Advances in Biology Laboratory Education
Publication of the Association for Biology Laboratory Education
Volume 43, Article 39, 2023

Composting – a sustainable activity for environmental sampling of microorganisms

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Composting is the biological decomposition of organic matter. Although a naturally occurring process, composting can be accelerated by active management to balance the ratios of organic inputs, moisture, oxygen, mechanical mixing, and heat. This balance ensures the diversity and abundance of organisms to optimize the degradation of organic substances during composting. Microorganisms such as bacteria, including actinomycetes, and fungi underlie the decomposition process. Composting is organic recycling that reduces our ecological footprint by diverting waste from landfills where it would break down anaerobically producing the greenhouse gas methane, and instead provides rich organic nutrients for regenerative agriculture, gardening, water filtration, and erosion control. This laboratory exercise is a multi-week project during which upper division microbiology students contribute household compostable materials, record weights and types of those inputs, and compost them in tumbler-style bins. This part of the activity adds relevance for the students, gives them an overall picture of the composting process, and introduces them to food waste and sustainability. For the laboratory portion, students hypothesize relative types, diversity, and abundance of microorganisms in typical household soil and two different compost samples. Extracts of microbial cells from these substrates are serially diluted and grown on selective agar plates to determine the number and diversity of colony-forming units (CFUs). At the end of the project, students visually inspect the compost outputs and reflect on the reduction in materials, ecological cycling, and impacts of composting food waste on their ecological footprints.

Keywords: compost, microbiology, environmental sampling, ecological footprint, sustainability, food waste

Introduction

This laboratory exercise introduces students to, or reminds them of, the importance of microorganisms in the aerobic decomposition of organic matter. Students gather, describe, and compost their own household food waste most of the semester to offer personal relevancy and provide them the larger picture of food waste, composting, and sustainability. Over three lab sessions, they also focus on cultivating and enumerating microorganisms from compost and soil samples. Students ultimately observe that total heterotrophs (i.e., primarily bacteria, but also fungi), actinomycetes (filamentous bacteria), and fungi are 10x-100x or more higher in abundance when evaluating active compost compared to typical (e.g., lawn) soil. Other learning objectives include the review of microbiological techniques (aseptic, serial dilution, plating, plate counts), understanding composting as a sustainable activity, and awareness of their own ecological footprint that comes from their food, landscape,

and paper waste. The learning outcomes and objectives, as we have implemented the activities so far, are listed on the student handout.

The lab is easily adaptable. It could be modified to be as short as a 2-lab activity or as long as a semester-long project. It could be converted to a more inquiry-based setup where lab groups form hypotheses and test these through collection of data from various compost/soil treatments. Independent variables could include open-air versus tumbler compost bins, turned versus unturned piles, food waste versus yard waste of the same weight, watered versus unwatered compost bins, time 1 versus time 2, and many more. Each group, or those lab groups with research questions that relate, could alternatively collect data besides microbial density and relative diversity. These new dependent variables could include pH of different treatment piles, nitrate levels, phosphorus levels, temperature, final weight over time, genus- or species-level identification of microorganisms through DNA typing, and many more. As another alternative for a multi-week lab, students could take samples of two or more compost setups at 30, 60, and 90 days from the start of the bin to look at a succession of the microbial community in these substrates over time. Instructors are cautioned, however, that starting compost from scratch at the beginning of the semester is unlikely to yield finished compost by the end. Relying on starter inputs from campus food services and managing green:brown ratios (i.e., nitrogen:carbon), moisture, and mechanical mixing, are more likely to lead to a productive pile in a semester-long course.

Instructors can learn more about composting from their county extension offices, some of which even have *master composter* programs, the US Composting Council (www.compostingcouncil.org), the Institute for Local Self-Reliance (www.ilsr.org), and the Environmental Protection Agency's Sustainable Management of Food pages (e.g., www.epa.gov/sustainable-management-food/reducing-impact-wasted-food-feeding-soil-and-composting). An overview of microorganisms in compost can be found at compost.css.cornell.edu/microorg.html, and an example of a peer-reviewed article to read is Partanen et al. (2010).

