Closing the Loop: Recycling PLA Waste from 3D Printing into Value-Added Filament at NC State University

Catherine Kirch,[a] and Daniel Saloni,[b]

The rapid growth of 3D printing in university makerspaces has created a new but often overlooked waste stream: discarded polylactic acid (PLA) filament from failed prints, support structures, and design errors. Although PLA is a bio-based and recyclable thermoplastic, most of this material currently ends up in landfills. This paper outlines a pilot project at NC State University to close this loop by collecting, processing, and re-extruding PLA waste into new 3D printing filaments. The system, developed through collaboration between the D.H. Hill Makerspace and Hodges Lab, employs a straightforward four-step process—collection, sorting, grinding, and extrusion—thereby achieving over 90% material efficiency. Besides demonstrating technical feasibility, the project emphasizes how campus-scale circular systems can reduce waste, lower costs, and serve as educational models for sustainable manufacturing. This initiative provides a replicable framework for universities and small-scale fabrication facilities seeking to incorporate circular economy principles into their operations.

DOI: 10.15376/biores.21.1.13-15

Keywords: PLA; 3D Printing; Recycling; Circular Economy; Makerspace

Contact information: a: Undergraduate Researcher, Department of Forest Biomaterials, NCSU; b: Associate Professor, Department of Forest Biomaterials, NCSU

Introduction: Addressing the Hidden Plastic Waste Stream in Makerspaces

When students and faculty use 3D printers on university campuses, the focus is often on design and innovation. Rarely does anyone think about the waste streams that these activities generate. Failed prints, excess support structures, scraps from design errors, and leftover material collectively contribute to significant volumes of plastic waste. At NC State University, Makerspaces provide free and easy access to 3D printing, with polylactic acid (PLA) as the primary feedstock. Though PLA is a bio-based and compostable plastic, in practice, most PLA waste ends up in landfills. The absence of a recovery system for this steady, dispersed waste stream creates both an environmental and operational challenge. This project establishes a closed-loop recycling system to intercept, process, and transform PLA waste into new, usable 3D printing filament, demonstrating that circular solutions can be applied directly at the university scale.

The Need for Circular Material Systems in Campus Makerspaces

Sustainability in manufacturing is often discussed at industrial scales, yet distributed fabrication hubs such as campus makerspaces produce steady, overlooked waste streams. Because the waste is generated in small amounts per user, it is easy to underestimate its impact. However, aggregated over time and across multiple campus locations, the volume of PLA waste becomes significant. Creating a campus-based recycling system not only diverts waste from landfills but also reduces demand for virgin filament, lowers costs, and offers an educational model for sustainable design and circularity in emerging manufacturing.

PLA: A Recyclable Thermoplastic for a Circular Economy

Polylactic acid (PLA) is a bio-based thermoplastic derived from corn starch, offering several advantages:

- Renewable feedstock compared to petroleum-based plastics
- Thermoplastic properties, allowing repeated melting and reshaping
- Low toxicity and ease of use in additive manufacturing

Despite these advantages, PLA waste often fails to enter composting or recycling systems. By focusing on PLA, this project targets a technically simple and logistically feasible material stream to close the loop within a university system.

Building the Closed-Loop System

The pilot system was developed through collaboration between the D.H. Hill Library Makerspace and Hodges Lab in the Department of Forest Biomaterials. The workflow involves four key steps shown in Fig. 1:

