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Sustainable Urban Composting: Determining Best Practices for Organic Waste Management in Burlington, Vermont

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SUSTAINABLE URBAN COMPOSTING

DETERMINING BEST PRACTICES FOR ORGANIC WASTE MANAGEMENT IN BURLINGTON, VERMONT

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Abstract

Diverting solid waste from landfills is an essential component in creating sustainable cities and communities in the United States. A large percentage of refuse waste is organic material (i.e., food waste) which can be managed through composting processes as an alternative to landfill disposal. Through the lens of sustainable urban planning, the development of an organic materials processing facility can be difficult as its operational processes are often undesirable and burdensome to surrounding communities, environments, and economies. Three examples of successful and sustainable urban organic waste management programs were examined to identify the balance among the social, environmental, and economic growth factors of sustainable development. Each case example (Dubuque, Iowa; Seattle, Washington; and Toronto, Ontario) was also used as the basis for sharp comparison to Chittenden County, Vermont. This study's findings resulted in the creation of a set of recommendations and best practices for the future development of a sustainable organic waste management program for Chittenden County and the urban area of Burlington, Vermont.

Key Terms

Compost; Sustainable development; Urban waste management; Burlington, Vermont; Dubuque, Iowa; Seattle, Washington; Toronto, Ontario

Important Acronyms

C:N - Carbon to Nitrogen Ratio
CSWD - Chittenden Solid Waste District
DMASWA - Dubuque Metropolitan Area Solid Waste Agency
DOPF - Dufferin Organic Processing Facility
EPA - Environmental Protection Agency
ICP - Intervale Compost Products
IDNR - Iowa Department of Natural Resources
MSW - Municipal Solid Waste
NOFA-VT/VOF - Northeast Organic Farming Association of Vermont/Vermont Organic Farmers
PAH - Polycyclic Aromatic Hydrocarbons
PFRP - Process to Further Reduce Pathogens
SPU - Seattle Public Utilities
TSWM - Toronto Solid Waste Management
WDTF - Waste Diversion Task Force (2010)
VTANR - Vermont Agency of Natural Resources

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Introduction

Solid waste is generated by every human on Earth no matter one's age, gender, location, or monetary income (Cunningham, 2007). By consuming the most basic necessities for survival, solid waste is created as a byproduct. Solid waste includes everything from leftover pizza, broken computers, toxic chemicals, old stuffed animals, and last month's magazines, to so much more. From cradle to grave, the chain of waste creation for a single commodity may be complicated and unnecessary; nevertheless, humans embrace the wants and needs of everyday life and therefore continue to consume. As this process is multiplied by the billions of people on Earth today, the amount of solid waste produced increases to irresponsible and uncontrollable levels.

As solid waste generation is directly connected to the high consumption habits of humans, actively decreasing these rates has become a major priority for many solid waste facilities around the world. By decreasing levels of waste generation, there is less stress placed on solid waste management facilities, surrounding communities, and local economies. There is also a drastic decrease on the environmental impact of solid waste management including a decrease in: soil degradation, water pollution, air pollution through the emission of greenhouse gases, the spread of human health hazards through the discharge of toxic substances, and the continued excessive extraction of Earth's natural resources.

Solid waste may be broken up into several categories including: refuse, recyclables, electronic waste, toxic/hazardous wastes, and compost. Once discarded of and labeled as a waste, each category has a specific route or path for disposal. Several of these methods include landfilling, incineration, shipment, recycling, composting, reusing, and de-manufacturing

(Cunningham, 2007). These complex disposal processes are ever changing and often require elaborate alterations or new design plans to successfully update and sustainably develop a facility's waste management methods.

With many urban waste management facilities dedicated to the reduction of solid waste through the development of waste diversion programs, acquiring a unique plan for sustainable growth is a necessity (Cunningham, 2007). This process can be incredibly complicated considering the dynamic nature of each individual urban community. Throughout the developmental process, an urban waste management facility focuses on finding an even balance between the disparate natures of three sustainable growth factors: social, environmental, and economic (Campbell, 1996).

To narrow the wide lens of solid waste management and sustainable growth within one urban area, this thesis project focused solely on the organic waste stream and how it is managed within an organic materials processing facility in Burlington, Vermont. With the relocation of this outdated facility to a nearby urban area in early July 2011, the social, environmental, and economic growth factors of both the old and new facilities were analyzed and compared to help create a set of future sustainable development recommendations. Research processes included examining the locations of organic waste creation within the Burlington urban area, the methods for transportation of organic waste to the old and new processing facilities, the methods or technology of composting at each location, and the overall cost of organic waste management for each processing facility and its contributing organic waste generators.

To further strengthen the set of developmental recommendations, three case example organic materials processing facilities were researched using the same criteria. Each progressive case example highlighted the individual relationship its organic materials processing facility holds with one specific sustainable growth factor it successfully represents. This resulted in a valuable model for the sustainable development of Burlington, Vermont's new organic waste management facility.

Literature Review

As each category of solid waste requires a specific management method, this thesis project singularly focused on organic waste and the processes by which it is managed. The study was narrowed further into the management processes of Chittenden County, Vermont's urban organic materials processing facility managed by the Chittenden Solid Waste District (CSWD). Historical, current, and projected future management plans regarding this specific facility are introduced and explored to ensure a complete understanding of the operation. Recognizing this facility's basic management procedures is a crucial first step in the formation of a primary understanding of the organization's inner-workings.

This thesis project studied the transition of CSWD's outdated organic materials processing facility, Intervale Compost Products (ICP), to a newer nearby facility entitled CSWD Compost[1]. Both the old and new organic materials processing facility were analyzed using the same research criteria. The old and new organic waste management systems and their corresponding management programs were individually examined based on their impacts on the surrounding community, environment, and economy. The resulting information was synthesized through comparison thereby producing a range of sustainable urban development recommendations for CSWD.

To further strengthen the depth and validity of these recommendations, three additional organic materials processing facilities were researched using the same research criteria. While far from entirely sustainable themselves, each case example was used as a malleable model for the

[1] It is important to notice that both of these facilities are currently owned and managed by CSWD. For the purposes of clarification, the remainder of the project will use the term ICP to represent the old CSWD organic materials processing facility. CSWD Compost will represent the new CSWD organic materials processing facility.

sustainable development of CSWD's organic materials processing facility and management programs. As no single case example could effectively serve as an exact plan for the development for CSWD, each case example was researched from the lens of a single social, environmental, or economic sustainable growth factor it effectively exemplified. The resulting information provided CSWD with the opportunity to learn where other developing organic materials processing facilities have succeeded and failed in their own pursuit for sustainable development.

Before research could begin, a basic understanding of the popular and widely accepted literature written on key topics. The literature review begins with a wide overview of sustainable development and solid waste management and is then further narrowed to organic waste management processes within one specific processing facility in Chittenden County, Vermont. Each section of the literature review is broken up into segments describing: urban planning and sustainable development practices, solid waste management plans for each type of waste, the basic science of composting, the benefits of composting, and the history and politics of composting within Chittenden Solid Waste District. Serving as a contextual background resource, this literature review provides information necessary for the further understanding of this thesis project.

Urban Planning and Sustainable Development

Urban Planning is a dynamic design and management process that involves a wide variety of educated planners, unbiased mediators, and local community members. Sustainable development is a common practice amongst urban planners as it ensures positive development and the conscious conservation of natural resources to avoid their potential depletion in the future (Graymore, 2008). Sustainable development is a crucial element to consider as urban areas are ever changing structures that require constant reassessment and redevelopment. Using sustainable development in urban planning is also important as it ultimately promotes the health of not only the urban community but the surrounding environment and local economy as well.

Using highly diverse and contrasting opinions is crucial in achieving an equal balance of ideas in the development process. This broad range of beliefs ensures a wide scope of focus areas and allows for the mediation of each conflicting opinion. These opposing perspectives are necessary in the developmental phase as they serve as the conception point for new management procedures and programs. Each perspective is typically represented by a set of professionals with knowledge in social, environmental, and economic realms (Campbell, 1996). These three disparate opinions symbolize the triangle of sustainable development. In this sustainable triangle, each perspective takes one point thereby leaving room for sustainability in the center of the triangle (Campbell, 1996). Coming together with three different development goals, the sustainability paradigm illustrated above explains the ability, to form an inclusive proposal that is ultimately the most uniform and sustainable production possible (Campbell, 1996).

Using this method for the development of urban areas, social, environmental, and economic ideals are meshed together under one coalition in order to produce healthy debates monitored by an arbitrator. Without these outside-party inputs, the debates may be lopsided, most commonly towards the area of economic development, as unmonitored arguments allow the most powerful planner to prevail (Campbell, 2006). Economic development usually holds authority during the planning process as funding for urban areas is frequently perceived as the most important facet in development compared to that of social equity or environmental sustainability.

To solve this unjust domination of power, the interjection of a mediator helps maintain a healthy balance of the three disparate points of view in order to successfully sustainable develop the urban area.

Upon completion of a development proposal, the plan is in need of evaluation and editing should an ideal need revision. Utilizing sustainability assessment models, urban areas are quickly able to produce an outline of the basic changes that are essential to the well-being of a city (Graymore, 2008). The five most common assessments given to a city include measuring the, “Ecological Footprint, Wellbeing, Quality of Life, Ecosystem Health, and Natural Resource Availability” (Graymore, 2008, p.362). Each of these assessments test some form of social, environmental, or economic behavior in the city as a whole, giving planners, mediators, and local citizens an idea as to where there is room for additional improvement.

Despite the large variety of areas urban planners focus on, solid waste management is one of the most significant. Communities depend on the continued success of this process daily. Although each city is unique in it’s needs, affluent areas commonly have a general distaste for solid waste management. This aversion may often lead to privatized facilities or an increase in the distance haulers need to travel to remove wastes from wealthy areas (Cunningham, 2007). These long distances add to the management costs and increase negative environmental impacts as more pollution is emitted into the air from waste trucks. These emissions add to the greenhouse gases in the atmosphere, eventually increasing the rate at which global warming occurs.

The location of a solid waste management facility is also reliant upon several factors including, “land prices, shipping rates, and demanding construction and maintenance” of the facility as a whole (Cunningham, 2007, p. 489). Finding a space that is stable enough for the construction of a solid waste management facility can be difficult. As a result, many urban areas municipalities across the nation have decided to forgo the establishment of a local solid waste facility in favor of what is commonly known as, "garbage imperialism" (Cunningham, 2007, p. 479). This method of disposal includes the collection of wastes from a certain area followed by the deposit of these waste in an unrelated area. This is common amongst urban areas as they have a strong tax base to send unwanted wastes to other areas. It is most commonly poverty-stricken areas that end up accepting these wastes onto their lands in exchange for a steady and substantial monetary fee. Many of these exchanges occur on Indian Reservations or in developing countries in search of a stable source of income (Cunningham, 2007).

Solid Waste Management

Solid waste is a broad term used to describe the unwanted and undesirable refuse of domestic, industrial, mining and construction sites, commercial organizations, and agrarian practices (Cunningham, 2007). Solid waste encompasses a wide variety of refuse, both solid or liquid form. Everyone is capable of creating solid waste, thereby adding to the waste stream (Thompson, 2009).

As everything created could eventually be conceived as a form of waste, at some point it all must be removed and processed, preferably out of the public eye (Thompson, 2009). When U.S. citizens were surveyed about environmental issues of greatest concern today, the resulting list included problems such as habitat destruction, energy use, climate change, and soil erosion (Thompson, 2009). The survey results showed a shockingly low general lack of concern in the rising rates of solid waste, illuminating the larger problem of rising consumption levels and society's general disaffiliation with personal waste.

Aside from the fact that solid waste management has become an invisible exercise lacking deserved attention, where unwanted waste ends up and the process with which it is dealt proves a hindrance on society. In the United States of America, over 11 billion tons of solid waste are generated each year equating to about ⅔ a ton for each U.S. resident per year (Cunningham, 2007). These waste production rates are some of the highest in the world allowing the U.S. to surpass many developing countries' waste rates five to ten times over (Cunningham, 2007). Humans blatantly attempt to be removed from all types of unwanted solid waste refuse to achieve an, "out of site, out of mind" sentiment (Kelly, 1973, p.42).

The majority of waste generators in the U.S. fail to recognize the individuality of each section of solid waste (Thomposon, 2009). Including refuse, recycling, electronic waste, toxic/ hazardous waste, and compost, the diverse varieties of solid waste deserve distinctive management procedures identified by national and local solid waste management facilities. Although the best possible method of solid waste disposal is to separate and divide refuse into groups of similar wastes thereby allowing potential resource reuse opportunities, many waste generators fail to sort what is thrown out. These wastes ultimately end up with other types of waste in one bin destined for a sanitary landfill (Cunningham, 2007; Krook, 2010).

Refuse Waste

A sanitary landfill may be identified as a geologically stable, monitored site in which an impermeable plastic, clay, or combination liner forms a base for waste that may be disposed of through the method of collection and piling (Cunningham, 2007). This site may be operational until the maximum allowable amount of refuse fills the sanitary landfill and a protective cap is built over the controlled waste heap to ensure stability and safety of the pile for future generations. Sanitary landfills are the most common forms of waste disposal and yet, they are a relatively new development for the solid waste management industry. Previous disposal methods included landfilling which lacked the protective liner that now ensures the increased protection of surrounding environments. There are still cases of undocumented and illegal waste disposal in the U.S.; nevertheless, the majority of citizens rely on local solid waste management sanitary landfills or transfer stations whose sole purpose is to transport local waste to larger management facilities further away (Cunningham, 2007; Chittenden Solid Waste District, 2009).

The construction of a sanitary landfill may be strongly opposed during the developmental phase of both urban and rural areas as they invite undesired elements into the surrounding environment. Communities tend to feel as if sanitary landfills are cumbersome, messy, and hazardous to humans often leaving the developmental designs to the city council members and local municipal solid waste industries (Thompson, 2009). After construction is complete and the sanitary landfill becomes operational, the service of solid waste collection creates of a range of environmental issues. A common concern associated with waste management services is the increased truck traffic needed to transport wastes. Aside from additional roadway congestion, these trucks also emit greenhouse gases such as carbon dioxide, methane, and sulfides which ultimately add to air pollution levels while simultaneously increasing global climate change.

A landfill itself also poses the problem of emitting unpleasant odors that may be attractive to unwanted animals. These scents may be masked through the covering of waste with soils; however, this remedy ultimately contributes to soil degradation and faster landfill closure as soil content may add up to over 20% of a landfill's mass. Both operational and closed landfills also leach toxic wastes through the process of rain and groundwater infiltration that penetrate the landfill's mass and leak out the base of the landfill. The leachate carries along heavy metals, organics, and nutrients that may contribute to water contamination (Cunningham, 2007; Thompson, 2009).

The environmental hazard emission levels of a sanitary landfill may be dependent upon the size and range in types of waste accepted at the sanitary landfill; nevertheless, rates of environmental contamination are so high that the Environmental Protection Agency (EPA), a U.S. government agency in Washington, D.C., enacted the Resource Conservation and Recovery Act (RCRA) in 1976 to protect surrounding environments (Thompson, 2009). The EPA claims that the RCRA's main goals include:

> "- Protect U.S. from the hazards of waste disposal
> - Conserve energy and natural resources by recycling and recovery
> - Recycle or eliminate waste; and
> - Clean up waste, which may have been spilled, leaked, or been improperly disposed" (Environmental Protection Agency [EPA], 2010)

With the creation of this act and its updated Hazardous and Solid Waste Amendments set in place in 1984, sanitary landfills were given a set of standards from which all municipal solid waste districts follow today (Thompson, 2009). These standards include:

> (a) landfills may not be located near certain kinds of areas, e.g., geological faults and wetlands; (b) landfills must have a 'composite liner,' which consists of a 60-mm-thick geoplastic liner over two feet of compacted soil; (c) leachate collection and removal systems must be installed; (d) methane levels must be controlled so that no explosions occur; (e) the waste must be covered frequently with soil, to reduce odors and to control vermin; (f) regular groundwater monitoring must be conducted; (g) the landfill operators must have an approved plan for closing the

> landfill and maintaining it safely for thirty years after closure; (h) if groundwater is contaminated beyond a certain point, the operator must take 'corrective action'; and (i) the operators must demonstrate the financial ability to undertake closure and post closure care (Thompson, 2009, p. 17).

Aside from this broad range of concerns, the EPA also closely monitors the gaseous emissions made by all sanitary landfills and incinerators. In 1970, the EPA enacted the Clean Air Act that required the monitoring of the following gases from both sanitary landfills and incineration plants: "particulate matter, cadmium, lead, mercury, acid gases, hydrogen chloride, dioxins/furans, nitrogen oxides, and sulfur dioxide" (Thompson, 2009, p. 20). All government sanitary landfills follow both of these national laws; however, many have constructed facilities that go beyond the basic requirements in sanitation and environmental protection to ensure that the solid waste treatment site is providing the best possible service to surrounding communities. Examples of this include double or even triple lining a sanitary landfill base or building a methane gas exhaust pipe system that collects refuse gas from the solid waste heap and provides the opportunity to generate energy from the released gases. Although most sites require this methane pipe system to ensure a safe and stable landfill, the option to generate energy from the gas rather than simply burn it off in excess is up to the discretion of each individual facility as it may increase spending costs (Thompson, 2009).

Sanitary landfills are noted as the most popular method for solid waste management as it is simply the easiest method of disposal for so many households, industries, and organizations alike. As stated before, the most effective method for solid waste management is through the sorting of wastes. This process drastically reduces the unnecessary amounts of recyclables, toxic/hazardous wastes, electronic wastes, and compostables that enter landfills. Regardless of the number of new technologies for dealing with waste, the two most basic formats of reducing waste are simply reducing the total amount of waste and educating people on the importance and methods of sorting waste (Engkvist, 2010).

Recyclables

Recycling, another form of solid waste management saw a 33% increase in activity from 2000 to 2010 (EPA, 2010). Recycling may be identified as the process by which used and unwanted materials are processed and transformed to create new materials. Recycling often means creating the same original product from used versions; however, there are recycling industries that focus on creating new goods from unrelated used waste. While most solid waste management municipalities in the U.S. have active and productive recycling facilities, there are a few drawbacks to the process that may defer the potential development of new facilities. Two examples include: recyclable waste has an unstable product cost that makes recycling a risky business and most recycling districts have a large problem with contamination of recyclable materials (Cunningham, 2007). Many states have attempted to combat these drawbacks by creating, “Bottle Bills” or more simply, by setting monetary deposits on bottles and cans thereby creating incentives to sort through wastes for recyclables (Cunningham, 2007, p. 487).

Recycling processes differ solely depending on the product being recycled and the aspired resulting material. Although some recycling facilities require the sorting of plastics, often by a number identified on the bottom of the product, some organizations will take recyclables unsorted as they include sorting in their waste management services. From the melting down of plastics, aluminum, and glass to the shredding and reformation of paper products, recycling processes are involved and ever changing, often adapting to the wants and needs of current product industries requiring these raw materials (Cunningham, 2007).

Recycling is a popular method of waste management as it relieves negative pressures on the environment. Recycling products substantially reduces the amount of greenhouse gas emissions that enter the air through the production of new products (EPA, 2010). Recycling also drastically reduces the amount of raw resource extraction and energy consumption levels that are necessary to create new and unused products. Both of these positives outweigh the small negative setbacks and have generated enough popularity to initiate over 8,660 curbside recycling organizations throughout the U.S. (EPA, 2010).

Electronic, Toxic, and Hazardous Wastes

Electronic waste, more commonly known as e-waste, is the refuse of electronics such as computers, cell-phones, mp3 music players, and clock radios. E-waste is an individually distinct environmental hazard that if not dealt with properly may pollute surrounding environments and sanitary landfills (Thompson, 2009). E-waste is considered a major problem as the breakdown of these electronics emits a large stream of toxic and hazardous waste into both soil and water sources. These toxins include heavy metals, toxic chemicals, and toxic plastics that are capable of being leached out of old equipment (Cunningham, 2007). Some of the most poisonous substances emitted from these wastes include the battery liquids that can highly contaminate surrounding environments (Cunningham, 2007).

One of the biggest problems with solid waste in the U.S. may be attributed to the management of toxic and hazardous wastes. Hazardous wastes are defined as any unwanted material that has been disposed of, in both liquid or solid form, that:

> "contain substances known to be (1) fatal to humans or laboratory animals in low doses, (2) toxic, carcinogenic, mutagenic, or teratogenic to humans or other life forms, (3) ignitable with a flash point less than 60 degrees Celsius, (4) corrosive, or (5) explosive or highly reactive (undergoes violent chemical reactions either by itself or when mixed with other materials)" (Cunningham, 2007, p.487).

Toxic wastes have also been identified as any substance capable of contaminating soils, natural habitats, or water resources (Cunningham, 2007, p. 487). Currently, over 40 million tons of toxic and hazardous wastes are emitted annually into the environment (Cunningham, 2007).

With over 36,000 critically contaminated toxic/hazardous waste sites across the U.S, the EPA created the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or more commonly known as the Superfund Act in 1980 (EPA, 2010; Cunningham, 2007). This act was created to, "(1) provide an immediate response to emergency situations that pose imminent hazards, and (2) to clean up or remediate abandoned or inactive sites" (Cunningham, 2007, p. 488). Still highly advocated by the EPA and local governments alike, the superfund is an excellent source in tracking toxic polluters who are creating a hazard for other humans and the environment.

Organic Waste

Organic waste may be identified as a composition of organic detritus that uses both naturally occurring aerobic decomposition or human monitored anaerobic decomposition to break down both solid and liquid organic components to a fertile soil composition. Organic waste makes up one of the largest portions of solid waste consuming over 12% of the waste stream (Cunningham, 2007). As organic waste is most often disposed in landfills, many solid waste municipalities are gaining interest in the future development of large scale composing facilities as the process prevents an excessive amount of organic detritus from entering the waste stream. In late 2010 there were roughly 3,510 organic materials processing facilities across the U.S. (EPA, 2010).

Organic materials processing facilities view the primary purpose of organic waste management as a method to increase waste diversion rates. Some facilities have developed incentives or curbside organic waste pick up programs in an attempt to further simplify the management process and increase waste diversion rates. Others have begun to create a waste to energy program in an attempt to gain compensation for the expensive process of large scale organic waste management.

While there are a range of benefits for composting organic waste ranging from the composting processes to the actual completed compost product, composting does have several drawbacks. One major drawback in the creation and management of an organic materials processing facility is the potential struggle it may have with a state or an additional compost agency's processing regulations. These regulations can be restrictive and often reduce or even completely eliminate a facility's interest to provide an organic waste management program (EPA, 2010).

Science of Composting

The act of composting[2] may be identified as a technique of solid waste management in which organic detritus is broken down through the process of biological decomposition in natural

[2] In this report, the terms, "composting," "organic waste management," or "organic waste processing" represent the methods by which organic wastes are processed or managed. The terms "compost," "completed compost," or "completed compost products" represent the final products or end results.

aerobic or engineered anaerobic systems (Golueke, 1991b). The end result is a completed compost product that is commonly used as natural amendment for degradated soils.

Aerobic Composting

Aerobic composting is by far the most prevalent method in modern composting practices as it is an odorless and rapid production of natural soil fertilizers preferred by both large and small agriculturalist (Golueke, 1991b). Occurring in the presence of oxygen, organic wastes are often stacked up in piles called windrows to allow organic detritus to naturally decompose until it reaches a stable point. Most organic materials processing facilities choose this method as the natural breakdown process effectively reaches the thermal extermination level of nearly all plant and animal pathogens producing a safe and high quality final compost product (Golueke, 1991b). Aerated composting relies on the constant monitoring of three essential elements: microbial organisms, aeration, and temperature levels; nutrient levels; and moisture levels (Golueke, 1991b). Maintaining the health and balance of all three elements is crucial in achieving a completed compost product.

Microbial Organisms, Aeration, and Temperature Levels

The aerobic composting process begins when the appropriate feedstocks are mixed together and built into windrows. The internal structure of each windrow is composed of an array of microbial organisms which are directly linked to the temperature of the pile. The three most common microbial organisms include basic bacteria, actinomycetes, and a variety of fungi (Gloueke, 1991b). Compost specialists continuously monitor and evaluate the levels of these microbial organisms throughout the compost process as lack or excess can cause the final compost product to suffer. These assessments are easily performed often taking place with a quick visual or olfactory evaluation (Keller, 1991). If a windrow or anaerobic heap is lacking an earthy odor or dark brown to black color scheme, most operators know that there is an imbalance in the amount of breakdown organisms residing within the internal confines of the compost.

As microbial organisms consume oxygen resources the windrow's internal temperature increases. Conversely, as oxygen levels are depleted microbial activity decreases and temperature levels drop (Rynk, 1992). The greater quantity and diversity of a microbe population, the more rapidly a compost pile may breakdown (Golueke, 1991b). Levels of oxygen must be maintained by either a passive or forced aeration process to keep microbial organisms active. A passive method of aeration includes turning the windrows to subject new microbes and organic wastes to the interior of piles. This operation occurs through the breakdown of a pile, the even spreading of the organic waste, and the rebuilding of a newly mixed windrow (Golueke, 1991c). A forced aeration process involves blowing oxygen into a static windrow with an oxygen diffuser system. This is accomplished by building windrows over perforated pipes connected to a controlled blower system (Golueke, 1991b).

