver.ca/engsvcs/solidwaste/documents/SWSummaryRp2010.pdf

2. Metro Vancouver. Multi-Family Sector Waste Audit 2011. Metro Vancouver Solid Waste Department; 2011.

3. Marashlian N. The effect of food waste disposers on municipal waste and wastewater management. Waste Management & Research. 2005 Feb 1;23(1):20–31.

4. Angus Reid Group. GVRD Residential Attitudes Towards Regional Environmental Management & Conservation Activities: Waste Water Management Report. 2000 May.

5. City of Vancouver. Greenest City Action Plan Administrative Report [Internet]. 2011 Jul. Available from: http://vancouver.ca/ctyclerk/cclerk/20110712/documents/rr1.pdf

6. Kosmak M. Personal correspondance with Monica Kosmak. 2012.

7. Boychuck G, McLean S. Organics Source Separation Curbside collection and Central Composting Versus Garbarators and Co-Digestion [Internet]. Halton Region Planning & Public Works Department; 2005. Available from: http://www.cwwa.ca/pdf_files/Garburators.pdf

8. Compass Resource Management Group. Food Waste Discharges to the Sewer System: A Preliminary Evaluation of Policy Options. Prepared for the Sewerage and Drainage Department, GVRD; 1997 Feb.

9. NYC Department of Environmental Protection. The Impact of Food Waste Disposers in Combined Sewer Areas of New York City [Internet]. 1999. Available from: http://www.nyc.gov/html/dep/pdf/grinders.pdf

10. Carey C, Phelan W, Boland C. Examining the Use of Food Waste Disposers [Internet]. Environmental Protection Agency Ireland; 2008. Available from: http://www.epa.ie/downloads/pubs/research/waste/strive_11_phelan_foodwaste_web1.pdf

11. Otten L. Wet–dry composting of organic municipal solid waste: current status in Canada. Canadian Journal of Civil Engineering. 2001;28(S1):124–30.

12. BC Ministry of the Environment. British Columbia Greenhouse Gas Inventory Report 2010 [Internet]. 2010. Available from: http://www.env.gov.bc.ca/cas/mitigation/ghg_inventory/pdf/pir-2010-full-report.pdf

13. BC Ministry of Environment. Developing Inventories for Greenhouse Gas Emissions and Energy Consumption: A Guidance Document for Partners for Climate Protection in Canada. [Internet]. 2008. Available from: http://www.fcm.ca/Documents/reports/PCP/Developing_Inventories_for_Greenhouse_Gas_Emissions_and_Energy_Consumption_EN.pdf

14. Lundie S, Peters GM. Life cycle assessment of food waste management options. Journal of Cleaner Production. 2005 Feb;13(3):275–86.

15. Bernstad A, la Cour Jansen J. Separate collection of household food waste for anaerobic degradation – Comparison of different techniques from a systems perspective. Waste Management. 2012 May;32(5):806–15.

16. Kim M-H, Song Y-E, Song H-B, Kim J-W, Hwang S-J. Evaluation of food waste disposal options by LCC analysis from the perspective of global warming: Jungnang case, South Korea. Waste Management. 2011 Sep;31(9-10):2112–20.

17. Tan R, Khoo H. Impact assessment of waste management options in Singapore. Journal of the Air & Waste Management Association. 2006 Mar;53(3):244–54.

18. US Composting Council. USCC Factsheet: Greenhouse Gases and the Role of Composting: A Primer for Compost Producers [Internet]. 2008. Available from: http://compostingcouncil.org/admin/wp-content/uploads/2010/09/Greenhouse-Gases-and-the-Role-of-Composting.pdf

19. Evans TD, Andersson P, Wievegg Å, Carlsson I. Surahammar: a case study of the impacts of installing food waste disposers in 50% of households. Water and Environment Journal. 2010 Dec;24(4):309–19.

20. BC Hydro. BC Hydro Quick Facts: For the Year Ended March 31, 2011 [Internet]. 2011. Available from: http://www.bchydro.com/etc/medialib/internet/documents/about/company_information/quick_facts.Par.0001.File.quick_facts.pdf

21. IN-SINK-ERATOR. IN-SINK-ERATOR Brief Summary and Interpretation of Key Points, Facts and Conclusions for the University of Wisconsin Study: Life Cycle Comparison of Five Engineered Systems for Managing Food Waste [Internet]. 1998. Available from: http://www.insinkerator.com/en-US/Documents/Disposer/uwstudy.pdf

