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Comparative Analysis of Mycelium Biocomposites as Potential Next-Generation Green Building Materials

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Abstract: The construction industry is responsible for approximately 40% of the environmental damage due to carbon emissions resulting from high energy consumption, production processes, product logistics, and application methods. The production and use processes of traditional building materials contribute to the depletion of natural resources and the disruption of ecological balance. The search for sustainable and eco-friendly materials is becoming increasingly important in this context. This study emphasises the potential and significance of fungal mycelium for the construction industry.

Mycelium biocomposites offer environmental benefits and exhibit important performance criteria such as thermal performance, acoustic performance, compressive strength, flexural strength, and radioactive shielding properties. In this research, the characteristics of the developed mycelium composites are compared with conventional environmentally harmful alternatives in the construction industry. The comparison is based on thermal conductivity, acoustic performance, compressive strength, and flexural strength tests, and the values of widely used products such as MDF, rock wool, and gypsum board in the literature are considered.

The findings demonstrate that mycelium biocomposites are a sustainable alternative and superior in some performance metrics. Specifically, they can compete with existing products in thermal and acoustic performance and exhibit superior compressive strength and flexural strength compared to certain products. Given the current environmental impacts of the construction industry, mycelium-based materials stand out as an innovative solution that preserves ecological balance and offers long-term sustainable building practice.

Keywords: Mycelium biocomposite, Construction industry, Biodegradable, Biodesign, Biotechnology

Yeni Nesil Yeşil Yapı Malzemesi Olarak Miselyum Biokompozitlerin Karşılaştırmalı Analizi

Öz: İnşaat sektörü, yüksek enerji tüketimi, üretim süreçleri, ürün lojistiği ve uygulama yöntemlerinden kaynaklanan karbon emisyonları nedeniyle oluşan çevresel hasarın yaklaşık %40'dan sorumludur. Geleneksel yapı malzemelerinin üretim ve kullanım süreçleri doğal kaynakların tükenmesine ve ekolojik dengenin bozulmasına katkıda bulunmaktadır. Bu bağlamda sürdürülebilir ve çevre dostu malzeme arayışı giderek önem kazanmaktadır. Bu çalışma, mantar miselyumunun inşaat sektörü için potansiyelini ve önemini vurgulamaktadır.

Miselyum biyokompozitleri yalnızca çevresel faydalar sağlamakla kalmaz, aynı zamanda termal performans, akustik performans, basınç dayanımı, eğilme dayanımı ve radyoaktif kalkanlama özellikleri gibi önemli performans kriterleri de sergiler. Bu araştırmada, geliştirilen miselyum kompozitlerinin özellikleri inşaat sektöründe yaygın olarak kullanılan ve çevreye zararlı alternatiflerle karşılaştırılmıştır. Karşılaştırma, termal iletkenlik, akustik performans, basınç dayanımı ve eğilme dayanımı testlerine dayanmaktadır ve literatürde yaygın olarak kullanılan MDF, taş yünü ve alçıpan gibi ürünlerin değerleri dikkate alınmıştır.

Bulgular, miselyum biyokompozitlerinin yalnızca sürdürülebilir bir alternatif olmadığını, aynı zamanda bazı performans ölçütlerinde de üstün olduğunu göstermektedir. Özellikle, termal performans ve akustik performansta mevcut ürünlerle rekabet edebilirler ve belirli ürünlere kıyasla üstün basınç dayanımı ve eğilme dayanımı sergilerler. İnşaat sektörünün mevcut çevresel etkileri göz önüne alındığında, miselyum bazlı malzemeler ekolojik dengeyi koruyan ve uzun vadede sürdürülebilir bir yapı uygulaması sunan yenilikçi bir çözüm olarak öne çıkmaktadır.

Anahtar kelimeler: Miselyum biyokompozit, İnşaat sektörü, Biyobozunur, Biyotasarım, Biyoteknoloji

Introduction

The construction industry heavily impacts nature due to its dependency on energy usage and raw material consumption in the production process. Approximately 40% of global energy is estimated to be used by the construction sector. In addition, 50% of the world's raw material consumption by weight is used in the construction sector (Pacheco-Torgal, 2015). While the construction industry consumes materials and energy, it produces waste throughout the process and becomes waste at the end of the cycle (Figure 1).

The relationship between environmental degradation and the construction lifecycle can be outlined in seven significant steps (Figure. 2).