Temperature for each windrow is measured periodically beginning 6-7 inches into the pile as the interior zone of the pile is the warmest. The organic matter naturally passes through two stages called mesophilic and thermophilic phases whose sole purpose is to eliminate any toxic or hazardous plant or animal pathogens (Golueke, 1991a). The cycle usually begins with the mesophilic temperatures which may range from 46º-50º Fahrenheit. This phase is the initial cycle due to the lower temperature range. As the compost windrow ages, the breakdown process produces heat that allows the temperatures to rise into the thermophilic range, 113º-122º

Fahrenheit. Once this temperature cycle has been reached, almost all pathogens and undesired wastes have been destroyed or removed in the form of a gaseous output (Golueke, 1991a). Upon reaching the thermophilic range, the temperatures eventually drop back down into Mesophilic and then finally dropping to equal the temperature of outside air. Once a pile reaches this level, the compost has fully matured (Keller, 1991).

While these temperature ranges do eliminate most plant and animal pathogens, the process does not reduce or remove the presence of Polycyclic Aromatic Hydrocarbons (PAHs), a common toxin found in urban completed compost products. PAHs are, "a group of semi-volatile atmospheric pollutants," created as a byproduct of decomposing organics (EPA, 2010). While there is no major harm in having low levels of PAHs in compost, excessive quantities can be as hazardous as large amounts of plant and animal pathogens. As there is no proven method to eliminate the presence of PAHs in organic waste, compost facilities must regularly test each batch of completed compost for high levels of the toxin.

Nutrient Levels (C:N Ratio)

A windrow's nutrient levels must also be monitored as their presence will ensure a faster decomposition process and a healthy final product. The most common nutrients within a compost pile include nitrogen, carbon, potassium, and phosphorous (Golueke, 1991b). Each individual nutrient is related in conjunction with others found throughout a compost heap. Compost specialists mix organic waste feedstocks based on what the organic materials processing facility receives and on composting recipes. Similar to baking, each compost recipe calls for a specific amount of each feedstock to maintain nutrient levels throughout the mixture. Composting recipes are unique to each processing facility and have been modified and revised to ensure the best possible completed compost products (Gloueke, 1991b).

The most important ratio of nutrients to monitor and asses within each recipe is the carbon to nitrogen (C:N) ratio (Golueke, 1991b). The ideal finished compost C:N ratio is usually around 30:1 (Rynk, 1992). Carbon represents the energy a compost pile is capable of consuming while nitrogen illuminates how quickly the compost's proto-plasm, or more simply the living internal components of cells, are synthesized (Golueke, 1991b). In simpler terms, Carbon based feedstocks tend to be dry and brownish in color while nitrogen based feedstocks are often green and wet organics (Rynk, 1992). Micro organisms, "use carbon for both energy and growth while nitrogen is essential for protein and reproduction" (Rynk, 1992, p. 8). As, "biological organisms...need about twenty-five times more carbon than nitrogen," it is important to find the appropriate ratio between carbon and nitrogen in a mix of organic waste (Rynk, 1992, p.9). The following chart identifies several of the most common feedstocks and their respective carbon and nitrogen nutrients ratios.

Typical Feedstocks and Nutrient Content			
Carbon Feedstocks "The Browns"		**Nitrogen Feedstocks "The Greens"**	
Leaves	54 : 1	Manure	1 : 20
Bark & Hard Woody Debris	223 : 1	Grass	1 : 17
Bark & Soft Woody Debris	496 : 1	Food Wastes	1 : 15
Sawdust	442 : 1	Shrub Trimmings	1 : 17

Typical Feedstocks and Nutrient Content			
Newsprint	600 : 1	Mixed Food & Paper Wastes	1 : 50

If there is an excessive imbalance of carbon to nitrogen, the biological breakdown within the heap may decrease or completely subside. With too much carbon in an organic waste pile, the decomposition process may drastically slow down. An excess in nitrogen may create ammonia, a chemical that destroys the compost pile's entire microorganism population (Golueke, 1991b). In an attempt to maintain a healthy C:N ratio within a compost pile compost specialists measure these ratios include using expensive technologies, complex mathematical formulas, or from using the most basic sensory clues similar to those used in the measurement of a windrow's level of micro organisms (Golueke, 1991b, p. 22).

Moisture Levels

The ideal moisture level of a compost pile is 100%. While anaerobic systems slurry their organic wastes at this moisture level, aerobic piles operate within a much lower rage of 45-50% (Golueke, 1991b). As moisture rates increase, due to high aeration, microbial organism, and temperature levels, the faster the compost will breakdown. Contrarily, as moisture rates decrease due to the lack of proper aeration, microbial organisms, and temperature levels, the decomposition process slows (Golueke, 1991b). Understanding these interconnection it becomes clear that moisture contents are heavily linked to the other two elements of composting.

Anaerobic Composting

The second method of composting requires the breakdown of organic materials in the absence of oxygen in a contained, "building, container, or vessel," (Rynk, 1992, p.37). Anaerobic composting methods include several different styles including bin composting, rectangular

Table 1: Typical Feedstocks and Nutrient Content (Rynk, 1992)

agitated bed composting, and rotating drums, transportable containers, and silo composting (Rynk, 1992). Large scale organic materials processing facilities most often choose the silo method as this system can handle large amounts of waste at one point (EPA, 2010). Regardless of the individual style, anaerobic composting occurs in the absence of air making anaerobic composting facilities extremely expensive and high maintenance as they must all be mechanized or enclosed systems (Golueke, 1991b).

Similar to aerobic composting systems, anaerobic composting requires constant monitoring to preserve the fragile natural construction of the products. While each individual method of anaerobic composting requires different management processes, all systems require the heat energy resources to reach the target temperature levels needed to ensure that all potentially pathogenic pathogens and toxins have been destroyed. Maintaining these systems can be costly and require a high amount of energy and labor thereby decreasing a solid waste management facility's interest in utilizing this method of organic waste management (EPA, 2010).

Environmental Benefits of Composting

The challenges of the composting process comes with major environmental benefits including, "significantly reduce greenhouse gas emissions quickly and at a low cost" (Platt, 2008, p. 57). Composting reduces greenhouse gas emissions by reducing, "landfill methane emissions, storing carbon in soils, decreasing emissions of carbon from soils, displacing chemical fertilizers and other chemical plant/soil additives, and increasing energy savings from displaced chemical additives," (Platt, 2008, p. 54-55) An increase in large-scale composting could, "have a substantial short-term impact on global warming" (Platt, 2008, p. 54). Prolonged development of more composting facilities over time could help drastically reduce humans' impact on the environment (Platt, 2008).

Other environmental advantages pertain to the use of completed compost product as a soil amendment. These products can help, "reduce plant disease, reduce reliance on synthetic fertilizers, increase organic agricultural production, increase the amount of reforested areas within the natural environments due to the modification of degraded soil structures, remediate soil structures influenced by toxic/hazardous waste, eradicate unwanted metals and debris within soils, and generate cost benefits compared to the heavy use of synthetic soils" (EPA, 2010; Platt, 2008). This extensive list of positive benefits from use of completed compost as a solid amendment often increases the rate of purchasing or utilizing these products in lieu of synthetic fertilizers or other harmful chemicals.

History of Chittenden Solid Waste District

Upon the enactment of the State of Vermont's Act 78 Solid Waste Management Law, on March 3, 1987 the Chittenden Solid Waste District (CSWD) was officially chartered as a state recognized sold waste municipality (Chittenden Solid Waste District [CSWD], 2004). Act 78 also promoted the joining together of municipalities to form "Solid Waste Districts" to divert waste from Vermont landfills. Granted the powers of both a municipal corporation and a cooperative waste management facility, CSWD became capable of running a solid waste management program for the entire county including the following urban areas: Bolton, Colchester, Hinesburg, Milton, Shelburne, Westford, Burlington, Essex, Huntington, Richmond, South Burlington, Williston, Charlotte, Essex Junction, Jericho, St. George, Underhill, and Winooski (CSWD, 2004).

Following Act 78's Title 24, Section 2202a(a), solid waste management within the District became the responsibility of CSWD (CSWD, 2004). Title 24 required CSWD to provide, "sanitary landfills, incinerators, recycling centers, intermediate processing facilities, composting plants, or resource recovery facilities or a combination thereof as the exclusive means for disposal of solid waste," for the entire District (CSWD, 2004). Title 24 also required CSWD to introduce easily understood waste reduction and prevention methods to all residents within the District as a means to increase waste diversion rates (CSWD, 2004).

With the enactment of Act 78, CSWD developed a solid waste management plan that would entail the construction of a new sanitary landfill, the installation of a solid waste drop-off centers across Chittenden County, the management organic yard waste, and the processing of commingled recyclables at a new materials recovery facility (CSWD, 2004). Before the proposal was approved by District residents, CSWD was prompted to include a service that would ensure that 87% of Chittenden County residents would be guaranteed curb-side recycling opportunities thereby increasing the ease and accessibility of recycling in Chittenden County (CSWD, 2004). This meant that the remaining 13% of residents would have to personally travel to local recycling drop-off sites. CSWD also added a regulation that called for the mandatory separation of solid waste from recyclable material, a rule that would ultimately increase the waste diversion rate.

CSWD was allotted over $6.6 million for the formation and production of the proposed solid waste management site that would properly utilize the most current techniques and technologies available ensuring a more successful operation (CSWD, 2004). The construction period moved quickly allowing for the development of a new materials recovery facility and a double lined sanitary landfill. Both facilities were completed by December 22, 1992 (CSWD, 2004). By 1994 seven drop-off facilities were open for operation within the county. These drop-off centers were proven to help increase the diversion rates of recycled materials in areas outside of the urban Burlington area (CSWD, 2004). With the exception of the purchase of an organic materials processing facility in 2008, these CSWD facilities and programs stood without major change until 2009 when the 1992 sanitary landfill began to reach capacity.

With the $4 million purchase of land in Williston, Vermont in late 2009, CSWD began to develop a new and updated solid waste management facility (CSWD, 2009). The official siting regulations for the new solid waste facility required that CSWD, "1) demonstrate that the facility will be in conformance with all local, state, and federal laws, rules, regulations, and ordinances while it is in operation and; 2) obtain the formal support of the Chittenden Solid Waste District in the form of a resolution of the District's Board of Commissioners to include the facility in this plan" (CSWD, 2009). These standards ensured that the new landfill was on par with modern development strategies and federal regulations.

The Williston location was quickly transformed into a solid waste treatment facility capable of managing the county's waste stream and was designed by two local environmental planning firms, Shaw Environmental and O'Leary Burke Civil Associates (CSWD, 2009). By late 2009, the old sanitary landfill was capped and the new sanitary landfill and materials recovery facility located Williston, Vermont were opened for use (CSWD, 2009).

Politics of Composting Within Chittenden Solid Waste District

Intervale Compost Products[3] (ICP) was established in 1987 by Gardeners Supply Company as a small-scale movement to manage the nearby Intervale Center's[4] food, yard, and animal wastes (Page, 2011). The organization was purchased by the nonprofit Intervale Center a year later in 1988 in an attempt to expand the operation to the surrounding Burlington community (Page, 2011; Intervale Compost Products [ICP], 2011a). For seven years ICP increased in popularity to the point of outgrowing its original facility. In need of more space and an updated composting facility, in 2005 an additional 53 acres of land were donated to ICP by a private donor (ICP, 2011a). This total renovation of the ICP facility and management programs allowed for an increase in the amount of organic wastes that could be processed annually.

Much of the facilities 2005 development was publicly covered in the local newspaper, *The Burlington Free Press*. This attracted more local residents, commercial institutions, businesses, and farms to dispose of their organic wastes at ICP. By 2007 ICP had drastically increased its intake of organic wastes. While this increase in waste diversion kept more organic waste out of the landfill, in late 2007, "the center ran into a barrage of regulatory problems," from the Vermont Agency of Natural Resources (VTANR) (Page, 2011). VTANR charged ICP with allegations including, "taking in more waste than its permit allow[s]," and not, "managing its composting operations properly, posing risk that bacteria-ridden liquids would reach nearby

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[3] ICP was originally named "Intervale Foundation". The name changed when the Intervale Center purchased the organization in 1988 (ICP, 2011a).

[4] More information on the Intervale Center can be found on page 40.

gardens and the Winooski River" (Hallenbeck, 2007). Aside from the excessive intake of organic wastes, the VTANR was most concerned that E. coli had leached from ICP compost windrows into nearby gardens thereby, "posing a threat to those who eat produce grown there" (Staff of The Burlington Free Press [SBFP], 2007). ICP was forced to stop accepting organic wastes until the excess organic waste tonnage intake claims were researched and actions were taken to clean up the potentially toxic leachate (SBFP, 2007).

Despite ICP's internal opinion that these allegations were made in a political attempt to shut down the organization, ICP quickly responded by pumping out potentially pathogenic leachate from nearby lagoons. The leachate was, "sent to the Essex Junction wastewater treatment facility," for proper disposal (Hallenbeck, 2007). Afterwards, ICP submitted, "paperwork clarifying the categories of food waste it accepted," and, "state officials determined...that the center had not exceeded its food waste limit and could start accepting [organic] waste immediately" (Hallenbeck, 2007).

In late 2007 ICP began working on a new design for the compost facility in an attempt to reduce the amount of runoff entering nearby soils and waterways. This plan was put to a halt when CSWD purchased ICP on October 13, 2008 (CSWD, 2009). CSWD also saw this purchase as an excellent opportunity to increase organic waste diversion from the sanitary landfill as statistically organic matter constitutes to over 33% of the CSWD solid waste stream, increase the amount of soil amendments, reduce the level of greenhouse gas emissions, all while stimulating local economies. (CSWD, 2010a). CSWD also funded a, "$150,000 compost inventory, $40,000 operational subsidy, $20,000 archeological study fund," to help further develop the facility (CSWD, 2009).

Soon after purchasing ICP, CSWD recognized the facility's outdated composting methods and began to develop plans for the construction of a new facility in Williston, Vermont. This new organic materials processing facility will open on July 1, 2011 (CSWD, 2009). Though ICP will continue to manage older organic wastes up until its closure date on July 1, 2011, it stopped accepting organic wastes on March 1, 2011. After July 1, 2011, leftover organic wastes from ICP and organic wastes collected during the transition period will be taken to another organic materials processing facility called GrowCompost located outside of the District in Moretown, Vermont (Page, 2007).

With the establishment of a new compost facility, CSWD also plans to take several steps to further develop the facility's management programs. CSWD considered developing a curbside organics collection program for the nearby urban area of Burlington, Vermont upon the completion of the new compost facility; however, it was deterred from the negative results of a 2000 CSWD curbside organics collection pilot program (CSWD, 2010a). In response, CSWD plans to continue promoting the organic waste collection services offered by: Casella[5], Gauthier Trucking, Myers Container, and One Revolution and two private small-scale haulers, One Revolution LLC and Earthgirl Composting! (CSWD, 2011a). While hiring a private hauling service is convenient, it can also be expensive as each hauling service sets its own rate, funds a fleet of vehicles capable of transporting organic waste, purchases the fuel needed for each truck, pays solid waste field personnel, and the $35 per ton tipping fee charged to all private haulers (CSWD, 2004).

[5] Previously known as "All-Cycle Waste", this report will refer to the private hauler by its new name "Casella".

Aside from transportation of organics, CSWD is also concerned with the education of its local residents about the compost process. During this four month transition period, CSWD plans to further educate the local communities within Chittenden County about the importance of composting organic wastes (CSWD, 2010a). CSWD plans to do this by contacting each resident through informational pamphlets and newsletters (CSWD, 2010a). While this is not the most committed approach, CSWD does hope to see some form of change in the amount of organic waste that is diverted from the refuse waste stream.

Methods

This research thesis is based upon the premise that the successful urban development of CSWD's new organic materials processing facility is based entirely upon achieving an even balance between the three sustainable growth factors: social, environmental, and economic. Given the history of CSWD, the development of a new organic materials processing facility is an improvement to the waste management system on the whole; however, the installation of an advanced composting system doesn't address all aspects of sustainable growth. By choosing to focus on the development of the facility's technology while simultaneously expanding its relationship with the nearby communities, the surrounding environment, and the local economics, sustainable growth may become an attainable goal rather than a distant ambition. The old and new CSWD organic materials processing facilities were compared to three case examples with the following set of focus questions. The result was a set of recommendations and goals for the sustainable development CSWD Compost's facility and the City of Burlington.

Research Questions:

CSWD's Old and New Organic Materials Processing Facilities:

- How are the old and new CSWD compost facilities managed and budgeted?
- What organic feedstocks are accepted and through which compost system are they processed into completed compost?
- How is organic waste transported to each facility?
- What are the future development plans for the CSWD Compost facility and program?

Case Examples' Organic Materials Processing Facilities:

- How is each case example compost facility managed and budgeted?
- What organic feedstocks are accepted and through which compost system are they processed into completed compost?

- How is organic waste transported to the facility?
- What are the future development plans for the compost facility and program?

Analysis Process:

Analyzing Sustainability of ICP and CSWD Compost:

ICP

- Using the social, environmental, and economic growth factors to measure the sustainability of ICP, what were the benefits and drawbacks of program?

CSWD Compost

- Using the social, environmental, and economic growth factors to measure the sustainability of CSWD Compost, what are the benefits and drawbacks of each program?
- Where does CSWD Compost have room to sustainably develop its relationship with the Burlington community?
- Where does CSWD Compost have room to sustainably develop its relationship with the surrounding environment?
- How does CSWD Compost financially managed and how might this method be improved?

Analyzing Sustainability of Case Examples

- Employ One Sustainable Growth Factor to Each Case Example:
    - Social Development: Dubuque, Iowa
    - Environmental Development: Seattle, Washington
    - Economic Development: Toronto, Ontario
- How does each case example exemplify one specific sustainable growth factor?
- How could the CSWD Compost facility benefit from adapting and installing some of the successful technologies or programs highlighted by each of these facilities?

Final Synthesis

- What are the most feasible social, environmental, and economic organic waste management sustainable development goals for CSWD Compost and the surrounding urban area of Burlington, Vermont?
- How are each of these sustainable growth factors interconnected?
- How may each sustainable growth goal be accomplished?

Case Example Approach

To provide additional comparison between the old and new CSWD composting facilities, I studied the management plans of three exceedingly successful urban composting facilities in: Dubuque, Iowa; Seattle, Washington; and Toronto, Ontario. I compared how each case example's compost facility thrives within an urban area compared to Burlington, Vermont in terms of population size, weather, or waste diversion goals. I drew out the exceptional sustainable qualities found in each compost program or facility to highlight how CSWD Compost could better manage the organic waste stream generated within the City of Burlington. This should allow CSWD Compost to benefit from improving Burlington residents' waste diversion rates, the environments affected by a compost site, and the finances of the composting operation.

The central thread that ties this research project together is based on the idea that each case example's compost facility will be researched for the purpose of serving as a model for the development of CSWD Compost and the City of Burlington. Each case example's results will be analyzed on the whole and then narrowed down to the perspective of one specific sustainable growth factor assigned based on the strengths presented by its results and their similarity with Burlington. After researching each case example composting facility on the whole and from the perspective of a singular growth factor, I drafted recommendations for CSWD Compost and the City of Burlington based upon the best possible balance of successful sustainable development ideas. With these suggestions, CSWD Compost should be able to team up with the City of Burlington to further develop a growth plan that can address current and future urban organic waste management issues.

Case Example Selection

For this research study, a range of compost facilities were analyzed as “critical cases” in an attempt to narrow the field down to the three that would yield the greatest information and have the greatest impact on the sustainable development of the CSWD Compost facility and the City of Burlington’s compost program (Patton, 2002, p. 447). As this research project is focused on redeveloping a sustainable urban compost program and facility, each case example was chosen based upon whether it exerted characteristics that successfully modeled the sustainable growth factors introduced in the literature review. Critically choosing successful case example compost facilities was also relevant in producing achievable recommendations and development goals for CSWD Compost as each case example’s results provides the feeling that, “if it happens there, it will happen anywhere,” (Patton, 2002, p. 236).

Each case example was selected to represent one sustainable growth factor it successfully illustrated. These decisions were based on the results of research presented in the popular compost magazine *BioCycle* (Yepsen, 2009). After analyzing several of the organic materials processing facilities and their corresponding programs described in the magazine, the three cities of Dubuque, Iowa; Seattle, Washington; and Toronto, Ontario were selected for this research project based on their relationship with social, environmental, and economic growth factors. The size, location, and weather patterns were also taken into consideration during the selection process. As no single case example city provides a perfect model for the sustainable development of CSWD Compost, the meshing of the three facilities and programs provided CSWD and the City of Burlington with and outline of possible recommendations.

Dubuque, Iowa provides an inside look at the *social* interworking of a composting facility exceedingly similar to CSWD based upon the population size and weather patterns. Seattle, Washington doesn't compare to Burlington's climate or population size. It does however illustrate the method of intertwining *environmental* awareness into the construction of an expanded and advanced composting technology at Cedar Grove Composting, a privately owned organic materials processing facility affiliated with Seattle. Cedar Grove Composting boasts a prominent composting system and developmental plan for this system the near future. Lastly, Toronto, Ontario's population size and weather patterns differ from Burlington; however, it does provide an *economic* plan that could easily be developed at CSWD Compost and among Burlington residents.

As all three social, environmental, and economic growth factors are interwoven with one another, some overlap of facility and program development is visible between the three case studies. By maintaining a narrow lens of analysis and utilizing the applicable factors, each case example element is successfully modeled for adaptation at CSWD Compost and in the City of Burlington.

Data Sources

The types of resources used for data collection included books, book sections, edited books, government documents, scholarly journal articles, online databases, online multimedia, pamphlets, personal communications, reports, and web sites. The books, book sections, edited books, scholarly journal articles, and online databases provided background information on the science behind composting processes and different types of compost technology. These were most useful in drafting the literature review and in developing a foundation on which to explain and expand upon the composting process used by each compost facility described throughout the report. The government documents were used to locate budget information for each solid waste district, each organic materials processing facility, and each curbside organics collection program if applicable. Most of this information was identified in official statistical reports that are available to the public via online resources. The online multimedia, pamphlets, reports, and numerous web pages were helpful in identifying information about each specific composting facility and program researched. Personal communication was unstructured and occurred with either the director or a compost specialist from each solid waste management district or compost facility. This communication helped identify and confirm information learned from previous resources while providing an inside view of the facility's inner-workings.

Analytical Framework

Studying the social, environmental, and economic benefits and drawbacks of both the old and new CSWD organic materials processing facilities, a range of results highlighted where CSWD could benefit from sustainable development, including in its interaction with the City of Burlington. After analyzing the benefits and drawbacks of the social, environmental, and economic growth factors of both the old and new facilities, I synthesized the resulting, "rich information," through comparative study (Patton, 2002).

Each case example was researched similarly. However, instead of being analyzed from all three growth factors, each case example was studied based upon the specific framework of one: social, environmental, or economic. Each case example was then studied based on the benefits and drawbacks of its one sustainable growth factor. Understanding both the benefits and drawbacks provided relatively balanced research results and clearly illustrated which aspects modeled by the case examples may help further sustainably develop CSWD Compost.

Searching for more support in the analysis of resulting information, I then considered the past successes and failures of CSWD's own pilot curbside organic management programs and compared them to the successful development models represented in one of the three case examples. The results of this comparison helped further strengthen the set of developmental recommendations and resulted in an influential resource for CSWD Compost and the City of Burlington, Vermont.

Limitations of Study

Throughout the research process, I drew distinct boundaries to the limitations of my research project. Strictly studying CSWD Compost's affects on the City of Burlington, I was able to gain a greater understanding of composting processes and programs affecting this specific area rather than spreading my investigation too thin rendering my topic overly broad. While I did study three additional case example compost facilities, these were used to contrast CSWD's compost facilities and serve merely as models or tools of comparison.

Some limitations and restrictions occurred during my research process potentially skewing or altering my research results. One identifiable example that noticeably skewed results was the climate and population data offered for each city. All three U.S. cities use the same census results and climate resources to identify this data; however, as Toronto is in Canada, this information was collected from Canada's resource equivalent meaning that the year in which the data was collected renders the information somewhat incomparable. Another limitation was found in the amount of information available for each case example compost facility or program.

While most had excessive amounts of public information, Dubuque, Iowa in particular lacked available information thereby restricting the depth of that case example's research. The final limitation in my data results is connected to the possibility that I received biased personal communications from each personal contact. While I can't confirm that I received skewed information, I can only assume that there was slight exaggeration or understatement in the data taken from my unstructured communications.

As the field of urban planning and sustainable development is dynamic and ever-changing, the process of improving CSWD Compost's facility and its relationship with the City of Burlington will never fully end. New processes for development methods or techniques are always being discovered meaning that this research project's results are subject to change alongside new emerging data. As to my own personal limitations as a researcher, I most certainly provide a slight bias based upon my background as an Environmental Studies student. Despite my attempts to provide the even balance and blending of the three disparate growth factors needed to achieve sustainable development, there is undoubtably a strong environmental focus found in the analysis of the results meaning that the recommendations assigned to CSWD Compost and the City of Burlington advocate for aggressive environmental transformation.

Results

Overview

Before analyzing Burlington, Vermont's composting program through the lens of sustainable urban growth, the city's organic materials processing facility and program must first be understood. This also includes describing Burlington's current relationship with organic waste management and the process by which organic waste moves through the chain of waste management from generators to the final compost product. To provide comparison for Burlington, the organic waste streams of three case example cities and their organic materials processing facilities were researched and analyzed. The basic statics of all four cities are briefly introduced before delving into their organic waste management programs allowing for an understanding of how each case example's residential population, number of households, and climate compare to the focus city of Burlington, Vermont. Each city is then individually analyzed to explain: the content and generators of organic wastes, the process of transporting organic wastes to each compost facility, the description of each compost facility, the current process used to compost organic wastes, and any relevant future development goals for the facility or the organic waste management program. Using the same criteria to evaluate each of the four cities easily illuminates the similarities and differences between each city's organic management program allowing for balanced comparison.