Student Outline

Learning Objectives

1. Review microbiological lab techniques
2. Learn microbiological sampling techniques from soil and compost substrates
3. Compare and contrast density and diversity of microorganisms in soil and compost
4. Relay the impact of composting as a landfill diversion and climate change mitigation activity

Student Learning Outcomes

1. Demonstrate the microbiological lab skills of aseptic technique, serial dilutions, plating, and plate counting
2. Estimate the relative abundance and community structure of *fungi, bacteria, and actinomycetes* from various soil and compost substrates
3. Explain how their choices about composting and food waste impact their ecological footprints
4. Describe the importance of organic material and microorganisms to overall soil health
5. Reflect on their and their communities' perspectives on sustainable choices

Overview of Composting, Microorganisms, and the Decomposition Process

Composting is the biological decomposition of organic matter (Dickson, *et al*., 1991). Although a naturally occurring process, decomposition and composting can be accelerated by active human management. Composting transforms yard, garden, and food waste into *soil-like* material suitable as an amendment for plant growth and other uses. Composting is considered the fifth tier of the EPA's Food Recovery Hierarchy, applied in an effort to maximize food production and utilization while eliminating energy-intensive landfill *and/or* incineration of household wastes (EPA, 2022). The benefits from composting and subsequent use are vast, including rapid turf establishment and weed suppression along roadways, decreasing phosphorus run-off and eutrophication, suitable alternative to chemical fertilizers for commercially grown flowers and other agricultural crops, and reduction of both human and plant pathogens during the composting process (Michel, 2011). During a year-long pilot study, composting kept an average of 996 pounds of waste destined for the landfill per household as part of the North Shore Recycling Program in British Columbia, Canada (Leboe, 2011). From a broad human perspective, composting is an easy way for informed citizens to reduce their overall ecological footprint – their demand on nature.

Decomposition involves the innate abilities of microorganisms to degrade organic substance into simple organic matter. As part of nutrient cycling, decomposition is critical for the recycling of organic matter that occupies the physical space in a given environment. As part of the physical space, the ecological footprint is the impact of human activities measured in terms of the area of biologically productive land and water required to produce the goods consumed and to assimilate the wastes generated (World Wide Fund for Nature, 2020). In terms of limiting our ecological footprint on the environment, people have turned to an ancient form of recycling organic wastes known as composting. Composting involves the decomposition of generated organic waste such as green waste (*including grass clippings and leaves*), paper waste (*newspaper, printer generated paper, and cardboard*), and food scraps (*from preparation and consumption of meals including leftover fruits, vegetables, coffee grounds, and bread*). Each of these generated organic wastes are typically fated for disposal in the landfill. However, decomposition *and* composting of organic wastes is relatively easy to accomplish, produces nutrient rich soil amendments for later use, and decreases the ecological footprint on the environment by limiting the amount of waste entering our landfills. In landfills, this organic waste takes longer to break down, and due to lack of oxygen, are decomposed through anaerobic processes producing the more powerful greenhouse gas, methane.

Microbial activity is essential for the biodegradation of organic substances and waste that drive the composting process. In terms of numbers, fungi are the most abundant aerobic eukaryotic organisms in soil environments. Growing from hyphal fungal cells, fungi spread in a filamentous manner to support heterotrophic lifestyles. Fungi offer excellent decomposition and nutrient cycling roles in soils. Similar to fungi, bacteria and actinomycetes are the most abundant prokaryotic organisms in soils. In a typical gram of soil, 10,000 different species of bacteria may be represented. Bacteria are very metabolically diverse and can thrive in most terrestrial environments. Actinomycetes are a group of prokaryotic organisms that exhibit filamentous cell growth like fungi. Like fungi, both bacteria and actinomycetes are important in nutrient cycling, biodegradation of organic substances, and are functionally important for alternative recycling efforts including composting. From a composting overview, bacteria are the first major community members early in the decomposition process, followed by actinomycetes and fungi in terms of abundance, respectively.

This laboratory exercise will last the entire semester due to your weekly donations of compostable material, though the in-lab activities will take place in two lab periods. You will collect your own household compostable waste, record the types of waste generated, weigh the overall amount of waste, and place the waste in a suitable compost treatment. Each group will take turns aerating the compost by physically moving the organic material (pitchfork for open bins, turning for the compost tumblers) and noting any observations about temperature, smell, or composition. For the in-lab activities, either this compost that you're making and/or finished compost produced by a local, commercial compost facility, will be used for our substrates to cultivate, and enumerate microorganisms.