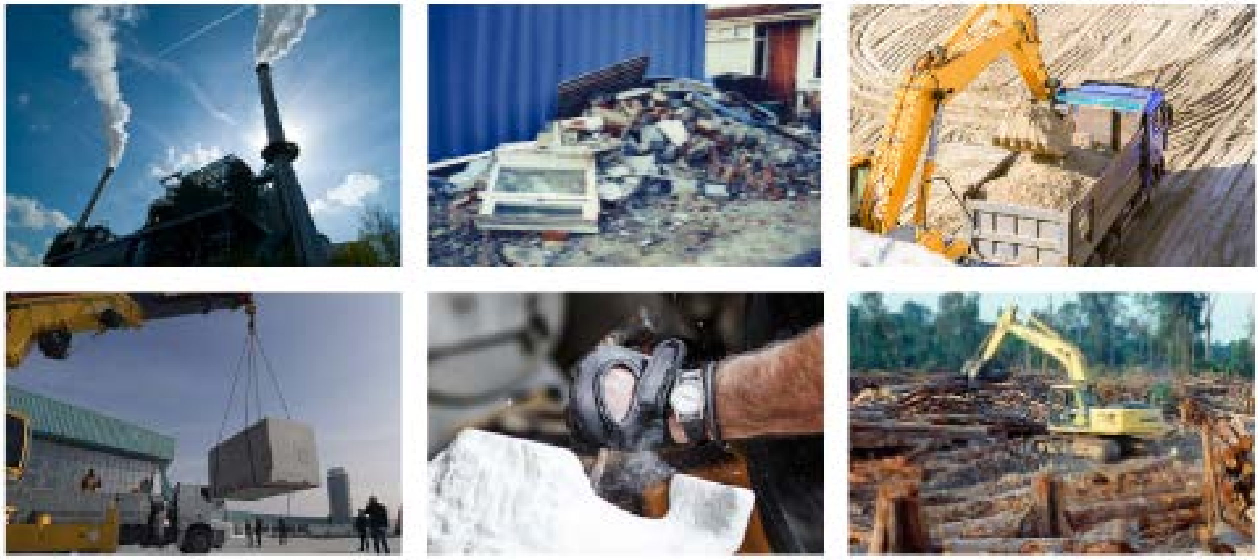

Figure 1. Harmful impact of conventional construction industry (Picture source: Canva)

Figure 2. Construction Lifecycle Steps & Environmental degradation (Personal archive)

1. **Raw Material Extraction**: This first step leads to the depletion of natural resources, destruction of ecosystems, deforestation, and increased emissions due to reliance on heavy machinery and unsustainable practices.
2. **Material Production**: Manufacturing building materials is energy-intensive, emitting pollutants and generating toxic by-products. This stage involves processes like cement production, one of the largest sources of CO_2 emissions globally.
3. **Transportation**: Transportation of raw materials, manufactured products, and construction debris contributes to CO_2 emissions and air pollution. This step supports and overlaps with raw material extraction, production, and waste management, amplifying the environmental footprint due to the heavy loads involved in the construction industry.
4. **Construction Process**: The construction phase primarily relies on fossil fuels for machinery and energy, resulting in pollution and substantial waste generation. The on-site treatment and assembly of materials add to local environmental impacts, including water and soil contamination.
5. **Operational Lifetime**: During the operational phase of a building's life, significant energy is consumed for heating, cooling, lighting, and running appliances. This energy often comes from non-renewable sources, contributing to global energy demands and emissions over the building's lifespan.
6. **Maintenance and Renovation**: To extend a building's functional life, operations such as replacing components or retrofitting for new purposes occur. This process consumes additional resources and produces waste. Renovations may also release hazardous materials, such as asbestos, into the environment.
7. **Demolition and End of Life**: When a building reaches the end of its life, the demolition process generates vast amounts of waste. Much of this material is not recycled, leading to landfill overcrowding and lost opportunities to repurpose or reuse valuable resources.

The Need for Biodesign in Architecture: A Regenerative Approach

Considering the extensive environmental damage associated with each phase of the construction lifecycle, it is clear that the industry requires a paradigm shift. Traditional building methods exacerbate environmental degradation at every stage, from raw material extraction to demolition. This is where **biodesign** offers a regenerative solution.

