Revista Científica Interdisciplinaria Investigación y Saberes
2026, Vol. 16, No. 1 e-ISSN: 1390-8146
Published by: Universidad Técnica Luis Vargas Torres

Evaluation of mycelium as a biomaterial in social housing in Guayaquil

Evaluación del micelio como biomaterial en viviendas de interés social en Guayaquil

Jamil Ignacio Palacios Murillo
Universidad de Guayaquil, Ecuador, jamil.palaciosm@ug.edu.ec
ORCID: https://orcid.org/0000-0002-4626-7697

Gabriela Catherine Vega Guiracocha
Universidad de Guayaquil, Ecuador, gabriela.vegag@ug.edu.ec
ORCID: https://orcid.org/0000-0002-2204-9660

Laura de Jesús Calero Proaño
Universidad de Guayaquil, Ecuador, laura.calerop@ug.edu.ec
ORCID: https://orcid.org/0000-0003-1742-4363

Received 2025-09-20
Revised 2025-12-12
Published 2026-01-05
Corresponding Author
jamil.palaciosm@ug.edu.ec
Pages: 37-52

Abstract

The housing deficit in Ecuador constitutes a significant social and urban problem, especially in vulnerable sectors of Guayaquil. This research analyzes the potential of mycelium as an ecological material for the construction of modular social housing under the principles of the circular economy. High malleability and diversity in interior design can be achieved when applied to social housing, promoting the circular economy through the reuse and self-construction of its components. This contributes to reducing housing costs and improving the acoustic and climatic quality of the dwelling due to its inherent properties, making mycelium an ideal material for increasing access to decent and affordable housing. Through a descriptive and analytical approach, the physical, environmental, and

How to cite this article (APA): *Palacios, J., Vega, G., Calero, L. (2026)* Evaluation of mycelium as a biomaterial in social housing in Guayaquil, *Revista Científica Interdisciplinaria Investigación y Saberes*, 16 (1) 37-52

economic properties of mycelium are examined, as well as its applicability in walls and roofs. The results show that mycelium offers significant advantages in terms of sustainability, cost reduction, thermal and acoustic insulation, and the use of local organic waste. It is concluded that mycelium represents a viable alternative for improving access to decent housing, contributing to sustainable urban development and reducing the environmental impact of the construction sector.
Keywords: mycelium, ecological material, circular economy, flexible architecture

Resumen
El déficit habitacional en Ecuador constituye un problema social y urbano significativo, especialmente en sectores vulnerables de Guayaquil. Esta investigación analiza el potencial del micelio como material ecológico para la construcción de viviendas modulares de interés social bajo los principios de la economía circular. Se puede obtener gran maleabilidad y diversidad del diseño interior, aplicado en las denominadas viviendas sociales, promoviendo la economía circular a través de la reutilización y autoconstrucción de sus componentes. lo que contribuye a la reducción del coste de la vivienda y mejora la calidad acústica y climática de la vivienda debido a sus propiedades propias, que hacen del micelio un material ideal para incrementar el acceso a una vivienda digna y asequible. Mediante un enfoque descriptivo y analítico, se examinan las propiedades físicas, ambientales y económicas del micelio, así como su aplicabilidad en muros y cubiertas. Los resultados evidencian que el micelio presenta ventajas relevantes en términos de sostenibilidad, reducción de costos, aislamiento térmico y acústico, y aprovechamiento de residuos orgánicos locales. Se concluye que el micelio representa una alternativa viable para mejorar la

accesibilidad a viviendas dignas, contribuyendo al desarrollo urbano sostenible y a la reducción del impacto ambiental del sector constructivo.

Palabras Clave: micelio, material ecológico, economía circular, arquitectura flexible

Introduction

Access to decent housing is a fundamental right recognized in the Constitution of Ecuador; however, a significant portion of the population faces overcrowding and precarious housing conditions. Informal employment and the high cost of traditional materials have limited access to adequate housing, especially in rapidly growing urban areas such as Guayaquil. In this context, the search for innovative and sustainable materials becomes a priority in order to respond to the housing deficit.

