

Review

A Review of Mycelium-Based Composites in Architectural and Design Applications

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Abstract

Mycelium-based composites are a promising sustainable material with inherent fire resistance and acoustic absorption properties, the extent of which depends on the fungal species, the substrate, and the growth technology. These materials exhibit superior fire performance compared to synthetic polymers, characterized by low heat release, minimal smoke production, and a high char yield that inhibits flame spread. Some composites have even demonstrated self-extinguishing capabilities. Despite these advantageous properties, their application in the construction industry remains limited. To assess mycelium's current trajectory, this study analyzes 90 real-world architectural and design projects. Our findings indicate that *Ganoderma lucidum* and *Pleurotus ostreatus* are the most commonly used fungi, cultivated on substrates such as straw, wood, and sawdust. Architectural applications are dominated by building blocks, insulation, and facade panels, whereas design and art applications focus on packaging, furniture, and sculptures. A key distinction emerges: architectural projects prioritize function, while artistic projects emphasize esthetic experimentation. Although commercially successful in packaging, the use of mycelium in construction is currently limited to temporary structures. Enhancing its structural and load-bearing properties through further research is essential for its widespread use in architecture. However, mycelium is poised to become a key material that drives innovation in sustainable construction.

Keywords: architecture; sustainable building materials; biocomposites; esthetic properties; design trends; circular economy; agricultural byproducts



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1. Introduction

The construction and operation of buildings are major contributors to global greenhouse gas emissions [1]. These emissions are associated with the extraction, processing, transportation, and manufacturing of building materials. Emissions are also generated by the operational energy consumption necessary for heating, cooling, and lighting buildings throughout their lifecycle. The UN's 2022 'Global Status Report for Buildings and Construction' reveals a concerning statistic: the building and construction sector is responsible for 38% of global energy-related CO₂ emissions [2]. This highlights the urgent need to develop energy-saving materials in production to minimize emissions throughout a building's lifecycle.

Over the last 20 years, the scope of use of mycelium-based composites (MBCs) in architecture and design has expanded. The wide range of applications for these materials is evident in the rapid increase in publications and patents since 2007 [3]. MBCs are innovative and sustainable building and construction materials. Characterized by the unique properties arising from the synergistic relationship between natural organic substrates and the mycelium, they could help reduce the use of non-renewable resources [4]. MBCs are currently being developed for packaging [5], industrial artifacts [6], furniture and art use [3], building materials [7,8], textiles [9], acoustic tiles [10], and thermal insulation materials [11]. Fungal mycelium is a promising option for generating biocomposites due to its excellent thermal performance and biodegradability [12].

Mycelium, a network of fungal fibers, acts as a natural binder of substrates, making mycocomposites lightweight, flexible, and biodegradable. The vegetative part of fungi can be cultivated on various organic feedstocks and transformed into a range of biobased materials, thereby making their production, use, and recycling more sustainable [13]. Mycelium-based composites (MBCs) exhibit density values ranging from 212 to 282 kg/m³, which are comparable to traditional materials [14]. However, foamed mycelium cellulose samples have densities ranging from 50 to 80 kg/m³ [15] and offer low thermal conductivity values ranging from 0.03 to 0.06 W/(m·K) at +10 °C [16].

Different types of fungi and growth substrates have a significant influence on the properties of mycelium-based composites (MBCs). By manipulating fungus species and substrate materials, such as agricultural waste, post-consumer waste, or industrial byproducts, designers and engineers can achieve varying degrees of strength, texture, insulation properties, and biodegradability [17]. For instance, some mycelium composites are optimized for structural performance, while others are cultivated for their esthetic qualities, offering designers and artists a flexible medium to explore organic forms and sustainable design solutions. This adaptability has led to their incorporation into numerous architectural and artistic projects, highlighting their potential to reduce the environmental impact of building materials and promote circular economies [18]. Specific qualities can be obtained by using different substrates to grow fungal materials [19]. When rice husks and glass fines are incorporated as substrates, there is a significant increase in the fire resistance of the mycelium biocomposite [12]. MBCs can also serve as an acoustic insulation material with good noise absorption capabilities. Appels et al. [20] demonstrated how different mycelium species and various substrates could produce materials with specific mechanical and thermal properties suitable for construction applications. Similarly, Wang and Jiahao explored the use of mycelium in art and design, emphasizing how the choice of substrate influences the final texture and appearance of installations [21]. These findings underscore the versatility of mycelium and its potential to drive innovation in both material science and design practices.

Despite the increasing exploration of mycelium-based biocomposites as sustainable materials, a comprehensive and systematic analysis of their current application landscape, material requirements, and emerging trends across architecture and design remains underdeveloped. The existing literature tends to focus on specific material science domains or isolated case studies, thereby creating a significant gap in the empirical understanding of aggregate, industry-wide adoption patterns and the design properties driving their uptake. Consequently, there is a lack of a systematic, synthesized, and evidence-based review that encompasses practical applications, specific material selections (species/substrates), and emerging market trends. This study is significant because it provides a critical, synthesized overview of state-of-the-art applications, offering a reference for material scientists, designers, and architects seeking to utilize mycelium effectively, thereby accelerating the

transition of this biomaterial from laboratory curiosity to a widely adopted construction and design solution. The specific objectives of the current study are as follows:

- To systematically identify the primary application fields of mycelium-based materials and determine the contexts (e.g., structural, insulating, esthetic) in which the material is currently employed.
- To identify the crucial functional properties (e.g., density, compressive strength, fire resistance) required for the material in specific application areas, correlating these needs with the type of mycelium strain and substrate utilized in the studied projects.
- To determine the dominant combinations of mycelium species and substrate types used in relation to a given application area.
- To discern and characterize the emerging trends in mycelium applications within the fields of architecture and design.

2. Materials and Methods

2.1. Methodology

This study employed a mixed qualitative–quantitative analytical methodology based on a comparative analysis of a dataset containing information on completed built projects utilizing mycelium-based artifacts. This approach comprised two complementary analytical components:

- Quantitative analysis: the statistical compilation and visualization of all project data to quantify distribution patterns (e.g., the percentage distribution of fungal species, substrates, and applications over time).
- Qualitative analysis based on contextual thematic grouping and interpretive comparison of the quantified findings against established material science research and industry reports (e.g., justifying the preference for *Ganoderma lucidum* based on its documented mechanical properties, as discussed in Sections 3.1 and 3.2).

Data on built projects were systematically aggregated via continuous monitoring of official press releases and project announcements disseminated by leading firms specializing in mycelium material production.

Furthermore, a focused archival search was conducted across key digital repositories: Academia.edu (Academia, Inc., San Francisco, CA, USA); ArchDaily (DAAily platforms AG, Zurich, Switzerland); and Dezeen (Dezen Ltd., London, UK). These online platforms, specializing in innovative and sustainable design, served as critical secondary data sources.

The selection of these outlets was predicated on their established global recognition for documenting novel materials and techniques, thus enabling the effective capture of the diverse spectrum of mycelium applications in architecture and design, ranging from commercial products and temporary artistic installations to large-scale construction projects.

2.2. The Selection Criteria

The criteria for selecting examples are as follows:

- Representing various applications in architecture, urban design, interior design, and art.
- Real-world projects only.
- Projects from 2007 to 2024, showcasing pioneering applications and more recent developments, indicating the evolution of mycelium-based solutions and the growing interest in their use.
- The analysis of each entry must document the fungal species and substrate composition, highlighting innovative approaches using agricultural byproducts and other organic materials.

3. Results and Discussion

3.1. Data Summary

The results are presented in two tables. Table 1 includes projects in architecture, construction, and urban planning. Examples in this group have been divided according to the general use of mycelium in projects, specified in the “application” column as follows:

- Building materials: building blocks, bricks, self-supporting structures, and columns;
- Insulation and facade panels, used in building construction;
- Bioremediation.

Table 1. An overview of the 40 existing projects with mycelium application in architecture, construction, and urban planning.

No.	Application	Name/Localization	Authors	Year	Fungus	Main Substrate Ingredients	Ref.
1	Building blocks	Hy-Fi Tower/Long Island City, NY, USA	David Benjamin, The Living (New York, NY, USA)	2014	<i>G. lucidum</i>	Straw and paper	[22]
2	Building blocks	MycoTree/Seul, KOR	ETH Zurich (CHE), Karlsruhe Institute of Technology (DEU), Future Cities Laboratory (SGP)	2017	<i>P. ostreatus</i>	Straw and plant waste	[23]
3	Building blocks	Hack the Root/Mann Island, Liverpool, UK	Mae-Ling Lokko and Ecovative (Green Island, NY, USA)	2018	<i>P. ostreatus</i>	Sawdust and hemp	[24]
4	Building blocks	Mycelium Composites/Emeryville, CA, USA	MycoWorks (Emeryville, CA, USA)	2016	<i>G. lucidum</i>	Straw and paper	[25]
5	Building blocks	The Hayes Pavilion “6”/Glastonbury, UK	Simon Carroll and Biohm (London, UK)	2023	<i>G. lucidum</i>	Hemp waste	[26]
6	Building blocks	The Circular Garden/Milan, ITA	Carlo Ratti Associati (Torino, ITA)	2019	<i>P. ostreatus</i>	Sawdust and straw	[27]
7	Building blocks	In Vivo/Venice, ITA	Vinciane Despret, Bento Architecture (Lisbon, PRT)	2023	<i>G. lucidum</i>	Not mentioned	[28]
8	Building blocks	Myco-Temple/Port-de-Bouc, FRA	Côme Di Meglio	2021	<i>G. lucidum</i>	Sawdust	[29]
9	Building blocks	Mycelium on board/Breda, NLD	Shannon Peuling	2022	<i>Trametes hirsuta</i> , <i>Ganoderma resinaceum</i> , <i>Lenzites betulina</i>	Processed cellulose, rapeseed straw, hemp shives, and hemp fibers	[30]
10	Building blocks	MycoShell/Bethel Woods, NY, USA	Cornell University, Department of Architecture (Ithaca, NY, USA)	2024	<i>G. lucidum</i>	Corn cobs and hemp hurds	[31]
11	Building blocks	Myco-architecture off-planet Project/Moffett Field, CA, USA	NASA Ames Research Center (Moffett Field, CA, USA), Stanford University (Stanford, CA, USA)	2016	<i>G. lucidum</i>	Yard waste and wood chips	[32]
12	Building blocks	MycoHab/Windhuk, NAM	BioHab (Windhuk, NAM)	2019	<i>P. ostreatus</i>	Acacia mellifera	[33]
13	Building blocks	Symbiocene Living/London, UK	PLP Architecture, PLP Labs (London, UK)	2023	Not mentioned	Straw and wood chips	[33]
14	Building blocks	SAMOROST/České Budějovice, CZE	MYMO Association (Prague, CZE)	2023	Not mentioned	Not mentioned	[34]
15	Building units	Mycelium Pavilion/Troy, NY, USA	School of Architecture at Rensselaer Polytechnic Institute (Troy, NY, USA)	2019	Not mentioned	Not mentioned	[35]
16	Bricks	The Growing Pavilion/Ketelhuisplein, NLD	Company New Heroes (Amsterdam, NLD)	2019	<i>G. lucidum</i>	Plant fibers and organic composites	[36]
17	Bricks	Mycelium Brick/Green Island, NY, USA	Ecovative Design (Green Island, NY, USA)	2014	<i>G. lucidum</i>	Corn	[37]
18	Bricks	Glastonbury Mycelium Pavilion/Glastonbury, UK	Simon Carroll	2024	<i>G. lucidum</i>	Bioplastic made from seaweed	[38]
19	Bricks	Future Pavilion/Warsaw, POL	Warsaw University of Technology, Faculty of Architecture (Warsaw, POL)	2024	<i>G. lucidum</i>	Wood	[39]
20	Bricks	Homegrown Wonderland/New York, NY, USA	Andre Kong Studio (London, UK) (with Ecovative Design [Green Island, NY, USA] and Arup [London, UK])	2024	<i>P. ostreatus</i>	Hemp	[40]
21	Bricks	Lego-like bricks of fungi/Edinburgh, GB-SCT	PLP Architecture, PLP Labs (London, UK)	2024	Not mentioned	Hemp	[41]
22	Self-supporting structures	Mycotecture Alpha, Düsseldorf, DEU	Phil Ross (inventor), Michael Sgambellone (design engineer) and Far West Fungi (Moss Landing, CA, USA)	2009	<i>G. lucidum</i>	Straw and paper	[42]

Table 1. Cont.

No.	Application	Name/Localization	Authors	Year	Fungus	Main Substrate Ingredients	Ref.
23	Self-supporting structures	Grown Structure (a mycelium chair), Paris, FRA	Klarenbeek and Dros (Amsterdam, NLD)	2018	<i>P. ostreatus</i>	Straw and sawdust	[43]
24	Self-supporting structures	MycoBuilt/Ithaca, NY, USA	Cornell University, College of Architecture, Art, and Planning, College of Agriculture and Life Sciences (Ithaca, NY, USA)	2018	<i>G. lucidum</i>	Plant waste and organic composites	[44]
25	Self-supporting structures	El Monolito Micelio/Atlanta, GA, USA	Interspecific Collective (Mexico City, MEX)	2019	<i>G. lucidum</i>	Straw and agricultural waste	[45]
26	Self-supporting structures	MycoCreate 2.0 pavilion/Charlottesville, VA, USA	Benay Gürsoy Toykoç and Middle East Technical University, Department of Architecture (Ankara, TUR)	2022	Not mentioned	Organic waste	[46]
27	Self-supporting structures	MyCera structures/ Graz, AUT	Graz University of Technology, Institute of Architecture and Media (Graz, AUT)	2022	<i>P. ostreatus</i>	Wood and sawdust	[47]
28	Self-supporting structures	BioKnit/London, UK	The Hub for Biotechnology and the Built Environment (Newcastle, UK)	2023	Not mentioned	Sawdust	[48]
29	Column	Op't Oog Columns/Begijnendijk, BEL	Blast Studio (London, UK)	2022	Not mentioned	Paper coffee cups	[49]
30	Column	Woven mycelium/Venice, ITA	Polytechnic University of Milan, Architecture and Civil Engineering of the Built Environment, Material Balance Research (Milano, ITA)	2021	<i>G. lucidum</i>	Hemp and rattan	[50]
31	Column	Scan The World/London, UK	Robbie Jenkins	2022	Not mentioned	Not mentioned	[51]
32	Insulation panel	Ecovative's Mushroom Tiny House/Green Island, NY, USA	Ecovative Design (Green Island, NY, USA)	2013	<i>G. lucidum</i>	Agricultural waste	[52]
33	Insulation panel	Insulation panel/Hilversum, NLD	Grown.bio (Amsterdam, NLD)	2016	<i>P. ostreatus</i>	Agricultural waste	[53]
34	Insulation panel	Mykoslab/Bristol, UK	Mykor (Bristol, UK)	2022	<i>G. lucidum</i>	Cellulose	[54]
35	Facade panels	Crema Lab Façade/Curitiba, BRA	FURF Design Studio (Curitiba, BRA) and MUSH Design (Rotterdam, NLD)	2024	<i>G. lucidum</i>	Corn, wheat, soy, beans, and agricultural leftovers	[55]
36	Remediation of industrial and construction waste	Industrial Waste Bioremediation/Bolingbrook, IL, USA	Mycocycle (Bolingbrook, IL, USA)	2023	Not mentioned	Construction and industrial waste materials	[56]
37	Soil regeneration and reforestation	Life Box/Olympic Rainforest, WA, USA	Paul Stamets and Fungi Perfecti (Olympia, WA, USA)	2025	Not mentioned	Organic plant material and seeds	[57]
38	Bioremediation of oil-contaminated soil	Oil Spill Remediation/Olympic Rainforest, WA, USA	Paul Stamets and Fungi Perfecti (Olympia, WA, USA)	2007	<i>P. ostreatus</i>	Hydrocarbon-contaminated soil	[58]
39	Degradation of plastic polymers	Fungi Mutarium/XUtrecht, NLD	Katharina Unger and the University of Utrecht, Faculty of Science (Utrecht, NLD)	2024	Not mentioned	Polyurethane and plastic waste	[59]
40	Water purification using biofiltration	Mycofiltration for Water Purification, Green Island, NY, USA	Ecovative Design (Green Island, NY, USA)	2019	<i>P. ostreatus</i>	Polluted water (bacteria, metals, chemicals)	[60]

Table 2 covers projects in the field of design and art. This group has been divided according to the methods of application of mycelium as follows:

- Furniture and lighting designs;
- Acoustic and decorative interior panels;
- Flooring;
- Upholstery and textiles;
- Coffins;
- Installations and sculptures of art;
- Packaging.