Biodesign integrates biotechnology and architectural principles to create structures that work with nature rather than against it. This approach embraces **multidisciplinary collaboration**, combining architecture with biology, material science, and sustainability practices (URL 1, 2024). The core idea seeks to design an architecture that belongs to nature, utilising living organisms as active agents in either the design process or the final product. Examples of this bio-collaborative relationship include Armstrong's proposed protocell architecture (Beesley & Armstrong, 2011), the production of bioblocks with calcifying bacteria (Gündoğdu et al., 2019), Neri Oxman's biofabrication studies with silkworms (Kırdök et al., 2019), and the creation of building materials from fungal mycelium (Karana et al., 2018).

Biocollaborative design processes focus on generating **complex living and non-living biological products** from raw materials, such as cells and molecules. This regenerative mindset contrasts sharply with the traditional linear approach to construction, where materials are used and discarded. In biodesign, materials form part of a **circular system**: they grow, fulfil their function, and then biodegrade, contributing back to the ecosystem rather than depleting it. For example, **mycelium biocomposites** offer insulation, acoustic performance, and structural strength while being fully biodegradable at the end of their lifecycle, reducing waste and resource consumption (Kırdök et al., 2020).

Looking forward, our buildings could become organic smart surfaces that **interact with nature** to create comfortable living conditions through a continuous exchange of materials. Dollens (2009) describes the "augmentation" of the built environment as "actones," transition zones between habitats that support locality and economy. But how can we effectively integrate living organisms and their capabilities into architecture? Can we treat nature as a **collaborator** to create structures that harmonise with the environment and have regenerative effects?

Adopting biodesign is a new toolset for architects that allows to address the environmental harms of the construction industry while the role of materials and the building process itself can be redefined. By integrating nature into architectural design, **biodesign** offers a regenerative, eco-friendly, and future-proof alternative to conventional building practices.

Conventional Construction Materials: A Comparative Overview

In the construction industry, various materials are employed for cladding, insulation, and structural functions, each offering distinct performance traits and environmental impacts. Commonly used materials include synthetic options like Expanded Polystyrene (EPS), Extruded Polystyrene (XPS), Medium Density Fiberboard (MDF), and Polyvinyl Chloride (PVC) panels, alongside natural materials such as stone, brick, and wood panels. These conventional materials are preferred due to their cost-effectiveness, ease of installation, and established performance. On the other hand these conventional materials pose significant environmental threats and challenges.

EPS and **XPS,** both derived from petrochemicals, are widely used for insulation due to their lightweight nature, thermal efficiency, and moisture resistance. However, these materials are non-biodegradable and difficult to recycle, contributing to waste issues at the end of their lifecycle. Additionally, their production process involves the release of harmful chemicals and greenhouse gases, increasing their carbon footprint.

MDF, a wood-based product, is commonly used in interior applications such as wall cladding due to its strength and stability. However, MDF resins often contain formaldehyde, a hazardous substance that releases volatile organic compounds (VOCs), affecting indoor air quality over time. While derived from wood, MDF is not easily recyclable, and its disposal in landfills can have environmental consequences.

PVC cladding panels are a synthetic option favored for their durability and water resistance, yet their production and disposal raise environmental concerns. The manufacturing of PVC involves toxic chemicals, and when burned, PVC can release harmful dioxins into the atmosphere. Furthermore, PVC is not biodegradable, contributing to long-term environmental hazards.

Natural stone and **brick cladding**, traditional materials in construction, are highly durable and offer excellent thermal mass, improving energy efficiency. However, quarrying and processing stones are resource-intensive, and these materials are heavy, increasing transportation-related energy consumption. Despite being recyclable, reusing stone and brick can be labor-intensive and costly.

Wood panels, often selected for their aesthetics and renewability, can be an eco-friendly option if sourced sustainably, as they sequester carbon during growth. Nonetheless, wood is vulnerable to moisture and fire damage, necessitating treatments with chemical preservatives, which introduce additional environmental and health concerns.

While these conventional materials have become industry standards for insulation and cladding, their environmental trade-offs are increasingly difficult to ignore. As global attention shifts towards sustainable construction, the need for eco-friendly alternatives like mycelium-based biocomposites becomes ever more pressing.

Biocomposites: A Sustainable Response to Conventional Materials

In this broader context of biodesign, **biocomposites** emerge as a critical innovation that bridges the gap between traditional and eco-friendly materials. **Biocomposites** are a class of materials formed by combining biological and synthetic components. They incorporate bio-based materials from nature, providing a viable alternative to the petrochemical-based products that dominate today's construction industry.