The City of Burlington, Vermont

Situated in the northwestern corner of Vermont in Chittenden County, Burlington, Vermont is currently the largest city in the state. In total, the 2000 U.S. Census[6] suggests that the area of Burlington can be measured at 15.5 square miles with approximately 38,889 residents and about 15,885 households residing within these city limits (U.S. Census 2010, 2011). Located in the heart of the Champlain Basin, the City of Burlington neighbors Lake Champlain, the Green and Adirondack Mountains, and upstate New York. Burlington annually experiences an average winter temperature high of 18ºF and an average summer temperature high of 70ºF. The average annual precipitation level within the city is about 34 inches with the majority occurring during the summer months. Experiencing moderate temperature swings from season to season and a moderate amount of annual precipitation, this city is classified as a humid continental cool summer climate (Morrissey, 2011; NASA Space Grant Consortium & Oklahoma East Central University, 2004).

Organic Materials Management in Burlington, Vermont

Management and Budget

The old organic materials processing facility is managed and funded by the Chittenden Solid Waste District (CSWD). Organic wastes generated in Burlington were formerly processed at CSWD's old organic materials processing facility, Intervale Compost Products (ICP), located on Intervale Road in Burlington, Vermont. While ICP is now owned and operated under CSWD, up until 2008 ICP was affiliated with the Intervale Center, an organization that strives to provide

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[6] 2010 Census Data was newly available for this research project; however, Vermont was the only state in the study with complete data. In an attempt to preserve the legitimacy of the data comparison, the 2000 U.S. Census data was used. Note: The 2010 Burlington, Vermont population was calculated to be 42,417 (U.S. Census 2010).

both farmers and local Burlington residents and businesses with agricultural land, organic foods, soil amendments, and space for the city's compost process. Food, yard, and animal waste composted by ICP was eventually sold in bulk to an array of local contractors, landscapers, and golf courses. Another portion of the completed compost was bagged for sale at nearby private retail gardeners supply centers and home improvement centers such as Aubuchon Hardware, Ace Hardware, Walmart Garden Center, Home Depot, Lowe's Home Improvement, and the Intervale Garden Center, a private for-profit gardener supply store associated with the Intervale Center.

ICP's fiscal budget for fiscal year 2010 was $9,211,884 (CSWD, 2010b). This budget funded all of the District's operating expenses including: the materials recycling facility, the waste reduction program, Intervale compost facility, the special waste processing facility, drop-off centers, the hazardous waste center, biosolids processing, special projects, future project development, finance, administration, marketing and communication, enforcement, property management, small sitework and building construction/repair, and landfill post-closure expense (CSWD, 2010b). Approximately $1,196,130 of this total fund was dedicated to management and maintenance of ICP. This is a $396,909 increase in funding from 2009. This increase in funding was 100% dedicated to financially preparing the facility for its impending closure on March 1, 2011 (Moreau, 2011).

Profile of Organic Waste and Generators

Each year, roughly 15,000 tons of organic waste are generated by Chittenden County residents, commercial institutions, businesses, or farms. This unwanted organic waste includes food scraps, nutrient rich animal manure, animal bedding, and small yard trimmings (ICP, 2011a). Despite the high amount of organic waste generated, ICP only had the capacity to manage about 6,000 tons of this waste. The remaining 9,000 tons of Chittenden County's organic waste that were not composted on site at ICP were transfered to either the CSWD landfill or to another organic materials processing facility in Moretown, Vermont (Moreau, 2011; Hallenbeck, 2007).

The District does not ban organic waste from entering landfills nor is there a mandated urban curbside organics collection program. This has deterred many local residents and business from participating in the composting process. Also, some residents have not been educated about the benefits of composting while others have found no motivation or incentive to justify sorting out organic wastes from their solid waste stream. Therefore, the majority of organic waste that was processed at ICP was generated by large local commercial institutions and farms. Several of these major organic waste contributors include IBM, the University of Vermont, and Fletcher Allen Hospital.

Transportation of Organic Waste to Intervale Compost Products

There is no city wide curbside pick up program for organic waste in Burlington, therefore organic waste generators were encouraged to manage their own backyard compost pile, hire a range of local private haulers for curbside pickup, or personally drop off organic waste at any CSWD Drop-Off location free of charge (CSWD, 2010a). Some Burlington residents, commercial institutions, and businesses chose to deposit of organic food wastes at the CSWD drop-off center located on Pine Street or at the ICP food scraps drop-off bin located on Intervale Road as both are conveniently located downtown (CSWD, 2011a). Local farmers could also personally drop off large amounts of nutrient rich animal manures and animal bedding at ICP free of charge (Moreau, 2011). While yard trimmings aid in the ICP composting processes, CSWD and ICP asked that any woody yard wastes larger than ½ inch in diameter be dropped off at the McNeil Wood and Yard Waste Depot, a facility owned and operated by the City of Burlington's Electric Department (CSWD, 2011b). The McNeil Wood and Yard Waste Depot is located directly across the street from ICP on Intervale Road.

Brief Description of the Old Organic Materials Processing Facility

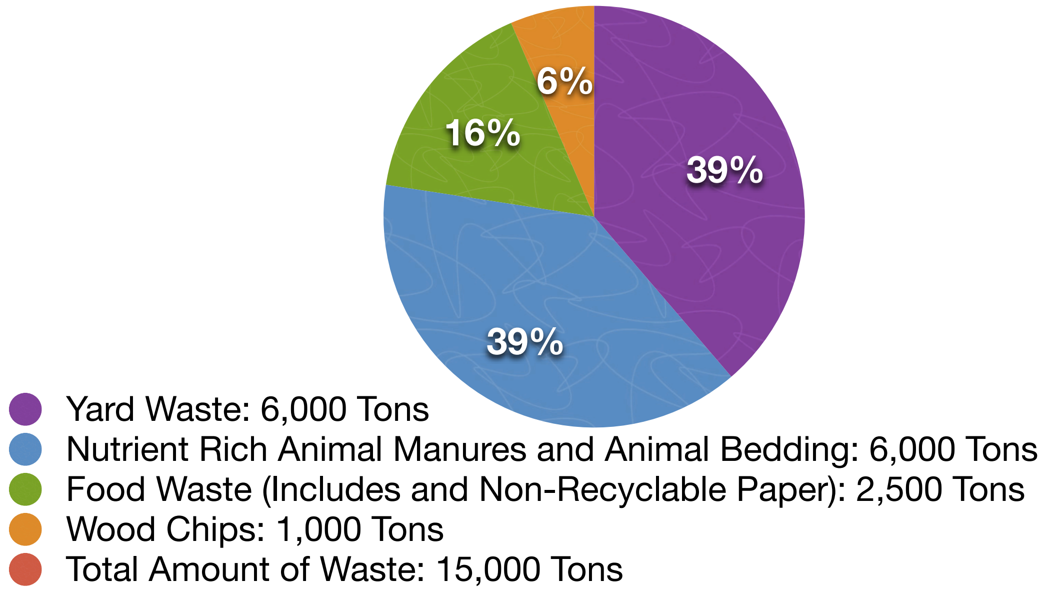
Situated on 16 acres of land, the ICP compost facility uses the traditional turned windrow composting system to breakdown unwanted organic wastes. In order to properly manage organic wastes, ICP rests its untreated organic waste on impermeable concrete pads and stores its completed compost on hard packed ground pads. Both pads are imbedded with an adequate drainage system that captures potentially pathogenic leachate. Using mechanical machinery to move organic materials and advanced computer technology to test compost batches and predict weather patterns, both the ICP compost manager and the team of compost specialists work together to adequately manage as much organic waste as possible at any point of the year despite potentially harsh weather patterns.

The Old Compost Process at Intervale Compost Products

Once the organic waste arrives at ICP, the composting process begins. Using the traditional turned windrow compost process, there are four major steps organic waste endures before it is deemed compost. Following proven recipes that are guaranteed to produce the high quality compost their customers have come to expect, the ICP manager and compost specialists mix each batch of compost based upon these guidelines and the feedstock ingredients available.

Step One: Pre-Processing and Blending

Profile of Organic Waste Received at ICP Annually



Graph 1 - Profile of Organic Waste Received at ICP Annually (Moreau, 2011)

This step of the composting process involves mixing a batch of food scraps, nutrient rich animal manure, animal bedding, and small yard trimmings ensuring that there is an appropriate Carbon to Nitrogen (C:N) ratio anywhere between 25:1 to 40:1 (Moreau, 2011). To maintain this ratio throughout the entire first step of composting, ICP compost specialists add in more brown and dry leafy material to increase carbon rates or more green and wet grass like material to increase nitrogen rates. This ensures the mix has just enough energy and microorganisms to completely break down all of the organic wastes.

ICP compost specialists attempt to keep the moisture level anywhere between 50-60% (Moreau, 2011). In a traditional turned windrow composting system, additional liquid and oxygen can always be added to maintain proper levels of moisture. Aeration occurs during the turning process ensuring an even mixture of moisture and oxygen throughout the pile. At ICP, the mixing phase of the traditional turned windrow compost process occurs with the use of a bucket loader that mechanically picks up and dumps piles of feedstocks (Moreau, 2011). This mixing and blending phase takes place on an impermeable concrete pad imbedded with a leachate/runoff drainage system.

Step Two: Active Composting (Phase One)

After the initial step of mixing each batch of organics, the second step involves building a compost windrow. Each freshly built windrow is then covered up to a foot thick in completed/aged compost. This layer of aged compost serves as a biofilter insulation blanket that captures nutrients and moisture and deters undesirable odors and vectors. Each windrow rests on impermeable concrete pad that is connected to a drainage system. This system captures any leachate or runoff that may potentially carry pathogens unsuitable for the surrounding environment. This leachate is collected and is either recycled by reintroducing it to step two compost or it is sent to the Burlington wastewater treatment facility where it is adequately treated. Each initial pile is built up about 6 feet high and 14 feet wide in the shape of a traditional windrow (Gardener's Supply Company, 2002). ICP may also slightly alter the shape of each pile dependent upon the weather. This includes building a flat top windrow for dryer or warmer periods allowing more moisture to soak into the heap.

During this second step of composting, the heap sits to undergo "the process to further reduce pathogens" (PFRP) (Moreau, 2011). As the composting process involves using organics that may potentially carry human or plant pathogens, by law, compost specialists must guarantee that before organic waste is deemed compost, all pathogens must be destroyed. Each pathogen is killed off from the organic pile by means of the high temperatures offered from the center of each heap. For ICP, the preferred PFRP temperature rests at 131° Fahrenheit. The temperature is measured each day with a compost thermometer that reaches into the center of the compost windrow towards the interior zone. The temperature should usually hover between 131° and 160° Fahrenheit by means of maintaining C:N ratios, a healthy 50-60% moisture level, and increased oxygen levels by turning each windrow at least 5 times every 15 days. If the piles aren't turned enough, the windrow can become anaerobic, meaning lack of oxygen, due to an increase in moisture content and can begin to smell. ICP ensures that each pile sits for 15-20 days at 131° Fahrenheit before it is tested for pathogens and is ready to move onto the next step of composting (Moreau, 2011).

Step Three: Curing

Curing compost can take anywhere between six to ten months. During the third step of composting, ICP moves each windrow to a new packed dirt pad that no longer requires leachate systems as the runoff from this grade of compost is no longer classified as toxic or pathogenic. Step three compost is turned once every one to two weeks to maintain a proper amount of aeration and moisture levels that reside anywhere between 40-45%. The third step of composting is not nearly as labor intensive as the first two steps. Organic materials age in these windrows for several months resulting in an odorless, dark-brownish, silky compost substance that has no trace of the food scraps, nutrient rich animal manure, animal bedding, or yard trimmings that were its primary components.

At this step, ICP then tests the compost for maturity, concentration of nutrients, potential ratings of phytotoxicity or the herbicide aminopyralid, and the presence of pathogens or heavy metal concentrations. The organic materials must pass the Northeast Organic Farming Association of Vermont / Vermont Organic Farmers (NOFA-VT/VOF) and the State of Vermont compost requirements before it is considered completed compost. ICP has a special interest in testing the final product to ensure that NOFA-VT/VOF standards are met as this ensures that the final compost product can be “certified organic” and used on organic farms throughout the state of Vermont (Northeast Organic Farming Association of Vermont [NOFA-VT], 2011). ICP also frequently tests its compost product for the presence of Polycyclic Aromatic Hydrocarbons (PAHs). While no standards limiting the presence of PAHs in compost products exist at state or Federal levels, ICP tests each batch of compost to ensure that the lowest levels of PAHs possible are present in completed compost product (Moreau, 2011).

Step Four: Post-Processing

The fourth and final step of composting at ICP involves screening the completed compost for large or unwanted components at ⅜ inch (ICP, 2011a). After screening, the compost that passes through is then bagged or sold in bulk as Intervale Complete Compost to any gardener or farmer searching for a natural soil amendment (NOFA-VT, 2011).

Future Development Plans for Intervale Compost Products: (February 1, 2011 - July 1, 2011)

On February 28, 2011, ICP stopped accepting organic wastes at its Burlington location. ICP plans to continue composting the rest of the organic waste it already holds and will continue to sell bulk compost and soil amendments until June 30, 2011. ICP stopped accepting organic wastes in February in an attempt to slowly phase out compost production at this Burlington location. Until the opening of the new Chittenden County compost location in Williston, Vermont on July 1, 2011, all Chittenden County drop-off centers will continue to accept organic waste. This temporary interim between compost locations will only last four months and should give CSWD enough time to transition equipment from ICP to the new location in Williston.

CSWD's Future Organic Materials Processing Facility

Development Plans for Management of CSWD Compost in Williston, Vermont

With the proposed move of Chittenden County's compost facility, CSWD has been given the opportunity to revaluate and redevelop its compost technology and methods. Recognizing room for sustainable urban growth in the new development, CSWD has attempted to build a more streamlined, efficient, and environmentally conscious composting program that will benefit not only those working within the compost facility, but the generators of organic waste as well. This includes the residents, commercial institutions, businesses, or local farms who on a daily basis rely on there being a place to dump unwanted organic materials (Moreau, 2011).

In early 2010, CSWD hired professional civil engineers, O'Leary-Burke Civil Associates, PLC, and professional compost consultants, O_2Compost, to aid in the design proposal for the new compost facility in Williston. CSWD asked that both design organizations work together to produce a new compost facility and program that would overcome some of the ICP compost program's drawbacks. One of the drawbacks included ICP's inability to process a large amount of organic waste due to the small size of the compost facility. As ICP has never been able to accept the full amount of food scraps, nutrient rich animal manure, animal bedding, and small yard trimmings delivered each year, CSWD requested a facility large enough to process over 20,000 tons of organic waste per year. CSWD was essentially searching for a 14,000 ton annual increase in compost production, an amount over two times larger than what was processed annually in the past. While this large target increase in the annual compost product yield seemed unachievable for the small amount of space offered at the new facility, the two design companies proposed developing a new compost technology that would allow CSWD to efficiently operate on a mere 16 acres. This technology would fundamentally allow CSWD to compost more organic waste and create more final compost product thereby relieving the solid waste stream of excess organic waste and increasing CSWD Compost's profit margins (Moreau, 2011).

Through the development of the new Williston compost facility, both design teams suggested abandoning the traditional turned windrow composting system used at ICP in favor of an advanced compost technology in hopes of producing the same high quality compost product at a lower price and at a faster rate. Understanding the spatial constraints of the new compost facility in Williston, the design teams recommended installing an aerated static pile compost system as this process would speed up the compost operation twofold. By decreasing the length of the compost process while simultaneously increasing the amount of organic waste that can be composted at one point, CSWD Compost would ultimately be capable of composting at least two times as much organic waste as it has in the past. This increase in annual production also comes at a smaller price than the production costs offered at ICP allowing CSWD Compost to highly favor this new technology's compost method.

Description of the New Organic Materials Processing Facility in Williston, Vermont

The new location of CSWD Compost will reside on the CSWD campus in Williston, Vermont. Part of the new organic materials processing facility will rest on a 180' x 220' = 39,600 Ft^2 (0.91 acres) concrete pad. This impermeable surface will provide a space to house feedstock bays, the mixing bay, four medium sized step two aerated static pile bays, and one large sized step three aerated static pile. Each bay on the concrete pad will have concrete walls built up around it to give additional structure to each organic waste pile. These walls will also serve as a separation line in between each heap thereby ensuring there is no contamination in between organic wastes. The concrete pad will also house an imbedded set of aerated static pile blowers/pumps that will rest under both step two and three's compost piles thereby allowing for forced aeration of each pile. These blowers/pumps have a valve that can adjust the speed and the direction of airflow through each pile. A positive setting blows air up through the pile while a negative setting sucks air down through the pile. Aside from the addition of aerated static pile technology, CSWD Compost also plans to add a mechanical mixer to aid in the speed and efficiency of this facility. The mechanical mixer will effectively blend the feedstocks entering step one of the composting process. Located in the mixing bay, the addition of the mechanical mixer will aid in the uniform blending of feedstocks and will require less manual mixing traditionally executed by diesel fuel bucket loader that mechanically pick up and dumps piles of feedstocks (Moreau, 2011).

Above 50' x 220' = 11,000 Ft^2 of the concrete pad there will be a roof structure that will house the first 21-28 days of composting. This roof will provide the new compost facility with protection from the elements. As moisture plays a key role in the success of composting, being able to manage how much rain, sleet, or snow comes in contact with the piles will allow the compost manager and specialists to control the exact percentage of moisture within each compost pile. Compost piles resting on the concrete pad in step one and two will connect to a built in drainage system that will collect potentially pathogenic leachate into a 20,000 gallon tank located just off of the concrete pad. Any leachate and runoff from the step three piles located on the impermeable concrete pad will be drained into an onsite lined collection pond. CSWD Compost plans to recycle this liquid adding it back into pre-PFRP organic waste batches to help maintain moisture levels or send it to the Burlington wastewater treatment facility where it will be properly decontaminated (Moreau, 2011).

There will also be a hard packed ground space that will serve as storage for yard waste and wood chips, the step four curing process, and for completed compost product storage located just off of the concrete pads. The curing pads will be directly connected to a lined curing collection pond to collect any leachate or runoff output; however, the completed compost product storage space will not have a drainage system as the liquid output from this pile isn't considered toxic or pathogenic and is completely safe for contact with the surrounding environment (Moreau, 2011). The hard packed ground space will also house the compost facility's large machinery when they are not in use on the concrete pad and will serve as a storage area for crushed gravel or concrete that may be recycled into the compost facility's infrastructure at some point.

Financial Expenses of the New Organic Materials Processing Facility in Williston, Vermont

Cost of Facility Construction

Building the new CSWD Compost facility from scratch, the overall construction costs of the roof structure, impermeable concrete pad, set of concrete compost pile bays, leachate drainage system, 20,000 gallon leachate collection tank, two lined leachate collection ponds, and the installation of the new imbedded blower/pump system will cost CSWD management about $2.2 million in total.

Cost of Machinery

Aside from relying completely on new equipment, CSWD Compost plans to move the majority of the equipment used at ICP to the new location in Williston. Due to this transfer of equipment, CSWD Compost will save thousands on new computers or weather predicting technology that is crucial in managing the facility. As CSWD Compost also plans to transfer the fleet of compost moving machinery including the old bucket loaders and straddle machines from ICP. This will save CSWD Compost over $500,000 on new machinery (Moreau, 2011). However, some new machinery will be purchased, including a used mechanical mixer for more efficient blending of feedstocks. This machine should cost about $100,000 (Moreau, 2011).

As CSWD Compost will come to rely on the new aerated static pile system to aerate each pile of organic waste, the use of expensive diesel fuel bucket loaders will dramatically decrease. CSWD Compost plans to use a maximum of $20,000 on diesel fuel each year meaning that CSWD Compost will save almost $40,000 a year in the cost of diesel fuel alone. While electricity will be needed to manage the blower/pump systems, in total CSWD plans to only spend a maximum of about $3,000 annually on electricity bills (Moreau, 2011).

Cost of Labor

CSWD Compost predicts not needing to add any additional compost specialists to adequately manage the new organic materials processing facility meaning that the cost of labor and maintenance at the new facility will not increase from that of ICP (Moreau, 2011).

The Future Compost Process at CSWD Compost

Unlike the older traditional turned windrow composting system, the new aerated static pile compost system works through a set of five major steps. While these steps may appear quite similar to ICP's, there are several major differences that distinguish the technologically based aerated static pile compost system.

Step One: Pre-Processing & Blending

The first step involves taking inventory of the feedstocks located in the mixing bay under the covered roof and on top of the impermeable concrete pad. Each feedstock will be blended into a mix that follows a compost recipe that is guaranteed to produce high a quality compost product. The CSWD Compost manager and compost specialists will mix each batch of compost based upon these guidelines and the feedstock ingredients available. CSWD Compost will mix a precise amount of: food scraps, nutrient rich animal manure, animal bedding, and small yard trimmings ensuring that there is an appropriate Carbon to Nitrogen (C:N) ratio (Moreau, 2011). Water will most likely be added during this step to achieve an appropriate percentage of moisture anywhere between 50-65%.

Step Two: Active Composting (Phase One)

After the blending phase, the well mixed organic waste heap will be transfered to an aerated static pile bay located under the covered roof and on top of the impermeable concrete pad. The pile will be constructed over a perforated air line that is imbedded within the floor and is connected to an electrically powered air blower/pump behind the bay wall. These blowers/pumps will have a scheduled timer and a variable speed control system that will allow the compost facility's manager and specialists to control how much oxygen enters into each static pile. When using a positive airflow, the static pile will be covered up to a foot thick in completed/aged compost before the blowers begin circulating air. This aged compost layer serves as a biofilter insulation blanket that captures nutrients and moisture and deters undesirable odors and vectors. When using a negative airflow, the pump's airflow output will be covered up to a food thick in completed/aged compost before the pump begins circulating air. In this case, the aged compost layer over the airflow output serves as a biofilter that prevents undesirable odors and vectors from entering into atmosphere. CSWD Compost plans to predominately use the positive blowing airflow for step two.

As both the State of Vermont and the Vermont Agency of Natural Resource (VTANR) regulations require that organic waste undergo PFRP before it can transition into the curing step, CSWD Compost must accurately monitor the temperature of each pile over the course of the active composting phase. CSWD Compost will test the temperature levels of each static pile at several locations to ensure that the entire pile reaches a temperature of 131° Fahrenheit for a minimum of three continuous days. Using the imbedded blower/pump's complex aeration system to increase oxygen flow through the heap will help carry excess heat away from the pile. This forced aeration method will be the primary process for controlling each aerated static pile's core temperature. CSWD Compost has found that the most affective oxygen concentration level for properly maintaining each aerated static pile's core temperature is anywhere between 5 - 20% aeration (Moreau, 2011).

For the first year after development, this active composting step will take about 28 days. After CSWD Compost has time to develop a steady and productive flow for the entire compost process, this active step will drop down to about 21 days. This drop in the amount of time needed to complete step two is directly related to the level of CSWD Compost's efficiency in processing organic waste.

Step Three: Active Composting (Phase 2)

After the first 21 to 28 days of active composting have finished, the organic material will be moved to the roofless portion of the impermeable concrete pad. This pile of organic waste doesn't require a roof as the addition of precipitation aids in the maintenance of moisture levels.

Using a bucket loader, a pile of organic material will be constructed over another set of aeration pipes where the oxygen concentration rests anywhere between 5 - 20%. While CSWD Compost must monitor the moisture content and the airflow levels, there is no need to strictly monitor C:N ratios or the temperature. This second active composting phase lasts anywhere between 21 to 35 days dependent upon the state of the organic material.

Step Four: Curing

After completing both active composting steps through aerated static composting for a minimum total of 42 days, the organic waste will be deemed stable; however, the organic material must age and cure for another 90 to 120 before it is considered compost. The organic material from step three will be transfered to the hard packed dirt curing pads. Aeration may occur periodically by turning the pile with a bucket loader.

At the end of the curing step, the completed compost will be tested for maturity, concentration of nutrients, potential ratings of phytotoxicity, the presence of pathogens or heavy metal concentrations. The organic material must pass the NOFA-VT/VOF, the State of Vermont, and VTANR requirements before it is considered completed compost. Much like testing that occurred at ICP, CSWD Compost plans to continue testing its compost product for the presence of PAHs. While no standards limiting the presence of PAHs in compost products exist at the State of Vermont or VTANR, CSWD Compost will test each batch of compost to ensure that the lowest levels of PAHs possible are present in completed compost product.

Step Five: Post-Processing

After the compost successfully passes through the curing step, it will then be put through post-processing which involves screening the completed compost for large or unwanted components at ⅜ inch. After screening, the compost that passes through will be bagged for sale or sold in bulk as CSWD Complete Compost to local gardeners or farmers searching for a natural soil amendment (ICP, 2011a; NOFA-VT, 2011).

Case Example: Dubuque, Iowa

The small urban City of Dubuque, Iowa is located in Dubuque County. In total, the 2000 U.S. Census suggests that the area of Dubuque is 27.7 square miles with approximately 57,686 residents and about 22,560 households residing within these city limits (U.S. Census 2010, 2011). Situated in the heart of the United States midwest, Dubuque borders the Mississippi River and the neighboring states of Illinois and Wisconsin. Dubuque annually experiences an average winter temperature high of 14ºF and an average summer temperature high of 85ºF. The average annual precipitation level ranges from 26-38 inches with the majority occurring the summer months. Experiencing major temperature swings from season to season and a moderate amount of annual precipitation, this city is classified as a humid continental warm summer climate (NASA Space Grant Consortium & Oklahoma East Central University, 2004).

