UBC Social Ecological Economic Development Studies (SEEDS) Student Report

Integrating Vermiculture into AMS Student Union Building Operations

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Executive Summary

The Student Union Building Vermiculture Program has developed into a multi stage project. This report reflects the findings of the first stage, the Alma Mater Society Food and Beverage Services' Vermicompost Pilot Project.

The vermiculture program was initiated because of the following reasons. There was a net environmental benefit from transporting less organic waste off-site. There would be a future need for vermicast at the new SUB rooftop garden. There was a potential to improve organic waste diversion through creating a relationship between SUB patrons and their organic waste composting habits. An opportunity would be created for vermicompost extension or education initiatives. The abundance of fruit flies in the loading bay over the summer may decline. Finally, the SUB organics waste would be converted into a value added and marketable vermiculture product.

The purpose of the student project was to explore the feasibility of incorporating vermiculture in the New SUB by creating a pilot project in the current SUB and to identify the value vermiculture provides, as well as the challenges it creates, to SUB operations. Scientific and popular literature was reviewed and interviews were conducted with community members to form decisions on how to establish a successful vermiculture pilot project. From the pilot project, primary data, observations and feedback were collected that could be used to address the questions of feasibility, values and challenges.

Investigating the feasibility of a vermiculture program required an understanding of the appropriate environment and feedstock composition that should be used. It was found that pre-consumer waste was the most appropriate, because they lack significant quantities of salt, dairy, meat or fish. These foods were associated in the literature with producing conditions unfavourable to worms, and often odours unfavourable to humans.

Results from the AMS Waste Audit found that 14 728 kg of pre-consumer food waste was being annually disposed of into the solid waste stream.

Of organizations using vermiculture, those which produce quantities of organic waste similar to that of the AMS are using in-vessel flow-through vermiculture systems that are more technology and capital intensive. Three of four universities with vermicompost programs, do so off-site at their school farm. However, because on-site processing and cost recovery are important to this program, aggregate growth through the successive purchase of mid-scale vermicompost units, such as Worm Wigwams, is recommended.

With incremental expansion, each additional Wigwam would divert 4 400 kg/yr of organic food waste and annually produce 3.14 cubic metres of vermicast. The economic value of this quantity of garden soil mix from a local supplier is $140. If also harvesting worms, the average price for a 1/4 kg of *Eisenia fetida* is $30 and the maximum quantity of earthworms per Wigwam is approximately 24 kg. However, annual sustainable removal rates would need to be known before the potential economic value of selling earthworms can be determined. There is also an unquantifiable social value that is gained through vermicomposting that is reflected by the enthusiasm of staff and students involved, as well as in the potential for education and extension workshops.

The Recycled Organics Unit of Australia estimates that a mid scale composting unit, such as the Worm Wigwam, requires 1.5 hours/day for preparing, feeding and cleaning, and another 2.5 hours/week for monitoring, aerating and pest management. Findings from integrating the vermicompost management duties into the responsibilities of a staff member in the pilot project, suggests these estimates may be overly cautious. In the pilot, the staff member typically spent a maximum of 30 minutes/day doing the full range of duties associated with the bin. These were collecting and preparing feedstock, monitoring different parameters, recording observations and cleaning up. Collecting and shredding straw and office paper for use as bulking agents were tasks that took place too far from the work area of kitchen staff and were too time constraining for incorporating into daily operations. Bulking agents were prepared by the student and made available in a container in the kitchen. When scaling up the pilot, labour and time saving techniques for preparing feedstock would need to be implemented and the full range of tasks would need to be incorporated in to the manager's responsibilities.

Fruit flies present a challenge to the adoption of vermicomposting at the SUB. Mitigating conflicts between staff and pests will be important to the future of the project. In addition, challenges that have been seen in reviewing other similar sized vermiculture programs have been inadequate infrastructure and poor market development for vermiculture products. Developing the infrastructure for worm composting in areas of the new SUB with low risks of vandalism and favourable environmental conditions will be critical to the program's success.

From the findings of the first stage of the SUB Vermiculture Program, there appears to be sufficient evidence to justify continuing the project in a second stage. Scaling up the pilot project in Stage two can provide more recommendations for how to effectively extend this initiative within the current and new SUB. Resolving challenges currently present is also possible in future stages. More rigorous research is needed into the economic sustainability of this project. There also remains a large portion of post-consumer organic food waste that is not able to be addressed with this vermiculture project. Research into potential value added end uses of these materials is recommended, if possible.

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1. Introduction

1.1 Background

The SUB Vermiculture program began in the Fall of 2010 when the AMS Impacts committee identified vermicomposting as a waste management strategy they were interested in pursuing. The Impacts committee consists of representatives from various Alma Mater Society (AMS) businesses and is dedicated to reducing the environmental impacts of the Student Union Building (SUB). In January of 2011, through the help of the AMS Sustainability Coordinator, the UBC SEEDS program coordinator, Queenie Bei, and with the supervision of Dr. Art Bomke, the AMS Food and Beverage Services Organics Waste Vermicompost Pilot Project was initiated through the APBI 497 directed studies course.

