Western Michigan University
Office for Sustainability

Krystal York
Sustainability Project Coordinator
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Western Michigan University

Aerated Static Pile Composting at the Gibbs Site

Introduction:

Composting is the aerobic decomposition of organic materials by microorganisms into a nutrient-rich, natural fertilizer (sometimes referred to as black gold). The organic materials can include vegetables, fruits, coffee grounds and filters, tea bags, bark and wood ash, egg and nut shells, yard clippings, manure (horse, cow, chicken, rabbit), and paper products. The food waste is usually referred to as nitrogen rich "greens" and the wood and paper products are usually referred to as carbon rich "browns." Some beneficial microorganisms including bacteria, fungi, molds, protozoa, actinomycetes, and other saprophytic organisms are mostly responsible for the initial breakdown of the organic waste, while slightly larger organisms such as mites, millipedes, centipedes, springtails, beetles, black soldier fly larvae, and earthworms can help further breakdown the materials faster. Aerobic decomposition means the organic materials decompose in the presence of oxygen and the microorganisms that are responsible for this process require oxygen. This process is faster and more efficient than its counterpart, anaerobic composting. Because of the need for oxygen, many composting methods incorporate some sort of aeration aid into the design. With the proper aeration, a compost pile should not smell bad, rather it should have an earthy smell. Several benefits come from the composting process such as saving landfill space, enriching soils, decreasing greenhouse gases, improving water quality, saving water, and even creating jobs [1-2].

There are several composting techniques including windrows, compost tea, vermicomposting, vertical flow, static piles, aerated static piles (ASP) [3], manure, and biochar. Before this semester, we composted using vermicomposting or static pile methods. Vermicomposting is the most commonly used indoor composting method that involves using worms to break down the organic waste. These are considered add-as-you-go type piles, where you add food scraps when available and cover them with shredded paper or other "carbon" products. Bigger systems such as windrows or ASPs are needed to increase the amount of food waste we can process. These are considered batch compost piles where you will have a large amount of brown and green feedstock. Other than being able to compost a lot of organic waste at once, another benefit for batch compost piles is that they heat up to much higher temperatures (~140° F is optimal). These higher temperatures are optimal for compost because it breaks down the pile faster and it will kill off most, if not all, unwanted pathogens. If a pile is getting too hot, you can aerate it more by either mixing it or pumping in air in the case of ASPs [3]. Lastly, for any pile, you want to make sure to regulate the moisture levels. A common check is that if you take a handful of the compost and squeeze it, you should see about 1-2 drops of water come out of it. Too wet of a pile usually means you have too many greens and you should add more browns. Excess greens will cause the pile to be smelly and the microorganisms can't digest all the food fast enough, so the excess is lost in the form of smelly ammonia gas. Too dry of a pile usually means you have too many browns and should either add greens or add some water. Too much carbon will cause decomposition to slow down. An adequate carbon to nitrogen ratio (C:N) is usually around one "bucket" of carbon to one "bucket" of nitrogen (by volume). The correct balance feedstock, temperatures, moisture, and oxygen will allow for the microorganisms to thrive, providing you with a wonderful composting product at the end of the process [1-2].

Methods and Results:

In the spring of 2020, we explored how to increase the amount of food scraps we could compost at the Gibbs site. To do this, I began to look into the aerated static pile (ASP) method. I learned about this method at the Association for the Advancement of Sustainability in Higher Education (AASHE) Conference, where I both presented about composting and attended talks on a wide range of sustainable topics. An ASP method is where you pump air through PVC pipes that are placed underneath your compost pile. Usually, the pumping of air only happens about 30 seconds to a minute every half hour. Those times can be adjusted according to the temperature and moisture as well as the stage (mesophilic, thermophilic, and curing) of the compost pile (Figure 1) [3]. A small ASP unit was built in the spring of 2020 (Figure 2). This was done to learn about ASP and train staff members on the process. Unfortunately, not much was learned from this pile because of the pandemic and it was left mostly unattended throughout the summer. I consider this set-up to be Version 1 of ASPs for the Gibbs site.

