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The Scoop on Composting: A Comprehensive Literature Review on Composting with a Focus on Grand Valley State University

Alexandria Snabes
Grand Valley State University

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Honors Senior Project

By

Alexandria Snabes

Grand Valley State University

Allendale, MI 49401

Abstract

This comprehensive review discusses the main microbial processes, methods, efficiency strategies, benefits, and drawbacks related to composting. Specifically, anaerobic, aerobic, and intermediate, or cold composting, decomposition processes are defined and assessed. This leads into a discussion of some common methods of composting, both large- and small-scale, which utilize these microbial processes to result in differing advantages and disadvantages. The efficiency of these methods can be increased using strategies that monitor oxygen levels, moisture levels, temperate levels, and overall size. Some benefits of composting discussed include diverting waste from landfills, improving soil nutrition and quality long-term, and increasing plant growth and yield. Some potential drawbacks of composting discussed include the possibility of containing hazardous heavy metals and high concentrations of salt, taking years to regenerate the nutrients in poor soils, and producing just as much methane gas as landfills at times. The discussion then turns to composting strategies currently used at Grand Valley State University both on campus and at the Sustainable Agriculture Project. After delving into the past and current strategies used at these locations, as well as strategies used by other universities, suggestions for improving the composting methods at Grand Valley State University were proposed. On campus, it would be beneficial to either buy back the finished compost product originally sent to composting facilities, or to introduce a small-scale composting method for educational purposes. At the Sustainable Agriculture Project, it would be beneficial to either improve the current compost pile, or introduce a smaller-scale underground closed composting bin.

Introduction

According to the United States Environmental Protection Agency, around 63.1 million tons of food waste was generated in the U.S. in 2018, and about 56% of that waste ended up in landfills where it slowly rotted and released methane gas, which is both bad for the environment and for humans

(USEPA, 2020). Not only does it release these harmful greenhouse gasses into the atmosphere, but food waste accounts for roughly 21.6% of landfills, which eventually fill up and sit there for a long time as the items in landfills take a long time to decompose (Venkat, 2011). One way that we can reduce the amount of food waste being sent to landfills, help put nutrients back into the soil, and potentially generate a profit, is through composting. Throughout this paper, the main microbial processes, methods, efficiency strategies, benefits, and drawbacks related to composting will be discussed. In addition, the ways in which Grand Valley State University composts on campus as well as at the off-campus farm, the Sustainable Agriculture Project, will be analyzed and suggestions for improvements will be included. These suggestions will be based on the utilization and success of composting strategies used at other college universities.

The Basics of Composting

Composting can be defined as an organic waste diversion process in which the organic waste decomposes to produce a nutrient-rich soil. In general, compost can be made up of food waste, plant waste such as grass clippings, animal waste, and tree waste such as woodchips, twigs, paper, and cardboard (Inckel et al., 2005). Most compost piles use the rule of maintaining a carbon to nitrogen ratio of 25-30:1 (Smith, 2009). This ratio is ideal because it allows for the pile to decompose at the most efficient speed as possible due to it creating the perfect environment for microbes. This ratio can be adjusted by the addition of either green waste, such as food waste and grass clippings, or the addition of brown waste, such as woodchips or dried leaves. Green waste is naturally high in nitrogen, whereas brown waste is naturally high in carbon, and when added in a one-to-one biomass ratio to form a compost pile, it will ideally create the 25:30 C:N ratio (Smith, 2009). Depending on the combination of these waste materials, management technique, and amount of materials used, this waste can be turned into usable and environmentally beneficial soil anywhere from two weeks to many years (Keller, 2019). Materials can be broken down and turned into soil in one of two ways: aerobically or anaerobically.

Aerobic composting is a method that uses oxygen to help decompose and breakdown the organic materials. These bacteria and microbes that help breakdown waste efficiently use the input of oxygen to survive and thrive. Oxygen can be introduced into a compost pile in ways such as not coving the pile, turning the pile to expose all parts of it to oxygen, or even placing tubes into the pile to allow for oxygen to flow into unexposed parts of the pile (Rasapoor et al., 2016). By allowing these aerobic microbes to thrive, the compost pile itself heats up because these microbes release heat as they work to decompose the organic materials. In fact, compost piles can reach up to 160 degrees Fahrenheit if they are aerated properly, which is why this type of composting is most often referred to as hot composting (Inckel et al., 2005). Because the pile gets so hot, it drastically speeds up the time it takes for the organic materials to fully break down. This style of composting also kills off many harmful bacteria that cannot survive in extremely hot temperatures, which essentially sterilizes the final soil product. The heat also kills off many unwanted weed seeds or plant pathogens that may have been introduced to the original compost pile (Bement, 2010). Although this method produces a final product the quickest, it can also be more labor intensive compared to other styles such as cold composting, which is considered a style that in between aerobic and anaerobic composting.

