Soren Ekstrom

April 4, 2025

Ecology, Environment, and the Anthropocene

Chris Jensen

The Use of Mycelium as a Valuable Bio-material

With the ongoing climate crisis and amassing waste that leaches chemicals into our environment and releases greenhouse gases into the atmosphere, we are on the precipice of an environmental disaster. If we don't find solutions to many of the ecological problems created by our industrialized society, we exacerbate the harm that human activities will have on the natural world. Requiring action on different scales across multiple sectors, a single material has stood out to me from its host of different flexible properties, its non-toxic and sustainable origin, the cost of production, and the ease of implementation.[1] Mycelium fungal growth can be used as a substitute material for many products within top industries that produce the majority of waste that leaches into our environment and produces copious amounts of carbon dioxide in the process.[2] Construction activities account for a huge percentage of worldwide carbon dioxide emissions and waste products as a result of cement production, which could be mitigated by the incorporation of mycelium within the construction sector.[3] Different forms of plastic make up a large portion of the physical pollution in our environment as well, leaching around 8 million tons of plastic into the ocean every year.[4] The dependence on plastic could be almost fully replaced

[1] (Manan et al.)
[2] (Alemu et al.)
[3] (Olivetti and Cullen)
[4] (Magnier et al.)

with the incorporation of mycelium in packaging and other products. Mycelium has the potential to mimic many of the same properties that plastic has with the use of different substrates or growing materials.[5] In the future, mycelium will hopefully be able to phase out traditional materials to create new products with little to no carbon footprint or waste.

Mycelium is a type of fungus that can be grown within a mold, using a host of different organic waste materials to feed on, creating a material that can be altered to suit various industrial applications. With the use of different substrate, or these waste materials, such as straw, corn husk, wheat bran, cardboard, sawdust, and many others - the final material will vary in its physical attributes, some making it denser and stronger, others making it more elastic and springy, and some even making it buoyant and able to float.[6] This tailor-made aspect of the material makes it the ideal candidate for sustainable production, being able to conform to a variety of sectors. Not only is mycelium a low-cost sustainable option as a material, but it has many inherent properties that make it perform better in some cases than traditional construction and packaging materials. This makes this fungi the ideal biomaterial, creating products that are biodegradable for many different industries. For example, many companies in recent years have been experimenting with mycelium growth for materials and found that it can be used to produce leather and fabric substitutes for clothing and shoes, furniture, paneling and insulation, packaging, medicine, cosmetics, sea buoys, and potentially much more. The material can be coated in natural waxes or oils to increase its hydrophobic properties and grown to any size and shape with the proper mold.[7] The only limitation is the incubation period, where the form must be temperature and moisture controlled to result in optimal strength and density.[8] The

[5] (Alemu et al.)
[6] (Manan et al.)
[7] (Iordache et al.)
[8] (Manan et al.)

possibilities for new design that produces low levels of carbon dioxide, are sustainable, and are easily biodegradable, without lasting impacts on the Earth, are extremely wide and varied with the use of mycelium-based materials. This fungus is accessible, low cost, non-toxic, and biodegradable (originating in nature and being 100% natural), making it an ideal sustainable material for replacing traditional materials that have proved to be detrimental to our environment.

Within the construction sector, the concrete industry makes up a huge amount of global energy expenditure and greenhouse gas emissions. The process of calcination of limestone into lime in the production of cement releases large amounts of carbon dioxide, producing about 0.85 tons of carbon dioxide for every ton of cement produced.[9] This process also consumes large amounts of fuel and electricity. Along with emissions from concrete, the majority of other building materials used today are toxic to humans and our environment. Wood sprayed or injected with insecticide treatments are highly toxic and can leach into rainwater and runoff into nearby water supplies. In the event of a fire, building materials like polyethylene and polyurethane foam insulation and polystyrene moulding release toxic fumes that lead to the majority of deaths during fires.[10] The harmful effects of the construction industry are extremely evident from the toxicity of materials, to the amount of energy and greenhouse gases that are released in producing these materials. To reduce the effect that these construction materials have on our planet, we must find solutions to reduce the amount that they are used as a whole, using sustainable and nontoxic alternatives to replace much of the value that these traditional materials hold within the construction industry. Though it is unlikely that mycelium alone can fully replace these materials, it can be used to reduce the amount that we depend on traditional construction

[9] (Maraveas)
[10] (Pacheco-Torgal and Jalali)

materials. Mycelium can be used to create bricks, paneling, insulation, and much more, holding inherent insulating, fire-safety, termiticide, and hydrophobic properties that can be seen in some instances to perform better than traditional materials. Different properties of mycelium can be enhanced to perform better in certain conditions without the added use of chemicals or toxins by altering the substrate material that the fungi feed on, as well as adding a natural wax or oil to the surface to increase its durability. The strength of mycelium is comparable to that of gypsum and polymer (extremely common interior materials in buildings) and is denser than gypsum. It is also around 20-30 times cheaper than each of these materials per kg.[11] Mycelium can be utilized within the construction sector to reduce the amount we rely on traditional building materials, offering cheaper and easier production, no carbon emissions within the process, and a nontoxic product material that reduces pollution within our environment.