We have partnered with the biology department on campus to increase our soil testing capabilities and offer them educational experiences for their students. In the fall of 2019 and the spring of 2020, an introductory biology class dedicated one of their lab sessions to testing our compost product. This involved testing a sample from one of our vermicomposting bins and a sample from a static pile and comparing the results. Although this was put on hold during the pandemic, we are hoping to continue this when classes resume as normal.

Moreover, Aurora Morkis, a graduate student in the biology department, is basing her thesis on profiling the microbial communities in our compost using sequence analysis. This semester (fall of 2020), I helped her set up the experiment (Figure 3 and 4). She wanted to test the differences between an ASP and a regular static pile. To do this, we made two piles for each composting method and recorded temperature [4], pH [5], moisture [6], and atmospheric oxygen concentration [7]. The temperature, moisture, and pH readings were recorded by a Raspberry Pi microcontroller [8] and the oxygen readings were taken by hand. I helped Aurora by programing the Raspberry Pi to automatically take these readings (see the Python code in the Appendix). The ASP piles had the blower push air under the pile for about 30 seconds every half hour. Aurora then took samples of the soil about once a week to analyze them using data sequencing techniques. The experiment began on October 16th and lasted until the end of the semester. I consider this set-up to be Version 2 of ASPs for the Gibbs site.

I learned a lot more about ASP from this version than I did from Version 1. The three main take-aways I had were from observing the temperature data from the four piles over the course of the project (Figure 5):

1. The temperatures for the ASP piles (Bin 1 and Bin 2) were significantly lower than the temperatures of the two regular static piles (Bin 3 and Bin 4). This is due to the air being pumped underneath the ASP piles. Therefore, during the winter months, we should monitor the temperatures of ASP piles and decrease the amount of time the

blower is on. For this research project, the blower was kept consistent in order to decrease the number of variables.

2. The temperatures are highly dependent on the outdoor temperatures during the later compost stages (i.e., after the active phase). This is made evident by the data observed from November 3rd through November 10th when the peak outdoor temperatures remained between 18°C and 24°C (66°F and 76°F).
3. The highest temperature for any of the piles was about 36°C, which is not nearly as warm as the desired peak temperature of at least 60°C [3]. This might be attributed to the piles being smaller than desired. A larger pile means there would be more microbial activity and insulation, thus, making the temperatures higher. You could also surround the piles with insulating materials, such as straw bales, to increase the temperatures. Insulating would be less important in the summer months.

All of these considerations have been taken into account for the Version 3 of the ASPs for the Gibbs site.

Graphics/Charts/Pictures:

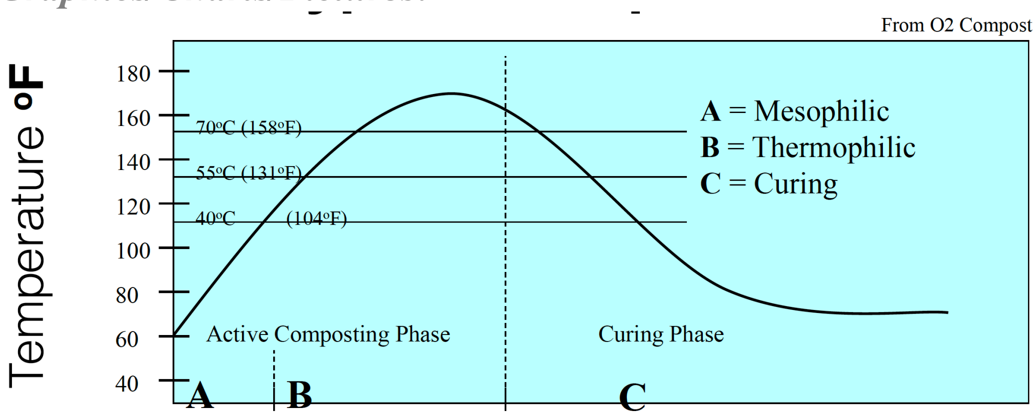

Figure 1: Temperature changes through the different stages in a typical compost pile [3].


