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REVIEW

Biophilic Architecture: A Holistic Approach to Healthy and Sustainable Spaces

Arquitectura Biofílica: Un Enfoque Integral para Espacios Saludables y Sostenibles

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ABSTRACT

Introduction: the article addresses biophilic architecture as a design approach that seeks to improve human well-being in built spaces through the integration of natural elements.
Objective: to analyze and synthesize the relationship between biophilic architecture and human well-being in built spaces, highlighting the importance of incorporating natural elements to promote better quality of life and user comfort.
Method: the methodology used in the article is a narrative review that analyzes the intellectual production on biophilic architecture from academic papers. International indexes such as ScienceDirect, Web Of Science and Scopus were searched using keywords related to biophilic architecture and its design. This methodology seeks to describe and qualitatively compare the findings of different relevant studies in the field.
Results: the results of the article highlight that the integration of natural elements has a positive impact on the emotional, cognitive and physiological well-being of users. Several studies reviewed demonstrate that biophilic architecture can reduce anxiety, improve cognitive performance and promote relaxation. Key features and findings from experimental studies validating these benefits were also presented.
Conclusions: biophilic architecture is presented as a valuable approach that fuses nature with architectural design to improve human well-being. The authors emphasize that by incorporating natural elements into built spaces, the health and comfort of occupants can be improved. They also stress the need for further research and development of best practices in this field to maximize its impact, while also addressing challenges related to maintenance and additional costs.

Keywords: Architecture; Biophilic Architecture; Healthy Spaces; Sustainable Spaces.

RESUMEN

Introducción: el artículo aborda la arquitectura biofílica como un enfoque de diseño que busca mejorar el bienestar humano en los espacios construidos mediante la integración de elementos naturales.
Objetivo: principal del artículo es analizar y sintetizar la relación entre la arquitectura biofílica y el bienestar humano en los espacios construidos, destacando la importancia de incorporar elementos naturales para fomentar una mejor calidad de vida y el confort de los usuarios.
Método: la metodología utilizada en el artículo es una revisión narrativa que analiza la producción intelectual sobre la arquitectura biofílica a partir de documentos académicos. Se realizaron búsquedas en índices internacionales como ScienceDirect, Web Of Science y Scopus, utilizando palabras clave relacionadas con la arquitectura biofílica y su diseño. Esta metodología busca describir y comparar cualitativamente los hallazgos de distintos estudios relevantes en el campo.
Resultados: los resultados del artículo destacan que la integración de elementos naturales tiene un impacto positivo en el bienestar emocional, cognitivo y fisiológico de los usuarios. Varios estudios revisados demuestran que la arquitectura biofílica puede reducir la ansiedad, mejorar el rendimiento cognitivo y promover la relajación. También se presentaron características y hallazgos clave de estudios experimentales que validan estos beneficios.
Conclusiones: la arquitectura biofílica se presenta como un enfoque valioso que fusiona la naturaleza con el diseño arquitectónico para mejorar el bienestar humano. Los autores enfatizan que, mediante la incorporación de elementos naturales en los espacios construidos, se puede mejorar la salud y el confort de los ocupantes. También se subraya la necesidad de continuar investigando y desarrollando mejores prácticas en este campo para maximizar su impacto, abordando además los desafíos relacionados con el mantenimiento y los costos adicionales.

Palabras clave: Arquitectura; Arquitectura Biofílica; Espacios Saludables; Espacios Sostenibles.

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INTRODUCTION

Biophilic architecture is a design approach that mimics nature to improve human well-being in built spaces. It is based on the idea that love for nature can be expressed through physical characteristics in a building.[1] This design approach recognizes people's innate connection with nature and seeks to incorporate natural elements such as sunlight, air currents, plants, and representations of the natural environment into architectural design. Studies have shown that integration positively impacts user comfort.[2]

However, factors such as lack of ambient temperature, insufficient ventilation, and absence of green areas affect user perception and satisfaction, resulting in discomfort during activities.[3] This design aims to reestablish the connection between humans and their natural environment, promoting a healthy lifestyle while encouraging environmental conservation.[4] It has even been observed that people tend to seek a connection with nature in any environment they find themselves in, as this interaction positively impacts their general well-being.[5]

Under these premises, it can be inferred that biophilic architecture has a favorable impact on its environment by using the innate connection between humans and nature. Its aim is to promote greater well-being and a better quality of life for occupants in healthier built environments.[6]

In short, biophilic architecture represents a fusion between architectural design and nature to improve human well-being and promote connection with our natural environment. Integrating natural elements into spaces aims to improve comfort and user health, promote a healthier lifestyle, and contribute to conserving the natural environment. Therefore, this narrative analysis aims to describe the intellectual output on biophilic architecture based on academic documents to provide an overview of the subject and contribute a tool for future research.