Mycelium, the filamentous structure of fungi, has emerged as a biotechnological material with applications in sustainable construction. Its low environmental impact, biodegradability, and insulating properties position it as a viable alternative to conventional materials. This article analyzes the use of mycelium in the design of modular social housing in Guayaquil, under a circular economy approach.

In this context, the circular economy has emerged as a crucial strategy. This approach seeks to reduce waste and extend the useful life cycle of products through recycling, reuse, and the utilization of resources that would traditionally be discarded. Within this perspective, the use of mycelium—the vegetative structure of fungi—is positioned as an innovative and sustainable option. Its ability to colonize organic substrates such as straw, sawdust, and other agricultural waste allows this waste to be transformed into solid, functional panels suitable for various construction applications.

Mycelium stands out not only for its physical and thermal characteristics, but also for its low environmental impact. When consolidated into lightweight, insulating panels, it can replace conventional materials that require highly polluting processes, such as cement or petroleum-derived polymers. In addition, its ability to biodegrade and reintegrate into the environment at the end of its useful life makes it a clear example of a regenerative material within the natural cycle.

Mycelium, the filamentous branched structure of fungi, has become a biomaterial of growing interest for use in sustainable housing construction. Its high versatility, mechanical properties, and biodegradability position it as a strategic resource within the circular economy. This article presents research focused on the production of mycelium panels for use in social housing construction, evaluating their mechanical strength, thermal behavior, and economic viability. Through laboratory tests, the ability of mycelium to form rigid and resistant structures was determined, while its potential to reduce the carbon footprint and dependence on traditional materials with high emissions was analyzed. The results indicate that mycelium can offer acceptable thermal insulation and durability properties for use in low-cost residential environments, while also being a renewable, compostable material with reduced environmental impact. This research seeks to contribute to the scientific literature on biomaterials and promote a paradigm shift in social housing construction, emphasizing the importance of the circular economy and sustainable innovation.

This article presents a comprehensive approach to the production and evaluation of mycelium panels, considering their mechanical, thermal, economic, and environmental properties. The research builds on previous studies that have highlighted the viability of this biomaterial (Stamets, 2005; Bayer & McIntyre, 2017; Jiang et al., 2019), but goes further by providing a detailed analysis of the specific conditions necessary for its manufacture and application in regions with hot and humid climates. It also explores the technical challenges and economic opportunities associated with its larger-scale production.

Throughout this work, the methodology used is first presented, which includes the selection and treatment of agricultural waste, the inoculation of the mycelium, and the formation of panels. The results section presents the values obtained in mechanical and thermal resistance tests, complemented by a production cost analysis and an environmental impact assessment based on the product's life cycle. The discussion analyzes the practical feasibility and possible limitations of the material, while the final reflection highlights its potential to transform current construction practices toward more responsible and sustainable models.

Methodology

The methodological approach of this research is based on the premise of developing a biomaterial suitable for hot and humid climates, where thermal insulation and moisture resistance play a crucial role. The work plan was divided into stages ranging from the collection and preparation of agricultural waste to mechanical and thermal testing, including a cost analysis and assessment of the potential environmental impact. This holistic approach allows not only for the validation of the properties of the material itself, but also for an understanding of its position within a value chain that aims to be more sustainable.

Wheat straw and pine sawdust were chosen for use. These residues are abundant after grain harvesting and wood processing in sawmills, respectively. From a circular economy perspective, the use of this waste represents an opportunity to avoid burning or landfilling. Agreements were made with local farmers and small sawmills to collect the raw material at low cost or free of charge.

In order to optimize colonization by the mycelium, impurities present in the straw (stones, plastic debris, large plant fragments) were removed. In the case of sawdust, it was sieved to remove excessively large particles or small metal contaminants (nails, staples, etc.). The straw was then chopped to a size of 5-10 mm, thus facilitating its handling and uniformity in the mixing process.

