Development of Large-Scale Composting Techniques at the SBRC

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Introduction

The Sustainable Barbados Recycling Centre (SBRC) is a privately-owned waste sorting facility contracted by the government of Barbados to produce 31,025 tonnes (MT) of finished compost product each year, through the construction and operation of a composting facility onsite (Dalati & Tasker, 2017). However, at present the SBRC only utilizes outdoor passive composting, which can take months to years to complete. In September 2017, two McGill University interns undertook the project of designing an active composting facility to replace the SBRC's current method of passive composting. Active composting can accelerate the maturity process of the compost. The large-scale, in-vessel facility currently being constructed by the SBRC utilizes a static aerated pile (SAP) method (Fig. 1). Previous experimentation to determine the most effective feedstock inputs was not successfully achieved, due to limitations in monitoring the compost piles and failure to control environmental conditions.

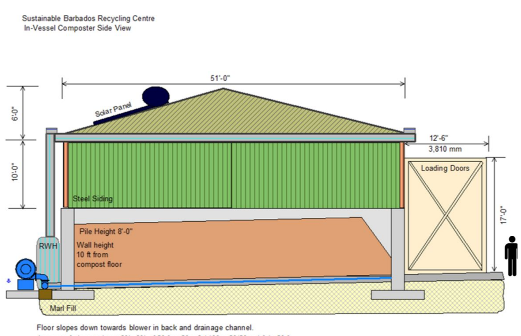

Figure 1. Composter Technical Design (modified from SBRC Active Composting Manual, 2017). Person not to scale.

Project Objectives

1) Design and implement an experiment to determine the relationship between compost particle size and optimum vegetable growth.
2) Compare two compost piles of varying inputs, and determine which one would produce a higher quality compost in a shorter amount of time.
3) Test quality differences of the SBRC's commercially available composts.

Materials and Methods

Objective One- Effect of compost particle size on vegetable growth

The two compost piles from the previous Mcgill interns, as well as the commercial compost currently produced by the SBRC, were screened into ⅜ inch (0.32 cm), $\frac{4}{8}$ inch (0.95 cm) and ⅛ inch (1.27 cm). Lettuce, sweet pepper, and bean seeds were planted into the different compost types, as seen in Figure 2. Measurements were taken weekly to monitor germination rate and overall performance of each vegetable type grown under the three compost sizes.

Figure 2. Germination of sweet pepper seeds using compost screened to ⅛ (0.32 cm), ⅜ (0.95 cm), and $\frac{4}{8}$ inch (1.27 cm).

Objective Two- Comparing two feedstock "recipes"

Six small-scale compost bins were constructed to allow testing of the compost "recipes" under controlled environmental conditions. These small-scale composters were designed to mimic the conditions of the large-scale active composter (Fig. 1). Active composting involves the activity of aerobic microbes, and hence the provision of oxygen during the composting process. This was done with the help of four PVC aeration pipes that ran through each pile.

The composters were built from recycled wood pallets, shade cloth, cardboard for insulation, and plastic tarps to protect the interior from the sun and rain (Fig. 3)

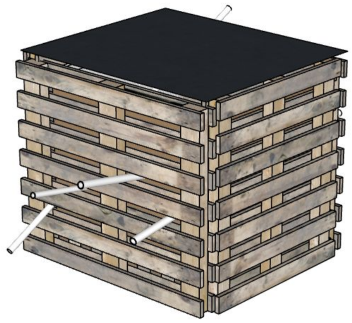

Figure 3. Design of small-scale composter.

The first recipe consisted of tree trimmings, coconut husks mixed with shredded pallet wood as a bulking agent, seaweed, and chicken manure. The second recipe consisted of the same but without the seaweed. The ratio of feedstock inputs was calculated as 1 part tree trimmings; 1 part sargassum; 1 part chicken manure; 4 parts coconut husks and shredded pallet wood for Pile One and the same for for Pile Two, but without the sargassum(Figure 4).

It was critical to monitor the piles at regular intervals in order to evaluate the composting process. Moisture levels were judged with a 'squeeze test' using a handful of compost from each pile. Temperature was monitored with a temperature probe.

<u>Objective Three- Testing differences between SBRC compost products</u>

To determine whether there was a significant difference in quality between the two compost grades produced by the SBRC, chemical analyses and plant bioassay tests were implemented. This involved planting the seeds in each compost grade using 2 parts compost; 2 parts coconut fibre; 1 part perlite. A small amount of slow-release fertilizer (Osmocote) was combined with the compost/ coconut fibre/ perlite mixture. The three seed types were planted into both soilless potting mixtures- one incorporating ⅜ inch commercial compost, the other with $\frac{4}{8}$ inch commercial compost. The vegetable seeds were also planted in a control medium (soilless mix without fertilizer). The relative seed germination, relative root growth, and germination index was calculated for each compost type and evaluated. The pH and electrical conductivity (EC) of the compost were also recorded as indicators of compost quality.

Results and Discussion

<u>Objective One- Effect of compost particle size on vegetable growth</u>

According to our ANOVA analyses, there is no statistically significant differences in germination rates between particle sizes for any of the compost types or plant species. The SBRC can therefore market both sizes similarly as media for seedling germination, or phase out the smaller size to increase efficiency.