Cold composting is a method of composting in which the compost pile does not reach temperatures as extreme as seen in hot composting. This is because in this method, the pile is not usually turned to allow for the influx of oxygen and, therefore, the influx of aerobic bacteria. Because there are less aerobic bacteria as oxygen is only able to reach the surface of the pile, it stays cooler and takes a much longer time to completely decompose and produce a final product (Bement, 2010). It is also important to avoid putting weeds that have gone to seed or diseased plants in this compost as they will be able to survive in the final product and may introduce more weeds or diseases in future plants where the compost is being used. Although this method takes longer to create a final product, it takes less labor and effort as waste can continually be added on top of the compost pile and no turning of the pile is necessary. Some argue, however, that cold composting should just be considered anaerobic composting, as anerobic bacteria and microbes far outnumber the amount of aerobic microbes present.

Anaerobic composting is defined as a method of composting that requires no oxygen. To do this, waste is usually covered by either a tarp or lid. This results in the ideal conditions for the growth of anaerobic microbes that work to decompose the waste. Although these microbes do produce heat, it is nowhere near the temperatures that would be seen in a hot composting aerobic system (PNRC, 2004). Instead of the heat helping to break down the organic materials, anaerobic microbes create a very acidic environment which helps to kill off pathogens and sterilize the final product. However, this sterilization takes a much longer time than in the hot composting method, and once the organic material becomes soil, it must sit for about a month to allow for aerobic microbes to grow and neutralize the acidic soil before being used (PNRC, 2004). Another thing to note about anaerobic composting is that it has a much stronger pungent smell than aerobic composting. This is due to the anaerobic microbes releasing hydrogen sulfide and ammonia as they are working to decompose the organic materials, which leads to it smelling slightly like rotten eggs (Xu et al., 2020). Although there are benefits and disadvantages of both aerobic and anaerobic composting, there are many different methods that are used today that draw on the knowledge of both of these strategies to make composting piles the most efficient they can be for a specific person or area.

Composting Methods

One of the most common composting methods used for large-scale or commercial composting, is arranging organic materials into what is called windrows. Windrows are long rows of compost that are about three feet wide, three to five feet tall, and anywhere from three to three hundred feet long (Zhu-

Barker et al., 2017). This mostly aerobic composting method is one of the fastest ways to convert organic materials to soil as the surface of the pile is exposed to oxygen allowing the pile to heat up fairly quickly. These rows of compost can be turned or mixed about every day or every other day in a way to ensure all parts of the pile are being exposed to oxygen, which helps to speed up the breakdown process (Zhu-Baker, 2017). However, sometimes the piles aren't turned at all, which is known as static windrow composting. These piles do take longer to produce the final soil product, but many times pipes or other materials such as sticks or woodchips are placed inside the piles to allow for a greater flow of oxygen (Waldren & Nichols, 2009). There are many different methods that can be used once these windrows are formed including covering the piles completely, but one common practice is to continuously add onto the windrows either on the ends of the piles, or directly into the center of the pile when it is being turned. One advantage to adding in more organic materials directly into the pile is that the temperature of the pile is already high, so the newly added materials take a shorter time to break down than if they were used to start a new pile from scratch (FAO, 2003). Another way in which this is helpful is that it allows you inspect and adjust your compost pile to ensure is has the correct levels of materials that will make your compost more speed efficient and nutrient rich.

Because windrows require large amounts of organic materials and require a lot of manual labor if the pile is large, they are not always the most efficient composting method for smaller households. One method that could be used instead is referred to as triple bin composting. This method requires three separate piles usually separated by open bins or three-sided box structures. The first bin is for fresh organic materials which can be continuously added onto as long as mixing of the pile is done every couple of days. Once this pile has reached the size you want, you stop adding onto the pile and continue to mix the pile until the internal temperature has reached around 150 degrees Fahrenheit. Once this is reached, the whole pile should be put into the second bin which allows for an influx of oxygen as it is transferred. While the material is in the second bin it continues to break down and should remain a fairly hot temperature. Once the pile has no recognizable food particles in it and has cooled down from being hot to just warm, it can be moved into the third bin. While in this bin, the compost will continue to cool down as the composting processes has been completed and no more breaking down of organic materials is occurring (The Daily Gardner, 2020). This method is convenient for smaller households as it requires less materials, can be fairly odorless if turned frequently enough, and is able to produce finished compost in around a month if attended to properly (The Daily Gardner, 2020). However, it does still require some manual labor and can start to smell and potentially upset neighbors if not turned frequently enough.

A common method used that avoids the manual labor of turning the compost by hand is by using a tumbler. This is a circular closed bin that is able to be manually rolled to allow for the turning of compost inside of it. Because this is a closed bin, the organic materials inside undergoes an anerobic process and can start to smell when the bin is opened, and can take around six months to a year for the materials to be fully decomposed depending on how often the bin is rotated (Waldren & Nichols, 2009). Because of this, people tend to have at least two tumblers so one can sit and decompose while the other can be continuously filled with food. Another advantage of this type of composting is that rodents are unable to get to the compost as the tumbler is a closed bin and is usually lifted off of the ground. The main disadvantage that most people have with this type of composting is that the tumbler itself can be fairly expensive, which makes other methods of composting more attractive to some.