Figure 2: Version 1 of an ASP.

Figure 3: Set-up for Version 2, aerated static pile project.

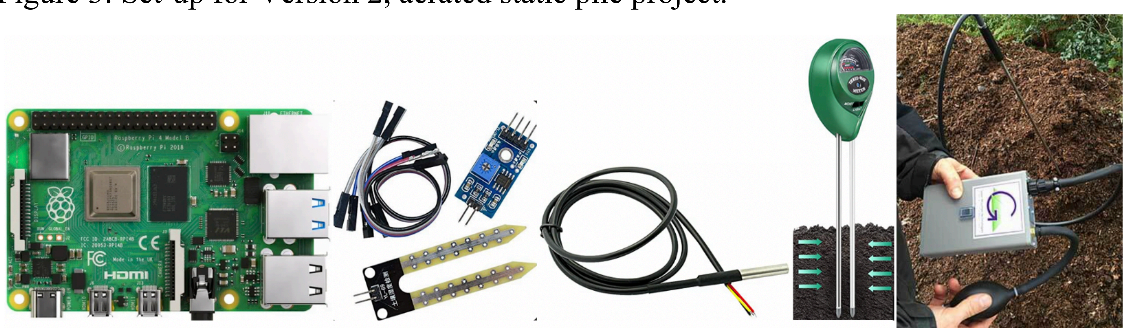

Figure 4: Microcontroller and sensors used for Version 2, aerated static pile project [4-8].

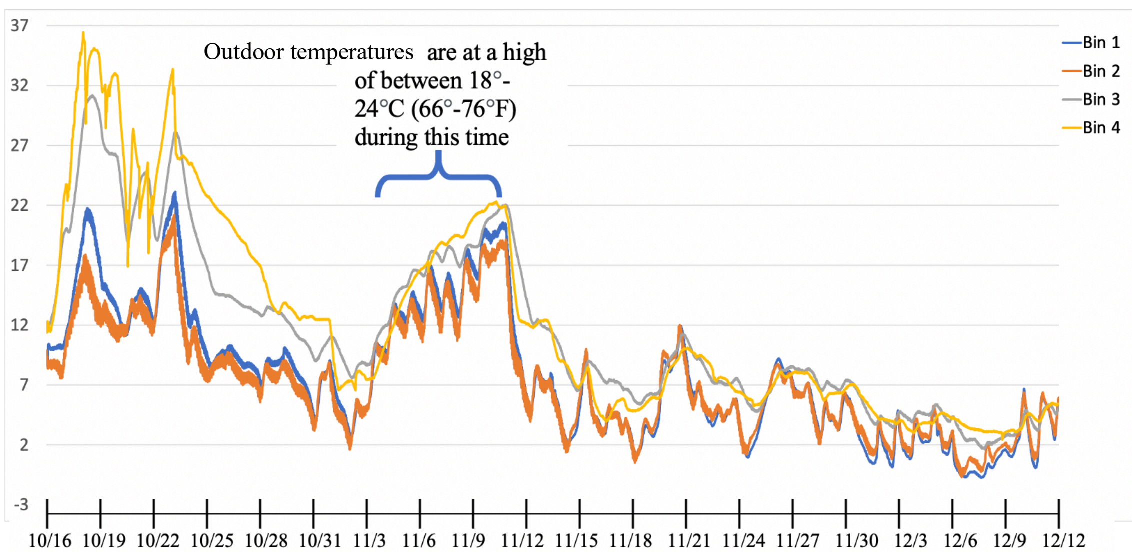

Figure 5: Temperatures (in Celsius) over the course of about two months of the four bins that were a part of the ASP composting project.

Next Steps:

This semester, I submitted a Student Sustainability Grant (SSG) for materials for a larger ASP system (Figure 6). This system will be made out of wood [9] and will have four separate piles. Each box (pile) will be 6x6 feet and will be 4 feet tall. This is the estimated amount of space needed to compost the food waste from the dining centers on campus. The blower [10] will be powered with a solar panel [11] and there will be sensors to record temperature [12] and moisture [13] automatically. We will test the final compost product either through our biology department or through Michigan State University's testing program [14]. The final compost product will be used around the Gibbs site, given to Landscape Services, and given to students and members of the community. I consider this set-up to be Version 3 of ASPs for the Gibbs site.