Organic Materials Management in Dubuque, Iowa

Management and Budget

The organic materials processing facility for Dubuque, Iowa is managed and funded by Dubuque county's Dubuque Metropolitan Area Solid Waste Agency (DMASWA). Any organic waste collected in Dubuque County or the City of Dubuque is processed at the DMASWA Compost facility located at the DMASWA waste management center on Highway 20 in Dubuque, Iowa. All organic waste composted at the DMASWA Compost Facility is sold to local gardeners and landscapers in search of a natural soil amendment. The completed compost product is most frequently used to, "improve soils, infiltrate stormwater, and reduce erosion" (Schultz, 2011). Profits from the sales of the completed compost products directly benefits DMASWA and the composting facility.

DMASWA's operating budget for fiscal year 2011 is $4,676,296 (Goddard, 2009). This budget funds the District's smaller subcategory budgets which include, "Landfill Operations, Composting Operations, Education/Communication Operations, E-Scrap Recycling Operations, Recycling Dropoff Operations, the Programs and Capital Projects budget, and the Equipment budget" (Goddard, 2009). Approximately $97,057 of this budget is allotted to the Composing Operations budget. DMASWA Compost breaks this budget down to: $23,200 for Employee Expenses, $69,710 for Supplies and Services, and $4,147 for Administrative Overhead (Goddard, 2009).

Profile and Generators of Organic Waste in Dubuque, Iowa

The City of Dubuque, Iowa composts about 112 tons of organic waste annually. This means that DMASWA Compost processes between one to two tons of organic waste each week depending on the season. While the DMASWA compost facility receives well above two tons of organic waste each week, the Iowa Department of Natural Resources (IDNR) closely restricts the amount of waste that can be composted each week to a two ton maximum. The DMASWA compost facility accepts food scraps, compostable paper products, and small yard trimmings into its organic waste stream; however, nutrient rich animal manures and animal beddings are prohibited due to restrictive IDNR regulations (Schultz, 2011).

DMASWA currently offers its organic waste drop-off free of charge to all 57,686 Dubuque residents and an increasing number of commercial institutions, and businesses. While the majority of organic waste is generated by Dubuque residents, DMASWA has started to see an increase in the amount of local colleges/schools, churches, restaurants, and other businesses that made the dedication to participate in composting their organic wastes.

The motivation Dubuque residents, commercial institutions, and businesses have to participate in the composting process stems from the high level of education and accessibility offered to the City of Dubuque. By teaching the city about the importance of composting and by simplifying the process, Dubuque has made the process of sorting out organic waste attractive to many thereby increasing the community's relationship with the DMASWA compost facility and benefiting the local environment and economy.

Transportation of Organic Waste to the DMASWA Compost Facility

In June 2006, DMASWA conducted a waste sort of Dubuque resident's household waste[7]. When DMASWA calculated that over 30% of the average Dubuque resident's household waste could be processed into compost, the city knew it was time to develop a workable diversion plan (Schultz, 2011). Creating several additional development goals including, "meeting the IDNR 50% waste diversion goal, collecting more feedstock materials, and reducing landfill methane emission levels, conserving valuable landfill space, and progressively and sustainably develop the composting program," DMASWA quickly realized the best method for sustainably developing their waste management programs would be through the development of an urban residential curbside organics pickup program (Schultz, 2011).

[7] The total amount of waste sorted was not provided by the source. Only the percentages were given.

In 2006 DMASWA launched a two year pilot urban curbside organics pickup study program for the City of Dubuque. Targeting a mix of residents, commercial institutions, and businesses, DMASWA asked the volunteers to divert their organics and yard debris from their refuse waste. The first year the pilot program ran, DMASWA collected 30 tons of waste and the second year over 35 tons were collected from the volunteer group (Schultz, 2011). At the end of the two year pilot study, DMASWA had each participant fill out a customer satisfaction survey about their experience with the pilot program. Some of the surprising positive comments included, “enjoyed having no more smelly kitchen trash, purchased fewer plastic garbage bags, saved on garbage disposal fees, and felt good about adding this sustainable practice into daily life” (Schultz, 2011). Learning the program was a success for the DMASWA compost facility and its participants, in 2009 DMASWA created a permanent curbside organics pickup program for the City of Dubuque.

By early 2010, just over two year after the start of the program, over 450 customers were subscribing to organics collection in addition to their usual refuse and recycling collection. While DMASWA has a long way to go before all 22,500 of its households are active customers, as of January 2011, DMASWA Compost had reached capacity on the amount of residents, commercial institutions, and businesses it could collect organic wastes from due to the weekly two ton compost cap. There is currently a long waiting list for customers interested in organic material collection.

Each customer receiving weekly refuse and recycling pickup from DMASWA pays a monthly fee of $9.35. Customers participating in curbside organics collection, pay an extra $1.25 making their monthly bill $10.60. Each composting resident can rent a two-gallon “Kitchen

Catcher" and a 13-gallon food scrap cart with a snap-lock lid for $.60 a month April through November and $1.30 a month December through March. Each commercial institution or business can rent a 48-gallon tipper cart for $5.50 a month April through November and $10 December through March. These city owned carts were purchased with a, "50% cost share from the Waste Minimization Fund of the DMASWA" (Schultz, 2011). While the rental fee may deter some potential customers, these carts are provided by the city in an attempt to increase motivation to participate in the program.

As the cart rental fee suggests, DMASWA currently experiences a high and low season of organic waste intake. The high season usually lasts from April through November while the low season lasts from December through March. These high and low seasons are directly related to the weather Dubuque experiences over the course of the year. At the inception of the composting program in 2009, the majority of Dubuque residents would cancel their composting pickup service as the set out of organic wastes became more expensive and burdensome process in the cold and snow. However, as the program has expanded and continued to restructure itself, a growing number of residents have begun to maintain their organics collection service year round due to increased incentives created by DMASWA. The major incentive that took place was the reduction of the monthly curbside organics waste removal bill from $3.25 in 2009 to $1.25 in 2010.

In just over two years of operation, DMASWA has seen tremendous improvement in the recapturing and management of organic wastes due to the curbside organics program. Since the creation of the permanent curbside organics collection program, "approximately 280,000 pounds of organic waste were collected and composted from residential subscribers averaging about seven pounds per resident per week" (Schultz, 2011). This large amount of collected organic waste means that DMASWA has increased its waste diversion rate to over 40% and is on track to achieving the goal diversion rate of 50%.

Description of the DMASWA Compost Facility

DMASWA Compost currently uses the traditional turned windrow composting system to breakdown organic waste material. Following restrictive IDNR composting regulations, the DMASWA compost facility is managed on a small plot of land and by low composting technology which hinders the speed and efficiency at which organic material is processed. The DMASWA compost facility is composed of a few small-scale impermeable concrete pads and hard packed ground pads that are imbedded with a drainage system that captures potentially pathogenic leachate and runoff. In addition to a small infrastructure, DMASWA Compost also uses minimal mechanical machinery to move organic material and little computer technology to test completed compost batches and help predict local weather patterns.

The Current Compost Process at DMASWA Compost

After all organic waste materials arrive at the DMASWA compost facility, the composting process begins. Similar to the ICP traditional turned windrow compost process, there are four major steps that organic waste endures before it is considered a completed compost product. Using a range of recipes depending on the types and amounts of feedstocks readily available, the DMASWA Compost manager and team of specialists aim to produce a high quality compost product that can be sold locally as a soil amendment.

Step One: Pre-Processing and Blending

This step of the composting process involves mixing a batch of food scraps, compostable paper products, and small yard trimmings ensuring that there is an appropriate Carbon to Nitrogen (C:N) ratio, an appropriate amount of moisture, and enough aeration to maintain the life of the mix. In this traditional turned windrow composting system, DMASWA may add additional liquid and oxygen during the turning process to maintain proper levels of moisture. DMASWA Compost works to achieve an exact C:N ratio that ensures that the mix will reach and maintain a moisture level of 50-60% and a specific temperature level of 131ºF as the organics break down and decompose.

At DMASWA Compost, the mixing and blending step of the traditional turned windrow compost process occurs with the use of a bucket loader that mechanically picks up and dumps piles of feedstocks. The mixing and blending site is situated on an impermeable concrete pad imbedded with a leachate/runoff drainage system. This leachate is collected and is either recycled on site by reintroducing it to stage one or two compost or it is sent to the Dubuque wastewater treatment facility where it is adequately treated.

Step Two: Active Composting

After the initial step of mixing each batch of organics, the second step involves building a more permanent compost windrow. Each freshly built windrow is then covered up to a foot thick in completed/aged compost. This layer of aged compost layer serves as a biofilter insulation blanket that captures nutrients and moisture and deters undesirable odors and vectors. Each windrow pile is build up about 7 feet high and 12 feet wide in the shape of a traditional windrow (Schultz, 2011). Similar to step one, these windrows rest on an impermeable concrete pad that is connected to a leachate/runoff drainage system.

During this second step of composting, the windrow sits and begins to heat up to a PFRP temperature of 131ºF (Schultz, 2011). The temperature of each windrow is measured every day during this process and is kept somewhere in between 131° and 160°F by means of maintaining healthy C:N ratios, moisture levels, and oxygen levels and by turning each windrow at least 5 times every two weeks. DMASWA Compost allows each windrow to rest for 20-25 days at 131°F or above before it is tested for PFRP and is moved to the next step (Schultz, 2011).

Step Three: Curing

The third step of composting is referred to as the curing step and can last anywhere between six to ten months thereby allowing for the maximum decomposition of organic nutrients. During the third step of composting, DMASWA Compost moves each windrow to a new packed dirt pad imbedded with a leachate/runoff drainage system. Step three compost is turned once every one to two weeks to maintain a proper amount of aeration and moisture levels that reside anywhere between 40-45% (Schultz, 2011). After the organic material ages in these windrows for several months, the outcome is an odorless, dark-brownish to black, and silky compost substance that has no trace of the food scraps, compostable paper, or yard trimmings that were originally its only components.

Step Four: Post-Processing

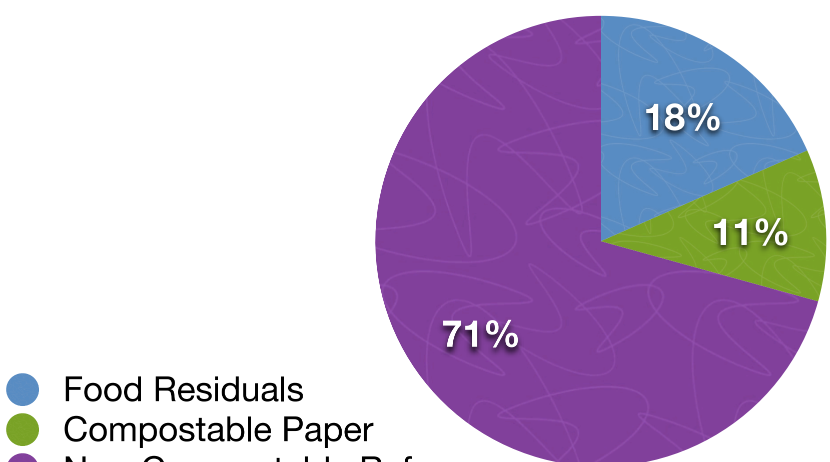
The final step of composting at DMASWA Compost involves testing the compost material for maturity, concentration of nutrients, and the presence of pathogens or heavy metal concentrations. The organic material must pass the State of Iowa and IDNR compost requirements before it is considered completed compost (Schultz, 2011). The compost material that passes each of these tests is then screened for large or unwanted components. After screening, the remaining compost is then bagged for sale or sold in bulk (Schultz, 2011).

Future Development Plans for DMASWA Compost

As DMASWA Compost currently experiences several tight regulations that restrict the way in which the facility is managed, DMASWA Compost has created several goals and guidelines that may help sustainably develop the current compost program offered to the City of Dubuque. The goals have been designed in a specific order as the development of some goals directly rely on the prior completion of another. These goals include:

Goal One: DMASWA Compost plans to, "apply for an MSW composting facility permit, which would require about $250,000 for site improvement," (Yepsen, 2009). By expanding upon their composting facility's infrastructure, DMASWA Compost hopes to further expand its tonnage cap thereby drastically increasing the amount of organic waste that is composted and

Profile of 2006 DMASWA Dubuque Residential Waste Sort Results



Graph 2 - Profile of 2006 DMASWA Dubuque Residential Waste Sort (Schultz, 2011)

further increasing the DMASWA waste diversion percentage.

Goal Two: Seek to increase the IDNR weekly compost tonnage cap that currently restricts composting to a maximum of two tons per week. By increasing this tonnage cap to six tons per week, DMASWA Compost believes it could adequately process enough organic waste to meet the 50% waste diversion goal set forth by IDNR. In January of 2009 DMASWA Compost, "applied for a variance...to expand to 6 tons/week;" however, it was denied permission to expand due to the size of the current compost facility (Yepsen, 2009; Schultz, 2011).

Goal Three: Decrease the fee for curbside organic waste removal. By lowering this prices, DMASWA foresees attracting a new group of customers who may take advantage of the curbside organic collection program. This may include local, "casinos, restaurants, global computer and software design companies, hospitals, manufacturers, grocery chains, city service departments, and residential customers on a waiting list" (Schultz, 2011). DMASWA Compost also hopes that by decreasing the price of curbside collection, more customers will participate in the collection of organic wastes during the low season from December through March.

Goal Four: Once the weekly compost tonnage capacity is raised, DMASWA Compost hopes to move to a "Pay As You Throw" program that would regulate the monthly bill of each individual customer dependent upon the amount of refuse, recyclables, and organic waste that is disposed.

Case Example: Seattle, Washington

The large metropolis of Seattle, Washington is located in King County. In total, the 2000 U.S. Census suggests that the area of Seattle is 83.9 square miles with approximately 563,374 residents and about 258,499 households residing within these city limits (U.S. Census 2010, 2011). Situated on the western coast of the United States, Seattle is located within a 100 mile inlet known as the Puget Sound. Seattle annually experiences an average winter temperature high of 40ºF and an average summer temperature high of 75ºF. Despite Seattle's close proximity to the ocean and often overcast skies, the average annual precipitation level is only about 37 inches. Experiencing minor temperature swings from season to season and a moderate amount of annual precipitation, this city is classified as a marine west coast climate (NASA Space Grant Consortium & Oklahoma East Central University, 2004).

Organic Materials Management in Seattle, Washington

Management and Budget

The organic materials processing facility for Seattle, Washington is managed by a for-profit private compost company called Cedar Grove Composting (White, 2008). The private company composts organic waste collected in 30 cities across Washington State at one of three Cedar Grove Composing locations (Cedar Grove Composting [CGC], 2011a). Any organic waste collected within Seattle City limits is transported to and processed at the facility located in Everett, Washington. All organic waste composted at Cedar Grove Composting is transformed into a range of completed compost, topsoil, and mulch products that are sold to local gardeners, landscapers, and contractors in search of a natural soil amendment (CGC, 2011c). While Cedar Grove Composting recommends that their compost products are not used without mixing in local clays and sands in order to provide necessary drainage and aeration, they claim that the addition of their product will help improve erosion control, levels of bioretention, and the overall health of the soil (CGC, 2011c). Profits from the sales of the completed compost products directly benefit the private company.

For fiscal year 2011 Seattle Public Utilities' (SPU) solid waste management department has an operating budget of $189,665,000 (Moorehead, 2010). This budget funds the District's smaller subcategory budgets which include, "Operating and Management Budgets, the Capital Improvement Program, and Debt Service" (Moorehead, 2010). Approximately $152,748,000 of this budget is allotted to Operations and Management leaving $362,000 of this fund for management of Seattle's organic wastes (Moorehead, 2010). While Cedar Grove Composting doesn't publicly publicize it's annual budget as it is a private company, upon disposal it does charge each truck load of organic material a $58.50 per ton tipping fee (CGC, 2009).

Profile and Generators of Organic Waste in Seattle, Washington

Cedar Grove Composing composts roughly 56,000 tons of Seattle's organic waste each year. Cedar Grove Composing accepts food waste, small yard trimmings, and clean wood waste into its organic waste stream (CGC, 2010). Currently, 80% of Cedar Grove's feedstock is yard waste, 16% is clean wood waste, and 4% is food waste (CGC, 2010). Cedar Grove Composing has chosen not to accept meat and dairy food wastes, nutrient rich animal manures, or animal beddings in an attempt to keep aminopyralids out of their final products (CGC, 2010). While aminopyralids would theoretically be killed off during the compost process due to the fatal environment created by increased temperature levels, the State of Washington prohibits the addition of animal byproduct feedstocks in 100% organic compost products (CGC, 2010). Cedar Grove Composing also feels as if its composting methods and products benefit from banning animal byproducts.

By January 2010 over 100,000 Seattle households were participating in the organic waste management service offered by SPU and Cedar Grove Composting. There are countless commercial institutions and businesses that also subscribe to this service including local churches, restaurants, hospitals, the Seattle Public School System, Seattle University, Seattle Central Community College, Cornish College of the Arts, and the University of Washington (Seattle Public Utilities [SPU], 2011a). By teaching Seattle citizens about composting's positive affects on the community, the local environment, and the local economy and by simplifying the disposal system, motivation levels to sort out organic wastes has increased thereby, "helping to shrink the waste stream coming out of Seattle" (White, 2008).

Transportation of Organic Waste to Cedar Grove Composting

"When the City of Seattle's last remaining landfill closed in 1986, Seattle began using the King County landfill. As a result, the city's costs tripled" (SPU, 2011b). The mayor of Seattle, "demanded that the Solid Waste Utility start a curbside recycling program" (SPU, 2011b). Seeing the addition of the recycling program increase Seattle's waste diversion rate to 47.5%, in 1989 the mayor enacted a curbside yard and clean wood waste collection program in an attempt to achieve a higher "Zero Waste" goal of diverting over 60% of Seattle's waste from the landfill (White, 2008). In 2005 Seattle signed a contract with Cedar Grove Composing in order to automatically increase the yard and clean wood curbside removal services to include food wastes for all 258,499 Seattle residential households, commercial institutions, and businesses (Ehrenfeld, 2011). Currently, all food wastes are accepted with the exception of meat, dairy, or grease wastes as Cedar Grove Composting doesn't process animal byproducts. Yard and clean wood wastes must be small scale and no larger than 1 inch in diameter.

Just as SPU holds a contract with Cedar Grove, SPU also has a contract with private organic waste collection companies Waste Management and Cleanscapes to transport organic wastes from Seattle to the Cedar Grove facility in Everett, Washington. Every Seattle resident, commercial institution, and business pays a monthly waste removal fee regardless of whether they participate in the curbside organic waste removal program. Participants who choose this option pay an additional fee dependent on the amount of waste they create. This additional organic waste fee is tacked onto their total waste removal bill for SPU. SPU uses the revenue funded by the organic waste fee to pay the private companies Waste Management and Cleanscapes bills for picking up Seattle's organic waste. Their income pays for the trucks, fuel, and solid waste field personnel that service Seattle and for the $58.50 per ton tipping fee Cedar Grove charges to dispose of organic wastes (SPU, 2009).

As Everett, Washington is a significant distance from Seattle, few residents choose to personally drop off their organic wastes at the Cedar Grove Composting facility. Also, while SPU holds a contract with Cedar Grove for the City of Seattle, residents cannot take unwanted food, yard, or wood debris to any SPU or King County Solid Waste Division Drop-Off stations as collection of organic wastes aren't offered from these locations by the two private organic waste collection companies. These obstacles complicating personal drop off tend to increase the amount of residents who participate in the simplified curbside pickup program (King County, 2011).

Requiring a minimum of a one year commitment to the curbside program, SPU rents several different sized city-owned carts to each customer dependent on the amount of organic waste generated on site (White, 2008). The monthly cart rental fee fluctuates dependent on the size of the cart and is tacked onto the monthly compost removal fee. As of January 2011, a 13-gallon (mini-can) service costs $4.35, a 32-gallon service costs $6.50, a 96-gallon service costs $8.35, and any additional yard waste bundle costs an extra $4.15 per pickup (SPU, 2011a). Food wastes can not be added to the yard waste bundles and must remain in the carts for pickup. No 13 or 32-gallon cart can exceed a weight of 60 pounds and no 96-cart can exceed a weight of 180 pounds (SPU, 2011a).

As bagging organic food waste simplifies the sorting process for curbside program participants, Cedar Grove Composting accepts organic wastes that have been bagged in, "approved compostable bags made of plant-based materials that break down in the composting process"(SPU, 2011c). Cedar Grove Composting accepts the following compostable bag brands: BioBag, EcoSafe, EcoGuard, Bag-to-Nature, Nature-Friendly, BioSak, AL-Pack, and Glad (SPU, 2011c).

Description of the Cedar Grove Composting Facility

A leader among the composting industry, Cedar Grove Composting has historically used the high-tech aerated static pile composting method to breakdown organic waste materials. "In 2002, Cedar Grove Composting began developing a technology upgrade incorporating a Gore-Tex™ cover In-Vessel System" (CGC, 2011g). Using Gore-Tex™ in-vessel technology, Cedar Grove Composting has revolutionized the efficiency of the traditional aerated static pile system increasing the rate at which organic materials are broken-down, creating higher quality compost products, reducing the amount of liquid resources needed to maintain each windrows moisture concentrations, and by drastically reducing the compost facility's impact on the surrounding environment (Foland, 2011). By also using a high-tech computer feedback system that informs the compost manager and team of specialists about the healthy of each compost windrow, Cedar Grove Composing has been able to increase the efficiency with which it process organic wastes. Cedar Grove Composting is 100% dedicated to developing new technologies for its facility in hopes of continuously increasing the sustainability of the organic materials management process.

The Current Compost Process at Cedar Grove Composting

After organic waste materials from the City of Seattle arrive at the Cedar Grove Composting facility in Everett, Cedar Grove immediately begins processing each batch of waste. Similar to the CSWD Compost aerated static pile system, organic waste endures five compost steps before it is considered a completed compost product. Cedar Grove Composting advertises using an, "exact recipe and science," that has been honed over the years and is proven to produce the highest quality compost products that can be made based on the feedstocks available (CGC, 2011a).

Step One: Pre-Processing and Blending

This step of the composting process begins with taking inventory of the feedstocks available. Food waste is placed on impermeable concrete pads in a covered holding bay while small yard wastes and clean wood scraps are processed through a, "high-speed hammer mill grinder," that shreds the organic waste into a more manageable size (CGC, 2011g). The shredded yard and clean wood waste is then mixed and blended with the food wastes in a mechanical mixer located within the holding bay. This mechanical mixer proves to be an incredibly useful tool in the mixing processes. It ensures an even blending of the organic wastes without further grinding the bulk of the feedstocks which could potentially cause the waste to liquify and quickly turn anaerobic, saves Cedar Grove Composting money on diesel that would fuel bucket loaders used to mix feedstocks, and greatly aids in the collection of potentially pathogenic leachate that is released from organic wastes during the blending process. The leachate is drained into the onsite collection tank and is frequently recycled by reintroducing it a a moisture amendment to stage one or two compost (CGC, 2011g).

Using exact recipes to determine how much of each feedstock is added to the mixture, each batch is composed of roughly 450 tons of organic waste (Foland, 2011). Cedar Grove Composting aims to reach a C:N ratio of about 23 and a moisture level of about 50% essentially searching for a mixture that will guarantee that the batch will reach and maintain a specific PFRP temperature level of 130ºF during step two (CGC, 2010).

Step Two: Active Composting (Phase One)

After evenly blending the feedstocks, the resulting mixture of organic waste is transfered via bucket loaders to a set of impermeable concrete pads, "that have been studded with air holes connected to variable speed blowers," and a leachate drainage system (CGC, 2011g). Organic material, "is stacked up to 17 feet high and 20 to 25 feet wide," over the imbedded aerated system (CGC, 2011g). This positive aeration system, "provides sufficient air to encourage the growth of naturally occurring microbes that degrade the material," over time (CGC, 2011g). A set of, "stainless steel probes are inserted into each pile to monitor oxygen and temperature parameters. This data is relayed to and stored in a computer system...that controls the aerators to keep pile conditions consistent" (CGC, 2011g). Set on this computer monitored time and speed controlled schedule, air is blown up through each windrow to adequately aerate and control the temperature of each pile. The compost manager and team of specialists can physically intervene with this computer programing at any point to alter how much oxygen is blown through each windrow or add in extra organic waste should the C:N ratios rotate out of proportion.

After each windrow is constructed, the specially designed Gore-Tex™ covers are placed over each pile. Each Gore-Tex™ cover is specially designed for Cedar Grove Composting and is composed of, “a Gore-Tex™ membrane laminated between two polyester layers” (CGC, 2011g). Each Gore-Tex™ cover, “creates an enclosed system that controls odors, microorganisms, creates a consistent process unaffected by outside environmental conditions...and ensures controlled conditions without the risk of damp pockets which can result in anaerobic conditions,” (CGC, 2011g). Aside from controlling the creation of damp pockets, the Gore-Tex™ cover also controls excessive odor emission by, “acting as a physical barrier against gas escape from the decomposing pile and by controlling the condensation on the interior of the cover” (CGC, 2011g). While a thin film of condensation will develop on the Gore-Tex™ membrane during the composting process, the blowers ensure that this moisture, “drips back onto the pile,” meaning that liquid additives, “are nominal because the in-vessel system retains the initial moisture within the system and only releases minimal amounts” (CGC, 2011g).