Table 1 highlights the diverse applications of mycelium composites, ranging from construction and insulation to environmental remediation, soil regeneration, packaging design, and art installations. It illustrates the innovative approaches to integrating sustainable materials into design and architecture, reflecting a growing trend toward eco-

friendly building practices. Including projects from well-known organizations, universities, and architects lends credibility and highlights recognized efforts in mycelium research and application.

Table 2. An overview of the 50 artifacts made of mycelium.

No.	Application	Name	Authors	Year	Fungus	Main Substrate Ingredients	Ref.
1	Furniture	Mycelium Chair	Eric Klarenbeek	2013	<i>P. ostreatus</i>	Agricultural waste	[61]
2	Furniture	MYX	Jonas Edvard and Kasper Kjaergaard	2013	<i>G. lucidum</i>	Linen fibers	[62]
3	Furniture	Mycelium + Timber	Sebastian Cox and Ninela Ivanova	2017	<i>G. lucidum</i>	Wood waste	[63]
4	Furniture	The Growing Lab	Maurizio Montalti and Officina Corpuscoli (Amsterdam, NLD)	2015	<i>P. ostreatus</i>	Various agricultural byproducts	[64]
5	Furniture	Rongo Design furniture	Rongo Design (Cluj-Napoca, ROU)	2021	Not mentioned	Coffee grounds and agroindustrial waste	[65]
6	Furniture	Endless pot, endless vase	Blast Studio (London, UK)	2022	Not mentioned	Cardboard packaging and coffee cups	[66]
7	Furniture	Toad Stool	Ed Linacre, Philippa Abbott, and Mycelium Studios (Melbourne, VIC, AUS) with Brendon Morse	2021	Not mentioned	Not mentioned	[67]
8	Lighting	Conch light	Marc Theodoor van der Voorn and NEFFA (Utrecht, NLD)	2018	<i>G. lucidum</i>	Agricultural waste	[68]
9	Lighting	MushLume Lighting Collection	Danielle Trofe	2014	<i>P. ostreatus</i>	Agricultural waste	[69]
10	Lighting	Mycelium Lights	Nir Meri Studio and Biohm (London, UK)	2018	Not mentioned	Not mentioned	[70]
11	Lighting	Luminaria Hogar	Ola Luminárias Acústicas (Curitiba, BRA), and Mush Mycotechnology Design (Ghent, BEL)	2024	Not mentioned	Corn, wheat, soy, beans, and agricultural leftovers	[71]
12	Acoustic panels	Mogu Acoustic Panels	Mogu (Inarzo, ITA)	2019	<i>G. lucidum</i>	Agricultural waste	[72]
13	Acoustic panels	FIKA acoustic panels	Allsfar (Swindon, UK)	2023	<i>G. lucidum</i>	Hemp	[73]
14	Acoustic pannels	Acoustic panels	MYCEEN OÜ (Tallinn, EST)	Not mentioned	Not mentioned	Industrial waste	[74]
15	Acoustic pannels	Fumo panels	mylab (Copenhagen, DNK)	2021	Not mentioned	Not mentioned	[75]
16	Acoustic and thermal insulation panels	Acoustic and thermal insulation panels	RongoDesign (Cluj-Napoca, ROU)	2021	Not mentioned	Not mentioned	[76]
17	Decorative structures	Mycelium Tiles	Terreform ONE (New York, NY, USA)	2017	<i>P. ostreatus</i>	Agricultural waste	[77]
18	Decorative structures	MycoBoard	Ecovative Design (Green Island, NY, USA)	2016	<i>G. lucidum</i>	Agricultural waste	[78]
19	Decorative panels	Growing a mycelium panel	Antoni Gandia	2014	<i>G. lucidum</i>	Wheat husks	[79]
20	Decorative structures	Fungal Futures	Katharina Unger	2013	<i>P. ostreatus</i>	Agricultural waste	[80]
21	Flooring	Mogu Floor	Mogu (Inarzo, ITA)	2019	<i>G. lucidum</i>	Agricultural waste	[81]
22	Flooring	Mycelium panels	Charlotte Kamman, Mark Fretz	2014	<i>G. lucidum</i>	Straw, sawdust, and hemp	[82]
23	Flooring	Myco-Alga Tiles	bioMATTERS (Vilnius, LTU)	2023	<i>P. ostreatus</i>	Agricultural waste	[83]
24	Flooring	Mycelium Flooring System	Stanislaw Młyński and Academy of Fine Arts and Design (Katowice, POL)	2020	<i>P. ostreatus</i>	Agricultural waste	[84]
25	Flooring	Grow It Yourself (GIY) Flooring	Ecovative Design (Green Island, NY, USA)	2016	<i>P. ostreatus</i>	Agricultural waste	[85]
26	Flooring	Orbit Floor-standing screens	Allsfar (Swindon, UK)	2023	<i>G. lucidum</i>	Hemp	[86]
27	Upholstery	Reishi™	MycoWorks (Emeryville, CA, USA)	2020	<i>G. lucidum</i>	Agricultural waste	[87]
28	Upholstery	Mylo™	Bolt Threads (Emeryville, CA, USA)	2018	<i>G. lucidum</i>	Agricultural waste	[88]
29	Upholstery	Muskin	Life Materials S.r.l. (Turin, ITA)	2015	<i>Phellinus ellipsoideus</i>	Agricultural waste	[89]

Table 2. Cont.

No.	Application	Name	Authors	Year	Fungus	Main Substrate Ingredients	Ref.
30	Upholstery	The furniture leather	MYKOS, University of California (Davis, CA, USA) and Yunnan Arts University (Kunming, CHN)	2019	<i>P. ostreatus</i>	Agricultural waste	[90]
31	Upholstery	Parycel shell	NEFFA (Utrecht, NLD)	2016	<i>G. lucidum</i>	Agricultural waste	[91]
32	Upholstery	Forager™ Foams and Hides	Ecovative Design (Green Island, NY, USA)	2022	<i>G. lucidum</i>	Not mentioned	[92]
33	Textiles	Mycotex (a dress from mycelium)	Aniela Hoitink and NEFFA (Utrecht, NLD)	2016	<i>G. lucidum</i> and <i>Fomes fomentarius</i>	Not mentioned	[93]
34	Textiles	Mylium	Mylium B.V. (Amsterdam, NLD)	2022	Not mentioned	Not mentioned	[94]
35	Textiles	SashiFungi	School for Thinking Visual (Milano, ITA)	2021	<i>P. ostreatus</i>	Not mentioned	[95]
36	Textiles	Ephea	Vegea S.r.l. (Milano, ITA)	2022	<i>P. ostreatus</i>	Not mentioned	[96]
37	Coffin and urn	The loop cocoon	Loop Biotech (Delft, NLD)	2020	<i>G. lucidum</i>	Hemp fibers	[97]
38	Sculptures	Faith	FURF Design Studio (Curitiba, BRA)	2022	<i>G. lucidum</i>	Corn, wheat, soy, beans, and agricultural wastes	[98]
39	Sculptures	Mushroom of immorality	Georgia Gerrard and Kingston University, Kingston School of Art (London, UK)	2022	<i>G. lucidum</i>	Alpaca wool, sheep wool, and straw	[99]
40	Art installation	Fungi Kingdom bio-art	Julio Oropel and Jose Luis Zacarias Otiñano (in Buenos Aires, ARG)	2023	<i>G. lucidum</i> , <i>P. ostreatus</i> , and <i>Cyclocybe aegerita</i>	Not mentioned	[100]
41	Art installation	Living mycelium dunes	YUME YUME and MycoWorks (Emeryville, CA, USA)	2023	<i>G. lucidum</i>	Not mentioned	[101]
42	Art installation	Mycelium mockup	AFJD Studio (Vancouver, BC, CAN)	2015	<i>P. ostreatus</i>	Sawdust	[102]
43	Art installation	Inverted architecture	Studio Link-Arc (New York, NY, USA)	2022	Not mentioned	Not mentioned	[103]
44	Packaging	Mushroom® packaging (myco foam)	Ecovative Design (Green Island, NY, USA)	2010	<i>P. ostreatus</i>	Grain husks and straw	[104]
45	Packaging	MOGU packaging	MOGU (Inarzo, ITA)	2015	<i>G. lucidum</i>	Plant fibers	[105]
46	Packaging	Eco Packaging and DIY kits	Grown.bio (Amsterdam, NLD)	2018	<i>P. ostreatus</i>	Seed husks and wood chips	[106]
47	Packaging	Mycelium packaging	Mycotech Lab (Bandung, IDN)	2015	<i>G. lucidum</i>	Bamboo fibers	[107]
48	Packaging	Handcrafted packaging using Reishi mycelium leather alternative	MycoWorks (Emeryville, CA, USA)	2013	<i>G. lucidum</i>	Plant fibers and sawdust	[87]
49	Packaging	MONC Mycelium packaging	MONC (London, UK)	2020	<i>P. ostreatus</i>	Rice husks and plant fibers	[108]
50	Packaging	Mushroom packaging	Magical Mushroom Company (Esher, UK)	2019	Not mentioned	Not mentioned	[109]

Table 2 provides an overview of notable products, installations, and material innovations utilizing mycelium, detailing its application, the responsible authors or companies, the type of fungus used, and the main substrate ingredients. This compilation highlights the material's potential to drive innovation across sectors.

3.2. Mycelium Types

Figure 1 illustrates the distribution of fungal species identified in the analyzed projects, categorized into distinct domains: architecture, construction, and built environment (Table 1); art and design (Table 2); and those projects that span both of these disciplinary groups.

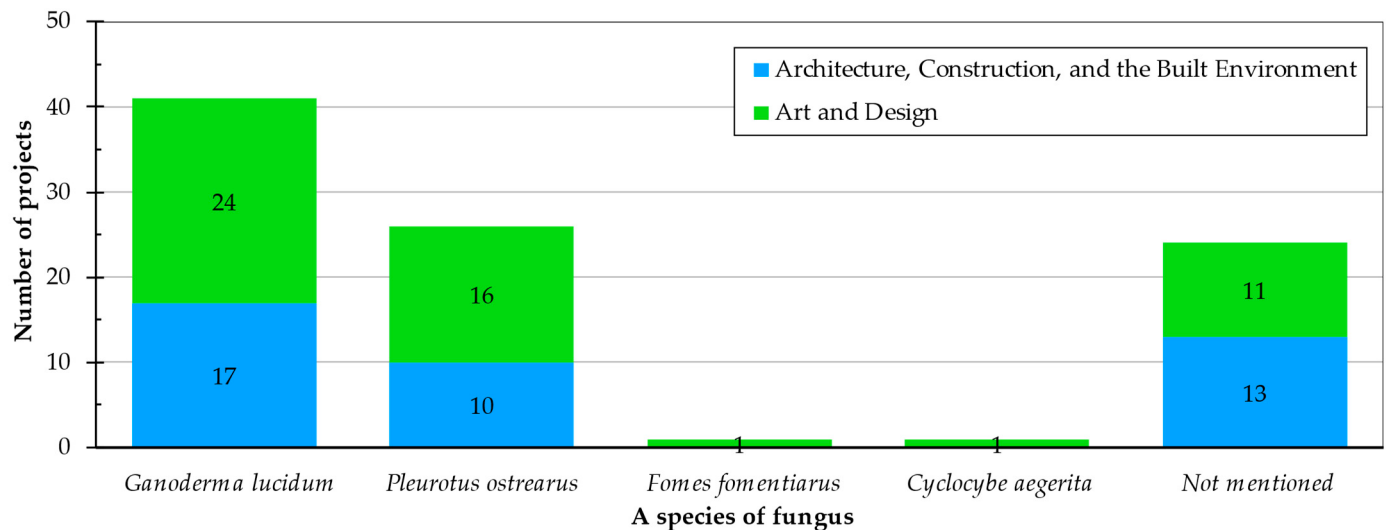


Figure 1. Comparative distribution of fungal species.

Following the general overview of fungal species utilization presented in Figures 1 and 2 provides a specific quantitative breakdown of the four most frequently identified species used across the analyzed projects. This visualization is essential for understanding material preference within current mycelium applications. It highlights the relative dominance of species such as *Ganoderma lucidum* and *Pleurotus ostreatus* in both the architecture/construction domain and the art/design domain while also tracking the frequency with which the fungal species information was not specified in the project documentation.