1.2 Purpose

The exploration of on-site vermicomposting was initiated for many reasons. There was an environmental benefit in reducing transportation and fossil fuel use through managing the organic waste of the SUB on-site. Upon its completion, there would be a demand for vermicast created from the new SUB rooftop garden (See Appendix 8.1 for definitions of Vermiculture terms). There was a hope that with increased public awareness and outreach, SUB users would be able to give an identity to organic waste management and as a result, diversion rates of organics from the solid waste stream could increase. Additionally, there was an opportunity for creating home vermicomposting extension and education projects. There was also a hope that in the summer months, when the waste collection frequency decreased, prompt vermicomposting of organics could help reduce fruit fly abundance in the loading bay. Lastly, the potential marketability of the value added vermicompost products – vermicast, worms and compost tea – suggested that cost neutrality maybe a possibility.

The ultimate purpose of the student project was to explore the feasibility of incorporating vermiculture into the New SUB by creating a pilot project in the current SUB and to identify the value and challenges vermiculture presents to SUB operations.

1.3 Scope

This report addresses the needs and requirements of establishing a successful vermicomposting initiative in the current SUB. Based on research and findings from an on-site pilot project, this report also attempts to make recommendations for the long term implementation of vermiculture into the organic waste management program in the new SUB.

The pilot project itself was conducted using a small scale domestic vermicompost system (worm bin) and worked to integrate management responsibilities into the role of a full time AMS Food and Beverage Services staff member. The waste management stream being used in the pilot began in the Pendulum Kitchen, with the selection and preparation of pre-consumer or *back of house* food scraps and ended with the incorporated of the feedstock into a worm bin in the prep kitchen.

The location and context for the pilot was ideal given the goal of integrating the worm compost management into the daily responsibilities of the AMS Food and Beverage staff member, the environmental conditions required, vandalism considerations and the distance, required by the health and safety inspector, of the unit from food preparation surfaces.

1.4 Limitations

There were 4 main limitations of the pilot project. First, the production of quality worm castings was not a priority. Second, considerations for harvesting and selling worms or castings from the pilot were not addressed. The volume of castings produced was too small to merit exploring these options at this time. Thirdly, the maintenance procedures for the domestic system used were not directly scalable to a larger system and volume of organic food waste. Lastly it was not easy to engage public in the project.

2. Methods

2.1 Research and Data Collection

Academic literature was reviewed to develop a perspective of the current vermiculture and vermicomposting industry, the range of available technology and the generally accepted ideal environment and growing conditions for vermicomposting. Popular literature and case studies were consulted for additional guidance on conducting a successful pilot project. Informal interviews with community members, researchers and commercial vermiculture producers were also conducted for this purpose.

After the pilot project was established, data and observations were collected according to the following items.

- Date
- Time taken
- Quantity of feed added
- Tasks done
- Observations

2.2 Pilot Project Design

Since February 28th, 2011 until at least April 25th, 2011, when this report was submitted, two different worm bins had been sequentially introduced into the AMS Prep Kitchen, in the basement of the current Student Union Building.

The first worm bin was an early model of the Worm Factory®. Worms were supplied by Transform Compost Products. One kg of worms was estimated to have been added to the first tray of the stacking system. The soil medium the worms had been supplied in was added to the tray as well. The bedding used was shredded newspaper.

After 2 weeks, the Worm Factory® was substituted with the Worm Composter unit that the City of Vancouver supplies. It was donated by the LFS Orchard Garden. An eight cm layer of straw was placed into the bottom of the unit. On top of the straw, a 5 cm layer of finished castings from an LFS Orchard Garden worm bin was added. This system was inoculated with 115 g of worms from the previous system and approximately ten cocoons. The bedding material used in this system was shredded office paper. Another 8 cm layer of straw was also maintained above the food scraps to deter fruit flies. This straw was gradually incorporated into the food scrap layer and replenished by the staff.

One staff member was selected to manage the worm bins and work in consultation with the author. Responsibilities for feeding, daily monitoring, and keeping a log book were assigned to the staff member. Supplying straw and shredded paper, setting fly traps and troubleshooting duties were designated to the student. (See Table 2 in the Findings section for a more detailed division of tasks)

3. Findings

3.1 Waste Audit

According to the 2009 waste audit of the AMS food outlets, the quantity of food waste that is being composted properly is approximately 9 818 kg/year. If organic waste diversion rates were to improve to full recovery, the cumulative weight of food waste available to vermicompost would be approximately 46 280 kg/yr. However, if only pre-consumer food waste is to be used, roughly 14 728 kg of food organics would be available per year. (MJ Waste solutions, 2010; data extrapolation calculations available in Table 3.1 in Appendix 8.3).