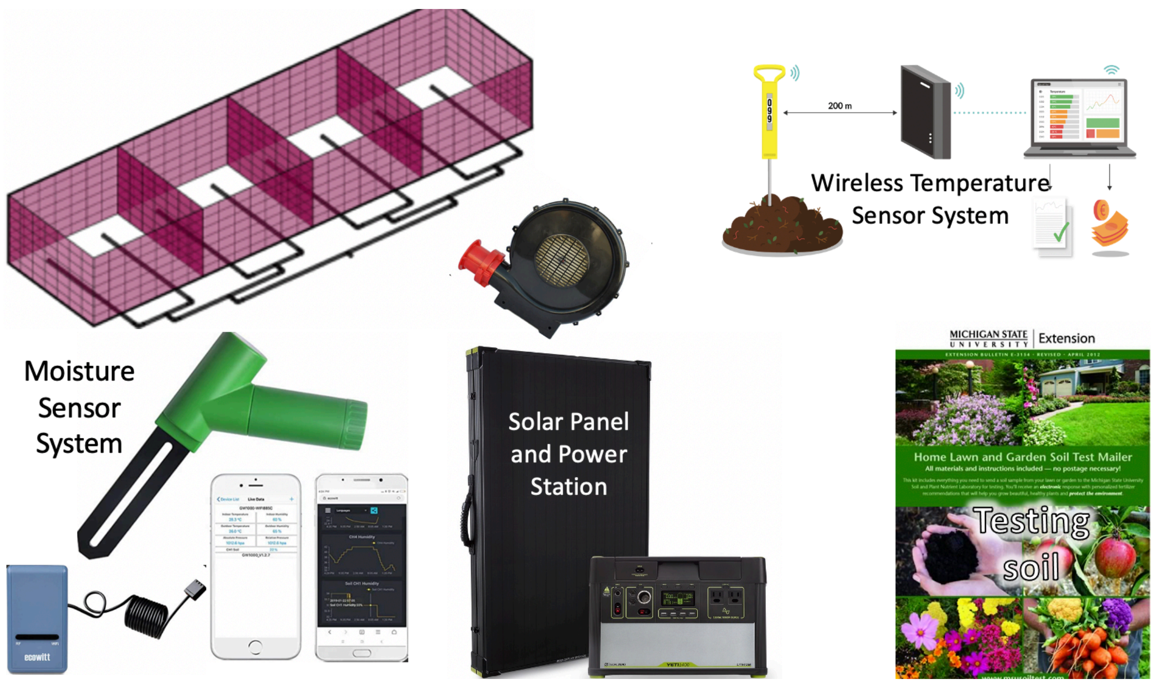

Figure 6: Set-up for Version 3 ASP that may be funded through the SSG [9-15].

References

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[2] http://www.homecompostingmadeeasy.com/index.html
[3] https://www.o2compost.com/aerated-composting-in-a-nut-shell.aspx
[4] https://www.amazon.com/Aideepen-DS18B20-Waterproof-Temperature-Stainless/dp/B01LY53CED?ref_=fsclp_pl_dp_5
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[13] https://www.amazon.com/ECOWITT-Moisture-Sensor-Humidity-Tester/dp/B07JM621R3/ref=pd_bxgy_img_2/138-5558864-1153262?_encoding=UTF8&pd_rd_i=B07JM621R3&pd_rd_r=4c0f4724-e66c-4aec-aebc-9f78f245a6df&pd_rd_w=4kF0e&pd_rd_wg=H6MS3&pf_rd_p=ce6c479b-ef53-49a6-845b-bbbf35c28dd3&pf_rd_r=AY1HJ6KFARHPV755HD7Y&psc=1&refRID=AY1HJ6KFARHPV755HD7Y
[14] https://shop.msu.edu/product_p/bulletin-e3154.htm
[15] https://conscious-compost.com/designing-and-building-small-scale-asp-systems/

