

Cotton and Biodegradability

Why Biodegradability Matters

When textile fibers are shed — during production, wear, laundering, or end-of-life disposal — their environmental impact depends on their toxicity, exposure, how long they remain in nature and not just how much is released.

- **Cotton microfibers**, made from plant-based cellulose, biodegrade naturally across aquatic, soil, wastewater, and compost environments — even when dyed or chemically finished.^{1,2}
- **Synthetic microfibers** are microplastics that show little to no biodegradation in any major environment.^{1,3} Instead, they fragment into smaller particles that persist, circulate globally, and bioaccumulate.^{3,4}

Persistence is now linked to increasing human exposure. Synthetic microplastics have been found in the brain, liver, kidney, and blood of human subjects, with concentrations rising over time.⁴ Cotton, by contrast, does not bioaccumulate because it degrades naturally.

Has cotton biodegradability been proven?

Yes. Cotton's ability to biodegrade has been proven across the major environments where fibers are found. This conclusion is supported by decades of research using globally recognized ISO (International Organization of Standards) and ASTM International standards, which are considered valid for these fiber types. These extensive tests confirm that cotton biodegrades in soil, compost, freshwater, seawater, and wastewater—even when dyed or finished.^{1,2}

Cotton biodegrades effectively while petroleum-based synthetics do not, as the results for each environment tested.^{1,2}

Biodegradability Comparison of Microfibers in Various Environments



¹ Zambrano, M. C., Pawlak, J. J., Daystar, J., Venditti, R. A., Ankeny, M., & Goller, C. C. (2020). Aerobic biodegradation in freshwater and marine environments of textile microfibers generated during laundering. Marine Pollution Bulletin, 151, 110826. <https://doi.org/10.1016/j.marpolbul.2019.110826>

² Alwala et al. (2024). The Compostability of Denim Fabrics Dyed with Various Indigos. https://bioresources.cnr.ncsu.edu/wp-content/uploads/2024/03/BioRes_19_2_2685_Alwala_PSBPADF_Compostability_Denim_Fabrics_Dyed_Indigos_23213.pdf

³ Kounina, A., Daystar, J., Chalumeau, S., Devine, J., Geyer, R., Pires, S., Uday Sonar, S., Venditti, R., Boucher, J. (2024). "The global apparel industry is a significant yet overlooked source of plastic leakage."

⁴ Nihart, A. J., Garcia, M. A., El Hayek, E. et al. (2025). Bioaccumulation of microplastics in decedent human brains. Nat Med 31, 1114–1119 (2025). <https://doi.org/10.1038/s41591-024-03453-1>

⁵ Zambrano, M. C., Pawlak, J. J., Daystar, J., Venditti, R. A., & Ankeny, M. (2021). Impact of Dyes and Finishes on the Aquatic Biodegradability of Cotton Textile Fibers and Microfibers Released on Laundering Clothes: Correlations between Enzyme Adsorption and Activity and Biodegradation Rates. Marine Pollution Bulletin 165, p. 112030. <https://www.sciencedirect.com/science/article/abs/pii/S0025326X21000643?via%3Dihub>

⁶ Hubbe, M. A., et al. (2025). Biodegradability of Cellulose Fibers, Films, and Particles: A Review. BioResources, 20(1), 2391–2458. <https://ojs.bioresources.com/index.php/BRJ/article/view/24209>

⁷ Smith, S., Ozturk, M., & Frey, M. (2021). Soil biodegradation of cotton fabrics treated with common finishes. <https://par.nsf.gov/servlets/purl/10325681>

⁸ Li, L., Frey, M., & Browning, K. J. (2010). Biodegradability Study on Cotton and Polyester Fabrics. Journal of Engineered Fibers and Fabrics, 5(4). <https://doi.org/10.1177/155892501000500406>

What about biodegradability in “real-world” environmental conditions (low temperature, low oxygen, low sunlight)?