3.2 Vermicast Output

Based on following 3 guidelines and assumptions, the 14 728 kg of food scraps could be converted to 10.5 cubic meters, valued at $ 452. (See calculations in Table 3.2.1 in Appendix 8.3).

- The Canadian Council of Ministers of the Environment requires that commercially marketed compost undergoes at least a 60% reduction in weight (2005).
- The Massachusetts Department of Environmental Protection estimates the weight to volume ratio of finished compost as ~561 kg/m^3 (2003).
- A local supplier of organic garden soil mix prices it at $\$43/m^3$ (West Creek, 2011).

3.3 Mid-Scale Vermicompost Examples

The amount of organic waste generated by institutions, such as universities, hospitals, prisons, town halls and schools, often place these operations in the mid scale vermicomposting category. They require a greater processing capacity than a domestic backyard composting system, but less than land extensive or capital intensive, commercial vermiculture operations. Some of these programs are done off-site by commercial waste management businesses or on their university farms. Alternatively, others are done on-site in basements or outside in semi-permanent structures used exclusively for vermicompost production. The majority are using pre-consumer food scraps. Some use organic food waste that has already been through a thermophilic composting process. Appendix 8.2 provides a summary of mid-scale vermicompost operations across North America. (Sherman, 2010)

Of the vermiculture programs that are known to have been discontinued, reasons for doing so have been poorly established markets for vermiculture products, limited space, and problems arising from inadequate ventilation, excess moisture, and inadequate grinding (Sherman, 2010). Others have been limited by the amount of feedstock they can acquire. For example, the capacity of the vermicompost program at the Eddy Center, in Connecticut, exceeded the amount of worm feed they could produce, and transportation problems limited the supplemental feedstock they could bring in from off site (Sherman, 2010).

3.4 Commercial Units

The three most common commercially available mid scale units are the Worm Wigwam, the Can-O-Worms and the Worm Factory 360. There is also a large scale reactor system made by the same company that manufactures the Worm Wigwam. All four of these systems are flow through reactors. See Table 1 for a comparison chart of these four options.

Table 1. Comparison of commercially available mid-scale vermicomposting units

Unit	**Wigwam**	**Can-O-Worms**	**Worm Factory 360**	**5 x 8 Industrial Flow Through Reactor**
Capacity[1]	4 400 kg/yr	1 655 kg/yr	200 kg/yr	16 550 kg/yr
# required to process all AMS pre-consumer food organics	4	9	74	1
Price[2] (Price for total # required)	$ 750 (4 x $ 750 = $3 000)	$ 144 (9 x $ 144 = $1 296)	$ 115 (74 x $ 115 = $8 510)	$ 5 135 ($ 5 135)
Size	Requires 1.2 m x 1.2 m	Requires 0.6 m x 0.6 m area, each	Requires 0.6 m x 0.6 m area	Require 1.5 m x 2.4 m area +

	area, each		each	working room
Additional notes	Needs to be placed on a elevated surface (eg. palette); excess moisture drains out bottom	Leachate/excess moisture that accumulates can be collected and disposed	Leachate/excess moisture that accumulates can be collected and disposed	Scalable design, Requires concrete/asphalt floor, Power requirement: (2) 110V single phase with a GFI circuit

1. Capacity estimated from daily/weekly feed loading rates or worm capacities publicized by manufacturers online. Assumes worms can process half their weight a day (Appelhof, 1997)
2. Prices for the Wigwam and Worm Factory 360 from Worm Composting Canada (http://worm-composting.ca/). Can-O-Worms price from The Worm Farm (http://www.thewormfarm.net/).

3.5 Species

Multiple epigeic earthworm species exist that are suitable for vermicomposting. Epigeic earthworms are used because they dominantly feed on soil organic matter and inhabit the organic horizons of soils (Appelhof, 1997). These species are most often differentiated by their size, feeding efficiency and environmental requirements. The most extensively used epigeic earthworm in vermicomposting systems in temperate regions is *Eisenia fetida*, it is commonly known as the Red Wriggler (Appelhof, 1997; Carver et al., 2008; Dominguez and Edwards, 2010; Ferris, 2002; Sherman, 2003). It is also the species of worm promoted by City Farmer (City Farmer, 2009). *Eisenia hortensis*, known also as *Dendrobaena veneta* and the European Nightcrawler, is becoming more common. It grows larger, but is considered to have a slow rate of maturity and reproduction (Dominguez and Edwards, 2010). It is generally used in the vermicomposting of excessively moist materials (Dominquez and Edwards, 2010). In warmer climates in the southern United States, *Amynthas gracillus*, *Eudrilus eugeniae* and *Perionyx excavatus* are suitable species for use in vermicompost systems (Appelhof, 1997).

