Compost Program Development at Educational Institutions:

Small-scale Approaches to Biomass Utilization and Environmental Regeneration

Emily Creegan, Lindsay Keller, and Robert Flynn[1]

aces.nmsu.edu/pubs • Cooperative Extension Service • Circular 702

The College of Agricultural, Consumer and Environmental Sciences is an engine for economic and community development in New Mexico, improving the lives of New Mexicans through academic, research, and Extension programs.

New Mexico State University
aces.nmsu.edu

ABSTRACT

Organic waste materials, including food, landscape, and animal biomass, constitute a significant portion of landfilled and incinerated waste streams worldwide. Organic materials serve a critical role in soil health, soil carbon sequestration as a climate change mitigation tactic, soil water conservation, and plant productivity. Unlike in-situ application of organic waste materials, proper compost processing has been shown to reduce materials pathogen load while providing a stable soil amendment for plant growth. By emulating natural systems and returning carbon-based materials to the soil, agricultural production can be more of a full-cycle regenerative process, with a reduced reliance on external synthetic inputs. Compost program development at institutional settings can serve as learning forums for organic waste utilization. This circular highlights real-world, small-scale compost program development, educational strategies, program development learning lessons, and common compost methodologies.

INTRODUCTION: BIOMASS ENVIRONMENTAL AND SOCIETAL IMPACTS

Living or once living materials, known as organic materials/organic matter/biomass, serve as a nexus for soil health, water conservation, climate change mitigation and resiliency, resource recycling and regeneration, and plant production. Organic waste, including paper and paperboard, yard trimmings, and food residues, accounts for the largest single waste stream in the United States (U.S. Environmental Protection Agency, 2018). Globally, organic waste materials are often landfilled or incinerated, posing harmful effects to watersheds and air

[1]Respectively, Compost Program Development, Curriculum, and Research Consultant; FarmHer, Natural ReLeaf Farms; and Extension Agronomist, Department of Extension Plant Sciences, New Mexico State University.

quality (Kallestad et al., 2008). Fossil fuels are comprised of highly decayed carbon-based materials. When burned for fuel, carbon is oxidized, creating carbon dioxide—the most abundant greenhouse gas. Methane gas is produced from the anaerobic (without oxygen) decomposition of organic materials, including landfill decomposition processes, and is around 25 times more potent than carbon dioxide as a greenhouse gas (Henson, 2014).

The phrase "waste-to-resource" challenges the predilections of modern landfilling and incinerating practices by cultivating a more "resource-based" approach (Hepperly et al., 2009). All ecosystems utilize materials; there is no waste in nature. Mimicking the natural environment and the planet's regenerative processes, organic materials can be employed to regenerate soil systems and promote more sustainable agricultural practices (Rosenani et al., 2016). By diverting organic materials from landfills, "carbon-farming" practices are being cultivated as a climate change mitigation strategy by returning carbon-based materials to the soil source (Velasquez-Manoff, 2018). Furthermore, soil organic matter (SOM) plays a crucial role in soil carbon and associated soil water retention, particularly during drought and in arid regions (Creegan, 2017).

Societally produced organic waste materials, including food, landscape materials, animal manure, and biosolids, are sources of macro- and micro-nutrients for plant production. Application of SOM increases plant nutrient availability and promotes greater soil microbiota and more resilient soil and plant systems (El-Gawad, 2008). Being less reliant on external inputs promotes self-reliant and resilient communities. Developing renewable systems that buffer against impending climate change effects is particularly important for low-income and disadvantaged communities (U.S. Global Change Research Program, 2018).

GENERAL COMPOSTING GUIDELINES

Compost processing is the controlled decomposition of organic materials (Cornell Composting, Science and Engineering, 1996). There are many forms of composting methods; the most common form of composting—aerobic compost processing—requires the following:

- **Microorganisms:** Naturally present in organic materials, microorganisms facilitate biomass decomposition and create heat under properly maintained conditions. The heat in a composting system is primarily produced through microbial enzymatic breakdown of carbohydrates.