One fairly inexpensive method is putting compost in a covered bin or bucket. This has the same advantages of the tumbler in that rodents have a hard time getting into the compost and smell is reduced since the bin is closed. However, because this is an anaerobic process and no mixing of materials is occurring, it takes much longer for the final compost product to be created (Smith, 2009). For some though, they may just be looking to reduce the amount of waste being sent to the landfill and have no need for the final product. In this case, some may choose to use this closed bin system but place the bin directly into the ground. When doing this, holes are drilled at or near the bottom of the bin, and then the bin is buried about halfway to completely into the ground. This compost system is very easy to use as you continuously throw organic materials into the bin and don't need to empty or turn it. This is because as the materials decay, worms and other insects take and move the materials outside of the bin so the bin never has to be emptied. Any liquid that may be created due to the anaerobic decomposition process is also able to seep into the grown which adds nutrients to the surrounding soil (Smith, 2009). Because of the nutrients being spread by the compost juices and insects, many people place one or more of these buried compost buckets next to their gardens to promote plant growth without having to spread compost all over the beds (PNRC, 2004).

In a similar fashion to the buried bucket method, some people dig holes into the ground and put organic materials directly into it. Although this has the same benefits as the bucket method in that an increase in nutrients is added to the soil, you may have to be careful that meat products are not added and that the hole is covered up properly so that animals don't try to dig up the organic materials. Again, this method takes a fairly long time as it is an anaerobic decomposition process so you must try to not dig in the same spot all the time (Misra et al., 2003). An even less labor-intensive method is just to put organic materials in a pile above ground. This pile can be continuously added to, but again without proper turning the pile will take a very long time to fully decompose and may end up starting to smell. You also have to be careful not to add any meat in this type of composting method as animals will gladly try to dig into the pile to eat it (Inckel et al., 2005).

The final method that will be talked about is referred to as vermicomposting, which is composting using worms in addition to the aerobic microbes. This method requires a bin that is safe for worms to thrive in which is usually made up of plastic, wood, or Styrofoam and contains many holes in the sides of the bin for ventilation. The bin is then filled with some bedding such as newspaper, some soil, and some worms of course. With this method of composting, you have to make sure not to feed the worms meat, dairy, fermented foods, or fatty foods as this may introduce unwanted bacteria that may drive the worms to leave the bin (Taeporamaysamai & Ratanatamskul, 2016). It is also helpful for the bin to be elevated so that airflow is maximized to introduce more oxygen and speed up the decomposing of organic materials by aerobic microbes. However, the bin does not necessarily need to be elevated and can actually be placed inside in places that are cool and the temperature is consistent such as under a sink as long as a pan is placed under the bin for excess liquid to collect in (Taeporamaysamai & Ratanatamskul, 2016). Because it can be placed inside, requires little to no manual labor, and doesn't have much an odor, this method of composting is very attractive to people who live in places where an outdoor composting system is not an option. Another advantage of this method is that the compost can be collect after a while and has even been shown to contain more nutrients than traditional compost due to the worms adding mucus and, therefore, extra microbes to the organic materials they consume (Taeporamaysamai & Ratanatamskul, 2016).

Compost Efficiency

When trying to start up and maintain a compost pile, it is important to consider how to make the compost pile the most efficient and nutrient rich it can be. One of the most important things to do if you want to speed up the decomposition process is to continue to introduce oxygen to the pile. As stated above, the more oxygen you introduce to the pile, the more the aerobic microbes can thrive and decomposed organic materials (Rasapoor et al., 2016). However, if a compost pile is turned too much, such as multiple times a day, it will actually hinder the decomposition process as the pile will not be able to build up enough heat to reach the level of decomposition that things such as weed seeds and diseases need to reach to become sterilized (PNRC, 2004). In an opposite fashion, if the pile does not get turned enough then the aerobic microbes may die off by reaching too hot of temperatures and decomposition will be momentarily halted. These aerobic microbes may also not have enough oxygen and in this case, anaerobic microbes will take over and cause the pile to not reach the sterilizing heat (PNRC, 2004). Therefore, it is important to check the temperature of compost piles, especially in aerobic compost piles, so that you know the pile is decomposing at the fastest rate possible.

Although the introduction of oxygen can help speed up the composting process, it is not the only thing that plays a role in the turnover rate from organic waste to final compost. Moisture levels are another very important thing to monitor when trying to speed up the composting process in both aerobic and anaerobic composting. It is known that throughout the aerobic composting process, the soil in the making should be moist enough to hold shape, but not moist enough to drip liquid when squeezed (Inckel et al., 2005). One way to easily add moisture is to either evenly water the compost pile, or add in more moist materials such as vegetable or plant waste. If the compost pile is too wet, dry materials such as woodchips, paper, or dried leaves can be added. When an aerobic compost pile is too wet, the pile may start to smell more as the aerobic microbes are not getting enough oxygen through the heavy pile and anaerobic microbes start to take over (Inckel et al., 2005). Even in anaerobic systems it is important to monitor moisture levels as piles can become too dry which halts microbial activity as both anaerobic and aerobic microbes need some water to carry out their internal processes (PNRC, 2004).