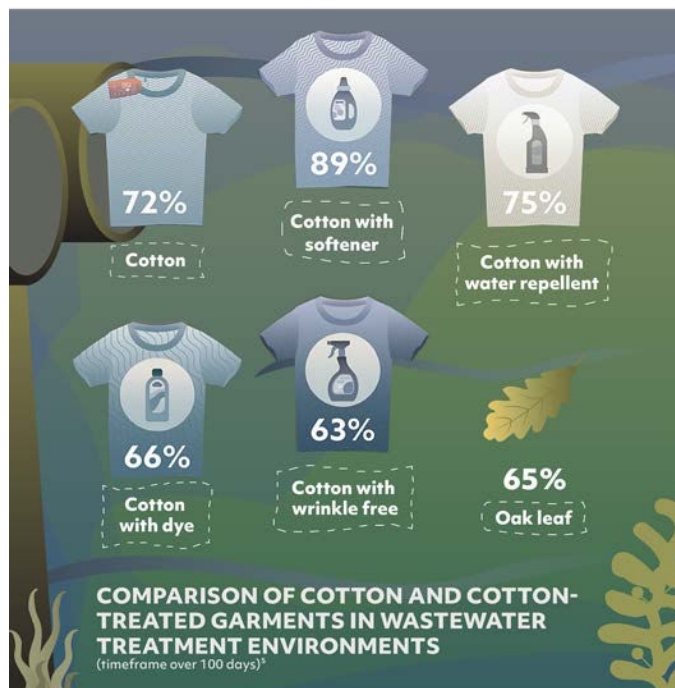
Real-world conditions strengthen cotton's advantage. Freshwater, seawater, marine sediment, lake water, and wastewater treatment tests show cotton microfibers biodegrading under realistic conditions; polyester shows negligible biodegradation.^{1,5}

In contrast, polyester does not meaningfully biodegrade in freshwater, marine, soil, or wastewater environments regardless of typical environmental conditions, due to its chemically resistant polymer structure.^{1,8}

Do dyes and finishes stop cotton from degrading?

No. The main difference is sometimes speed, not whether it happens.

- Softeners can make it degrade faster in soil⁷ and wastewater treatment⁵ environments.
- Crosslinking finishes may slow it down, but do not prevent it.⁷
- Indigo and different dyeing methods do not prevent biodegradation in compost.²



Is microfiber identification a barrier for biodegradability?

No. Identification challenges may make monitoring difficult, but they do not affect the scientific proof of cotton's biodegradability. Studies with controlled sources consistently confirm that cotton biodegrades^{1,2} while synthetic fibers remain persistent regardless of identification.

Does biodegradability solve other sustainability concerns?

It directly addresses persistence — a main hazard of synthetic microfibers. Cotton does not accumulate over time in air, water, or soil. Synthetic fibers do accumulate — and make up about 89% of apparel-related plastic leakage worldwide.³ Synthetic fibers show no measurable biodegradation in freshwater, marine water, soil, or wastewater systems^{1,2} and therefore persist and can accumulate in airborne, terrestrial, and aquatic environments.⁹

Are there human health differences between cotton and synthetics?

Yes — persistence and composition create risks. Synthetic microplastics have been found in the human brain, liver, kidney, and blood.⁴ Concentrations are increasing. Synthetics can also pick up and carry toxic chemicals because their hydrophobic surfaces attract other hydrophobic pollutants.¹⁰

Cotton's hydrophilic, biodegradable nature means it's less likely to attract and carry pollutants from an aquatic environment and it doesn't persist long enough to pose the same bioaccumulation risk.^{1,2}

What's the bottom line for brands and designers?

If microplastics pollution is a concern, fiber choice is critical.

- Biodegradable fibers like cotton reduce long-term plastic pollution and are supported by strong scientific peer reviewed literature and evidence.
- Using synthetics means adding to the stock of persistent microplastics already in the environment.

Biodegradability isn't a “nice to have” — it's a key sustainability filter for making responsible fiber choices.

For more information about cotton biodegradability and sustainability, visit cottontoday.cottoninc.com



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⁹ Wang et al. (2021). Airborne Microplastics: A Review on the Occurrence, Migration and Risks to Humans. Bulletin of Environmental Contamination and Toxicology. <https://link.springer.com/article/10.1007/s00128-021-03180-0>

¹⁰ Fu et al. (2021). Adsorption behavior of organic pollutants on microplastics. Ecotoxicology and Environmental Safety. <https://www.sciencedirect.com/science/article/pii/S0147651321003183>