- **Organic waste:** For small-scale and residential systems, utilize non-meat/non-dairy wastes and aim for a ratio of 30:1 carbon to nitrogen, or, as reported by the Bernalillo County Extension Master Composters (personal conversation with John Zarola, February 5, 2021), approximately two parts "browns" (e.g., dried grass clippings and leaves, paper towels, shredded newspaper, etc.) with one part "greens" (e.g., most fresh food waste, green grass clippings, etc.) by weight or volume.

- **Surface area:** The greater the surface area (the more shredded the organic material), the more the organic material is exposed to air and water, resulting in increased microbial action and faster compost system decomposition rates.

- **Oxygen:** Most microorganisms require oxygen to survive and thrive. In an aerobic compost system, simply turn the compost with a shovel or trowel to enhance exposure to oxygen. However, static (non-turned) piles can also be a good option. Aerated static piles facilitate system aeration with forced aeration mechanisms, which does not require turning and results in less system microbial disturbance.

- **Moisture:** Microorganisms require adequate moisture to properly function. The rule of thumb for aerobic compost moisture levels is "moist as a wrung-out sponge"—simply add water to your system as needed.

- **Environmental considerations:** Keep the environment in mind when constructing and maintaining your compost system (see "Composting in the desert" bullet below).

COMMON COMPOSTING METHODS

"Hot" compost

Properly maintained hot compost systems can quickly reach temperatures of around 49–77°C (120–170°F). If maintained for a duration of time (a recommended minimum of three consecutive days), pathogen potential and weed seed transference is significantly reduced or eliminated. Finished compost product completion times vary depending on substrate materials, materials surface area, and system maintenance practices. The Bernalillo County Extension Master Composters (personal conversation with John Zarola, February 5, 2021) reports a well-managed static pile system is 6–12 months to completion.

Vermicomposting

Vermicomposting is compost processing utilizing earthworms (often red-wigglers, *Eisenia fetida*) as the primary system decomposers. Red-wigglers are topsoil dwellers and are natural prolific organic materials decomposers. This composting technique can be done with limited space and is ideal for lower-volume organic waste producers. Worm castings (poop!) are an excellent plant fertilizer for indoor and outdoor plants and landscaping. Unlike much of the fast-growing bacteria in "hot" compost systems, vermicomposting should not produce high heat and does not require turning since the worms provide this (Creegan and Flynn, 2019). For

more information, see NMSU Extension Guide H-164, *Vermicomposting* (https://aces.nmsu.edu/pubs/_h/H164.pdf).

The following information may be printed and placed near or on your compost bin.

Worm Care for Vermicomposting

- Put the bin in a **shady area** (not too hot or too cold—they can be kept under the kitchen sink and will not leave their bin unless they are not getting something they need).

- **Food sources:** Vegan (non-dairy/non-meat) kitchen scraps—coffee grounds, paper towels, tea bags, vegetable and fruit scraps, old (non-moldy) bread and rice. Minimal to no citrus input for vermicomposting is recommended because the acidity can be harmful to the worms.

- **Air spaces:** Create enough holes in the bin for adequate air circulation; if the vermicompost system is too moist, the system will be uninhabitable and may go anaerobic.

- **Environmental conditions:** Remember, these little critters' environmental requirements resemble those of our own: not too hot or cold, plenty of aeration, and not too much and not too little food sources (your organic waste).

GENERAL COMPOST SYSTEM TROUBLESHOOTING

- **Smelly bin or lots of flies** (yes—your compost bin should not smell bad!): Cut down the amount of nitrogen-based (e.g., food waste, fresh green grass) organic material you are putting into the bin, increase the organic material's surface area by shredding or chopping the organic material, add more shredded carbon-based materials (e.g., dried grass clippings, shredded newspaper), and/or increase pile aeration.

- **Worms trying to get out of the bin:** It is too hot or too cold or they are getting too much (resulting in mold, etc.) or too little food.