Another simple way to speed up the composting process is to make everything about it physically smaller. When the pieces of organic material are cut up into smaller chunks, it allows for both aerobic and anaerobic microbes to have more surface area on the material and are, therefore, able to finish decomposing the material faster (Smith, 2009). When the entire compost pile itself is smaller, this also speeds up the decomposition process. In aerobic conditions, this is because more surface area is able to be exposed to the surrounding oxygen, which promotes microbial growth and activity (PNRC, 2004). However, if an aerobic composting pile is too small, it may not be able to produce the necessary heat needed to break down materials in the most efficient manner, especially if the pile is in a cooler surrounding environment. A smaller pile also speeds up anaerobic composting as the microbes have less physical organic material to break down.

Benefits and Drawbacks of Composting

One important topic that this paper has yet to discuss, is exactly how beneficial composting really is. On a large environmental scale, the main benefit of composting is that waste is being diverted from landfills. As discussed earlier in the paper, this helps to reduce the amount of methane gas emissions that are being expelled from landfills which, in turn, helps to decrease the effects of climate change (USEPA, 2020). Another big benefit of compost is how impactful it can be on overall soil quality. Compost is full of many important nutrients which, when added to nutrient depleted soil, can revive the soil quality and structure. One example of how it improves soil structure is that in increasing the water-holding capacity of soil, meaning the soil can stay moist enough to efficiently hydrate crops and other microorganisms (Chen & Wu, 2005). Because of this, less water is needed to be applied to the crops which can be both monetarily and environmentally beneficial. With better soil structure, the soil is also less effected and damaged by things such as water and wind erosion (Chen & Wu, 2005). This means that less soil will be lost due to the elements and through things such as water runoff.

Not only are the nutrients in the soil beneficial for reducing erosion, but the increased microbe communities present in compost, such as fungi mycelia networks, also help bind the soil together to increase soil stability and decrease erosion (Chen & Wu, 2005). The increase in biodiversity of microorganisms also encourages and promotes even more growth of beneficial microorganisms and earthworms which continuously improve soil quality (Chen & Wu, 2005). When soil quality is low and lacks enough nutrients, it tends to become compacted and lacks the proper composition to allow for plant roots to have enough gas exchange allowing them to continue to grow. When compost is added to the soil, the long-term nutritional value of the soil itself increases. This not only allows plants to receive and hold more nutrients, but also improves soil aeration, which allows for roots to access and exchange oxygen and carbon dioxide more easily (Chen & Wu, 2005). There is also no need to buy artificial nutrients year after year if compost is used as it is naturally full of nutrients and improves soil quality long-term, which further helps to save money. Because plants have access to more nutrients, they become healthier and are less susceptible to disease which both increases plant growth and yield (Chen & Wu, 2005).

Although there are many benefits of composting, there can also be some potential drawbacks. One of these drawbacks is that it can contain small traces of hazardous heavy metals (Cerda et al., 2018). This can be dangerous as compost is unable to completely break heavy metals down, leading to accumulation of metals. Not only can this lead to the produce grown on this soil to contain heavy metals, but it can also impact the microbiome of the soil which leads to soil low in nutritional value. Another problem that may occur is creating compost containing high concentrations of salt. This can inhibit plant growth by negatively affect soil structure and an imbalance of soil nutrients (Cerda et al., 2018). Even though heavy metals and high salt contents may sound harmful, these can both be avoided if you ensure the materials being put into the compost do not contain heavy metals or high concentrations of salt.

A slightly less harmful sounding drawback is that it takes a few years for compost to regenerate the nutrients in previously poor soils, which is not the case for fast working chemical fertilizers (Inckel, 2005). For farmers who have leached almost all of the nutrients out of their soils, switching from chemical fertilizer directly to compost to make up for the lack of soil nutrients would not be possible as the soil will not have had enough time to regenerate. This means that farmers must implement it slowly or in partial sections which takes time that they might not have. The final drawback of compost is that it has the potential to produce just as much methane gas as landfills (Zhu-Barker et al., 2017). However, this is only for anaerobic composting systems as the chemical processes it goes through produces excess methane gas as a byproduct. This means that anaerobic composting systems may contribute to climate change just as much as landfills and are, therefore, hurting the environment rather than helping the environment.

Composting at Grand Valley State University

Grand Valley State University continuously strives to find ways in which they can be more environmentally conscious and sustainable. One of the ways they accomplish this is through composting on campus, such as in dining areas. The composting program on campus was established in 2009 in which only a few compost cans were available at two campus dining locations (USGBC, 2010). The composting program has grown a lot since its genesis, and today, compost cans are seen in almost every building on campus including housing areas, the library, educational halls, at athletic events, and more, not just in a few dining halls.