These materials address a core issue: the environmental impact of conventional composites, which rely heavily on non-renewable resources and are often difficult to recycle. Biocomposites, by contrast, are designed with sustainability in mind. They can be customized to meet specific requirements—whether for strength, insulation, or flexibility—while minimizing ecological footprints.

Why Biocomposites Matter:

1. **Inspired by Nature:** Biocomposites leverage organic and natural materials, making them more aligned with natural ecosystems and cycles.
2. **Effective Biodegradation:** Unlike traditional materials, biocomposites offer a quick return to nature, biodegrading at the end of their useful life.
3. **Light but Strong:** These materials combine lightness and durability, often outperforming conventional composites in terms of strength-to-weight ratio.
4. **Thermal and Acoustic Insulation:** With their high insulation performance, biocomposites provide superior protection against both heat loss and noise.
5. **Waste Minimization:** They promote sustainability by reducing waste throughout their lifecycle—from production to eventual disposal.
6. **Repurposing:** Biocomposites offer waste conversion opportunities, reusing organic and inorganic components to create new materials.
7. **Collaboration with Living Things: Biofabrication** taps into the power of living organisms to enhance material properties and performance. Adamatzky et al. (2020) describe biofabrication as "the production of complex living and non-living biological products from raw materials such as living cells or biomolecules." This process utilizes the inherent capabilities of living organisms to self-assemble materials with molecular precision, a complexity that current mechanical tools cannot replicate (Attias et al., 2019). As advancements in biofabrication accelerate, they are set to drive a profound transformation in traditional industries.
8. **Flexibility and Diversity**: The versatility of biocomposites enables a wide range of forms and applications, making them suitable for various construction needs.

The importance of biotechnology in shaping the future cannot be overstated. With the growing need for sustainable solutions in sectors such as construction, healthcare, and manufacturing, biotechnological innovations offer the potential to create materials and processes that are both efficient and environmentally friendly. Biofabrication, in particular, could pave the way for a new era of material science, where products are not only biodegradable but also self-repairing or adaptive. This shift is poised to redefine how industries approach resource management, production efficiency, and waste reduction, further reinforcing biotechnology's critical role in building a sustainable future. As we explore the transformative potential of biotechnology in addressing the challenges of modern industries, it becomes essential to focus on specific innovations that embody this paradigm shift. Mycelium-based materials stand out as a remarkable example of how biofabrication can yield not only environmentally friendly solutions but also materials with unique properties suited for a variety of applications.

Properties of Mycelium Biocomposites

Mycelium-based materials are created through biofabrication, where the fungal mycelium grows into and binds various biological substrates. This process not only ensures sustainable production but also aligns with zero-waste principles, as the primary substrates are often agricultural or industrial by-products. This upcycling of waste into valuable materials emphasizes the eco-friendly and resource-efficient nature of mycelium composites (Kırdök et al., 2022).

One of the key advantages of mycelium biocomposites is their alignment with natural growth and decomposition cycles. After fulfilling their intended use, these materials rapidly biodegrade, leaving behind no harmful residues and returning valuable nutrients to the environment. This makes mycelium biocomposites particularly attractive for promoting circular economy principles in the construction sector. In contrast to traditional synthetic materials like expanded polystyrene (EPS) and extruded polystyrene (XPS), mycelium-based materials offer a sustainable, zero-waste alternative.

The production of mycelium biocomposites is influenced by factors such as fungal species, substrate composition, and post-processing techniques. Haneef et al. (2017) demonstrated how different substrates, like microcrystalline cellulose (MCC), influence the mechanical properties of the resulting composites. For example, MCC-based substrates produced stiffer materials due to their harder-to-digest nature for fungi, showing how substrate selection plays a critical role in defining the material's final characteristics. Similarly, Appels et al. (2018) explored how substrate type, fungal species, and post-processing methods like hot pressing can affect morphology, density, tensile strength, and water absorption.

Mycelium-based materials are lightweight yet strong, making them ideal for sustainable construction and design applications. Their fully vegan nature, derived solely from fungi and plant-based substrates, also adds appeal for industries seeking ethical, cruelty-free solutions. The properties of mycelium composites can be further tailored by incorporating organic or inorganic additives, such as fire retardants or water-resistant components, enhancing their usability across various sectors.