- **Composting in the desert:** Sun intensity, heat, and drought in arid and semiarid regions necessitate optimizing compost system moisture conservation.The lining of compost bins made out of cloth or chicken wire should be loosely covered. Place the compost bin in a shaded, non-concrete/asphalt, preferably soil-based area. Pre-soak denser organic materials that would otherwise be hydrophobic (e.g., leaves) before putting them in the compost bin to increase system moisture retention. Add bulking materials (e.g., wood chips, cornstalks, and straw) to the system to increase internal system airflow space (Bernalillo County Extension Master Composters, 2018).

Table 1. Results of NMSU Taos Cafeteria Waste Audit Conducted on April 27, 2017

Audit Time	Compostables	Recyclables	Landfill
8 a.m.	62 lb/28.1 kg	64 lb/29 kg	19 lb/8.6 kg
2 p.m.	46 lb/20.9 kg	45 lb/20.4 kg	13 lb/5.9 kg

Recyclables: Metal, clean plastics, paper, and cardboard.

Compostables: All compostable wares, soiled paper waste, and food waste.

Landfill: Non-recyclables and non-compostables.

CASE STUDIES: SMALL-SCALE COMPOST PROGRAM UNIVERSITY MODELS

Small-scale waste audits

Waste audits are important in determining total approximate waste generation volumes and can help determine the needed compost system bin size (Creegan and Flynn, 2019). A waste audit was conducted at the main New Mexico State University (NMSU) Taos Cafeteria with various NMSU departments and Sodexo Inc. (the primary food vending company at NMSU). All Taos Cafeteria waste is currently being landfilled. The Taos Cafeteria waste audit was conducted on April 27, 2017, and included sampled bags of non-retail, kitchen waste only. The waste audit determined that recyclables and compostables accounted for the majority of the cafeteria waste stream (Table 1).

Small-scale waste audits can be conducted following these basic steps:

- As a safety precaution, wear thick gloves, closed-toed shoes, and long pants while conducting the audit.

- Lay down three medium-sized tarps to separate organics, recyclables, and landfill materials.

- Separate the source material (from the waste bins/bags) and weigh all materials on at least two separate days to get a relative average for the organics, recyclables, and landfill materials.

NMSU Skeen Compost Club (SCC)

The NMSU Skeen Compost Club (SCC) compost program and its associated organic waste diversion educational materials were developed in 2017. The Club collects and processes organic waste materials from one of three floors in the NMSU Plant and Environmental Sciences Department. The kitchen space on the third floor is used by both students and faculty and is the SCC education and collection point. Figure 1 shows educational signage created by the Skeen Compost Club demonstrating the types of organic materials to be placed within the collection bins: non-dairy and non-meat food waste, paper towels, coffee grounds, and tea bags. As is common in small-scale compost systems, this non-meat, non-dairy system was established to deter pathogens and their potential vectors

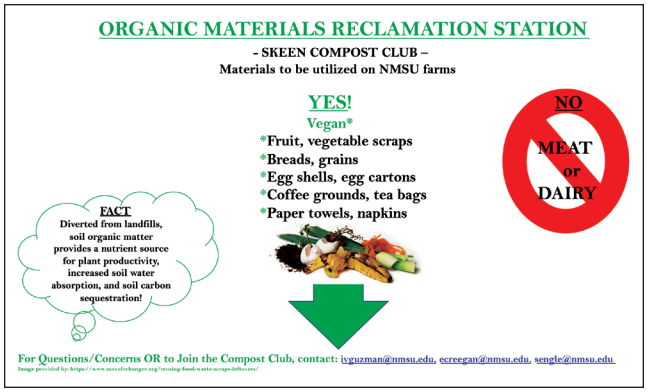

Figure 1. **NMSU Skeen Compost Club kitchen organic waste materials utilization signage.**

Figure 2. **NMSU Skeen Compost Club plant organic waste utilization signage.**

(i.e., insects, rats, mice, etc.). SCC collected and processed approximately 112 kg (247 lb) of organic waste from the NMSU cafeteria during the in-school months of September, October, and November in 2017 alone.