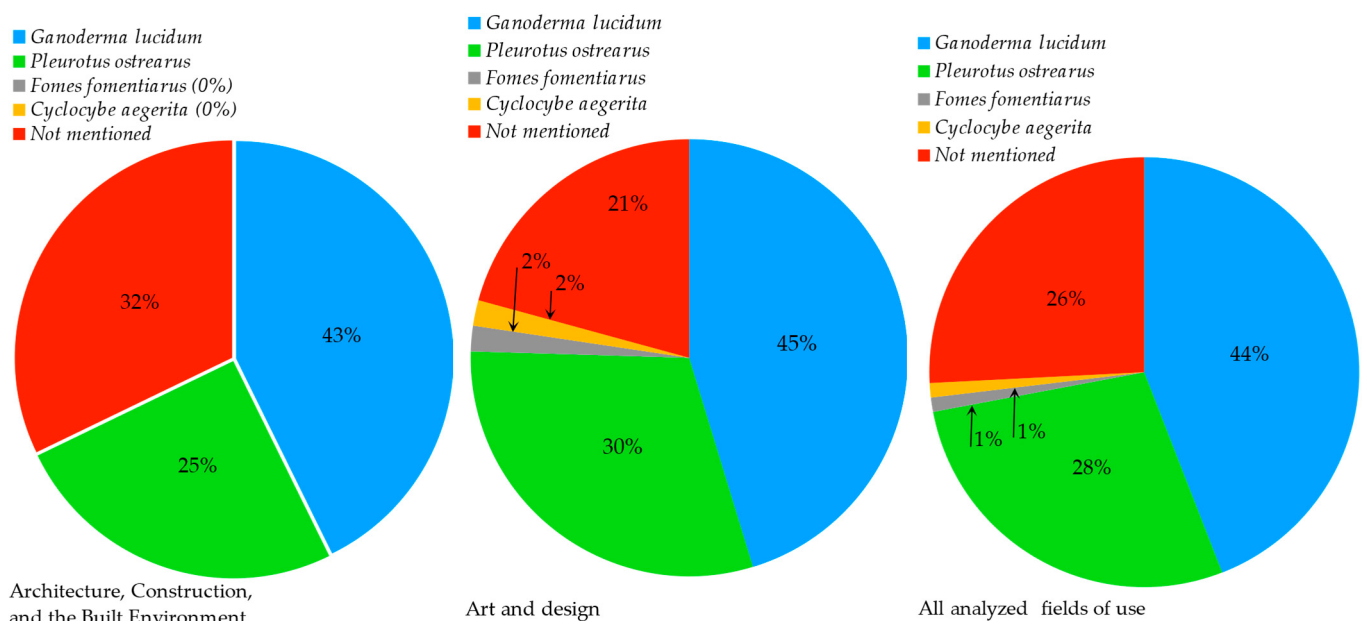


Figure 2. Usage percentage of key fungal species.

Figures 1 and 2 show that the most commonly used species of mycelium in the analyzed projects is *Ganoderma lucidum* (44%). This prevalence aligns with the existing literature, notably the comprehensive review by Yang et al. (2021) on mycelium-based biocomposites [110] and corroborating findings by Sydor et al. (2022) [111].

This species exhibits mechanical characteristics that render it suitable for compression-only structures and insulation applications [112]. Its elevated chitin content confers durability and fire-resistant properties, surpassing conventional synthetic foams in performance

metrics [113]. These structural advantages establish *Ganoderma lucidum* as a viable alternative to traditional building materials.

Beyond its functional properties, this mycelium species exhibits aesthetic qualities through its distinctive textures and morphological forms, facilitating innovative design solutions in artistic contexts [114]. The material's versatility enables the creation of visually compelling architectural structures while adhering to sustainability principles [6]. From an environmental perspective, mycelium-based composites derived from *Ganoderma lucidum* represent a renewable alternative that substantially reduces carbon emissions compared to conventional materials [115]. The utilization of agricultural waste substrates for cultivation further enhances the material's ecological profile [114].

The second most commonly used type of mycelium in both construction and artistic structures projects is *Pleurotus ostreatus*, which is utilized in 28% of all projects. *P. ostreatus* is relatively easy to grow, making it convenient for projects that require large amounts of material. Like *Ganoderma lucidum*, this fungal species may offer interesting visual qualities, which makes it a popular choice for artistic projects. While *G. lucidum* maintains predominance in current applications, alternative species such as *P. ostreatus* demonstrate potential for specialized implementations, suggesting considerable diversity within the mycelium-based materials sector that merits continued investigation [115].

Recent studies comparing the mycelium composites of *Ganoderma lucidum* and *Pleurotus ostreatus* highlight significant differences in their mechanical and thermal properties. *G. lucidum* exhibits a higher compressive strength, reaching up to 1.91 MPa in specific substrates, while *P. ostreatus* shows much lower strength values of around 0.03 MPa under similar conditions [116]. This indicates that *G. lucidum* is better suited for structural or load-bearing applications. In addition, *G. lucidum* composites can achieve very low densities ($\sim 60 \text{ kg/m}^3$) while maintaining modest mechanical strength (0.1686 MPa at 50% deformation), making them ideal for lightweight insulation panels or non-structural partitions [117]. Thermal conductivity measurements further support the insulation capacity of *G. lucidum* composites, with values around $0.047 \text{ W/(m}\cdot\text{K)}$ [117]. On the contrary, *P. ostreatus* composites tend to have higher densities ($\sim 343 \text{ kg/m}^3$) and generally lower mechanical strength; however, when combined with fiber reinforcements, *P. ostreatus* composites can reach compressive strengths up to 2.9 MPa, although pure mycelium materials remain comparatively weaker [118]. Overall, *G. lucidum* presents superior mechanical robustness and reliable thermal insulation properties, making it a more suitable choice for sustainable building projects where structural integrity and energy efficiency are essential. In contrast, *P. ostreatus* remains valuable for non-structural applications such as packaging, acoustic panels, or artistic design, primarily when used in conjunction with reinforcement [116,118]. While *P. ostreatus* is the second most commonly used species (28% of projects) due to its ease of growth and visual qualities, its comparative mechanical weakness (lower strength and higher density compared to *G. lucidum*) limits its role to non-structural uses such as packaging and acoustic panels, a pattern clearly reflected in the distribution of applications within our collected data, as presented in Figures 1 and 2.

3.3. Substrates

Figure 3 illustrates the most commonly used substrate types among the examples analyzed in the projects from Group 1 (architecture, construction, and the built environment), Group 2 (art and design), and all the projects listed in Table 1. These are substrates that have been utilized in multiple projects. They include agricultural waste, such as straw, wood, bamboo, and sawdust, as well as paper and cellulose, hemp, corn, and various plant fibers.

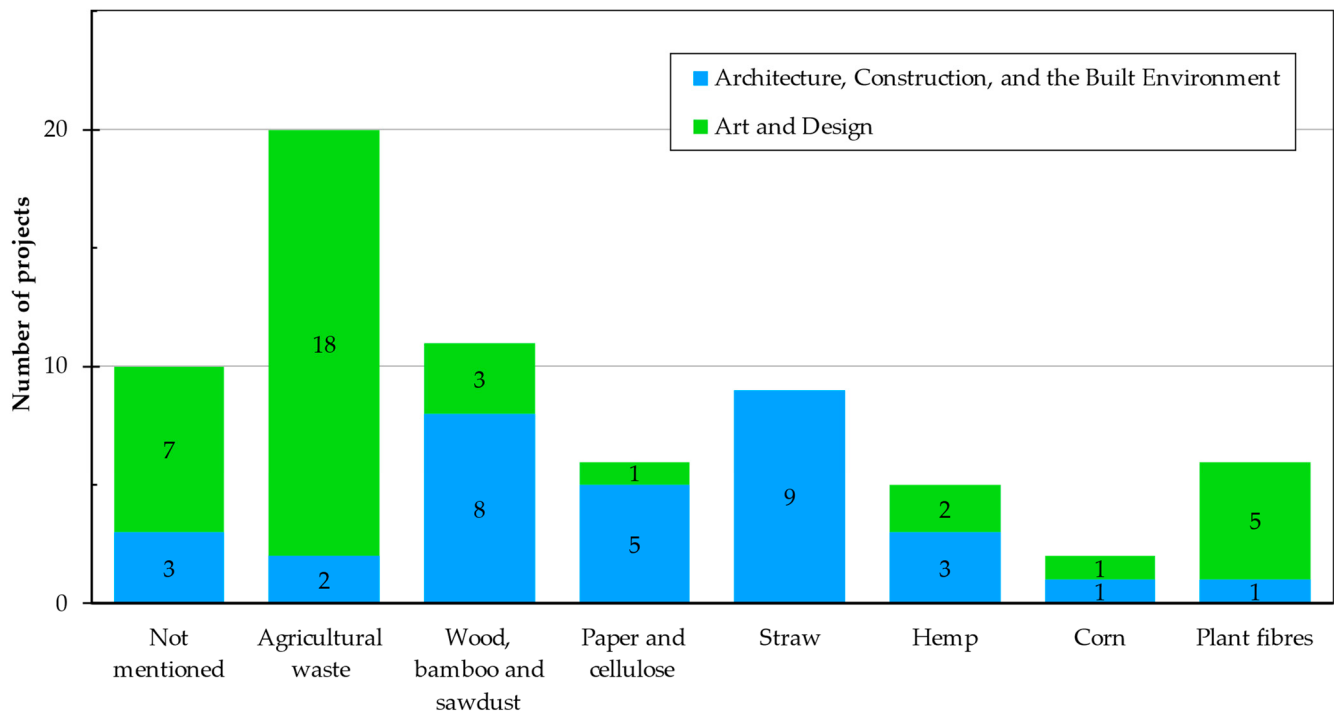


Figure 3. Substrate utilization frequency.

Figure 4 illustrates the percentage share of projects with specific substrates from Group 1 (architecture, construction, and the built environment) and Group 2 (art and design), as well as all projects.

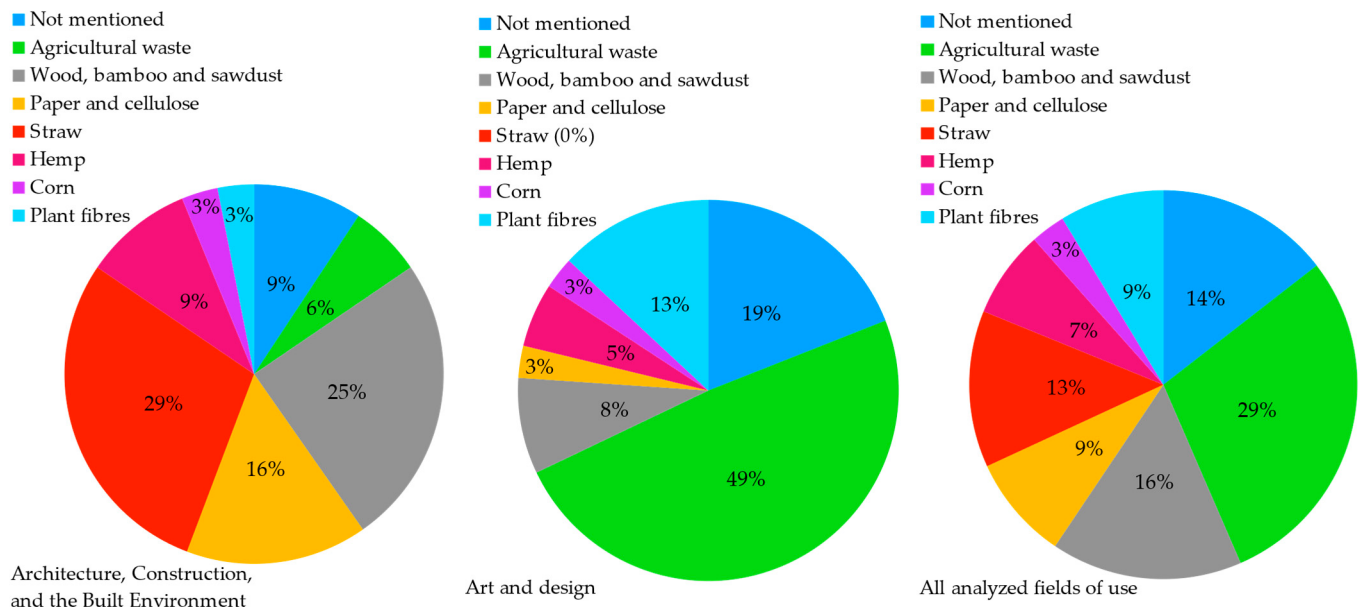


Figure 4. Percentage share of specific substrates by project domain.

The results shown in Figures 3 and 4 indicate that the choice of substrates is more specific in projects that incorporate mycelium into construction elements, with straw, wood, bamboo, and sawdust being the most commonly used materials. Straw was used as a substrate in 28% of architectural projects; the second most used substrates were wood, bamboo, and sawdust materials, comprising 25%. The observed preference for straw and wood/sawdust in construction-related projects (28% and 25%, respectively) is likely due to

findings in the material science literature that suggest that lignocellulosic materials, such as wood chips and straw, provide a matrix that results in composites with superior mechanical strength and reduced shrinkage compared to finely ground substrates. Densified maize straw exhibited significant increases in tensile strength (598.6 MPa) and Young's modulus (16.6 GPa) through chemical treatment and hot pressing, demonstrating the potential for high-performance applications [119]. Incorporating nanocellulose from wood sawdust into cement composites improved the mechanical properties and reduced crack propagation, showcasing the benefits of lignocellulosic materials in enhancing the durability of building materials [120]. This finding substantiates the selective use of these specific substrates in applications demanding greater structural integrity.

In art and design projects, the type of mycelium was most commonly generalized as agricultural waste (49% of projects). A total of 19% of projects did not describe the substrates used. In addition, 14% of the selected art and design projects made with MBCs used plant fibers as the substrate.

3.4. Main Manufacturers

After analyzing the scope of the projects in the table, it became apparent that several manufacturers offer a range of products suitable for various types of mycelium applications. The selection of the leading manufacturers of mycelium products was based on several key criteria that helped identify companies with the most significant impact on this sector, especially in design and architecture.

One of the criteria considered was the diversity of the product offered by companies. For example, MycoWorks created Reishi™, which imitates leather, a pioneering solution for the fashion industry, and Ecovative Design offers both packaging and building materials. The diversity of the product portfolio testifies to the versatility of mycelium technology. Pioneering and innovation were other criteria. Companies such as Ecovative Design and MycoWorks are pioneers in this field, having been the first to develop mycelium technology on a large scale. Their research into the various applications of mycelium, ranging from packaging to building materials, often serves as the foundation for the development of the entire sector. The last consideration was the application of mycelium in design and architecture. The selected companies actively use mycelium in architecture, construction, and interior design projects.

Each manufacturer of mycelium products uses different species of mycelium and substrates, tailored to the specific properties of their products. Table 3 summarizes the details on the types of mycelium and substrates used by the major manufacturers.

Table 3. An overview of the leading producers, the types of mycelium and the substrates involved, and the range of mycelium-based products they offer in the field of architecture and design.