The quantity of worms required for processing the estimated 14 728 kg of pre-consumer waste produced by the SUB would be 80 kg, as they consume approximately half their weight a day (Appelhof, 1997). *E. fetida* and *E. hortensis* are commercially available epigenic worm species in the Vancouver area. The pricing of *E. fetida* varies marginally depending on the supplier, but is most often around $30 for 1/2 kilogram. The only price found locally for *E. hortensis* was $60/kg. Discounts are often available on bulk orders when suppliers are contacted directly.

3.6 Environmental Conditions

Providing the ideal environmental conditions for *E. fetida* is a product of site location, as well as feedstock composition and application rates. There are four environmental conditions that are recognized as important for a successful vermicompost system. They are aeration, temperature, moisture and acidity.

3.6.1 Aeration

The importance of aeration was stressed from numerous sources (Appelhof, 1997; Carver et al., 2008; Dominguez et al., 2010; Ferris, 2002; Sherman, 2003). However, specific oxygen concentration values were not found in the literature or measured in the pilot. It has been suggested that the best method of determining if aerobic conditions are present in the bin is through smell (Peter Stovell, personal communication, April 9, 2011). The odour method was used in the pilot. Foul odours were only detected in the liquid collection tray of the first worm bin system.

3.6.2 Temperature

The lower limits of the tolerable temperature range for *E. fetida* varies between 0°C and 12°C (Dominguez et al., 2010, Sherman, 2003). Exceeding a temperature of 25 is generally not recommended and the consensus on an optimal temperature range is between 15°C – 20°C for vermicomposting (Appelhof, 1997; Carver et al., 2008; Dominguez et al., 2010; Ferris, 2002; Sherman, 2003).

3.6.3 Moisture

The survivable range of *E. fetida* is recognised as being between 60% and 90% moisture. However, research from Domínguez and Edwards (1997) suggests the optimum is 85% while research from Nova Scotia suggests drier conditions of 75% (GEORG, 2004).

3.6.4 Acidity

The tolerated pH range for *E. fetida* is between 5 – 9 (Dominguez et al., 2010). The scientific research suggests that worms under ideal circumstances prefer a pH of 5 (Edwards, 2010). The popular literature favours a pH range closer to neutral, between 6.8 and 7.2 (Carver et al., 2008; Sherman, 2003). An acidic pH, less than 6.8, is not recommended because of the preference of the red mite pest organism for more acidic environments (Munroe, 2007, Sherman, 2003). For this reason, some suggest a pH of 7.5 – 8 (Munroe, 2007). However, alkalinity is also considered unfavourable because of the tendency for nitrogen loss through the release of ammonia gas at higher pH values (Carver et al., 2008). A pH range between 6.8 and 7.5 optimises these recommendations.

3.6.5 Vibrations

Vibrations were a consideration when deciding where to located our pilot project. When vibrations are significant worms will stop feeding and can migrate out of the vermicompost unit (Sherman, 2000; Peter Stovell, personal communication, April 9, 2011). The kitchen presented no problems with this.

3.7 Feed Stock

The ratio of food scraps to bulking agent and the weekly weight of food scraps per surface area that can be added vary with the composition of the organic materials being used (Ferris, 2002). According to Ferris (2002) the following compositions and feeding rates should be used.

Fruit and Vegetable

- Fruit : Vegetable : Bulking agent
- Volume – 41% : 41% : 18%
- 16.5 $kg/m^2/week$

Mixed Food Organics

- Fruit : Vegetable : Bread : Meat : Bulking agent
- Volume – 22% : 20% : 3% : 9% : 21%
- 10 $kg/m^2/week$

Miscellaneous Food Residuals

- Pre-consumer : Post-consumer : Bulking agent
- Volume – 51% : 30% : 19%
- 13.3 $kg/m^2/week$

The pilot project used a mixture of preconsumer fruits and vegetables with the occasional addition of coffee grinds and crushed egg shells.

Dr. Peter Stovell's experiments with vermicomposting have found that waste streams with up to 35% coffee grinds showed no significant decreases in worm activity and health (Personal communication, April 9, 2011). Coffee grinds, in moderation, are also promoted by popular literature sources (Appelhof, 1997; Ferris, 2002)

There are some organic food waste materials that the popular literature sources do not recommend for use in vermicompost systems because of their tendency to either attract pests, create anaerobic conditions or produce foul odours (Ferris, 2002). The potential risky foods include:

- Dairy
- Meat
- Seafood
- High fat/oily foods
- Foods with high salt content
- Unwashed fruit peels
- Mono-streams of breads, pastries, rice and flour

In contrast, Stovell feels that meats and fish can be vermicomposted without producing foul smells. His research has found that fish and meat need to be diluted with other food scraps and a bulking agent and also added in thin, vertically oriented strips (Peter Stovell, personal communication, April 9, 2011). However, it should be noted that his operation is outdoors and well ventilated.