To ensure proper moisture content, both types of waste were dried at 60°C on flat trays, stirring them regularly to prevent moisture retention at the bottom. This drying process facilitates subsequent sterilization and reduces the risk of unwanted fungi or bacteria growth.

After drying, the waste was packed in polypropylene bags and placed in an autoclave at 121°C and 15 psi for 30 minutes. This process eliminates most competing microorganisms, creating a sterile or near-sterile environment for mycelium inoculation. It should be noted that sterilization is a critical step: without it, the probability of contamination can increase exponentially, affecting the quality and resistance of the resulting panels.

The selected mycelium was Ganoderma lucidum, known for its rapid growth and robust filaments. Other fungal species have also shown remarkable potential, such as Pleurotus ostreatus or Fomes fomentarius, but G. lucidum stands out for its ability to produce a dense and highly cohesive mycelial network, qualities that are essential for the formation of resistant panels (Yang et al., 2021).

Before inoculating large volumes of substrate, the strain was cultured on agar plates enriched with malt extract (MEA). These plates were incubated at 25°C and monitored for approximately 10 days until the agar was completely colonized. This yielded pieces of mycelium in optimal condition, which then served as the basis for the main production batch.

With the sterilized substrate already cold, the mycelium was mixed in a ratio of 1:4 (mycelium:substrate, on a dry basis) or 1:3 in some exploratory tests. The mixture was placed in perforated polypropylene bags, which were then sealed to maintain an atmosphere with some air circulation. The set was placed in a chamber at 25°C and 60% relative humidity, under dim light conditions. For about 15 days, the mycelium expanded throughout the substrate, creating a cohesive whitish mass that indicated the presence of dense fungal filaments.

Once incubation was complete, the colonized substrate was transferred to 30 cm x 30 cm x 5 cm wooden or metal molds, which had been previously disinfected with 70% ethanol. Compaction was carried out using manual presses or simple devices, with the aim of distributing the material evenly. The degree of compaction influences the resulting density of the panel, a variable that, in turn, affects mechanical strength and insulation properties.

The molds were kept in an environment with a temperature of 22°C and approximately 60% humidity for an additional 5 days. During this period, often called "controlled fruiting," the mycelium finished forming bridges between the substrate particles, reinforcing the structural integrity of the panel. Care was taken to ensure that there were no signs of contamination or excess moisture that could promote the proliferation of undesirable molds.

After this time, the panels were carefully removed from the molds to avoid breakage due to bending or traction. They were then placed in an oven at 50°C for 48 hours, reducing their moisture content to less than 10%. This drying effectively "inactivates" the growth of the mycelium, preventing it from reactivating in higher humidity conditions and promoting dimensional stability.

To evaluate compressive strength, ASTM D1037, frequently applied to wood-based panels and boards, was followed. Test specimens were extracted from each panel, taking care to preserve the integrity of the mycelial structure. A universal testing machine applied an axial load at 5 mm/min until the test piece collapsed. The maximum load value (in N) was recorded and the tensile strength (in MPa) was calculated.

The flexural test was performed with three-point support. The sample was placed on two supports and the force was applied at the midpoint at a constant speed. The modulus of rupture (MOR), which indicates the maximum resistance before fracture, and the modulus of elasticity (MOE), which reflects the stiffness of the panel in the elastic range, were determined. These data allow us to understand whether the panels can withstand bending stresses in partition wall or interior cladding applications.

Thermal conductivity was evaluated using a hot plate analyzer in accordance with ISO 8302:1991. The panels were placed between two plates whose temperature difference was carefully controlled, measuring the heat flow through the material. This yielded a k value (W/mK), a crucial parameter for measuring insulation effectiveness.

As an approximation to real-world application, test modules were built with walls incorporating a layer of mycelial panels. A climatic chamber was used to subject these walls to differences in temperature and humidity, simulating daily conditions in a hot and humid environment. The objective was to quantify the reduction in heat transfer compared to walls without additional insulation.