To find out more about how composting on campus is done today, I contacted the Director of the Office of Sustainability Practices at GVSU, Yumiko Jakobcic. Ever since she began working at GVSU in 2014, she has seen an enormous growth in the level of composting and sustainable practices used. In fact, she even stated that in 2014, GVSU was diverting 50% of waste away from landfills, and today that number is nearing 70%. This is a significant accomplishment when taking into consideration the large 25,000 student population plus faculty, and how much physical waste the 20% difference actually accounts for. When looking at how much physical waste is composted at GVSU, Jakobcic stated that in the 2020 fiscal year, 917 tons of waste was collected and sent to be composted. A major reason for such a large amount of diverted waste comes from the use of compostable cups, silverware, bags, and more that campus dining locations provide. This number will continue to rise as well, as students are continually becoming more educated and motivated to use the compost cans on campus.

A big part of this education surrounding composting on campus and what can and cannot be composted, comes from the helpful signs on all waste bins. These signs describe both in pictures and words whether an item can be composted, recycled, or put into the trash. This helps to clarify how waste should be sorted and encourages people to compost or recycle by reducing the doubt that waste is being put in the wrong can. However, some people may choose to ignore the signs or still feel unsure about trying to sort their waste, which is why GVSU also gets helps from the Green Team to help people out. The Green Team is a student organization that aims to help educate fellow students and reduce the uncertainty around waste sorting. These students stand at the waste bins and ask people if they need help sorting their waste as they approach the bins. By helping to clarify which items should be put into which bin, they hope to encourage people to build a habit of sorting their waste, as well as reduce the amount of waste that is put into the incorrect bins. The Green Team is especially sent out "at the start of the semester or if we notice there is a contamination problem in a certain area," according to Jakobcic. This makes sense as these are the times in which education on waste sorting is the most needed and useful. Another time in which the Green Team is extra helpful, is during the GVSU zero waste football games. These are games in which the goal is to produce zero waste that gets sent to landfills. Because of this goal, it is important that people understand what can be composted or recycled instead of being thrown away, which is why the Green Team plays such a big role at these special football games.

After composted is collected on campus, whether that be from football games, dining halls, or any of the other locations, it gets sorted to ensure that compostable and recyclable items were put into the correct bins. It then gets sent off to Cocoa, a large-scale compost facility which creates long windrows and uses a compost turner to create high quality compost. In addition, they screen their compost to make the final product finer so that it is a better planting medium and is more aerated which allows roots to grow more easily (Ly, 2013). Although the organic matter sent to Cocoa is not returned to GVSU as compost for the university to use, it is still very beneficial for GVSU and the environment. This is because the amount of compostable waste collected at GVSU that is turned into compost is far more than is needed on campus, and by giving away our compostable items to a compost plant, it allows those items to be diverted from landfills which is environmentally beneficial and sustainable.

Figure 1: *The Cocoa Process*

Note. A compost turner and windrows found at the Cocoa composting facility.

Another area in which GVSU is striving to be more sustainable is on the off-campus farm named the Sustainable Agriculture Project, or SAP. This farm was started in 2008 by six GVSU students in hopes to help educate other students on "agriculture practices that are ecologically durable, socially responsible, and economically viable" (Darwich & Eardley, 2015). The SAP has turned a once over-tilled, nutrient insufficient, and compacted soil area into a fairly healthy and nutrient filled ecosystem that is able to produce a plethora of crops through the use of sustainable farming methods. One of these methods that has been introduced in the last few years, is the addition of compost on the crop beds, which is produced in part by the SAP itself.

The SAP composts most of their waste, but in a much different way than how composting is done on campus. To find out more about the composting methods used on the SAP, I talked to the GVSU Farm Manager and Educator, Michael Hinkle. As of right now, the farm currently uses a mostly anaerobic composting method of having a pile of compostable materials in which more material is added to throughout the year. Although this pile is mostly anaerobic, Hinkle did note that it gets turned about once a year to encourage breakdown and to help shape the pile to look neater. The pile itself is made up of both food waste from produce grown at the farm, and plant materials such as weeds or dead crops. Because there is little brown waste in this pile, there is a lower Carbon to Nitrogen ratio, which causes the pile to decompose at a very slow rate as discussed above. The combination of the pile being mostly anaerobic and containing little brown waste results in little usable finished compost at the farm because of how long the decomposition process takes. Another way in which composting is done at the farm, is composting in place. This is when produce that can't be used or sold is left on the produce beds to decompose at a slow rate. Although this is beneficial to the soil as it is able to take back some of the nutrients that was given to the plant to make the food in the first place, it still produces little nutrients when compared to adding finished compost to the produce beds. To make up for the small amount of usable compost created at the farm, compost from another source is brought in to use on the crops. This compost comes from Top Grade, a company that provides soil and other aggregates for construction and agricultural projects.