The scientific literature recommends salt contents less than 0.5% (Dominguez et al., 2010). Measuring electrical conductivity (EC) as an indicator of salt content is also possible, however the threshold values tolerable by worms would first need to be determined. Post consumer food waste is avoided partially because it tends to contain higher proportions of sodium, fats and oils. As a result, a few mid-scale operations (See Appendix 8.2 for descriptions) use post consumer food waste in their vermicompost systems only after it has been through a thermophilic compost process (Sherman, 2010).

Unwashed fruit peels have been suggested by online forums as being a potential source of fruit fly eggs in vermicompost bins. These forums suggest freezing and microwaving food scraps prior to incorporating them as a means of destroying any eggs. However, these two methods were not tested or validated in the pilot and scientific sources.

Avoiding monostreams of breads or carbohydrate rich foods is suggested because of the difficulty in simultaneously maintaining an environment with sufficient moisture and aeration properties within the vermicompost systems (Ferris, 2002).

3.8 Bulking agent

The suggested carbon to nitrogen ratio, to prevent ammonia off-gassing, is 20-25:1 (Ferris, 2002, Sherman, 2003). In addition, it is recommended to not add organic waste with an ammonia concentration greater than 1mg/g (Dominguez et al., 2010). Mixing food scraps with a carbonaceous bedding/bulking agent can aid in meeting the C:N requirement and can also increase aeration in the unit (Appelhof, 1997; Ferris, 2002).

From observations of the bulking agent used in the first worm bin during the pilot, the use of shredded newspaper was not found to be suitable because when moist, it impeded air flow and created anaerobic conditions. Using shredded moist shredded cardboard is often suggested over using paper for this reason (Carver and Christie, 2008; Ferris, 2002; Robert Crofton-Sleigh, personal communication, 16 April 2011).

Observations of the second worm bin found that the mixture of straw and shredded paper maintained more aerated conditions than before. Straw is slow to decompose relative to paper and cardboard materials, making it relatively unavailable as a carbonaceous material (Rylo Santana, Personal communication, March 10, 2011).

3.9 Grinding Feedstock

Often grinding or reducing the source of bulking agents and food scraps is required (Edwards, Medium, 2010; Ferris, 2002). In the pilot, the scale allowed for the staff member to dice food scraps with a kitchen knife. Cutting straw to fit into the worm bin was done with scissors and was too time consuming for the staff member to do during daily operations. At larger scales a large plastic tote and a flat nosed shovel can be used for shredding feedstock (Ferris, 2002).

Chipboard can be shredded by modifying a 15 sheet paper shredder (Robert Crofton-Sleigh, personal communication, April 16, 2011). For corrugated cardboard, Crofton-Sleigh suggests to first moisten the cardboard, then cut across the corrugations and rip it in the opposite direction, with the corrugations (Personal communication, April 16, 2011). In larger vermicompost facilities, wood chippers and other motorized grinding apparatuses are used (Carver and Christie, 2008; Sherman, 2010)

3.10 Integrating tasks into Operations

The duties and responsibilities of the staff member and student managing the vermicompost unit are summarized below in Table 2. On average, the duration of time the staff member spent managing the vermicompost system varied between 5 minutes a day and 30 minutes a day. Longer days were associated with the completion of the full list of tasks in Table 2. However, the Recycled Organics Unit suggested 11 hours/week for managing the vermicompost system of a restaurant open 6 days/week (Ferris, 2002). These hours were divided into 1.5 hours/day for preparing, feeding and cleaning; 1 hour/week for monitoring; 30 minutes/week for aerating; and 30 minutes/week for dealing with pests.

Table 2. Division of tasks between student and staff

Staff	**Student**
Collecting organic residuals	Supplying bulking agent (straw and shredded paper)
Reducing the size of organic residuals	Troubleshooting
Mixing food scraps with shredded paper	Setting fruit fly traps
Keeping things clean and tidy	Monitoring the success of attempted fruit fly traps
Qualitatively monitoring worm activity	Answering questions and providing instructions for staff
Monitoring fruit fly abundance	
Recording observations and tasks	

3.11 Pests

3.11.1 Rodents

Although rats have not been a problem in the pilot project, openings into outdoor vermicompost system should be protected using thick gauge wire mesh screens (Peter Stovell, personal communication April 9, 2011).

3.11.2 Fruit Flies

Fruit flies have been a problem with the pilot project. They were amoung multiple reasons for restarting with a new bin. The staff member managing the system has suggested changing the location because of the fruit flies. In addition, other staff members have expressed concern about washing and preparing food in the sink above where the bin is located.