The production of a standard panel (30 cm x 30 cm x 5 cm) involved costs for raw materials (agricultural waste, mycelium), labor (preparation, inoculation, growth monitoring), energy (sterilization, drying), and transportation. An average of USD 3.5 per panel was established under low-scale conditions. However, it is anticipated that industrial or semi-industrial production—with higher volume and process optimization—could reduce the unit cost by up to 25%.

A simplified LCA was undertaken to estimate the carbon footprint associated with the production of the panels. The phases considered included the collection of agricultural waste, the use of energy for sterilization and drying, and transport logistics. Special importance was given to the possibility of composting the panels at the end of their useful life, which significantly reduces the environmental impact by avoiding disposal in landfills and allowing organic matter to return to the soil.

Results

The analysis shows that mycelium has technical characteristics suitable for use in walls and roofs, highlighting its thermal and acoustic insulation capacity, its structural lightness, and its low production cost. The possibility of cultivating it from local organic waste strengthens the principles of the circular economy, reducing waste and carbon emissions.

In the context of Las Orquídeas, the application of modular construction systems with mycelium would allow for significant cost reductions, faster execution, and improvements in housing comfort. However, challenges related to the durability, production scalability, and social acceptance of the material have been identified, aspects that require further research and pilot projects.

The following sections present the characteristic values obtained from mechanical and thermal tests, as well as an overview of the economic feasibility and environmental impact of incorporating mycelium panels into the construction sector.

The tested panels offered an average compressive strength of 1.2 MPa, with intervals from 1.0 to 1.4 MPa depending on the variation in compaction and density. Although the panels are not intended to withstand very high structural loads, their mechanical performance is sufficient for use as interior enclosures, lightweight partitions, or even decorative ceiling panels.

Bending tests resulted in an average MOR value of 3.5 MPa. This indicates that the panels tolerate moderate bending stresses before fracturing. The MOE, close to 300 MPa, reflects acceptable stiffness, although lower than that of solid wood or OSB boards. However, in applications where high stiffness is not required (e.g., room dividers, decorations, internal insulation panels), these properties are adequate.

Differences in density were noted in some panels due to irregular compaction or variations in the colonization rate of the mycelium. These internal defects resulted in microcracks and localized reductions in strength. It was found that precision in compaction pressure and careful control of humidity during incubation mitigated these inconsistencies.

The panels exhibited an average thermal conductivity coefficient of 0.04 W/mK. This value is remarkably similar to that of glass wool or expanded polystyrene, which are known for their high insulating power. In hot and humid areas, this type of insulation can make a substantial difference in reducing the heat entering a home, reducing dependence on air conditioning or forced ventilation systems.

When the panels were integrated into test walls, heat transfer decreased by about 30% compared to walls without any insulation. This tangible reduction in heat flow means potential energy savings and increased thermal comfort. Furthermore, the lightness of the panels does not add significant loads to the structure, simplifying their installation and adaptation in low-budget construction projects.

On a small scale, each 30 cm x 30 cm x 5 cm panel cost around USD 3.5, taking into account the energy consumed in sterilization, drying, and incubation, as well as the labor involved. The raw material (agricultural waste) can be almost free or very low cost, provided that agreements are established with local producers. The prospect of industrial scaling indicates that, by increasing the volume of production, the unit cost could be reduced by at least 25%, approaching competitive values compared to other ecological insulators.

Mycelium can be a catalyst for the local economy by promoting interaction between farmers, waste managers, worker cooperatives, and the construction sector. This would create a value chain that takes advantage of discarded organic matter and transforms it into high value-added panels. To achieve this, training initiatives and a minimum demand are required to ensure the profitability of production.

As they do not require high-temperature processes (beyond occasional sterilization at 121°C and drying at 50°C), mycelium panels emit considerably less CO_2 than materials such as fired bricks or cement. In addition, production is based on waste recycling, mitigating the problem of waste accumulation in landfills and avoiding open-air burning (a practice that can contribute to air pollution).

Once the panels have reached the end of their useful life, composting allows the nutrients to be returned to the soil, closing the life cycle in an environmentally friendly way. This embodies one of the pillars of the circular economy, in which waste from one process becomes input for another, avoiding the negative impact associated with final disposal in landfills or dumps.