Manufacturer	Fungal Species	Substrate	Mycelium Products
Ecovative Design LCC (Green Island, NY, USA) [121]	<i>P. ostreatus</i> , <i>G. lucidum</i>	Agricultural waste: rice husks, straw, seed husks, sawdust	Eco-friendly packaging, composite materials, MycoFlex (flexible textiles)
MycoWorks Inc. (Emeryville, CA, USA) [122]	<i>G. lucidum</i>	Sawdust, agricultural waste, organic biomass	Reishi™ (leather-like material), leather finishes (fashion, interior design)
MOGU S.r.l. (Inarzo, ITA) [123]	<i>P. ostreatus</i>	Agricultural waste: straw, hemp waste, organic residues	Acoustic panels, flooring, decorative elements made from mycelium
Biohm Ltd. (London, UK) [124]	<i>P. ostreatus</i>	Sawdust, straw, organic waste	Mycelium insulation panels, bio-based construction materials
Grown.bio B.V. (Amsterdam, NLD) [125]	<i>P. ostreatus</i>	Agricultural waste: straw, sawdust, organic biomass	Furniture (tables, chairs, lamps), decorative items, packaging, architectural elements

3.5. Trends and Prospects

To study trends in the use of mycelium-based composites, we analyzed 90 examples divided into two categories, as shown in Table 1.

- Architecture, construction, and urban planning: Forty examples were analyzed. Next, the examples were divided into groups according to the type of mycelium application used in the project, as shown in Table 1. In the “Application” section, trends were examined across smaller subgroups.
- Design and art: An analysis was carried out on 50 examples, which were then further divided into groups according to the type of mycelium application used in the project, as shown in Table 1. In the “Application” section, trends were examined across smaller subgroups.

Figure 5 illustrates the number of projects in the field of architecture, construction, and the built environment which were created between 2007 and 2024, categorized into groups, as listed in Table 1 under the “Application” column.

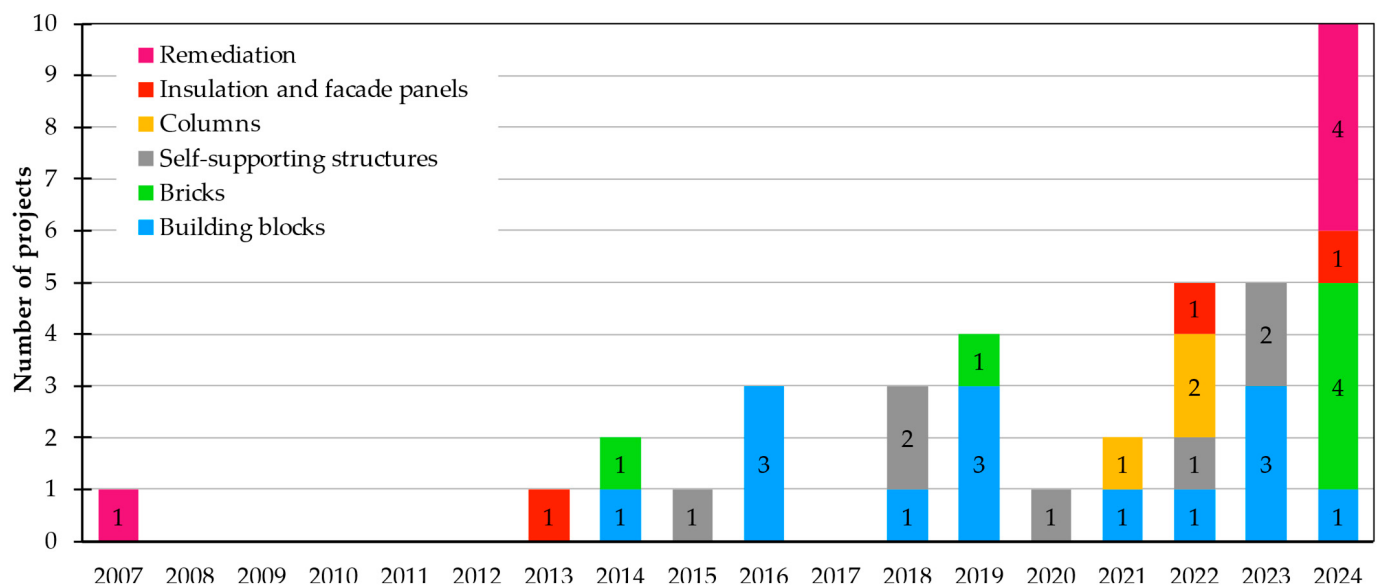


Figure 5. The annual number of projects in the field of Architecture, Construction, and the Built Environment (2007–2024).

The results in Figure 5 indicate that building blocks comprise the largest number of existing projects in which mycelium is used in construction, architecture, and spatial management. There are at least 14 examples of such mycelium use.

Figures 6 and 7 illustrate the trends in the number of architecture, construction, and the built environment projects utilizing mycelium applications from 2007 to 2024, categorized into groups. The data highlight the evolution of interest and adoption in various industries, showcasing significant milestones, periods of growth, and notable fluctuations.

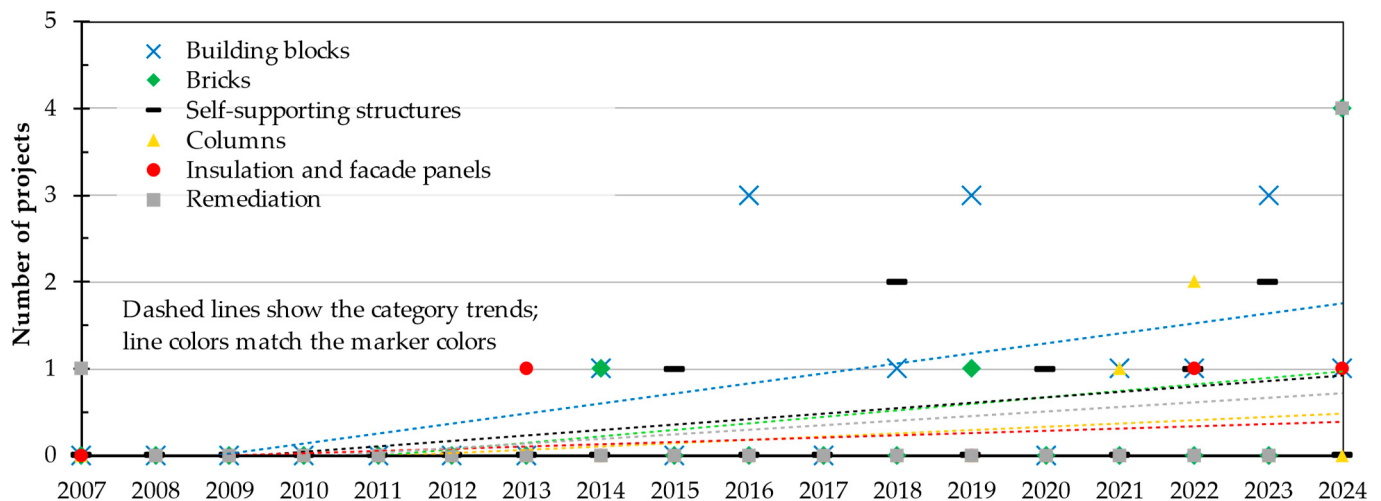


Figure 6. General trend in the number of architecture, construction, and the built environment projects by category (2007–2024).

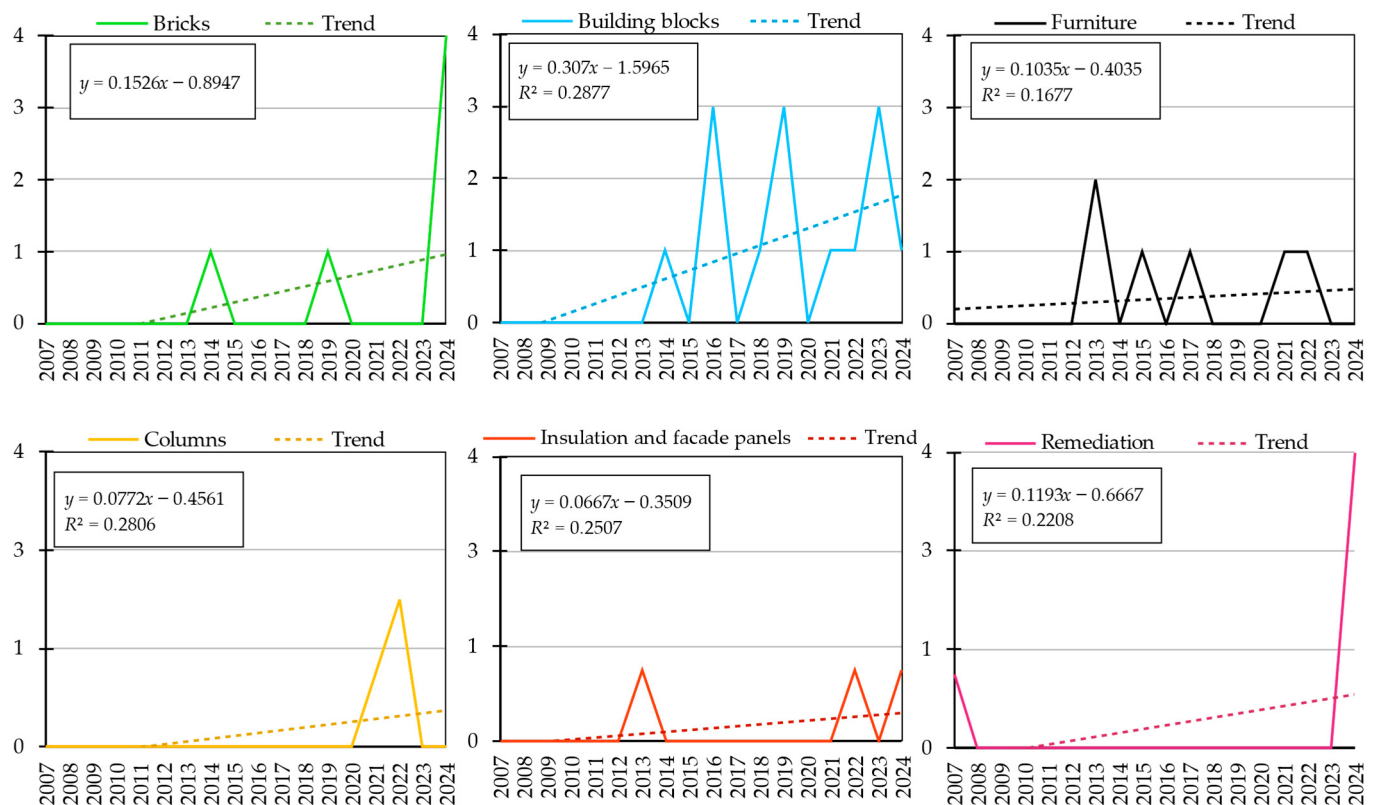


Figure 7. The detailed trends in the number of projects in the field of architecture, construction, and the built environment (2007–2024).

Further analysis of the trends illustrated in Figure 7 reveals distinct developmental trajectories for different architectural applications of mycelium. The most prominent trend is the consistent and significant growth in the use of modular components, particularly building blocks and bricks, which indicates a robust and growing interest in mycelium as a primary construction material. In contrast, applications such as self-supporting structures show more moderate but steady development, while areas like insulation, facade panels, and remediation have experienced notable growth in recent years. Table 4 provides a detailed overview of these trends, offering an interpretation for each category.

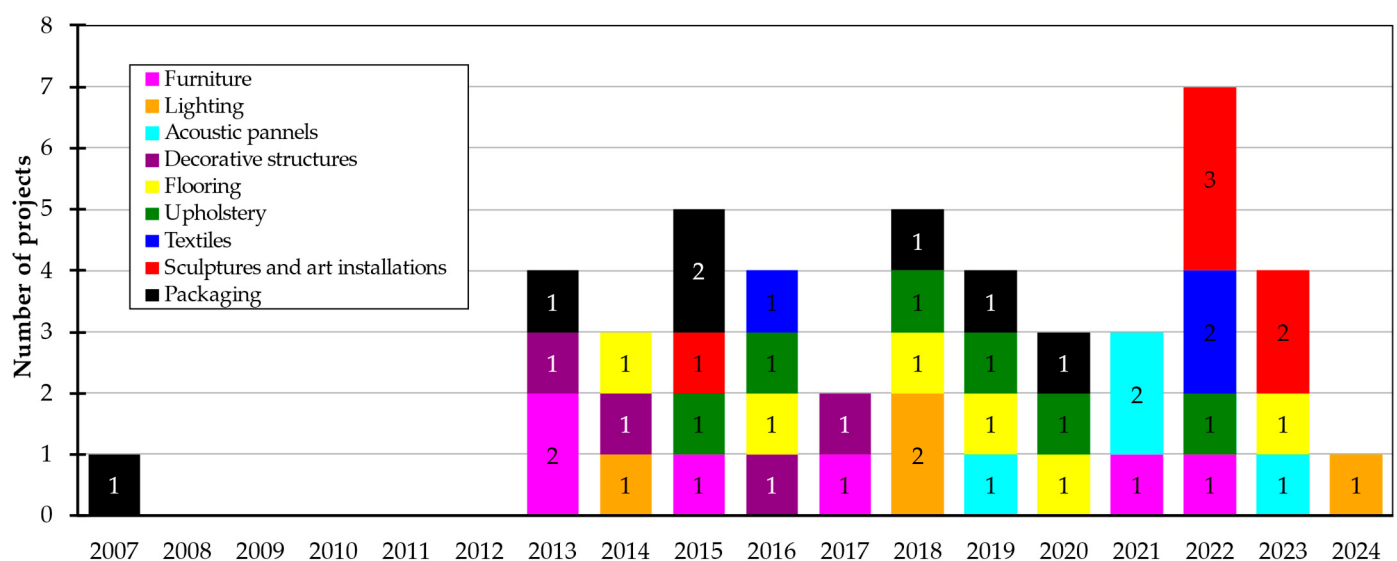
Table 4. An overview of the trends is illustrated in Figure 7, providing insight into each category of application.

Category	Trend	Insight
Bricks	An upward trend, especially in recent years	Shows growing interest and development of building materials using mycelium
Building blocks	A consistent growing trend, the most prominent among others	Shows growing interest and development of building materials using mycelium
Self-supporting structures	A moderate and steady trend	Reflects potential in structural and architectural applications due to the mycelium's natural properties
Column	Limited with a slight growth	Suggests that this is not a primary focus area for mycelium applications
Insulation and facade panels	Slight growth, especially in recent years	Indicates the development in this field in recent years
Remediation	Growth, especially in recent years	Highlights the development in this field in recent years

The consistent and significant growth of modular components (bricks and building blocks, mentioned in Table 4) is directly attributed to the industry's increasing demand for materials that enable sustainable and prefabricated construction, driven by global carbon reduction mandates and the need to obtain the necessary structural certifications, including for non-load-bearing applications. Modular construction techniques, such as off-site fabrication, contribute to substantial reductions in carbon emissions by minimizing waste and optimizing resource use [126]. Prefabrication has led to a 30% reduction in carbon emissions and an 84% decrease in on-site waste [127]. The use of eco-friendly materials and energy-efficient systems further enhances the sustainability of modular buildings [126].