Methods and Data Collection

Every Week

- You will collect your food/paper household waste in class-provided compostable bags. This material should be food waste (fruits, veggies, grains; but not meats, fats, oils, dairy) and paper waste (shredded paper, paper towel rolls). Once a week, at each lab, you will weigh your bag containing compostable waste and record in a class lab notebook or Google Sheet. The bags will be collected in a bucket in lab, to be taken out to the compost bins by the biology greenhouses by the assigned lab group.
- Each lab group will rotate through "compost duty" on their assigned weeks. They will take the compost bags out to the bins, inspect, and make notes about the open-air and barrel bins (odor, composition, moisture, temperature), and aerate the organic material.

Lab Exercise 1: Sampling Soil and Compost Substrates for Microbes

Estimating the abundance of bacteria, including actinomycetes, and fungi can be accomplished by extracting cells from soil/compost samples, serially diluting those extractions, and growing the cells on selective agar plates. The number of colony-forming units (CFUs) on those plates will then be counted to calculate the microbial abundance per gram of the original substrate material. Selective media include plate count agar (*for general bacteria*), casein-glycerol agar (*for actinomycetes*), and Rose Bengal chloramphenicol agar (*for fungi*). Relative abundances and community structure of various substrates will provide insights towards understanding the environmental conditions and overall ecology of soil and compost.

<u>Microbial Extraction, Dilution, and Growing</u>

1. Extract 10 grams of compost material from each of the provided treatments (*fresh, wet material* of soil and two types of compost), unless your instructor is splitting samples across lab groups. Working aseptically (Bunsen burner on, working in the cone of sterility), place **10 grams** each material in separate labeled 250 ml flasks, add **95 ml** of extraction buffer to each, and rotary shake the flasks for one hour at 120 rpms. The original samples have now been diluted to 1/10 or 10^{-1}.
2. The resulting extracted compost/soil materials can now be serially diluted by removing **<u>1 ml</u>** from the shaken flask into a test tube containing 9 ml of Butterfield's dilution buffer and mix. Proceed by removing 1 ml of diluted solution from that first test tube and add it to 9 ml of dilution buffer in the subsequent test tube, then mix. Continue to the 5th test tube (Figure 1). You should now have the following dilutions: the original shaken flask (10^{-1}), 10^{-2} dilution, 10^{-3} dilution, 10^{-4} dilution, 10^{-5} and 10^{-6} dilution.

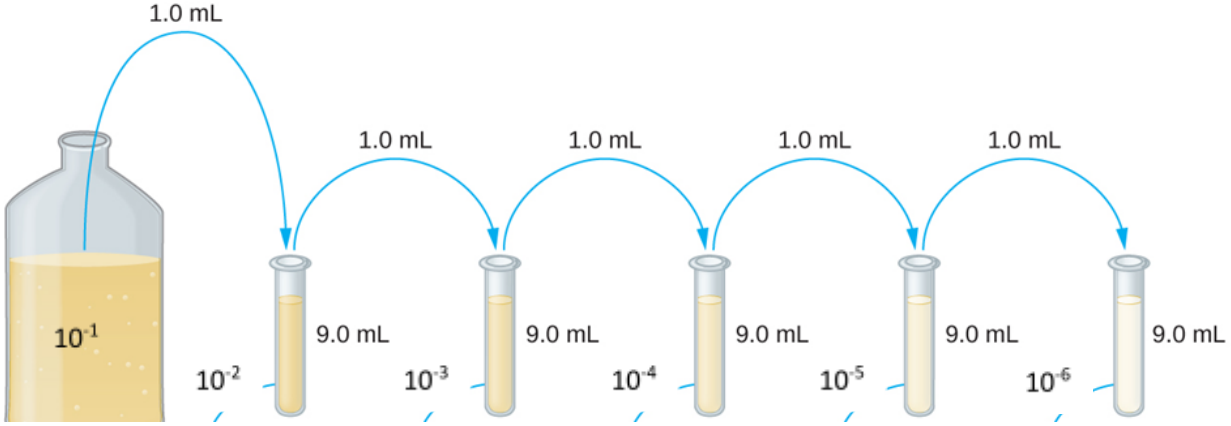

Figure 1. Serial dilution from compost/soil extract at 10^{-1} dilution down to 10^{-6} dilution. Source OpenStax: Microbiology