Plastic contributes to the majority of waste in landfills and waterways, causing pollution on many different scales and leaching potentially harmful chemicals into our environment and many of our food sources. The problem with plastic is that its production using petroleum means that it cannot naturally decompose. Without any natural processes in the environment able to break down the strong chemical bonds within plastic, it remains in the environment for decades to centuries. It breaks down into smaller pieces over time, is eaten by animals, and becomes extremely difficult to detect and dispose of.[12] Though it seems like these problems can be solved by recycling, in reality, less than 15% of plastic packaging actually gets recycled in the United States, leaving the rest to accumulate in landfills and our environment.[13] This may be due to the fact that the cost of recycling is higher than the costs of the energy to produce plastic, and store it

[11] (Alemu et al.)
[12] (MacLeod et al.)
[13] (Boz et al.)

in landfills, leading to much higher rates of plastic ending up as waste. Instead of contributing to this cycle of irresponsibility and pollution, utilizing non-toxic and biodegradable alternatives to plastic will reduce the amount of waste that we produce and contribute to a healthier environment as a result. By phasing out petrochemical-based plastic use in the packaging of everyday objects, we will reduce the build-up of waste plastic that can't be recycled. This can be done by creating these products out of mycelium fungal growth, a biodegradable material that releases no greenhouses gases in the process of its creation, grows within a mold, and can be adapted with the use of different substrate, or food for the fungi when it is growing to have different properties in the final material. It is also a cheaper alternative to these traditional materials, and it is sustainable as a grown bio-material, so there is an unlimited supply.

The scientific concepts I plan on focusing on throughout my term project are how fungal mycelium can provide a sustainable (without producing greenhouse gases during their creation) and non-toxic alternative to traditional building materials like foam, gypsum, polymers, and concrete, how replacing plastics with mycelium can mitigate the amassing waste from plastics and allow for the creation of new products, and how we can use mycelium to produce products solely with organic and biodegradable materials to reduce further waste production. These concepts have guided my research of mycelium in finding a number of different ways in which the growth of this fungi can be used to create different products for various purposes. Focusing on the substitution of traditional, polluting materials in my project, I wanted to look at the most polluting industries and find solutions to the problems that they create. I have found that the versatility of mycelium gives it the potential to be implemented across the construction industry, the plastics sector, and looking towards a future with zero waste production processes. Addressing these three challenges in my work is meant to highlight the use of alternative

materials and sustainability within design and hopefully inspire others to create with mycelium or other biomaterials to reduce the impact of their designs on the environment. My term project will address the pollution and harm created by production worldwide and offer a solution in the form of mycelium-based design.

Throughout my research, I have decided on three different options to present my findings on the numerous properties and applications that mycelium could have on a large scale across different industries. With an emphasis on demonstrating the ease and accessibility of creating this material, I could create a video documenting the process that I undergo to create a block of mycelium, then bring this block to class and show the viability of the final product. This plan would show the ability to create new products with zero waste using mycelium and work well for involving the class in the project and calling them to try to create mycelium themselves and use it within their designs. However, this plan is lacking an explanation as to why mycelium should be incorporated into different industries on a large scale, and only addresses how it is created. Creating something to explain this part of the project on top of the video and material may be too much work and may not be as viable as other options for my final project. Another idea I have for the final product of the term project is finding one product that should be replaced with sustainable materials and reproduce it completely with mycelium, from start to finish, to prove that this material can directly be used to replace specific items in our lives and make them fully sustainable. This idea demonstrates my main point well, and shows exactly why we might incorporate mycelium into further projects and designs, and how it can replace plastics and other traditional materials heavily relied on in the creation of new products, but I feel that a single example might not showcase the variety of uses the material has. This is why I believe that creating three separate pieces of material out of mycelium, utilizing different substrates during

the growing process will allow me to properly showcase the versatility of the mycelium material as well as how important it could be for achieving a sustainable future. These examples would be coupled with an infographic explaining the problem that each piece of mycelium solves, from construction material to packaging and insulation. This focus will tackle both how constructing this material works, as well as why we should implement it for different purposes, demonstrating my main scientific concepts and different ways to sustainably create new products for designers.

Overall, research has revealed that mycelium can be used in a number of different ways to produce valuable materials that have the potential to reduce and mitigate harm to our environment through pollution and waste of traditional materials from different industries. Tackling the greatest polluting sectors like construction and packaging will allow the material to have the greatest benefit to our society and environment in transitioning away from toxic and non-degradable or recyclable materials that are produced with large amounts of energy and release greenhouse gases. By utilizing this key tool in design in the future, keeping in mind the benefits that it has to our environment and the harmful effects that traditional materials can have, I believe that great changes can be made for the better in our fight against climate change and the degradation of our natural environment across the world. It is innovation and the hunt for new solutions to fix problems that have arisen from polluting industries that have the potential to ultimately save our planet.