METHOD

Narrative reviews are qualitative research that focuses on describing, comparing, and analyzing the findings of previous studies without using statistical methods to synthesize the data. This review provides a holistic view of the topic, highlighting trends, approaches, and contexts the studies address qualitatively. Unlike systematic reviews, which seek to quantify results through meta-analysis, narrative reviews provide a more descriptive and contextualized analysis of the available information, facilitating a deeper understanding of an area of knowledge. In biophilic architecture, this narrative review explores studies and approaches to how integrating nature into architectural spaces affects human well-being, sustainability, and energy efficiency. To carry out this review, a search was conducted in international databases such as ScienceDirect, Web of Science, and Scopus, using keywords such as "biophilic architecture," "biophilic architecture and design," and "architecture AND nature." This way, various sources were collected and analyzed, offering diverse perspectives and enriching the understanding of biophilic architecture.

RESULTS

Table 1. Characteristics of the included studies

Author	Year	Objective / Sample	Key Findings
Jung et al.[7]	2023	A machine learning approach and statistical analysis were applied to differentiate emotional changes related to biophilic design. Seventy-five participants were divided into three groups to investigate the different effects of three types of biophilic design.	The use of both green walls and digital elements in healthcare settings can have a complementary effect on emotional well-being by reducing negative emotions and enhancing positive ones.
Zhong et al.[8]	2023	To this end, we introduced "green pockets" (three-dimensional green spaces) as a distinct typology from two-dimensional green roofs and walls/facades.	Green pockets help to integrate multiple experiences of "nature" into buildings and develop sustainable architecture. The design of green pockets with visibility, accessibility, and spatial characteristics (e.g., perspective and shelter, organized complexity, danger, and mystery) of "nature" improves the quality of buildings.
Schleck et al.[9]	2024	Applying eco-ableism and material circularity in an architectural framework, this study aims to investigate gaps and possibilities for access, applications of natural materials, and resulting US natural buildings, based on critical studies on disability and semi-structured interviews with natural building professionals.	Natural and climate-specific building materials and methods present a potential pathway towards a more sustainable built future: low-carbon, locally sourced, minimally processed, and non-toxic materials. Despite critical overlap, there is little published research on access to materials in the production phase and human access in the occupancy phase of natural buildings.
Latini et al.[10]	2024	A 3x3 between-subjects design study is presented, comparing three office designs (green interior, green exterior, and non-biophilic) and three acoustic scenarios (office, office + traffic, and office + nature). 198 participants completed a test session consisting of three cognitive tasks for each acoustic condition and a survey.	The results of cognitive tests revealed that audiovisual connection with nature can positively influence working memory, inhibition, and task switching.
Teki et al.[11]	2023	The aim of this article is to offer a new reading of Maggie's contribution to cancer support by examining all these data through the lens of biophilia, which clarifies the impact of nature-related design decisions on the lives of cancer patients.	The systematically selected data helped identify and classify the biophilic design parameters that appear most critical for promoting and supporting human health and well-being in non-clinical therapeutic environments, from the user's perspective.