3. Repeat this serial dilution process for the other 2 samples of your soil/compost, unless your instructor has split samples across groups.
4. For each compost/soil treatment, spread plates will be inoculated in triplicate for 3 different dilutions. This is so that during next lab, you can take the average of the three plates' CFUs to better estimate microbial abundance. Therefore, a total of 27 plates are generated to enumerate bacteria (9 plates), actinomycetes (9 plates), and fungi (9 plates) for EACH of the compost/soil samples. Prepare by labeling the bottom of each plate. The result will be 81, labeled plates, unless your lab instructor is splitting samples between groups.
    a. For bacterial media: 10^{-4} dilution (x3), 10^{-5} dilution (x3), and 10^{-6} dilution (x3)
    b. For actinomycete selective media plates, label for 10^{-3} dilution (x3), 10^{-4} dilution (x3), and 10^{-5} dilution (x3)
    c. For fungi-selecting media plates, label for 10^{-3} dilution (x3), 10^{-4} dilution (x3), and 10^{-5} dilution (x3).
5. Working aseptically, extract **<u>0.1 ml</u>** from the MOST diluted tube mentioned above and transfer it onto the appropriately labeled plate, then spread with a hockey stick (Figure 2). Do the same for the other 2 duplicates. Continue to the other growth media with the same dilution. Next, move to the middle dilution (you can use the same pipette and hockey stick because they are 10-fold more concentrated) in triplicate for all 3 media, then move on to the LEAST dilute. Repeat with new pipette and sterilized hockey stick for the 2nd then 3rd substrate sample dilutions, unless your lab instructor is splitting up samples between groups.

Figure 2. Spread plate method using a "hockey stick" spreader with one of the bacterial dilutions. Source https://microbeonline.com/spread-plate-technique

6. Turn plates upside down to be incubated at room temperature (~25°C) for 5-7 days.

Lab Exercise 2: Evaluating Microbial Abundance and Diversity in Soil and Compost

<u>Enumerating Microbes and their Diversity</u>

After plates have been incubated for sufficient time, count the colony forming unit (CFUs) on each of your plates and record the results (Table 1). Each colony of cells theoretically arose from a single microbial cell, so it is appropriate to represent total colony numbers as equivalent to individual cell numbers – bacteria, actinomycetes, or fungi. Only use the plates that yielded between 30-300 CFUs. On your datasheet, average the number of colonies from the 3 replicate plates to estimate the CFU number for that dilution of that sample on that media. In addition, make note of the diversity of appearance (color, texture, shape) of the growing cells on the plates, including how many CFUs of each.

To determine the density of microbes per gram of original substrate sample, you will multiply the average CFUs by the inverse of the dilution:

Number of CFUs = (1 / dilution factor) X number of colonies

<u>Example</u>: 200 CFUs were counted on the 10^{-5} dilution
# of CFUs = (1 / 10^{-5}) / 200 CFUs = (1 / 0.00001) / 200 CFUs = 2.00 X 10^{7} CFUs / g of wet soil
or # of CFUs = (1x10^{5}) X 200 CFUs = 2.00 X 10^{7} CFUs / g of wet soil

Table 1. Colony Forming Units (CFUs) of soil and compost samples on three selective media across three dilutions

Substrate Sample: ________________

	Dilution:______			av g	**Dilution:______**			av g	**Dilution:______**			av g
Media: ___________	Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3	
Media: ___________	Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3	
Media: ___________	Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3	

Substrate Sample: ________________

	Dilution:______			av g	**Dilution:______**			av g	**Dilution:______**			av g
Media: ___________	Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3	
Media: ___________	Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3	
Media: ___________	Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3	

Substrate Sample: ________________

	Dilution:______			av g	**Dilution:______**			av g	**Dilution:______**			av g
Media: ___________	Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3	
Media: ___________	Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3	
Media: ___________	Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3		Plate 1	Plate 2	Plate 3	

Laboratory Exercise Questions

In your final lab report where you explain how you carried out this lab, the data you collected, and your interpretation of the data, be sure to also answer these content-related questions in your discussion section:

- How would you summarize the appearance, odor, and temperature of the composting materials over time?
- How many bacterial, actinomycetes, and fungal cells per gram of compost and soil material were estimated? Are there differences across the 3 substrate samples? Why or why not?
- What roles do bacteria, actinomycetes, and fungi provide in the environment? Why are they important in the composting process and in healthy soils?