22. Kelleher Environmental. Region of Peel Integrated Waste Management Discussion Paper [Internet]. 2009 Feb. Available from: http://www.google.ca/url?sa=t&rct=j&q=peel%20integrated%20waste%20management%20discussion%20paper&source=web&cd=1&ved=0CEwQFjAA&url=http%3A%2F%2Fwww.peelregion.ca%2Fplanning%2Fofficialplan%2Fpdfs%2FDiscussion_Paper_-_Peel_Integrated_Waste_Management_Feb.2009.pdf&ei=U7TPT4uvFqSl2AW-rJy9DA&usg=AFQjCNGOp8WTZZ4hMbJzXF6xqLhpk_eWQA&cad=rja

23. SYLVIS Environmental. Land Application Guidelines for the Organic Matter Recycling Regulation and the Soil Amendment Code of Practice [Internet]. BC Ministry of Environment; 2008. Available from: http://www.env.gov.bc.ca/epd/mun-waste/regs/omrr/pdf/land-app-guidelines.pdf

24. Evans TD. Domestic food waste – the carbon and financial costs of the options. Proceedings of the ICE - Municipal Engineer. 2012 Mar 1;165(1):3–10.

25. Hospido A, Carballa M, Moreira M, Omil F, Lema JM, Feijoo G. Environmental assessment of anaerobically digested sludge reuse in agriculture: Potential impacts of emerging micropollutants. Water Research. 2010 May;44(10):3225–33.

26. Wu L, Cheng M, Li Z, Ren J, Shen L, Wang S, et al. Major nutrients, heavy metals and PBDEs in soils after long-term sewage sludge application. Journal of Soils and Sediments. 2012 Feb 28;12(4):531–41.

27. Buyuksonmz F. Full-scale VOC emissions from green and food waste windrow composting. Compost Science & Utilization. 2012;20(1):57–62.

28. Kumar A, Alaimo CP, Horowitz R, Mitloehner FM, Kleeman MJ, Green PG. Volatile organic compound emissions from green waste composting: Characterization and ozone formation. Atmospheric Environment. 2011 Mar;45(10):1841–8.

29. BC Ministry of the Environment. Organic Matter Recycling Regulation [Internet]. 2007. Available from: http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/18_2002

30. Environment Canada. Threats to Sources of Drinking Water and Aquatic Ecosystem Health in Canada [Internet]. 2001. Available from: http://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&ved=0CFIQFjAC&url=http%3A%2F%2Fwww.ec.gc.ca%2Finre-nwri%2F235D11EB-1442-4531-871F-A7BA6EC8C541%2Fthreats-eprint.pdf&ei=57UaUN2aH-n5iwKY5YDgAw&usg=AFQjCNE13cmB5OUSTxOs7kqPKeoBPV9tYg

31. Hellström D, Baky A, Jeppsson U, Jönsson H, Kärrman E. Comparison of Environmental Effects and Resource Consumption for Different Wastewater and Organic Waste Management Systems in a New City Area in Sweden. Water Environment Research. 2008 Aug 1;80(8):708–18.

32. Metro Vancouver. The Greater Vancouver Sewerage and Drainage District Quality Control Annual Report [Internet]. 2009. Available from: http://www.metrovancouver.org/about/publications/Publications/GVSDD_Quality_Control_Annual_Report_2010.pdf

33. City of Toronto. Recycling and Garbage for Multi-Unit Dwellings [Internet]. 2012. Available from: http://www.toronto.ca/garbage/multi/faq.htm

34. European Commission. Caring For Our Future - Acidification [Internet]. 2012. Available from: ec.europa.eu/environment/archives/caring/en/caring12_en.pdf

35. Bernstad A, la Cour Jansen J. A life cycle approach to the management of household food waste – A Swedish full-scale case study. Waste Management. 2011 Aug;31(8):1879–96.

36. Diggelman C, Ham RK. Household food waste to wastewater or to solid waste? That is the question. Waste Management & Research. 2003 Dec 1;21(6):501–14.

37. Khoo HH, Lim TZ, Tan RBH. Food waste conversion options in Singapore: Environmental impacts based on an LCA perspective. Science of The Total Environment. 2010 Feb;408(6):1367–73.

38. Evans T. Environmental Impact Study of Food Waste Disposers for the County Surveyors' Society and Herefordshire Council and Worcestershire County Council [Internet]. 2007 Jun. Available from: http://www.timevansenvironment.com/2007%20FWD%20Environmental%20Impact%20Study%20-%20H&W%20-%20Evans.pdf

39. Lundie S. Assessment of Food Disposal Options in Multi-Unit Dwellings in Sydney [Internet]. 2000. Available from: ww.aham.org/ht/a/GetDocumentAction/id/51836