Figure 2: *Composting at the Sustainable Agriculture Project*

Note. This is the compost pile that is currently being used at the SAP for crop and produce waste

Although the SAP has turned to outside help to keep up with compost needs at the farm, Hinkle mentioned that many different composting strategies have been used in the past to increase the creation of compost at the farm. Apparently, many composting interns at the SAP, along with students from some GVSU classes, have been tasked with coming up with and implemented their own composting strategies for the farm to use. Of the many composting bins and ideas that have been used, Hinkle states that only one strategy besides the anaerobic pile have really been effective and long-lasting, and that is a small vermicomposting bin. Although it is great to hear that at least one other form of composting has stuck at the farm, this composting method is also very small scale and can't keep up with the large amount of compostable materials that the farm produces.

When I asked why none of the other methods are being used that have been implemented in the past, Hinkle said that they have run into two main problems: permanence and size effectiveness.

When it comes to permanence of the farm and its operations, the farm doesn't always have the most control over what is able to remain where for an extended period of time as it is still quite young. Situational factors have caused many things on the farm to change location or change who manages what over the years. Because of this, it is hard to build a permanent structure for composting as it is unknown how long it will be allowed to stay there, and it is hard to ensure that it will be taken care of. Size effectiveness is another problem that needs to be taken into account when people are coming up with composting strategies. In order for composting to be done on a large scale and efficiently, it usually requires a large amount of labor and time compared to small scale composting strategies, as well as more input of monetary resources. On the other hand, most small-scale strategies started at the SAP can not keep up with the large compostable material created and are inevitably abandoned. Therefore, in order for composting strategies to be effective at the farm, they need to be big enough to keep up with the large amount of compostable material created, while still remaining small enough to need little labor, time, and monetary input, which could be used more effectively elsewhere on the farm.

Composting at Other Universities

Equipped with all the knowledge and research behind composting, many schools and universities have begun to implement composting methods throughout their campuses. Many campuses have introduced simple strategies such as providing composting bins at dining locations and in libraries to help divert waste from going to the landfill, or providing more education surrounding composting (Ecker & Yang, 2017). Although Grand Valley State University has implemented more than just this on their campus, two other universities here in Michigan that have taken composting a step further are Central Michigan University and Michigan State University.

Central Michigan University is a major leader in environmental sustainability and waste diversion on college campuses, receiving both state and national recognized awards, such as the national 2019 WasteWise College/University Partner of the Year Award given out by the U.S. Environmental Protection Agency (Johnston, 2020). One thing that makes this university really stand out is their waste sorting systems in campus dining locations. Not only do they have composting bins in all of their major dining locations such as Grand Valley State University, but that have put into effect a zero-waste program that allows them to either recycle, compost, or reuse everything that is used at these locations (Ecker & Yang, 2017). Although we have zero waste football games here at Grand Valley where we get close to diverting all waste from landfills, Central Michigan has taken this a step further and implemented the zero-waste mindset in their everyday dining operations that allows for complete diversion of all waste from landfills. Another exciting thing that Central Michigan University does to increase their effectiveness and usefulness of the compost they collect, is that they create a cyclical system where they receive some of their compostable materials back in the form of ready-to-use compost. They do this by partnering with an off-campus compost processing center where they send all of their compostable materials, and then they buy a portion of it back in the form of soil that is used all over campus for things such as gardens and even the marching band field (CMU, 2020). This cyclical composting process can be shown off in an educational and motivational way to students, as they are able to physically see the end product of their unfinished meal being turned into something useful rather than it just sitting in a landfill.

Michigan State University has also implemented some successful and efficient composting strategies on their campus. The main driving factor behind the composting strategies used at this university is the focus on reducing food waste in dining locations before students even have the opportunity to place their food into compost bins. One example of this is the implementation of what is called the “Clean Plates at State” waste management plan (Ecker & Yang, 2017). This plan focuses on educating and encouraging students to take smaller portions of food at first and then go back for more food if they are still hungry. The hope is that students will initially take less food and, therefore, will have less food to compost at the end of their meal compared to if they were given a bigger portion initially. This program has seen some positive results as there has been a reduction from an average of 3.16 oz. of food waste per person, down to 2.96 oz of food waste per person in the 2018-2019 school year (MSU, 2021). Yet another way in which they divert food from being composted, is by donating food that can no longer be sold at campus dining locations, but is still edible, to local food banks (Ecker & Yang, 2017). This not only helps support the local community, but also reduces the amount of food needed to be diverted to composting. Besides these diversion strategies, Michigan State also uses on campus composting methods such as anaerobic digesters and vermicomposting that produce finished compost that is used on campus and at the university farm (MSU, 2021). Excess compostable materials is also sent to a local farms rather than being sent to commercial compost businesses (MSU, 2021). Michigan State University is yet another great example of how cyclical composting within the university and surrounding community can be accomplished.