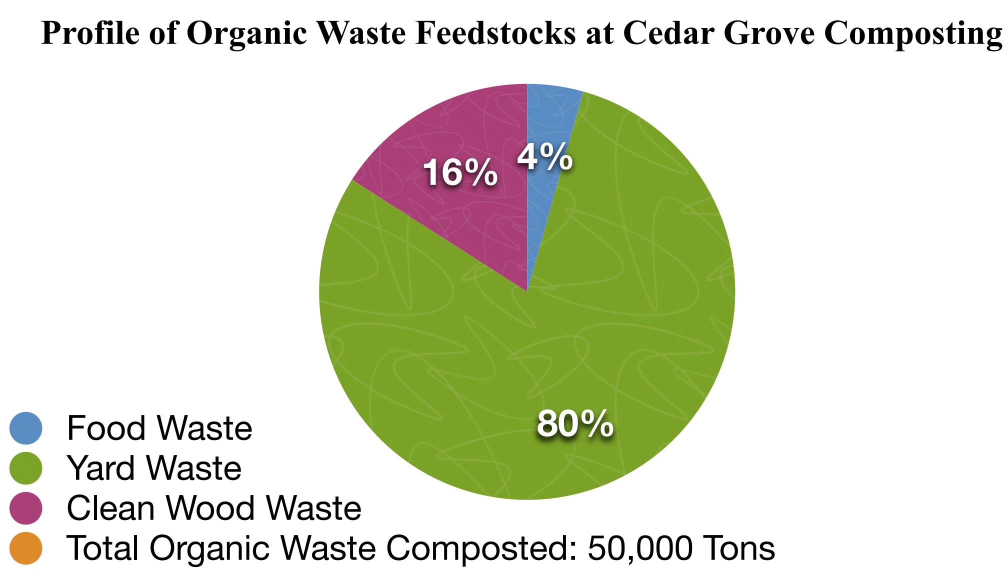
Each windrow pile in active composting (phase one) sits for about four weeks in its initial placement under Gore-Tex™ covers. The organic material’s temperature must rise to 130ºF for at least 21 days before it can move to the next active composting phase. This ensures that the organic material has reached PFRP and has eliminated, “weed seeds, pesticides, herbicide residues, or other plant pathogens” (CGC, 2011g). Reaching PFRP is a crucial step for Cedar Grove Composting as it determines whether the final compost product will pass several rigorous tests that deem is capable of being sold as an organic soil amendment.

Step Three: Active Composting (Phase Two)

After the first four weeks of active composting, the Gore-Tex™ cover is removed and the organic waste is transferred via a bucket loader to another set of impermeable concrete pads imbedded with a set of air blowers and a leachate drainage system. The organic waste is constructed in the shape of another 17 foot by 20-25 foot windrow and is covered once again with a Gore-Tex™ cover. Using the same step two computer monitoring system that measures C:N ratios and regulates moisture and oxygen levels, the organic waste is left to decompose for two weeks.

Step Four: Curing

After completing both active composting phases through aerated static composting for a minimum total of six weeks, the organic material from step three is transfered to hard packed dirt curing pads where it is constructed into another set of windrows and is left uncovered to cure. These curing pads aren't imbedded with a leachate drainage/collection system or an aeration



Graph 3 - Profile of Organic Waste Feedstocks at Cedar Grove Composting (CGC, 2010) system. Aeration occurs once a week by turning the pile with a bucket loader. While step four organic waste is deemed stable, the organic material must age and cure for another two weeks before it is considered completed compost. While it only takes another two weeks to create completed compost, the majority of Cedar Grove Composting's final products are left to age anywhere from six to eighteen months allowing for the maximum amount of breakdown and development of healthy nutrient levels.

At the end of the curing step, the completed compost is tested for levels of maturity, stability, soluble salts, pH, and moisture percent, and presence of trace metals, weed and seed pathogens, nutrient and organic matter content (CGC, 2011d). The organic material must then meet the US Composting Council, the Washington State Department of Natural Resources, and the State of Washington's 100% organic compost testing regulations before it is considered completed organic compost (CGC, 2011d).

Step Five: Post-Processing

After the compost successfully meets each testing regulation, it is then put through post-processing which involves screening the completed compost for unwanted components. Bagged compost products are screened to ⅜ inch while bulk compost is screened to ½ inch. The compost that passes through screening is then bagged or set out onto hard packed dirt holding pads and is ready to be sold within 15 days (CGC, 2011g).

Cedar Grove Composting currently creates several natural soil amendment products including, "Compost and Booster Blend," several soil blends including, "Two Way Topsoil, Builders Blend, and Vegetable Garden Mix," and a mulch called, "Northwest Garden

Mulch” (CGC, 2011b). While each product differs in its overall makeup, every product is a direct result of composting the same initial feedstocks of food, yard, and clean wood organic wastes.

Future Development Plans for Cedar Grove Composting

As Cedar Grove, “boasts a closed loop business model,” that is, “always seeking proven new technologies to bring waste materials to a higher use," CEO Steve Banchero has publicly dedicated 100% of his Cedar Grove’s efforts to sustainable growth (Marino, 2010). Steve Banchero and Cedar Grove’s compost managers have together created a plan that continuously develops Cedar Grove’s relationship with the Seattle community, the surrounding environment, and the local economy. Cedar Grove’s current major development goals include: educating Seattle’s local citizens about the importance of composting and developing new compost technology.

Goal One: Cedar Grove strongly believes that by educating Seattle’s citizens, more residents, commercial institutions, and businesses will participate in sorting organics out of their solid waste streams thereby increasing the solid waste diversion rate to Seattle’s goal rate of 60%. This increased waste diversion rate would also help decrease the city budget that is dedicated to managing solid waste and landfill space (Hoffman,2011). To further educate the local community, Cedar Grove has committed itself to providing onsite training to any participating commercial institutions and business who request more information on the compost process (Foland, 2011).

Goal Two: As a result of educating more Seattle locals and attracting new compost participants, Cedar Grove plans to increase the amount of organic waste that enters its compost facility. Requiring either a larger facility or new compost technology to handle increasing amounts of organic waste, Cedar Grove has began to study ways in which its current infrastructure can be changed to drastically improve its composting processes and products. In July 2010, Cedar Grove announced its plans to install a new anaerobic digester composting system. Starting with one pilot small scale anaerobic digester, Cedar Grove conducted a study to research the effectiveness of the new system in hopes of fully abandoning the current covered aerated static pile composting.

Aside from increasing the speed at which organic waste is composted and saving ground space due to the small nature of each anaerobic digestion unit without sacrificing compost product quality, the new anaerobic digestion compost system should also drastically improve Cedar Grove's impact on the environment and decrease the cost of composing organic wastes. This may be attributed to research conducted by Cedar Grove in 2010 that has helped prove the use of anaerobic digestion's biogas byproduct (Marino, 2010). By enhancing the natural composing process within the anaerobic digester, Cedar Grove has the power to, "transform food scraps and yard clippings into a viable fuel," meaning that the resulting, "biogas produced can be used as either a natural gas used for fuel in auto trucks or for electricity production" (Marino, 2010).

This anaerobic digestion project, "is considered one of the first and largest of its kind in the United States. Once the digester is fully operational, it will generate energy equivalent to the electricity used of 400 homes, or the fuel of 1,100 passenger vehicles annually" (Marino, 2010). With the development of a new composting system that has the capability to, "produce green energy from food scraps and yard waste," Cedar Grove has the opportunity to redefine not only its personal compost system, but set a new standard for the way in which organic waste is managed and processed across the entire United States (Marino, 2010).

Case Example: Toronto, Ontario

The City of Toronto is the capital of the province Ontario and is located on the south-eastern boarder of Ontario and the United States. In total, the 2006 Canadian Census suggests that the area of Toronto can be measured at 243.2 square miles with approximately 2,503,281 residents and about 979,440 households residing within these city limit (County of Dufferin, 2011). Situated on the southern boarder of Ontario, Toronto is located on the northern shore of Lake Ontario. Toronto annually experiences an average winter temperature high of 34ºF and an average summer temperature high of 80ºF. The summer months in Toronto can be extremely humid in hot with some days well exceeding 90ºF while the winter is known to be brutally cold often going weeks without breaking above freezing. Despite Toronto's close proximity to Lake Ontario, its average annual precipitation level is only about 32 inches. Experiencing major temperature swings from season to season and a mild amount of annual precipitation, this city is classified as a humid continental warm summer climate (County of Dufferin, 2011).

Organic Materials Management in Toronto, Ontario

Management and Budget

The organic materials processing facility for Toronto, Ontario is managed by the City of Toronto's Solid Waste Management (TSWM) division. TSWM manages the entire Toronto solid waste stream, including refuse, recycling, and organic wastes. Any organic waste collected within Toronto is currently taken to the TSWM Dufferin Organic Processing Facility (DOPF) located on Vanley Crescent Street in downtown Toronto (County of Dufferin, 2011). All organic wastes composted at the DOPF Compost facility are eventually sold as soil amendments to local Toronto residents, landscapers, nurseries, garden centers, golf courses, the Toronto Department Parks and Recreation municipality, the Toronto Grounds Maintenance municipality, Toronto roadside services, and local Ontario farms and quarries/mines (Envirosris, 2001). These soil amendments include completed compost, potting soils, and topsoil dressings and are most frequently used for, professional landscaping, gardening, golf course turf management, pit and quarry rehabilitation, mine rehabilitation, farmland application, tree plantation management, and municipal erosion control (Envirosris, 2001). Profits from the sales of the completed compost products directly benefit TSWM's DOPF Compost program.

TSWM was allotted $342.6 million budget in fiscal year 2011. This budget must fund the District's $500 million assets including, "7 Transfer Stations, Green Lane Landfill, 1 Material Recovery Facility, 1 Green Bin Processing Facility, 1 Durable Goods Reuse/Recycle Centre, 4 Collection Yards and 1 Litter Collection Yard, 161 Former Landfills, 6 Household Hazardous Waste Depots, and 734 Vehicles" (The City of Toronto [TCT], 2011g). In January 2011, TSWM announced a rate increase of 3% (TCT, 2011g). As the rate has remained the same since 2008, TSWM saw the new year as an opportunity to raise the additional $4.8 million it needs to, "support diversion initiatives and maintain adequate and reliable processing capacity for Green Bin organics and recyclables" (TCT, 2011h).

Profile and Generators of Organic Waste in Toronto, Ontario

DOPF Compost processes roughly 85,000 tons of Toronto resident's organic waste each year (TCT, 2011b). DOPF Compost accepts food scraps, non-recyclable paper, yard wastes, nutrient rich animal manures, animal bedding, and even baby diapers and feminine sanitary products into its organic waste stream (TCT, 2011e). While no breakdown of organic waste feedstocks that are composted on an annual basis at DOPF Compost exists, it is apparent from the wide range of organic waste materials accepted that DOPF hosts a highly effective and efficient compost method and technology.

Before the development of an organic materials processing facility in Toronto, all organic waste was mixed in with other refuse solid wastes where it was taken to the Keele Valley landfill. When Keele Valley reached capacity in 2000, the site was closed and capped requiring TSWM to find another location to dispose of Toronto's unwanted refuse waste (McKeown, 2011). A ten year contract was signed with private landfill Carlton Farms in New Boston, Michigan. While this contract bought TSWM some time to restructure its waste management program and some landfill space, refuse, "disposal costs increased by more than 300%" (McKeown, 2011; TCT, 2005). In acknowledgement of the city's rapidly growing waste management issues, on January 29, 2001, Toronto Mayor Mel Lastman and City Councillor Betty Disero developed a Waste Diversion Task Force 2010 (WDTF) (Waste Diversion Task Force [WDTF], 2010). The overall goal for the WDTF was to draft a comprehensive waste diversion plan that would essentially divert, "30% of household waste by 2003; 60% by 2006; and, 100% by 2010" (WDTF, 2010).

By January 2011, just under a decade after the creation of the WDTF, the task force's motivation made it possible for over 510,000 single-family households and 324 buildings/66,000 multi-residential units to gain access to the organic waste management programs offered by TSWM and DOPF (TCT, 2011d). Other positive changes included increasing the overall diversion rate to 47% and breaking TSWM's ten year contract with the New Boston, Michigan

Carlton Farms landfill (TCT, 2011g). On January 1, 2001, TSWM signed a new contract with a city owned Ontario based landfill, Green Lane landfill thereby saving the city money on transportation costs and on a lower refuse tipping fee (TCT, 2011a; TCT, 2011g). While WDTF's ambitious waste reduction goals were not met by January 2010, each small change makes a difference in achieving the overall goal. By continuing to provide educational tools and simplified opportunities for residents to participate in the sorting of organic wastes the waste diversion rate and Toronto resident's motivation to participate in will continue to increase.

Transportation of Organic Waste to the Toronto Organic Materials Processing Facility

Knowing that residents are the largest generators of organic waste in the TSWM solid waste stream, the WDTF quickly realized the best method for sustainably developing the Toronto waste stream would be through the development of an urban residential curbside organics pickup program. Suggesting that a residential curbside organics pickup program would simplify the process of disposing organic wastes and increase residents' motivation to help raise Toronto's waste diversion rates, in 2002, TSWM and DOPF began a pilot weekly curbside organics collection program in Toronto's Etobicoke area (TCT, 2005). Providing one free city-owned green organic waste bin and a set of informational pamphlets to each household, TSWM hoped to prepare and educate its residents about the importance of composting and the reason that their community, surrounding environment, and local economy would benefit from sorting out organic wastes from the refuse waste stream. Showing a high rate of success, the curbside organics pickup program's popularity grew rapidly.

By October 25, 2005, just three short years after the inception of curbside organics pickup, the program became a permanent service, known as the "Green-Bin" project and became offered to all single-family households within the greater Toronto area (TCT, 2005). While this was an impressive addition to the solid waste stream, TSWM and the WDTF searched for ways to further develop the organic waste management program. As over half of Toronto residents live in multi-residential buildings, TSWM and the WDTF quickly realized that half of the city's citizens weren't receiving access to organic waste management programs. TSWM and WDTF decided to conduct a pilot study on the addition of multi-residential buildings to the curbside program in late 2005. Monitoring 30 multi-residential buildings for three years, 2008 pilot results proved that, "multi-residential buildings had achieved a rate of 16% organic waste disposal" (TCT, 2011c). This diversion rate was lower than TSWM and WDTF had hoped for; nevertheless, the pilot program was considered a success and more multi-residential buildings were slowly added to the curbside organics collection program.

With 510,000 Toronto single-family households, and roughly 66,000 multi-residential units receiving curbside organics collection in 2009, TSWM and WDTF decided to pass a mandate that required each of these households to participate in the program in hopes of further increasing the waste diversion rate. The new mandate resulted in a slight increase in the amount of organic waste that was being diverted from the solid waste stream; however, residents seemed to struggle with motivation as many neglected to see how taking the extra time to sort out organic waste benefited them personally. Seeing this large lack of incentive in the curbside plan, in June 2007 TSWM and WDTF developed a new payment system that drastically increased each personal household's motivation to remain actively involved (TCT, 2011f). As the disposal of recycling and organic waste is free, TSWM chose to develop a "pay as you throw" payment plan that would regulate each individual household's annual solid waste removal bill dependent on the amount of refuse it disposed. While it seems difficult to calculate how much refuse a resident is deposing, as each individual household is given three separate city-owned waste collection bins: a black refuse bin, a blue recycling bin, and a green organic waste bin; the total waste removal fee is calculated based on the size and the amount of times of the black refuse bin is filled.

Each single-family residential household is charged an annual Solid Waste Management service fee dependent on the size of its black refuse bin at a rate of: $199 a year per small city-owned garbage bin, $248 a year per medium city-owned garbage bin, $342 a year per large city-owned garbage bin, and $399 a year per extra-large city-owned garbage bin (TCT, 2011f). At the end of each 122 day pay period, a portion of each individual household's flat rate Solid Waste Management fee is reimbursed dependent on the amount of times it disposed of refuse. Every week a household doesn't dispose of refuse, its weekly waste removal rate is refunded meaning that the overall pay period fee is reduced each time recycling or organic waste is correctly sorted of in a blue or a green bin rather than the black refuse bin.

Each multi-residential buildings' annual solid waste removal bills are structured from the same "pay as you throw" payment plan as single-family households; however, instead of being charged dependent on the size of the bin that is emptied, these buildings are charged based on the frequency at which refuse is picked up from the building's communal extra large black refuse bin. If a bin is emptied: biweekly, the fee is $399 a year; weekly, the fee is $679 a year; or twice weekly, the fee is $1,241 a year (TCT, 2011f). This fee is broken up evenly among the amount of units within the building meaning that each residential-building has to work together to correctly sort out recyclable and organic waste from refuse keep the cost of the solid waste management bill down (TCT, 2011f).

Organic wastes placed in the city-owned green bins are collected weekly for each single-family household and either biweekly, weekly, or twice-weekly for multi-residential buildings. TSWM provides the trucks, fuel, and solid waste field personnel needed to transportation the city's residential organic wastes to the DOPF compost facility. Using specially designed collection trucks to collect each household's recycling and organic waste on the same day reduces the amount of, " trucks going up and down neighborhood streets," each week (TCT, 2005). Each collection truck has, "two separate compartments – while it may look like all materials are going in the same place, organics are placed in a separate compartment from the garbage or recyclables," (TCT, 2005). After collection, the organic wastes are dropped off at the DOPF facility free of charge. Residents living in multi-residential buildings without access the curbside organics collection program do have the option of dropping off unwanted organic wastes at TSWM Drop-Off or Transfer stations; however, few choose to do this as transporting the organic waste to these stations can be difficult and time consuming in downtown Toronto.

In just less than a decade Toronto has felt the major benefits of establishing a residential curbside organics collection program that recaptures and manages the city's organic wastes. The success of the program is most visible in the increased diversion rate of organic wastes that has annually sent, "3,225 fewer trucks to the landfill," (TCT, 2005). Other successes are seen in the local community's high level engagement in the movement to sort out organic wastes, the decreased environmental impact by actively reducing the amount of landfill space needed to contain refuse, and in the amount of money TSWM has saved on the price of the fuel needed to truck solid waste to Michigan and the refuse tipping fees imposed by the landfill (TCT, 2011c).

Description of the Current Organic Materials Processing Facility

A leading composting industry in North America, DOPF in partner with Canada Composting, Inc., uses a, "wet mesophilic anaerobic digestion," compost system to breakdown organic waste materials (Goldstein, 2005). This, "technology manages organics in a closed vessel without the presence of oxygen, which results in the production of bio-gas as a by-product...that can be used as the fuel source for a boiler, which in turn produces steam that can be used to power a generator" (WDTF, 2010). A seemingly complex system, the anaerobic digestion system proves to be a simple process capable of creating high quality compost products at faster rates and in smaller spaces than other compost methods, reducing the amount of resources needed to sustain the composting process, and by drastically reducing the compost facility's impact on the surrounding environment. DOPF is dedicated to the active development of new composting technologies and is continuously working alongside WDTF to restructure not only the DOPF composting program but the relationships it shares with local communities, environments, and economies.

The Current Compost Process in Toronto, Ontario

Once the organic waste arrives at DOPF, the composting process begins. Using the anaerobic digestion composting method, there are four major steps that organic waste endures before it is deemed compost. The major difference between anaerobic digestion and traditional turned windrow or aerated static pile systems is the level of oxygen used during the active breakdown process. While windrows use a plethora of oxygen resources, anaerobic digestion relies of the complete absence of air flow.

Step One: Pre-Processing

This step of the composting process begins with taking inventory of the feedstocks available. Trucks dump organic wastes into a trommel screen that, "opens plastic bags and sorts non-biodegradable contaminants," that may impede the digestion process from usable organic feedstocks (Goldstein, 2005). The trommel screen with four and six inch holes then separates each feedstock into three different sizes of, "2 ½ inches, 10 inches, and overs" (Goldstein, 2005). The 10 inch and "overs" materials are conveyed through a set of magnets and, "eddy current separators" that further reduces the amount of unwanted contaminants (Goldstein, 2005). The 2 ½ inch materials are then mixed in with the remaining 10 inch and overs materials and are loaded into a mechanical hydropulper. About, "10 tons/batch are loaded into the hydropulper...it is then filled water recycled from the previous batch" (Goldstein, 2005). An agitator, "mounted at the top of the tank spins very quickly,...pulping the contents until the process is complete," a rake-like unit, "then passes through the liquid to remove excess plastics and other floating light fraction materials...a trap in the bottom of the pulper captures heavy objects such as glass, coins and silverware" (Goldstein, 2005).

After completing the pulping stage, the remaining pulp is transfered from the hydropulper to an airtight, "100 ton fiberglass surge tank, which acts as a holding tank between the batch operation of the pulper and the continuous feed mode of the digester unit" (Goldstein, 2005). The surge tank houses the second contaminant elimination system, called the hydrocyclone. The hydrocyclone spins surge tank's organic waste material to, "remove very small pieces of heavy fraction material, such a pieces of glass that are smaller than a grain of rice, collectively referred to as grit" (Goldstein, 2005). The clean organic waste is transfered into the surge tank's clean slurry compartment while the waste is sent to the gritty slurry compartment. The clean slurry is placed on a closed loop of the hydrocyclone for about 70 minutes in hope of removing the maximum amount of contaminants, usually about. "one ton of grit" (Goldstein, 2005). DOPF has calculated that each 100 ton batch of clean slurry processed costs the facility about $130 in energy.

Step Two: Anaerobic Digestion and Energy Recovery

The 1,060 ton airtight glass-lined steel anaerobic digester unit collects clean slurry material from surge storage tank and heats the organic material to a temperature of about 98.6ºF (Goldstein, 2005). "Material is continuously withdrawn and a screw press is used to separate the liquids and solids. Liquids are recycled back to the hydropulper," keeping the digestate level, "at about 25 to 30 percent solids" (Goldstein, 2005). As the solids breakdown and begin to loose volume thermal heat is created. This heat is captured and used to reheat recycled liquids and to maintain the overall temperature level of the anaerobic digester at 98.6ºF. During the summer months DOPF doesn't need to worry about reusing the thermal heat and oftentimes ends up releasing it; however, during the cold winter months, the recycling of this heat becomes crucial.

As aged solids fall to the bottom of the digester, they are collected and transfered to step three of anaerobic digestion. The liquids that fall to the bottom of the digester unit are drained into one of, "eight pipes that feed the bottom of the tank" (Goldstein, 2005). Liquid that has been cycled though the tank several times is eventually captured and sent to a wastewater treatment plant where it is properly treated (Goldstein, 2005). Younger liquid is cycled back to the top of the unit where it is reheated it to 98.6ºF via the excess thermal heat before it is released over the remaining solid mixture (Goldstein, 2005). As the liquid falls back to the bottom of the mix it releases a combustible bio-gas, "derived from decomposing biological waste. Biogas normally consists of 50 to 60 percent methane....the remaining portion of the gas is made up of primarily carbon dioxide" (Minnesota Department of Agriculture [MDA], 2011). Each of these gases are, " are captured and cleaned prior to being fed into cogeneration equipment" (Goldstein, 2005). Methane and carbon dioxide gases that are captured in the cogeneration equipment are transfered into the usable resource electricity and is used to help offset the energy the plant needs to operate.

The amount of biogas that is produced is determined by the, "volatile solid content, hydraulic retention time, temperature, and management" (MDA, 2011). Most of these factors including the hydraulic retention time, temperature, and management can be controlled by DOPF; however, the volatile solid content depends solely on the types of organic wastes that are taken to the composting facility.

Step Three: Anaerobic Digestion (Phase Two)

The remaining solid are fed into a, "Seko blender, where they are mixed with wood chips greater than a half-inch size" (Goldstein, 2005). The mixture is then transfered to a passively aerated, "vertical silo composting cell" (Goldstein, 2005). As material is fed onto the top of the vertical cell, "an equivalent amount of material is unloaded via a drag chain conveyor from the bottom" (Goldstein, 2005). Materials are digested for about 7 days before being unloaded and transported to a soil blending facility called All-Treat Farms in Arthur, Ontario.

Step Four: Curing

Once the solid, digested organic materials arrive at All-Treat Farms, the wastes are cured similar to step three of traditional turned windrow composting or step four of aerated static pile composting systems. The material is build up into windrows on hard packed ground pads and are left to cure uncovered for up to four weeks or covered, with a Gore-Tex™, membrane for up to two weeks (Alltreat Farms, 2011). Each batch of All-Treat Farms cured organic material must meet the U.S. Test Methods for Examination of Composting and Compost (TMECC) regulations that includes testing for the presence of pathogens, heavy metals, foreign matter, and for the organic material's nutrient level (The Composting Council of Canada, 2004). The organic material isn't considered completed compost unless it meets each TMECC standard.

Step Five: Post-Processing

After the compost batch successfully meets the TMECC testing regulations, it is then put through post-processing which involves screening the completed compost for unwanted components. Compost that passes through screening is either bagged for sale as a completed compost products or loaded onto hard packed ground storage pads where the compost waits to be sold as a bulk soil amendment (Alltreat Farms, 2011).

Future Development Plans for Toronto Solid Waste Management and Dufferin Organic Processing Facility

Despite the failure to reach the WDTF's city waste diversion goals by 2010, WDTF is still searching for new ways to methodically improve each Toronto resident's relationship with the processing of organic wastes, the DOPF compost facility, and the TSWM residential curbside organic collection program. All three organizations ultimately aim to increase the amount of organic waste that is processed each year thereby further increasing the refuse diversion rate; however, as DOPF frequently reaches its maximum organic waste intake, it is currently impossible for DOPF to receive and process more than 120,000 tons of Toronto residents' organic waste each year.

On top of the lack of processing equipment, a 2010 routine maintenance inspection of the DOPF's anaerobic digester showed that the, "flexible seal, or scrim, between the walls and roof has deteriorated. The purpose of the scrim is to provide an air-tight seal while allowing the digester roof to raise and lower in response to the pressure changes from the biogas. Biogas pressure levels increase and decrease when the digester is being filled and emptied" (TCT, 2011b). The scrim must be replaced to, "prevent the release of biogas into the atmosphere," requiring the, "complete shut down of the anaerobic digester for three months" (TCT, 2011b). Patching can temporarily fix the problem; however, if the scrim wear and tear issue is ignored, the entire anaerobic digester unit may eventually break thereby shutting down the entire facility's compost operations.