Additional educational materials were created for the outdoor Plant and Environmental Sciences Department green-waste collection program (Figure 2). The educational signage colorfully highlights what cannot be composted and cites an engaging educational fact on why composting is beneficial.

SCC program development learning lessons

- Place the organic waste collection bins with labels such as "coffee grounds and used paper towels to be composted" in strategic locations (e.g., next to the coffee maker) in the kitchen area (Figure 3).

- Using a waste bin for kitchen organic materials collection with a pedal to open the lid by foot and a laminated sign on the lid showing what to place in the bin increased bin patron use.

- Careful consideration and practices should be implemented to account for composting in arid conditions. This includes minimizing compost system airflow, pre-soaking hydrophobic (e.g., leaves) organic materials to increase moisture retention, and placing the compost bin in a shaded area.

NMSU Environmental Science Student Organization (ESSO)

The Environmental Science Student Organization (ESSO) is based out of the Plant and Environmental Sciences Department within the NMSU College of Agricultural, Consumer and Environmental Sciences (College of ACES). This collegiate organization strives to participate in community service events and volunteer activities that benefit the environment and provide learning experiences to further environmental education and awareness. ESSO collaborates with the School of Hospitality, Restaurant and Tourism Management (HRTM) to divert food waste from the landfill via a small-scale compost program. Instructor John Hartley oversees the 100 West Café culinary program. The HRTM students within this program learn how to design, prepare, and serve culinary dishes while gaining experience in customer relations.

HRTM students also learn how to divert large amounts of organic waste by collaborating with ESSO members. Collection bins (Figure 4) are strategically placed in the

Figure 3. **NMSU Skeen Compost Club kitchen materials collection bins and educational signage.**

learning kitchen for food preparers to efficiently collect organic materials, while abiding by food regulations. This collaboration diverts around 9.1 kg (20 lb) of organic waste weekly during the fall and spring semesters.

ESSO program development learning lessons

- Students collect and incorporate the buckets of organic waste when 100 West Café is closed, reducing potential ESSO personnel time constraints.

- During the winter months, active piles should be covered with tarps to trap in heat for optimal system decomposition.

- The commitment of a leader is needed to foster student engagement, monitor bin collection and compost processing, and facilitate compost science and program development learning lessons.

COMPOST UTILIZATION, AND EDUCATIONAL INSTITUTIONS AND COMMUNITY BENEFITS

The finished compost product may be used once the organic residues have been fully decomposed; many composters also allow the finished product to sit (curate) for 1–3 months before application (U.S. Composting Council, 2013). Compost can be applied and incorporated at around 2.54–12.7 cm (1–5 inch) depths into garden beds, farmlands, and landscaped environments. Compost application rates can be calculated using a compost depth calculator, such as the one found at https://www.savingwater.org/lawn-garden/soil-mulch-compost-fertilizers/compost-mulch-calculator/.

At the NMSU campus, various agricultural, horticultural, and landscaping courses may utilize the finished compost product. Dr. Ivette Guzman, a faculty member in the NMSU Plant and Environmental Sciences Department, anticipates incorporating an organic materials program into her permaculture courses by spreading and watering-in the finished compost product at the on-campus farm plots. By fostering hands-on, student-run organic waste-to-resource initiatives in her courses, Dr. Guzman believes this promotes more holistic organic farming techniques. Educational institutions can serve as an educational model in organic waste program development, compost product production, and student-led learning. Beyond the NMSU campus, compost program development may be expanded to K-12 educational settings through FFA, 4-H, and other related organizations. Educational institution biomass program development can serve to teach the community at large and facilitate climate change mitigation, community resiliency, and enhanced agricultural and environmental practices.

Figure 4. **ESSO kitchen organic waste materials collection bin.**

ACKNOWLEDGMENTS

Thank you to the Skeen Compost Club (SCC) members, Dr. Ivette Guzman (SCC advisor and mentor), and the current club President, Angelica Swanson. Thank you to John Zarola, John Hartley, Barbara Hunter, and Drs. Soum Sanogo and Sarah Pierpont for their input and guidance. This research was funded by the USDA National Needs Fellow program, Grant #2015-38420-23706 for biomass utilization.