Though research on mycelium biocomposites has gained momentum in recent years, significant gaps remain due to the variability in substrates, fungal strains, and production conditions. Nonetheless, many studies agree on the material's strengths and weaknesses. For instance, Attias et al. (2020) noted that mycelium composites generally have lower density, flexural strength, and water resistance compared to synthetic alternatives like EPS and XPS, which drives ongoing research focused on improving these properties for commercial use.

Jones et al. (2017a; 2017b; 2018; 2019; 2020) studied the fire resistance of mycelium biocomposites, demonstrating how natural fire-retardant substrates can enhance the material's fire resistance. This highlights the critical role of substrate composition in expanding the range of applications. Similarly, Islam et al. (2017, 2018) explored the mechanical behaviour of mycelium composites under compression, revealing complex properties like the "Mullins effect," commonly seen in elastomeric materials, showcasing the material's potential for further optimisation.

In addition to their structural benefits, mycelium biocomposites are excellent insulators, providing thermal and acoustic insulation. Girometta et al. (2019) reviewed these properties, noting that mycelium composites can achieve comparable insulation performance to conventional materials, with added benefits like potential radiation shielding. The material's low density enhances its insulation capabilities, making it ideal for energy-efficient applications.

The sustainability of mycelium biocomposites is further amplified by their use of waste-derived substrates, minimising resource consumption and supporting recycling and upcycling practices. Karana et al. (2018) emphasised that factors such as substrate type, particle size, and processing methods significantly affect the material's strength and overall performance. Lelivelt (2015) added that combining non-woven hemp or wood fibres with fungi can produce composites with high compressive strength, making them suitable for load-bearing applications.

Ghazvinian et al. (2019) explored mycelium composites for wall construction in structural applications. They found that straw-based biocomposites might lack sufficient compressive strength for specific uses, while chip-based composites, with adequate reinforcement, could serve as viable alternatives to conventional materials. Adjusting the substrate composition or adding reinforcing elements demonstrates the adaptability of mycelium composites to diverse requirements.

Integrating mycelium materials into architectural and industrial design also presents exciting opportunities for innovation. Camere & Karana (2018) and Adamatzky et al. (2020) discussed the potential of using living organisms in design, with applications ranging from packaging to structural building elements. Although production speed and cost challenges remain, the ecological advantages, vegan composition, and versatility of mycelium biocomposites offer promising solutions for a more sustainable, zero-waste future.

In summary, mycelium biocomposites offer desirable properties such as biodegradability, structural integrity, insulation, and the ability to utilise waste substrates. Their fully vegan, biofabricated nature positions them as eco-friendly alternatives to conventional materials. With ongoing research improving their mechanical and physical characteristics, mycelium biocomposites have the potential to transform the construction and material science industries, promoting sustainability, recycling, and circularity (Figure 3).

Material and Metod

Three main aspects were examined for the comparative analysis between BIOP Mycelium Biocomposites and conventional building materials: physical properties, environmental impact, and SWOT analysis. This analysis aimed to highlight the potential of mycelium-based materials as next-generation solutions for the construction industry, while identifying the challenges that need to be addressed for broader market adoption.

A comprehensive literature survey gathered the physical properties of conventional materials such as brick, plywood, stone, XPS, EPS, rock wool, and gypsum board. This survey included published data on thermal conductivity, sound absorption coefficient, density, compressive strength, and flexural strength. These values provided a benchmark for comparison with the BIOP Mycelium Biocomposites.

For the BIOP Mycelium Biocomposites, several laboratory tests were conducted. Thermal conductivity was measured using a Thermal Conductivity Meter at the Mechanical Engineering Laboratories of Ege University. This test involved placing the mycelium composite samples in the meter and measuring their heat transfer efficiency under controlled conditions. Acoustic performance was evaluated using an impedance tube test to determine the sound absorption coefficient of the material. This test was conducted at Karakutu Acoustic Laboratories and will be followed by more comprehensive tests, such as reverberation room analysis, in future studies.

The density of the mycelium biocomposites was calculated based on the mass-to-volume ratio (g/cm³), using a precision scale to measure the weight of the samples. At the same time, their volume was determined from sample dimensions. Compressive strength and flexural strength were tested at the Materials Testing Laboratory (MATAL) of Ege University. For compressive strength, a uniaxial compression test was conducted to measure the maximum load that the mycelium biocomposites could withstand before failure. A three-point bending test was carried out for flexural strength to evaluate the material's resistance to bending forces.