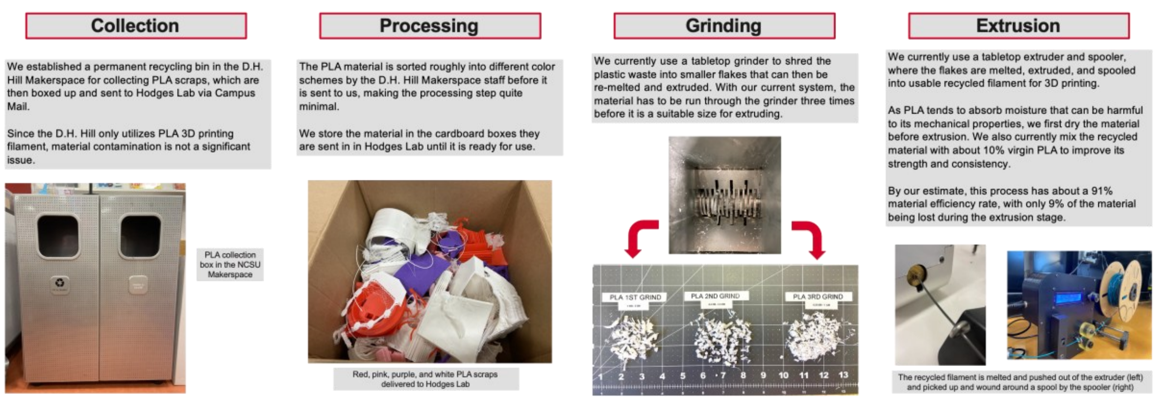

Fig. 1. Building the closed-loop system

Challenges and Next Steps

Although the pilot program has proven effective, several opportunities remain to scale and optimize the process:

- Acquisition of high-capacity grinders and extruders for larger throughput
- Process refinement to improve filament quality and consistency
- Mechanical and thermal materials testing of recycled filament
- Data collection to quantify waste diversion and communicate impact
- Development of educational and outreach programs for sustainable design habits
- Expansion to multiple makerspaces on campus and beyond

Impact Factors

Table 1 outlines the sustainability performance of the PLA recycling pilot.

Table 1. Impact Factors for Recycling PLA

Impact Factor	PLA Recycling Pilot	Notes
Raw Materials	High	PLA sourced from corn (renewable) and industrial biodegradable
Energy Use	Moderate	Low energy processing with small extruders
Waste Reduction	High	Intercepts and recycles PLA before landfill disposal
Product Value	High	Functional recycled filament

Conclusion

The PLA Recycling Pilot demonstrates how small, targeted interventions in localized manufacturing can yield outsized sustainability benefits. Combining technical feasibility, student engagement, and circular material flows, this project transforms what was once invisible waste into a valuable resource. Scaling and refining this system can position universities as living laboratories for circular economy practices, bridging innovation, education, and sustainability.

References

Flynt, J. (2017). "Polylactic acid (PLA): The environment-friendly plastic," *3D Insider.* Industrial Quick Search. (n.d.). Plastic Extrusion.

Kirch, C., and Saloni, D. (2025). *Recycling PLA Waste from 3D Printing into Value-Added Filament*, Department of Forest Biomaterials, NC State University.

Mervine, N., Brätt, K., and Saloni, D. (2020). "A review of sustainable materials used in thermoplastic extrusion and powder bed melting additive manufacturing," in: *Advances in Manufacturing, Production Management and Process Control*, B. Mrugalska, S. Trzcielinski, W. Karwowski, M. Di Nicolantonio, E. Rossi, (eds), AHFE 2020. Advances in Intelligent Systems and Computing, vol 1216. Springer, Cham. https://doi.org/10.1007/978-3-030-51981-0_12

McLaughlin, K., Webb, A., Brätt, K., and Saloni, D. (2020). "Bioplastic modified with woodflour for additive manufacturing," in: *Advances in Manufacturing, Production Management and Process Control*, B. Mrugalska, S. Trzcielinski, W. Karwowski, M. Di Nicolantonio, E. Rossi, E. (eds). AHFE 2020. Advances in Intelligent Systems and Computing, vol 1216. Springer, Cham. https://doi.org/10.1007/978-3-030-51981-0_11

Saloni, D., and Mervine, N. (2020). "Investigation of bioplastics for additive manufacturing," in: *Advances in Additive Manufacturing, Modeling Systems and 3D Prototyping,* M. Di Nicolantonio, E. Rossi, T. Alexander (eds). AHFE 2019. Advances in Intelligent Systems and Computing, vol 975. Springer, Cham. https://doi.org/10.1007/978-3-030-20216-3_34

Vivas, K., Gonzales, R., and Saloni, D. (2023). "From a sustainability perspective, Why should bioplastics be used for additive manufacturing?" *Polymer Sci. Peer Rev. J.* 4(4), PSPRJ. 000594. 2023. https://doi.org/10.31031/PSPR.2023.04.000594