Some preventative measures suggested in online forums are doing a 30 second microwave of food scraps and freezing food scraps. There are also commercially available beneficial organisms, such as the predatory mite, *Hyposaspis miles,* which some retailers claim can reduce or prevent fruit fly infestations (Rylo Santana, personal communication, March 9, 2011). For a list of fruit fly prevention and eradication techniques attempted see Appendix 8.4.

4. Discussion

4.1 Feedstock

The pilot only included pre-consumer organic food waste because of the decreased risk of creating high salt or anaerobic conditions unfavourable to worms. Continuing to process post-consumer organic waste off-site can help prevent these problems in the future. The pilot also restricted meat because of potential health concerns about having meat – cooked or raw – being composted in the kitchen. A food safety risk assessment needs to be done to determine if organic food waste that contains meat should continue to be sent off-site for processing at the in-vessel thermophilic composter or if they can be vermicomposted in the kitchen.

4.2 Bulking Agent

Although straw is currently being used in the pilot project, it's resistance to decomposition makes it undesirable. Although its structural stability helps to maintain aerated pores in the composting material. Shredded newspaper did not perform well in the pilot. If proper moisture and aeration can be maintained, materials like shredded paper or cardboard would be a better bulking agent to use in the future.

4.3 AMS Staff Responsibilities

The pilot demonstrated that at up to 30 minutes a day of the managing staff member's time could be spent with the vermicompost program without a significant reduction in his productivity in other areas. However, when scaling up the program, the time consuming and labour intensive processes of grinding and shredding feedstock will require modification. Where mechanized shredding of bulking agents and food scraps is not possible, using pre-shredded office paper and reducing food scraps sizes in a rubber tote using a flat ended shovel are the next best options. If there are multiple units, this task could be done centrally and bulking agents distributed to individual kitchens.

4.4 Comparison to Other Mid-Scale Vermicompost Operations

When making considerations for the long term, the quantity of organic food waste being produced is important. This value can then be used to compare the SUB Vermiculture Program with similar initiatives that have been previously established (Appendix 8.2). Therefore recapturing the 14 728 kg/year of pre-consumer food scraps from the solid waste stream would create a quantity of feedstock most comparable to that of the Medical University of South Carolina (See Appendix 8.2). With finished compost weight reductions of 60%, this would be able to produce 5 891 kg of vermicompost each year for the rooftop garden (See Table 3.2 in Appendix 8.3 for calculations). However, assuming an aggregate growth of the program through the use of on-site Worm Wigwams, each unit would contain a maximum of 24 kilograms of *E. fetida* worms, be able to accept approximately 4 400 kg/year and produce 3.14 m^3 of vermicast annually (See Calculation in Table 3.2.2 in Appendix 8.3). These cumulative value of these products after one year would be approximately $3 000, although this assumes zero earthworms are retained for the following year. A sustainable removal rate needs to be determined to provide a more accurate economic value.

4.5 Worm species

E. fetida have been used in the pilot because of their widespread use in the popular literature and extensive availability. They have performed well in the pilot. As a commercial product, *E. fetida* have a well established market. However, when considering selling worms as bait it may be best to use the *E. hortensis* because they are a slightly larger worm and are also more valuable.

4.6 Pests

Precautionary measures were taken in the second worm bin to deter fruit flies. These are listed in Appendix 8.4. The lack of success in preventing an increase in fruit fly abundance in the second bin suggests that eggs are being introduced with foodscraps. This can occur when fruit and vegetable skins and peels are not thoroughly washed or are left unexposed. Once fruit flies are established, the traps are not sufficient to control their populations.

5. Recommendations

5.1 For AMS Staff

a. Decide and inform the stage two student on what unit should be used to scale up the project.
b. Implement pest prevention measures upstream by placing lids on white compost collection bins when not in use.

5.2 For Design Team

a. Assuming the aggregate growth of vermicomposting units processing AMS pre-consumer organic food waste in New SUB, plan to reserve four, 1.2m x

1.2m areas with access to water. They should also be in location with non-fluctuating temperatures, where they can be protected from potential vandalism.

5.3 For future SEEDS Projects

a. Create a vermicompost staff training manual to build capacity within the AMS to sustain the project.
b. Expand educational opportunities through developing vermicompost workshops directed at students and staff.
c. Conduct financial feasibility study of the vermicompost initiative for AMS food and beverage Services

5.4 For Future Students

a. Incorporate quantitative monitoring of soil acidity, electrical conductivity and temperature to assist in troubleshooting
b. Continue using pre-consumer food waste residuals.
c. Replace straw bulking agent with cardboard or shredding paper.
d. Change fruit fly trap designs to ones with funnel tops.
e. Continue experimenting with different attractants in fruit fly traps.
f. Experiment with fruit fly prevention techniques such as microwaving or freezing food scraps before incorporating them. Costs; $ energy and labor
g. Apply for funding to purchase supplies to scale up the project (Consult budget in Appendix 8.5 for guidance.
h. Increase awareness through signage and posters, twitter or other means of social media.