R*eflective Questions and Thoughts*

You should also include a reflections section in your report where you consider your perspectives of environmental health and sustainability, giving evidence of the level of transformative growth you may have experienced, to be recorded on your Student Transformative Learning Record (STLR). To assist you in reflection, please respond to 3 or more of these prompts:

- What was the most surprising or upsetting thing you learned about composting?
- How easy *or* hard is it for you to start or continue composting where you live and why?
- If you compost, what motivates/will motivate you to keep doing it?
- What additional experiments or information would you need from this lab to enhance your motivation to compost on your own?
- What would you say to someone who wonders if composting is "*worth it?*"
- Reflect on the amount of household waste that you generate in your daily life. How much of this material could be diverted from the landfill, where it would produce greenhouse gases, through composting? How much material did you add to the compost treatments, and what impact did that have on your ecological footprint?
- What are the implications of depleting soil health on human nutrition and health, and how does that make you feel?

Cited References

Dickson N, Richard T, Kozlowski R. 1991. Composting to reduce the waste stream – a guide to small scale food and yard waste composting. NRAES-43 (Northeast Regional Agricultural Engineering Service). pgs. 52.

EPA (Environmental Protection Agency). 2022. Reducing the impact of wasted food by feeding the soil and composting. Sustainable management of food. https://www.epa.gov/sustainable-management-food/reducing-impact-wasted-food-feeding-soil-and-composting.

Leboe, E. 2011. Value and benefits of backyard composting. BioCycle. 52(10):35-37.

Michel, F. 2011. Composting yields blend of benefits and challenges. Compost Science and Utilization. 19(3):145.

Student Transformative Learning Record. 2022. University of Central Oklahoma. https://stlr.uco.edu.

World Wide Fund for Nature. 2020. Ecological Footprint. https://wwf.panda.org/discover/knowledge_hub/all_publications/ecological_footprint2

Materials

- Substrates for sampling:
    - At least one source of soil (e.g., campus grounds, student yards) and two sources of compost (best if you can provide one vegetable-based and one manure-based to have differing samples). Each group only needs 10 grams of each substrate, and we have them collect them in ziplocks, if they are providing samples, assuming that is fairly sterile.
    - If you are making your own compost (e.g., semester-long project), you'll need access to at least 2 compost bins (open air, barrel tumblers, vermicompost bins) to make at least 2 different types of compost to compare. If students are only contributing kitchen waste ("greens") you will need to mix in at least double that weight in "browns" (shredded leaves, sawdust, paper towel rolls, etc.) to have a good nitrogen:carbon ratio. If each group is making their own hypotheses, having more of each or more types is preferred to give them options for their research questions.
- 250 ml flask: Three per group for their soil/compost extraction of their three substrates, unless you are assigning just one or two substrates per lab group to cut down on number of prepared plates.
- Test tubes: We give each group a set of 18 test tubes that have 9 ml of Butterfield's dilution buffer so they can serially dilute their three samples from 10^{-2} to 10^{-7} for later plating. Or if each group only has 1 substrate, 6 test tubes (or even just 5, if only diluting to 10^{-6}) will work.
- Compost/soil extraction buffer:
    - Soil extraction buffer reduces negative charges associated with clays, liberates soil organic matter, and reduces osmotic shock during extraction.
    - Here is the formula P. Olson created: 0.1% (1 g / L) sodium hexametaphosphate, 0.1% (1 g / L) sodium pyrophosphate, 0.1% (1 g / L) monobasic potassium phosphate, 0.1% (1 g / L) dibasic potassium phosphate.
    - If you do not have access to sodium hexametaphosphate (= Calgon soap at the store) or sodium pyrophosphate – don't worry about. Just make some kind of phosphate buffer (e.g., 3 grams of any potassium phosphate in a liter of water = 0.3% solution).
- Rotary shaker: 60 minutes at 120 rpms for the *soil/compost – extraction buffer* in the 250 ml flasks, releasing more cells into solution (separated from soil/clay). Alternatively, students can periodically "swill" their solution by hand over a 60-minute period.
- Butterfield's dilution buffer: Reduces cellular osmotic shock during serial dilutions
    - Stock = 34 grams monobasic potassium phosphate, 175 ml sodium hydroxide, 825 ml water.
    - Dilution buffer = 1.25 ml of stock / L
    - Labs routinely use sterile water for dilutions. That's fine as well, just perform dilutions and spread plates in an efficient manner (i.e., go quickly).
- Petri dishes: 81 plates (3 treatments x 3 media x 3 dilutions x in triplicate) per lab group, to inoculate in triplicate from each of 3 dilutions on each of the selective media types from each of 3 substrates
    - Alternatively, if the whole class is using the same 3 samples of compost/soil that you provide, you could have them pick, or assign them, a certain treatment, media, or dilution and combine data as a class to get the microbial density across all treatments.
    - Alternatively, if lab groups are making their own hypothesis and experimental designs, they may only do duplicate plating, decide to try different media, or have fewer or more treatments, requiring different numbers/types of plates.
- Growth media for plates:
    - Plate count agar; Nutrient Agar, or Tryptic Soy Agar are alternatives to Standard Methods Agar (Plate Count Agar)
    - Any fungal media (e.g., Rose Bengal chloramphenicol agar)
    - A casein-glycerol agar; I now use Actinomycete agar**.**
- Petri dish spreaders: One reusable L-shaped (hockey stick) spreader per lab group
- Bunsen Burner and igniter: Each group will need to work in a "zone of sterility" within 12 inches (30 centimeters) of the burner during the plating of dilutions.
- Pipettes: At least 6 pipettes with pipette pump, or 6 micropipette tips with pipettor, per lab group, with capacity in the 0.1 to 1 ml range.