Zarie et al.[12]	2024	This study demonstrates the potential for expansion and revitalization of urban public green spaces in Qasrodasht by proposing a framework for designing them in the vertical dimension.	Ultimately, this study presents design alternatives, a framework for the design of vertically oriented public green spaces, and policies and strategies for implementing such designs in Qasrodasht through expert interviews.
Manan et al.	2023	This research aimed to investigate the challenges limiting the adoption of DNI strategies in Australia through the lens of innovation adoption theories.	As in previous studies, "budget constraints" and "maintenance burden" were identified as key barriers in this research, thus affirming their persistent negative impact on the adoption of BID. However, the innovation adoption framework led to the identification of new barriers such as "builder influence" (socio-political influences), "working circumstances" (designer), and "business difficulties" (organization).
Macruz et al.[13]	2024	This research explores the capacity of emerging technologies to improve well-being. The aim is to generate biophilic 2D geometries to represent human-responsive built environments and to conduct inter-individual and intra-individual analyses to evaluate human responses using a range of technologies within the fields of facial microexpression analysis and the use of EEG biosensors.	The results of this analysis allow these geometries to be classified in terms of emotional valences, levels of meditation, and subjective preferences. These graded geometries can then be used in specific architectural texts, such as interior decoration, wallpaper, furniture surfaces, or other architectural and interior components.
Sadick et al.	2024	This study aims to identify strategies to promote the integration of biophilic design in Australian buildings. To this end, semi-structured interviews were conducted with 24 architects and building sustainability consultants.	The study identified nine strategies to accelerate the adoption of biophilic design, including making biophilic design a core subject in architecture and building sustainability education, improving building codes and regulations to mandate minimum biophilic characteristics, demonstrating the business benefits of biophilic design to clients, incorporating biophilic design as a core value in design organizations, and disseminating research and information on the cost-effective application of local vegetation for biophilic design.
Tabatabaeifard et al.	2023	This research addresses biophilic design opportunities in Arctic indoor environments through a comprehensive methodology that incorporates architectural features, extreme cold climate conditions, and integrative lighting attributes.	The results highlight the potential of the method to support biophilic design in Arctic interior spaces. It demonstrates how 360° FOV visualization of human responses to lighting conditions can provide a biophilic perspective on a space and its architectural properties.
Mahrous et al.[14]	2023	This article aims to identify the attributes of biophilic design that can contribute to improving student satisfaction levels. To this end, an experimental search design with virtual reality will be used in a design study at the British University of Egypt. Each participant (N = 52) was exposed to the existing condition and then to the virtual experience. Before and after each exposure, cognitive and performance assessments were administered, and this assessment was analyzed using SPSS.	The results show a very positive effect of natural lighting, natural ventilation, green areas, large windows, indirect connection to nature, and natural finishing materials on student satisfaction levels.
Latini et al.	2024	In particular, the study investigates the independent and interaction effects of audiovisual connection with nature on 1) the office soundscape and 2) physiological parameters, and 3) explores possible correlations between the physiological response and that of the soundscape. In a between-subjects design experiment, three different visual scenarios (Interior Green, Exterior Green, and Non-Biophilic) and three sound environments (Office - O, Office + Traffic - O + T, and Office + Nature - O + N) were combined for a virtual office environment.	The results show a significant effect of the sound factor on the evaluation of the soundscape: the O + N scenario is more pleasant and eventful than the O scenario, i.e., a more vibrant office soundscape.
Espinoza-Sanhueza et al.[15]	2024	This paper investigates occupants' photobiological responses to analogous biophilic patterns such as electric lighting and surface color configuration during periods of darkness in Nordic architecture.	The results demonstrate the spatial diversification generated by electric lighting for different visual tasks and circadian stimulation throughout a day. The study also demonstrated that various color surfaces and luminaire configurations can generate similar photopic and melanopic lighting conditions despite their perceived spatial color temperature.

For the creation of urban green spaces or areas, according to Zarie et al.[12], three aspects must be taken into account: perception, function, and the environment where the design is applied. Espinoza-Sanhueza et al.[15] even recommend that spatial diversification refers to the variation in lighting according to the environment and the visual activities required, where electric lighting can be adapted to meet different visual needs and affect the circadian rhythm, which is the sleep-wake cycle of the human body.

This implies that lighting systems can be designed to provide adequate lighting for various visual tasks and also influence circadian rhythm regulation, regardless of the subjective perception of light color.