REFERENCES

Bernalillo County Extension Master Composters. 2018. Desert composting recommendations. Retrieved from https://bernalilloextension.nmsu.edu/mastercomposter/desert-composting.html

Cornell Composting, Science and Engineering. 1996. The science and engineering of composting. Cornell University. Retrieved from http://compost.css.cornell.edu/science.html

Creegan, E.F. 2017. *Effects of compost and biochar application on turf soil nitrate and carbon content under water deficit conditions* [Unpublished master's thsesis]. California State Polytechnic University, Pomona. Retrieved from http://broncoscholar.library.cpp.edu/discover?query=Emily+Creegan&submit=Go&scope=

Creegan, E.F., and R. Flynn. 2019. Full cycle organic waste-to resource compost program development: Addressing poverty and environmental sustainability. United Nations, SDG (Sustainable Development Goal) 2, Zero Hunger. Singapore: Springer Nature.

El-Gawad, A.A. 2008. Employment of bio-organic agriculture technology for Zea mays cultivation in some desert soils. *Research Journal of Agriculture and Biological Sciences*, 4(5), 553–565.

Henson, R. 2014. *The thinking person's guide to climate change*. Boston: American Meteorological Society.

Hepperly, P., D. Lotter, C.Z. Ulsh, R. Seidel, and C. Reider. 2009. Compost, manure and synthetic fertilizer influences on crop yields, soil properties, nitrate leaching and crop nutrient content. *Compost Science & Utilization*, 17, 117–126.

Kallestad, J., J. Mexal, and T.W. Sammis. 2008. Mesilla Valley pecan orchard pruning residues: Biomass estimates and value-added opportunities [Research Report 764]. Las Cruces: New Mexico State University Agricultural Experiment Station.

Rosenani, A.B., R. Rovica, P.M. Cheah, and C.T. Lim. 2016. Growth performance and nutrient uptake of oil palm seedling in prenursery stage as influenced by oil palm waste compost in growing media. *International Journal of Agronomy,* 1–8. doi:10.1155/2016/6930735

U.S. Composting Council. 2013. Model compost rule template version 1.1. Retrieved from https://compostingcouncil.org/

U.S. Environmental Protection Agency (EPA). 2018, August 1. Guide to the facts and figures report about materials, waste and recycling. Retrieved from https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/guide-facts-and-figures-report-about-materials#NationalOverview

U.S. Global Change Research Program. 2018. Chapter 10: Agriculture and rural communities [Executive summary]. In *Fourth National Climate Assessment: Impacts, Risks, and Adaptation in the United States, vol. II* (pp. 392–395). Retrieved from https://nca2018.globalchange.gov/downloads/NCA4_Ch10_Agriculture_ExecSum.pdf

Velasquez-Manoff, M. 2018, April 18. Can dirt save the earth? *The New York Times Magazine.* Retrieved from https://www.nytimes.com/2018/04/18/magazine/dirt-save-earth-carbon-farming-climate-change.html

Emily Creegan earned her B.S. from Humboldt State University, M.S. from California State Polytechnic University, and Ph.D. from NMSU. Dr. Creegan is the founder of NM Compost Company (www.nmcompostcompany.com), a compost program development and earth cycles educational consulting company.

Lindsay Keller earned B.S. degrees in horticulture and turfgrass science and her M.S. from NMSU. Her research focuses on utilizing biochar (black carbon derived from various biomass feedstocks) as a soil conditioner in pinto bean and sorghum-Sudan grass crop production.

Robert Flynn is an Associate Professor of agronomy and soils and an Extension Agronomist at New Mexico State University. He earned his Ph.D. at Auburn University. His research and Extension efforts aim to improve grower options that lead to sustainable production through improved soil quality, water use efficiency, and crop performance.

March 2022 **Las Cruces, NM**