6. Conclusion

The academic research involved in this report was important to the development of the pilot project. From this research and the data, observations and feedback received from the pilot project, it was possible to determine in-part, if on-site vermicomposting at the Student union Building was achieving the purposes for which it was initially intended.

Although, the volume of organic materials being collected from the SUB would be reduced by the vermicompost of pre-consumer food waste, there will continue to be food scraps transported off-site and the fruit fly problem in the loading bay would likely not improve, unless collection frequencies increased. However, the quantity of vermicast produced from the pre-consumer organics food waste alone would be enough to support at least three Worm Wigwam units, each producing 3.14 cubic meters of vermicompost per year. The prediction that diversion rates will increase if patrons associate the identity of a worm with their own composting habits has not yet been tested. Nor has the feasibility of marketing other vermiculture products, like worms or compost teas, been thoroughly determined. Education, extension and outreach programs are the current suggestion for vermiculture products as these end uses require significantly smaller quantities of worms be harvested and can potentially develop a small market for composting worms over time.

The initial stage of the SUB vermiculture program has determined that there is a capacity within the AMS Food and Beverage Services to expand the pilot project to a larger vermicomposting system. Logistical challenges have presented themselves in this first stage, but they can be overcome with appropriate adjustments. The project can provide an economic, social, and environmental value to SUB operations, but full costs are not yet known. The aggregate expansion of the pilot project through a second stage will be important to developing stronger recommendations and conclusions on how to effectively move forward with vermiculture in the current and future Student Union Building.

7. References

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8. Appendices

8.1 Terminology

Vermiculture: the growth and production of earthworms (ex. bait worm production)

Vermicomposting: the bioconversion of organic waste into plant growth medium through the use of worms

Thermophilic Composting: the heat generating bioconversion of organic waste into plant growth medium through the use of aerobic microbes

Vermicast: worm castings; the end product of organic waste breakdown by worms. (Appelhof, 1997)

Compost Tea: aqueous extract from composts being tested for its plant growth enhancing properties. (Salter and Edwards, 2010)

8.2 Comparison of Vermicomposting Operations

Place	National Institute of Enviroment and Health Sciences	Metro Hall	Len Foote Hike Inn	Seattle Kingdom (stadium)	IKEA	Eddy Center	Evergreen State college	Southern Illinois University Carbondale	University of Oregon	Medical University of South Carolina	Huron Hospital
Location	North Carolina	Toronto, Ontario	Dawsonville, Georgia	Seattle, Washington	Schaumburg, Illinois	Middelton, Connecticut	Olympia, Washington	Carbondale, Illinois	Eugene, Oregon	Charleston, Couth Carolina	East Cleveland, Ohio
Capacity	2520 kg / yr	2700+ kg/yr + 750kg towels	680 kg/yr	1400 kg/yr	?	1000 kg/yr	~25000 L/yr	~80000 kg/yr	~12000 kg/yr	21000 kg/yr	8400 kg/yr
Unit	2 – Wigwam	1 – Flow through reactor	10 – Large worm bins	12 – 100L sized worm bins	4 – Flow Through Reactors	4 – Wooden earthworm bins	4 – Modular flow through reactors	1 – Flow through reactors	Orchard floor	1 – Flow through reactor	?
Cost	Amer. $750	?	?	?	?	$ 36000 grant	?	$ 150 000 in grants	?	$56000	?
Selling Vermicompost Products	No	no	No	No	Attempted	Planning	No	No – conducting research growth trials	No	No	No
On/off site	On site - outside	On site - basement	On site basement	?	On site – inside trucks parked in loading bay	Off site - Greenhouse	Off site – University Farm	Off site – University Farm	Off site – University Farm	On site – constructed addition building	Off site – private company pick up
Heated / Cooled	Heated	?	?	?	Both	Heated	Neither	Heated	Neither	Cooled	?
Feedstock	Pre-consumer	Pre and post-consumer	Pre and post-consumer	Pre-consumer	Pre and post-consumer	Pre-consumer	Thermo-philic compost products	Pre and post-consumer	Pre-consumer	Pre-consumer – begining to precompost	Pre-consumer
Meat	?	No	?	?	?	?	Yes	?	?	?	?
Bulker	Leaves, animal bedding, shredded paper	Paper towels from bath room	Cardboard Paper Cotton and wool clothing Mop heads	Leaves and shredded newspaper	Paper	?	Straw, shredded newspaper, manure and animal bedding	Shredded paper	Grass leaves Shredded branches	Cardboard	?
Shredding	?	Machine shredded	?	?	Grinder/mixer	Small grinder	Yes – means unknown	pulper		Shredder – but now broken	?