In addition to physical properties, the environmental impact of both the conventional materials and mycelium biocomposites was assessed. This analysis considered factors such as energy consumption during production, biodegradability, recyclability, toxicity, and end-of-life impact. For conventional materials, data from existing lifecycle assessments (LCA) and environmental product declarations (EPD) were utilized. The environmental impact of BIOP Mycelium Biocomposites was based on internal production data, which emphasise low energy consumption, biodegradability, and zero-waste biofabrication practices. A SWOT analysis was then performed to evaluate the strengths, weaknesses, opportunities, and threats associated with mycelium biocomposites compared to conventional materials. This analysis revealed the unique sustainability advantages of mycelium biocomposites, particularly in terms of biodegradability and environmental impact, while identifying areas for improvement, such as mechanical strength and market scalability.

Figure 3. Properties of mycelium-based biocomposites (Source: biopbiotech.com)

Results and Discussion

When comparing the physical properties of mycelium biocomposites to conventional building materials such as EPS, XPS, MDF, and others, it becomes evident that each material offers unique strengths and weaknesses in areas like thermal conductivity, sound absorption, density, compressive strength, and flexural strength. Table 1 provides a comprehensive comparison of these properties across several materials commonly used in construction (Budiwati, 2009; You, 2011; Mokhtar et al., 2012; Nindiyasari, 2016; Solomon & Latha, 2017; Troppová et al., 2017; Shah et al., 2019; URL 2, 2024; URL 3, 2024; URL 4, 2024; URL 5, 2024; URL 6, 2024; URL 7, 2024; URL 8, 2009; URL 9, 2021; URL 10, 2024; URL 11, 2024; URL 12, 2024). This comparison highlights the competitive performance of mycelium biocomposites, particularly in terms of their insulation properties and mechanical strength, making them a promising alternative to synthetic and mineral-based products.

Following the physical property comparison, assessing these materials' environmental impact is essential. Table 2 focuses on critical ecological factors such as energy consumption during production, biodegradability, recyclability, toxicity, and end-of-life impact. This comparison demonstrates that conventional materials often excel in performance, but their environmental impact is substantial. On the other hand, mycelium biocomposites offer clear advantages in terms of sustainability, with lower energy consumption, high biodegradability, and a minimal ecological footprint. Such characteristics position them as an environmentally responsible choice for modern construction practices.

Table 1. Comparison of physical properties of mycelium biocomposites to conventional building materials

Property	Mycelium Biocomposites	EPS	XPS	Rock Wool	MDF	Gypsum Board	Natural Stone (Marble)	Wood panel (plywood)	Brick
Thermal Conductivity (W/m.K)	0.088	0.038	0.035	0.044	0.12	0.19	3	0.1	0.5
Sound Absorbtion Coefficient (α)	0.4	0.22	0.2	0.9	0.3	0.01	0.01	0.05	0.05
Density (g/cm3)	0.33	0.02	0.03	0.04	0.75	0.7	2.75	0.5	2
Compressive Strength (MPa)	80	0.07	0.3	0.05	10	10	65	50	11.2
Flexural Strength (Mpa)	1	0.1	0.15	0.03	22	5.65	12	55	0.1

Table 2. Comparison of the environmental impact of mycelium biocomposites to conventional building materials

Properties	Mycelium Biocomposites	EPS	XPS	Rock Wool	MDF	Gypsum Board	Natural Stone (Marble)	Wood Panel (Plywood)	Brick
Environmental Impact	Low	High	High	Moderate	Moderate to High	Moderate	High	Moderate	Moderate to High
Energy Consumption (Production)	Low	High	High	High	Moderate	Moderate	Very High	Low to Moderate	Very High
Biodegradability	Biodegradable	Non-biodegradable	Non-biodegradable	Non-biodegradable	Non-biodegradable	Non-biodegradable	Non-biodegradable	Biodegradable (if untreated)	Non-biodegradable
Recyclability	Compostable/ Reusable	Difficult	Difficult	Recyclable	Limited due to resins	Recyclable in some cases	Limited	Limited due to adhesives	Recyclable
Toxicity	Non-toxic	Releases harmful chemicals	Contains harmful HFCs	Non-toxic but hazardous dust	Formaldehyde-based resins	Non-toxic	Non-toxic	Some adhesives can be toxic	Non-toxic
End of Life Impact	Decomposes naturally	Long-lasting landfill waste	Long-lasting landfill waste	Energy needed for recycling	Difficult to recycle due to resin	Limited recycling infrastructure	Energy-intensive disposal	Adhesive use complicates recycling	Energy-intensive but long-lasting

The findings from performance and environmental impact comparisons indicate that mycelium biocomposites have significant potential to replace or complement traditional materials across various construction applications. While certain conventional materials may still excel in specific mechanical properties, mycelium biocomposites advance in sustainability and adequate physical performance, which makes them a promising option for greener construction practices. However, widespread market adoption will require further research and development to address existing limitations and enhance the performance of these biocomposites, as outlined in Table 3.