<u>Objective Two- Comparing two feedstock "recipes"</u>

It was important for the compost to heat up to a temperature of 55℃-65℃ for the first three days in order for pathogens to be killed off. However, during the first three days,both piles remained at an average temperature of 25℃, so the 3-day initial period was restarted as a second trial. The composters were adjusted to 3 parts tree trimmings; 3 parts chicken manure; and 4 parts coconut husks and pallet wood, while keeping sargassum at only 1 part.

After revising the feedstock inputs and modifying the pipes, the average temperature for each compost pile was still unable to reach the necessary 55-65℃ range required to effectively destroy pathogens, weed seeds, and insect larvae.

Due to the time required to construct the small-scale composters and failure of the compost to heat up, the composting process was delayed. Since the breakdown of feedstock material had only just begun for both piles, the goal of finding the more efficient feedstock recipe was not reached by the end of August.

Figure 4. Small-scale composters containing compost materials.

<u>Objective Three- Testing differences between SBRC compost products</u>

The differences in quality of the SBRC's compost products was determined by comparing pH and electrical conductivity. The plant growth potential of each compost type was analyzed through bioassay testing, which compared the germination index of both products.

It was determined that the pH of both compost particle sizes falls within a suitable range. The electrical conductivity results showed that both products contain a reasonable level of soluble salts. To compare plant germination potential, the germination index (GI) was calculated for both compost sizes as a component in soilless mix. However, due to the small size of the sample, conclusive results cannot be extrapolated. More data would have to be collected from different plant species, with a greater number of seeds per trial.

According to our analysis, there is no statistically significant differences in germination rates between particle sizes or fertilizer treatments for any of the plant species. Since there was no difference between the treatment with and without fertilizer, inferences can be made regarding compost's functionality as a fertilizer in seedling germination. However, more experimentation must be done with greater replication and longer time frames in order to determine if compost can wholly replace fertilizer in soilless potting media.

Conclusions and Recommendations

Potential use of small-scale composters

The purpose of this experiment was to facilitate active composting by designing and building a structure that would mimic the conditions of the large-scale compost facility. While these scaled-down versions were successfully constructed, the time required to do so delayed the start of the composting process. To be able to see clear results and compare two feedstock recipes, more time would be needed.

It is recommended that the SBRC restart the composting process, but optimization of the small-scale composters will need to be performed. A number of factors of the original composter design may have contributed to the failure of the piles to heat up. To determine whether it was an issue of aeration or if there was a lack of proper insulation, each small-scale composter should be modified and compared against one another. This will allow the SBRC to pinpoint and fix the problem of the composter design and allow the SBRC (or prospective McGill interns) to use them for future experiments. Each pile will need to have the same feedstock inputs. In this case, the same recipe can be used from Trial 2 of the preliminary experiment, without sargassum. In order to determine if there was an excess or deficiency of air flow, the composters should vary in the number of closed aeration pipes. To address the potential issue of insulation, the walls of some composters should be fortified with an additional layer of cardboard.

The compost piles should be monitored for two weeks to determine if optimal temperature levels have been met. If none of the piles show an improvement, then it can be said that either 1) the feedstock recipe is inappropriate and needs to be reconsidered or 2) the failure of the compost to heat up is an issue of moisture level. However, if one of the compost piles have met and maintained proper temperature levels, these modifications should be applied to the remaining composters. This will allow the SBRC to test different feedstock recipes, and continue our original objective to investigate the decomposition rate of sargassum. After the compost has fully matured, the end-product quality can then be analyzed and compared.

Determining quality of future compost

Testing the quality of matured compost is important for identifying its chemical, biological, and physical properties. It also allows for recognizing potential problems with compost use. The final task of this project was creating the "SBRC Compost Quality and Maturity Assessment Manual". This manual should be used to test the quality of the finished compost from the small-scale composters, as well as any future compost samples produced by the SBRC. It includes basic assessment procedures that can be done on-site, using the SBRC Greenhouse, or at a local laboratory. Although there are many different parameters that can be used to test compost quality and maturity, the methods contained in the manual are ones that can be done inexpensively and/or without any technical training. Methods to interpret the results and their relevance to compost quality are also included in the manual.

Conclusion

From our planting trials, we concluded that there were no significant differences between vegetable growth rate for different compost particle sizes for both pure compost and for compost as a component of soilless mix. We found minimal difference in pH, electrical conductivity, and germination indices of the two sizes. This brings into question whether the SBRC should continue investing in producing two sizes. Based on our experiments, we recommend that they discontinue the ⅜ inch compost as it serves the same function as ½ inch compost, but poses additional costs.

Although we were unable to compare the decomposition rate of the different feedstock recipes (one including sargassum and one without), this project provided the SBRC a means to apply static aerated pile (SAP) composting on a small scale. Experimentation with the organic waste received at the SBRC will offer important information on feedstock recipes, timing, and other variables associated with SAP composting. The small-scale composters will allow the SBRC to test the decomposition efficiency of different feedstocks within a controlled environment. The Compost Quality and Maturity Assessment Manual (2018) will provide the SBRC viable ways to test end-product quality. Quality testing will make an important contribution to the long-term revenue and profitability of the SBRC.

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