Appendix

Code for temperature and moisture:

```
from subprocess import call
import sys
import math
import os
#from gpiozero import DigitalInputDevice
import busio
import digitalio
import board
import time
import datetime
import adafruit_mcp3xxx.mcp3008 as MCP
from adafruit_mcp3xxx.analog_in import AnalogIn
import glob
import RPi.GPIO as GPIO

base_dir = '/sys/bus/w1/devices/'
device_folder = glob.glob(base_dir + '28*')[0]
device_file = device_folder + '/w1_slave'
file1 = open("/home/pi/temp_data.txt","a+")
file2 = open("/home/pi/moisture_data.txt","a+")
# create the spi bus
spi = busio.SPI(clock=board.SCK, MISO=board.MISO, MOSI=board.MOSI)
# create the cs (chip select)
cs = digitalio.DigitalInOut(board.CE0)
# create the mcp object
mcp = MCP.MCP3008(spi, cs)
# create an analog input channel on pin 0
chan = AnalogIn(mcp, MCP.P0)

def read_temp_raw():
    fi = open(device_file, 'r')
    lines = fi.readlines()
    fi.close()
    return lines

def read_temp():
    lines = read_temp_raw()
    while lines[0].strip()[-3:] != 'YES':
        time.sleep(0.2)
        lines = read_temp_raw()
    equals_pos = lines[1].find('t=')
    if equals_pos != -1:
        temp_string = lines[1][equals_pos+2:]
        temp_c = float(temp_string) / 1000.0
        temp_f = temp_c * 9.0 / 5.0 + 32.0
        textdata=str(temp_c)
        file1.write(date_time+'\t'+textdata+'\n')
        file1.flush()
        return temp_c, temp_f

while True:
    date_time = time.strftime("%a\t%d\t%m\t%Y\t%H\t%M\t%S")
    read_temp()
    print('Raw ADC Value: ', chan.value)
    print('ADC Voltage: ' + str(chan.voltage) + 'V')
    raw_adc_value = str(chan.value)
    moisture_level = str(chan.voltage)
    moisture_convert = -24.4541700028*chan.voltage*chan.voltage*chan.voltage + 174.0052979493*chan.voltage*chan.voltage -
421.8185513328*chan.voltage + 375.7250828068
    moisture_percentage = str(moisture_convert)
    file2.write(date_time+'\t'+moisture_level+'\t'+raw_adc_value+'\t'+moisture_percentage+'\n')
```

```
    file2.flush()
    time.sleep(600)
```

Code for pH:

```
from subprocess import call
import sys
import math
import os
import busio
import digitalio
import board
import time
import datetime
import adafruit_mcp3xxx.mcp3008 as MCP
from adafruit_mcp3xxx.analog_in import AnalogIn
import glob
import RPi.GPIO as GPIO
import dropbox

GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)
GPIO.setup(18,GPIO.OUT)

    # Read in file and upload
def upload_picture():
    TOKEN = 'C-9FH5Pk3WkAAAAAAAAAAZAFZnSbl0D_lc-oEFLQDVBHLmjjAiiu8tPFemrtJwo5'
    dbx=dropbox.Dropbox(TOKEN)
    dbx.users_get_current_account()
    with open(file_name, 'rb') as file3:
        dbx.files_upload(file3.read(), uploadPath)

while True:
    time.sleep(1)
    GPIO.output(18,GPIO.HIGH)
    time.sleep(1)
    date_time_2 = time.strftime("%a_%d_%m_%Y_%H_%M_%S")
    os.system("raspistill -o /home/pi/picamera/" + str(date_time_2) + ".jpg")
    time.sleep(1)
    GPIO.output(18,GPIO.LOW)
    file_name='/home/pi/picamera/' + str(date_time_2) + '.jpg'
    uploadPath = '/' + str(date_time_2) + '.jpg'
    upload_picture()
    time.sleep(10800)
```