With these two major issues in mind, in 2010, WDTF and TSWM created workable improvement goals that will aid in the expansion and renovation of the DOPF compost facility's infrastructure thereby increasing the amount of organic waste DOPF is able to process into completed compost products. While this development plan involves investing a large amount of money into maintenance fees and additional compost digesters, WDTF, TSWM, and DOPF will see a major financially attractive payback within three to seven years due to an increase in compost product revenues and a decrease in refuse truck fuel costs, Carlton Farms landfill refuse tipping fees, and in the energy bills needed to sustain the current compost facility (TCT, 2011b). The goals set to overcome these challenges and achieve these desired outcomes include:

Goal One: With a $25,100 budget from the TSWM, DOPF plans to construct a second anaerobic digester before shutting down the existing structure for repairs (TCT, 2011a; TCT, 2011b). This new digester will allow the facility to remain open and up to current organic waste management capacity during the repair process. After the construction of a new digestion vessel, in addition to replacing the scrim on the current digester, DOPF also plans to, "construct a spill containment system around both the new and existing anaerobic digesters...that ensures organic liquid contents would be retained on-site in the event of a spill or leak," and, "replace the existing biofilter with a new state-of-the-art odour treatment system that will collect air from the facility and remove odours prior to their release. It will also include a 40 metre stack to aid in odour dispersion. The new biofilter will be constructed before the existing biofilter is removed" (TCT, 2011b).

Once repairs are completed, "both vessels will be used to process Green Bin materials," thereby doubling the amount of organic waste that can be processed each year (TCT, 2011b). The addition of a new construction began in January 2011 and should be completed in Spring 2012. Information about the facility's renovation was sent to Toronto residents in the form of a public notice in an attempt to keep the community educated and involved (TCT, 2011b).

Goal Two: After the repairs on the current digester and the construction of the new digester is complete, WDTF, TSWM, and DOPF are hoping to further expand the Green Bin curbside organics pickup program to more multi-residential buildings across Toronto. By expanding the program to every resident in the city, WDTF expects the waste diversion rate to increase slightly. In an attempt to meet the original diversion rate of 100%, WDTF has dedicated itself to increased education of residents by reinstating the monthly motivational newsletter that is sent to each Green Bin participant. WDTF is also considering increasing the residential solid waste management bill for refuse disposal an extra $3-$12 depending on the size of the bin and the frequency of pickup as an incentive to properly sort out recycling and organic waste (TCT, 2011h).

Tables and Charts: Summarizing Results

Basic Statistics of Each City				
	Burlington, Vermont	**Dubuque, Iowa**	**Seattle, Washington**	**Toronto, Ontario**
Total Population	38889	57686	563374	2503281
Total Households	15885	22560	258499	979440
Area of City Limits	15.5 Square Miles	27.7 Square Miles	83.9 Square Miles	243.2 Square Kilometers
Climate Type	Humid Continental: Cool Summers	Humid Continental: Warm Summers	Marine West Coast	Humid Continental: Warm Summers
Average Temperature	**Average High in January:** 18ºF **Average High in July:** 70ºF	**Average High in January:** 14ºF **Average High in July:** 85ºF	**Average High in January:** 40ºF **Average High in July:** 75ºF	**Average High in January:** 34ºF **Average High in July:** 80ºF
Average Rainfall	**Average Annual Precipitation:** 34 inches	**Average Annual Precipitation:** 26-38 inches	**Average Annual Precipitation:** 37 inches	**Average Annual Precipitation:** 32 inches

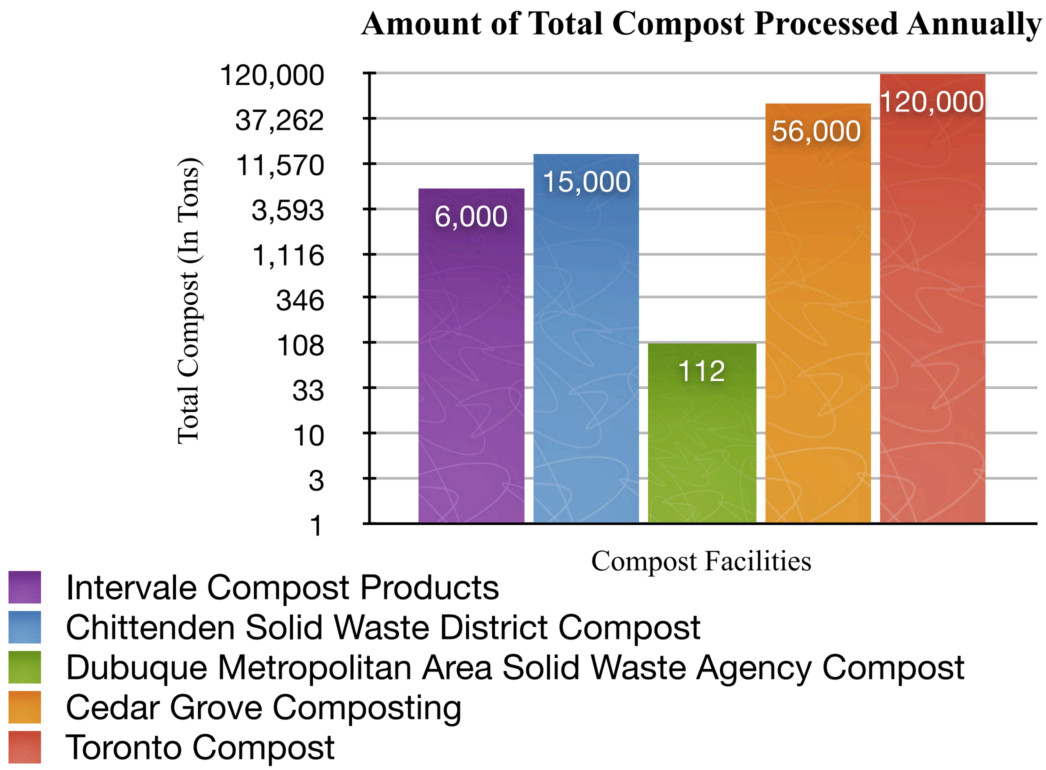
Table 2: Basic Statistics of Each City (U.S. Census 2010, 2011; NASA Space Grant Consortium & Oklahoma East Central University, 2004)

Technical Information of Each Organic Materials Processing Facility					
	Chittenden Solid Waste District: Intervale Compost Products	**Chittenden Solid Waste District: Compost Program**	**Dubuque Metropolitan Area Solid Waste Agency: Compost Program**	**Seattle Public Utilities & Cedar Grove Composting**	**Toronto Solid Waste Management: Dufferin Organic Processing Facility**
Feedstocks	* Food Scraps * Nutrient Rich Animal Manure * Animal Bedding * Small Yard Trimmings	* Food Scraps * Nutrient Rich Animal Manure * Animal Bedding * Small Yard Trimmings	* Food Scraps * Compostable Paper Products *Small Yard Trimmings	* Food Scraps * Small Yard Trimmings * Clean Wood Waste	* Food Scraps * Non-Recyclable Paper * Yard Wastes * Nutrient Rich Animal Manures * Animal Bedding * Baby Diapers * Feminine Sanitary Products
Composting Method	Traditional Turned Windrows	Aerated Static Piles System	Traditional Turned Windrows	Gore-Tex™ Covered Aerated Static Pile System	Anaerobic Digestion
Laws Limiting the Amount of Organic Waste That is Composted	Vermont Agency of Natural Resources (VTANR)	VTANR	Iowa Department of Natural Resources (IDNR) Restricts DMASWA Compost to 2 Tons of Compost Per Week	Washington State Department of Natural Resources (WADNR)	None
Compost Testing Regulations	*VTANR *The State of Vermont *Northeast Organic Farming Association of Vermont / Vermont Organic Farmers (NOFA-VT/ VOF)	*VTANR *The State of Vermont *NOFA-VT/ VOF	*IDNR *The State of Iowa	*WADNR *The State of Washington *U.S. Composting Council	*U.S. Testing Methods for Examination of Composting and Compost

Table 3: Technical Information of Each Organic Materials Processing Facility (Moreau, 2011; Schultz, 2011; CGC, 2011; TCT, 2011c)

Legal and Social Management of Each Organic Materials Processing Facility					
	Chittenden Solid Waste District: Intervale Compost Products	**Chittenden Solid Waste District: Compost Program**	**Dubuque Metropolitan Area Solid Waste Agency: Compost Program**	**Seattle Public Utilities & Cedar Grove Composting**	**Toronto Solid Waste Management: Dufferin Organic Processing Facility**
Generators	Residents, Commercial Institutions, Businesses, & Farms	Residents, Commercial Institutions, Businesses, & Farms	Residents, Commercial Institutions, & Businesses	Residents, Commercial Institutions, & Businesses	Residents
Collection Process	Private Sector	Private Sector	City	Public Sector	Public Sector
Site Management	Public: CSWD	Public: CSWD	Public: DMASWA	Private: Cedar Grove Composting	Public: TSWM
Regulating Ordinance	Voluntary Participation	Voluntary Participation	Voluntary Participation	Mandatory Participation	Mandatory Participation
Curbside Organics Collection Program	No	No	Yes	Yes	Yes
Fees	Tip Fee for Private Hauler Drop off: $35 Per Ton Free Drop off for any resident	Tip Fee for Private Hauler Drop off: $35 Per Ton Free Drop off for any resident	Monthly Curbside Organic Waste Removal Fee Per Customer: $1.25 Monthly Organic Waste Bin Rental Fee April - November: $1.30 Monthly Organic Waste Bin Rental Fee December - March: $.60	Monthly Curbside Organic Waste Removal Fee Per Household or Residential Unit Based on Size of Bin: * 13-Gallon: $4.35 * 32- Gallon: $6.50 * 96-Gallon: $8.35 * Yard Waste Bundle: $4.15	Curbside Organic Waste Removal Free to Residents Yearly Waste Removal Fee Per Household or Residential Unit Based on Size and Frequency of Refuse Waste Removal: * Small: $199 * Medium: $248 * Large: $342 * Extra-Large: $399

Table 4: Legal and Social Management of Each Organic Materials Processing Facility (Moreau, 2011; Schultz, 2011, CGC, 2011; TCT, 2011f)



Graph 4: Amount of Total Compost Processed Annually (Moreau, 2011; Schultz, 2011; CGC, 2010; TCT, 2011c)

Discussion

Sustainable Development Growth Factors

Campbell's sustainability paradigm, discussed in the literature review, was used to analyze the sustainability of the old and new CSWD organic materials processing facilities (Campbell, 1996). Both the ICP and CSWD Compost facilities were individually evaluated based on their relationship with all three of the paradigm's sustainable growth factors: social, environmental, and economic. The following are adaptations of Campbell's definitions for each sustainable growth factor. These definitions serve as guidelines for the analysis of each organic materials processing facility and its adjoining composting program:

- Social: Education about the importance of composting and methods composting, the ease of involvement in organic waste sorting and drop off, participation ratings, the surrounding community's acceptance of the facility, and the facility's effects on human health
- Environmental: The organic materials processing facility's effects on the surrounding environment
- Economic: The current and future expenses of managing and developing the organic materials processing facility

After analyzing the benefits and drawbacks offered by each growth factor at each facility, the information was weighed as a whole in order to highlight how the three factors currently interact and how they could benefit from change in the near and distant future. This involved measuring the development, resource, and property conflicts that arise with the development of each compost facility (Campbell, 1996). It is important to notice that just as each of the three growth factors interconnect, the studied topics within each individual growth factor also interconnect. While the following growth sections aren't broken up into each individual element researched, they were still considered and are visible in the construction of the set of recommendations for the sustainable urban growth of CSWD Compost.

Analyzing the Benefits and Drawbacks of Each Sustainable Growth Factor: CSWD's Old Organic Materials Processing Facility

Benefits for ICP's Organic Materials Processing Facility

Social Benefits

The old location of the ICP has been a great benefit for the social aspect of composting. Located in downtown Burlington, the ICP has been able to increase education about composting to local residents, commercial institutions, businesses, or local farmers. Education about composting at ICP involves offering free on site public tours of the composting processes, traveling to local schools to educate young children about composting, and working in tandem with the Intervale Center, a center dedicated to local and organic farming and gardening, offering free compost workshops and volunteer opportunities to the Burlington Community. By teaching Burlington about the benefits of composting, more residents and businesses have taken an interest in sorting through their solid waste in order to consciously remove organic wastes (Moreau, 2011).

Aside from education, the location has also been a great benefit for ICP as it is located in an extremely convenient area for people to drop off organic wastes. Instead of having to travel many miles to dispose of organic wastes, which often ultimately deters many from participating in the sorting of organic waste from other solid wastes, many more local residents are motivated to commit to properly sorting waste as they are able to easily travel to ICP themselves. The location has also benefited commercial institutions, businesses, or local farmers who are interested in hiring a low priced private hauler to dispose of their organic wastes as the cost of traveling from downtown Burlington to ICP is far lower than if a hauler was forced to drive out of Burlington to dispose of wastes.

ICP works to successfully achieve a high grade compost product that can be sold to the gardeners and farmers who have come to rely on natural soil amendments. ICP maintains a positive image by setting high standards in the products they produce and have therefore gained a following of loyal customers. ICP dedicates itself to meet the NOFA-VT/VOF criteria set forth by organic farmers and gardeners, the State of Vermont, and the VTANR requirements of compost products are met.

Environmental Benefits

ICP manages a small plot of land in its management of organic material meaning that less land is impacted by the compost process. ICP chooses to use the traditional turned windrow compost method as it a biological advantage over other complex technologically advanced methods of composting. This method of composting guarantees a uniform decomposition of all organic materials thereby easing the steps of pre-processing and post-processing. This may include spending less time mixing the initial batch of compost feedstocks or less time screening the final product as the traditional turned windrow compost process ensures a uniform breakdown of organics. This uniform breakdown of the particle size of each organic material occurs during the compost process as every material is exposed to the, “active interior zone of a pile” (Diaz et al., 2000, p.149).

Other environmental benefits include the loss of excessive moisture levels during the aeration process which prevents the pile from quickly turning anaerobic and becoming unmanageable. Also, the prime location of ICP drastically reduces transportation impacts as the organic materials processing facility is located in downtown Burlington in close proximity to residents, commercial institutions, businesses, and local farms generating organic wastes.

Economic Benefits

There are few economic benefits for ICP. As ICP is managed by CSWD, the organization is funded and supported by the solid waste tip fee charged to each private hauler who disposes of organic wastes. While this fortunately ensures the life and stability of the organic materials processing facility, aside from the revenue acquired from the sale of Interval Complete Compost, the program as a whole is an expensive endeavor for CSWD to maintain (Moreau, 2011).

Drawbacks for ICP's Organic Materials Processing Facility

Social Drawbacks

While the traditional turned windrow compost process appears entirely reliable, there are drawbacks that ICP faces. Human health issues can rise quickly if windrows aren't well maintained. Some of the human health risks include the potential emission of pathogens in the form of liquid leachate/runoff. Should potentially pathogenic liquid leachate/runoff enter the nearby soils or groundwater, contamination can occur. Should the contaminated groundwater come in contact with soils or groundwater, a human could potentially ingest or inhale the pathogenic contaminates.

Aside from health risks, neighbors of the ICP can be generally displeased with the compost operation should the feedstocks or windrows emit unpleasant odors or attract unwanted vectors. While the proper compost processes shouldn't smell or generate undesirable odors, from time to time ICP can emit a stench that may displease locals, especially on the days windrows are turned. This is due to the fact that odors occurs when there is a lack of oxygen. When ICP aerates the windrows, there is a flash of odor; however, this stench quickly dissipates when the freshly turned windrow is covered with a biofilter layer of aged compost. While the presence of vectors doesn't greatly affect the overall compost process, their existence can deter a community's interest in having a compost facility near residential areas and can lower their interest in participating in the compost process.

Environmental Drawbacks

The traditional turned windrow compost method can require a large amount of maintenance and can turn anaerobic quickly without proper care. Improper care for traditional turned windrow compost windrows can result in environmental health issues should leachate or runoff leak from unmaintained piles. While step one and two rested upon impermeable concrete pads, step three and four rested on hard packed soil pads which can result in the leaching of pathogens into nearby soils and groundwater. As ICP is located in a sensitive wetland near a riparian zone and small river, as a precaution it should have installed a liquid drainage and collection system to capture any potentially pathogenic leachate/runoff from both pads.

While it is impossible to create a compost product that doesn't have Polycyclic Aromatic Hydrocarbons (PAHs), fICP continuously monitors each batch's level of PAHs presence. By advertising that, "PAHs do not pose acute health risks at low levels such as those found in our compost when applied according to normal usage guidelines," ICP is showing their dedication to testing and monitoring the levels of PAHs within their compost products (ICP, 2011a).

Unfortunately the traditional turned windrow compost method has been proven to emit up to 20% more greenhouse gases, including methane (CH_4) and carbon dioxide (CO_2), into the atmosphere compared to that of the aerated static pile method of composting (The Staff of

BioCycle, 1991b). This is a direct result of aerating the windrows by means of manually turning each pile. While ICP attempts to allow the feedstocks that tend to emit the largest amount of greenhouse gases, mainly nutrient rich animal manures, to age for up to four weeks in an effort to reduce the rate of these emissions, the ICP doesn't have enough space or time to commit to this process. While the traditional turned windrow compost method is an effective composting method, as Chittenden County's organic waste stream continues to grow on ICP's lack of workable space.

Economic Drawbacks

Due to the fact that ICP doesn't charge residents for organic waste drop off, it does charge private haulers a tipping fee of $35 per ton (ICP, 2011a). Only generating about 6,000 tons of compost product each year, it can be difficult for ICP to maintain a healthy budget for the compost program (Moreau, 2011). The traditional turned windrow compost method also can take longer than other methods of composting causing ICP to have to wait before a completed compost product is ready to be sold thereby prolonging the presence of necessary funding.

The financial expense of properly managing ICP can be highly expensive. This is due to the fact that ICP has to maintain machinery essential to the composting process while also purchasing the fuel needed to run these machines. Some of the machinery ICP has purchased in the past has included bucket loaders and high speed drum mixers. In total, this equipment can cost anywhere between $30,000 to $200,000 dependent upon the age and quality of each machine (Moreau, 2011). Aside from the machinery itself, ICP has also had to pay anywhere between $55,000 to $60,000 a year in diesel fuel to keep each machine working out onsite. ICP also has an expensive array of computer and weather prediction technology to maintain and upkeep.

Analyzing the Benefits and Drawbacks of Each Sustainable Growth Factor: CSWD's New Organic Materials Processing Facility

Benefits for CSWD Compost's Organic Materials Processing Facility

Social Benefits

CSWD has proposed that as technology increases over time, eventually the municipal solid waste stream won't require separation of recyclables or organic wastes from solid waste. While the addition of this sort technology would ease the disposal of waste and would greatly benefit the health of the solid waste stream, this technology isn't a current reality. Nevertheless, by choosing to move the location of the CSWD organic materials processing facility from downtown Burlington to Williston, Vermont, the new CSWD Compost facility will fortunately be located on site with the county's landfill and materials recovery facility (MRF). Over time as technology increases, CSWD Compost will be able to work directly with the other solid waste facilities to ensure the best possible waste management services for Chittenden County.

Aside from seeing the benefit of the new CSWD Compost location in the far future, immediately upon opening commercial institutions, businesses, local farmers, and private haulers who choose to dispose of organic wastes within Chittenden County will benefit from the new location. As each individual will no longer have to travel to different places to dump solid waste, recyclables, and organic waste, the motivation to begin sorting out organic wastes will drastically increase. Aside from the creators of waste, Chittenden County private waste haulers may also recognize the benefits of having all of the CSWD programs in one location and may begin offering an organic waste collection program if one isn't already offered.

CSWD recognized that by relocating the organic materials processing facility from the downtown Burlington location to rural Williston location, fewer residents may find motivation to continue composting as it may mean traveling to the new CSWD Compost facility to dispose of organic wastes. To combat this potentially negative change, CSWD plans to continue offering organic waste drop off free of charge to any resident at all CSWD drop-off locations, including the location in downtown Burlington.

As the new location of CSWD Compost is extremely rural compared to that of the old urban location of ICP, CSWD Compost may find that they benefit from working in an area with fewer neighbors. As the aerated static piles are turned far less often than the traditional turned windrow composting system, CSWD Compost will no longer have to worry about undesirable odors escaping from aerated static piles. While some odors may escape during transportation between one step to the next, this odor shouldn't reach the surrounding neighbors as the facility is located a great distance from the closest cluster of homes.

Aside from odors, the new aerated static pile technology will greatly reduce the presence of potentially harmful human health issues or unwanted vectors. Reducing the rate of vectors will improve the efficiency of the composting process and will increase the local community's level of acceptance of having a compost facility near their homes. Each group of residents located near the Williston facility were approached before the construction began and were asked to sign a waiver stating that they have been educated about the compost process and that they understand how their community may be impacted by the facility's daily operations.

Environmental Benefits

Aside from easing both the process of separation of wastes in the municipal solid waste stream and the processes of transportation to one singular CSWD center, the move of the Chittenden County composting site from Intervale Road, Burlington, Vermont to Williston, Vermont will greatly benefit the overall composting process. As the move to the new compost facility involves developing a new aerated static pile compost system, CSWD Compost will be able to successfully compost a significantly greater amount of organic waste. Due to this new technology, CSWD Compost predicts an additional 9,000 tons of organic waste will be processed into high quality compost annually (Moreau, 2011). This drastic increase in the amount of recovered organic waste that will enter the organic materials processing facility has nothing to do with an expansion of land space, in fact, ICP and CSWD Compost are identical in size. The aerated static pile compost technology will merely speed up the compost process allowing more organic waste to enter the stream each year.

The new compost system will also benefit the environment as CSWD Compost will rely on a lower amount of fossil fuel technology to manage the facility. Instead of depending heavily upon diesel fuel to move, mix, and aerate organic wastes, the new facility will use electricity to push the composting process along. Aside from reducing greenhouse gas emissions from the machinery used in the compost process, the aerated static pile system will also allow the organic waste piles to emit far lower levels of methane and carbon dioxide during steps two and three as there will be no manual mixing of the organic wastes.

CSWD Compost has run several pilot trials of the new compost technology and have found that the aerated static pile system releases 20% fewer methane and carbon dioxide greenhouse gases into the atmosphere compared to that of ICP's old traditional turned windrow compost process. To further aid in the lowering of greenhouse gas emissions during steps two and three, CSWD Compost has also planned to allow all nutrient rich animal manure, a feedstock known to emit high rates of methane gas, to age in the feedstock bay for up to four weeks before it will be used during mixing or blending. This will allow these feedstocks to decompose and reduce their methane content before being actively blended and released into fresh air sources.

While making smarter and more sustainable development choices on site, CSWD Compost plans to capture the leachate/runoff that enters the collection tank and lined collection ponds. By capturing this leachate/runoff, CSWD Compost is ensuring that it doesn't enter and damage the nearby soils or groundwater systems. CSWD Compost also plans to recycle this leachate/runoff on site in hopes of keeping this liquid waste out of the Chittenden County wastewater treatment facility. By recycling this leachate/runoff as a moisture additive in step two of active composting, CSWD Compost will actively reduce the amount of fresh water resources needed to manage the composting processes (Moreau, 2011).

Economic Benefits

Despite the drastic increase in the amount of processed organic waste and the addition of expensive new technology and facility construction costs, the price for managing the compost facility will be far less than the cost of managing the ICP facility. This may be directly related to the increase in the compost product yield and to the smart financial choices CSWD Compost has made during the planning and development phase. Aside from the financial savings explained in the financial expenses section, a specific example of the smart planning CSWD has made is visible in their choice not to waste money on all brand new technology. CSWD Compost plans to purchase some used equipment from other organic materials processing facilities across the

United States, including a used mechanical mixer that will save CSWD Compost almost $100,000 off of a new priced mechanical mixer which can cost up to $200,000 (Moreau, 2011). Another example of financial savings is visible in CSWD Compost's overall cost of running the organic materials processing facility. By transiting to use a superior form of compost technology, CSWD Compost will no longer rely heavily on the use of expensive diesel fuel thereby saving CSWD Compost almost $37,000 a year in the cost of overall operation (Moreau, 2011).

Drawbacks for CSWD Compost's Organic Materials Processing Facility

Social Drawbacks

In addition to losing motivation to compost due to the distance between downtown Burlington and the new CSWD Compost facility in rural Williston, fewer Burlington residents may begin to accept the process of sorting organic waste from other refuse waste. As the Intervale Center endorsed the ICP compost program through community outreach and education, after the closing of ICP, fewer local residents, commercial institutions, businesses, or local farmers will have the information they need to start an organic waste collection program. To counteract this negative trend, after the final shutdown of ICP in July 1, 2011, the Intervale Center plans to continue educating locals about the importance of composting. However, without offering a CSWD managed center dedicated to teaching the surrounding community about the importance of proper waste management, over time CSWD Compost may begin to recognize a community detachment to the processing of organic wastes.

Environmental Drawbacks

While the installation of an aerated static pile system should aid in the reduction of excessive greenhouse gas emissions, CSWD Compost will still emit methane and carbon dioxide gases during the initial phase of the composting process. This release of greenhouse gas is directly related to the breakdown of organic waste material in feedstock form. Before it is blended with other feedstocks and is covered with a biofilter of completed compost, these organic wastes will emit greenhouse gases thereby increasing their presence and ratings in the atmosphere.

Similar to ICP, CSWD Compost will struggle with the presence of PAHs within all of their completed compost products. To combat this issue, CSWD Compost plans to continuously monitor each completed compost batch's level of PAHs presence. CSWD Compost is dedicated to working alongside with the Vermont Agency of Natural Resources and the Northeast Organic Farming Association of Vermont in hopes of developing standards that closely monitor and work to lower the presence of these substances in all of their compost products (ICP, 2011a).