Proposed Improvements for Composting at Grand Valley and the SAP

Looking at the successful composting initiatives and strategies used at other universities, it is clear that Grand Valley has room for improving their own strategies. One way in which Grand Valley can do this is by finding a way to make the composting cycle come full circle where the products of the compostable items thrown into bins on campus can be used and seen by students. This not only is very sustainable and cost effective as compost or soil from other sources will not have to be bought for use on campus, but it will also help motivate students to compost more as they will be able to see how their compostable materials are actually being turned into something that is benefiting the school and overall environment. Some steps that might be taken to achieve this, is by first implementing a small-scale composting method such as an anaerobic digester or the three bin method on campus which could be taken care of by student volunteers or potentially by classes in an educational manner. Although funding and manpower may be problems that need to be addressed and overcome, I believe that if enough students and faculty are passionate about it, they can easily apply for grants for funding, and will be able to find volunteers to help out with these small-scale composting methods. There are many grant opportunities related to environmental sustainability found through websites such as the Environmental Protection Agency who are currently giving out the Environmental Education Grant, which could be applied for. Eventually, if enough interest and funding can be put together, larger scale compost windrows could be constructed and potentially maintained by a composting class through Grand Valley or through other volunteers. In fact, there is currently an excess of branches and leaves that are collected each year at Grand Valley that could be combined with the current food waste that is collect on campus, which could be used to create a successful and efficient large-scale composting system.

If this is not an option, Grand Valley could close the composting cycle another way by partnering with a compost processing plant that will sell back the compost made from the compostable materials that Grand Valley is collecting. Currently, the compostable materials collected at Grand Valley are sent to Cocoa, and the finished product is never seen by anyone on campus. If we could either purchase some compost back from them, or partner with a different composting plant in the area that is willing to sell compost to the university at a lower price, the students at the university will be able to see the complete cycle of compost. This will further encourage and motivate students to continue in their composting efforts on campus if they can see what their food scraps can be turned into.

Another thing that Grand Valley can do to encourage more composting and waste diversion on campus in general, is to implement only compostable, recyclable, or reusable materials in dining halls, and phase out the use of trash cans. This is currently being done in the dining halls at Central Michigan University, and they have seen much success in the decline of materials being sent to landfills. By not even having the option of sending items to the landfill, students will start to become more comfortable composting and recycling materials. This may also lead to students using these bins rather than trash bins at other locations around campus, due to them feeling more educated about what is able to be composted and recycled.

When it comes to composting at the SAP, the problem of a lack of a cyclical process and closing the composing loop is just as prevalent as it is on campus. If this can be fixed, the potential benefits that the SAP could see include reducing costs that come with buying compost from another source, turning current farm biomass waste into something usable, being able to have quality control over the materials put into the final compost product, and potentially selling excess compost for profit. Although the SAP has a small compost pile already, it is fairly ineffective in producing usable compost for the plants at the farm as it is mostly anaerobic and is very slow to decompose materials. However, this is a step in the right direction and has the potential to be turned into a much more efficient compost pile.

Some simple steps that could be taken by the farm to make their current pile more efficient include turning the pile more often, monitoring moisture of the pile, and monitoring the carbon to nitrogen ratio of the compost pile more effectively. By turning the pile more often, more oxygen will be able to be introduced into the pile which, as previously stated, helps speed up the decomposition process. When doing this, you are also able to assess moisture levels throughout the pile to make sure it is not too wet or dry, as well as have the opportunity to add more compostable materials to adjust carbon or nitrogen piles. The farm also already has a soil thermometer which can be used to monitor the temperature of the pile to help determine when the pile should be turned and when it is finished decomposing. Although this will take more effort than just throwing compostable materials into a pile, I believe the current compost interns could manage such tasks while at the same time making their position more effective, as they are currently coming up with new composting strategies that have historically failed to remain long-term at the farm.

I believe this proposed plan solves the problem of both permanence and size feasibility that the farm currently has. The permanence of the pile is not forever as it can be easily moved elsewhere, and no new construction or space is needed as a pile is currently already there. The size of the pile will also remain about the same as the same materials that are currently being put into the anaerobic pile would just be placed into this pile, so it should potentially be big enough to keep up with the amount of compostable material created at the farm. The only thing that may need to be added to the pile that currently isn't added to the anaerobic pile, is more dry materials such as paper, woodchips, or dry leaves which could be donated to the farm or potentially bought. This will help the decomposition of the pile go much faster, as well as decrease the acidity of the pile so that the finished protect will be ready to be used directly on the beds after decomposition is complete.

Another composting strategy that could be used at the SAP, is the use of inground anaerobic composting buckets. As discussed above, these covered buckets with holes in the bottom of them are placed in the ground, and compostable materials can continuously be added to them. Because this is mainly practiced around garden beds and is mostly used to improve soil quality underground rather than to create finished compost for the tops of planting beds, I propose that they could be installed around the current community garden beds. These beds are meant for surrounding community members and university students to have an area to plant their own crops and get involved and educated about sustainable farming. I also believe the soil would benefit from this continual influx of nutrients as it is unknow which crops will be planted in each bed from year to year, meaning the nutrients from some beds may be depleted more than others. This can also become an opportunity for those community members who own a bed for a season to place their own compostable materials from home into these buckets. This will mean that little to no labor will be needed to be done with this composting strategy besides the occasional removal of mostly composted scraps from the buckets if they become too full.