The noticeable growth in remediation projects reflects the increasing recognition of mycelium's unique capacity to degrade persistent pollutants via mycoremediation, positioning it as a scalable, low-cost biotechnological solution to environmental challenges. Mycelium acts as a biological agent that breaks down complex pollutants through enzymatic processes. Fungi such as *Pleurotus ostreatus* and *Phanerochaete chrysosporium* are particularly effective in degrading organic contaminants and heavy metals [128]. While mycoremediation represents a promising solution to environmental challenges, it is essential to consider the limitations, such as the need for further research on scalability and optimization of fungal strains for specific pollutants.

Figure 8 illustrates the number of design and art projects, divided into groups, as listed in Table 1 under the “Application” column, from 2007 to 2024.

**Figure 8.** The annual number of design and art projects (2007–2024).

The results in Figure 8 indicate that the packaging sector comprises the largest number of existing projects incorporating mycelium into design and art. There are at least seven examples of such use of mycelium.

Figures 9 and 10 illustrate the trends in the number of projects in the design and art fields utilizing mycelium applications from 2007 to 2024, categorized by groups. The data highlight the evolution of interest and adoption of mycelium in various industries, showcasing significant milestones, periods of growth, and notable fluctuations.

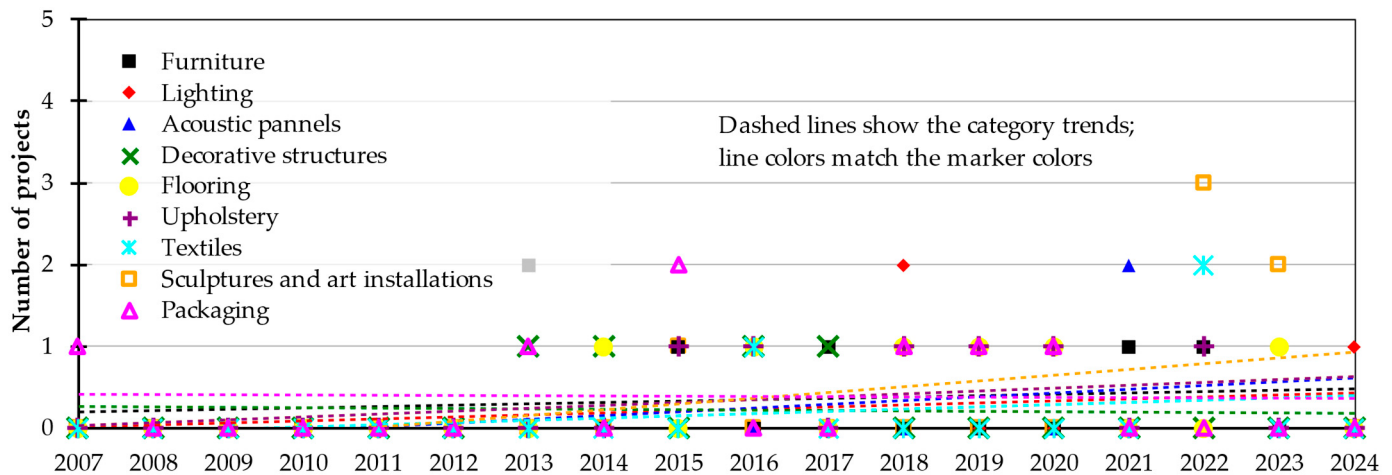


Figure 9. General trend in the number of design and art projects by category (2007–2024).

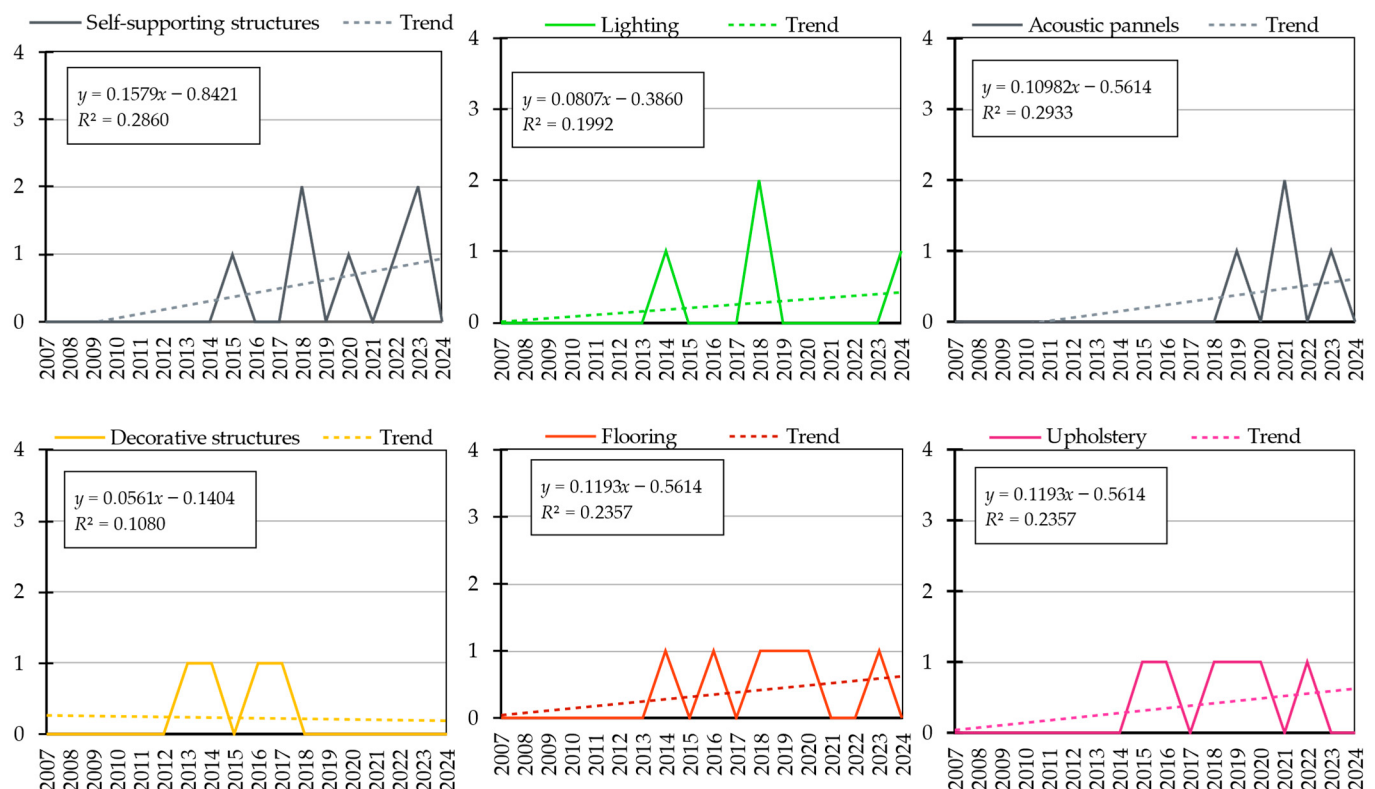


Figure 10. The detailed trends in the number of microembolization design and art projects (2007–2024).

Table 5 provides an overview of the trends shown in Figure 10, offering insight into each category of application.

Table 5. An overview of the trends from Figure 10, with an insight into each category of application.

Category	Trend	Insight
Furniture	Slight upward trend	Occasional interest, indicating a growing niche for innovative uses of mycelium in furniture.
Lighting	Irregular but increasing	Shows growing interest in aesthetic and functional lighting solutions using mycelium.
Acoustic Panels	Moderate and steady trend	Reflects potential in acoustic insulation applications due to the natural properties of mycelium.
Decorative Structures	Limited with a slight decline	Suggests that this is not a primary focus area for mycelium applications.
Flooring	Moderate and consistent growth	Indicates practical uses of mycelium in interior design and architecture.
Upholstery	Moderate and consistent growth	Highlights potential for further adoption in interior applications.
Textiles	Limited and sporadic	The remainder is experimental, with few projects exploring this category.
Sculptures and Art Installations	Significant upward trend	Reflects growing popularity in the creative and artistic industries.
Packaging	Relatively stable	Aligns with sustainable packaging solutions and shows moderate adoption.

The limited and sporadic nature of mycelium-based textiles underscores the current technical challenges in achieving the required material properties. Mycelium textiles lack the robustness required for everyday wear, making them less appealing to consumers who prioritize longevity [129]. Achieving the right balance of flexibility while maintaining structural integrity remains a challenge, as mycelium can be rigid and less adaptable compared to traditional fabrics [130]. Current production methods are not yet optimized for large-scale manufacturing, a crucial requirement for meeting market demands [131].

The figures presented in this study show that the number of projects related to packaging made from mycelium has increased in recent years. Several projects, such as MycoFoam by Ecovative and MOGU Packaging, point to the emergence of mycelium as a sustainable alternative to plastic packaging. These mycelium-based solutions are biodegradable, non-toxic, and can be grown using a variety of low-impact substrates, significantly reducing the environmental impact of packaging materials.

Mycelium's ability to act as both a sound absorber and a thermal insulator suggests a promising future for its role in energy-efficient building design. Over the last four years, numerous new projects utilizing mycelium-made insulation panels have been developed.

Several projects explore the potential of mycelium as a modular design material, particularly in flooring and construction elements. The Grow It Yourself Flooring by Ecovative Design and Mogu Floor highlights the ease of customizing and scaling mycelium materials. These modular systems enable users to engage with the material production process and create customized products, aligning further with DIY sustainability movements.

Mycelium-based materials have gained prominence in art installations and public projects over the past few years. These installations explore the artistic possibilities of mycelium while raising awareness of the sustainability and ecological impact of fungal biomaterials. Such projects aim to popularize mycelium and educate recipients, familiarizing them with the appearance and specifications of this material, while promoting environmentally friendly solutions.

Recent research on the long-term behavior of mycelium-based composites (MBCs) suggests that, while these materials are promising, their utility in humid or soil contact environments is limited without protective treatment. For example, mycelium composites made with *Ganoderma lucidum* on a 30% Arboloco and 70% Kikuyu grass substrate exhibited a density of approximately $60.4 \pm 4.5 \text{ kg/m}^3$, a compressive strength of

0.1686 MPa at 50% deformation, and a thermal conductivity of $0.047 \pm 0.002 \text{ W/(m}\cdot\text{K)}$ [117]. These composites also demonstrated notable shrinkage and high water absorption. In a soil burial test conducted under controlled conditions, mycelium-based composites were incubated in potting soil for up to 16 weeks. After this period, inert composites made from *Ganoderma resinaceum* and hemp fibers exhibited a weight loss of approximately 43%, whereas living composites of the same material underwent further degradation, with a mass loss of around 50.8% [35]. A review of mycelium biocomposites also highlighted that although MBCs can offer insulation and ecological benefits, their outdoor durability is questionable unless coatings or design modifications are applied [132]. These findings emphasize the importance of protective strategies, such as hydrophobic treatments or encapsulation, if MBCs are to be used in environments with long-term exposure to moisture or biological decay.

3.6. Extrapolation of the Trends and Possible Future Impacts

Analysis of current trends reveals distinct trajectories for mycelium-based composites across various sectors, primarily driven by the material's functional properties and its alignment with sustainability goals.

In architecture and construction, the most significant growth is observed in modular components. Mycelium bricks exhibit a strong upward trend, while building blocks show consistent and prominent development, suggesting a trajectory toward becoming mainstream materials in prefabricated construction systems. Similarly, applications in insulation and facade panels are expanding, driven by stricter energy efficiency regulations and the demand for biodegradable building solutions. In contrast, structural applications show more varied progress. Although there is a steady, niche interest in self-supporting structures for experimental bio-architecture, the use of mycelium for load-bearing columns remains limited, indicating that significant advances in material strength are required for broader adoption in this area. Flooring also shows moderate and consistent growth, positioning it to become a staple in green building projects.

Mycelium is gaining traction as a sustainable alternative to conventional materials within the interior design and product sectors. Its inherent sound-absorbing properties have led to steady growth in acoustic panels, making it a viable option for residential and commercial acoustic solutions. Furniture, lighting, and upholstery applications demonstrate moderate but consistent expansion, fueled by consumer and designer demand for environmentally friendly esthetics and materials. However, mycelium-based textiles remain a niche experimental field, facing challenges in scalability and durability that currently hinder widespread development.

Beyond its structural and decorative roles, the applications of mycelium in art, industry, and environmental science highlight its versatility. The use of mycelium in sculptures and art installations shows a significant upward trend, as artists increasingly adopt it as a medium for environmental art. Conversely, general decorative structures have seen a slight decline, possibly due to challenges in production scaling. In industrial applications, mycelium packaging has achieved moderate but stable adoption as a sustainable alternative to plastics, with its growth poised to accelerate amid the global push for waste reduction. Finally, environmental remediation is a rapidly emerging area where mycelium's capacity to degrade pollutants presents a scalable solution for soil and water restoration, signaling a future role in large-scale ecological management.

Based on current trends, mycelium is projected to disrupt sustainable construction and eco-conscious design. As detailed in Table 5, applications ranging from building blocks to furniture are on a path toward mainstream adoption, while mycelium's role in envi-

ronmental remediation could become revolutionary. Table 6 summarizes the extrapolated growth for each category and outlines the anticipated future impact.

Table 6. A summary of the projected trends and the anticipated impacts of mycelium across different application areas.