Economic Drawbacks

In addition to the financial expenses explained in the results section, the new CSWD Compost facility plans to experience a lack of increase in profit for the first year of operation despite the increase in the completed compost product yield. This is directly related to the facility's reliance on using completed compost as a resource in the composting process. Using completed compost to cover organic waste piles in the second step of composting, CSWD plans to lose about $130,000 in profit the first year. CSWD Compost predicts that this dip in profits will only last for the first year of operation as the compost process will become more efficient and streamlined with increased experience over time.

How can CSWD Compost Continue to Increase Sustainable Urban Growth?

From analyzing the benefits and drawbacks of both the old and new CSWD organic materials processing facilities, it becomes quite clear that the new CSWD Compost program will greatly improve the management of the organic waste stream. The social, environmental, and economic growth factors at CSWD Compost will continuously develop as new technologies and progressive programs redefine the ways in which waste is managed. With the dynamic nature of these technologies, the process of further sustainably developing the organic waste management system will never be fully complete.

As Chittenden County is the home to the urban area of Burlington, Vermont, CSWD is continuously searching for new ways to sustainably develop its relationship with the residents of this city. In this search, the CSWD Compost program is constantly forced to reevaluate the relationships it holds with the local community, the surrounding environment, and the budget it is allotted by CSWD. In order to further improve these social, environmental, and economic factors, CSWD Compost will need to reevaluate its old and new relationships with each of these developmental factors. This may mean identifying whether the social factors include and empower the voices of the surrounding community; whether the environmental factors display resiliency and stability; and whether the economic factors show promise of positive growth and efficiency.

Having an uneven relationship may mean that one or two of the growth factors are neglected leaving another to dominate and thereby disrupt the balance of sustainable urban growth. CSWD Compost will need to remember that each of these three factors are incapable of standing on their own as all three must come into balance with one another to successfully achieve sustainable urban growth. By neglecting to evenly evaluate each growth factor, CSWD may also run the risk of developing an organic materials processing facility incapable of working effectively and efficiently with the surrounding community, environment, and economy.

Sustainably Developing CSWD Compost

CSWD's Proposed 5-Year Sustainable Development Plans for CSWD Compost

In March of 2009, CSWD released a document known as the "5-Year Work Plan" (CSWD, 2009b). The sole purpose of this document was, "to identify the most important tasks that should be accomplished within the next five years in order to enable CSWD, to continue to fulfill its chartered purpose and remain Vermont's leader in the management of solid waste" (CSWD, 2009b). As CSWD continuously seeks to, "focus primarily on waste reduction," the 2009 5-Year Work Plan was published as a proposal for potential areas of development that may benefit the organization in the future (CSWD, 2009b). The 5-Year Work Plan includes both highly achievable goals for development of CSWD over the next five years as well as rough developmental ideas CSWD may potentially expand upon in the extended future. Much of this potential expansion depends solely upon budget; however, it may also depend on whether or not there is enough interest in a program for it to succeed at CSWD.

CSWD dedicates an entire section of the 5-Year Work Plan to analyzing the urban organic waste stream in Chittenden County. CSWD highlights the urban section as it is currently one of the largest generators of organic waste that isn't offered a formal system of waste removal. Within the 5-Year Work Plan, CSWD questions whether the incorporation of a formal residential curbside organics pickup program would sustainably develop the relationship between CSWD Compost and Burlington residents. As the development of a curbside program of this size would require a significant amount CSWD's time and financial dedication, it would need to be carefully considered. CSWD claims that first step in sustainably developing the urban organic waste stream would be to conduct a study of the social, environmental, and economic benefits and drawbacks of developing a new urban curbside organics collection system.

Weighing the Benefits and Drawbacks of Developing an Urban Curbside Organics Collection Program in Burlington, Vermont

Social Benefits

By developing an urban curbside organics collection program, CSWD has the potential to educate thousands of residents about the benefits of using composting as a method for disposing of organic wastes. By providing urban residents with the opportunity to separate organic wastes from other solid wastes, CSWD can empower local residents with the chance to make a move towards living in a waste free community. While it would be impossible to have 100% participation in this program, by offering the curbside collection of organic wastes CSWD would see a far lower amount of organic waste entering the solid waste stream. The development of this program would also increase inclusiveness of the community as it would benefit the entire urban area rather than only certain demographics or locations.

Environmental Benefits

CSWD publicly advertises that organic waste makes up about 26% of the solid waste stream (CSWD, 2009b). Many urban residents choose to forgo the separation of organic wastes by their own means, including in either home backyard composting system, by dropping off organic wastes at CSWD Drop-Off Centers or the organics material processing facility, or by hiring a private hauler to collect and dispose of organic waste (CSWD, 2009b). Organic wastes that are not processed in this manner end up being disposed of in the general solid waste stream.

This waste is then landfilled where it takes up unnecessary space and will never return to the soil. By neglecting to offer urban residents with a simple method to dispose of their organic wastes, CSWD is essentially prolonging the problem of organic wastes contaminating the solid waste stream. CSWD recognizes that by providing a curbside organics collection program to urban residential areas, such as Burlington, urban residents would drastically improve the sorting of solid wastes and would help keep their portion of the 26% of organic wastes out of landfills (CSWD, 2009b). The addition of an urban curbside organics collection program may also benefit not only the sorting of organic wastes, but the sorting of recyclables, toxic wastes, and garbage as well thereby further streamlining the overall management of solid wastes.

Economic Benefits

As the increased cost of disposing solid waste in landfills increases involvement in recycling and organic waste management programs, over time CSWD could save a tremendous amount of money in the management of landfills. The cost of storing waste in a landfill will never end as landfills must constantly be managed and maintained. Even after a landfill is closed, a management team will need to monitor the landfill's gaseous outputs and toxic leachate. While the costs of managing recycling and organic waste management facilities can be expensive initially, the programs are ultimately capable of turning a profit if each program runs efficiently and manages to effectively create useful raw materials or completed compost products. As these products can be sold, the cost of transforming materials from waste to a new resource is overshadowed by the ultimate worth of the entire recycling and composting process.

Through the establishment of an urban curbside organics collection program, less unnecessary waste will enter the refuse solid waste stream meaning that less organic waste will enter the landfill. By keeping organic waste out of the landfill and entering it into an organics material processing facility, CSWD would save thousands of dollars a year. Aside from CSWD alone, urban residents who choose to participate in the urban curbside organics collection program could also potentially save a significant amount of money if they are successful in sorting out the organic waste that enters their refuse waste stream. As residents are charged a tipping fee for every bag or pound of garbage waste they dispose of, no matter the method of disposal, ie. private haulers or personal drop off at CSWD Drop-Off centers; by disposing of less garbage wastes, residents would pay less to dispose of their wastes. While this seems to be a simple observation, this potential monetary savings may be incentive enough to persuade Burlington residents to participate in a CSWD sponsored curbside organics collection program.

Social Drawbacks

While CSWD recognizes the benefits of offering a curbside organics collection program in the 5-Year Work Plan, it also highlights several major drawbacks which include a lack of interest or participation from residents. This may be directly attributed to residents' lack of education about the importance of sorting out organic wastes from the solid waste stream or because residents see no personal gain from paying an increased fee for organics removal or from taking the time to sort through organic waste. Despite these obstacles, CSWD believes the main social reason an urban curbside organics collection program would fail in Burlington is simply because residents can't get over the, "yuk factor," of having to sort through their refuse for organic waste (CSWD, 2009b).

Environmental Drawbacks

With the creation of an urban curbside organics collection program, the 5-Year Work Plan highlights CSWD's worry that an increased amount of refuse or recycling waste may enter the organic waste stream. As refuse contaminated organics are often disposed of in landfills, CSWD worries that without the proper education, few participating residents will understand the process of sorting organic wastes thereby leading to large amounts of unusable contaminated organic wastes.

CSWD is also concerned with the amount of truck traffic that will be required to successfully collect the amount of waste offered by Burlington residents. CSWD foresees using an excessive amount diesel fuel that will be ultimately emitted as a greenhouse gas into the atmosphere. The use of this fossil fuel is in itself an inefficient means of powering each collection vehicle; nevertheless, the fact that greenhouse gases are emitted as a byproduct is an even bigger obstacle for a company hoping to develop a smarter and more environmentally sustainable waste collection program.

Economic Drawbacks

The main reason CSWD cites for not supporting the development of an urban curbside organics collection program is directly related to the costs to start up and maintain the program. Upon the creation of the new urban curbside organics collection program, CSWD recognizes having to fund a new team to plan out the curbside program, a new team to educate Burlington residents about the curbside organics collection program, and potentially a future study on the program to determine whether CSWD is truly benefiting from the addition of an organic collection program.

Private haulers currently offering organics removal for commercial institutions and businesses, each utilize a collection vehicle dedicated to organics wastes. While these private haulers would be required to purchase and maintain extra organic waste vehicles, CSWD predicts having to help fund a new fleet of collection vehicles capable of handling organic wastes for Burlington Public Works (BPW). BPW is a city managed department that helps manage the city's, "Construction Permits, Equipment Maintenance, Recycling & Solid Waste, Stormwater, Streets & Sidewalks, Transportation, and Water & Wastewater" (Losch, 2011). As BPW currently offers each Burlington resident curbside removal of recyclable wastes, it may potentially share a role in the disposal of Burlington resident's organic wastes.

CSWD understands the large risks taken with the potential development of a curbside organic collection program. Should a significant amount of residents fail to participate in the collection of organics, CSWD may face an increase in the cost needed to manage and maintain the program and the compost facility. This would be directly related to the lack of funding generated from each resident's organic waste removal bill and the decreased amount of organic waste collected from the Burlington area. By collecting less organic wastes, a lower rate of completed compost product can be created and sold meaning that there will be a large drop in the incoming revenue that ultimately supports the CSWD Compost facility.

A Sustainable Solution: Curbside Organic Collection

Upon weighing the benefits and drawbacks of developing a new curbside organics collection program in Burlington it becomes clear that the social, environmental, and economic benefits far outweigh the drawbacks. By analyzing the benefits, CSWD should realize that by building a new curbside pick up program for Burlington, they are sustainably developing and further streamlining residents' relationship with solid waste removal, the CSWD Compost waste stream, and the entire MSW stream. While the benefits do overshadow the drawbacks, they shouldn't be forgotten or ignored. In fact, while developing the curbside pick up plan for Burlington, the drawbacks will provide insight on restrictions or obstacles that should be overcome.

Aside from using potential drawbacks as an outline for development, CSWD has two additional tools at its disposal that will greatly aid in the development of the program. The first involves reevaluating a pilot curbside organics collection program CSWD ran in 2000 and the second requires further researching the curbside programs of superior composting facilities across the United States. By analyzing the social, environmental, and economic benefits and drawbacks of the 2000 pilot program and other composting programs, CSWD will be able to predict what obstacles it may potentially incur during development of a new curbside pickup program and can therefore make more informed decisions about how to overcome each obstacle.

The CSWD 2000 Pilot Program

By analyzing the results of the 2000 pilot curbside collection program, CSWD has the potential to evaluate what worked well and what could be improved in a future curbside organics collection program. As this pilot program focused on downtown Burlington, this study may be one of the most beneficial gauges in developing and evaluating a new organic waste management plan for the city.

Background Information on the 2000 CSWD Curbside Collection Pilot Program

The pilot program ran for eight months in an attempt to run for enough time to get a feel for how effective a full scale curbside organics program would be in Burlington. Each volunteer resident was selected at random across the City of Burlington and was asked to separate organic waste from their refuse waste stream (Moreau, 2011). CSWD vehicles picked up organic wastes once a week from January 1st through August 31st. This time frame was specifically chosen to include both winter and summer months to study the weather's affects on participation levels (Moreau, 2011). After collecting the program's resulting data, the benefits and drawbacks of an urban curbside organics collection program were analyzed and discussed. CSWD immediately disqualified the development of a full-scale organics collection program and deemed the pilot program a failure (Moreau, 2011). The 2009 5-Year Work Plan agrees with the pilot program's results and refuses to reanalyze the data or conduct a more recent study despite the amount of time that has since passed and the amount of changes that have occurred in Burlington since 2000. By reevaluating the 2000 pilot program results, potential factors that may have been initially overlooked or misinterpreted may be analyzed from the perspective of a later date.

Benefits of the CSWD 2000 Pilot Program

Social Benefits

The most common and most positive feedback CSWD received from volunteers that participated in the pilot program, were the comments that spoke about how excited each volunteer was to decrease his or her personal impact on the environment by reducing the amount of organics unnecessarily entering the solid waste stream (Moreau, 2011). Knowing the future of a city wide curbside organics collection program relied on the positive results of their collective study, each highly motivated participant also professed his or her strong attempts to correctly sort organic wastes from the refuse waste stream. Some volunteers also commented on enjoying the simplicity of having to take their organics wastes no further than the curbside to properly dispose of them (Moreau, 2011). While not all volunteers agreed with these statements or made comments in support of the development of a city wide organics collection program, few disagreed that eventually it would become an essential addition for the proper management of Burlington’s wastes (Moreau, 2011).

Environmental Benefits

The pilot program resulted in a 5% increase in the amount of organic waste diverted from each volunteer’s overall refuse waste stream (Moreau, 2011). This same diversion rate of 5% was predicted to carry over to the entire City of Burlington should the curbside organics program become permanent. CSWD predicted that should 50% of Burlington household participate in the sorting of organics with a 5% diversion rate, 6,000 extra tons of organic waste would be diverted from the refuse waste stream each year (Moreau, 2011). While this isn’t startling tonnage, in 2000, when the pilot program originally ran, the ICP couldn’t have handled this drastic increase in organic waste materials do to infrastructure and compost technology restraints.

Economic Benefits

Each volunteer was invited to participate in the pilot program free of charge meaning that CSWD was forced to fully front the costs of the program’s development, of the collection of organic wastes from each volunteer’s household each week, and of the study and analysis of the program’s results. This meant paying for the creation of the curbside program, the green bins distributed to each volunteer, the vehicles, the fuel, and the solid waste field personnel needed to collect wastes, and the team of researchers who analyzed the pilot program’s results. While

CSWD was allotted a budget to conduct this study[8], the high cost severely limited the amount of residents CSWD could involve in the permanent city wide program.

Benefits of the CSWD 2000 Pilot Program

Social Drawbacks

The 5-Year Work Plan strongly credits the failure of the pilot curbside organics collection program to the social lack of interest of each volunteer resident. As, "less than half of the households invited to participate in the pilot project," continued to volunteer throughout the entire eight month study, this low rate of volunteer participation generates questions about the education each volunteer was offered about the importance and process of sorting of organic wastes (Moreau, 2011). While each resident was distributed informational pamphlets alongside the organic waste green bin, there is no way of determining how many residents read or truly understood the meaning of organic waste diversion.

As the pilot program time length wore on, CSWD also fears that volunteers began to drop out as few began to see any personal gain they received from taking the time to sort through their refuse for organic waste. Many began to question the real impact their individual diversion of organics would make on the larger scale (Moreau, 2011). Seeing the program as a waste of time and energy, several volunteers stopped participating and quickly returned to disposing of most or all their organics wastes in the refuse waste stream.

While each of these reasons may be attributing factors for the ultimate failure of the 2000 pilot as a program and a study, CSWD claims that the main reason volunteers eventually gave up organic waste pickup was most likely due of the "yuk factor" that comes along with the disposal

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[8] The exact amount of money budgeted to the CSWD 2000 Curbside Organics Pilot Program is unknown.

of organic wastes (Moreau, 2011). As volunteers were not able to dispose of the organics in biodegradable bags, each volunteer was forced to place all organics in a green bin as a conglomerate mass. As each green bin was required to be rinsed out each week after organic wastes were picked up for sanitary purposes, the program quickly became a time consuming hassle and undesired task.

Environmental Drawbacks

As the data results proved that each volunteer only diverted about 5% of his or her organic waste from the refuse waste stream, CSWD quickly questioned the benefits of the curbside organics collection program. Composting 5% of organic wastes rather than disposing of them in landfill is clearly a better management plan; nevertheless, CSWD didn't see the benefit of running a program that's return would hardly equal out the overall emission of greenhouse gases created by the vehicles used collect the organic wastes (Moreau, 2011).

In 2000, ICP's compost facility was less advanced meaning that the 6,000 tons of organic wastes collected by a new organic waste collection program in Burlington would have created a spatial burden on the composting process. ICP would not be able to handle the additional 6,000 tons of waste a year meaning that the majority of the collected organics would end up entering the landfill completely countering the whole purpose of separately sorting and collecting organics (Moreau, 2011).

Economic Drawbacks

The 5-Year Work Plan identifies the main reason that a curbside organics collection program was never established or expanded in Burlington was, "due to the high cost of collection" (CSWD, 2009b). As CSWD completely supported the collection of wastes, no additional public or private haulers were used as they are in the removal or refuse and recycling. As CSWD doesn't traditionally collect any form of wastes, the increased costs for vehicles, fuel, and solid waste field personnel were too much for the pilot program's budget to handle. The cost of the study's development and analyzation and the materials needed to educate and prepare each volunteer were also extremely expensive meaning that CSWD quickly became negative about the potential future costs of the curbside collection program.

Incorrect Interpretations of the Pilot Program's Results

The curbside organics pilot program's results appear to have been misinterpreted in several areas. Reinterpretation may show how the pilot program wasn't exactly the "failure" CSWD deemed it and was actually an important tool in showing how CSWD needs to plan for Burlington's residents ever changing waste management needs.

Misinterpretation One: As the curbside program was originally designed to last a total of eight months in an attempt to watch each volunteer's level of commitment to the program as the weather and the seasons changed, CSWD didn't receive proper data in this specific area as more volunteers dropped out about halfway through the program meaning that most stopped participating when the weather was no longer an obstacle in participation. As one would predict that warmer weather would increase a volunteer's motivation to set out organic wastes, the pilot program's results counter this assumption meaning that the latter half of the results most likely provide skewed or useless data.

Misinterpretation Two: While participating volunteers were given a set of educational tools to prepare them for the curbside program, there is no way of calculating how many actually read through and retained the information offered in each pamphlet or newsletter. The curbside results can’t successfully assume that each volunteer had a vast amount of knowledge about the compost or organic waste sorting methods.

Misinterpretation Three: As CSWD was required to provide their own transportation for the curbside pick pilot program, they failed to calculate how much BPW and local private haulers would become involved in the collection of Burlington resident’s organic wastes meaning that their financial burden of transporting organics would drastically decrease.

Misinterpretation Four: CSWD saw the high cost of transporting each volunteers organic wastes but failed to recognize the poor choices the development team made in choosing which households to involve in the pilot program. Instead of asking one or two full streets to participate, CSWD chose homes all across the city meaning that trucks were required to travel the length of Burlington just to collect a few green bins (Moreau, 2011). By scattering the homes studied, CSWD also received skewed data about the cost of fuel needed to manage a curbside program as the pilot program provided inefficient test results.

Misinterpretation Five: CSWD failed to recognize the changing social, environmental, and economic realms of Burlington. The pilot studied the 2000 Burlington community and didn’t look towards the future in terms of how the program and its participants would change or adapt over time. This includes how residents may become more environmentally conscious or aware, how the ICP compost facility would develop its compost technology or composting program, and how the cost of offering a curbside program would drastically decrease over time as the program fee is offset by the revenue created from selling an increased amount of completed compost products (Moreau, 2011).

Overcoming Obstacles From the 2000 Pilot Program

To overcome the obstacles presented by the 2000 pilot study, CSWD needs to redesign the organic waste pickup program to suit the dynamic Burlington community. While some of the environmental or technological obstacles the 2000 program faced have already been addressed with the creation of the new CSWD Compost facility, there is still room for improvement in the social and economic factors. These include:

•Dedicating CSWD Compost funding to educating Burlington residents about the benefits of composting.

•Simplifying the processes of resident organic waste disposal. Example: Allowing residents to use biodegradable bags to manage their organic waste.

•Creating motivation and incentive to increase resident participation levels. Examples: Creating a ban on organics entering the refuse waste stream, lowering the cost of participation in the curbside organic waste disposal program, or developing a new “pay as you throw” refuse waste payment plan.

•Develop a contract for organic waste transportation with either public, private, or both types of organic waste haulers.

•Continue to develop the composting technology CSWD Compost uses to manage organic wastes.

Using Each Case Example as a Model for Development

While the 2000 curbside organics collection program illuminated potential areas for sustainable development, by using three separate superior composting programs and their curbside organics collection programs as models for sustainable development, CSWD has the invaluable opportunity to design the most successful organic waste management program possible for Burlington. While completely copying another cities curbside collection program would be socially, environmentally, and economically inefficient, CSWD will benefit from understanding the successes and failures other organizations have faced and can thereby create a more effective program for Burlington. The three urban curbside organics collection programs that will be evaluated are found in the three case example cities of Dubuque, Iowa; Seattle, Washington; and Toronto, Ontario.

The case example results section has shown how different each of the three cities and their organic materials processing facilities differ in terms of: population size, climate, level of the residents' education or motivation to participate, area of curbside pickup, size of the facility, composting method and technology, limiting composting laws, and alloted budgets; however, all three cities share one common thread of providing a more sustainable composting system through the means of a successful urban curbside collection program.

For the purpose of this thesis research, each case example city will be assigned to one specific sustainable growth factor it successfully represents: Dubuque, Iowa will represent the social factor, Seattle, Washington will represent the environmental factor, and Toronto, Ontario will represent the economic factor. Narrowing the view of each case example city to one growth factor allows the best sustainable developmental ideal that they offer to be highlighted and analyzed for use in Burlington. While each individual growth factor appears to have singlehandedly sustainably transformed the compost program and facility within each case example city, it is important to notice that no matter how much one specific element is developed or changed, the entire system won't truly improve unless there is an equal balance between all three of the social, environmental, and economic growth factors.

Dubuque, Iowa: Social Growth Factor

Despite the Iowa Department of Natural Resource's restrictive compost limit laws, DMASWA's small organic waste management budget, and the limiting low-tech traditional turned windrow compost method, Burlington's CSWD Compost could benefit from adopting a mission statement similar to DMASWA's which directly recognizes the organization's dedication to, "embracing economic prosperity, social/cultural vibrancy, and environmental integrity to create a sustainable legacy for generations to come" (Schultz, 2011). Dedicating itself to leaving a, "sustainable legacy," DMASWA publicly acknowledges that the growth and development process of a waste management facility shouldn't be focused solely on cutting costs as the surrounding environment and community are equally affected by DMASWA's choices. Focusing on the social relationship with waste management, the mission statement clarifies how every decision DMASWA makes involves determining how change will affect the community.

The most prime example of DMASWA's social awareness is in its establishment of an urban curbside organic collection program. Knowing that Dubuque wouldn't continue to sustainably develop without an increase in the refuse diversion rate, DMASWA began to develop an organic materials processing program and facility. DMASWA researched the establishment of a refuse sorting program that would efficiently separate recyclables and organic wastes from a single stream of refuse waste; however, the high price tag left the organization in search of another method.

Seeing how using Dubuque residents' sorting of organic wastes could decrease both refuse waste's negative impact on the environment and the high financial costs of disposing this waste, DMASWA decided to develop an organic materials processing facility that would engage the Dubuque community in the sorting of organic wastes. Trusting in each resident's ability to sort out organic wastes with the proper tools and education, DMASWA began to alert the community about an impending change in the removal of solid wastes. DMASWA held public city meetings and information sessions about the installation of the new curbside organics pickup program (Schultz, 2011). Not seeing a high level of response, DMASWA slightly changed its approach and began to directly contact each Dubuque resident through informational pamphlets. Using motivational bylines, DMASWA did its best to explain why composting is an important process that will help reduce the cost of refuse disposal and protect the surrounding environment. This drew some attention; however, few residents seemed to understand how they personally benefited from sorting out organics from refuse or why they should be asked to pay extra to dispose of unwanted wastes.

Knowing that the sorting of resident's organic waste was the key to increasing the refuse diversion rate, DMASWA took Dubuque resident's resistance as a challenge and began committing 100% funding to the development and expansion of the curbside program. DMASWA quickly realized that the community wouldn't begin to participate if the disposal of organics was a difficult, time consuming, or seemingly pointless process. DMASWA created more incentives for residents participating in the sorting of organic wastes including reducing the monthly fee for participation in the curbside collection program and beginning to allow organic wastes to be disposed of in biodegradable bags. DMASWA also simplified the process by which residents, commercial institutions, and businesses apply to become a member of the curbside collection program by offering online registration and delivering each city-owned organic waste green bin rather than expecting each customer to personally apply for the curbside program in person or pick it up from the DMASWA Compost facility. By making these small sacrifices to further engage the Dubuque community, DMASWA saw the popularity of the program increase to the point of meeting DMASWA Compost's two ton per week compost capacity (Schultz, 2011). This dramatic increase also meant that DMASWA Compost raised the refuse diversion rate thereby increasing environmental health of the solid waste stream and decreasing the financial burden of managing expensive refuse.

Seattle, Washington (Cedar Grove Composting): Environmental Growth Factor

Seattle's organic materials processing facility, Cedar Grove Composting, is an excellent example of using increased technology to benefit the entire organic waste management system and its impacts on the surrounding environment. Cedar Grove Composting also commits itself to consistently redesigning its facility and program to improve its relationship with the Seattle community and the local economy (CGC, 2010). Cedar Grove Composting explains this commitment in its mission statement:

> "maintain a leadership role nationally in the development of innovative methods in the composting process; design products that take life-cycle thinking into account and minimize environmental impacts in production, use and disposal; develop products from recovered waste material; find the highest and best use for the amount of material that has not been incorporated into a salable products; practice environmental sensitive manufacturing, applying the best available control technology to product manufacturing areas, while managing with an Environmental Management System; design operational units to minimize impact to the environment; recognize impacts from the processing facility concerning the community and participate in open discussions with local citizens to work through issues; and continuously strive to reduce air emissions to levels below the nuisance threshold" (CGC, 2011f).