The comparison between mycelium materials and traditional building materials reveals significant insights into the potential of mycelium biocomposites in sustainable construction. Mycelium materials offer notable advantages, such as being eco-friendly and possessing excellent thermal and sound insulation properties. Although they currently face challenges, like limited strength and moisture sensitivity, ongoing research and development in this novel field hold promise for overcoming these limitations. In contrast, while reliable and well-established, conventional materials often come with substantial environmental drawbacks and poor biodegradability. As the construction industry increasingly seeks greener alternatives, mycelium biocomposites have a genuine opportunity to carve out a niche. Addressing existing weaknesses and threats through targeted research will be crucial for maximising the strengths and opportunities of mycelium materials, ultimately paving the way for a more sustainable future in construction.

Table 3. SWOT analysis of Mycelium Biocomposites and conventional materials

SWOT	Mycelium Biocomposites	Conventional Materials
Strengths	- Sustainable and biodegradable	- Established market presence
	- Low energy production requirements	- Wide availability and supply chains
	- Excellent thermal insulation	- Proven performance and reliability
	- Effective acoustic performance	- Advanced manufacturing techniques
Weaknesses	- Mechanical limitations	- Environmental impact during production
	- Sensitivity to moisture	- Limited biodegradability
	- Durability concerns	- Higher energy consumption
	- Higher initial production costs	- Potential toxicity of some materials
Opportunities	- Growing demand for eco-friendly materials	- Innovation in synthetic materials
	- Government support for sustainable practices	- Expansion into emerging markets
	- Advances in material treatment	- Brand loyalty to traditional materials
	- Circular economy initiatives	- Cost reductions through scale
Threats	- Intense market competition	- Market saturation and declining margins
	- Resistance to change among industry professionals	- Regulatory challenges and compliance costs
	- Ongoing advancements in synthetic materials	- Fluctuations in raw material costs
	- Brand loyalty towards established materials	- Consumer perception of new materials

Conclusion

In conclusion, this analysis underscores the significant potential of mycelium biocomposites as a sustainable alternative to conventional building materials. The comparative tables highlight the performance characteristics of mycelium biocomposites, showing competitive results in thermal conductivity, acoustic insulation, compressive strength, and flexural strength. Furthermore, the environmental impact analysis reveals that mycelium biocomposites offer energy consumption, biodegradability, and recyclability advantages, contributing to a more sustainable construction industry.

While conventional materials may still outperform mycelium biocomposites in certain mechanical aspects, the overall balance of sustainability and adequate physical performance positions mycelium biocomposites as a viable solution for greener construction practices. The challenges identified in the SWOT analysis emphasise the need for ongoing research and development to address existing limitations and enhance the performance of mycelium biocomposites.

Looking ahead, advancements in fungal biotechnology, biodesign, and integrating these innovative materials into architecture can potentially revolutionize the construction industry. As mycelium technologies advance, we may witness the emergence of “concrete forests”, where mycelium spreads through urban landscapes, transforming how we view and interact with our built environments. Additionally, as mycelium applications spread throughout urban environments, integrating these materials into the concrete fabric of our cities could transform how we approach sustainability in design. This shift toward sustainable practices reflects a growing awareness of environmental challenges and paves the way for a new paradigm in architecture and construction, where ecological considerations play a central role in design and material selection.

The findings from this study suggest that with continued innovation and investment in mycelium technology, there is a strong possibility for these biocomposites to gain traction in the mainstream building industry. As the sector moves toward more environmentally friendly practices, mycelium biocomposites can be crucial in reshaping construction standards and promoting sustainable development.

Author contributions

All the authors have equal contributions.

Conflicts of interest

The authors declare no competing interests.

Ethical Statement:

It is declared that scientific and ethical principles have been followed while carrying out and writing this study and that all the sources used have been properly cited (Onur KIRDÖK, S. Kübra TOKER, Orkun KIVRAK, T. Didem ALTUN, E. Esin HAMEŞ).

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