Category	Extrapolation	Future Impact
Furniture	Steady growth is expected as sustainability becomes a priority, creating a niche for innovative, modular, or multifunctional designs.	Disruption in traditional furniture manufacturing and adoption by eco-friendly brands are expected.
Lighting	Rising interest in esthetic and functional designs is expected, as is growing recognition of its sustainability benefits and unique appearance.	Mainstream adoption of eco-conscious design is expected in residential, commercial, and public spaces.
Acoustic Panels	Continued steady growth is expected due to its natural sound-absorbing properties, making this material appealing in sustainable architecture.	It is expected to become widely used in residential and commercial soundproofing projects, with increased demand in the building industry.
Decorative Structures	The decline suggests limited growth potential; however, niche applications in art and design may persist.	It is unlikely that this trend will become a mass-market trend, but it may continue to find a home in specialized artistic projects.
Flooring	Moderate and consistent growth is expected, with sustainable building materials driving adoption.	It is expected to become mainstream in green building projects and prominent in eco-conscious residential and commercial developments.
Upholstery	Steady adoption as an alternative to synthetic materials in interior design is expected.	Strong growth in eco-friendly living and luxury markets, particularly in furniture design, is expected.
Textiles	The integration of mycelium in textiles remains limited and experimental, primarily due to persistent challenges in achieving scalability and durability.	The future can bring long-term breakthroughs for eco-conscious fashion and functional fabrics, but near-term growth remains a niche market.
Sculptures and Art	A significant upward trend is expected in line with an increasing use in creative and artistic industries.	The signature materials of environmental art are expected to feature more heavily in future installations and sculptures.
Packaging	Stable growth is expected as it represents a sustainable alternative to plastic, particularly for food and consumer goods.	Driven by anti-plastic initiatives, broader adoption is expected across the e-commerce, food, and electronics industries.
Bricks	The strong upward trend suggests continued innovation and increased adoption of mycelium-based bricks in sustainable construction. These bricks may become more competitive with traditional materials as material science advances.	This could lead to greater regulatory support and certification for sustainable building materials.
Building Blocks	Given the consistent and prominent growth, mycelium building blocks are likely to become a mainstream choice in modular, lightweight construction systems.	Enhanced integration of mycelium blocks into global supply chains could transform affordable housing and disaster relief construction.
Self-Supporting Structures	The steady trend suggests a growing niche market for mycelium in architectural innovation. We may see more experimental and functional uses in art installations as designers explore its unique properties.	In time, advances in engineering techniques may allow mycelium to play a more substantial role in permanent structural applications.
Columns	Limited growth suggests that this category may remain secondary unless significant breakthroughs in material strength and load-bearing capacity occur.	While not a primary focus, mycelium columns might find specialized applications in lightweight structures, artistic designs, or low-load installations.
Insulation and Facade Panels	Recent growth points to increasing adoption, particularly in energy-efficient buildings.	Mycelium panels could become standard in green construction, especially in retrofitting existing buildings.
Remediation	The noticeable growth suggests expanding research and deployment in this field. Mycelium's ability to degrade pollutants and restore ecosystems is likely to become a critical tool in environmental management.	Mycelium-based remediation could revolutionize the way industries handle pollution, offering scalable solutions for soil restoration, water purification, and even carbon sequestration. Partnerships with environmental organizations and governments may accelerate adoption.

Despite their promising sustainability and insulating properties, mycelium-based composites (MBCs) exhibit several limitations related to long-term performance and durability. Studies indicate that these composites generally have low thermal conductivity values, often ranging between 0.038 and 0.058 W/(m·K), which is favorable for insulation purposes [133]. However, MBCs tend to readily absorb moisture, with water absorption reported to be over 200% by weight, leading to potential mechanical weakening and dimensional instability [133]. Compressive strength varies widely based on the fungal species and substrate used, with values typically reported between 0.05 and 0.18 MPa [17].

These materials exhibit relatively low elastic moduli, which limit their application to non-structural uses.

Furthermore, biodegradation tests reveal significant mass loss—up to 50% over 16 weeks in soil burial conditions—indicating susceptibility to microbial attack and degradation, particularly for composites that retain living fungal mycelium [134]. This biodegradability is beneficial for end-of-life sustainability but poses challenges for long-term durability in building applications. Therefore, while MBCs offer an eco-friendly alternative with good thermal performance, their high water uptake, moderate mechanical strength, and biodegradability require careful consideration, protective treatments, and further research to improve their service life in real-world environments.

A precise, universally comparable cost analysis remains infeasible given the highly experimental and non-standardized nature of contemporary mycelium-based composite (MBC) projects. However, a review of the material's inherent economic structure offers critical insights into its market viability compared to conventional alternatives.

MBCs demonstrate a potential raw material cost advantage rooted in the utilization of low-cost, abundant agricultural and lignocellulosic waste streams as substrates. This mechanism effectively transforms a waste product into a valuable resource, offering clear economic superiority over the resource-intensive extraction and manufacturing processes required for traditional materials.

Nonetheless, this initial benefit is currently mitigated by production scaling challenges. The necessity of a high initial capital investment in specialized, sterile bioprocessing infrastructure, coupled with the reliance on non-standardized growth protocols, collectively contributes to a comparatively elevated unit cost for current small-scale MBC production. From a logistical standpoint, while raw material scalability is theoretically robust due to the ubiquity of waste availability, widespread adoption is currently constrained by the requirement for regionalized production facilities and the inherent long biological growth cycle of the fungus. This biological constraint limits high-volume output compared to the rapid, continuous production lines characteristic of traditional factory processes, thereby hindering the achievement of true cost parity with mass-produced conventional materials.

Furthermore, the absence of standardized performance data—particularly concerning long-term durability, validated fire ratings, and predictable structural integrity—constitutes the primary systemic barrier to obtaining requisite building code approvals and material certifications in major construction markets (e.g., those governed by ASTM, ISO, or CE standards). Consequently, the applications of MBCs are predominantly constrained to non-structural roles, a strategic limitation that intentionally circumvents the purview of stringent regulatory scrutiny. Therefore, the research imperative must be strategically refocused to generate standardized, certifiable performance datasets, enabling the successful navigation and breakdown of this critical regulatory impediment to widespread adoption of construction.

3.7. Study Limitations

While this study offers a comprehensive synthesis of mycelium applications, several limitations inherent to the emerging nature of the field must be acknowledged. First, although a significant number of projects were analyzed, the rapidly evolving and diverse nature of the MBC industry suggests that the data collected may not fully encompass the entire spectrum of current applications.

Second, the reliance on trend extrapolation to forecast potential market developments introduces a degree of inherent speculation. While these projections are grounded in observable data, they may not account for unforeseen changes in market dynamics, disruptive technological advancements, or future regulatory shifts. Consequently, these indicative

assumptions should be treated with academic caution and require continuous validation to ensure their long-term accuracy and relevance.

Finally, a consistent limitation encountered during data collection was the non-specificity of material documentation. Many publicly documented projects and patents frequently generalized substrate details (e.g., citing ‘agricultural waste’ rather than a specific crop residue, such as wheat straw). While this permitted broad categorization, it ultimately constrained the ability to conduct more granular analyses concerning the specific impact of single-source substrates on final composite properties.

4. Conclusions

This study successfully analyzed the current application landscape of mycelium-based materials across architecture and design, fulfilling all stated objectives by correlating material selection, functional requirements, and emerging market trends.

This study identified the primary application fields and determined the dominant material combinations. It can be noticed that:

- Architectural and technical applications primarily rely on *Ganoderma lucidum* and carefully selected lignocellulosic substrates (e.g., straw and wood/sawdust).
- Art and design projects show greater experimental diversity, frequently utilizing *Pleurotus ostreatus* and generalized agricultural waste for esthetic and conceptual purposes.

This distinct usage pattern directly addresses the objective of identifying the crucial functional properties of such composites. Architectural projects prioritize technical performance (e.g., structural integrity and insulation), which justifies the selection of the mechanically superior *G. lucidum*. Conversely, art and design projects prioritize aesthetic appeal, creative flexibility, and the use of low-cost raw materials. The prevalence of mycelium in non-load-bearing, temporary structures (such as pavilions and decorative blocks) highlights that the material’s moderate mechanical strength, moisture sensitivity, and lack of proven long-term durability remain significant limitations that restrict wider adoption in permanent construction.

Analysis of emerging trends indicates an accelerated growth trajectory for mycelium as it moves toward mainstream use. Significant expansion is projected, particularly within non-structural, high-volume consumer goods categories, including packaging, furniture, and lighting. While a consistent, albeit slower, upward trend exists for highly specialized applications, such as textiles and artistic structures, their market share is contingent upon overcoming specific material performance and scalability challenges.

In conclusion, this study provides a foundational synthesis for the circular economy by mapping the rise of mycelium. To accelerate its broad adoption and realize its potential as a true alternative to resource-intensive materials, future research must be aggressively targeted at the following:

1. Broadening the functional material palette by increasing the number of robust mycelium species utilized beyond the current two dominant strains.
2. Developing protective treatments and processing techniques to significantly enhance mechanical strength, improve resistance to moisture uptake, and ensure long-term service life for applications requiring greater load-bearing capacity and outdoor exposure.

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References

1. Dyson, A.; Keena, N.; Lokko, M.; Reck, B.K.; Ciardullo, C. *Building Materials and the Climate: Constructing a New Future*; Technical Reports; United Nations Environment Programme, & Yale Center for Ecosystems + Architecture: Nairobi, Kenya, 2023; p. 138.
2. United Nations Environment Programme (UNEP). *2022 Global Status Report for Buildings and Construction: Towards a Zero-Emission, Efficient and Resilient Buildings and Construction Sector*; United Nations Environment Programme: Nairobi, Kenya, 2022; ISBN 978-92-807-3984-8.
3. Sydor, M.; Bonenberg, A.; Doczekalska, B.; Cofta, G. Mycelium-Based Composites in Art, Architecture, and Interior Design: A Review. *Polymers* **2022**, *14*, 145. [\[CrossRef\]](#)
4. Jiang, L.; Walczyk, D.; McIntyre, G.; Bucinell, R. A New Approach to Manufacturing Biocomposite Sandwich Structures: Mycelium-Based Cores. In Proceedings of the ASME 2016 11th International Manufacturing Science and Engineering Conference, Blacksburg, VA, USA, 27 June–1 July 2016; American Society of Mechanical Engineers: Blacksburg, VA, USA, 2016; Volume 1, p. V001T02A025.
5. Holt, G.A.; McIntyre, G.; Flagg, D.; Bayer, E.; Wanjura, J.D.; Pelletier, M.G. Fungal Mycelium and Cotton Plant Materials in the Manufacture of Biodegradable Molded Packaging Material: Evaluation Study of Select Blends of Cotton Byproducts. *J. Biobased Mat. Bioenergy* **2012**, *6*, 431–439. [\[CrossRef\]](#)
6. Attias, N.; Danaï, O.; Abitbol, T.; Tarazi, E.; Ezov, N.; Pereman, I.; Grobman, Y.J. Mycelium Bio-Composites in Industrial Design and Architecture: Comparative Review and Experimental Analysis. *J. Clean. Prod.* **2020**, *246*, 119037. [\[CrossRef\]](#)
7. Zimele, Z.; Irbe, I.; Grinins, J.; Bikovens, O.; Verovkins, A.; Bajare, D. Novel Mycelium-Based Biocomposites (MBB) as Building Materials. *J. Renew. Mater.* **2020**, *8*, 1067–1076. [\[CrossRef\]](#)
8. Alaneme, K.K.; Anaele, J.U.; Oke, T.M.; Kareem, S.A.; Adediran, M.; Ajibuwa, O.A.; Anabaranze, Y.O. Mycelium Based Composites: A Review of Their Bio-Fabrication Procedures, Material Properties and Potential for Green Building and Construction Applications. *Alex. Eng. J.* **2023**, *83*, 234–250. [\[CrossRef\]](#)
9. Cerimi, K.; Akkaya, K.C.; Pohl, C.; Schmidt, B.; Neubauer, P. Fungi as Source for New Bio-Based Materials: A Patent Review. *Fungal Biol. Biotechnol.* **2019**, *6*, 17. [\[CrossRef\]](#)
10. Pelletier, M.G.; Holt, G.A.; Wanjura, J.D.; Lara, A.J.; Tapia-Carillo, A.; McIntyre, G.; Bayer, E. An Evaluation Study of Pressure-Compressed Acoustic Absorbers Grown on Agricultural by-Products. *Ind. Crops Prod.* **2017**, *95*, 342–347. [\[CrossRef\]](#)
11. Girometta, C.; Picco, A.M.; Baiguera, R.M.; Dondi, D.; Babbini, S.; Cartabia, M.; Pellegrini, M.; Savino, E. Physico-Mechanical and Thermodynamic Properties of Mycelium-Based Biocomposites: A Review. *Sustainability* **2019**, *11*, 281. [\[CrossRef\]](#)
12. Zhang, X.; Fan, X.; Han, C.; Li, Y.; Price, E.; Wnek, G.; Liao, Y.-T.T.; Yu, X. (Bill) Novel Strategies to Grow Natural Fibers with Improved Thermal Stability and Fire Resistance. *J. Clean. Prod.* **2021**, *320*, 128729. [\[CrossRef\]](#)
13. Vandeloos, S.; Elsacker, E.; Van Wylick, A.; De Laet, L.; Peeters, E. Current State and Future Prospects of Pure Mycelium Materials. *Fungal Biol. Biotechnol.* **2021**, *8*, 20. [\[CrossRef\]](#)
14. Aiduang, W.; Jatuwong, K.; Jinanukul, P.; Suwannarach, N.; Kumla, J.; Thamjaree, W.; Teeraphantuvat, T.; Waroonkun, T.; Oranratmanee, R.; Lumyong, S. Sustainable Innovation: Fabrication and Characterization of Mycelium-Based Green Composites for Modern Interior Materials Using Agro-Industrial Wastes and Different Species of Fungi. *Polymers* **2024**, *16*, 550. [\[CrossRef\]](#) [\[PubMed\]](#)
15. Islam, M.R.; Tudryn, G.; Bucinell, R.; Schadler, L.; Picu, R.C. Morphology and Mechanics of Fungal Mycelium. *Sci. Rep.* **2017**, *7*, 13070. [\[CrossRef\]](#) [\[PubMed\]](#)
16. Amstislavski, P.; Pöhler, T.; Valtonen, A.; Wikström, L.; Harlin, A.; Salo, S.; Jetsu, P.; Szilvay, G.R. Low-Density, Water-Repellent, and Thermally Insulating Cellulose-Mycelium Foams. *Cellulose* **2024**, *31*, 8769–8785. [\[CrossRef\]](#)
17. Elsacker, E.; Vandeloos, S.; Brancart, J.; Peeters, E.; De Laet, L. Mechanical, Physical and Chemical Characterisation of Mycelium-Based Composites with Different Types of Lignocellulosic Substrates. *PLoS ONE* **2019**, *14*, e0213954. [\[CrossRef\]](#)
18. Livne, A.; Wösten, H.A.B.; Pearlmutter, D.; Gal, E. Fungal Mycelium Bio-Composite Acts as a CO₂-Sink Building Material with Low Embodied Energy. *ACS Sustain. Chem. Eng.* **2022**, *10*, 12099–12106. [\[CrossRef\]](#)
19. Haneef, M.; Ceseracciu, L.; Canale, C.; Bayer, I.S.; Heredia-Guerrero, J.A.; Athanassiou, A. Advanced Materials From Fungal Mycelium: Fabrication and Tuning of Physical Properties. *Sci. Rep.* **2017**, *7*, 41292. [\[CrossRef\]](#)