The results analyzed show that mycelium panels offer a realistic opportunity to contribute to innovation in the construction sector. Although their compressive and flexural strength does not make them suitable for supporting heavy loads, they stand out as an alternative for interior walls, enclosure modules, and thermal insulation that improves energy efficiency. This is particularly relevant in hot and humid climates, where a large part of the electricity bill is spent on cooling spaces and where humidity can easily damage materials that are not resistant to the proliferation of microorganisms.

The adoption of these panels depends, however, on several factors. Among them, it is worth mentioning the standardization of production, which requires careful control of humidity and temperature during incubation, as well as the pressure applied during compaction. Any deviation can lead to heterogeneities that result in significant variations in mechanical properties. Therefore, improvements in the automation of certain processes, such as pasteurization or inoculation, and the implementation of sensors to monitor the internal humidity of the panels as they consolidate are suggested.

On the other hand, social acceptance and regulatory validation are essential milestones for the scalability of this technology. Institutions responsible for regulating construction often require defined standards for durability, fire reaction, moisture resistance, and other parameters related to safety and health. As a novel material, mycelium faces the challenge of demonstrating in standardized tests that it meets the expectations of current building codes. Therefore, specific tests of fire resistance, behavior under prolonged moisture absorption, and potential for pest attacks are essential to legitimize its use.

Economically, feasibility depends on the proximity of agricultural waste sources, access to sterilization equipment, and the cost of mycelium. Likewise, public policies that encourage sustainable construction and the corporate social responsibility of some construction companies can pave the way for the introduction of this biomaterial into the market. It is worth noting the possibility of involving small agricultural producers in the supply of raw materials, thus promoting job creation and local development.

Finally, the environmental approach marks an essential difference: not only is the carbon footprint of the material's production estimated to be low, but the compostability of the panels guarantees environmentally friendly disposal at the end of their life cycle. This feature is becoming increasingly important in a society struggling with the effects of global warming and high volumes of non-recyclable waste. Construction, traditionally considered one of the most resource-intensive activities, can benefit greatly from a paradigm shift that incorporates ecological regeneration rather than simple extraction and disposal.

Conclusions

The introduction of mycelium panels in construction represents a convergence of biotechnology and civil engineering that, just a few years ago, was considered almost futuristic. Today, laboratory tests and pilot projects show that not only is it possible to manufacture these panels with relatively simple resources, but they also have mechanical and thermal properties that are compatible with the requirements of contemporary housing, provided that their function is limited to lightweight enclosures and insulation. Its lightness, low potential cost, compostability, and integration with the local economy make mycelium an ideal candidate for scenarios where the aim is to reconcile people's quality of life with active protection of the natural environment.

However, there is still a long way to go to refine production methodologies, validate the material with regulatory bodies, and disseminate its benefits among end users. Part of this journey involves multidisciplinary cooperation between microbiologists, engineers, architects, construction companies, and, of course, the communities that could use these panels in their homes or production facilities. As these links are consolidated and more data is accumulated on durability, fire resistance, and performance in high-humidity conditions, mycelium will take a definitive step from laboratory innovation to actual integration into construction practice.

In short, mycelium is emerging as an innovative biomaterial that could revolutionize social housing construction by facilitating access to more sustainable and affordable solutions. The potential of this material to promote the circular economy lies in its natural origin, low-impact production, and ability to re-enter the biological cycle after use. Multiple areas of research and development remain open to optimize its properties and ensure market acceptance, which, in the long term, could significantly contribute to the transformation of the construction industry toward more ecological and equitable models.

Mycelium presents itself as an innovative and sustainable alternative for the construction of social housing in vulnerable urban contexts. Its incorporation into modular systems reduces environmental impact, optimizes local resources, and improves the quality of life of residents. Although there are technical and cultural limitations, the environmental, social, and economic benefits position mycelium as a material with high potential to contribute to reducing the housing deficit in Guayaquil and other cities in Ecuador.