Works Cited

Alemu, Digafe, et al. “Mycelium-Based Composite: The Future Sustainable Biomaterial.” *International Journal of Biomaterials*, vol. 2022, no. 8401528, Mar. 2022, p. 8401528, https://doi.org/10.1155/2022/8401528.

Arevalo-Gallegos, Alejandra, et al. “Lignocellulose: A Sustainable Material to Produce Value-Added Products with a Zero Waste Approach—a Review.” *International Journal of Biological Macromolecules*, vol. 99, June 2017, pp. 308–18, https://doi.org/10.1016/j.ijbiomac.2017.02.097. Accessed 10 Feb. 2022.

Boz, Ziynet, et al. “Consumer Considerations for the Implementation of Sustainable Packaging: A Review.” *Sustainability*, vol. 12, no. 6, Mar. 2020, p. 2192, https://doi.org/10.3390/su12062192. MDPI.

Iordache, Ovidiu, et al. “MYCELIUM BIO-COMPOSITES: THE FUTURE of PACKAGING MATERIALS.” *ANNALS of the UNIVERSITY of ORADEA FASCICLE of TEXTILES, LEATHERWORK*, vol. 24, no. 1, EBSCO Publishing, 2023, research.ebsco.com/c/wfa666/viewer/pdf/5ku46rtw3b. Ebsco. Accessed 4 Apr. 2025.

Knapcikova, L., et al. “Using a Discrete Event Simulation as an Effective Method Applied in the Production of Recycled Material.” *Advances in Production Engineering & Management*, vol. 15, no. 4, Dec. 2020, pp. 431–40, https://doi.org/10.14743/apem2020.4.376. Accessed 5 Apr. 2021.

MacLeod, Matthew, et al. “The Global Threat from Plastic Pollution.” *Science*, vol. 373, no. 6550, July 2021, pp. 61–65, https://doi.org/10.1126/science.abg5433.

Magnier, Lise, et al. “Turning Ocean Garbage into Products – Consumers’ Evaluations of Products Made of Recycled Ocean Plastic.” *Journal of Cleaner Production*, vol. 215, no.

215, Apr. 2019, pp. 84–98, https://doi.org/10.1016/j.jclepro.2018.12.246.

Manan, Sehrish, et al. “Synthesis and Applications of Fungal Mycelium-Based Advanced Functional Materials.” *Journal of Bioresources and Bioproducts*, vol. 6, no. 1, Feb. 2021, pp. 1–10, https://doi.org/10.1016/j.jobab.2021.01.001.

Maraveas, Chrysanthos. “Production of Sustainable Construction Materials Using Agro-Wastes.” *Materials*, vol. 13, no. 2, Jan. 2020, p. 262, https://doi.org/10.3390/ma13020262.

Mohamed, Abdelaziz F., et al. “Comparative Study of Bio-Materials versus Conventional Materials in Building Construction Methods; Economical Evaluation of Different Building Materials.” *SN Applied Sciences*, vol. 1, no. 10, Sept. 2019, https://doi.org/10.1007/s42452-019-1218-5. Accessed 9 Apr. 2020.

Mroueh, Ulla-Maija, and Margareta Wahlström. “By-Products and Recycled Materials in Earth Construction in Finland—an Assessment of Applicability.” *Resources, Conservation and Recycling*, vol. 35, no. 1-2, Apr. 2002, pp. 117–29, https://doi.org/10.1016/s0921-3449(01)00126-4. Accessed 29 June 2020.

Olivetti, Elsa A., and Jonathan M. Cullen. “Toward a Sustainable Materials System.” *Science*, vol. 360, no. 6396, June 2018, pp. 1396–98, https://doi.org/10.1126/science.aat6821.

Pacheco-Torgal, Fernando, and Said Jalali. “The Coastal Built Environment: A Source of Current and Future Marine Debris? Amount of People Amount of Material the Coasts Are Changing.” *International Journal of Sustainable Engineering*, vol. 4, no. 11, Apr. 2011, https://doi.org/10.1080/19397038.2011.569583.

Saphores, Jean-Daniel M., and Hilary Nixon. “How Effective Are Current Household Recycling Policies? Results from a National Survey of U.S. Households.” *Resources, Conservation and Recycling*, vol. 92, Nov. 2014, pp. 1–10,

https://doi.org/10.1016/j.resconrec.2014.08.010.

Subramanian, P. M. “Plastics Recycling and Waste Management in the US.” *Resources, Conservation and Recycling*, vol. 28, no. 3-4, Feb. 2000, pp. 253–63, https://doi.org/10.1016/s0921-3449(99)00049-x.