- Alternatively, if the whole lab is using the same 3 samples of compost/soil and pooling data, they may only need 2 (one for serial dilutions, strongest to weakest) and one for plating (weakest to strongest).
- Alternatively, if lab groups are making their own hypothesis and experimental designs, they may require different numbers of pipettes to maintain aseptic technique.

Notes for the Instructor

During the lab, we usually work out some of the math on the board to explain the dilution factors -- putting 10g of soil/compost in 95 ml of extraction buffer gives you a 10^{-1} dilution, so then taking 1 ml from that to put in the 9 ml of Butterfields in the first test tube gives you a 10^{-2} dilution.

We typically guess on the correct dilutions for the microorganisms to actually plate. For compost and "healthy soil" plate from the following higher dilution tubes:

- For fungi and actinomycetes: add 0.1 ml from the 10^{-4}, 10^{-5}, and 10^{-6} dilution test tubes.
- For bacteria: add 0.1 ml from the 10^{-5}, 10^{-6}, and 10^{-7} dilution test tubes. NOTE HERE: that even though the lab called for diluting to 10^{-6}, we have often found that the bacteria need to be even more dilute to get usable CFU counts. It will depend on the health of your compost samples.

Just before they plate, so that they label the plates correctly and to reiterate the importance of labeling, I remind students that when adding 100 µl from the test tube to the prepared plates and spreading the diluted cells, you will be introducing an additional 1/10 dilution overall. Therefore, when they spread 100 µl from the 10^{-7} dilution tube it is considered a 10^{-8} dilution on that plate for counting purposes.

Regarding enumerations, I don't worry about a "water moisture correction factor" - basing the enumerations on the same amounts of compost or soil based on dry weight. This is because the results are still able to show higher density of microorganisms in compost than soils even when I don't have them do this. You could introduce it, mention it, or be ready to answer their questions about it.

For this lab, students are expected not just to learn about microbiology, but to reflect on their own food or organics waste that they send to that landfill, that could otherwise be composted by these microorganisms to create a nutrient-rich soil additive. This learning objective is tied to our campus-wide Student Transformative Learning Record (https://stlr.uco.edu) that helps us meet our mission of providing transformative learning experiences to all our students. For that reason, the final lab report includes both evidence of growth in the students' understandings of the microbiology content, but also evidence of how much they did or did not expand their perspectives in one of our campus transformative learning tenets (Health & Wellness, in particular on environmental health).