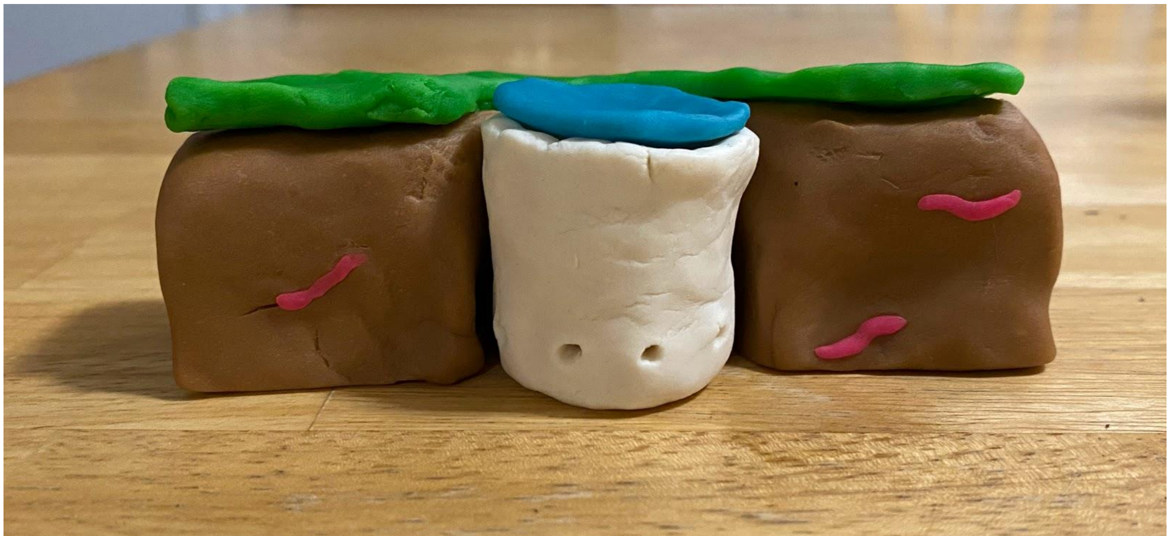
Conclusion

Composting is a very unique process as it can be composed from many different materials, can take on many different forms and sizes, and can undergo multiple different microbial processes which all slightly change the nutritious quality and speed at which the final compost material is produced. This can be both a beneficial and a hindrance as it allows both small-scale and large-scale production to occur, as well as allow for nutrient specific material to be produced. However, it can also result in ununiform end products, and potentially create the need for expensive equipment or large amounts of time to produce as much end product as one may need. Overall, the method of composting can be adjusted to satisfy the specific needs of each individual person and limit these potential drawbacks while making the process as efficient as possible.

When it comes to the benefits of composting, it is clear to see that it has the potential to be environmentally sustainable, improve soil structure and quality, improve plant quality, and be monetarily valuable in many ways. Although compost has the potential to contain heavy metals, high salt content, and produce methane gas, all of these factors can be somewhat avoidable if the compost system is treated in a specific manner.

After taking into account all that is known about composting and looking at effective strategies that other universities have in place, I was able to analyze the effectiveness of composting methods that Grand Valley currently has in place. Although it has come a long way from what it began and is making a real impact on campus, it is clear that there is room for improvement. On campus, slowing moving to a zero-waste platform in the on-campus dining facilities, as well as establishing a small-scale interactive composting area to spread awareness and education around composting, are steps that could be taken to close the compost loop and improve the current composting systems. At the Sustainable Agriculture Project, either making the current compost pile more efficient or installing inground composting buckets are two great ways to improve their composting systems.

Prototypes



This is a prototype for the Sustainable Agriculture Project. The prototype constructed out of playdough is supposed to represent an in-ground bucket that compostable items can be added to. The bin itself contains holes at the bottom to allow for the compost liquid remains to seep into the surrounding soil. It also allows for worms or other insects to move through and within the bin. This compost system is mostly anaerobic as no turning of the pile is needed and the lid of the bucket is always kept on. The top of the bin is level with the ground to avoid any tripping hazards. To further limit this tripping hazard, a sign could also be placed next to the bucket to make people aware of it. This system is very low maintenance as the bucket only needs to be taken out of the ground if it needs to be emptied. This will only happen if too much is put into the bin in too short of a time.

This is a prototype that could be implement for an on-campus composting system education example. This prototype constructed out of playdough is a replication of a triple bin system. To build this system, a wooden structure with two dividers is used to separate three potential piles of compost. The first slot is used for fresh compostable materials and the degradation process is usually not far along at this point. Turning of this pile is done every few days if possible. Once this first pile reaches the desired size, you stop adding fresh materials until the internal temperate reaches 150 degrees Fahrenheit. Next, the pile is moved into the second slot where it is able to receive an influx of oxygen and is able to continue to break down. Meanwhile, fresh compostable materials can now be added to the first bin again. Once the pile in the second slot has no recognizable food particles in it and has cooled down from hot to just warm, it can be moved into the third slot. While in this bin, the compost will continue to cool down as the composting processes has been completed and no more breaking down of organic materials is occurring. This finished compost can then be used on campus or given away to students.

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