The sound factor has a significant impact on the evaluation of the soundscape in office environments. A more vibrant soundscape, which could be associated with a greater variety of sounds, results in a more favorable evaluation compared to a soundscape that lacks such variety. This suggests that the presence of a diversity of sounds can contribute to creating a more pleasant and stimulating office environment.[10]

Similarly, audiovisual connections with nature can have a positive effect on several areas of cognitive function. Working memory refers to the ability to retain and manipulate information in the mind for a short period, and findings suggest that exposure to nature can improve this ability. In addition, inhibition refers to the ability to control impulses and suppress automatic responses, while task switching involves the ability to switch between different activities or cognitive demands.[10]

Mahrous et al.[14] consider that the influential elements are natural lighting, natural ventilation, green areas, and large windows due to the indirect connection with nature and natural finishing materials. The results indicate that the presence of these environmental elements in educational spaces has a very positive effect on student satisfaction levels. Natural lighting, natural ventilation, and large windows can improve indoor air quality by providing natural light and fresh air, creating a more comfortable and stimulating environment for learning. The presence of green areas and indirect connection to nature can also contribute to a more relaxing and pleasant environment, positively influencing students' emotional well-being and overall perception of the educational environment. In addition, using natural finishing materials can provide a sense of warmth and connection to the environment, which can also contribute to student satisfaction levels.

"Graduated geometries" are considered to be geometric shapes or patterns that vary in complexity, size, arrangement, or some other aspect, where these geometries, in terms of their emotional impact, their ability to induce states of meditation, and people's subjective preference for them. This implies that some geometries may have a more positive or negative emotional effect, facilitate concentration and meditation, and may be more or less preferred by different individuals.

These findings could have practical applications in interior design and architecture. For example, these classified geometries could be used in interior decoration, wallpaper design, furniture surface treatment, or other architectural and interior components. By selecting and using appropriate geometries, designers can create environments that promote positive emotions, facilitate concentration, and satisfy the aesthetic and emotional preferences of the people who experience them.[13]

This includes the term "green pockets," which refers to areas of vegetation or green spaces incorporated into the structure or around buildings where these green pockets not only contribute to the integration of natural experiences into built environments but can also help develop more sustainable architecture by providing environmental benefits such as reducing the urban heat island effect, improving air quality, and promoting urban biodiversity.

The design of these green pockets focuses on aspects such as visibility and accessibility for building occupants, as well as spatial characteristics that mimic natural elements, such as perspective and shelter. In addition, concepts such as organized complexity, danger, and mystery are mentioned, which can be incorporated to create richer sensory and emotional experiences that improve the overall quality of buildings.[8] For Jung et al.[7], "green walls" refer to walls or spaces decorated with live or artificial plants, while "digital elements" could include screens displaying images, videos, or other visual content. He suggests that combining these elements can have a complementary effect on the emotional well-being of people in healthcare settings, such as hospitals or medical centers. Green walls can create a more natural and relaxing environment, while digital elements provide visual distractions or valuable information for patients and medical staff. Reducing negative emotions and enhancing positive ones can improve the overall experience in healthcare settings, which can be especially important for patients facing stressful or adverse health situations. However, Schleck et al.[9] suggest using natural and climate-adapted building materials and methods to move toward a more sustainable built future. These materials and methods are characterized by their low carbon footprint, local origin, minimal processing, and lack of toxicity, where the main idea is that the use of these materials can offer a path toward sustainability in construction, as they reduce dependence on non-renewable resources, minimize pollution, and promote a healthier indoor environment for building occupants. However, although there is recognition of the importance of these materials, there is little information available on how to access them during the production phase and how to meet human needs during the occupancy phase of buildings constructed with these materials. It is therefore determined that, despite their potential, areas still need to be explored and addressed to achieve wider adoption of sustainable and natural building materials.

CONCLUSIONS

Biophilic architecture is emerging as a powerful approach combining nature with architectural design to improve human well-being and promote connection with our natural environment. By integrating natural elements into built spaces, the aim is to improve the comfort and health of occupants and encourage a healthier lifestyle while contributing to environmental conservation.

The reviewed studies consistently show biophilic architecture's emotional, cognitive, and physiological benefits, from reducing anxiety to improving cognitive performance and promoting relaxation. In addition, the importance of considering accessibility in the design of natural spaces is highlighted, as well as the need to address the challenges associated with maintenance and additional costs.

In conclusion, biophilic architecture offers a path toward healthier and more sustainable built environments, where connection with nature becomes an integral design component. However, to maximize its impact and address its challenges, it is crucial to continue researching and developing best practices in this emerging area of design and construction.

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None.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORSHIP CONTRIBUTION

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