20. Appels, F.V.W.; Camere, S.; Montalti, M.; Karana, E.; Jansen, K.M.B.; Dijksterhuis, J.; Krijgsheld, P.; Wösten, H.A.B. Fabrication Factors Influencing Mechanical, Moisture- and Water-Related Properties of Mycelium-Based Composites. *Mater. Des.* **2019**, *161*, 64–71. [CrossRef]
21. Wang, J.; Liu, X.; Lee, K.-P. Unraveling the Sensorial Properties in Material Identity Innovation: A Study on Mycelium-Based Composite. In Proceedings of the DRS2024, Boston, MA, USA, 23–28 June 2024; Design Research Society: London, UK, 2024; p. 23.
22. Sharma, K.; Dhiman, S.; Mukherjee, G. Embracing Microbial Systems in Built Environments Fostering Sustainable Development through Circular Economy Practices. In *Waste to Wealth: Emerging Technologies for Sustainable Development*; Dhiman, S., Mukherjee, G., Eds.; CRC Press: Boca Raton, FL, USA, 2025; pp. 1–32, ISBN 978-1-040-45378-0.
23. Heisel, F.; Schlesier, K.; Lee, J.; Rippmann, M.; Saeidi, N.; Javadian, A.; Hebel, D.E.; Block, P. Design of a Load-Bearing Mycelium Structure through Informed Structural Engineering. The MycoTree at the 2017 Seoul Biennale of Architecture and Urbanism. In Proceedings of the World Congress on Sustainable Technologies (WCST-2017), Cambridge, UK, 11–14 December 2017; Infonomics Society: London, UK, 2017; pp. 45–49.
24. *Beautiful World, Where Are You?* Mc Carthy, S., Ed.; Art/Books: London, UK, 2018; ISBN 978-1-908970-44-2.
25. Ross, P. Method for Producing Fungus Structures. Patent US 9410116 B2, 9 August 2016.
26. Carroll, S.; Price, B.; Bourdon, P.; Gibby, P. *The Hayes Pavilion 2023 6—An Investigation into Mycelium as an Alternative Material for the Creative Industries*; Hayes Pavilion; Team Love and Temple Design Studio, in Association with Glastonbury Festival: Bristol, UK, 2023; p. 21.
27. Ratti, C. A Living Architecture for the Digital Era. *Disegno* **2019**, 177–188. [CrossRef]
28. Despret, V.; Mahieu, F.; Dalon, C.; Aventin, C.; Salme, J. *Demeurer en Mycélium/Living in Mycelium*; Cellule Architecture de la Fédération Wallonie-Bruxelle: Brussels, Belgium, 2023; ISBN 978-2-930705-49-1.
29. Meglio, C.D. MycoTemple. Available online: www.comedimeglio.com/copie-de-mycotemple-fr (accessed on 25 October 2025).
30. Rovers, I.; La Bianca, I.; Peuling, S.; Vette, J.; Ng-Caradt, W.; Pelkmans, J. *Whitepaper: Building on Mycelium*; Centre of Expertise Biobased Economy (CoE BBE): Breda, The Netherlands, 2022; p. 10.
31. MycoShell at BuildFest. Available online: <https://labs.aap.cornell.edu/node/1127> (accessed on 25 October 2025).
32. Rothschild, L.J.; Maurer, C.; Paulino Lima, I.G.; Senesky, D.; Wipat, A.; Head, J., III. *Myco-Architecture of Planet: Growing Surface Structures at Destination*. NIAC 2018 Phase I Final Report; NASA Ames Research Center: Mountain View, CA, USA, 2019; p. 57.
33. Tupper, P. Welcome to Symbiocene Living! PLP Architecture International Ltd. 2023. Available online: <https://plplabs.com/symbiocene/> (accessed on 25 October 2025).
34. Beneš, V. The Exhibition “Into the Depths of Fungi” Opens the Door. Inovace od Buřinky. 2023. Available online: www.inovaceodburinky.cz/en/the-exhibition-into-the-depths-of-fungi-open-the-door/ (accessed on 25 October 2025).
35. Crembil, G.; Lokko, M.-L.; Roland, T. Mycelium Pavilion [Summer Design & Build Studio]. Rensselaer Architecture. 2019. Available online: www.arch.rpi.edu/2019/09/2019su-summerstudio/ (accessed on 25 October 2025).
36. *Material Atlas. The Growing Pavilion*; van den Berg, J., Konings, B., Eds.; Company New Heroes: Amsterdam, The Netherlands, 2019; Available online: <https://drive.google.com/drive/folders/157rALVRRQzTuxdGf0MUf63IjbwVHWtD-> (accessed on 25 October 2025).
37. Jones, M.; Mautner, A.; Luenco, S.; Bismarck, A.; John, S. Engineered Mycelium Composite Construction Materials from Fungal Biorefineries: A Critical Review. *Mater. Des.* **2020**, *187*, 108397. [CrossRef]
38. Jennifer Hahn Glastonbury’s Hayes Pavilion “Pushes the Boundaries” of What Bioplastic Can Do. Dezeen. 2024. Available online: www.dezeen.com/2024/06/27/glastonbury-hayes-pavilion-reright-design/ (accessed on 25 October 2025).
39. Wierzbicka, A.M.; Jagiełło-Kowalczyk, M.; Ławińska, K.; Haupt, P.; Gubert, M.; Paoletti, G.; Lollini, R.; Kavka, U. Innovative Use of Mycelium in Construction. *Sr. Mieszk. Hous. Environ.* **2024**, *49*, 180–198. [CrossRef]
40. Kong, A. Homegrown Wonderland. Andre Kong Studio. 2024. Available online: www.andrekong.com/homegrown-wonderland.html (accessed on 25 October 2025).
41. Tupper, P. PLP Labs Showcase Mycelium Blocks at Edinburgh’s Fungi Forms. PLP Architecture. 2024. Available online: <https://plparchitecture.com/plp-labs-showcase-mycelium-blocks-at-edinburghs-fungi-forms/> (accessed on 25 October 2025).
42. Jain, A.; Ardern, J. Mycotecture (Phil Ross). Design and Violence. 2014. Available online: <https://www.moma.org/interactives/exhibitions/2013/designandviolence/mycotecture-phil-ross/> (accessed on 25 October 2025).
43. Brayer, M.-A. Organic Design: Towards New Artefacts. PCA-STREAM. 2021. Available online: <http://www.pca-stream.com/en/explore/organic-design-towards-new-artefacts/> (accessed on 25 October 2025).
44. Meyer, V.; Schmidt, B.; Pohl, C.; Schmidts, C.; Hoberg, F.; Weber, B.; Stelzer, L.; Angulo Meza, A.; Saalfrank, C.; Sharma, S.; et al. *Engage with Fungi*; Meyer, V., Pfeiffer, S., Eds.; Berlin Universities Publishing: Berlin, Germany, 2022; ISBN 978-3-98781-001-5.
45. Dessi-Olive, J. Monolithic Mycelium: Growing Vault Structures. In Proceedings of the 8th International Conference on Non-Conventional Materials and Technologies—IC NOCMAT, IC-NOCMAT 2019, Nairobi, Kenya, 24–26 July 2019; pp. 2–15.
46. Mohseni, A.; Vieira, F.R.; Pecchia, J.A.; Gürsoy, B. Three-Dimensional Printing of Living Mycelium-Based Composites: Material Compositions, Workflows, and Ways to Mitigate Contamination. *Biomimetics* **2023**, *8*, 257. [CrossRef]

47. Jauk, J.; Gosch, L.; Vašatko, H.; Christian, I.; Klaus, A.; Stavric, M. MyCera. Application of Mycelial Growth within Digitally Manufactured Clay Structures. *Int. J. Archit. Comput.* **2022**, *20*, 31–40. [CrossRef]
48. Kaiser, R.; Bridgens, B.; Elsacker, E.; Scott, J. BioKnit: Development of Mycelium Paste for Use with Permanent Textile Formwork. *Front. Bioeng. Biotechnol.* **2023**, *11*, 1229693. [CrossRef]
49. Chaudhary, A.; Davidson, A.; Ravi, D.; Batmaz, D.; Do, D. *Symbiocene Architecture: Building with Mycelium*; Report; PLP Architecture: London, UK, 2024.
50. *How Will We Live Together?* Sarkis, H., Ed.; La Biennale di Venezia; La Biennale di Venezia in Collaboration with Silvana Editoriale: Venice, Italy, 2021; Volume 1, ISBN 978-88-366-4859-7.
51. Robbie Jenkins Building Organic Sculptures Using Mycelium. Available online: <https://www.myminifactory.com/stories/robbie-jenkins-building-organic-sculptures-using-mycelium> (accessed on 30 October 2025).
52. Yang, K. Investigations of Mycelium as a Low-Carbon Building Material. Bachelor's Thesis, Dartmouth College, Hanover, NH, USA, 2020. Available online: <https://digitalcommons.dartmouth.edu/engs88/21> (accessed on 25 October 2025).
53. Dias, P.P.; Jayasinghe, L.B.; Waldmann, D. Investigation of Mycelium-Miscanthus Composites as Building Insulation Material. *Results Mater.* **2021**, *10*, 100189. [CrossRef]
54. Wattanavichean, N.; Phanthuwongpakdee, J.; Koedrith, P.; Laoratanakul, P.; Thaithatgoon, B.; Somrithipol, S.; Kwantong, P.; Nuankaew, S.; Pinruan, U.; Chuaseeharonnachai, C.; et al. Mycelium-Based Breakthroughs: Exploring Commercialization, Research, and Next-Gen Possibilities. *Circ. Econ. Sust.* **2025**, *5*, 3211–3253. [CrossRef]
55. Noronha, M. Crema Lab. Furf Design Studio. 2024. Available online: <http://furf.it> (accessed on 25 October 2025).
56. Rodriguez, J. How It Works. Available online: <https://mycocycle.com/> (accessed on 25 October 2025).
57. Shaw, M. What Is a Life Box and Who Is Paul Stamets, Anyway?—The Colorado Mycological Society. Available online: <https://cmsweb.org/what-is-a-life-box-and-who-is-paul-stamets-anyway/> (accessed on 25 October 2025).
58. Stamets, P. The Petroleum Problem. *Fungi Perfecti*. 2010. Available online: <https://fungi.com/blogs/articles/the-petroleum-problem?srsltid=AfmBOooM5CXcWF81qjmMm6HuC8KitL0xq6SyXu-0HSD0-z30HLwcusXw> (accessed on 25 October 2025).
59. Khatua, S.; Simal-Gandara, J.; Acharya, K. Myco-Remediation of Plastic Pollution: Current Knowledge and Future Prospects. *Biodegradation* **2024**, *35*, 249–279. [CrossRef]
60. Brun, A.; Mora, G.C. Mushroom Tech Cleans Up at Lake Erie State Park. New York State Parks and Historic Sites Blog. 2019. Available online: <https://nystateparks.blog/2019/12/10/mushroom-tech-cleans-up-at-lake-erie-state-park/> (accessed on 25 October 2025).
61. Deniz, I.; Keskin Gundogdu, T. Biomimetic Design for a Bioengineered World. In *Interdisciplinary Expansions in Engineering and Design with the Power of Biomimicry*; Kokturk, G., Altun, T.D.A., Eds.; IntechOpen: London, UK, 2018; pp. 57–75, ISBN 978-953-51-3936-2.
62. Kieft, R. Waste as Resource. Mediamatic. 2014. Available online: www.mediamatic.net/nl/page/222463/waste-as-resource (accessed on 25 October 2025).
63. Frearson, A. Mushroom Mycelium Used to Create Suede-Like Furniture by Sebastian Cox and Ninela Ivanova. Dezeen. 2017. Available online: www.dezeen.com/2017/09/20/mushroom-mycelium-timber-suede-like-furniture-sebastian-cox-ninela-ivanova-london-design-festival/ (accessed on 8 December 2025).
64. Karana, E.; Blauwhoff, D.; Hultink, E.-J.; Camere, S. When the Material Grows: A Case Study on Designing (with) Mycelium-Based Materials. *Int. J. Des.* **2018**, *12*, 119–136.
65. Totaro, A.I. Startup: Mycelium-Based Furniture and Packaging from RongoDesign Materia Rinnovabile. Renewable Matter. 2023. Available online: <https://www.renewablematter.eu/en/Startup-Mycelium-based-Furniture-Packaging-from-RongoDesign-biomaterials> (accessed on 25 October 2025).
66. Garnousset, P.; Detoeuf, M.; de Pingon, P. Tree Table/Endless Vase. Biobased Materials. 2022. Available online: <https://biobasedmaterials.org/material/tree-table-endless-vase/> (accessed on 8 December 2025).
67. Edward Linacre Godlight and Toadstool: Mycelium Furniture and Lighting. Available online: <https://www.edwardlinacre.com.au/light/-/object/nest-s7r92-4z6wb-zbpw4-3gft2t> (accessed on 30 October 2025).
68. Van der Voorn, M.T. Conch Light. Marc Th. van der Voorn | Allround Furniture Designer 2023. Available online: <https://marcvandervoorn.nl/category/lighting> (accessed on 8 December 2025).
69. Saint, A. The Magic of Mushrooms for Sustainability [Sustainability Innovation]. *Eng. Technol.* **2021**, *16*, 37–39. [CrossRef]
70. Hitti, N. Nir Meiri Makes Sustainable Lamp Shades from Mushroom Mycelium. Dezeen. 2019. Available online: <https://www.dezeen.com/2019/01/07/nir-meiri-mycelium-lamps-design/> (accessed on 8 December 2025).
71. *Those Light Fixtures Are Made out of Mushroom*; Hogar line; Ola Luminárias Acústicas: Curitiba, Brasil, 2024; p. 12. Available online: <https://ola-br.com/catalogos/> (accessed on 8 December 2025).
72. Montalti, M. *Acoustic. Acoustic Mycelium-Based Products*; Mogu: Inarzo, Italy, 2023; p. 4.
73. Ravenscroft, T. FIKA Acoustic Wall Tiles by AllSfär | Dezeen Showroom. Dezeen. 2023. Available online: <http://www.dezeen.com/2023/05/22/fika-allsfar-acoustic-wall-panel-mycelium-dezeen-showroom/> (accessed on 8 December 2025).