Grading Rubrics

Assignment Rubric	**Mastery** – Exceed General Expectations	**Adequate Effort** – Met Most Expectations	**Less than average** effort compared to expectations	**Minimal *to* no effort** to address expectations
Content Development (80% of points)	Demonstrates **comprehensive understanding** and attention to detail. *28-25 pts*	Demonstrates **adequate consideration** to the concepts. *24-21 pts*	Demonstrates **some awareness** to concepts. *19-15 pts*	Demonstrates **minimal *to* no effort** to the overall concepts. *14-0 pts*
Conventions, syntax *and* mechanics (20% of points)	**Skillfully communicates** with clarity and fluency and is virtually error-free. *7-6 pts*	Uses **straightforward language** to convey the general meaning, with few errors. *5-4 pts*	Uses **constrained language** to convey general meaning, with some errors. *3-2 pts*	Uses **minimal *or* no language** to convey the general meaning because of repetitive errors. *1-0 pts*

STLR STUDENT TRANSFORMATIVE LEARNING RECORD

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Tenet	Transformation	Integration	Exposure	Not Achieved
	The student provides strong evidence of profound growth *or* **major shift in values, beliefs, *or* perspectives** in holistically changed personal choices *for* sustainable living due to this lab work. Or, the students is now passionately educating others about the impact of food waste on our ecological footprint.	The student clearly articulates an **understanding** of personal choices, awareness of their ecological footprint *and* the roll that waste reduction *and* composting can have on the environment due to this lab activity. Or, the student is critically questioning and planning shifts in their personal choices towards a sustainable lifestyle through actions such as composting.	The student has an **awareness** of the composting process *and* consequences of household waste in their daily life on the environment. Additionally, the student presents a **willingness** *and* is developing an understanding of how our personal choices impact the overall environment.	The student did not participate in the lab and/or has not yet provided evidence of openness to or awareness of the how composting is connected to environmental health. Or the student has constricted their perspective on how personal choices impact environmental health.

https://stlr.uco.edu

Cited References

Partanen P, Hultman J, Paulin L, Auvinen P, Romantschuk M. 2010. Bacterial diversity at different stages of the composting process. BMC Microbiology, 10(1):1-11.

Student Transformative Learning Record. 2022. University of Central Oklahoma. https://stlr.uco.edu.

Acknowledgments

The authors thank ABLE for the 2019 Roberta Williams Teaching Initiative Grant for funding the development of this lab; the feedback of the students enrolled in the University of Central Oklahoma's Environmental Microbiology class; and our Department of Biology for the space for the composters and lab preparation staffing.

About the Authors

Mark Walvoord holds a M.S. in Zoology and is Assistant Director at the Center for Excellence in Transformative Teaching and Learning (faculty development office) at the University of Central Oklahoma. He is pursuing a Ph.D. in Educational Psychology (Learning Sciences) at the University of Oklahoma to explore transformative shifts in non-major biology students' identities as ecologically literate citizens. Mark is president of the Oklahoma Compost and Sustainability Association, a board member for three non-profits (Partners for Madagascar, Association for Biology Laboratory Education, and Joiners Inc.), and principal investigator on a grant for food waste management.

Paul Olson completed his B.S. and M.S. in Biology at the University of Central Oklahoma with an emphasis on plant physiology and ecology. Subsequently, he continued his interests in environmental biology at the University of Oklahoma (OU) while working on vegetation-assisted microbial bioremediation and restoration of industrial hazardous waste near Houston, Texas. After earning a Ph.D. in Botany at OU, he worked as a post-doctoral fellow on an U.S. Environmental Protection Agency sponsored project (Ecological Restoration of Polycyclic

Aromatic Hydrocarbon-Contaminated Soils) in dual appointments representing the Departments of Biology and Engineering at Colorado State University. Today, Paul Olson enjoys working with all students on topics in environmental biology including microorganisms involved in pollution biodegradation, environmental quality of both aquatic and soil habitats, conservation of the natural environment, composting, and even questions involving “Why do we get sick?” (evolutionary medicine).

Mission, Review Process & Disclaimer

The Association for Biology Laboratory Education (ABLE) was founded in 1979 to promote information exchange among university and college educators actively concerned with teaching biology in a laboratory setting. The focus of ABLE is to improve the undergraduate biology laboratory experience by promoting the development and dissemination of interesting, innovative, and reliable laboratory exercises. For more information about ABLE, please visit http://www.ableweb.org/.

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Citing This Article

Walvoord ME, Olson P. 2023. Composting – a sustainable activity for environmental sampling of microorganisms. Article 39 In: Boone E and Thuecks S, eds. *Advances in biology laboratory education*. Volume 43. Publication of the 43rd Conference of the Association for Biology Laboratory Education (ABLE).
https://doi.org/10.37590/able.v43.art39