(Sherman, 2010)

8.3 Calculations

Table 3.1 Estimated cumulative production of pre and post consumer food wastes from the AMS food outlets at the SUB.

Annual weight of AMS compost waste	46 750 kg/yr
Percentage of annual AMS compost waste that is from food organics	21%
Weight of food organics in AMS compost waste	= 46 750 kg/yr x 0.21 = 9 818 kg/yr
Weight of pre and post-consumer compostable food waste in the AMS solid waste stream	36 464 kg/yr
Cumulative total of organic food waste produced by the AMS (assuming 100% recovery of organics from solid waste stream)	= 36 464 kg/yr + 9 818 kg/yr = 46 281 kg/yr
Preconsumer Only	
Total pre-consumer food wastes in solid waste stream associated with being produced by the AMS	14 728 kg/yr[a]
Quantity of worms required to process AMS pre-consumer food wastes; assuming worms consume 50% of their weight a day	= 14 728 kg/yr / 365 day/yr x 2 kg worm/kg = 80

Table 3.2.1 Calculations for quantity of annual vermicast production

Annual weight of pre-consumer food waste produced at SUB	**= 14 728 kg**
Weight after composting	= 14 728 kg x (1 – 0.6)[c] = **5 891 kg**
Volume of finished compost	= 5 891 kg x m^3 / 561 kg[d] **= 10.5 m^3**
Estimated price	= 10.5 x $ 43 /m^3[e] **= $ 452**

Table 3.2.2 Calculations for quantity of annual vermicast production per Wigwam

Maximum Wigwam output	= 75 lbs/week[b] x 0.45 kg/lb x week/7 days x 365 days/year = 1 760 kg/year
Weight of feedstock required for max output	= 1 760 kg/year x 1/(1-0.6[c]) **= 4 400 kg/year**
Volume of finished compost/Wigwam	= 1 760 kg x cubic meter / 561 kg[d] **= 3.14** m^3
Estimated price of vermicompost/Wigwam	= 3.14 m^3 x $ 43 /m^3 [e] **= $ 135**
Number of wigwams required to process 14 728 kg/yr of AMS pre-consumer food waste; assuming worms consume half their weight a day (Applehof, 1997)	= 14 728 kg/yr / 4 400 kg/yr **= 3.34 Wigwams**

a. (MJ Waste solutions, 2010)

b. 75 lbs of vemicompost output/week, Worm Wigwam Website (www.wormwigwam.com).

c. The estimated weight reduction of finished compost from starting material is 60% (CCME, 2005).

d. The estimated weight to volume ratio of finished compost is 561 kg/cubic metre (Massachusetts DEP, 2002).

e. Price of Organic Garden Soil Mix per cubic metre from a local supplier (West Creek, 2010).

8.4 Methods used to deal with fruit flies

Attempted:

- The two different brands of fruit fly traps used already by the kitchen staff (opaque circular orange trap & opaque triangular white trap) – unable to see inside to determine effectiveness
- Beer and banana traps with cellophane around top and holes punctured into it – very effective at attracting flies and containing them, but holes often too large and flies can escape; use inside the bin now being tried
- Tupperware container half filled with apple cider vinegar and 3 drops of dish soap. Nine to ten holes punctured in the lid – not as successful as the beer and banana traps when used outside the bin

Mary Appelhof suggests the following method of making a fruit fly trap:

You will need a jar, a rubber band, a plastic sandwich bag, and some beer or juice. Place about an 3 centimeters of beer or juice in the bottom of the jar. Punch a small hole in the corner of the sandwich bag. Place the bag like a funnel with the corner with the hole pointing down but not touching the liquid. Open the bag over the rim of the jar and secure with the rubber band around the rim so that the bag forms a funnel over the liquid. Fruit flies will make their way through the hole at the corner and not be able to get back out, so they will get stuck in the liquid. Change the liquid as often as needed

8.5 Budget

Item	**Price**
Worm Wigwam Unit	$ 750
10 kg Worms (22 lb) (price $80/2lbs)	$ 880
Flat nose shovel	$ 15
Rubbermaid tote	$ 10
Box cutters	$ 5
Thermometer	$30
pH meter	$ 25
EC meter	$ 25
Total	**$ 1740**

1. Estimates based on Earthworks in Chiliwack, Canadian Tire and Vermico (www.vermico.com)

8.6 Contacts

Name	**Contact information**
John Paul PhD President Transform Compost Systems Ltd	[redacted]
Peter Stovell Vermicompost Researcher Kerrisdale	[redacted] [redacted] [redacted]
Robert Crofton-Sleigh	[redacted]
Rylo Santana	[redacted] [redacted]