74. Astbury, J. Mycelium Insulates Experimental Timber Pavilion by Myceen and EKA PAKK. Dezeen. 2025. Available online: www.dezeen.com/2025/09/21/myceen-eka-pakk-pavilion-mycelium/ (accessed on 8 December 2025).
75. Osekowska, M. Fumo Panels. Mycelium Wall Panels. 2025. Available online: <https://fumopanel.com/> (accessed on 8 December 2025).
76. Barta, G. Rongo Design. Available online: https://rongodesign.com/?elementor_library=coming-soon (accessed on 25 October 2025).
77. Yoneda, Y. Terreform ONE Unveils Mushroom Chair Grown out of Fungi in Just Seven Days Mycelium | Inhabitat-Green Design, Innovation, Architecture, Green Building. Inhabitat-Green Design, Innovation, Architecture, Green Building | Green Design & Innovation for a Better World 2016. Available online: <https://inhabitat.com/terreform-one-unveils-mushroom-chair-grown-out-of-fungi-in-just-seven-days/terreform-one-unveils-mushroom-chair-grown-out-of-fungi-in-just-seven-days-mycelium/> (accessed on 8 December 2025).
78. Castenson, J. MycoBoard Offers an Innovative, Sustainable Solution for Building Products. Builder Magazine. 2017. Available online: www.builderonline.com/products/mycboard-offers-an-innovative-sustainable-solution-for-building-products_o (accessed on 8 December 2025).
79. Gandia, A. Growing a Mycelium Panel. Available online: www.mediamatic.net/en/page/227540/growing-a-mycelium-panel (accessed on 30 October 2025).
80. Wösten, H. Fungal Futures. Officina Corpuscoli. 2014. Available online: www.corpuscoli.com/projects/fungal-futures/ (accessed on 8 December 2025).
81. Lempi, V. Bio-Based Industry: Is It Possible? Interni Magazine. 2023. Available online: <http://www.internimagazine.com/features/industria-bio-based-si-puo/> (accessed on 8 December 2025).
82. Dorsch, E. Student Researcher Develops Building Materials from Mycelium. Available online: <https://news.uoregon.edu/student-researcher-develops-building-materials-mycelium> (accessed on 30 October 2025).
83. Melendez, F. bioMATTERS Crafts Tiling System by 3D Printing Mycelium, Algae, and Organic Waste. Designboom | Architecture & Design Magazine. 2023. Available online: <https://www.designboom.com/design/biomatters-sustainable-tiling-system-3d-printing-mycelium-algae-myco-alga-11-06-2023/> (accessed on 8 December 2025).
84. Jarz, H. Re-Cell/Stanislaw Mlynski. Available online: www.archdaily.com/141008/re-cell-stanislaw-mlynski (accessed on 25 October 2025).
85. McCandless, M. Appalachian Students Partner with Biomaterials Company, Build Sustainable Products. Available online: <https://today.appstate.edu/2017/04/21/ecovative-design> (accessed on 25 October 2025).
86. Michaeloudis, C. Orbit—Floor-Standing Screens. AllSfär. 2023. Available online: <https://allsfar.com/product/orbit/> (accessed on 8 December 2025).
87. Williams, E.; Cenian, K.; Golsteijn, L.; Morris, B.; Scullin, M.L. Life Cycle Assessment of MycoWorks' Reishi™: The First Low-Carbon and Biodegradable Alternative Leather. *Environ. Sci. Eur.* **2022**, *34*, 120. [CrossRef]
88. Brocklehurst, G. *Profile of Bolt Threads: A Leader in Novel Biomaterials*; Performance Apparel Markets; Textiles Intelligence: Cheshire, UK, 2021; pp. 69–81.
89. Meyer, M.; Dietrich, S.; Schulz, H.; Mondschein, A. Comparison of the Technical Performance of Leather, Artificial Leather, and Trendy Alternatives. *Coatings* **2021**, *11*, 226. [CrossRef]
90. Ko, A.; Somme, A.; Venzon, C.M.; McConihe, E.-M. The Furniture. Available online: www.mykotecture.com/furniture-leather-team (accessed on 30 October 2025).
91. Hoitink, A. Not Grown, Not Sewn: NEFFA Robotic Textiles from Mycelium | Tocco. Available online: <https://tocco.earth/article/neffa-robotic-textiles-from-mycelium/> (accessed on 30 October 2025).
92. Chittenden, T. Foraging for Fashion's Future: The Use of Mycelium Materials and Fungi Intelligence in Fashion Design. *Fash. Style Pop. Cult.* **2025**, *12*, 145–168. [CrossRef]
93. Morby, A. Aniela Hoitink Creates Dress from Mushroom Mycelium. Dezeen. 2016. Available online: <http://www.dezeen.com/2016/04/01/aniela-hoitink-neffa-dress-mushroom-mycelium-textile-materials-fashion/> (accessed on 8 December 2025).
94. Wagenaar, D. The Next Smart Move. A Decision Support System for Urban Implementation of Smart Mobility Solutions. Master's Thesis, Delft University of Technology, Delft, The Netherlands, 2020.
95. Veenhoven, T. Mycelium—Textile. Studio Tjeerd Veenhoven. 2021. Available online: http://www.tjeerdveenhoven.com/portfolio_page/mycelium-textile/ (accessed on 8 December 2025).
96. Montalti, M.; Babbini, S. Sustainable Materials Mycelium-Based Biomaterials. Ephea®. 2022. Available online: <https://ephea.bio/product/> (accessed on 8 December 2025).
97. Hendriks, B. Loop Living Cocoon™. Available online: https://loop-biotech.com/product/living-cocoon/?srsltid=AfmBOorLtYnDrUc2NftVt81I3_dwrK7PzSnWELbdTAAIoTsx-PtTCoGc (accessed on 25 October 2025).
98. Khan, R. Furf Design Studio Grows Mycelium in 3D Printed Molds to Sculpt Sustainable Divine Deities. Designboom | Architecture & Design Magazine. 2022. Available online: <https://www.designboom.com/art/furf-design-studio-grows-mycelium-3d-printed-molds-sculpt-sustainable-divine-deities-12-26-2022/> (accessed on 8 December 2025).

99. Gerrard, G. Fantastic Fungi: Harnessing the Magic of Mycelium to Create Striking Sculptures. Available online: <https://www.lboro.ac.uk/alumni/news/2022/october/graduate-creates-sculptures-using-fungi/> (accessed on 30 October 2025).
100. Howarth, D. Fungi Kingdom Bio-Art Installation Offers Contemplative Space in Buenos Aires. Dezeen. 2023. Available online: www.dezeen.com/2023/12/02/fungi-kingdom-urban-farm-installation-buenos-aires-julio-oropel-jose-luis-zacarias-otin%cc%83ano/ (accessed on 8 December 2025).
101. Zeitoun, L. YUME YUME x MycoWorks Debut Head-to-Toe Outfit Made of Mycelium Leather. Designboom | Architecture & Design Magazine. 2023. Available online: www.designboom.com/design/yume-yume-mycoworks-debut-head-to-toe-outfit-made-of-mycelium-leather-reishi-interview-12-05-2023/ (accessed on 8 December 2025).
102. Dahmen, J. Mycelium Mockup. SALA. 2015. Available online: <https://sala.ubc.ca/research/mycelium-mockup/> (accessed on 8 December 2025).
103. Hill, J. Studio Link-Arc's "Inverted Architecture". Available online: www.world-architects.com/en/architecture-news/found/studio-link-arcs-inverted-architecture (accessed on 25 October 2025).
104. Chowdhury, M.F.; Islam, Q.T.; Islam, Q.T. *Ecovative: Growing a Sustainable Future in the Startup Ecosystem*; SAGE Publications: Thousand Oaks, CA, USA, 2025; ISBN 1-0719-6885-8.
105. Šuput, D.; Popović, S.; Hromiš, N.; Ugarković, J. Degradable Packaging Materials: Sources, Application and Decomposition Routes. *J. Process. Energy Agric.* **2021**, *25*, 37–42. [CrossRef]
106. Violano, A.; Del Prete, S. A Bio-Based Grown Material for Living Buildings. In Proceedings of the Beyond All Limits: International Congress on Sustainability in Architecture, Planning, and Design, Ankara, Turkey, 17–19 October 2018; pp. 762–768.
107. Hemmings, J. Grown Beneath Our Feet. *Surf. Des. J.* **2022**, 24–29. Available online: https://www.jessicahemmings.com/uploads/general/4_Feature_GrownBeneathOurFeet_JessicaHemmings.pdf (accessed on 8 December 2025).
108. Bros, C. Monc Mycelium Packaging | Shortlists | Dezeen Awards 2024. Dezeen. Available online: <http://www.dezeen.com/awards/2024/shortlists/monc-mycelium-packaging/> (accessed on 8 December 2025).
109. Thielen, A. UK Start-Up The Magical Mushroom Company Moves to Large-Scale Production Plastic-Free Packaging. Available online: www.bioplasticsmagazine.com/en/news/meldungen/20210315-UK-start-up-The-Magical-Mushroom-Company-moves-to-large-scale-production-plastic-free-packaging.php (accessed on 25 October 2025).
110. Yang, L.; Park, D.; Qin, Z. Material Function of Mycelium-Based Bio-Composite: A Review. *Front. Mater.* **2021**, *8*, 737377. [CrossRef]
111. Sydor, M.; Cofta, G.; Doczekalska, B.; Bonenberg, A. Fungi in Mycelium-Based Composites: Usage and Recommendations. *Materials* **2022**, *15*, 6283. [CrossRef] [PubMed]
112. Vašatko, H.; Gosch, L.; Jauk, J.; Stavric, M. Basic Research of Material Properties of Mycelium-Based Composites. *Biomimetics* **2022**, *7*, 51. [CrossRef] [PubMed]
113. Porter, D.L.; Hotz, E.C.; Uehling, J.K.; Naleway, S.E. A Review of the Material and Mechanical Properties of Select Ganoderma Fungi Structures as a Source for Bioinspiration. *J. Mater. Sci.* **2023**, *58*, 3401–3420. [CrossRef]
114. Ghazvinian, A.; Gursoy, B. Basics of Building with Mycelium-Based Bio-Composites. *J. Green Build.* **2022**, *17*, 37–69. [CrossRef]
115. Escalera, R.M.; Campos, M.J.; Alves, M.L. Mycelium-Based Composites: A New Approach to Sustainable Materials. In *Sustainability and Automation in Smart Constructions*; Rodrigues, H., Gaspar, F., Fernandes, P., Mateus, A., Eds.; Advances in Science, Technology & Innovation; Springer International Publishing: Cham, Switzerland, 2021; pp. 261–266, ISBN 978-3-030-35532-6.
116. Lanza, F.A.; Reyes, J.C. Compressive Strength and Water Absorption Percentage of *Pleurotus ostreatus* and *Ganoderma lucidum* Mycelium. In Proceedings of the 21th LACCEI International Multi-Conference for Engineering, Education and Technology (LACCEI 2023): "Leadership in Education and Innovation in Engineering in the Framework of Global Transformations: Integration and Alliances for Integral Development", Bogota, Colombia, 19–21 July 2023; Latin American and Caribbean Consortium of Engineering Institutions: Boca Raton, FL, USA, 2023; pp. 1–10.
117. Jiménez-Obando, G.; Arcila, J.S.; Tolosa-Correa, R.A.; Valencia-Cardona, Y.L.; Montoya, S. Development and Characterization of Mycelium-Based Composite Using Agro-Industrial Waste and *Ganoderma lucidum* as Insulating Material. *J. Fungi* **2025**, *11*, 460. [CrossRef]
118. Kuştaş, S.; Gezer, E.D. Physical and Mechanical Properties of Mycelium-Based Insulation Materials Produced from Desilicated Wheat Straws—Part A. *BioRes* **2024**, *19*, 1330–1347. [CrossRef]
119. Ge, J.; Li, F.; Gao, Y.; Jin, J.; Jiang, W. A High-Performance Structural Material Based on Maize Straws and Its Biodegradable Composites of Poly (Propylene Carbonate). *Cellulose* **2021**, *28*, 11381–11395. [CrossRef]
120. Badawy, A.H.; El-Feky, M.S.; El-Tair, A.M.; Kohail, M. Wood Sawdust Waste-Derived Nano-Cellulose as a Versatile Reinforcing Agent for Nano Silica Cement Composites: A Systematic Study on Its Characterization and Performance. *Sci. Rep.* **2023**, *13*, 12811. [CrossRef]
121. Ecovative Design. Available online: <https://ecovative.com/> (accessed on 22 September 2025).
122. MycoWorks. Available online: www.mycoworks.com (accessed on 22 September 2025).
123. Mogu. Available online: <https://mogu.bio/> (accessed on 22 September 2025).

124. BIOHM. Available online: <https://www.biohm.co.uk/mycelium> (accessed on 22 September 2025).
125. GROWN Bio BV. Available online: www.grown.bio (accessed on 22 September 2025).
126. Sullcapuma Morales, M.A. Modular Construction: A Sustainable Solution for Carbon Emission Reduction in the Construction Industry. *Int. J. Eng. Appl. Sci. Technol.* **2023**, *5*, 393–401. [[CrossRef](#)]
127. Chippagiri, R.; Bras, A.; Sharma, D.; Ralegaonkar, R.V. Technological and Sustainable Perception on the Advancements of Prefabrication in Construction Industry. *Energies* **2022**, *15*, 7548. [[CrossRef](#)]
128. Sharp, C.; Suchar, I.; Noonan, S.; Baidoo-Davis, J. Mycelium Filtration for Heavy Metal Removal from Water. In Proceedings of the 2025 Waste-Management Education Research Conference (WERC), Las Cruces, NM, USA, 23 May–13 June 2025; IEEE: Las Cruces, NM, USA, 2025; pp. 1–7.
129. Camilleri, E.; Narayan, S.; Lingam, D.; Blundell, R. Mycelium-Based Composites: An Updated Comprehensive Overview. *Biotechnol. Adv.* **2025**, *79*, 108517. [[CrossRef](#)] [[PubMed](#)]
130. Le Ferrand, H. Critical Review of Mycelium-Bound Product Development to Identify Barriers to Entry and Paths to Overcome Them. *J. Clean. Prod.* **2024**, *450*, 141859. [[CrossRef](#)]
131. Verma, N.; Jujavarapu, S.E.; Mahapatra, C. Green Sustainable Biocomposites: Substitute to Plastics with Innovative Fungal Mycelium Based Biomaterial. *J. Environ. Chem. Eng.* **2023**, *11*, 110396. [[CrossRef](#)]
132. Elsacker, E.; Zhang, M.; Dade-Robertson, M. Fungal Engineered Living Materials: The Viability of Pure Mycelium Materials with Self-Healing Functionalities. *Adv. Funct. Mater.* **2023**, *33*, 2301875. [[CrossRef](#)]
133. Angelova, G.; Yemendzhiev, H.; Zaharieva, R.; Brazkova, M.; Koleva, R.; Stefanova, P.; Baldzhieva, R.; Vladev, V.; Krastanov, A. Mycelium-Based Composites Derived from Lignocellulosic Residual By-Products: An Insight into Their Physico-Mechanical Properties and Biodegradation Profile. *Appl. Sci.* **2025**, *15*, 6333. [[CrossRef](#)]
134. Van Wylick, A.; Elsacker, E.; Yap, L.L.; Peeters, E.; De Laet, L. Mycelium Composites and Their Biodegradability: An Exploration on the Disintegration of Mycelium-Based Materials in Soil. In Proceedings of the 4th International Conference on Bio-Based Building Materials, Barcelona, Spain, 16–18 June 2021; pp. 652–659.

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