By using more efficient composting technology, Cedar Grove recognizes its ability to increase its intake of local resident's organic waste and the byproduct amount of completed compost all while decreasing its reliance on energy resources, land space requirements, and the financial costs needed to effectively manage the compost facility. Since 1989 Cedar Grove Composting has searched for new technologies to benefit the organic waste management stream.

It has continued to redevelop its compost system from traditional turned windrows, to aerated static piles, to the more recent addition of unique Gore-Tex™ covers that trap in greenhouse gases, capture potentially pathogenic leachate, and regulate the moisture and airflow concentrations of each windrow (CGC, 2011e).

In July 2010, Cedar Grove Composting announced its development plans for the installation of a new anaerobic digestion composting process. The anaerobic digestion technology seems to be the next logical step for Cedar Grove Composting as the organization is in search of a composting process that will drastically increase the amount of organic waste that can be accepted and processed. As the anaerobic digester unit will cut the compost process time in more than half, Cedar Grove Composting will decrease the amount of time organic waste is processed and house within the facility's composting infrastructure (CGC, 2011g). By increasing the amount of organic waste that is accepted and an increasing in the speed at which organic waste is broken down and composted, Cedar Grove Composting has the opportunity to more than double the amount of compost product that is created (Marino, 2010).

As even the technologically advanced covered aerated static pile windrow system still release potentially pathogenic leachate or greenhouse gases into nearby soils, groundwater, and the atmosphere, the anaerobic digester unit has been proven to capture and reuse 100% of all leachate and harmful gases. Moving to a completely closed loop system, the anaerobic digester will capture and collect the biogas and leachate created from the breakdown of organic materials (Marino, 2010). While Cedar Grove is still currently testing the viability of capturing this gas and transforming it into a usable fuel or electrical resource, Cedar Grove Composting predicts that eventually it will completely offset its facility's maintenance costs from the production of its own energy equivalent to, “the electricity used of 400, homes or the fuel of 1,100 passenger vehicles annually” (Marino, 2010).

After completing a successful pilot program of the anaerobic digester unit, Cedar Grove Composting began questioning how this new system would benefit the organization other than by decreasing the facility’s impact on the environment and increasing the speed and efficiency of composing. Cedar Grove Composting quickly realized that if the anaerobic digester composting process is properly developed and introduced, the entire facility would sustainably redevelop and restructure its relationships with the local community and economy. While the ultimate success of the new composting technology does rely on increased community involvement to spur the rate at which organic waste is composted and biogas is created, Cedar Grove Composting proves that advanced technology is one of the first steps in sustainably transforming the composting process as there is no real way to expand composting rates until the technological infrastructure can handle a larger organic waste stream (Marino, 2010).

Toronto, Ontario: Economic Growth Factor

Toronto Solid Waste Management (TSWM) dedicates itself, “To be a leader in providing innovative waste management services to residents, businesses and visitors within the City of Toronto in an efficient, effective and courteous manner, creating environmental sustainability, promoting diversion and maintaining a clean city” (TCT, 2011g). Outrightly devoting itself to the sustainable development of the relationships between residents, the environment, the economy, and organic waste management, TSWM’s most impressive sustainable development growth factor is visible in its consistent economic growth through the development of a successful resident solid waste management payment plan.

Searching for a way to increase the refuse diversion rate after developing a curbside organics collection program, in June 2007 TSWM established a “pay as you throw” payment system that essentially tracks the amount of refuse solid waste each Toronto resident disposes of. While recycling and organic waste removal is free, TSWM decided the best method for ensuring that each resident is correctly sorting their solid waste stream is to charge each resident a refuse removal fee. This new payment plan smartly and fairly distributes the cost of waste management across the Toronto resident population by charging each resident an annual solid waste management service fee that is rebated and reduced dependent on the amount of personal refuse thrown away. By tracking this amount, TSWM is able to provide each resident with monetary incentive to reduce the amount of refuse that is disposed of by simply making them pay for it.

A seemingly simple addition to the waste management program, the “pay as you throw” plan is one of the most beneficial changes TSWM made in creating a more sustainable solid waste program. In late 2007 when the new payment program was initially introduced, few residents seemed to understand their ability to take charge of their household’s cost of solid waste removal. This resulted in a dramatic increase in the rates of TSWM’s incoming revenue. Each resident that neglects to adapt healthy recycling and organic waste sorting habits essentially pays a higher solid waste management bill thereby increasing TSWM’s incoming revenue, a seemingly attractive benefit for TSWM; however, the central reasoning behind the creation of the payment program was to leave residents in charge of the cost of their waste removal bills and forcefully educate each resident about the reasoning behind the higher cost of refuse disposal.

As time wore on, residents began to realize that by reducing the amount of refuse they generated by recycling and sorting out organic wastes, the size of their refuse removal bill would simultaneously diminish. Each fiscal year since 2007, TSWM has recorded an increase in the amount of rebates administered to residents who choose to consciously partake in curbside recycling and organic wastes from their refuse waste stream (TCT, 2011h). While the “pay as you throw” plan clearly improves the relationship between financing waste removal and the Toronto community’s generation rates of refuse waste, the payment plan also obviously creates higher organic waste diversion rate thereby further reducing TSWM’s environmental burden of landfilling the remaining refuse.

Recommendations

Sustainable Urban Development Proposal for CSWD Compost

In an attempt to continue sustainably developing the CSWD Compost program while building healthy relationships with the community, surrounding environment, and the local economy, the remainder of this thesis will focus primarily on creating successful and manageable development goals for a new Burlington curbside organics collection program. While there are many solutions to reducing the rate of solid waste, CSWD needs the most relevant development plans to ensure the most successful growth of their composting program. This requires paying sharp attention to the costs, benefits, and drawbacks of engaging the community and the environment in these changes.

Keeping these goals and obstacles in mind, CSWD may find success in learning from the mistakes of select parts of the 2000 CSWD curbside organics pickup pilot study while also using each model curbside organic waste removal program illustrated in the case examples as a reference guide. Again, while each program can't be completely copied, by reproducing and expanding certain elements and components, CSWD Compost may find a new and successful solution for sustainably developing the City of Burlington's relationship with disposal of organics wastes.

Social Development Goals

Community-Based Social Marketing

While each growth factor must balance out the other two to successfully sustainably develop CSWD Compost's curbside organic pickup program for the City of Burlington, social development may be the key to drastically transforming the amount of collected organic wastes. It is important to note that while DMASWA Compost has seen an increase in the amount of residents participating in its curbside organics collection program due to its educational programs, "numerous studies show that behavior change rarely occurs as a result of simply providing information" (McKenzie-Mohr, 1999, p. 1). To, "foster sustainable behavior," within the Burlington community, CSWD Compost should consider developing an outreach program similar to DMASWA Compost's multifaceted, "education team," that educates and provides initiatives to Burlington residents (McKenzie-Mohr, 1999, p. 1; Schultz, 2011). This requires CSWD Compost to use, "community-based social marketing," rather than solely, "an information-based campaign," (McKenzie-Mohr, 1999, p. 1).

Community-based social marketing uses four steps to educate and change behaviors. These steps include, "1) Identifying the barrier and benefits to an activity, 2) Developing a strategy that utilizes 'tools' that have been shown to be effective in changing behavior, 3) Piloting the strategy, and 4) Evaluating the strategy once it has been implemented across the community" (McKenzie-Mohr, 1999, p. 1). While this process seems long and demanding, by following this strategy CSWD may completely alter the way in which organic wastes are managed by Burlington residents.

Step 1. Identifying Barriers and Creating Incentives

As not every Burlington resident will initially have the motivation to commit to sorting out organics, CSWD Compost will most likely receive a similar response to the new program as it did in the 2000 CSWD pilot program. To overcome this potential pitfall, CSWD Compost needs to anticipate which areas of the program seem difficult or undesirable. CSWD Compost will need to find ways to simplify and redevelop these areas of the program to better suit the community. To bridge the gap between the CSWD Compost's potential success and the community's ignorance or negative outlook, CSWD Compost should model its approach after Dubuque's successful curbside organics collection program.

Step 2: Utilizing "Tools"

A change in waste management or organics collection will not occur overnight and will constantly evolve over time with the help of the surrounding community. After identifying some of the obstacles of a curbside organics collection program, CSWD Compost should use "tools" to provide the public with incentives, regulations, norms, and prompts to increase the amount of residents that will actively participate in the program (McKenzie-Mohr, 1999, p. 3).

Tool 1: Creating Incentives

Monetary Incentive: Decrease the Fee of Curbside Collection

Creating a manageable fee for participation in the curbside collection program is largely an economic development goal; however, residents' level of involvement in the program may be inextricably linked to the price of organic waste removal. Just as DMASWA Compost made a conscious effort to reduce the prices of participation in its curbside collection program, CSWD Compost will need to maintain a reasonable collection fee or it may struggle attracting a large number of motivated customers. More strategies for reducing the costs of the curbside organic waste program are discussed in the economic section of recommendations.

Non-Monetary Incentive: Simplify the Sorting Process

While monetary incentives are often successful in the development of new community-based programs, non-monetary incentives, "exert a strong influence upon behavior," often proving to be the more successful development tool (McKenzie-Mohr, 1999, p. 6). Examples of incentives CSWD Compost should create address the issue of the curbside collection program being too difficult to participate in. CSWD Compost should adapt some of the changes DMASWA Compost in order simplify its curbside organics collection program and attract new participants. By agreeing to drop off each city owned organic waste bin to each participant rather than rely on them to collect it from the compost facility and by allowing residents to dispose of organic wastes in biodegradable bags supplied by each resident, the process of sorting organics was drastically simplified. These two changes alone would simplify resident's time consuming commitment of sorting organic wastes.

Non-Monetary Incentive: Simplifying Removal Services With Private Haulers and Burlington Public Works

CSWD Compost could greatly benefit from the development of a public organics hauling service similar to the curbside recycling service offered by Burlington Public Works (BPW). With three trucks, three field staff personnel, and the monetary support of Burlington taxpayers and the recycling tip fee, BPW manages to successfully remove and transport Burlington resident's recyclables each day (Losch, 2011). As some private refuse haulers offer recycling pick up as apart of their service, these haulers and residents sign a wavier that proclaims their conscious refusal of BPW's curbside recycling removal service.

BPW is funded by the addition of an extra $3.10 fee tacked on to each household's monthly refuse removal bill. After paying this fee, each private hauler that doesn't offer recycling services to its clients pays BPW a bill determined by multiplying $3.10 by the number of the removal service's customers. Private haulers who offer recycling are exempt from this monthly billing process. After each Burlington resident pays his or her refuse removal bill his or her household is then eligible to place recycling on the curbside in a blue container provided by the city once a week for pickup. BPW has started to see an increased amount of, "free-riders" (Losch, 2011). These are Burlington residents who participate in the curbside recycling program who don't pay private haulers to remove their refuse waste thereby neglecting to pay BPW the $3.10 recyclables removal fee. While these residents do impose an extra expense and burden to BPW, as long as the number of, "free-riders," remains small BPW doesn't see reason for taking immediate action (Losch, 2011).

BPW's recycling program appears extremely similar to DMASWA's public recycling removal and may potentially evolve similarly by beginning to offer organics pick up in addition to recycling. CSWD may quickly realize, just as DMASWA did, that many residents and private haulers will initially rely on a public organics removal service offered by the city in order to participate and establish a successful program. While expanding what BPW currently picks up will greatly benefit the city's diversion of organic wastes from the refuse waste stream, the process will by no means be a simple endeavor.

Tools 2 & 3: Creating Regulations and Community Norms

This process should involve informing Burlington residents on how they should, "view themselves as environmentally concerned," by establishing community organic waste disposal norms (McKenzie-Mohr, 1999, p. 3-4). By creating community norms, Burlington residents will see participating in the curbside organic waste collection program as a standard routine. To reaffirm the idea that, "everyone is doing it," CSWD could consider creating a ban on the disposal of organics wastes entering the refuse waste stream (Losch, 2011). This should not only increase the amount of residents that participate in the collection services, but also increase the amount of organic waste collected.

Recognizing how effective the 1989 ban on recyclables was by diverting over, “5,940,000 pounds of recycling a year,” by banning organics from entering the landfill, CSWD could greatly increase the amount of organic wastes processed into compost while decreasing landfill space and the costs needed to manage this waste (Department of Public Works, 2011). A ban on organics will by no means fully motivate every resident to completely sort out all organics from the refuse waste stream; nevertheless, a ban would require each household to pay to participate in the curbside organics collection program meaning that even with apathetic participation levels, the program would be worthwhile to CSWD Compost and BPW.

Tool 4: Creating Educational Prompts

By showing residents how the composting process works in a simple manner, DMASWA Compost was able to reach each resident and educate them about making smarter waste management choices. If CSWD Compost adopts a similar approach, it will find that Burlington residents may begin to better connect with the movement and actively participate in the curbside removal program. CSWD Compost should share information about the processes of sorting organic wastes and the composting system via the internet, informational pamphlets and newsletters, and even through free presentations to all community members (Moreau, 2011).

Steps 3 and 4: Piloting and Evaluating the Strategy

As the 2000 CSWD pilot program was viewed as a failure, conducting a new study will help illuminate how Burlington residents’ views on organic waste management have changed over the past decade. Creating a study that speaks as accurately as possible for the new curbside collection program will ultimately determine whether the program is officially developed and implemented.

How social growth is related to environmental and economic growth? Social sustainable development of the curbside organics collection program relies on a larger or more effective composting system to handle greater amounts of organic waste, and environmental growth factor. The social growth factor also requires developing several financial motivators to keep residents involved in the new program.

Environmental Development Goals

Reducing the Environmental Impact

In order to process an increased amount of organic wastes at the CSWD Compost facility, CSWD will need to consider expanding the size of its composting facility or developing a new composting technology that can handle a greater amount of organic materials at one time. While CSWD Compost's adoption of a new aerated static pile system composting unit in June 2011 will drastically increase the amount of organic materials that can be processed each year, CSWD Compost has yet to confront the fact that, "the need to reduce air pollution is increasingly become an important concern...since the population is less disposed to bear health risks and offending odors deriving from industrial activities" (Chiumenti, 2005, p. 72). After opening the new compost facility in Williston, CSWD Compost should greatly consider shifting to a more advanced composting system to address these environmental concerns.

While the addition of a Gore-Tex™ cover, similar to the ones used at Cedar Grove Composting, may increase the speed at which CSWD Compost processes organic materials while also reducing the presence of unwanted odors, it is clear that these custom covers would provide little assistance in capturing the greenhouse gases that negatively impact the atmosphere (Moreau, 2011). It is known that these Gore-Tex™ covers would also prove economically inefficient as each cover would, "need to be replaced after six years of use due to the presence of heavy snow and ice," in Williston, Vermont (Moreau, 2011). Due to these setbacks, these fabrics would provide little assistance in truly capturing the greenhouse gases created by decomposing organic waste meaning that this system is not the most sustainable choice for the developing compost facility.

Despite the ill fit of the covered aerated static pile system currently modeled by Cedar Grove Composting, the facility's proposed advanced anaerobic digester unit may prove to sufficiently address all of CSWD Compost's many environmental concerns. As Cedar Grove Composting illustrates, anaerobic digester units not only double the amount of organic waste that can be processed into completed compost each year on a smaller facility size, it also greatly reduces the facility's impact on the surrounding environment as the anaerobic digestion of organic wastes is a closed loop circuit that captures greenhouse gases and unwanted potentially pathogenic leachate created by decomposing organics. Collecting these gasses and leachate dramatically reduces the greenhouse gas and undesirable odor output of the composting process and keeps unwanted pathogens out of nearby soils and groundwater. This compost digester also reduces the need for excessive water treatment of leachate created by decomposing organic wastes. This is due to the reusing of liquid outputs in maintaining a set moisture level during step two of the anaerobic composting process. By removing the three of these elements, a compost facility using anaerobic digestion will also see a reduction in the amount of unwanted vectors that infiltrate and populate traditional turned or aerated static pile compost windrows.

Creating Natural Energy Resources (Offsetting the Need For Traditional Energy)

Cedar Grove Composting has advertised how anaerobic digesters not only reduce a composting facility's contamination of the atmosphere, soil, and groundwater, but also have the capability to harness energy from the high rate of biogas emitted in the composting process. By using these existing resources rather than allowing them to flow into the atmosphere, CSWD Compost could potentially acquire and offset the energy required to manage the facility from onsite natural energy resources. By generating green energy from methane outputs, CSWD Compost would no longer require expensive traditional energy sources that also degradate the environment during creation, refinement, and consumption.

Similar to Cedar Grove Composting, over time CSWD Compost could potentially harvest enough natural energy resources to completely offset not only the compost facility, but the entire CSWD waste management facility in Williston thereby further extending sustainable development (Moreau, 2011). CSWD Compost could also sell this biogas byproduct back to the energy grid thereby continuing to reduce surrounding community's dependency on degradative resources (Moreau, 2011).

Increasing the Grade of Completed Compost

Aside from creating two times more completed compost product each year with the anaerobic digestion compost system, CSWD Compost has the ability to also increase the grade of the final compost product. While the traditional turned and aerated static pile windrows both produce a high quality product, the anaerobic digestion process will simplify the methods of achieving this compost while continuing to meet or surpass the VTANR, the State of Vermont, and NOFA-VT/VOF standards.

How environmental growth is related to social and economic growth? By developing a new composting system that reduces environmental impacts, the system also conversely processes a larger quantity of organic wastes more effectively thereby taking in more of resident's organic wastes and increasing incoming revenue from a larger amount of completed compost product. While expensive to install, overtime this system is cheaper to manage due to the energy offsets created by harnessing natural energy resources from onsite biogas.

Economic Development Goals

Financing the Sustainable Development of a New Composting System

While CSWD's 5 Year Work Plan illustrates an interest in potentially developing a waste sorting system that would allow residents to dispose of all solid wastes in one stream rather than relying on them to sort out recyclables and organics from refuse. This waste management program would significantly simplify the process of removing wastes from resident's households; however, CSWD has not progressed to the point either financially or logistically to develop this type of management system.

While a full-scale sorting waste management program isn't quite yet a financial possibility for CSWD, CSWD Compost has plenty of resources to further expand and manipulate it's infrastructure to redesign and further develop its management of organic materials. By adopting anaerobic digestion as the new organic waste management process, CSWD Compost will face a large upfront development cost of about, "$5 million," (Moreau, 2011). This large fee may deter CSWD's selection of this method; however, as illustrated earlier in this research study, the social and environmental benefits will eventually allow this digester to essentially pay for itself as the digester generates usable green energy resources and begins to drastically increase its output amount of high grade compost products that are sold for a profit.

Financial Logistics of Developing a Curbside Organics Removal Program

With the creation of a more sustainable compost technology, CSWD Compost will be able to increase its organic waste intake. This spurs the develop of a curbside organics collection program in Burlington that may efficiently help divert organic wastes from the refuse waste stream. TSWM's curbside pickup program can be adapted to work effectively in Burlington minus the creation of a CSWD funded waste management removal service. For the purpose of creating a successful and manageable sustainable development plan, the new curbside organics removal program will need to be installed without disturbing the current public and private waste hauling dynamic. The development plan should also smoothly invite the curbside removal of organic wastes without forcing each hauler to adapt to an ill-fitting organics management system.

With these stipulations and challenges, the most financially sustainable method of installing the new program means initially establishing BPW as the central hauler of both recyclables and organic wastes. Private haulers can obviously offer their own organics removal programs; however, by creating BPW as the main hauler, the financial income created by resident's organic waste removal bills can go directly towards the further development of BPW's curbside program, a key feature in creating a workable plan as the initial develop of a curbside organics collection program at BPW may be relatively expensive due to the need to purchase and maintain several vehicles capable of hauling organic waste, the fuel for each vehicle, and potentially an additional set of solid waste field staff personal.

One way BPW can help lower these expensive upfront costs is by strategically purchasing hauling vehicles that are capable of collecting both recycling and organic wastes while also continuing to use the same street collection schedule for the recycling program, with this technology and planning both types of waste can be removed on the same day, thereby simplifying the resident's role in waste removal and saving more money on fuel and labor costs. Another means of lowering the cost of this program would be by charging each household a premium to have its organics removed each week. With large involvement, overtime this expense will drop as essential tools and resources are required and BPW begins to increase necessary funding by attracting more household participants. Also, as BPW becomes more efficient and successful, private haulers may begin to see the benefits of offering organics removal and may begin to offer a similar program alongside their refuse or recycling removal services.

Financial Logistics of Developing a Pay as you Throw Payment Plan

While the logistics of educating Burlington residents is truly a social element, one large motivational factor for participation levels depends strongly on the cost of organic waste removal. By modeling and adapting TSWM's Pay as you Throw financial payment plan, CSWD Compost could help the City of Burlington and BPW a curbside organics pickup program that efficiently motivates residents; to remove all organic wastes from their refuse waste. By charging residents based on the amount of refuse they dispose of, more households will adopt healthy solid waste sorting habits that promote the proper disposal of wastes. The creation of a payment plan will successfully leave each Burlington household in charge of its personal waste removal bill allowing each resident to choose his or her commitment level to the sorting of solid wastes with or without the intention of dramatically reducing the removal fee.

The most effective means of measuring the amount of refuse waste disposed by each household throughout Burlington would be easily calculated, based on the size of the refuse waste container rented from private haulers and the amount of times refuse waste is picked up each month. BPW would collect money the way they currently do by billing private haulers relying on BPW to remove recycling and organic wastes a set fee each month dependent on the amount of households they serve. Private haulers can determine their own set fee for the removal of organic wastes; nevertheless, as the program expands competition will eventually arise between the public and private haulers thereby driving down the cost of organic waste removal while simultaneously building a stronger and more lasting curbside organics removal program.

How economic growth is related to social and environmental growth? By fronting the cost of a new composting system that reduces environmental impacts and increases the ability for social involvement, a large increase in revenue will arise from the collection of more household organic waste and the creation of a larger amount of completed compost product. While expensive to install, overtime this system is cheaper to manage due to the energy offsets created by harnessing natural energy resources from biogas and the reduced cost of managing potentially pathogenic leachate liquids. By developing a pay as you throw payment plan, more residents will be motivated to participate in the urban curbside organics collection program thereby increasing the amount of organic waste that will be diverted from the refuse waste stream.

Conclusion

CSWD's goals for sustainably developing its organic waste management program include increasing the waste diversion rate by: simplifying the removal of organic wastes for residents, decreasing the facility's negative environmental impacts, and decreasing the cost of compost technology management. From these development goals, success will be determined by whether CSWD Compost can maintain an equal balance of the three sustainable growth factors: social, environmental, and economic. From the suggested recommendations, one can see how the development of some growth factors must take place successively before others. During this process, the balance of the three factors may tip to one or two sides at certain points; however, most often development will rely on collectively manipulating all three elements simultaneously. As this method can be difficult to gauge and control, achieving sustainable development will only occur with careful planning and management of each factor.

Aside from relying solely on the literature review's information on composting processes and the history of ICP and CSWD to successfully develop CSWD Compost, the 2000 CSWD curbside organics collection pilot results provided an inside look at an older curbside collection program in Burlington. The results of this study were useful in identifying where CSWD initially failed to successfully develop a curbside program. The three additional case example research results were also helpful in designing a sustainable CSWD Compost facility and program. Each case example served as a model for potential future development of one sustainable growth factor it successfully illustrated.

Using the resulting information, the benefits and drawbacks of the old and new CSWD compost facilities, the 2000 CSWD pilot program, and each case example were then analyzed.

This allowed for comparison between each compost facility and management program thereby illuminating which facilities exert stronger sustainable practices over others. This process of comparison also showed how each growth factor truly relies on the success of the other two when identifying sustainable development goals.

The first case example, Dubuque, Iowa's organic waste management program, showed strong social and community development ideals. These were altered slightly to allow for education of local Burlington residents and development of community-based marketing tools to create incentives for participation in the urban composting program. The second case example, Cedar Grove Composting, illuminated environmental development ideas that could transform the methods of organic waste management at CSWD Compost. Cedar Grove Composting's anaerobic digestion program highlighted possible processes for increasing organic waste intake while maintaining a healthy relationship with the surrounding environment. By abandoning its new aerated static pile compost method for a more technologically advanced anaerobic digestion program, CSWD Compost could also increase the amount of processed organic waste while reducing its environmental impact. Finally, the third case example, Toronto, Ontario's organic waste management program, illustrated a new "pay as you throw" payment strategy that places the financial burden of organic waste disposal on the waste generators while creating monetary incentives to sort organic waste from refuse.

While the CSWD has attempted to make changes in the way it manages organic waste with the relocation and expansion of its organic materials processing facility, there is still need for further sustainable development in order to achieve an ultimate goal of zero waste. Utilizing the tactics and future goals introduced by each case example, CSWD Compost will be able to redesign each area of its program in order to find a healthy balance of the three sustainable growth factors. After committing to the development of an efficient urban organic waste removal program and the redevelopment of CSWD Compost's compost facility, CSWD must plan to consistently reevaluate and question the success of the most current infrastructure.

Just as dynamic and ever changing as cities, CSWD Compost will need to be continuously reexamined to ensure the optimal development of its organic waste management program and facility for present-day and the future. Accepting that this process of developing is never-ending, CSWD Compost will be better prepared to make adjustments as the community, environment, and economy continue to change and grow over time.

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