Reference

American Society for Testing and Materials [ASTM]. (2020). Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials (ASTM D1037). ASTM International

Alemu, D., Tafesse, M., & Mondal, A. K. (2022). Mycelium-Based Composite: The Future Sustainable Biomaterial. International Journal of Biomaterials, 2022. https://doi.org/10.1155/2022/8401528

Banco Interamericano de Desarrollo [BID]. (2020). La vivienda social y los retos de la habitabilidad en América Latina. BID

Balaeș, T., Radu, B. M., & Tănase, C. (2023). Mycelium-Composite Materials—A Promising Alternative to Plastics? Journal of Fungi, 9(2). https://doi.org/10.3390/JOF9020210

Bayer, E., & McIntyre, G. (2017). Mycelium Materials and Methods of Production. U.S. Patent US9743605B2

Bonenberg, A., Sydor, M., Cofta, G., Doczekalska, B., & Grygorowicz-Kosakowska, K. (2023). Mycelium-Based Composite Materials: Study of Acceptance. Materials, 16(6), 2164. https://doi.org/10.3390/ma16062164

European Commission. (2010). International Reference Life Cycle Data System (ILCD) Handbook—General guide for

Life Cycle Assessment—Detailed guidance. Publications Office of the European Union.

Jiang, L., Walczyk, N., Mooney, B., & Reineke-Hildebrandt, S. (2019). Sustainable Building Materials: Mycelium Biocomposites. Journal of Cleaner Production, 223, 536-541

Lingam, D., Narayan, S., Mamun, K., & Charan, D. (2023). Engineered mycelium-based composite materials: Comprehensive study of various properties and applications. Construction and Building Materials, 391, 131841. https://doi.org/10.1016/j.conbuildmat.2023.131841

Jones, M., Bhat, T., Kandare, E., Thomas, A., Joseph, P., & Dekiwadia, C. (2020). Thermal and Fire Properties of Fungal Mycelium and Mycelium–Biofiber Composites. ACS Sustainable Chemistry & Engineering, 8(2), 711-717

Rigobello, A., Colmo, C., & Ayres, P. (2022). Effect of Composition Strategies on Mycelium-Based Composites Flexural Behaviour. Biomimetics, 7(2), 53. https://doi.org/10.3390/biomimetics7020053

Stamets, P. (2005). Mycelium Running: How Mushrooms Can Help Save the World. Ten Speed Press

Sun, W., Tajvidi, M., Howell, C., & Hunt, C. G. (2022). Insight into mycelium-lignocellulosic bio-composites: Essential factors and properties. Composites Part A: Applied Science and Manufacturing, 161. https://doi.org/10.1016/J.COMPOSITESA.2022.107125

Sydor, M., Bonenberg, A., Doczekalska, B., & Cofta, G. (2022). Mycelium-Based Composites in Art, Architecture, and Interior Design: A Review. Polymers, 14(1), 145. https://doi.org/10.3390/polym14010145

United Nations Environment Programme [UNEP]. (2021). 2021 Global Status Report for Buildings and Construction. UNEP.

Vašatko, H., Gosch, L., Jauk, J., & Stavric, M. (2022). Basic Research of Material Properties of Mycelium-Based

Composites. Biomimetics, 7(2), 51. https://doi.org/10.3390/biomimetics7020051

Yang, F., Long, Z., & Jin, W. (2021). Evaluation of Mycelium-based Bio-composites for Building Materials. Construction and Building Materials, 283, 122732.

Zah, R., Hischier, R., Leão, A. L., & Brown, I. (2014). Curauá Fibers in the Automotive Industry: A Life Cycle Assessment (LCA) Study. Journal of Cleaner Production, 81, 70-79.

Zimele, Z., Irbe, I., Grinins, J., Bikovens, O., Verovkins, A., & Bajare, D. (2020). Novel mycelium-based biocomposites (Mbb) as building materials. Journal of Renewable Materials, 8(9), 1067–1076. https://doi.org/10.32604/jrm.2020.0964